*Volume 0 (1981), Number 0 pp. 1–204* COMPUTER GRAPHICS *forum*

# A General BRDF Representation Based on Tensor Decomposition: Supplemental Material

Ahmet Bilgili[1†], Aydın Öztürk[2‡], and Murat Kurt[1§]

[1]International Computer Institute, Ege University, Turkey
[2]Department of Computer Engineering, Yasar University, Turkey

## 1. Introduction

Global illumination algorithms solve the rendering equation, first formulated by Kajiya [Kaj86]:

$$L_o(x,\vec{\omega}_o) = L_e(x,\vec{\omega}_o) + \int_{\Omega_+} L_i(x,\vec{\omega}_i)\rho(x,\vec{\omega}_i,\vec{\omega}_o)(\vec{\omega}_i\cdot\mathbf{n}_x)d\vec{\omega}_i, \quad (1)$$

where $\rho(x,\vec{\omega}_i,\vec{\omega}_o)$ is the Bidirectional Reflectance Distribution Function (BRDF) [NRH*77] for a given point $x$. In the rest of the paper, we ignore the notation of the point in the BRDF (see Table 4 for notation). In Monte Carlo rendering algorithms, the outgoing radiance is calculated such as:

$$L_o(\vec{\omega}_o) \approx \frac{1}{\#samples}\sum_{s=1}^{\#samples} L_i(\vec{\omega}_s)\frac{\rho(\vec{\omega}_s,\vec{\omega}_o)(\vec{\omega}_s\cdot\mathbf{n})}{p_i(\vec{\omega}_s \mid \vec{\omega}_o)}. \quad (2)$$

This document is supplemental to the paper titled *A General BRDF Representation Based on Tensor Decomposition* and describes $\rho(\vec{\omega}_i,\vec{\omega}_o)$ and $p_i(\vec{\omega}_i \mid \vec{\omega}_o)$ functions used for renderings of analytical BRDF models, which were employed in our comparisons. In Section 2, we list the equations for the analytical BRDF models. In Section 3, we describe the importance sampling procedure used for importance sampling of the analytical BRDF models. The rest of the document contains complete fitting results for the 100 isotropic BRDFs measured by Matusik et al. [MPBM03], rendered and false-color difference images. For further information, please refer to the original paper.

## 2. Analytical BRDF Models

We used 1 diffuse lobe and 3 specular lobes for fitting analytical BRDF models to measured BRDF data. So, we can use following general formulation to represent all analytical BRDF models:

$$\rho(\vec{\omega}_i,\vec{\omega}_o) = \frac{k_d}{\pi} + \sum_{j=1}^{3} k_s\rho_s(\vec{\omega}_i,\vec{\omega}_o,\vec{\mathbf{p}}_j), \quad (3)$$

where $k_d = [k_{dr},k_{dg},k_{db}]$ is diffuse albedo with three color parameters, $k_s = [k_{sr},k_{sg},k_{sb}]$ is specular reflectivity with three color parameters and other notations are listed in Table 4.

**Ashikhmin-Shirley BRDF model**: Specular lobe of the Ashikhmin-Shirley BRDF model [AS00] has the following form:

$$\rho_s(\vec{\omega}_i,\vec{\omega}_o,\vec{\mathbf{p}}) = \frac{D(\vec{\omega}_h,\vec{\mathbf{p}})F(\vec{\omega}_o\cdot\vec{\omega}_h,\vec{\mathbf{p}})}{4(\vec{\omega}_o\cdot\vec{\omega}_h)\max\{(\vec{\mathbf{n}}\cdot\vec{\omega}_i),(\vec{\mathbf{n}}\cdot\vec{\omega}_o)\}}, \quad (4)$$

$$D(\vec{\omega}_h,n) = \frac{n+1}{2\pi}\left[(\vec{\mathbf{n}}\cdot\vec{\omega}_h)\right]^n, \quad (5)$$

$$F(\vec{\omega}_o\cdot\vec{\omega}_h,f_0) = f_0 + (1-f_0)(1-(\vec{\omega}_o\cdot\vec{\omega}_h))^5, \quad (6)$$

where $\vec{\mathbf{p}} = [f_0,n]$ is the parameter vector; and other notations are listed in Table 4. We use Schlick's approximation [Sch94] for the Fresnel function, which is described in Equation (6).

**Cook-Torrance BRDF model**: Specular lobe of the Cook-Torrance BRDF model [CT81] has the following form:

$$\rho_s(\vec{\omega}_i,\vec{\omega}_o,\vec{\mathbf{p}}) = \frac{D(\vec{\omega}_h,\vec{\mathbf{p}})G(\vec{\omega}_i,\vec{\omega}_o)F(\vec{\omega}_o\cdot\vec{\omega}_h,\vec{\mathbf{p}})}{\pi(\vec{\mathbf{n}}\cdot\vec{\omega}_o)(\vec{\mathbf{n}}\cdot\vec{\omega}_i)}, \quad (7)$$

$$D(\vec{\omega}_h,m) = \frac{1}{m^2\cos^4\delta}\exp\left[-\left(\frac{\tan\delta}{m}\right)^2\right], \quad (8)$$

$$G(\vec{\omega}_i,\vec{\omega}_o) = \min\left\{1, \frac{2(\vec{\mathbf{n}}\cdot\vec{\omega}_h)(\vec{\mathbf{n}}\cdot\vec{\omega}_o)}{(\vec{\omega}_o\cdot\vec{\omega}_h)}, \frac{2(\vec{\mathbf{n}}\cdot\vec{\omega}_h)(\vec{\mathbf{n}}\cdot\vec{\omega}_i)}{(\vec{\omega}_o\cdot\vec{\omega}_h)}\right\} \quad (9)$$

$$F(\vec{\omega}_o\cdot\vec{\omega}_h,f_0) = f_0 + (1-f_0)(1-(\vec{\omega}_o\cdot\vec{\omega}_h))^5, \quad (10)$$

where $\vec{\mathbf{p}} = [f_0,m]$ is the parameter vector; and other notations are listed in Table 4. We use Schlick's approxima-


Published by Blackwell Publishing, 9600 Garsington Road, Oxford OX4 2DQ, UK and 350 Main Street, Malden, MA 02148, USA.

| Symbol | Meaning |
|---|---|
| $L_i(x,\vec{\omega}_i)$ | Incident radiance function |
| $L_o(x,\vec{\omega}_o)$ | Outgoing radiance function |
| $L_e(x,\vec{\omega}_o)$ | Emitted radiance function |
| $\vec{\omega}_i,\vec{\omega}_o$ | Unit-length incident and outgoing vectors |
| $\vec{\mathbf{n}}$ | Unit-length surface normal vector |
| $\hat{\omega}_h$ | Unnormalized halfway vector: $(\vec{\omega}_i+\vec{\omega}_o)$ |
| $\vec{\omega}_h$ | Unit-length halfway vector: $(\vec{\omega}_i+\vec{\omega}_o)/\parallel\vec{\omega}_i+\vec{\omega}_o\parallel$ |
| $\delta$ | Angle between $\vec{\mathbf{n}}$ and $\vec{\omega}_h$: $\arccos(\vec{\mathbf{n}}\cdot\vec{\omega}_h)$ |
| $\vec{\mathbf{p}}$ | Nonlinear parameter vector |
| $\Omega_+$ | Unit hemisphere above the surface |
| $D(\vec{\omega}_h,\vec{\mathbf{p}})$ | Distribution function |
| $F(\vec{\omega}_o\cdot\vec{\omega}_h,\vec{\mathbf{p}})$ | Fresnel function |
| $G(\vec{\omega}_i,\vec{\omega}_o)$ | Geometrical attenuation factor |
| $\rho(\vec{\omega}_i,\vec{\omega}_o)$ | Bidirectional Reflectance Distribution Function |
| $\rho_s(\vec{\omega}_i,\vec{\omega}_o,\vec{\mathbf{p}})$ | Specular lobe of the BRDF |
| $p_i(\vec{\omega}_i \mid \vec{\omega}_o)$ | Probability density function (pdf) |

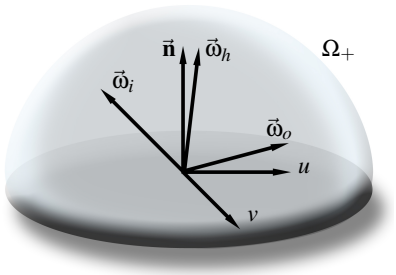



**Table 1:** *Notation used throughout this paper.*

tion [Sch94] for the Fresnel function, which is described in Equation (10).

**Edwards et al. BRDF model**: Specular lobe of the Edwards et al. BRDF model [EBJ*06] has the following form:

$$\rho_s(\vec{\omega}_i,\vec{\omega}_o,\vec{\mathbf{p}}) = \frac{D(\hat{\omega}_h,\vec{\mathbf{p}})F(\vec{\mathbf{n}}\cdot\vec{\omega}_o,\vec{\mathbf{p}})\parallel\vec{\omega}_i+\vec{\omega}_o\parallel^2}{4(\vec{\omega}_i\cdot\vec{\omega}_h)^2}, \quad (11)$$

$$D(\hat{\omega}_h,R,n) = \frac{n+1}{\pi R^2}\left[1-\left(\frac{\hat{\omega}_{hu}}{R}\right)^2-\left(\frac{\hat{\omega}_{hv}}{R}\right)^2\right]^n, \quad (12)$$

$$F(\vec{\mathbf{n}}\cdot\vec{\omega}_o,f_0) = f_0+(1-f_0)(1-(\vec{\mathbf{n}}\cdot\vec{\omega}_o))^5, \quad (13)$$

where $\vec{\mathbf{p}}=[f_0,R,n]$ is the parameter vector; and other notations are listed in Table 4. We use Schlick's approximation [Sch94, EBJ*06] for the Fresnel function, which is described in Equation (13).

**Ward BRDF model**: Specular lobe of the Ward BRDF model [War92] has the following form:

$$\rho_s(\vec{\omega}_i,\vec{\omega}_o,\vec{\mathbf{p}}) = \frac{D(\vec{\omega}_h,\vec{\mathbf{p}})}{\sqrt{(\vec{\mathbf{n}}\cdot\vec{\omega}_o)(\vec{\mathbf{n}}\cdot\vec{\omega}_i)}}, \quad (14)$$

$$D(\vec{\omega}_h,\alpha) = \frac{1}{4\pi\alpha^2}\exp\left[-\left(\frac{\tan\delta}{\alpha}\right)^2\right], \quad (15)$$

where $\vec{\mathbf{p}}=[\alpha]$ is the parameter vector; and other notations are listed in Table 4.

**Ward-Duer BRDF model**: Specular lobe of the Ward-Duer BRDF model [Due05] has the following form:

$$\rho_s(\vec{\omega}_i,\vec{\omega}_o,\vec{\mathbf{p}}) = \frac{D(\vec{\omega}_h,\vec{\mathbf{p}})}{(\vec{\mathbf{n}}\cdot\vec{\omega}_o)(\vec{\mathbf{n}}\cdot\vec{\omega}_i)}, \quad (16)$$

$$D(\vec{\omega}_h,\alpha) = \frac{1}{4\pi\alpha^2}\exp\left[-\left(\frac{\tan\delta}{\alpha}\right)^2\right], \quad (17)$$

where $\vec{\mathbf{p}}=[\alpha]$ is the parameter vector; and other notations are listed in Table 4.

## 3. Importance Sampling of Analytical BRDF Models

**Importance sampling of diffuse lobe**: Let $\xi_1$ and $\xi_2$ be two canonical uniform random variables in the range $[0,1]$. Importance sampling equations for the diffuse lobe are:

$$\theta_i = \arcsin\left(\sqrt{\xi_1}\right), \quad (18)$$

$$\phi_i = 2\pi\xi_2. \quad (19)$$

With the help of Equation (18) and Equation (19), we can calculate the sampling direction $\vec{\omega}_i$ with the following formula:

$$\vec{\omega}_i = [\sin\theta_i\cos\phi_i,\sin\theta_i\sin\phi_i,\cos\theta_i]. \quad (20)$$

Probability density function $p_d(\vec{\omega}_i \mid \vec{\omega}_o)$ for the diffuse lobe is:

$$p_d(\vec{\omega}_i \mid \vec{\omega}_o) = \frac{(\vec{\mathbf{n}}\cdot\vec{\omega}_i)}{\pi}. \quad (21)$$

**Importance sampling of Ashikhmin-Shirley BRDF model**: Let $\xi_1$ and $\xi_2$ be two canonical uniform random variables in the range $[0,1]$. Importance sampling equations for the Ashikhmin-Shirley BRDF model [AS00] are:

$$\theta_h = \arccos\left(\sqrt[n+1]{\xi_1}\right), \quad (22)$$

$$\phi_h = \frac{\pi\xi_2}{2}. \quad (23)$$

With the help of Equation (22) and Equation (23), we can calculate the *halfway vector* $\vec{\omega}_h$:

$$\vec{\omega}_h = [\sin\theta_h\cos\phi_h, \sin\theta_h\sin\phi_h, \cos\theta_h]. \quad (24)$$

After that, we can find the sampling direction $\vec{\omega}_i$ with the following formula:

$$\vec{\omega}_i = 2(\vec{\omega}_o \cdot \vec{\omega}_h)\vec{\omega}_h - \vec{\omega}_o. \quad (25)$$

Probability density function $p_s(\vec{\omega}_i \mid \vec{\omega}_o)$ for the Ashikhmin-Shirley BRDF model [AS00] is:

$$p_s(\vec{\omega}_i \mid \vec{\omega}_o) = \frac{D(\vec{\omega}_h, \vec{\mathbf{p}})}{4(\vec{\omega}_o \cdot \vec{\omega}_h)}, \quad (26)$$

where $D(\vec{\omega}_h, \vec{\mathbf{p}})$ is from Equation (5).

**Importance sampling of Edwards et al. BRDF model**: Let $\xi_1$ and $\xi_2$ be two canonical uniform random variables in the range $[0,1]$. Importance sampling equations for the Edwards et al. BRDF model [EBJ*06] are:

$$\theta = 2\pi\xi_1, \quad (27)$$

$$r = R\sqrt{1 - \sqrt[n+1]{\xi_2}}. \quad (28)$$

We use *the orthogonal projection*, which was suggested by Edwards et al. [EBJ*06] for fitting measured BRDF data. So, with the help of Equation (27) and Equation (28), we can calculate the *unnormalized halfway vector* $\hat{\omega}_h$ using the following formulas:

$$\hat{\omega}_H = [r\cos\theta, r\sin\theta, (\vec{\mathbf{n}} \cdot \vec{\omega}_o)], \quad (29)$$

$$\hat{\omega}_d = \hat{\omega}_H - \vec{\omega}_o, \quad (30)$$

$$(\vec{\mathbf{n}} \cdot \vec{\omega}_i) = \sqrt{1 - \hat{\omega}_{du}^2 - \hat{\omega}_{dv}^2}, \quad (31)$$

$$\hat{\omega}_h = [r\cos\theta, r\sin\theta, (\vec{\mathbf{n}} \cdot \vec{\omega}_o) + (\vec{\mathbf{n}} \cdot \vec{\omega}_i)]. \quad (32)$$

After that, we normalize $\hat{\omega}_h$ vector to get $\vec{\omega}_h$. Now, we can find the sampling direction $\vec{\omega}_i$ with the following formula:

$$\vec{\omega}_i = 2(\vec{\omega}_o \cdot \vec{\omega}_h)\vec{\omega}_h - \vec{\omega}_o. \quad (33)$$

Probability density function $p_s(\vec{\omega}_i \mid \vec{\omega}_o)$ for the Edwards et al. BRDF model [EBJ*06] is:

$$p_s(\vec{\omega}_i \mid \vec{\omega}_o) = \frac{D(\hat{\omega}_h, \vec{\mathbf{p}}) \parallel \vec{\omega}_i + \vec{\omega}_o \parallel^2}{4(\vec{\omega}_i \cdot \vec{\omega}_h)^2}, \quad (34)$$

where $D(\vec{\omega}_h, \vec{\mathbf{p}})$ is from Equation (12).

**Importance sampling of Ward BRDF model**: Let $\xi_1$ and $\xi_2$ be two canonical uniform random variables in the range $[0,1]$. Importance sampling equations for the Ward BRDF model [War92] are:

$$\theta_h = \arctan\left(\alpha\sqrt{-\log\xi_1}\right), \quad (35)$$

$$\phi_h = 2\pi\xi_2. \quad (36)$$

With the help of Equation (35) and Equation (36), we can calculate the *halfway vector* $\vec{\omega}_h$:

$$\vec{\omega}_h = [\sin\theta_h\cos\phi_h, \sin\theta_h\sin\phi_h, \cos\theta_h]. \quad (37)$$

After that, we can find the sampling direction $\vec{\omega}_i$ with the following formula:

$$\vec{\omega}_i = 2(\vec{\omega}_o \cdot \vec{\omega}_h)\vec{\omega}_h - \vec{\omega}_o. \quad (38)$$

Probability density function $p_s(\vec{\omega}_i \mid \vec{\omega}_o)$ for the Ward BRDF model [War92] is:

$$p_s(\vec{\omega}_i \mid \vec{\omega}_o) = \frac{D(\vec{\omega}_h, \vec{\mathbf{p}})}{(\vec{\omega}_h \cdot \vec{\omega}_o)(\vec{\mathbf{n}} \cdot \vec{\omega}_h)^3}, \quad (39)$$

where $D(\vec{\omega}_h, \vec{\mathbf{p}})$ is from Equation (15).

**Importance sampling of Cook-Torrance BRDF model**: Since Cook-Torrance BRDF model [CT81] does not have any importance sampling procedure, we use importance sampling of Ward BRDF model for sampling of Cook-Torrance BRDF model.

**Importance sampling of Ward-Duer BRDF model**: Since Duer [Due05] suggests to use importance sampling of Ward BRDF model for sampling of Ward-Duer BRDF model [Due05], we use importance sampling of Ward BRDF model for sampling of Ward-Duer BRDF model.

The analytical BRDF models consist of diffuse lobe and specular lobes, therefore we have to combine sampling strategies of all lobes. Sampling weights for each lobe are calculated as:

$$w_d = \frac{k_{dr} + k_{dg} + k_{db}}{k_{dr} + k_{dg} + k_{db} + 3(k_{sr} + k_{sg} + k_{sb})}, \quad (40)$$

$$w_s = \frac{k_{sr} + k_{sg} + k_{sb}}{k_{dr} + k_{dg} + k_{db} + 3(k_{sr} + k_{sg} + k_{sb})}. \quad (41)$$

After that, we choose samples according to these weights and combine pdfs of all lobes with these weights:

$$p_i(\vec{\omega}_i \mid \vec{\omega}_o) = w_d p_d(\vec{\omega}_i \mid \vec{\omega}_o) + w_s(p_{s1}(\vec{\omega}_i \mid \vec{\omega}_o) + p_{s2}(\vec{\omega}_i \mid \vec{\omega}_o) + p_{s3}(\vec{\omega}_i \mid \vec{\omega}_o)). \quad (42)$$

## 4. Implementation Details of Lawrence et al. BRDF Model

Lawrence et al. [LRR04] used variable resolutions and number of factors for factorizing Matusik et al.'s measured BRDF data [MPBM03]. This is shown in Table 2. Lawrence et al. factorized only the blue-metallic-paint, the nickel and the yellow-matte-plastic which are glossy, specular and highly specular materials, respectively. When we factorize other materials from Matusik et al.'s measured BRDF data, we used material types for selecting proper resolutions and number of factors.

We used the same number of factors and resolutions for diffuse and glossy materials as Lawrence et al. did for the blue-metallic-paint, which are given in Table 2. We used the same number of factors and resolutions for specular materials as Lawrence et al. did for the nickel, which are given in Table 2. We used the same number of factors and resolutions

| Measured BRDF | Resolution $(\theta_o \times \phi_o \times \theta_h \times \phi_h)$ | Terms $(J \times K = L)$ | Material Type |
|---|---|---|---|
| Blue-metallic-paint | $16 \times 16 \times 128 \times 16$ | $4 \times 1 = 4$ | Glossy |
| Nickel | $16 \times 16 \times 128 \times 16$ | $2 \times 1 = 2$ | Specular |
| Yellow-matte-plastic | $16 \times 16 \times 128 \times 16$ | $3 \times 1 = 3$ | Highly Specular |

**Table 2:** *Number of factors and resolution of Lawrence et al.'s factorization-based BRDF model. The table also includes material types, which are used for factorizing other materials of Matusik et al.'s measured BRDF dataset.*

for highly specular materials as Lawrence et al. did for the yellow-matte-plastic, which are given in Table 2.

## References


[AS00] ASHIKHMIN M., SHIRLEY P.: An anisotropic Phong BRDF model. *Journal of Graphics Tools 5*, 2 (2000), 25–32. 1, 2, 3

[CT81] COOK R. L., TORRANCE K. E.: A reflectance model for computer graphics. *Computer Graphics 15*, 3 (1981), 307–316. (Proc. SIGGRAPH '81). 1, 3

[Due05] DUER A.: On the Ward model for global illumination. Unpublished material, 2005. 2, 3

[EBJ*06] EDWARDS D., BOULOS S., JOHNSON J., SHIRLEY P., ASHIKHMIN M., STARK M., WYMAN C.: The halfway vector disk for brdf modeling. *ACM TOG 25*, 1 (Jan. 2006), 1–18. 2, 3

[Kaj86] KAJIYA J. T.: The rendering equation. *Computer Graphics 20*, 4 (1986), 143–150. (Proc. SIGGRAPH '86). 1

[LRR04] LAWRENCE J., RUSINKIEWICZ S., RAMAMOORTHI R.: Efficient BRDF importance sampling using a factored representation. *ACM TOG 23*, 3 (2004), 496–505. (Proc. SIGGRAPH '04). 3

[MPBM03] MATUSIK W., PFISTER H., BRAND M., MCMILLAN L.: A data-driven reflectance model. *ACM TOG 22*, 3 (July 2003), 759–769. (Proc. SIGGRAPH '03). 1, 3

[NRH*77] NICODEMUS F. E., RICHMOND J. C., HSIA J. J., GINSBERG I. W., LIMPERIS T.: *Geometrical Considerations and Nomenclature for Reflectance*. Monograph, National Bureau of Standards (US), Oct. 1977. 1

[Sch94] SCHLICK C.: An inexpensive BRDF model for physically-based rendering. *Computer Graphics Forum 13*, 3 (1994), 233–246. (Proc. Eurographics '94). 1, 2

[War92] WARD G. J.: Measuring and modeling anisotropic reflection. *Computer Graphics 26*, 2 (1992), 265–272. (Proc. SIGGRAPH '92). 2, 3

**Material Name**: alum-bronze

**Fitted Parameters/PSNR**

| Material Name | alum-bronze | $k_{sr}$ | 0.144923 | $f_{02}$ | 0.160220 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.112152 | $n_2$ | 319.0319 |
| $k_{dr}$ | 0.039569 | $k_{sb}$ | 0.097115 | $f_{03}$ | 0.491985 |
| $k_{dg}$ | 0.029366 | $f_{01}$ | 0.074743 | $n_3$ | 24.63192 |
| $k_{db}$ | 0.010779 | $n_1$ | 5367.346 | PSNR | 34.37023 |

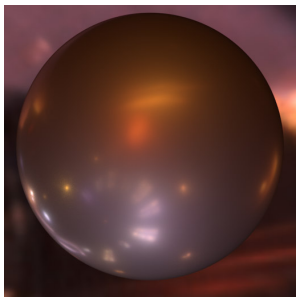
| Material Name | alum-bronze | $k_{sr}$ | 0.026138 | $f_{02}$ | 0.120320 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.020211 | $m_2$ | 0.049594 |
| $k_{dr}$ | 0.056752 | $k_{sb}$ | 0.017520 | $f_{03}$ | 0.080642 |
| $k_{dg}$ | 0.042707 | $f_{01}$ | 0.487096 | $m_3$ | 0.016055 |
| $k_{db}$ | 0.022282 | $m_1$ | 0.167667 | PSNR | 30.86150 |

| Material Name | alum-bronze | $k_{sg}$ | 0.127499 | $R_2$ | 0.355642 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.109940 | $n_2$ | 103.3311 |
| $k_{dr}$ | 0.069427 | $f_{01}$ | 0.008126 | $f_{03}$ | 0.288584 |
| $k_{dg}$ | 0.052386 | $R_1$ | 0.280099 | $R_3$ | 2.347751 |
| $k_{db}$ | 0.030877 | $n_1$ | 1000.130 | $n_3$ | 177.3963 |
| $k_{sr}$ | 0.164436 | $f_{02}$ | 0.054006 | PSNR | 27.98193 |

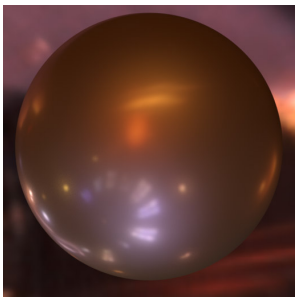
| Material Name | alum-bronze | $k_{db}$ | 0.046842 | $\alpha_1$ | 0.081186 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.022550 | $\alpha_2$ | 0.081186 |
| $k_{dr}$ | 0.079875 | $k_{sg}$ | 0.015572 | $\alpha_3$ | 0.017165 |
| $k_{dg}$ | 0.064507 | $k_{sb}$ | 0.010806 | PSNR | 25.47534 |

| Material Name | alum-bronze | $k_{db}$ | 0.041931 | $\alpha_1$ | 0.080905 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.017241 | $\alpha_2$ | 0.074110 |
| $k_{dr}$ | 0.078477 | $k_{sg}$ | 0.012604 | $\alpha_3$ | 0.016314 |
| $k_{dg}$ | 0.061567 | $k_{sb}$ | 0.009760 | PSNR | 26.14620 |

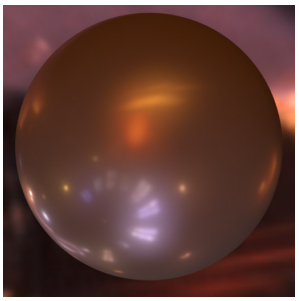
**Rendered Images**



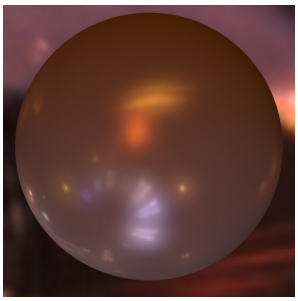
Reference image



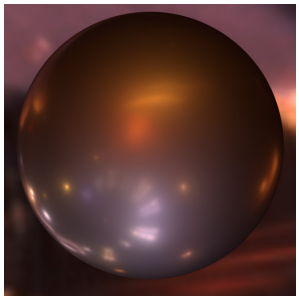
Ashikhmin-Shirley
(PSNR=34.37023)



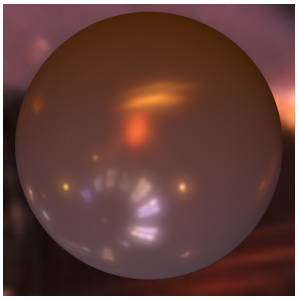
Cook-Torrance
(PSNR=30.86150)



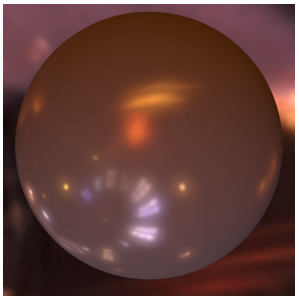
Edwards et al.
(PSNR=27.98193)



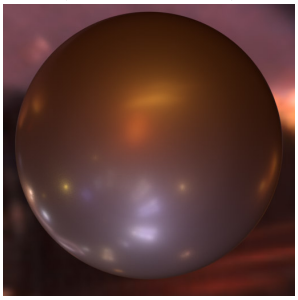
Lawrence et al.
(PSNR=32.62862)



Ward
(PSNR=25.47534)

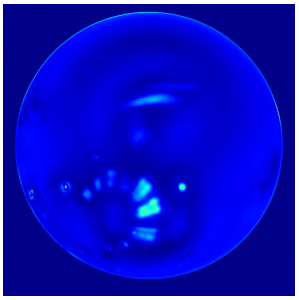


Ward-Duer
(PSNR=26.14620)

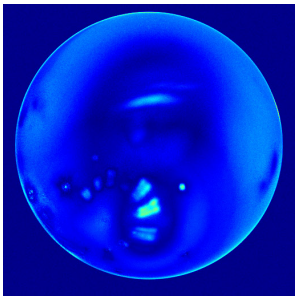


Our factored model
(PSNR=37.86640)

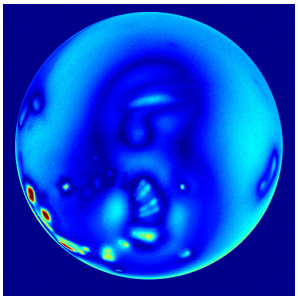
**Difference Images**



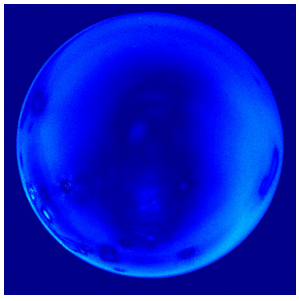
Ashikhmin-Shirley



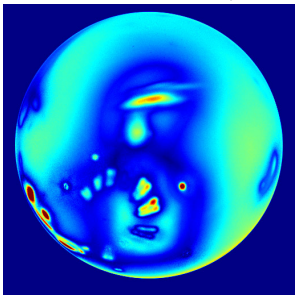
Cook-Torrance



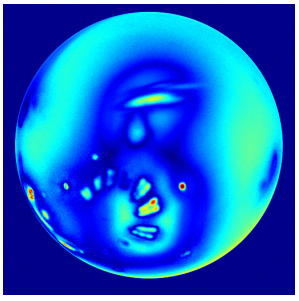
Edwards et al.



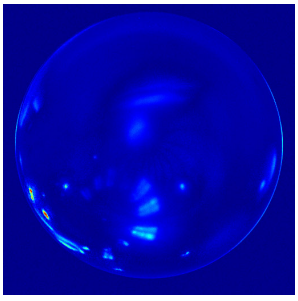
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: alumina-oxide

**Fitted Parameters/PSNR**

| Material Name | alumina-oxide | $k_{sr}$ | 0.067323 | $f_{02}$ | 0.058814 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.068508 | $n_2$ | 4202.835 |
| $k_{dr}$ | 0.316616 | $k_{sb}$ | 0.077399 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.290545 | $f_{01}$ | 0.183472 | $n_3$ | 4299.263 |
| $k_{db}$ | 0.255283 | $n_1$ | 33460.28 | PSNR | 34.98997 |

| Material Name | alumina-oxide | $k_{sr}$ | 0.026035 | $f_{02}$ | 0.023642 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.027201 | $m_2$ | 0.002888 |
| $k_{dr}$ | 0.317690 | $k_{sb}$ | 0.032419 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.291189 | $f_{01}$ | 0.110108 | $m_3$ | 0.024275 |
| $k_{db}$ | 0.254938 | $m_1$ | 0.012022 | PSNR | 34.52542 |

| Material Name | alumina-oxide | $k_{sg}$ | 0.153175 | $R_2$ | 0.192114 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.174141 | $n_2$ | 168.3131 |
| $k_{dr}$ | 0.312698 | $f_{01}$ | 0.026130 | $f_{03}$ | 0.043872 |
| $k_{dg}$ | 0.286254 | $R_1$ | 0.190826 | $R_3$ | 1.754046 |
| $k_{db}$ | 0.250277 | $n_1$ | 998.6901 | $n_3$ | 96.18564 |
| $k_{sr}$ | 0.148460 | $f_{02}$ | 0.043683 | PSNR | 35.02439 |

| Material Name | alumina-oxide | $k_{db}$ | 0.250705 | $\alpha_1$ | 0.013747 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.007827 | $\alpha_2$ | 0.013747 |
| $k_{dr}$ | 0.317264 | $k_{sg}$ | 0.007590 | $\alpha_3$ | 0.005377 |
| $k_{dg}$ | 0.292018 | $k_{sb}$ | 0.011455 | PSNR | 33.56218 |

| Material Name | alumina-oxide | $k_{db}$ | 0.232641 | $\alpha_1$ | 0.122567 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.012003 | $\alpha_2$ | 0.017226 |
| $k_{dr}$ | 0.300450 | $k_{sg}$ | 0.011778 | $\alpha_3$ | 0.007804 |
| $k_{dg}$ | 0.275325 | $k_{sb}$ | 0.015242 | PSNR | 34.08734 |

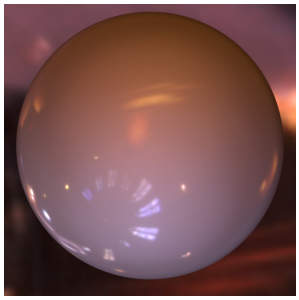
**Rendered Images**

Reference image

Ashikhmin-Shirley
(PSNR=34.98997)

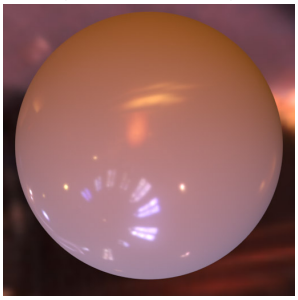
Cook-Torrance
(PSNR=34.52542)

Edwards et al.
(PSNR=35.02439)



Lawrence et al.
(PSNR=21.07882)

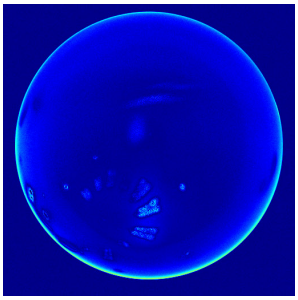
Ward
(PSNR=33.56218)



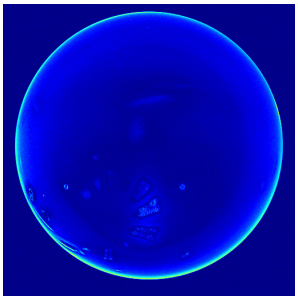
Ward-Duer
(PSNR=34.08734)

Our factored model
(PSNR=40.95900)

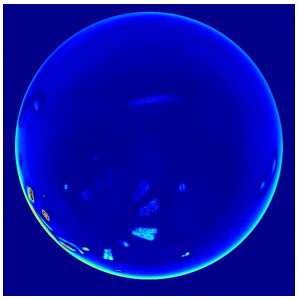
**Difference Images**



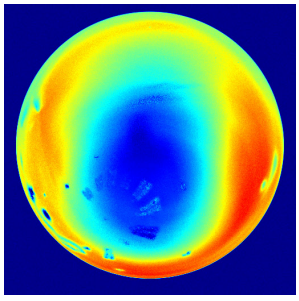
Ashikhmin-Shirley



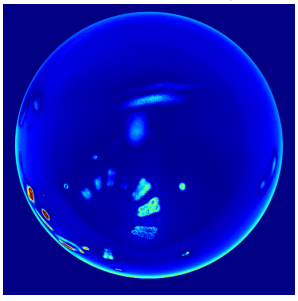
Cook-Torrance



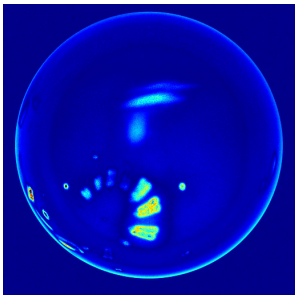
Edwards et al.



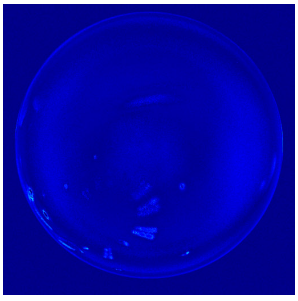
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: aluminium

**Fitted Parameters/PSNR**

| Material Name | aluminium | $k_{sr}$ | 0.049922 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.039153 | $n_2$ | 5020.543 |
| $k_{dr}$ | 0.044224 | $k_{sb}$ | 0.041284 | $f_{03}$ | 0.653819 |
| $k_{dg}$ | 0.047940 | $f_{01}$ | 0.106301 | $n_3$ | 58407.46 |
| $k_{db}$ | 0.050182 | $n_1$ | 680545.5 | PSNR | 22.03553 |

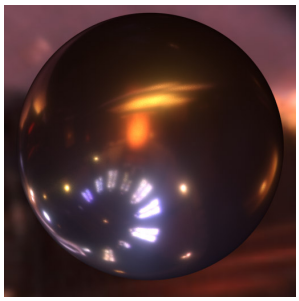
| Material Name | aluminium | $k_{sr}$ | 0.012936 | $f_{02}$ | 0.599966 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.010141 | $m_2$ | 0.005265 |
| $k_{dr}$ | 0.044729 | $k_{sb}$ | 0.010660 | $f_{03}$ | 0.062621 |
| $k_{dg}$ | 0.048363 | $f_{01}$ | 0.999999 | $m_3$ | 0.001272 |
| $k_{db}$ | 0.050848 | $m_1$ | 0.018616 | PSNR | 21.92037 |

| Material Name | aluminium | $k_{sg}$ | 0.098010 | $R_2$ | 0.310571 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.102484 | $n_2$ | 100.0468 |
| $k_{dr}$ | 0.040927 | $f_{01}$ | 0.277867 | $f_{03}$ | 0.031203 |
| $k_{dg}$ | 0.045279 | $R_1$ | 0.137541 | $R_3$ | 0.003287 |
| $k_{db}$ | 0.047987 | $n_1$ | 249.9151 | $n_3$ | 0.602681 |
| $k_{sr}$ | 0.124833 | $f_{02}$ | 0.387081 | PSNR | 22.24549 |

| Material Name | aluminium | $k_{db}$ | 0.057110 | $\alpha_1$ | 0.013933 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.034611 | $\alpha_2$ | 0.013933 |
| $k_{dr}$ | 0.052409 | $k_{sg}$ | 0.026769 | $\alpha_3$ | 0.003863 |
| $k_{dg}$ | 0.055192 | $k_{sb}$ | 0.028551 | PSNR | 20.94873 |

| Material Name | aluminium | $k_{db}$ | 0.058458 | $\alpha_1$ | 0.016926 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.025368 | $\alpha_2$ | 0.012129 |
| $k_{dr}$ | 0.054385 | $k_{sg}$ | 0.019746 | $\alpha_3$ | 0.003733 |
| $k_{dg}$ | 0.056352 | $k_{sb}$ | 0.021022 | PSNR | 20.69082 |

**Rendered Images**

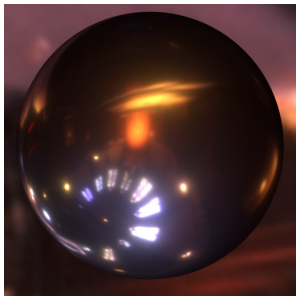


Reference image

Ashikhmin-Shirley
(PSNR=22.03553)

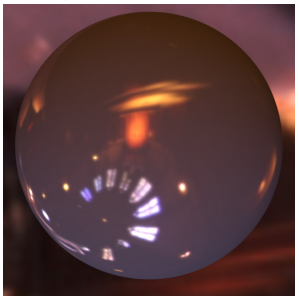
Cook-Torrance
(PSNR=21.92037)

Edwards et al.
(PSNR=22.24549)

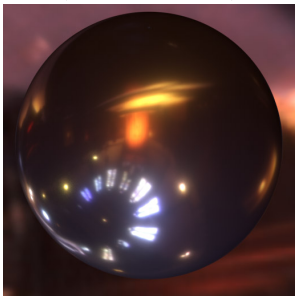


Lawrence et al.
(PSNR=34.84567)

Ward
(PSNR=20.94873)

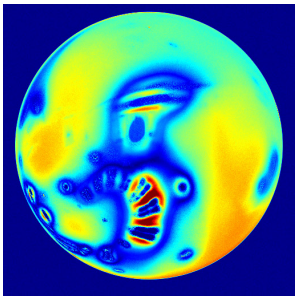


Ward-Duer
(PSNR=20.69082)

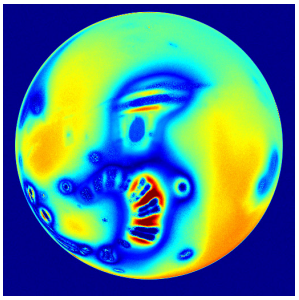


Our factored model
(PSNR=36.15733)

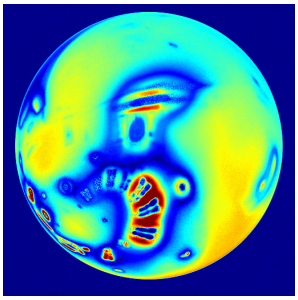
**Difference Images**



Ashikhmin-Shirley

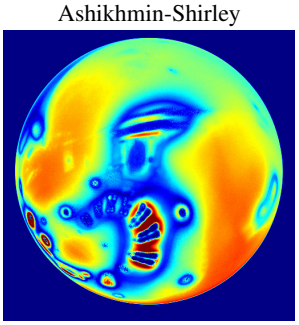


Cook-Torrance

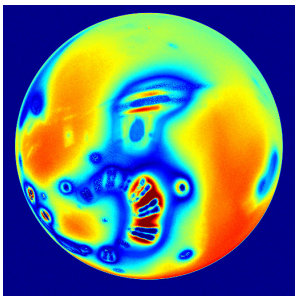


Edwards et al.

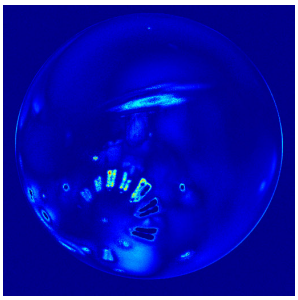
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: aventurnine

**Fitted Parameters/PSNR**

| Material Name | aventurnine | $k_{sr}$ | 0.052261 | $f_{02}$ | 0.073564 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.047355 | $n_2$ | 10687.43 |
| $k_{dr}$ | 0.057447 | $k_{sb}$ | 0.049779 | $f_{03}$ | 0.032912 |
| $k_{dg}$ | 0.064701 | $f_{01}$ | 0.017990 | $n_3$ | 2257.074 |
| $k_{db}$ | 0.056012 | $n_1$ | 277326.5 | PSNR | 39.01257 |

| Material Name | aventurnine | $k_{sr}$ | 0.012699 | $f_{02}$ | 0.073991 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.011505 | $m_2$ | 0.013476 |
| $k_{dr}$ | 0.057353 | $k_{sb}$ | 0.012094 | $f_{03}$ | 0.018573 |
| $k_{dg}$ | 0.064618 | $f_{01}$ | 0.036420 | $m_3$ | 0.002690 |
| $k_{db}$ | 0.055925 | $m_1$ | 0.030299 | PSNR | 39.03459 |

| Material Name | aventurnine | $k_{sg}$ | 0.041605 | $R_2$ | 0.116949 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.043721 | $n_2$ | 94.58522 |
| $k_{dr}$ | 0.058709 | $f_{01}$ | 0.032594 | $f_{03}$ | 0.072628 |
| $k_{dg}$ | 0.065884 | $R_1$ | 0.175405 | $R_3$ | 0.388906 |
| $k_{db}$ | 0.057258 | $n_1$ | 1000.287 | $n_3$ | 290.2939 |
| $k_{sr}$ | 0.046221 | $f_{02}$ | 0 | PSNR | 36.36662 |

| Material Name | aventurnine | $k_{db}$ | 0.055826 | $\alpha_1$ | 0.019067 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.004000 | $\alpha_2$ | 0.019067 |
| $k_{dr}$ | 0.056536 | $k_{sg}$ | 0.003443 | $\alpha_3$ | 0.006007 |
| $k_{dg}$ | 0.064270 | $k_{sb}$ | 0.003496 | PSNR | 35.09335 |

| Material Name | aventurnine | $k_{db}$ | 0.052374 | $\alpha_1$ | 0.031577 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.004257 | $\alpha_2$ | 0.018524 |
| $k_{dr}$ | 0.052992 | $k_{sg}$ | 0.003707 | $\alpha_3$ | 0.007788 |
| $k_{dg}$ | 0.061097 | $k_{sb}$ | 0.003844 | PSNR | 36.14716 |

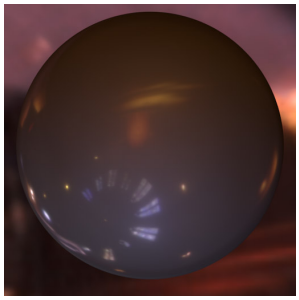
**Rendered Images**

Reference image

Ashikhmin-Shirley
(PSNR=39.01257)

Cook-Torrance
(PSNR=39.03459)

Edwards et al.
(PSNR=36.36662)



Lawrence et al.
(PSNR=27.32613)

Ward
(PSNR=35.09335)

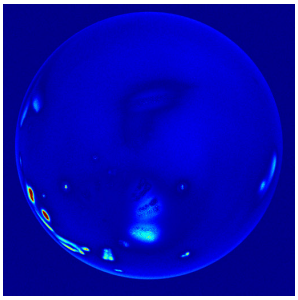
Ward-Duer
(PSNR=36.14716)

Our factored model
(PSNR=42.07024)

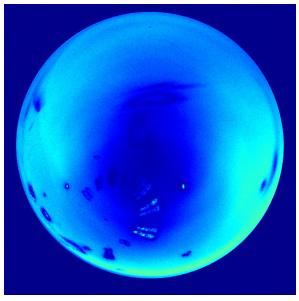
**Difference Images**

Ashikhmin-Shirley

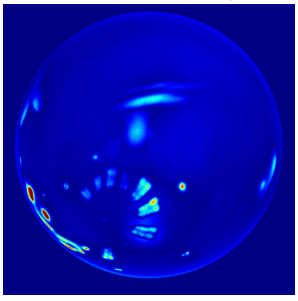
Cook-Torrance



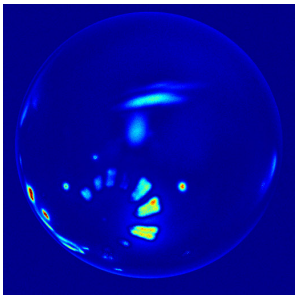
Edwards et al.



Lawrence et al.



Ward



Ward-Duer

Our factored model

**Material Name**: beige-fabric

**Fitted Parameters/PSNR**

| Material Name | beige-fabric | $k_{sr}$ | 0.118192 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.108363 | $n_2$ | 0 |
| $k_{dr}$ | 0.198894 | $k_{sb}$ | 0.097194 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.127126 | $f_{01}$ | 0.999999 | $n_3$ | 0 |
| $k_{db}$ | 0.107353 | $n_1$ | 0.449412 | PSNR | 39.31856 |

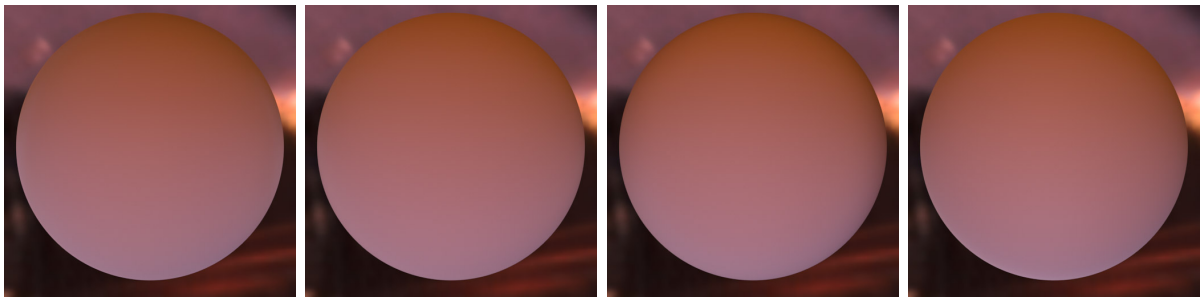
| Material Name | beige-fabric | $k_{sr}$ | 0.008377 | $f_{02}$ | 0.343948 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.007252 | $m_2$ | 0.411028 |
| $k_{dr}$ | 0.222136 | $k_{sb}$ | 0.006142 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.151033 | $f_{01}$ | 0.999999 | $m_3$ | 0.999999 |
| $k_{db}$ | 0.130996 | $m_1$ | 0.999999 | PSNR | 34.26464 |

| Material Name | beige-fabric | $k_{sg}$ | 0.179986 | $R_2$ | 6.747573 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.147818 | $n_2$ | 49.91196 |
| $k_{dr}$ | 0.261912 | $f_{01}$ | 0.038881 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.185083 | $R_1$ | 5.980217 | $R_3$ | 7.395876 |
| $k_{db}$ | 0.160089 | $n_1$ | 99.98289 | $n_3$ | 9.665184 |
| $k_{sr}$ | 0.199850 | $f_{02}$ | 0 | PSNR | 35.32689 |

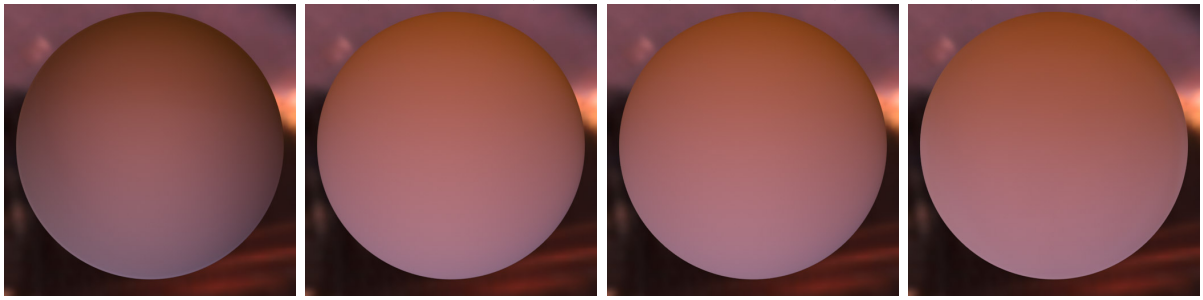
| Material Name | beige-fabric | $k_{db}$ | 0.164607 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.009908 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.259933 | $k_{sg}$ | 0.006169 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.186920 | $k_{sb}$ | 0.002776 | PSNR | 33.64021 |

| Material Name | beige-fabric | $k_{db}$ | 0.159864 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.008578 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.257111 | $k_{sg}$ | 0.006536 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.182955 | $k_{sb}$ | 0.004544 | PSNR | 33.77871 |

**Rendered Images**

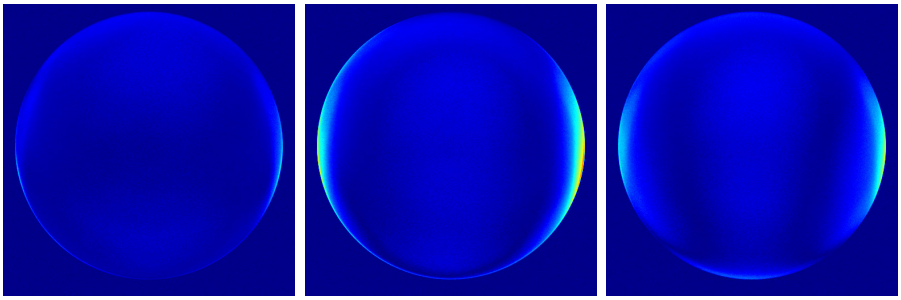


Reference image | Ashikhmin-Shirley (PSNR=39.31856) | Cook-Torrance (PSNR=34.26464) | Edwards et al. (PSNR=35.32689)

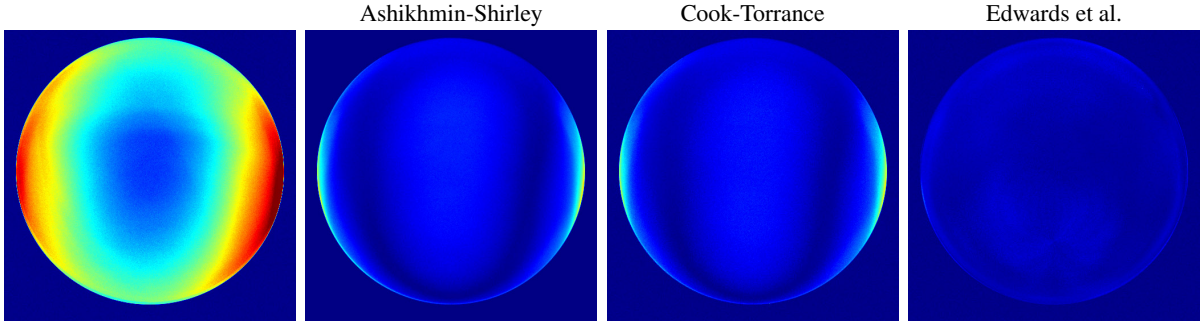


Lawrence et al. (PSNR=21.52343) | Ward (PSNR=33.64021) | Ward-Duer (PSNR=33.77871) | Our factored model (PSNR=39.91502)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: black-fabric

**Fitted Parameters/PSNR**

| Material Name | black-fabric | $k_{sr}$ | 0.014404 | $f_{02}$ | 0.087702 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.011909 | $n_2$ | 6.013200 |
| $k_{dr}$ | 0.011159 | $k_{sb}$ | 0.011538 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.005629 | $f_{01}$ | 0.984548 | $n_3$ | 10.77202 |
| $k_{db}$ | 0.005117 | $n_1$ | 0.480779 | PSNR | 47.56870 |

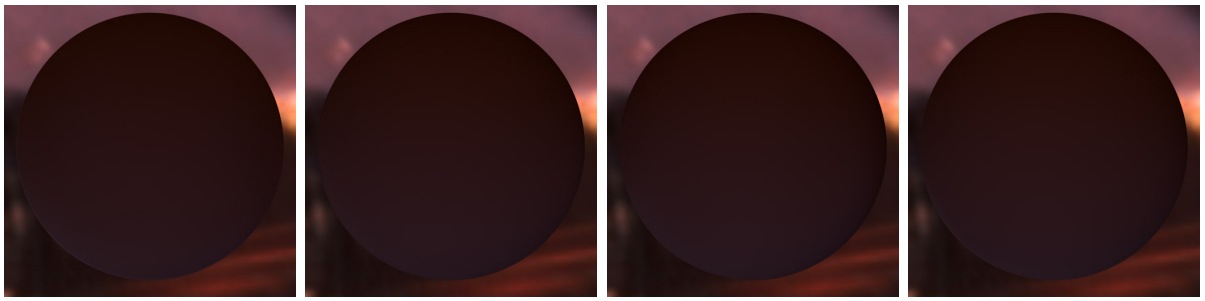
| Material Name | black-fabric | $k_{sr}$ | 0.002755 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.002267 | $m_2$ | 0.696268 |
| $k_{dr}$ | 0.012024 | $k_{sb}$ | 0.002193 | $f_{03}$ | 0.358440 |
| $k_{dg}$ | 0.006359 | $f_{01}$ | 0.101858 | $m_3$ | 0.999999 |
| $k_{db}$ | 0.005829 | $m_1$ | 0.362900 | PSNR | 46.56473 |

| Material Name | black-fabric | $k_{sg}$ | 0.008561 | $R_2$ | 3.582903 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.008281 | $n_2$ | 49.59715 |
| $k_{dr}$ | 0.014830 | $f_{01}$ | 0.002547 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.008671 | $R_1$ | 1.824357 | $R_3$ | 0.901784 |
| $k_{db}$ | 0.008065 | $n_1$ | 100.4231 | $n_3$ | 0.855950 |
| $k_{sr}$ | 0.010482 | $f_{02}$ | 0.036129 | PSNR | 47.68886 |

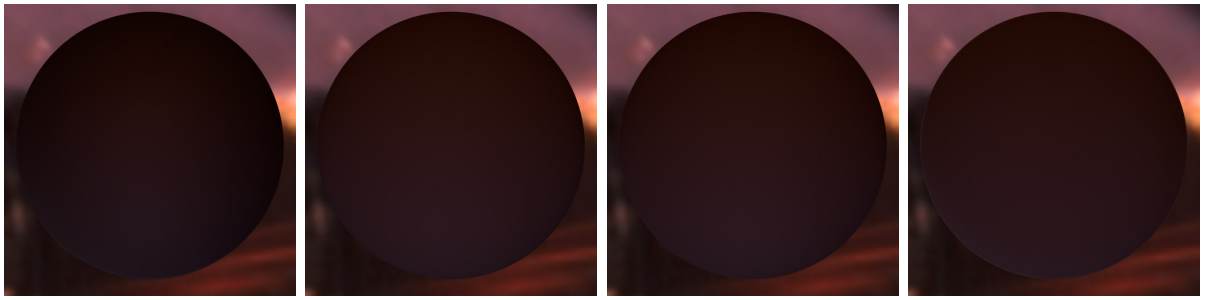
| Material Name | black-fabric | $k_{db}$ | 0.007520 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.001120 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.014064 | $k_{sg}$ | 0.000859 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.008119 | $k_{sb}$ | 0.000840 | PSNR | 43.85959 |

| Material Name | black-fabric | $k_{db}$ | 0.007047 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.001109 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.013488 | $k_{sg}$ | 0.000881 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.007621 | $k_{sb}$ | 0.000853 | PSNR | 43.88456 |

**Rendered Images**

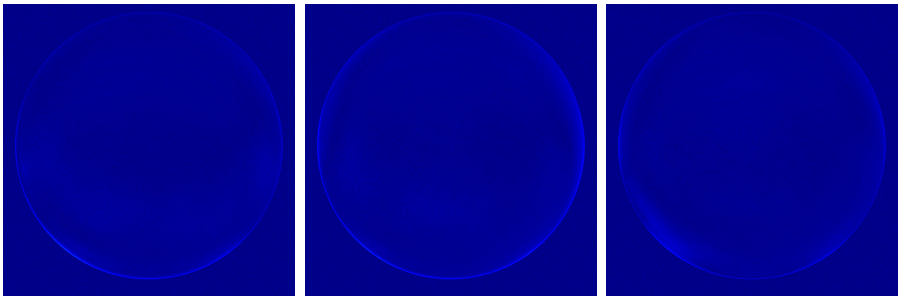


Reference image | Ashikhmin-Shirley (PSNR=47.56870) | Cook-Torrance (PSNR=46.56473) | Edwards et al. (PSNR=47.68886)

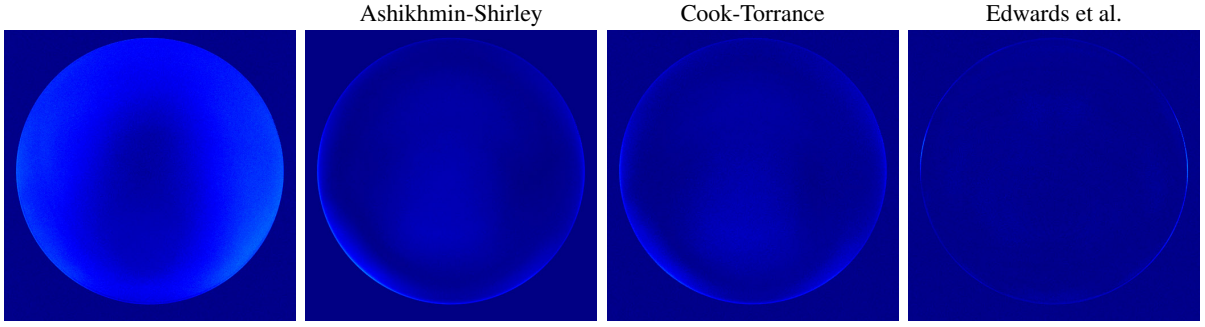


Lawrence et al. (PSNR=33.20778) | Ward (PSNR=43.85959) | Ward-Duer (PSNR=43.88456) | Our factored model (PSNR=48.86774)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: black-obsidian

**Fitted Parameters/PSNR**

| Material Name | black-obsidian | $k_{sr}$ | 0.051460 | $f_{02}$ | 0.022460 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.046709 | $n_2$ | 2802.760 |
| $k_{dr}$ | 0.001566 | $k_{sb}$ | 0.050822 | $f_{03}$ | 0.074876 |
| $k_{dg}$ | 0.001142 | $f_{01}$ | 0.027614 | $n_3$ | 10659.65 |
| $k_{db}$ | 0.000949 | $n_1$ | 175355.4 | PSNR | 38.16986 |

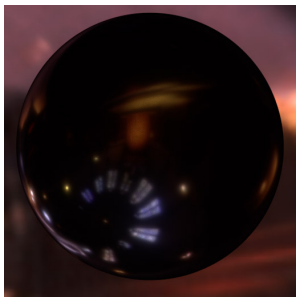
| Material Name | black-obsidian | $k_{sr}$ | 0.012664 | $f_{02}$ | 0.074298 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.011488 | $m_2$ | 0.013518 |
| $k_{dr}$ | 0.001472 | $k_{sb}$ | 0.012505 | $f_{03}$ | 0.028080 |
| $k_{dg}$ | 0.001061 | $f_{01}$ | 0.025369 | $m_3$ | 0.003383 |
| $k_{db}$ | 0.000857 | $m_1$ | 0.027692 | PSNR | 38.55817 |

| Material Name | black-obsidian | $k_{sg}$ | 0.043651 | $R_2$ | 0.024065 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.047544 | $n_2$ | 3.248808 |
| $k_{dr}$ | 0.001720 | $f_{01}$ | 0.029903 | $f_{03}$ | 0.074755 |
| $k_{dg}$ | 0.001320 | $R_1$ | 0.120158 | $R_3$ | 0.348470 |
| $k_{db}$ | 0.001135 | $n_1$ | 524.5117 | $n_3$ | 181.1373 |
| $k_{sr}$ | 0.048359 | $f_{02}$ | 0.017829 | PSNR | 33.27479 |

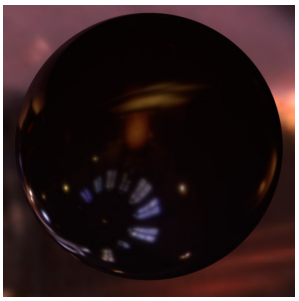
| Material Name | black-obsidian | $k_{db}$ | 0 | $\alpha_1$ | 0.017256 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.003964 | $\alpha_2$ | 0.005647 |
| $k_{dr}$ | 0.000696 | $k_{sg}$ | 0.003779 | $\alpha_3$ | 0.017256 |
| $k_{dg}$ | 0 | $k_{sb}$ | 0.003980 | PSNR | 31.14686 |

| Material Name | black-obsidian | $k_{db}$ | 0 | $\alpha_1$ | 0.016751 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.004408 | $\alpha_2$ | 0.007454 |
| $k_{dr}$ | 0 | $k_{sg}$ | 0.004024 | $\alpha_3$ | 0.033456 |
| $k_{dg}$ | 0 | $k_{sb}$ | 0.004312 | PSNR | 32.86222 |

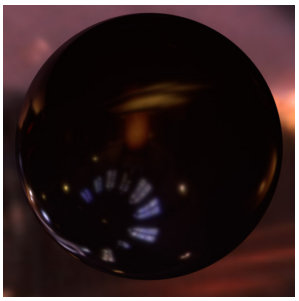
**Rendered Images**



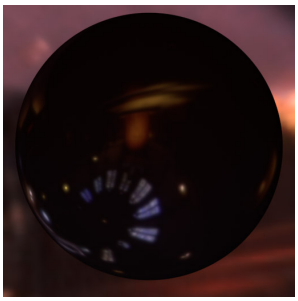
Reference image



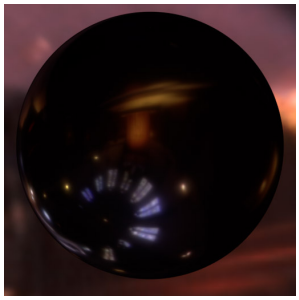
Ashikhmin-Shirley
(PSNR=38.16986)



Cook-Torrance
(PSNR=38.55817)

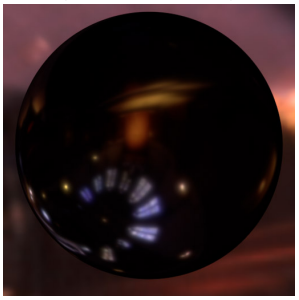


Edwards et al.
(PSNR=33.27479)

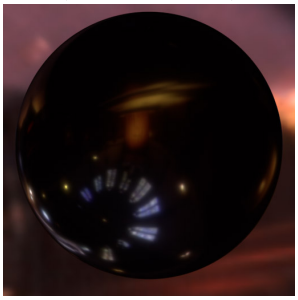


Lawrence et al.
(PSNR=36.83045)

Ward
(PSNR=31.14686)

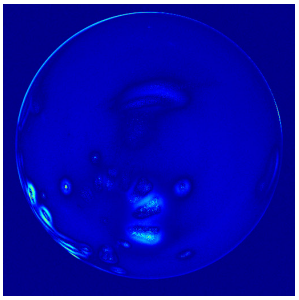


Ward-Duer
(PSNR=32.86222)

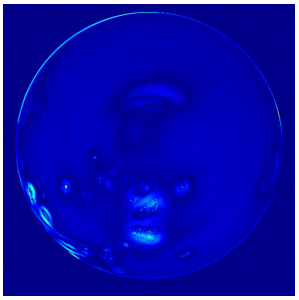


Our factored model
(PSNR=41.32933)

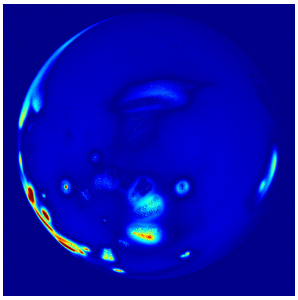
**Difference Images**



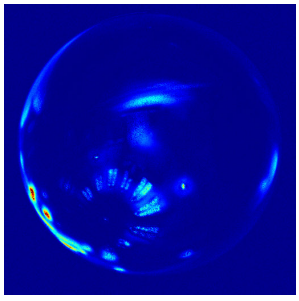
Ashikhmin-Shirley



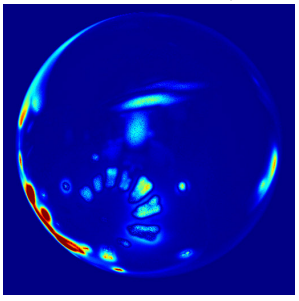
Cook-Torrance



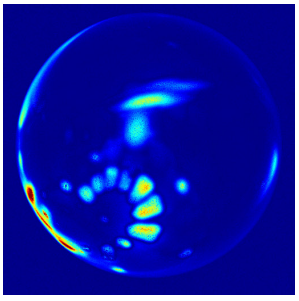
Edwards et al.



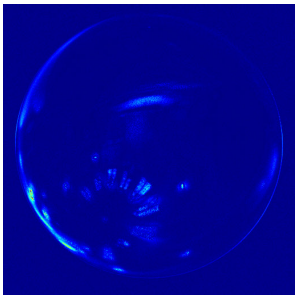
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: black-oxidized-steel

**Fitted Parameters/PSNR**

| Material Name | black-oxidized-steel | $k_{sr}$ | 0.109289 | $f_{02}$ | 0.120879 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.104364 | $n_2$ | 38.07845 |
| $k_{dr}$ | 0.000125 | $k_{sb}$ | 0.100003 | $f_{03}$ | 0.413287 |
| $k_{dg}$ | 0 | $f_{01}$ | 0 | $n_3$ | 2.361348 |
| $k_{db}$ | 0 | $n_1$ | 46.78441 | PSNR | 38.68289 |

| Material Name | black-oxidized-steel | $k_{sr}$ | 0.023145 | $f_{02}$ | 0.163050 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.022108 | $m_2$ | 0.950890 |
| $k_{dr}$ | 0.002380 | $k_{sb}$ | 0.021192 | $f_{03}$ | 0.052717 |
| $k_{dg}$ | 0.001750 | $f_{01}$ | 0.151328 | $m_3$ | 0.166426 |
| $k_{db}$ | 0.001681 | $m_1$ | 0.318363 | PSNR | 40.95220 |

| Material Name | black-oxidized-steel | $k_{sg}$ | 0.094135 | $R_2$ | 1.918388 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.090177 | $n_2$ | 90.57276 |
| $k_{dr}$ | 0.013510 | $f_{01}$ | 0 | $f_{03}$ | 0.158649 |
| $k_{dg}$ | 0.012391 | $R_1$ | 1.988347 | $R_3$ | 11.28177 |
| $k_{db}$ | 0.011893 | $n_1$ | 500.7621 | $n_3$ | 519.9583 |
| $k_{sr}$ | 0.098612 | $f_{02}$ | 0.024321 | PSNR | 37.26038 |

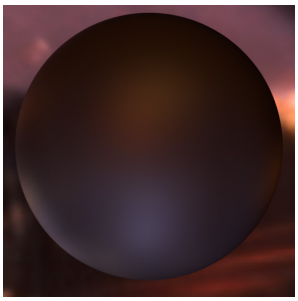
| Material Name | black-oxidized-steel | $k_{db}$ | 0.004425 | $\alpha_1$ | 0.194172 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.016354 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.005814 | $k_{sg}$ | 0.015785 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.004782 | $k_{sb}$ | 0.015239 | PSNR | 29.42816 |

| Material Name | black-oxidized-steel | $k_{db}$ | 0.002100 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.013036 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.003151 | $k_{sg}$ | 0.012538 | $\alpha_3$ | 0.182697 |
| $k_{dg}$ | 0.002303 | $k_{sb}$ | 0.012072 | PSNR | 30.99778 |

**Rendered Images**

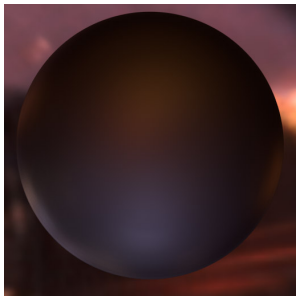
Reference image

Ashikhmin-Shirley
(PSNR=38.68289)

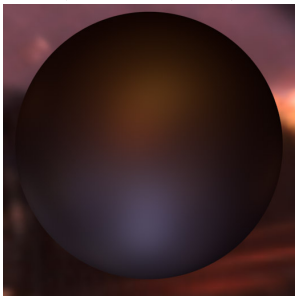


Cook-Torrance
(PSNR=40.95220)

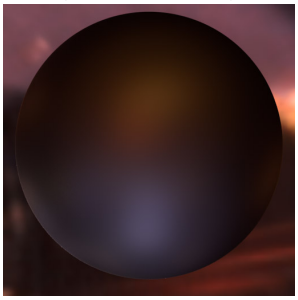
Edwards et al.
(PSNR=37.26038)



Lawrence et al.
(PSNR=34.79894)



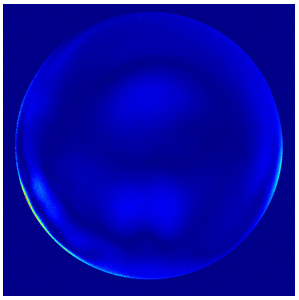
Ward
(PSNR=29.42816)



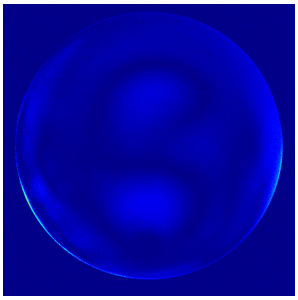
Ward-Duer
(PSNR=30.99778)

Our factored model
(PSNR=45.00212)

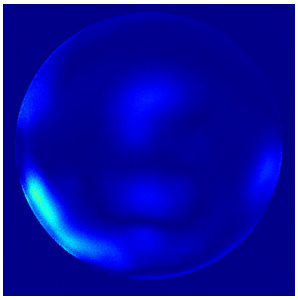
**Difference Images**



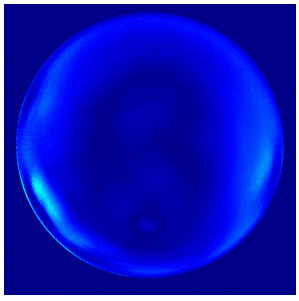
Ashikhmin-Shirley



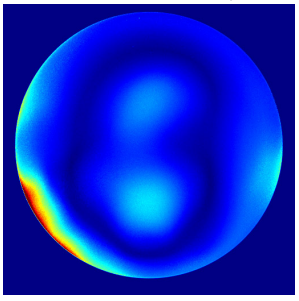
Cook-Torrance



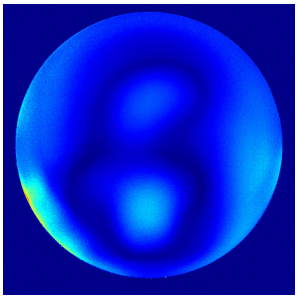
Edwards et al.



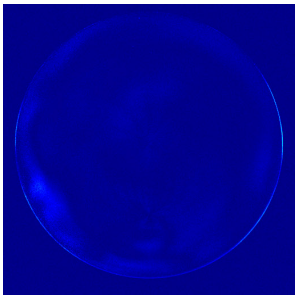
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: black-phenolic

**Fitted Parameters/PSNR**

| Material Name | black-phenolic | $k_{sr}$ | 0.029172 | $f_{02}$ | 0.313994 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.027568 | $n_2$ | 2013.655 |
| $k_{dr}$ | 0.000233 | $k_{sb}$ | 0.026419 | $f_{03}$ | 0.158352 |
| $k_{dg}$ | 0.000902 | $f_{01}$ | 0.216197 | $n_3$ | 391.7568 |
| $k_{db}$ | 0.002313 | $n_1$ | 10083.03 | PSNR | 36.57649 |

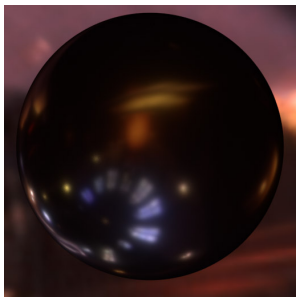
| Material Name | black-phenolic | $k_{sr}$ | 0.006638 | $f_{02}$ | 0.210930 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.006274 | $m_2$ | 0.013512 |
| $k_{dr}$ | 0.000136 | $k_{sb}$ | 0.006014 | $f_{03}$ | 0.182730 |
| $k_{dg}$ | 0.000808 | $f_{01}$ | 0.353283 | $m_3$ | 0.070812 |
| $k_{db}$ | 0.002219 | $m_1$ | 0.029593 | PSNR | 36.52127 |

| Material Name | black-phenolic | $k_{sg}$ | 0.052102 | $R_2$ | 0.155320 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.049717 | $n_2$ | 80.91078 |
| $k_{dr}$ | 0.003744 | $f_{01}$ | 0 | $f_{03}$ | 0.207092 |
| $k_{dg}$ | 0.004327 | $R_1$ | 0.166553 | $R_3$ | 0.786942 |
| $k_{db}$ | 0.005658 | $n_1$ | 499.1310 | $n_3$ | 319.4883 |
| $k_{sr}$ | 0.055522 | $f_{02}$ | 0.063168 | PSNR | 31.66837 |

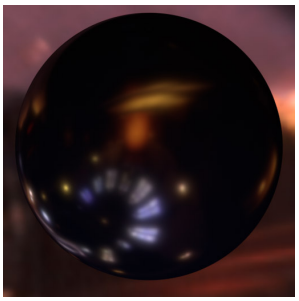
| Material Name | black-phenolic | $k_{db}$ | 0 | $\alpha_1$ | 0.224636 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.012811 | $\alpha_2$ | 0.015973 |
| $k_{dr}$ | 0 | $k_{sg}$ | 0.012326 | $\alpha_3$ | 0.038125 |
| $k_{dg}$ | 0 | $k_{sb}$ | 0.012405 | PSNR | 28.96152 |

| Material Name | black-phenolic | $k_{db}$ | 0.000386 | $\alpha_1$ | 0.028032 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.007389 | $\alpha_2$ | 0.014055 |
| $k_{dr}$ | 0 | $k_{sg}$ | 0.007036 | $\alpha_3$ | 0.056184 |
| $k_{dg}$ | 0 | $k_{sb}$ | 0.006883 | PSNR | 33.74399 |

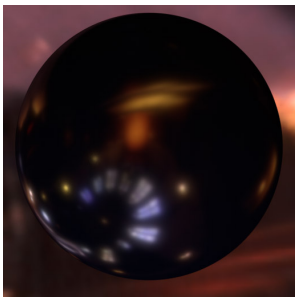
**Rendered Images**



Reference image

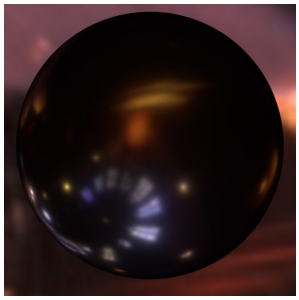


Ashikhmin-Shirley
(PSNR=36.57649)

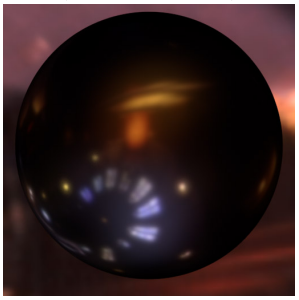


Cook-Torrance
(PSNR=36.52127)

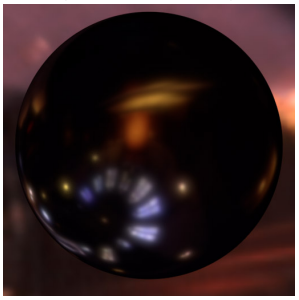
Edwards et al.
(PSNR=31.66837)



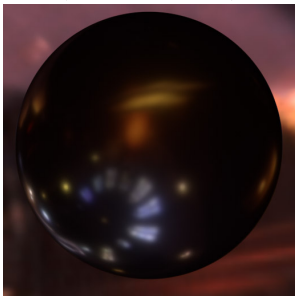
Lawrence et al.
(PSNR=41.66913)



Ward
(PSNR=28.96152)

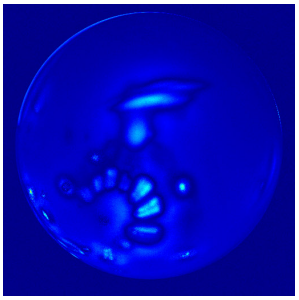


Ward-Duer
(PSNR=33.74399)



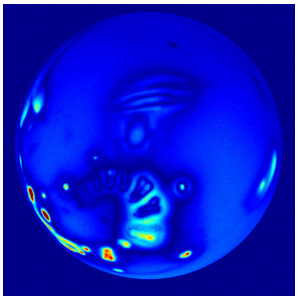
Our factored model
(PSNR=42.14374)

**Difference Images**

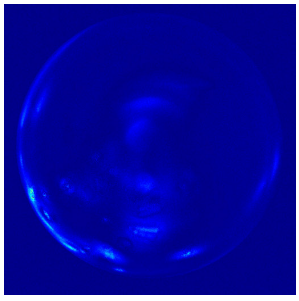


Ashikhmin-Shirley

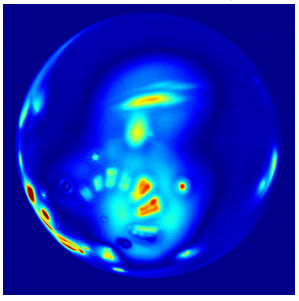
Cook-Torrance



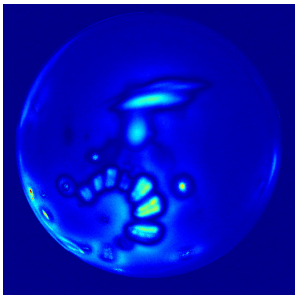
Edwards et al.



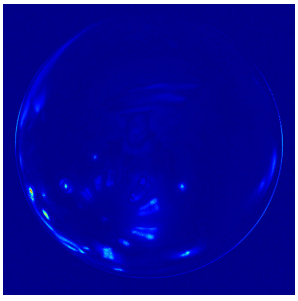
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: black-soft-plastic

**Fitted Parameters/PSNR**

| Material Name | black-soft-plastic | $k_{sr}$ | 0.090443 | $f_{02}$ | 0.189237 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.089631 | $n_2$ | 16.68954 |
| $k_{dr}$ | 0 | $k_{sb}$ | 0.089780 | $f_{03}$ | 0.337991 |
| $k_{dg}$ | 0 | $f_{01}$ | 0 | $n_3$ | 0.825645 |
| $k_{db}$ | 0 | $n_1$ | 5.916934 | PSNR | 36.84484 |

| Material Name | black-soft-plastic | $k_{sr}$ | 0.013571 | $f_{02}$ | 0.094965 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.013451 | $m_2$ | 0.494224 |
| $k_{dr}$ | 0 | $k_{sb}$ | 0.013479 | $f_{03}$ | 0.207396 |
| $k_{dg}$ | 0 | $f_{01}$ | 0.191372 | $m_3$ | 0.285730 |
| $k_{db}$ | 0 | $m_1$ | 0.999999 | PSNR | 36.97694 |

| Material Name | black-soft-plastic | $k_{sg}$ | 0.075146 | $R_2$ | 3.593447 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.075302 | $n_2$ | 99.97809 |
| $k_{dr}$ | 0.007549 | $f_{01}$ | 0.003751 | $f_{03}$ | 0.122073 |
| $k_{dg}$ | 0.007370 | $R_1$ | 3.719814 | $R_3$ | 2.194157 |
| $k_{db}$ | 0.007459 | $n_1$ | 499.9961 | $n_3$ | 10.01888 |
| $k_{sr}$ | 0.075868 | $f_{02}$ | 0.057918 | PSNR | 37.92802 |

| Material Name | black-soft-plastic | $k_{db}$ | 0.002870 | $\alpha_1$ | 0.279579 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.011725 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.003073 | $k_{sg}$ | 0.011701 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.002808 | $k_{sb}$ | 0.011737 | PSNR | 29.93828 |

| Material Name | black-soft-plastic | $k_{db}$ | 0.001333 | $\alpha_1$ | 0.278866 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.009224 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.001463 | $k_{sg}$ | 0.009172 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.001268 | $k_{sb}$ | 0.009196 | PSNR | 31.73530 |

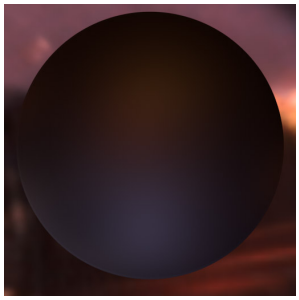
**Rendered Images**

Reference image

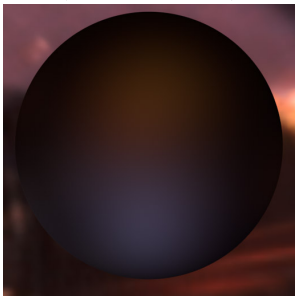
Ashikhmin-Shirley
(PSNR=36.84484)

Cook-Torrance
(PSNR=36.97694)

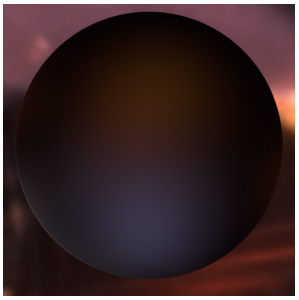
Edwards et al.
(PSNR=37.92802)



Lawrence et al.
(PSNR=37.17897)



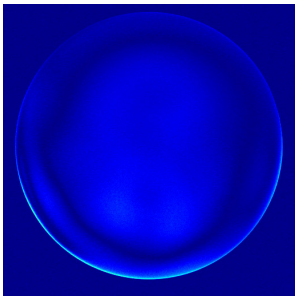
Ward
(PSNR=29.93828)



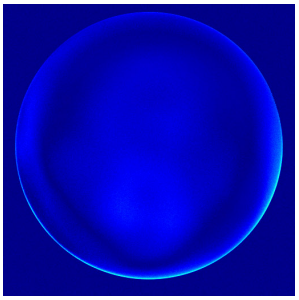
Ward-Duer
(PSNR=31.73530)

Our factored model
(PSNR=43.99585)

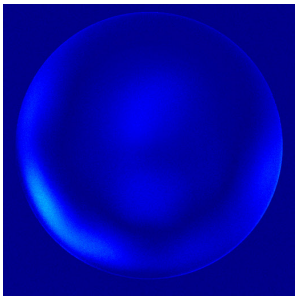
**Difference Images**



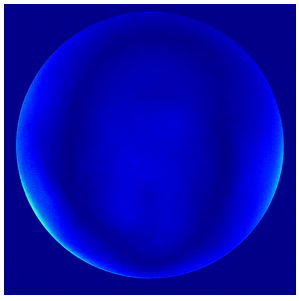
Ashikhmin-Shirley



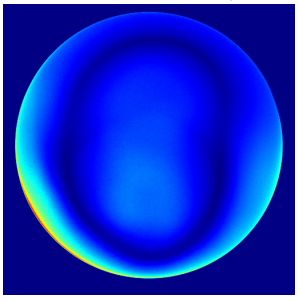
Cook-Torrance



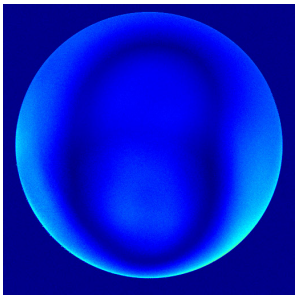
Edwards et al.



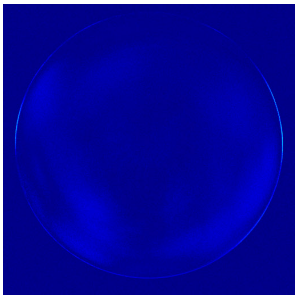
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: blue-acrylic

**Fitted Parameters/PSNR**

| Material Name | blue-acrylic | $k_{sr}$ | 0.045096 | $f_{02}$ | 0.055256 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.043693 | $n_2$ | 3234.838 |
| $k_{dr}$ | 0.016108 | $k_{sb}$ | 0.039500 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.040049 | $f_{01}$ | 0.111282 | $n_3$ | 4200.226 |
| $k_{db}$ | 0.110707 | $n_1$ | 25940.35 | PSNR | 35.66625 |

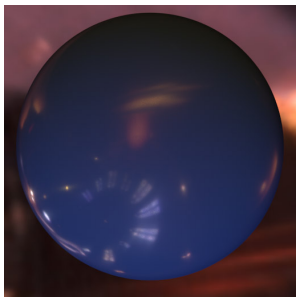
| Material Name | blue-acrylic | $k_{sr}$ | 0.010947 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.010612 | $m_2$ | 0.020904 |
| $k_{dr}$ | 0.015883 | $k_{sb}$ | 0.009589 | $f_{03}$ | 0.110720 |
| $k_{dg}$ | 0.039827 | $f_{01}$ | 0.065013 | $m_3$ | 0.008554 |
| $k_{db}$ | 0.110510 | $m_1$ | 0.025524 | PSNR | 35.85214 |

| Material Name | blue-acrylic | $k_{sg}$ | 0.062980 | $R_2$ | 0.024554 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.056772 | $n_2$ | 6.518906 |
| $k_{dr}$ | 0.016779 | $f_{01}$ | 0.026980 | $f_{03}$ | 0.061450 |
| $k_{dg}$ | 0.040645 | $R_1$ | 0.134869 | $R_3$ | 0.408269 |
| $k_{db}$ | 0.111266 | $n_1$ | 508.9490 | $n_3$ | 229.7919 |
| $k_{sr}$ | 0.064549 | $f_{02}$ | 0.000147 | PSNR | 33.57378 |

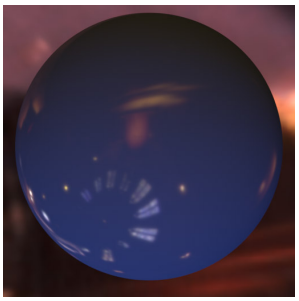
| Material Name | blue-acrylic | $k_{db}$ | 0.105971 | $\alpha_1$ | 0.058991 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.006639 | $\alpha_2$ | 0.019434 |
| $k_{dr}$ | 0.010710 | $k_{sg}$ | 0.006025 | $\alpha_3$ | 0.008060 |
| $k_{dg}$ | 0.035682 | $k_{sb}$ | 0.005819 | PSNR | 31.88510 |

| Material Name | blue-acrylic | $k_{db}$ | 0.101323 | $\alpha_1$ | 0.021824 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.006817 | $\alpha_2$ | 0.009229 |
| $k_{dr}$ | 0.005478 | $k_{sg}$ | 0.006391 | $\alpha_3$ | 0.092119 |
| $k_{dg}$ | 0.030353 | $k_{sb}$ | 0.005996 | PSNR | 31.06521 |

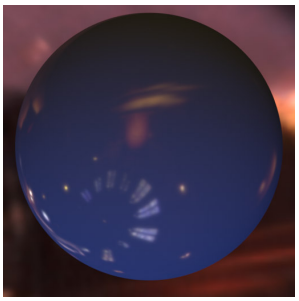
**Rendered Images**



Reference image

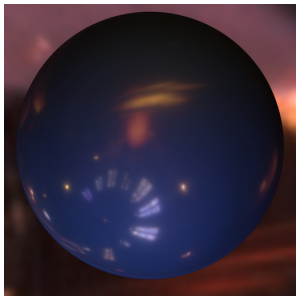


Ashikhmin-Shirley
(PSNR=35.66625)

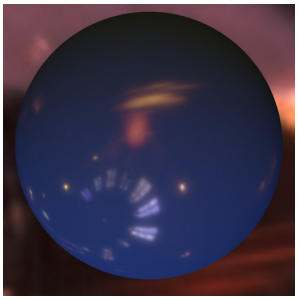


Cook-Torrance
(PSNR=35.85214)

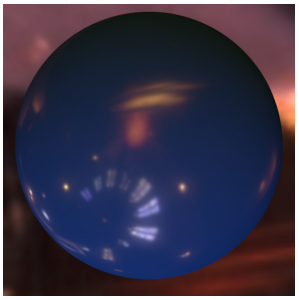
Edwards et al.
(PSNR=33.57378)



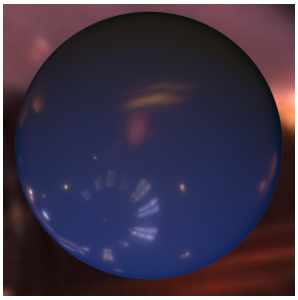
Lawrence et al.
(PSNR=27.19925)



Ward
(PSNR=31.88510)



Ward-Duer
(PSNR=31.06521)

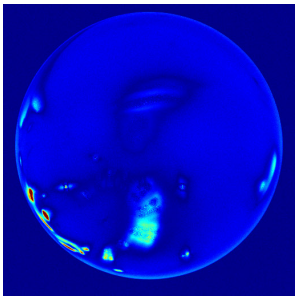


Our factored model
(PSNR=38.95231)

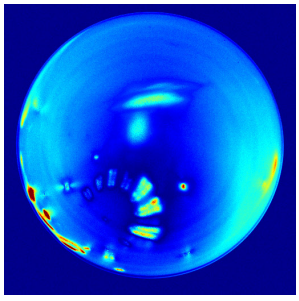
**Difference Images**

Ashikhmin-Shirley

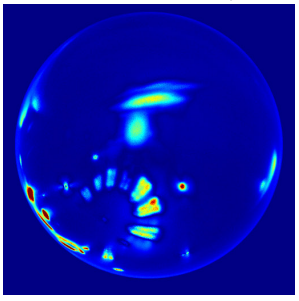
Cook-Torrance



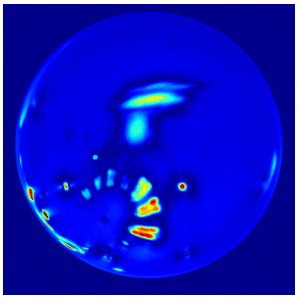
Edwards et al.



Lawrence et al.



Ward



Ward-Duer

Our factored model

**Material Name**: blue-fabric

**Fitted Parameters/PSNR**

| Material Name | blue-fabric | $k_{sr}$ | 0.061746 | $f_{02}$ | 0.000132 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.068423 | $n_2$ | 0.037471 |
| $k_{dr}$ | 0.002464 | $k_{sb}$ | 0.109860 | $f_{03}$ | 0.857170 |
| $k_{dg}$ | 0.003252 | $f_{01}$ | 0.515109 | $n_3$ | 0.055193 |
| $k_{db}$ | 0.023790 | $n_1$ | 2.151506 | PSNR | 42.80882 |

| Material Name | blue-fabric | $k_{sr}$ | 0.006429 | $f_{02}$ | 0.125492 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.007133 | $m_2$ | 0.999999 |
| $k_{dr}$ | 0.007913 | $k_{sb}$ | 0.011364 | $f_{03}$ | 0.604496 |
| $k_{dg}$ | 0.009266 | $f_{01}$ | 0.278883 | $m_3$ | 0.999999 |
| $k_{db}$ | 0.033695 | $m_1$ | 0.433549 | PSNR | 38.58843 |

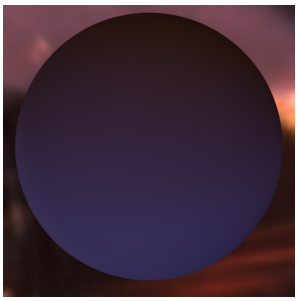
| Material Name | blue-fabric | $k_{sg}$ | 0.054980 | $R_2$ | 2.275815 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.087118 | $n_2$ | 7.455095 |
| $k_{dr}$ | 0.019739 | $f_{01}$ | 0.003546 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.022416 | $R_1$ | 2.169308 | $R_3$ | 1.519656 |
| $k_{db}$ | 0.054699 | $n_1$ | 50.48861 | $n_3$ | 1.932839 |
| $k_{sr}$ | 0.049777 | $f_{02}$ | 0.132918 | PSNR | 41.62924 |

| Material Name | blue-fabric | $k_{db}$ | 0.053698 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.004835 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.019308 | $k_{sg}$ | 0.005461 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.021782 | $k_{sb}$ | 0.008649 | PSNR | 36.36667 |

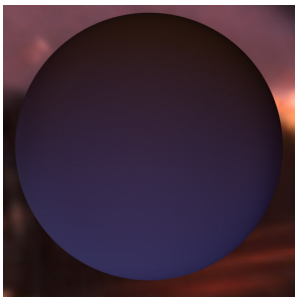
| Material Name | blue-fabric | $k_{db}$ | 0.051372 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.004188 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.017927 | $k_{sg}$ | 0.004673 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.020328 | $k_{sb}$ | 0.007414 | PSNR | 37.56142 |

**Rendered Images**

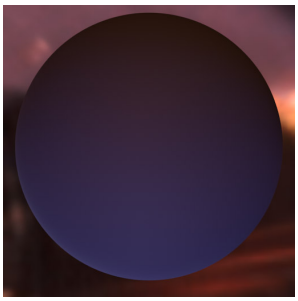
Reference image



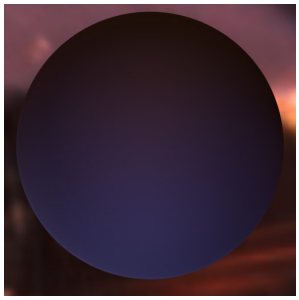
Ashikhmin-Shirley
(PSNR=42.80882)



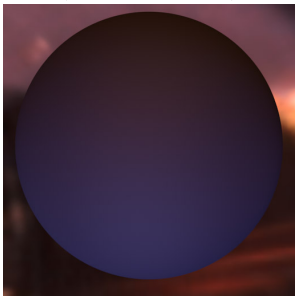
Cook-Torrance
(PSNR=38.58843)



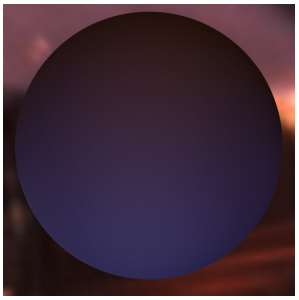
Edwards et al.
(PSNR=41.62924)



Lawrence et al.
(PSNR=31.75041)



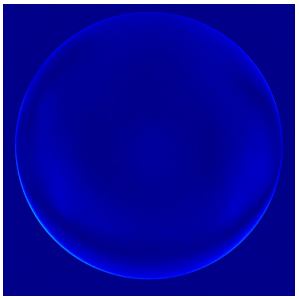
Ward
(PSNR=36.36667)



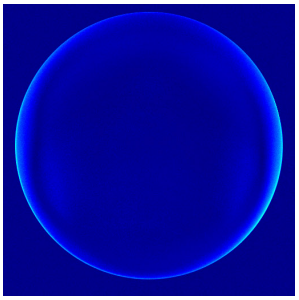
Ward-Duer
(PSNR=37.56142)

Our factored model
(PSNR=46.36932)

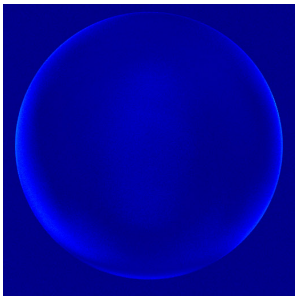
**Difference Images**



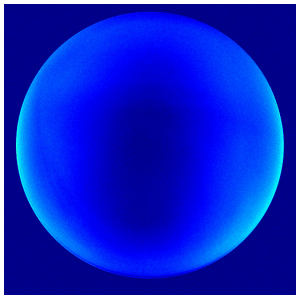
Ashikhmin-Shirley



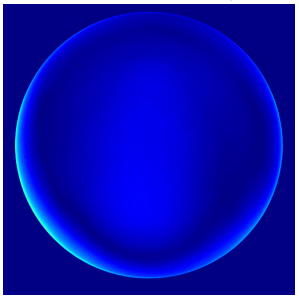
Cook-Torrance



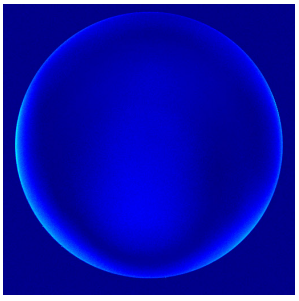
Edwards et al.



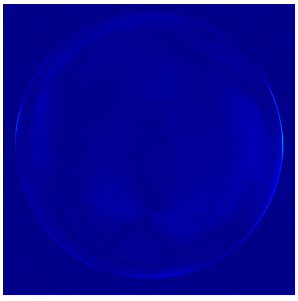
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: blue-metallic-paint

**Fitted Parameters/PSNR**

| Material Name | blue-metallic-paint | $k_{sr}$ | 0.036113 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.034448 | $n_2$ | 10.14016 |
| $k_{dr}$ | 0.004699 | $k_{sb}$ | 0.077821 | $f_{03}$ | 0.169653 |
| $k_{dg}$ | 0.001238 | $f_{01}$ | 0.999999 | $n_3$ | 0 |
| $k_{db}$ | 0.015569 | $n_1$ | 47.12926 | PSNR | 36.37612 |

| Material Name | blue-metallic-paint | $k_{sr}$ | 0.004388 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.004191 | $m_2$ | 0.321652 |
| $k_{dr}$ | 0.009930 | $k_{sb}$ | 0.009329 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.006159 | $f_{01}$ | 0.999999 | $m_3$ | 0.321652 |
| $k_{db}$ | 0.028216 | $m_1$ | 0.156190 | PSNR | 34.08268 |

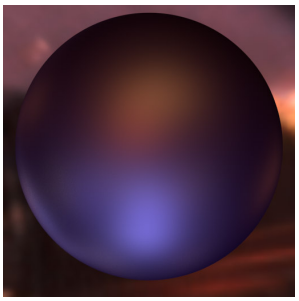
| Material Name | blue-metallic-paint | $k_{sg}$ | 0.048649 | $R_2$ | 19.06632 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.115222 | $n_2$ | 6199.989 |
| $k_{dr}$ | 0.006474 | $f_{01}$ | 0.005172 | $f_{03}$ | 0.879320 |
| $k_{dg}$ | 0.002843 | $R_1$ | 8.864809 | $R_3$ | 37.23951 |
| $k_{db}$ | 0.013843 | $n_1$ | 8199.989 | $n_3$ | 5199.979 |
| $k_{sr}$ | 0.050909 | $f_{02}$ | 0.402044 | PSNR | 35.39784 |

| Material Name | blue-metallic-paint | $k_{db}$ | 0 | $\alpha_1$ | 0.169154 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.035545 | $\alpha_2$ | 0.385873 |
| $k_{dr}$ | 0.000768 | $k_{sg}$ | 0.033958 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0 | $k_{sb}$ | 0.081350 | PSNR | 31.08335 |

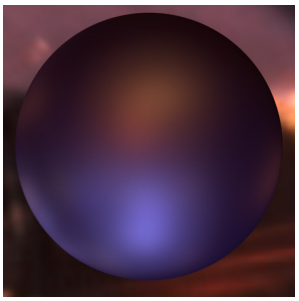
| Material Name | blue-metallic-paint | $k_{db}$ | 0.028666 | $\alpha_1$ | 0.360372 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.020297 | $\alpha_2$ | 0.166126 |
| $k_{dr}$ | 0.010134 | $k_{sg}$ | 0.019391 | $\alpha_3$ | 0.360372 |
| $k_{dg}$ | 0.006351 | $k_{sb}$ | 0.043148 | PSNR | 33.43710 |

**Rendered Images**

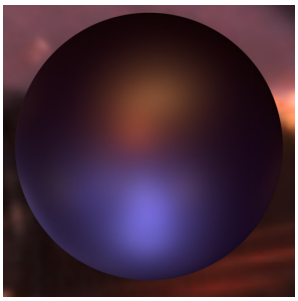
Reference image



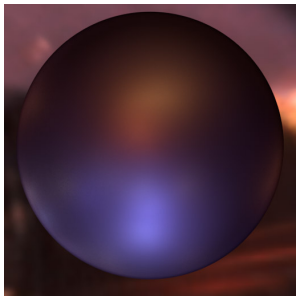
Ashikhmin-Shirley
(PSNR=36.37612)



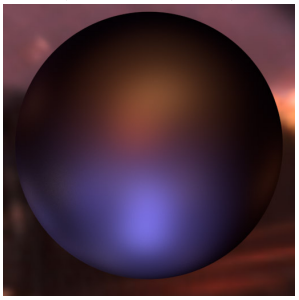
Cook-Torrance
(PSNR=34.08268)



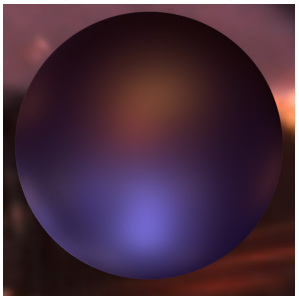
Edwards et al.
(PSNR=35.39784)



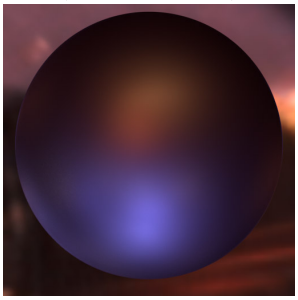
Lawrence et al.
(PSNR=37.35783)



Ward
(PSNR=31.08335)

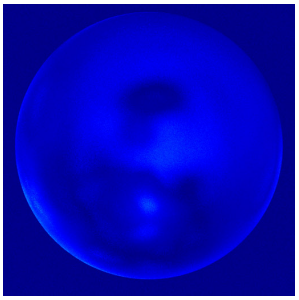


Ward-Duer
(PSNR=33.43710)

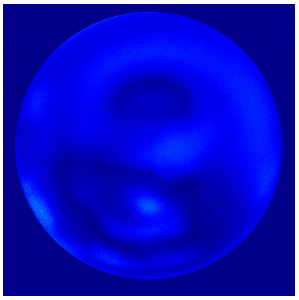


Our factored model
(PSNR=41.34928)

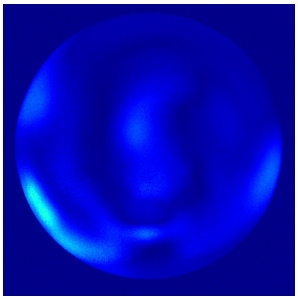
**Difference Images**



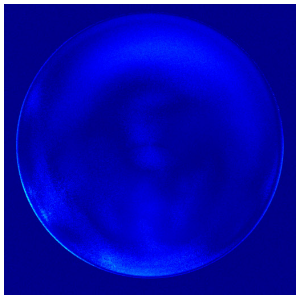
Ashikhmin-Shirley



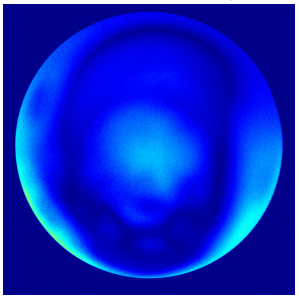
Cook-Torrance



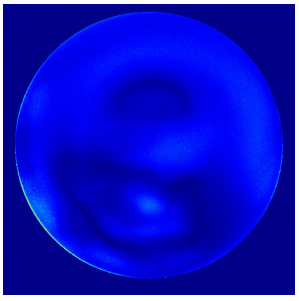
Edwards et al.



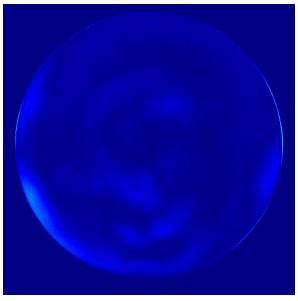
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: blue-metallic-paint2

**Fitted Parameters/PSNR**

| Material Name | blue-metallic-paint2 | $k_{sr}$ | 0.020049 | $f_{02}$ | 0.784282 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.030441 | $n_2$ | 11075.49 |
| $k_{dr}$ | 0.014019 | $k_{sb}$ | 0.060138 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.021162 | $f_{01}$ | 0.097466 | $n_3$ | 1183.437 |
| $k_{db}$ | 0.040976 | $n_1$ | 211165.7 | PSNR | 25.04949 |

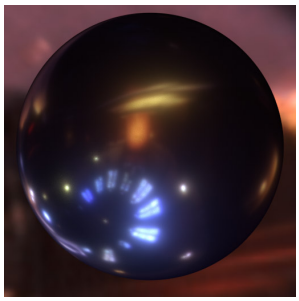
| Material Name | blue-metallic-paint2 | $k_{sr}$ | 0.004784 | $f_{02}$ | 0.856113 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.007268 | $m_2$ | 0.014390 |
| $k_{dr}$ | 0.013173 | $k_{sb}$ | 0.014356 | $f_{03}$ | 0.129086 |
| $k_{dg}$ | 0.019841 | $f_{01}$ | 0.999999 | $m_3$ | 0.003549 |
| $k_{db}$ | 0.038378 | $m_1$ | 0.044137 | PSNR | 25.55186 |

| Material Name | blue-metallic-paint2 | $k_{sg}$ | 0.080653 | $R_2$ | 0.055795 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.159038 | $n_2$ | 8.277491 |
| $k_{dr}$ | 0.015242 | $f_{01}$ | 0.046983 | $f_{03}$ | 0.368891 |
| $k_{dg}$ | 0.022531 | $R_1$ | 0.120926 | $R_3$ | 3.375500 |
| $k_{db}$ | 0.043877 | $n_1$ | 384.7243 | $n_3$ | 3852.930 |
| $k_{sr}$ | 0.052631 | $f_{02}$ | 0.242942 | PSNR | 23.97068 |

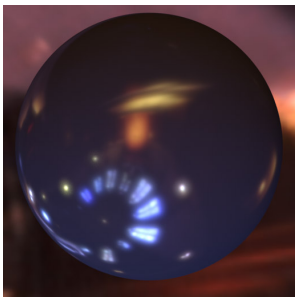
| Material Name | blue-metallic-paint2 | $k_{db}$ | 0.040823 | $\alpha_1$ | 0.023753 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.015468 | $\alpha_2$ | 0.039313 |
| $k_{dr}$ | 0.016957 | $k_{sg}$ | 0.024959 | $\alpha_3$ | 0.008853 |
| $k_{dg}$ | 0.022485 | $k_{sb}$ | 0.050608 | PSNR | 24.15071 |

| Material Name | blue-metallic-paint2 | $k_{db}$ | 0.056384 | $\alpha_1$ | 0.027695 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.010836 | $\alpha_2$ | 0.027695 |
| $k_{dr}$ | 0.018806 | $k_{sg}$ | 0.016383 | $\alpha_3$ | 0.008241 |
| $k_{dg}$ | 0.028627 | $k_{sb}$ | 0.032137 | PSNR | 22.73673 |

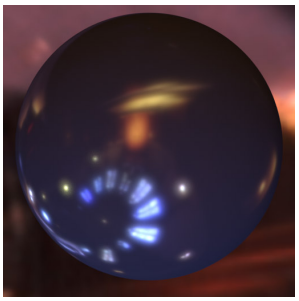
**Rendered Images**



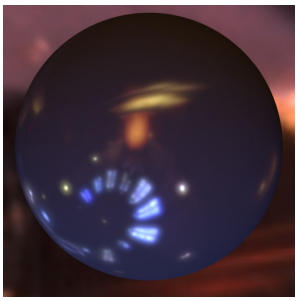
Reference image



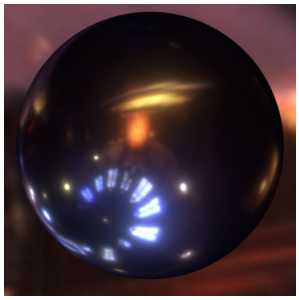
Ashikhmin-Shirley
(PSNR=25.04949)



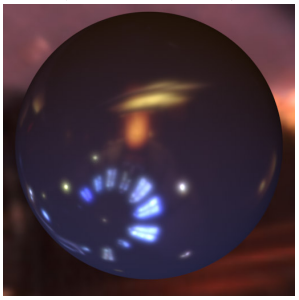
Cook-Torrance
(PSNR=25.55186)



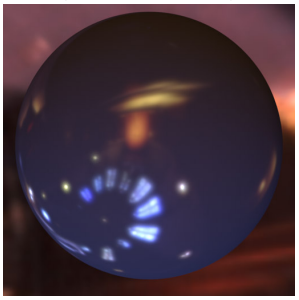
Edwards et al.
(PSNR=23.97068)



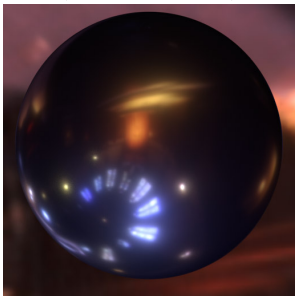
Lawrence et al.
(PSNR=30.82155)



Ward
(PSNR=24.15071)

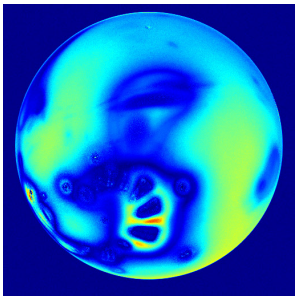


Ward-Duer
(PSNR=22.73673)

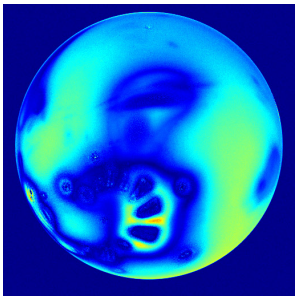


Our factored model
(PSNR=37.32425)

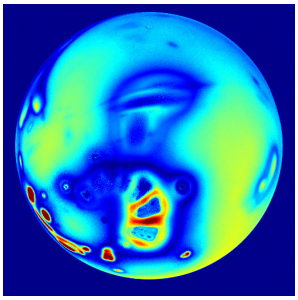
**Difference Images**



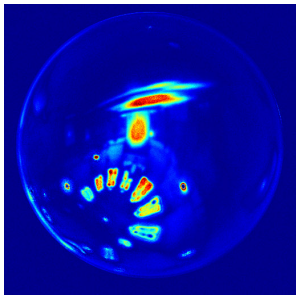
Ashikhmin-Shirley



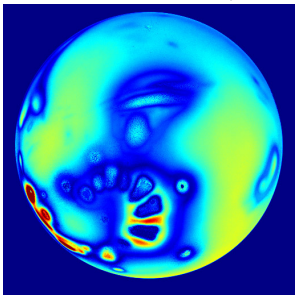
Cook-Torrance



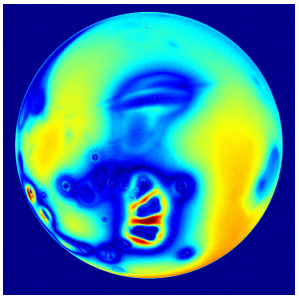
Edwards et al.



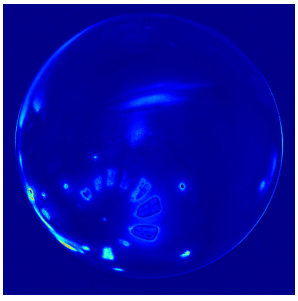
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: blue-rubber

**Fitted Parameters/PSNR**

| Material Name | blue-rubber | $k_{sr}$ | 0.133597 | $f_{02}$ | 0.081251 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.130658 | $n_2$ | 28.40198 |
| $k_{dr}$ | 0.017105 | $k_{sb}$ | 0.127331 | $f_{03}$ | 0.564176 |
| $k_{dg}$ | 0.056305 | $f_{01}$ | 0 | $n_3$ | 1.002851 |
| $k_{db}$ | 0.137390 | $n_1$ | 53.66535 | PSNR | 44.12855 |

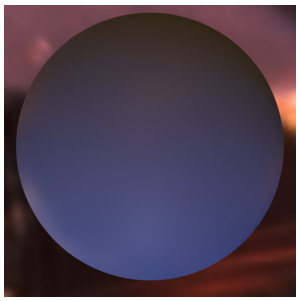
| Material Name | blue-rubber | $k_{sr}$ | 0.027013 | $f_{02}$ | 0.113467 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.026412 | $m_2$ | 0.316479 |
| $k_{dr}$ | 0.024246 | $k_{sb}$ | 0.025719 | $f_{03}$ | 0.170342 |
| $k_{dg}$ | 0.063294 | $f_{01}$ | 0.019476 | $m_3$ | 0.999999 |
| $k_{db}$ | 0.144221 | $m_1$ | 0.163997 | PSNR | 43.41980 |

| Material Name | blue-rubber | $k_{sg}$ | 0.088520 | $R_2$ | 5.558293 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.086349 | $n_2$ | 165.5088 |
| $k_{dr}$ | 0.038080 | $f_{01}$ | 0.004264 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.076818 | $R_1$ | 0.359525 | $R_3$ | 2.216619 |
| $k_{db}$ | 0.157370 | $n_1$ | 2.193843 | $n_3$ | 794.8339 |
| $k_{sr}$ | 0.090505 | $f_{02}$ | 0.124046 | PSNR | 39.84899 |

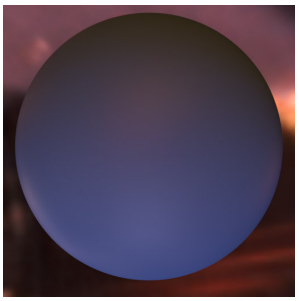
| Material Name | blue-rubber | $k_{db}$ | 0.148937 | $\alpha_1$ | 0.201985 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.012835 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.030924 | $k_{sg}$ | 0.013140 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.068933 | $k_{sb}$ | 0.013309 | PSNR | 33.44793 |

| Material Name | blue-rubber | $k_{db}$ | 0.145817 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.011119 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.026930 | $k_{sg}$ | 0.011140 | $\alpha_3$ | 0.186054 |
| $k_{dg}$ | 0.065354 | $k_{sb}$ | 0.011043 | PSNR | 34.70772 |

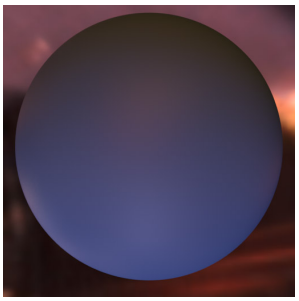
**Rendered Images**



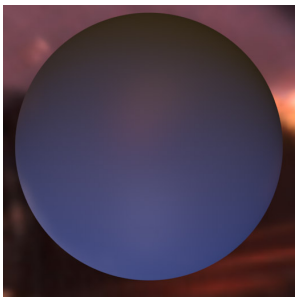
Reference image



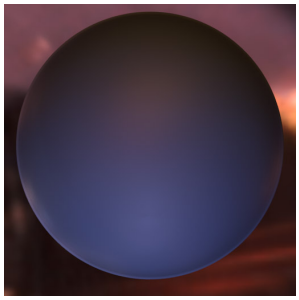
Ashikhmin-Shirley
(PSNR=44.12855)



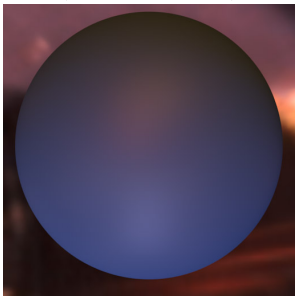
Cook-Torrance
(PSNR=43.41980)



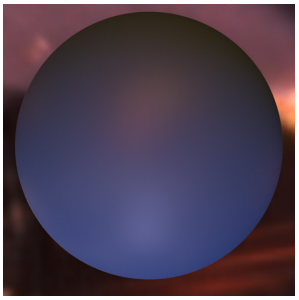
Edwards et al.
(PSNR=39.84899)



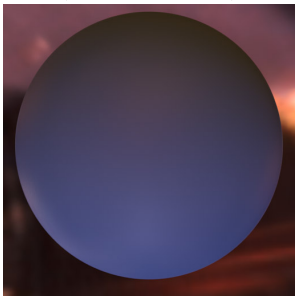
Lawrence et al.
(PSNR=26.91126)



Ward
(PSNR=33.44793)

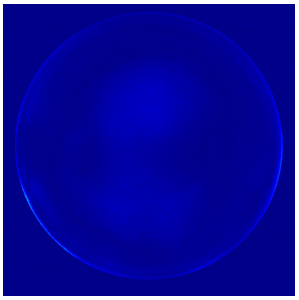


Ward-Duer
(PSNR=34.70772)

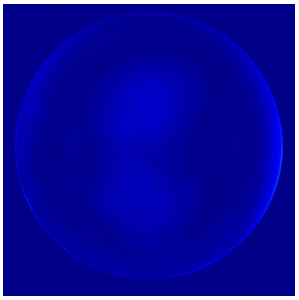


Our factored model
(PSNR=44.45962)

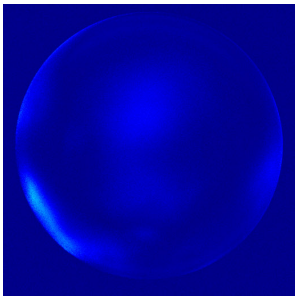
**Difference Images**



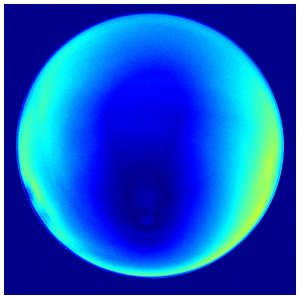
Ashikhmin-Shirley



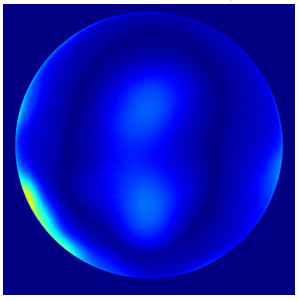
Cook-Torrance



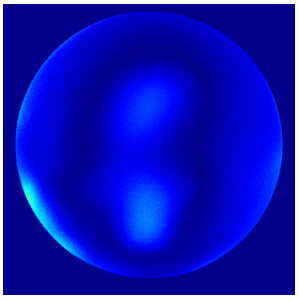
Edwards et al.



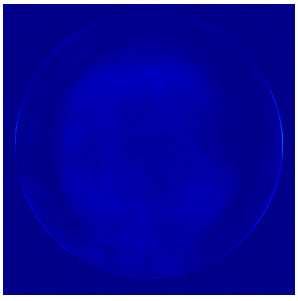
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: brass

**Fitted Parameters/PSNR**

| Material Name | brass | $k_{sr}$ | 0.057805 | $f_{02}$ | 0.913559 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.038223 | $n_2$ | 7380.944 |
| $k_{dr}$ | 0.048517 | $k_{sb}$ | 0.018427 | $f_{03}$ | 0.379371 |
| $k_{dg}$ | 0.036104 | $f_{01}$ | 0.040793 | $n_3$ | 78226.84 |
| $k_{db}$ | 0.022952 | $n_1$ | 1317749 | PSNR | 23.70799 |

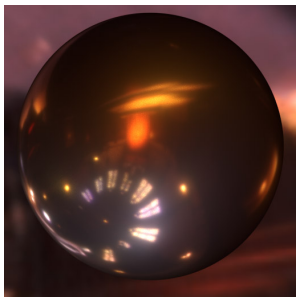
| Material Name | brass | $k_{sr}$ | 0.017704 | $f_{02}$ | 0.297354 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.011755 | $m_2$ | 0.004689 |
| $k_{dr}$ | 0.049712 | $k_{sb}$ | 0.005681 | $f_{03}$ | 0.021031 |
| $k_{dg}$ | 0.036691 | $f_{01}$ | 0.736341 | $m_3$ | 0.000903 |
| $k_{db}$ | 0.023177 | $m_1$ | 0.016005 | PSNR | 23.52232 |

| Material Name | brass | $k_{sg}$ | 0.112755 | $R_2$ | 0.085910 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.054068 | $n_2$ | 100.0407 |
| $k_{dr}$ | 0.052783 | $f_{01}$ | 0.239122 | $f_{03}$ | 0.017721 |
| $k_{dg}$ | 0.038595 | $R_1$ | 0.529140 | $R_3$ | 0.003276 |
| $k_{db}$ | 0.024275 | $n_1$ | 500.0020 | $n_3$ | 0.628518 |
| $k_{sr}$ | 0.169333 | $f_{02}$ | 0.144742 | PSNR | 22.88734 |

| Material Name | brass | $k_{db}$ | 0.027394 | $\alpha_1$ | 0.014118 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.030905 | $\alpha_2$ | 0.014118 |
| $k_{dr}$ | 0.055590 | $k_{sg}$ | 0.020171 | $\alpha_3$ | 0.004190 |
| $k_{dg}$ | 0.041365 | $k_{sb}$ | 0.008862 | PSNR | 22.54483 |

| Material Name | brass | $k_{db}$ | 0.026077 | $\alpha_1$ | 0.014625 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.023200 | $\alpha_2$ | 0.014625 |
| $k_{dr}$ | 0.055589 | $k_{sg}$ | 0.015182 | $\alpha_3$ | 0.004140 |
| $k_{dg}$ | 0.041249 | $k_{sb}$ | 0.007100 | PSNR | 22.66031 |

**Rendered Images**

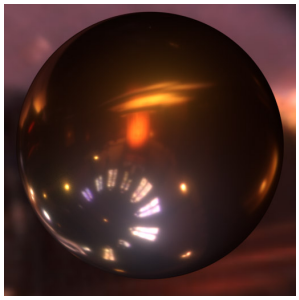


Reference image

Ashikhmin-Shirley
(PSNR=23.70799)

Cook-Torrance
(PSNR=23.52232)

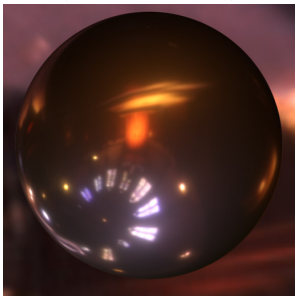
Edwards et al.
(PSNR=22.88734)



Lawrence et al.
(PSNR=35.29349)

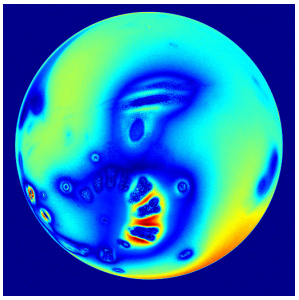
Ward
(PSNR=22.54483)

Ward-Duer
(PSNR=22.66031)

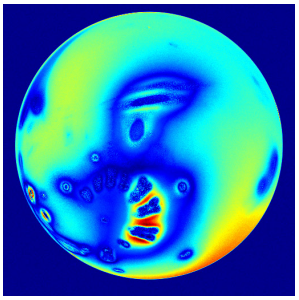


Our factored model
(PSNR=34.47368)

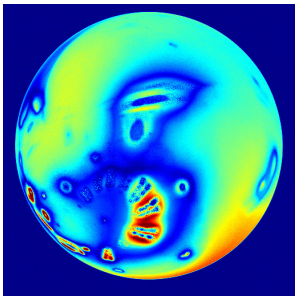
**Difference Images**



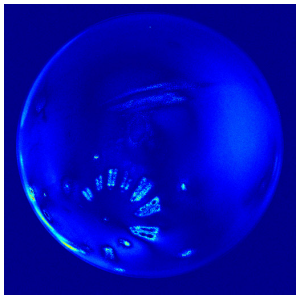
Ashikhmin-Shirley



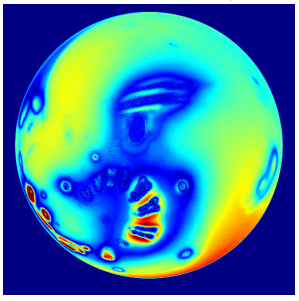
Cook-Torrance



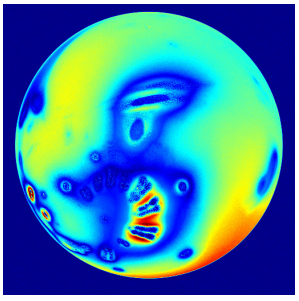
Edwards et al.



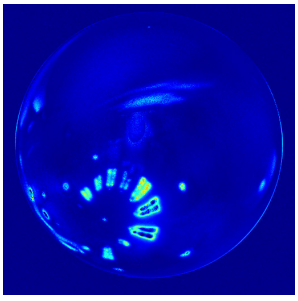
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: cherry-235

**Fitted Parameters/PSNR**

| Material Name | cherry-235 | $k_{sr}$ | 0.115759 | $f_{02}$ | 0.082200 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.114503 | $n_2$ | 122.2703 |
| $k_{dr}$ | 0.037858 | $k_{sb}$ | 0.114619 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.014628 | $f_{01}$ | 0.113620 | $n_3$ | 32.39048 |
| $k_{db}$ | 0.006988 | $n_1$ | 12.20049 | PSNR | 42.62141 |

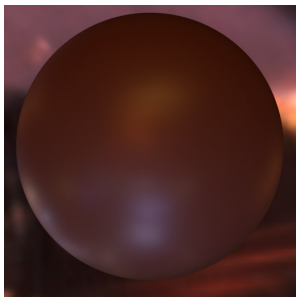
| Material Name | cherry-235 | $k_{sr}$ | 0.020812 | $f_{02}$ | 0.087599 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.020598 | $m_2$ | 0.112132 |
| $k_{dr}$ | 0.039411 | $k_{sb}$ | 0.020625 | $f_{03}$ | 0.026816 |
| $k_{dg}$ | 0.016155 | $f_{01}$ | 0.086747 | $m_3$ | 0.231754 |
| $k_{db}$ | 0.008511 | $m_1$ | 0.322024 | PSNR | 44.51484 |

| Material Name | cherry-235 | $k_{sg}$ | 0.079129 | $R_2$ | 1.123276 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.079099 | $n_2$ | 99.25955 |
| $k_{dr}$ | 0.042449 | $f_{01}$ | 0 | $f_{03}$ | 0.150745 |
| $k_{dg}$ | 0.019166 | $R_1$ | 1.162407 | $R_3$ | 1.658415 |
| $k_{db}$ | 0.011550 | $n_1$ | 500.0469 | $n_3$ | 41.15712 |
| $k_{sr}$ | 0.079976 | $f_{02}$ | 0.016362 | PSNR | 37.90639 |

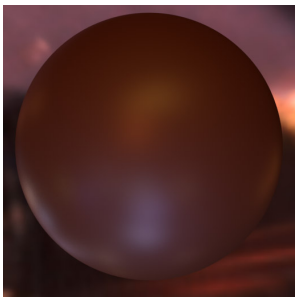
| Material Name | cherry-235 | $k_{db}$ | 0.002997 | $\alpha_1$ | 0.294516 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.013906 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.033256 | $k_{sg}$ | 0.013646 | $\alpha_3$ | 0.110387 |
| $k_{dg}$ | 0.010260 | $k_{sb}$ | 0.013435 | PSNR | 30.84928 |

| Material Name | cherry-235 | $k_{db}$ | 0.000806 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.010920 | $\alpha_2$ | 0.108234 |
| $k_{dr}$ | 0.031300 | $k_{sg}$ | 0.010766 | $\alpha_3$ | 0.275244 |
| $k_{dg}$ | 0.008223 | $k_{sb}$ | 0.010679 | PSNR | 32.30819 |

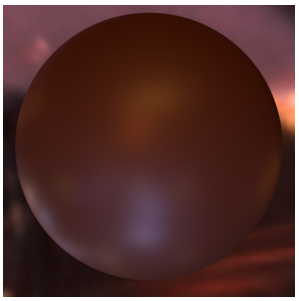
**Rendered Images**



Reference image



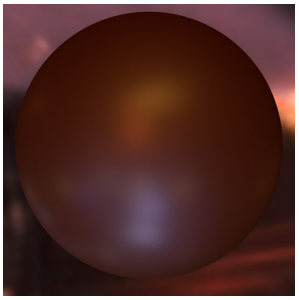
Ashikhmin-Shirley
(PSNR=42.62141)



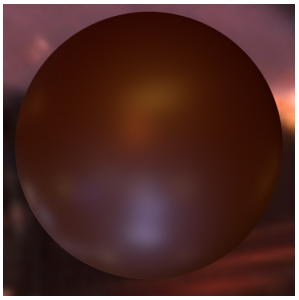
Cook-Torrance
(PSNR=44.51484)

Edwards et al.
(PSNR=37.90639)

Lawrence et al.
(PSNR=31.38560)



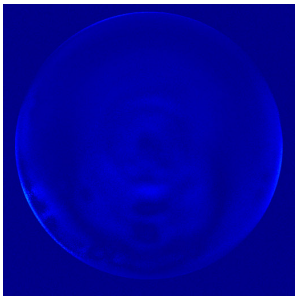
Ward
(PSNR=30.84928)



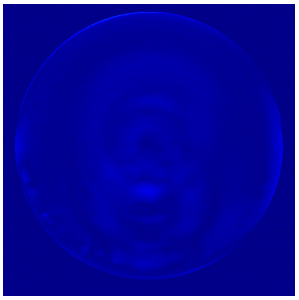
Ward-Duer
(PSNR=32.30819)

Our factored model
(PSNR=42.86775)

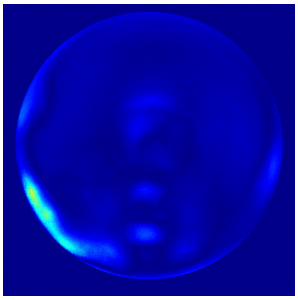
**Difference Images**



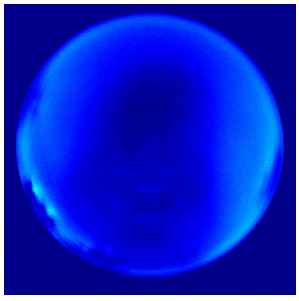
Ashikhmin-Shirley



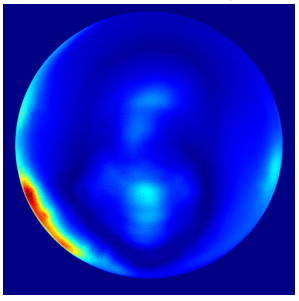
Cook-Torrance



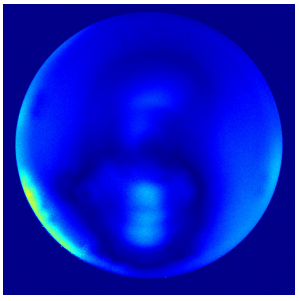
Edwards et al.



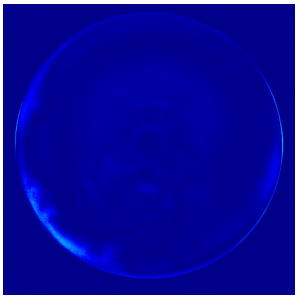
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: chrome

**Fitted Parameters/PSNR**

| Material Name | chrome | $k_{sr}$ | 0.061706 | $f_{02}$ | 0.573433 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.066720 | $n_2$ | 106082.3 |
| $k_{dr}$ | 0.023977 | $k_{sb}$ | 0.076112 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.003109 | $f_{01}$ | 0.094623 | $n_3$ | 13877.06 |
| $k_{db}$ | 0 | $n_1$ | 1091633 | PSNR | 25.64200 |

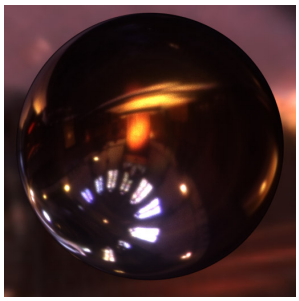
| Material Name | chrome | $k_{sr}$ | 0.016797 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.018060 | $m_2$ | 0.010921 |
| $k_{dr}$ | 0.025668 | $k_{sb}$ | 0.020821 | $f_{03}$ | 0.037805 |
| $k_{dg}$ | 0.005539 | $f_{01}$ | 0.456976 | $m_3$ | 0.000850 |
| $k_{db}$ | 0 | $m_1$ | 0.003574 | PSNR | 25.13978 |

| Material Name | chrome | $k_{sg}$ | 0.125951 | $R_2$ | 0.002984 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.146134 | $n_2$ | 0.085848 |
| $k_{dr}$ | 0.031716 | $f_{01}$ | 0.542218 | $f_{03}$ | 0.180273 |
| $k_{dg}$ | 0.011752 | $R_1$ | 0.222858 | $R_3$ | 0.014157 |
| $k_{db}$ | 0.000181 | $n_1$ | 253.0019 | $n_3$ | 5.007800 |
| $k_{sr}$ | 0.116807 | $f_{02}$ | 0.066675 | PSNR | 23.26261 |

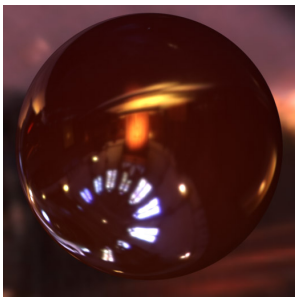
| Material Name | chrome | $k_{db}$ | 0.001460 | $\alpha_1$ | 0.010176 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.042823 | $\alpha_2$ | 0.003011 |
| $k_{dr}$ | 0.029678 | $k_{sg}$ | 0.045535 | $\alpha_3$ | 0.010176 |
| $k_{dg}$ | 0.010972 | $k_{sb}$ | 0.051846 | PSNR | 23.60450 |

| Material Name | chrome | $k_{db}$ | 0.002766 | $\alpha_1$ | 0.010289 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.031800 | $\alpha_2$ | 0.010289 |
| $k_{dr}$ | 0.031595 | $k_{sg}$ | 0.034288 | $\alpha_3$ | 0.002980 |
| $k_{dg}$ | 0.011626 | $k_{sb}$ | 0.038848 | PSNR | 23.73466 |

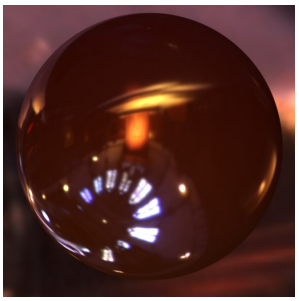
**Rendered Images**



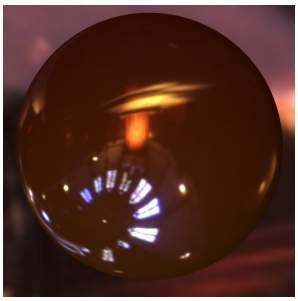
Reference image



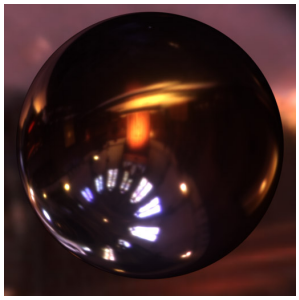
Ashikhmin-Shirley
(PSNR=25.64200)



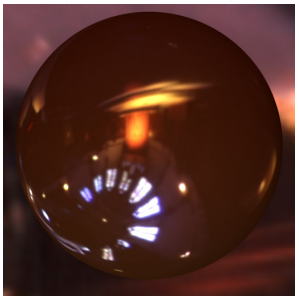
Cook-Torrance
(PSNR=25.13978)



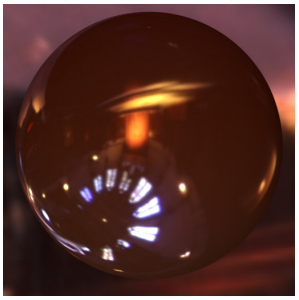
Edwards et al.
(PSNR=23.26261)



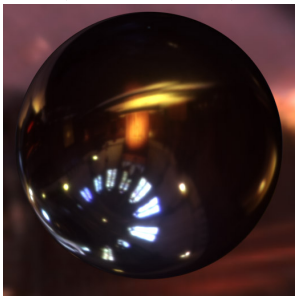
Lawrence et al.
(PSNR=38.49004)



Ward
(PSNR=23.60450)

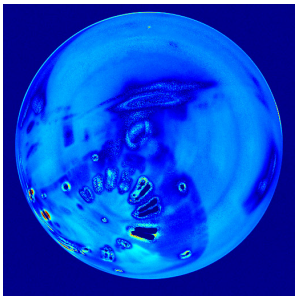


Ward-Duer
(PSNR=23.73466)

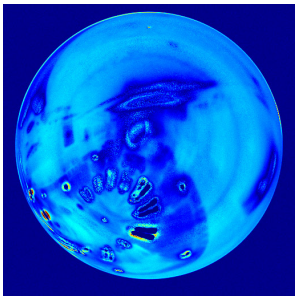


Our factored model
(PSNR=32.44571)

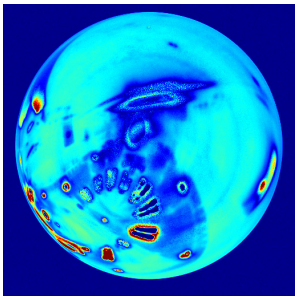
**Difference Images**



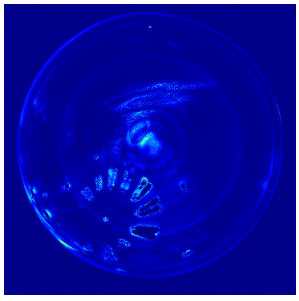
Ashikhmin-Shirley



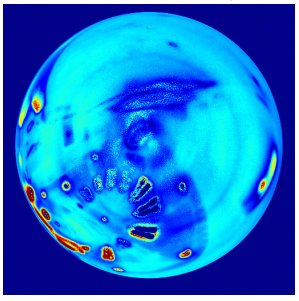
Cook-Torrance



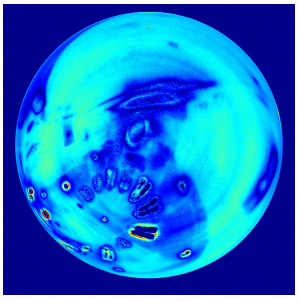
Edwards et al.



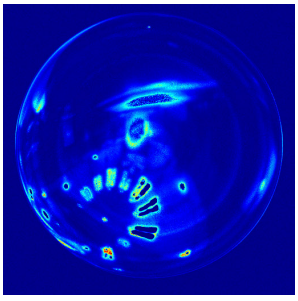
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: chrome-steel

**Fitted Parameters/PSNR**

| Material Name | chrome-steel | $k_{sr}$ | 0.049604 | $f_{02}$ | 0.404929 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.042364 | $n_2$ | 4355.853 |
| $k_{dr}$ | 0.038766 | $k_{sb}$ | 0.086828 | $f_{03}$ | 0.629630 |
| $k_{dg}$ | 0.027758 | $f_{01}$ | 0.455084 | $n_3$ | 24912.61 |
| $k_{db}$ | 0 | $n_1$ | 193256.0 | PSNR | 22.10365 |

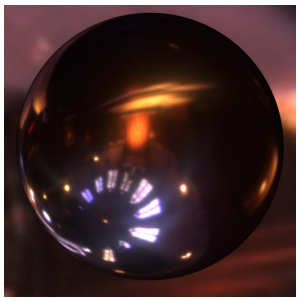
| Material Name | chrome-steel | $k_{sr}$ | 0.009365 | $f_{02}$ | 0.789467 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.008006 | $m_2$ | 0.007533 |
| $k_{dr}$ | 0.040210 | $k_{sb}$ | 0.016552 | $f_{03}$ | 0.474285 |
| $k_{dg}$ | 0.028935 | $f_{01}$ | 0.674694 | $m_3$ | 0.002889 |
| $k_{db}$ | 0 | $m_1$ | 0.017651 | PSNR | 21.86986 |

| Material Name | chrome-steel | $k_{sg}$ | 0.091663 | $R_2$ | 0.403137 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.190737 | $n_2$ | 691.9999 |
| $k_{dr}$ | 0.050011 | $f_{01}$ | 0.027844 | $f_{03}$ | 0.225203 |
| $k_{dg}$ | 0.037578 | $R_1$ | 0.003250 | $R_3$ | 0.248093 |
| $k_{db}$ | 0.005112 | $n_1$ | 0 | $n_3$ | 1748.000 |
| $k_{sr}$ | 0.107775 | $f_{02}$ | 0.293116 | PSNR | 20.40264 |

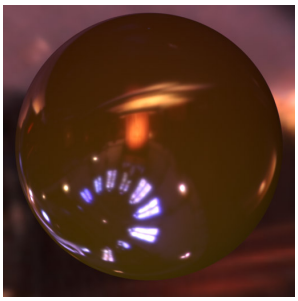
| Material Name | chrome-steel | $k_{db}$ | 0 | $\alpha_1$ | 0.012038 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.029685 | $\alpha_2$ | 0.009157 |
| $k_{dr}$ | 0.045414 | $k_{sg}$ | 0.024790 | $\alpha_3$ | 0.003193 |
| $k_{dg}$ | 0.034683 | $k_{sb}$ | 0.053073 | PSNR | 20.87218 |

| Material Name | chrome-steel | $k_{db}$ | 0 | $\alpha_1$ | 0.014148 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.023000 | $\alpha_2$ | 0.008840 |
| $k_{dr}$ | 0.043704 | $k_{sg}$ | 0.019593 | $\alpha_3$ | 0.003196 |
| $k_{dg}$ | 0.032123 | $k_{sb}$ | 0.040622 | PSNR | 21.31680 |

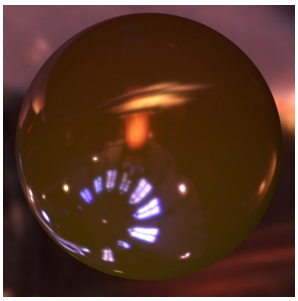
**Rendered Images**



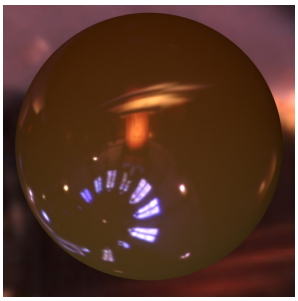
Reference image



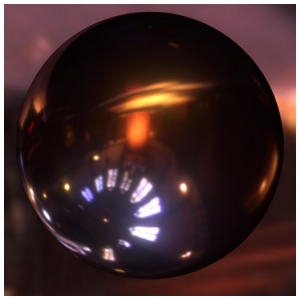
Ashikhmin-Shirley
(PSNR=22.10365)



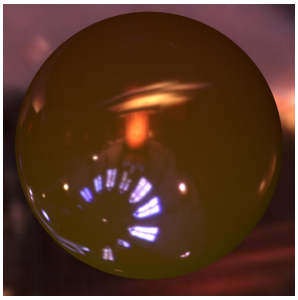
Cook-Torrance
(PSNR=21.86986)



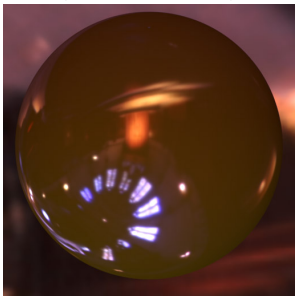
Edwards et al.
(PSNR=20.40264)



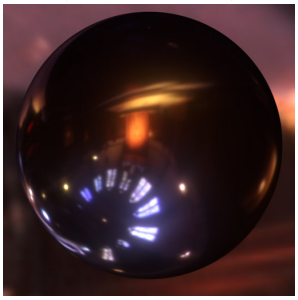
Lawrence et al.
(PSNR=35.81495)



Ward
(PSNR=20.87218)

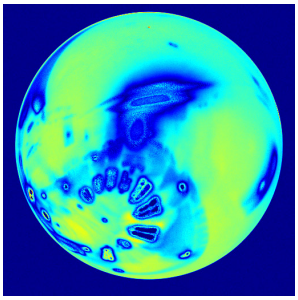


Ward-Duer
(PSNR=21.31680)

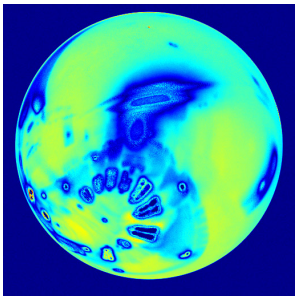


Our factored model
(PSNR=31.52095)

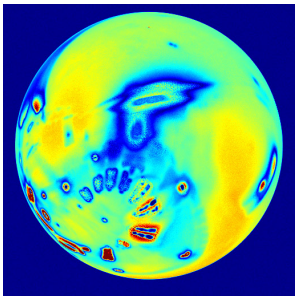
**Difference Images**



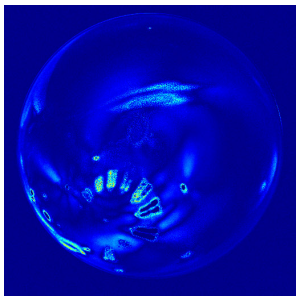
Ashikhmin-Shirley



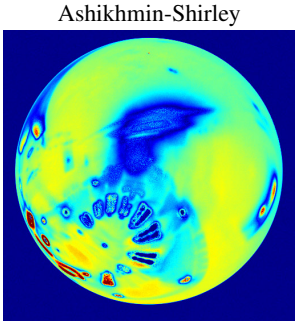
Cook-Torrance



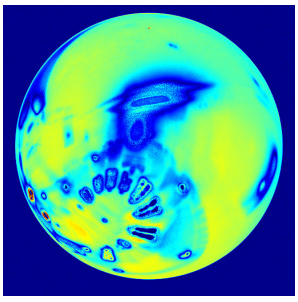
Edwards et al.



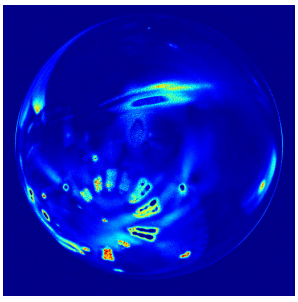
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: colonial-maple-223

**Fitted Parameters/PSNR**

| Material Name | colonial-maple-223 | $k_{sr}$ | 0.177063 | $f_{02}$ | 0.072435 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.166516 | $n_2$ | 10.72594 |
| $k_{dr}$ | 0.076103 | $k_{sb}$ | 0.162297 | $f_{03}$ | 0.283876 |
| $k_{dg}$ | 0.016765 | $f_{01}$ | 0.071294 | $n_3$ | 0.019733 |
| $k_{db}$ | 0.001533 | $n_1$ | 43.48787 | PSNR | 42.54264 |

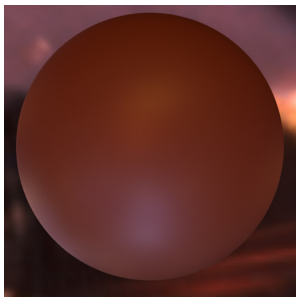
| Material Name | colonial-maple-223 | $k_{sr}$ | 0.024611 | $f_{02}$ | 0.084757 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.023209 | $m_2$ | 0.479438 |
| $k_{dr}$ | 0.084800 | $k_{sb}$ | 0.022629 | $f_{03}$ | 0.034114 |
| $k_{dg}$ | 0.024888 | $f_{01}$ | 0.099218 | $m_3$ | 0.311589 |
| $k_{db}$ | 0.009445 | $m_1$ | 0.183908 | PSNR | 41.48656 |

| Material Name | colonial-maple-223 | $k_{sg}$ | 0.079871 | $R_2$ | 1.263954 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.078052 | $n_2$ | 47.98275 |
| $k_{dr}$ | 0.089309 | $f_{01}$ | 0 | $f_{03}$ | 0.182158 |
| $k_{dg}$ | 0.029206 | $R_1$ | 0.823886 | $R_3$ | 2.175501 |
| $k_{db}$ | 0.013619 | $n_1$ | 101.0878 | $n_3$ | 36.42120 |
| $k_{sr}$ | 0.085050 | $f_{02}$ | 0.014018 | PSNR | 38.14446 |

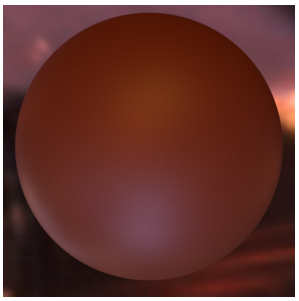
| Material Name | colonial-maple-223 | $k_{db}$ | 0.004369 | $\alpha_1$ | 0.178950 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.018372 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.077909 | $k_{sg}$ | 0.016453 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.019720 | $k_{sb}$ | 0.016066 | PSNR | 31.46654 |

| Material Name | colonial-maple-223 | $k_{db}$ | 0.002081 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.014141 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.076080 | $k_{sg}$ | 0.013007 | $\alpha_3$ | 0.176673 |
| $k_{dg}$ | 0.017359 | $k_{sb}$ | 0.012692 | PSNR | 33.17073 |

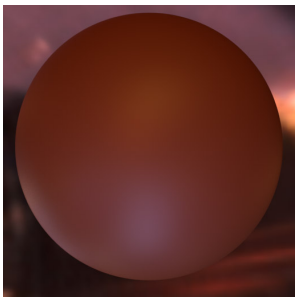
**Rendered Images**



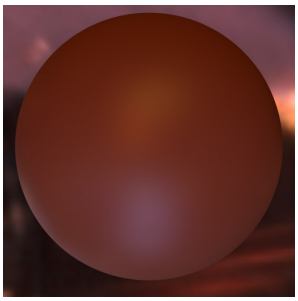
Reference image



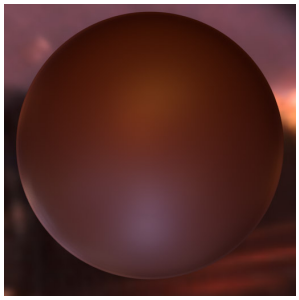
Ashikhmin-Shirley
(PSNR=42.54264)



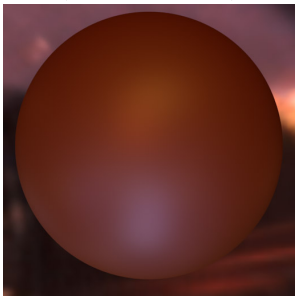
Cook-Torrance
(PSNR=41.48656)



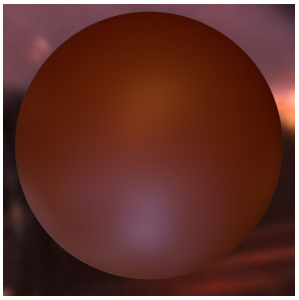
Edwards et al.
(PSNR=38.14446)



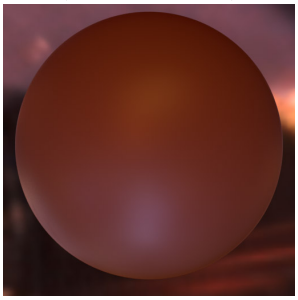
Lawrence et al.
(PSNR=28.21684)



Ward
(PSNR=31.46654)

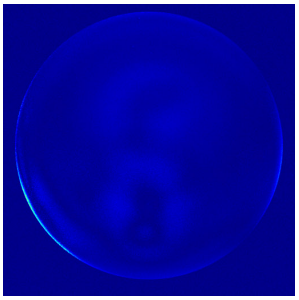


Ward-Duer
(PSNR=33.17073)



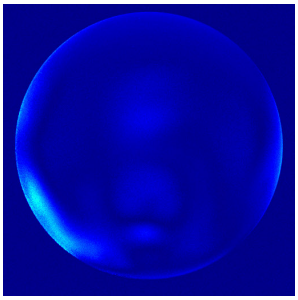
Our factored model
(PSNR=42.38540)

**Difference Images**

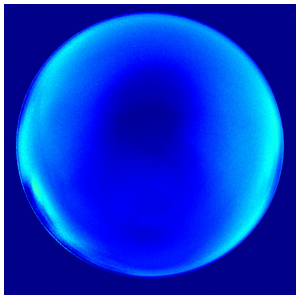


Ashikhmin-Shirley

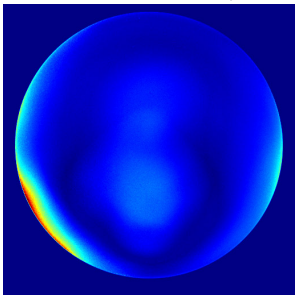
Cook-Torrance



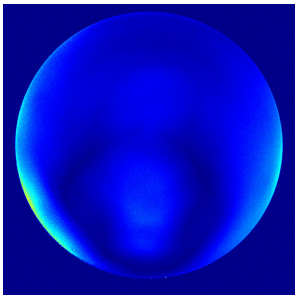
Edwards et al.



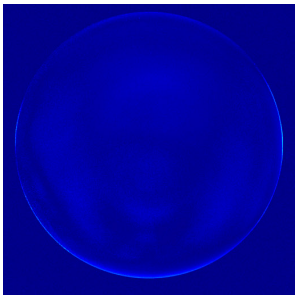
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: color-changing-paint1

**Fitted Parameters/PSNR**

| Material Name | color-changing-paint1 | $k_{sr}$ | 0.093280 | $f_{02}$ | 0.193243 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.098184 | $n_2$ | 155.8615 |
| $k_{dr}$ | 0.001557 | $k_{sb}$ | 0.096606 | $f_{03}$ | 0.129150 |
| $k_{dg}$ | 0.006403 | $f_{01}$ | 0.022935 | $n_3$ | 1241.403 |
| $k_{db}$ | 0.006652 | $n_1$ | 6872.535 | PSNR | 34.73596 |

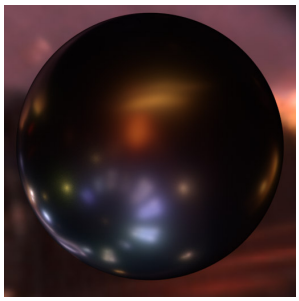
| Material Name | color-changing-paint1 | $k_{sr}$ | 0.021251 | $f_{02}$ | 0.129633 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.022354 | $m_2$ | 0.037386 |
| $k_{dr}$ | 0.002841 | $k_{sb}$ | 0.022009 | $f_{03}$ | 0.021709 |
| $k_{dg}$ | 0.007776 | $f_{01}$ | 0.193489 | $m_3$ | 0.016485 |
| $k_{db}$ | 0.007982 | $m_1$ | 0.101113 | PSNR | 32.69404 |

| Material Name | color-changing-paint1 | $k_{sg}$ | 0.120686 | $R_2$ | 0.041067 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.119232 | $n_2$ | 1.501418 |
| $k_{dr}$ | 0.008599 | $f_{01}$ | 0 | $f_{03}$ | 0.175088 |
| $k_{dg}$ | 0.014061 | $R_1$ | 0.194429 | $R_3$ | 1.637008 |
| $k_{db}$ | 0.014082 | $n_1$ | 508.0009 | $n_3$ | 413.0004 |
| $k_{sr}$ | 0.115746 | $f_{02}$ | 0.017396 | PSNR | 26.66199 |

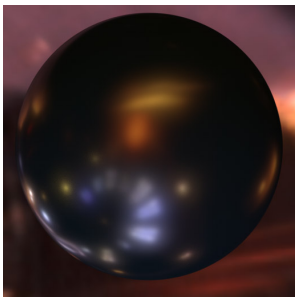
| Material Name | color-changing-paint1 | $k_{db}$ | 0.004784 | $\alpha_1$ | 0.063762 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.016329 | $\alpha_2$ | 0.023073 |
| $k_{dr}$ | 0 | $k_{sg}$ | 0.017258 | $\alpha_3$ | 0.101491 |
| $k_{dg}$ | 0.003724 | $k_{sb}$ | 0.016615 | PSNR | 29.08388 |

| Material Name | color-changing-paint1 | $k_{db}$ | 0.004215 | $\alpha_1$ | 0.087757 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.012200 | $\alpha_2$ | 0.054943 |
| $k_{dr}$ | 0 | $k_{sg}$ | 0.012873 | $\alpha_3$ | 0.019926 |
| $k_{dg}$ | 0.003434 | $k_{sb}$ | 0.012495 | PSNR | 31.29670 |

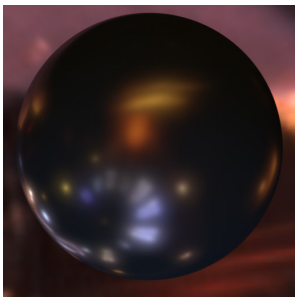
**Rendered Images**



Reference image

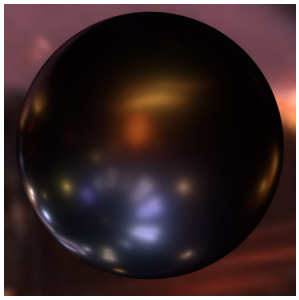


Ashikhmin-Shirley
(PSNR=34.73596)

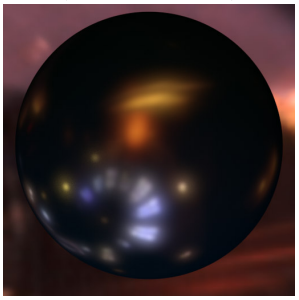


Cook-Torrance
(PSNR=32.69404)

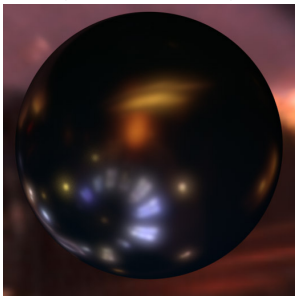
Edwards et al.
(PSNR=26.66199)



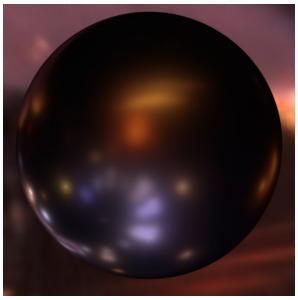
Lawrence et al.
(PSNR=42.73357)



Ward
(PSNR=29.08388)

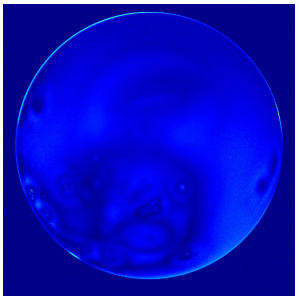


Ward-Duer
(PSNR=31.29670)

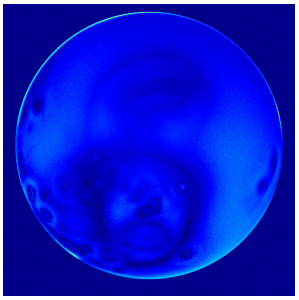


Our factored model
(PSNR=38.29365)

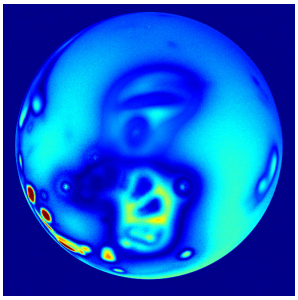
**Difference Images**



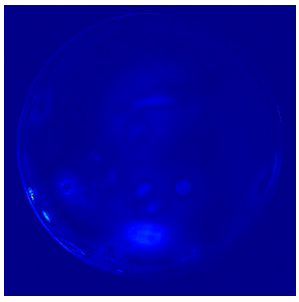
Ashikhmin-Shirley



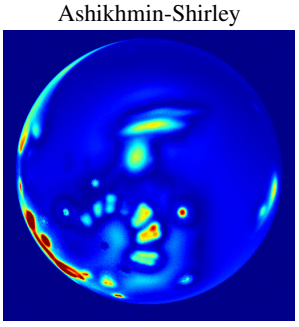
Cook-Torrance



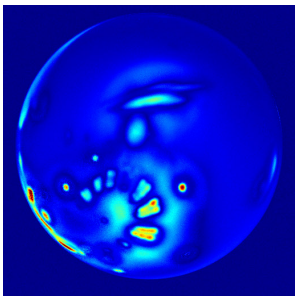
Edwards et al.



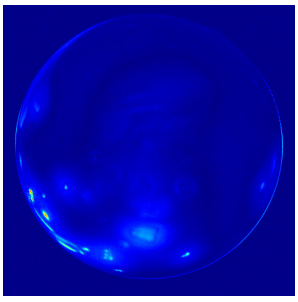
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: color-changing-paint2

**Fitted Parameters/PSNR**

| Material Name | color-changing-paint2 | $k_{sr}$ | 0.108238 | $f_{02}$ | 0.138117 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.104467 | $n_2$ | 1250.711 |
| $k_{dr}$ | 0.022018 | $k_{sb}$ | 0.100210 | $f_{03}$ | 0.443715 |
| $k_{dg}$ | 0.003704 | $f_{01}$ | 0 | $n_3$ | 138.0879 |
| $k_{db}$ | 0.013710 | $n_1$ | 6477.182 | PSNR | 29.39267 |

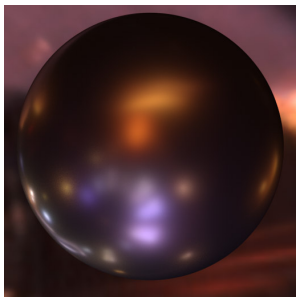
| Material Name | color-changing-paint2 | $k_{sr}$ | 0.024778 | $f_{02}$ | 0.133502 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.023945 | $m_2$ | 0.037435 |
| $k_{dr}$ | 0.024767 | $k_{sb}$ | 0.022953 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.006288 | $f_{01}$ | 0.432565 | $m_3$ | 0.017084 |
| $k_{db}$ | 0.016226 | $m_1$ | 0.110450 | PSNR | 28.37075 |

| Material Name | color-changing-paint2 | $k_{sg}$ | 0.138710 | $R_2$ | 0.043329 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.132933 | $n_2$ | 1.062656 |
| $k_{dr}$ | 0.029852 | $f_{01}$ | 0 | $f_{03}$ | 0.338266 |
| $k_{dg}$ | 0.011215 | $R_1$ | 0.213076 | $R_3$ | 2.136982 |
| $k_{db}$ | 0.020959 | $n_1$ | 511.3020 | $n_3$ | 333.5090 |
| $k_{sr}$ | 0.143571 | $f_{02}$ | 0.010542 | PSNR | 26.25725 |

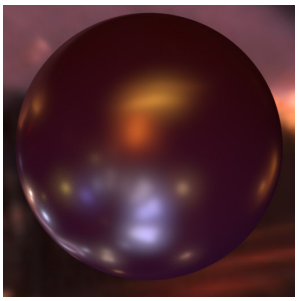
| Material Name | color-changing-paint2 | $k_{db}$ | 0.009500 | $\alpha_1$ | 0.112908 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.032082 | $\alpha_2$ | 0.112908 |
| $k_{dr}$ | 0.014252 | $k_{sg}$ | 0.026935 | $\alpha_3$ | 0.034971 |
| $k_{dg}$ | 0.004556 | $k_{sb}$ | 0.028264 | PSNR | 29.19744 |

| Material Name | color-changing-paint2 | $k_{db}$ | 0.015532 | $\alpha_1$ | 0.096426 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.020605 | $\alpha_2$ | 0.096426 |
| $k_{dr}$ | 0.022779 | $k_{sg}$ | 0.018762 | $\alpha_3$ | 0.027380 |
| $k_{dg}$ | 0.007605 | $k_{sb}$ | 0.018680 | PSNR | 28.84545 |

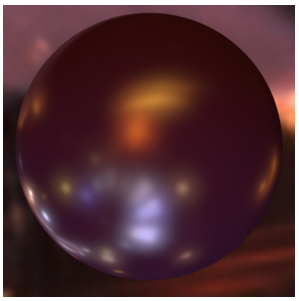
**Rendered Images**



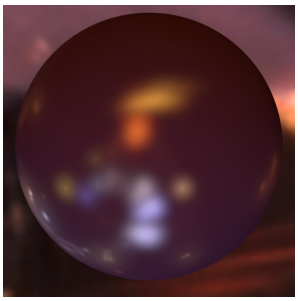
Reference image



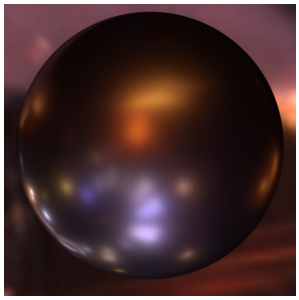
Ashikhmin-Shirley
(PSNR=29.39267)



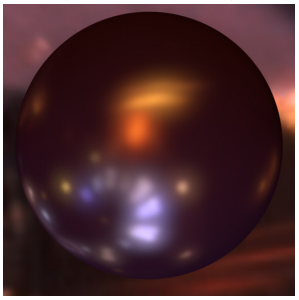
Cook-Torrance
(PSNR=28.37075)



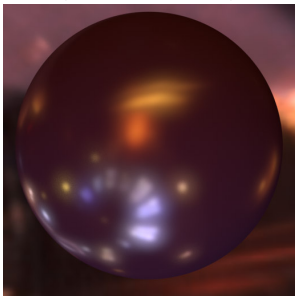
Edwards et al.
(PSNR=26.25725)



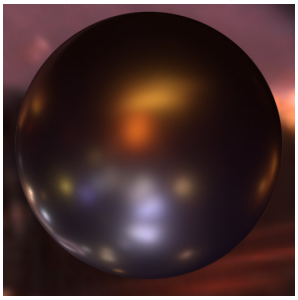
Lawrence et al.
(PSNR=39.09232)



Ward
(PSNR=29.19744)

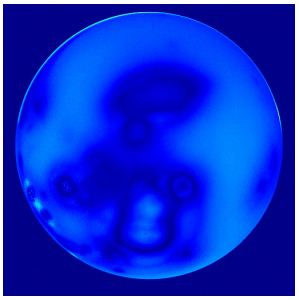


Ward-Duer
(PSNR=28.84545)

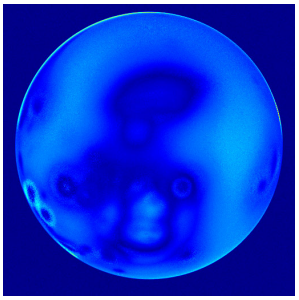


Our factored model
(PSNR=36.73280)

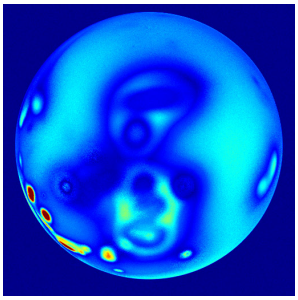
**Difference Images**



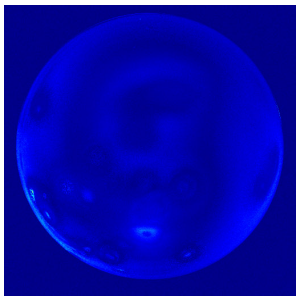
Ashikhmin-Shirley



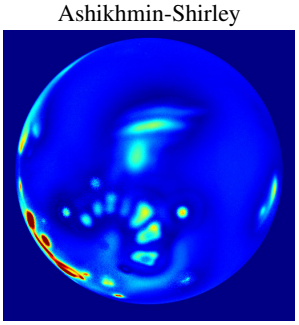
Cook-Torrance



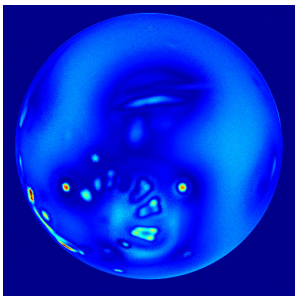
Edwards et al.



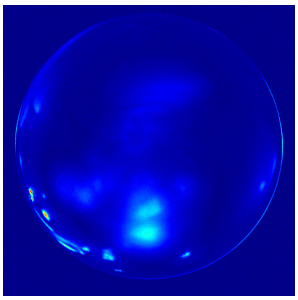
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: color-changing-paint3

**Fitted Parameters/PSNR**

| Material Name | color-changing-paint3 | $k_{sr}$ | 0.097727 | $f_{02}$ | 0.187556 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.098621 | $n_2$ | 239.6429 |
| $k_{dr}$ | 0.009239 | $k_{sb}$ | 0.099722 | $f_{03}$ | 0.048213 |
| $k_{dg}$ | 0.008487 | $f_{01}$ | 0.039422 | $n_3$ | 1649.284 |
| $k_{db}$ | 0.002555 | $n_1$ | 3755.097 | PSNR | 31.16797 |

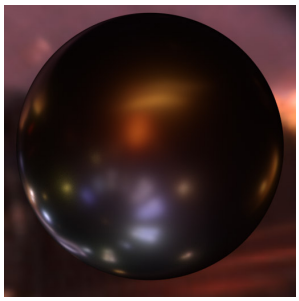
| Material Name | color-changing-paint3 | $k_{sr}$ | 0.022209 | $f_{02}$ | 0.041750 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.022423 | $m_2$ | 0.022849 |
| $k_{dr}$ | 0.010382 | $k_{sb}$ | 0.022679 | $f_{03}$ | 0.044462 |
| $k_{dg}$ | 0.009627 | $f_{01}$ | 0.190634 | $m_3$ | 0.032326 |
| $k_{db}$ | 0.003701 | $m_1$ | 0.082545 | PSNR | 30.07349 |

| Material Name | color-changing-paint3 | $k_{sg}$ | 0.129964 | $R_2$ | 0.047547 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.131683 | $n_2$ | 1.976052 |
| $k_{dr}$ | 0.012781 | $f_{01}$ | 0 | $f_{03}$ | 0.147984 |
| $k_{dg}$ | 0.012052 | $R_1$ | 0.254225 | $R_3$ | 1.711177 |
| $k_{db}$ | 0.006110 | $n_1$ | 505.0003 | $n_3$ | 352.0005 |
| $k_{sr}$ | 0.128731 | $f_{02}$ | 0.013656 | PSNR | 27.56082 |

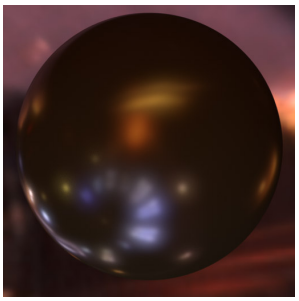
| Material Name | color-changing-paint3 | $k_{db}$ | 0 | $\alpha_1$ | 0.025290 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.016626 | $\alpha_2$ | 0.065778 |
| $k_{dr}$ | 0.002032 | $k_{sg}$ | 0.016602 | $\alpha_3$ | 0.126488 |
| $k_{dg}$ | 0.001581 | $k_{sb}$ | 0.015811 | PSNR | 28.99736 |

| Material Name | color-changing-paint3 | $k_{db}$ | 0 | $\alpha_1$ | 0.124509 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.013104 | $\alpha_2$ | 0.056994 |
| $k_{dr}$ | 0 | $k_{sg}$ | 0.013218 | $\alpha_3$ | 0.022961 |
| $k_{dg}$ | 0 | $k_{sb}$ | 0.012933 | PSNR | 30.66858 |

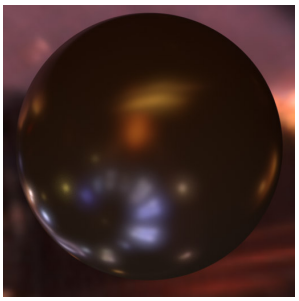
**Rendered Images**



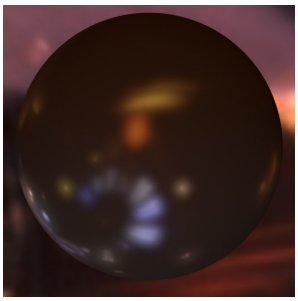
Reference image



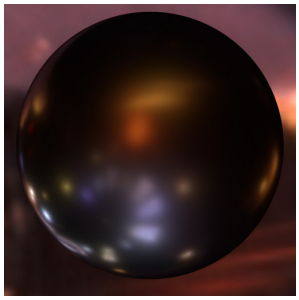
Ashikhmin-Shirley
(PSNR=31.16797)



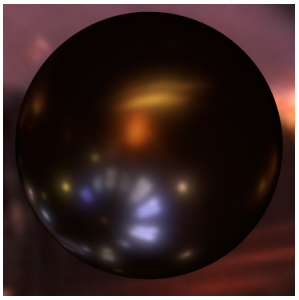
Cook-Torrance
(PSNR=30.07349)



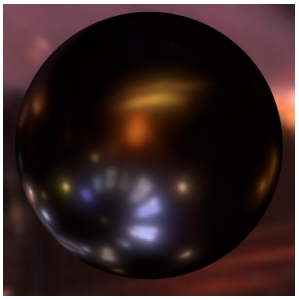
Edwards et al.
(PSNR=27.56082)



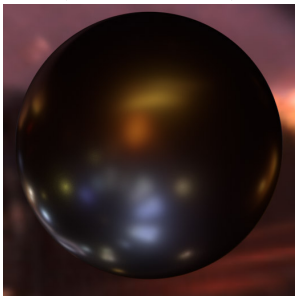
Lawrence et al.
(PSNR=40.76700)



Ward
(PSNR=28.99736)

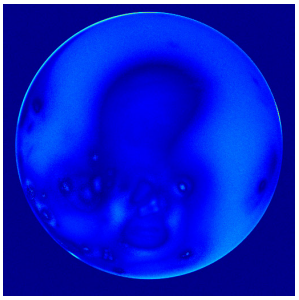


Ward-Duer
(PSNR=30.66858)

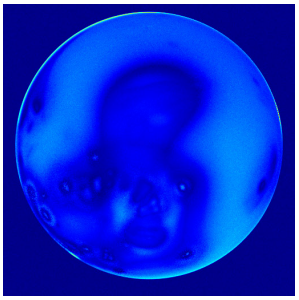


Our factored model
(PSNR=37.44097)

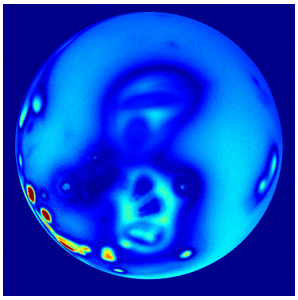
**Difference Images**



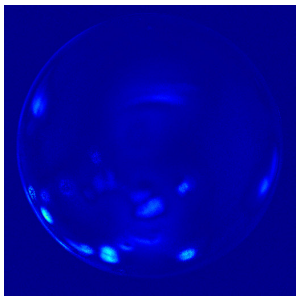
Ashikhmin-Shirley



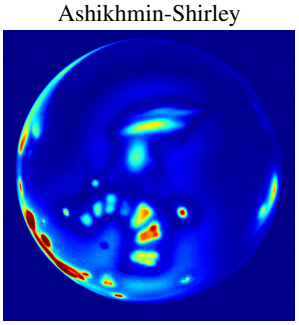
Cook-Torrance



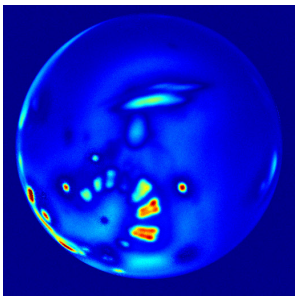
Edwards et al.



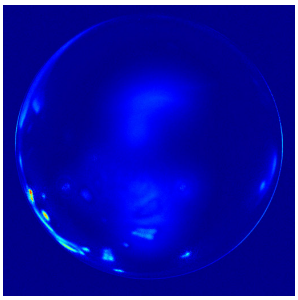
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: dark-blue-paint

**Fitted Parameters/PSNR**

| Material Name | dark-blue-paint | $k_{sr}$ | 0.113586 | $f_{02}$ | 0.119124 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.096467 | $n_2$ | 9.438310 |
| $k_{dr}$ | 0 | $k_{sb}$ | 0.099814 | $f_{03}$ | 0.286352 |
| $k_{dg}$ | 0.003084 | $f_{01}$ | 0.094278 | $n_3$ | 0.717450 |
| $k_{db}$ | 0.030805 | $n_1$ | 26.84780 | PSNR | 38.48015 |

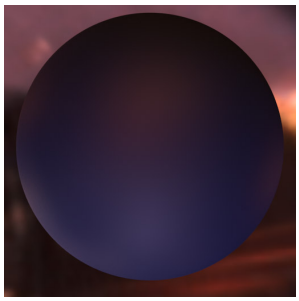
| Material Name | dark-blue-paint | $k_{sr}$ | 0.018404 | $f_{02}$ | 0.147667 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.015656 | $m_2$ | 0.999999 |
| $k_{dr}$ | 0 | $k_{sb}$ | 0.016213 | $f_{03}$ | 0.116966 |
| $k_{dg}$ | 0.003841 | $f_{01}$ | 0.159138 | $m_3$ | 0.231087 |
| $k_{db}$ | 0.031570 | $m_1$ | 0.424032 | PSNR | 39.76585 |

| Material Name | dark-blue-paint | $k_{sg}$ | 0.070486 | $R_2$ | 1.938043 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.072832 | $n_2$ | 49.61814 |
| $k_{dr}$ | 0.008203 | $f_{01}$ | 0 | $f_{03}$ | 0.171175 |
| $k_{dg}$ | 0.012468 | $R_1$ | 1.202355 | $R_3$ | 2.072890 |
| $k_{db}$ | 0.040534 | $n_1$ | 100.2621 | $n_3$ | 12.78437 |
| $k_{sr}$ | 0.082847 | $f_{02}$ | 0.036553 | PSNR | 38.84473 |

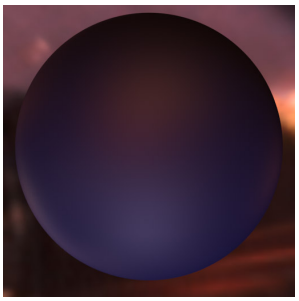
| Material Name | dark-blue-paint | $k_{db}$ | 0.034994 | $\alpha_1$ | 0.245685 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.015160 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.001278 | $k_{sg}$ | 0.012389 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.007330 | $k_{sb}$ | 0.012957 | PSNR | 30.56255 |

| Material Name | dark-blue-paint | $k_{db}$ | 0.033426 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.011503 | $\alpha_2$ | 0.234337 |
| $k_{dr}$ | 0 | $k_{sg}$ | 0.009628 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.005800 | $k_{sb}$ | 0.010054 | PSNR | 32.91368 |

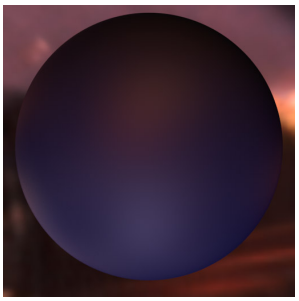
**Rendered Images**



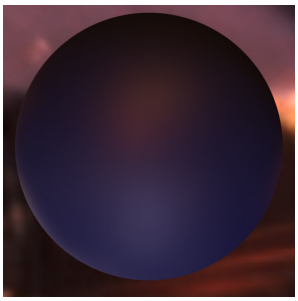
Reference image



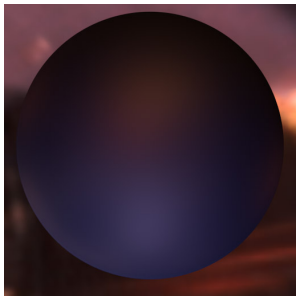
Ashikhmin-Shirley
(PSNR=38.48015)



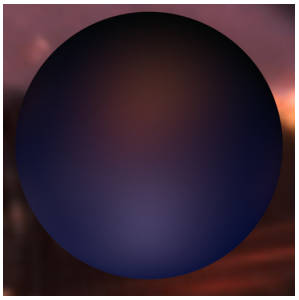
Cook-Torrance
(PSNR=39.76585)



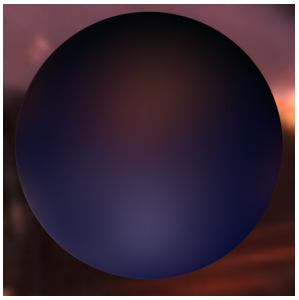
Edwards et al.
(PSNR=38.84473)



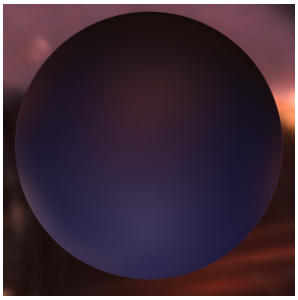
Lawrence et al.
(PSNR=33.51518)



Ward
(PSNR=30.56255)

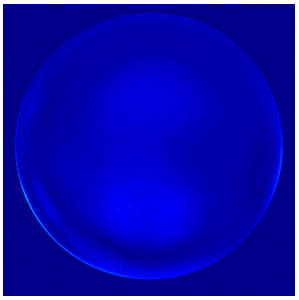


Ward-Duer
(PSNR=32.91368)

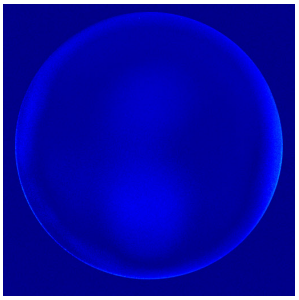


Our factored model
(PSNR=45.19071)

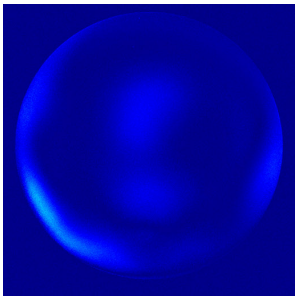
**Difference Images**



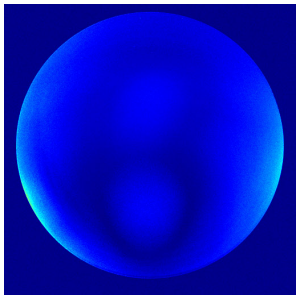
Ashikhmin-Shirley



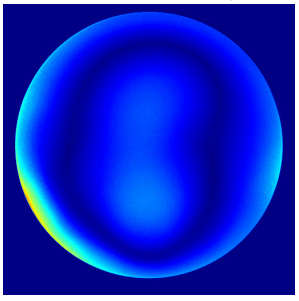
Cook-Torrance



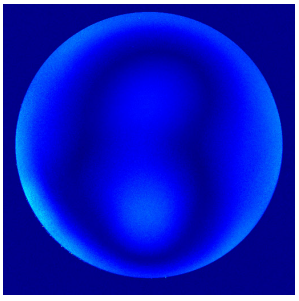
Edwards et al.



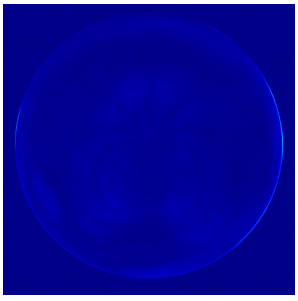
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: dark-red-paint

**Fitted Parameters/PSNR**

| Material Name | dark-red-paint | $k_{sr}$ | 0.095241 | $f_{02}$ | 0.128198 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.082030 | $n_2$ | 12.09345 |
| $k_{dr}$ | 0.242301 | $k_{sb}$ | 0.080263 | $f_{03}$ | 0.450892 |
| $k_{dg}$ | 0.022422 | $f_{01}$ | 0 | $n_3$ | 1.701770 |
| $k_{db}$ | 0.000556 | $n_1$ | 33.72606 | PSNR | 41.80996 |

| Material Name | dark-red-paint | $k_{sr}$ | 0.017080 | $f_{02}$ | 0.186672 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.014861 | $m_2$ | 0.405834 |
| $k_{dr}$ | 0.246947 | $k_{sb}$ | 0.014522 | $f_{03}$ | 0.019991 |
| $k_{dg}$ | 0.026246 | $f_{01}$ | 0.153969 | $m_3$ | 0.205755 |
| $k_{db}$ | 0.004320 | $m_1$ | 0.924443 | PSNR | 42.15514 |

| Material Name | dark-red-paint | $k_{sg}$ | 0.054411 | $R_2$ | 2.033564 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.053280 | $n_2$ | 49.98397 |
| $k_{dr}$ | 0.254496 | $f_{01}$ | 0 | $f_{03}$ | 0.233993 |
| $k_{dg}$ | 0.032982 | $R_1$ | 1.048151 | $R_3$ | 2.093658 |
| $k_{db}$ | 0.010880 | $n_1$ | 100.0030 | $n_3$ | 9.969224 |
| $k_{sr}$ | 0.063503 | $f_{02}$ | 0.008447 | PSNR | 41.45709 |

| Material Name | dark-red-paint | $k_{db}$ | 0.006936 | $\alpha_1$ | 0.345821 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.013246 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.248390 | $k_{sg}$ | 0.009386 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.030527 | $k_{sb}$ | 0.010280 | PSNR | 35.59531 |

| Material Name | dark-red-paint | $k_{db}$ | 0.006326 | $\alpha_1$ | 0.279470 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.008949 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.248962 | $k_{sg}$ | 0.007213 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.029162 | $k_{sb}$ | 0.007464 | PSNR | 37.16597 |

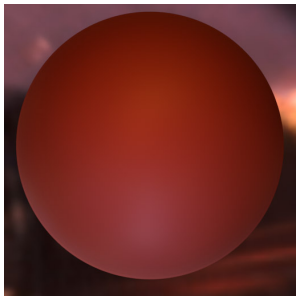
**Rendered Images**

Reference image

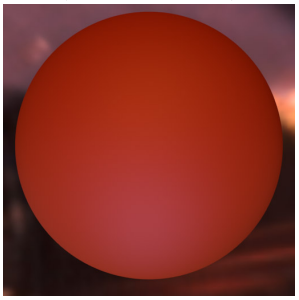
Ashikhmin-Shirley
(PSNR=41.80996)

Cook-Torrance
(PSNR=42.15514)

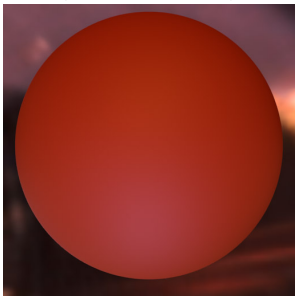
Edwards et al.
(PSNR=41.45709)



Lawrence et al.
(PSNR=23.72657)



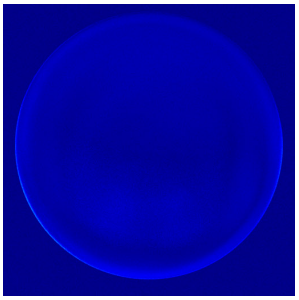
Ward
(PSNR=35.59531)



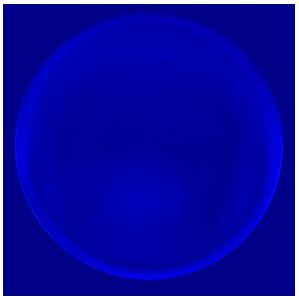
Ward-Duer
(PSNR=37.16597)

Our factored model
(PSNR=40.69810)

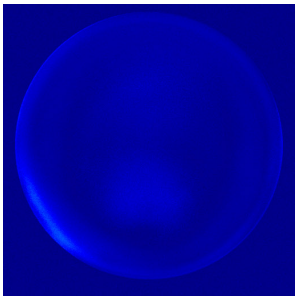
**Difference Images**



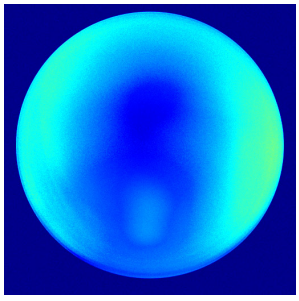
Ashikhmin-Shirley



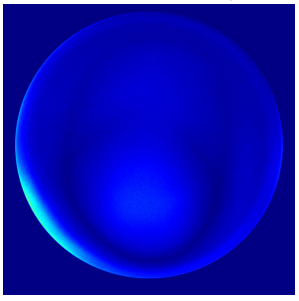
Cook-Torrance



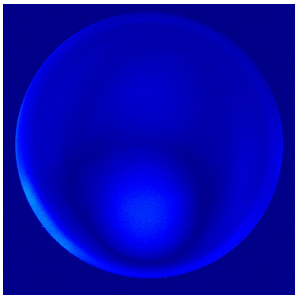
Edwards et al.



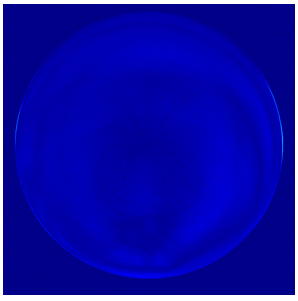
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: dark-specular-fabric

**Fitted Parameters/PSNR**

| Material Name | dark-specular-fabric | $k_{sr}$ | 0.122958 | $f_{02}$ | 0.049620 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.115903 | $n_2$ | 25.39880 |
| $k_{dr}$ | 0.011390 | $k_{sb}$ | 0.111567 | $f_{03}$ | 0.268557 |
| $k_{dg}$ | 0 | $f_{01}$ | 0.010899 | $n_3$ | 1.787452 |
| $k_{db}$ | 0 | $n_1$ | 56.50412 | PSNR | 41.15242 |

| Material Name | dark-specular-fabric | $k_{sr}$ | 0.024829 | $f_{02}$ | 0.089863 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.023414 | $m_2$ | 0.339256 |
| $k_{dr}$ | 0.012452 | $k_{sb}$ | 0.022536 | $f_{03}$ | 0.020098 |
| $k_{dg}$ | 0.000834 | $f_{01}$ | 0.116857 | $m_3$ | 0.161075 |
| $k_{db}$ | 0 | $m_1$ | 0.999999 | PSNR | 42.37278 |

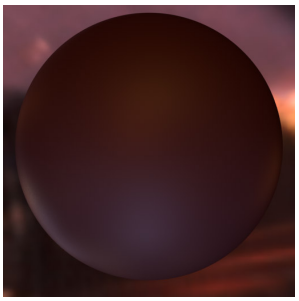
| Material Name | dark-specular-fabric | $k_{sg}$ | 0.074214 | $R_2$ | 2.889269 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.071047 | $n_2$ | 36.80157 |
| $k_{dr}$ | 0.021361 | $f_{01}$ | 0.003391 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.009265 | $R_1$ | 1.257046 | $R_3$ | 2.002335 |
| $k_{db}$ | 0.007709 | $n_1$ | 48.35672 | $n_3$ | 669.4480 |
| $k_{sr}$ | 0.078946 | $f_{02}$ | 0.112138 | PSNR | 37.95411 |

| Material Name | dark-specular-fabric | $k_{db}$ | 0.002660 | $\alpha_1$ | 0.195588 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.010492 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.015191 | $k_{sg}$ | 0.009597 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.003868 | $k_{sb}$ | 0.009110 | PSNR | 30.23986 |

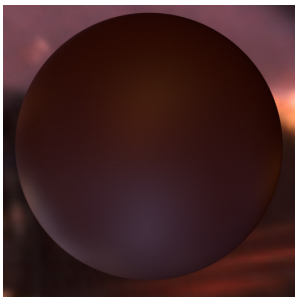
| Material Name | dark-specular-fabric | $k_{db}$ | 0 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.009001 | $\alpha_2$ | 0.175266 |
| $k_{dr}$ | 0.012085 | $k_{sg}$ | 0.008380 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.000718 | $k_{sb}$ | 0.007997 | PSNR | 30.69883 |

**Rendered Images**

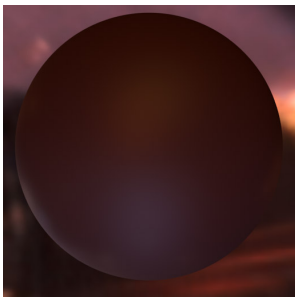
Reference image



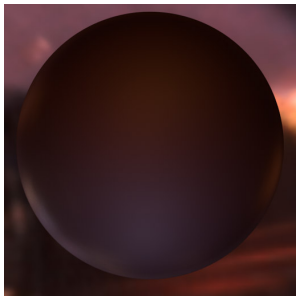
Ashikhmin-Shirley
(PSNR=41.15242)



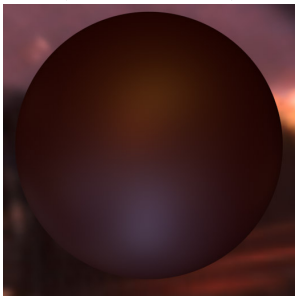
Cook-Torrance
(PSNR=42.37278)



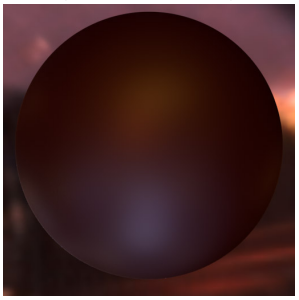
Edwards et al.
(PSNR=37.95411)



Lawrence et al.
(PSNR=34.54973)



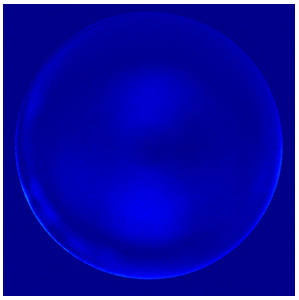
Ward
(PSNR=30.23986)



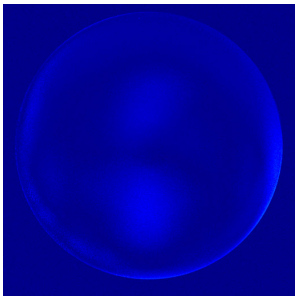
Ward-Duer
(PSNR=30.69883)

Our factored model
(PSNR=45.04639)

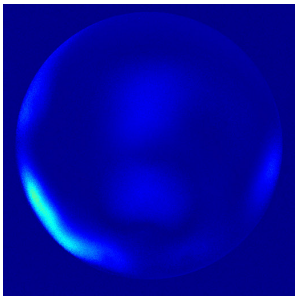
**Difference Images**



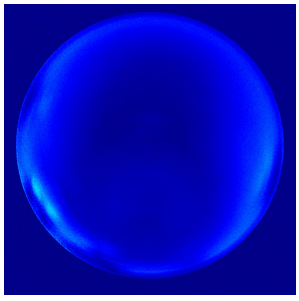
Ashikhmin-Shirley



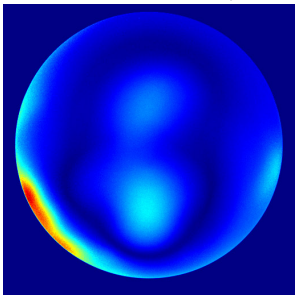
Cook-Torrance



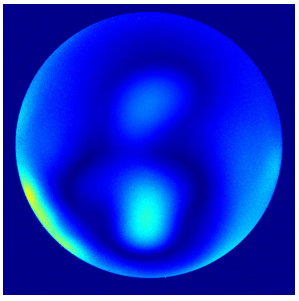
Edwards et al.



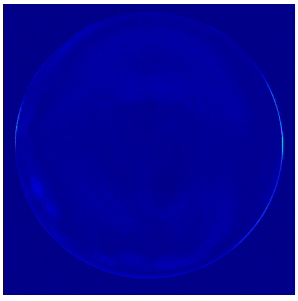
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: delrin

**Fitted Parameters/PSNR**

| Material Name | delrin | $k_{sr}$ | 0.109184 | $f_{02}$ | 0.104484 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.106705 | $n_2$ | 69.01556 |
| $k_{dr}$ | 0.258091 | $k_{sb}$ | 0.098345 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.247426 | $f_{01}$ | 0.004821 | $n_3$ | 2.221444 |
| $k_{db}$ | 0.213782 | $n_1$ | 421.0755 | PSNR | 38.70341 |

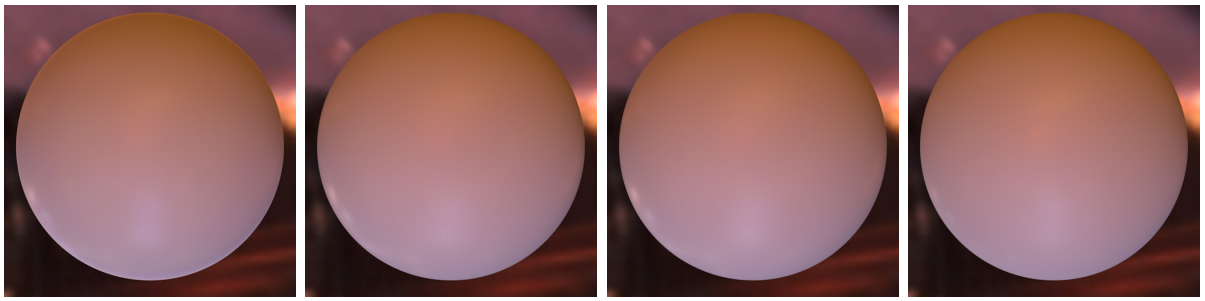
| Material Name | delrin | $k_{sr}$ | 0.022150 | $f_{02}$ | 0.131000 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.021680 | $m_2$ | 0.159048 |
| $k_{dr}$ | 0.274566 | $k_{sb}$ | 0.019922 | $f_{03}$ | 0.003152 |
| $k_{dg}$ | 0.263468 | $f_{01}$ | 0.369392 | $m_3$ | 0.060988 |
| $k_{db}$ | 0.228672 | $m_1$ | 0.582316 | PSNR | 38.87057 |

| Material Name | delrin | $k_{sg}$ | 0.113559 | $R_2$ | 0.308651 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.105404 | $n_2$ | 61.70706 |
| $k_{dr}$ | 0.286598 | $f_{01}$ | 0.036845 | $f_{03}$ | 0.237232 |
| $k_{dg}$ | 0.275532 | $R_1$ | 1.258641 | $R_3$ | 3.124398 |
| $k_{db}$ | 0.239513 | $n_1$ | 79.58259 | $n_3$ | 29.42703 |
| $k_{sr}$ | 0.117276 | $f_{02}$ | 0 | PSNR | 38.69817 |

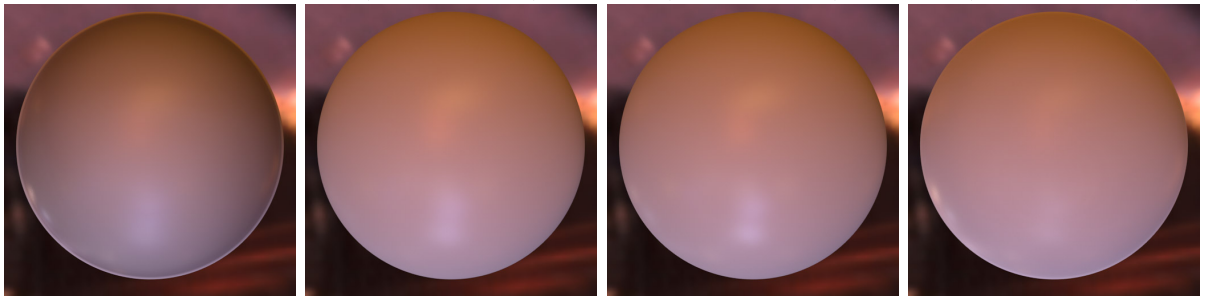
| Material Name | delrin | $k_{db}$ | 0.236249 | $\alpha_1$ | 0.451716 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.017267 | $\alpha_2$ | 0.451716 |
| $k_{dr}$ | 0.285971 | $k_{sg}$ | 0.017258 | $\alpha_3$ | 0.113708 |
| $k_{dg}$ | 0.274054 | $k_{sb}$ | 0.017190 | PSNR | 35.76773 |

| Material Name | delrin | $k_{db}$ | 0.234708 | $\alpha_1$ | 0.411804 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.013404 | $\alpha_2$ | 0.411805 |
| $k_{dr}$ | 0.283108 | $k_{sg}$ | 0.013179 | $\alpha_3$ | 0.097191 |
| $k_{dg}$ | 0.271693 | $k_{sb}$ | 0.012774 | PSNR | 37.07363 |

**Rendered Images**

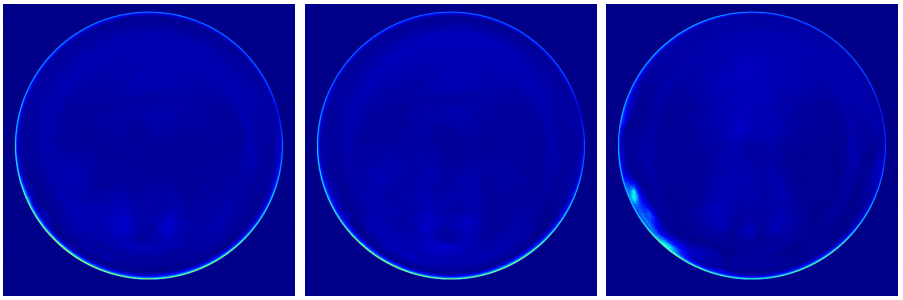


Reference image | Ashikhmin-Shirley (PSNR=38.70341) | Cook-Torrance (PSNR=38.87057) | Edwards et al. (PSNR=38.69817)

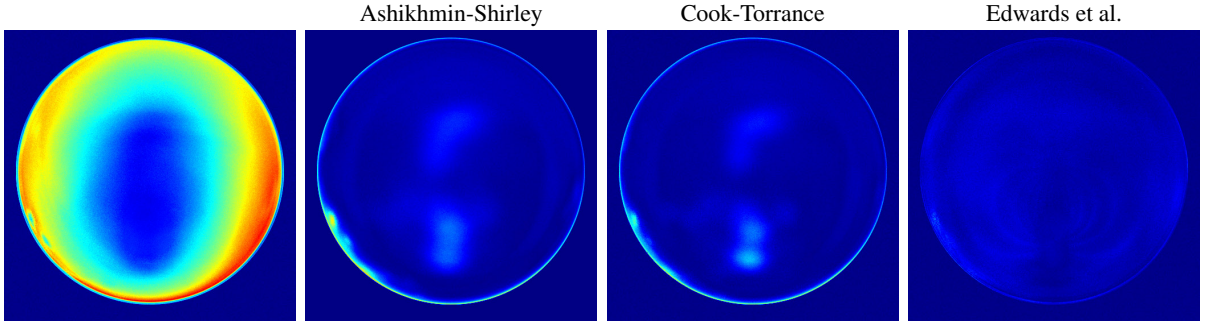


Lawrence et al. (PSNR=22.11131) | Ward (PSNR=35.76773) | Ward-Duer (PSNR=37.07363) | Our factored model (PSNR=39.85073)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: fruitwood-241

**Fitted Parameters/PSNR**

| Material Name | fruitwood-241 | $k_{sr}$ | 0.145174 | $f_{02}$ | 0.052169 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.138238 | $n_2$ | 205.8583 |
| $k_{dr}$ | 0.046335 | $k_{sb}$ | 0.132815 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.032380 | $f_{01}$ | 0.116001 | $n_3$ | 88.10362 |
| $k_{db}$ | 0.017452 | $n_1$ | 21.18167 | PSNR | 41.51187 |

| Material Name | fruitwood-241 | $k_{sr}$ | 0.027966 | $f_{02}$ | 0.049032 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.026630 | $m_2$ | 0.087546 |
| $k_{dr}$ | 0.047479 | $k_{sb}$ | 0.025608 | $f_{03}$ | 0.021772 |
| $k_{dg}$ | 0.033469 | $f_{01}$ | 0.102830 | $m_3$ | 0.139525 |
| $k_{db}$ | 0.018482 | $m_1$ | 0.273449 | PSNR | 42.82529 |

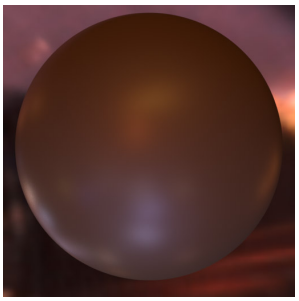
| Material Name | fruitwood-241 | $k_{sg}$ | 0.115173 | $R_2$ | 0.817296 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.110519 | $n_2$ | 97.98577 |
| $k_{dr}$ | 0.052261 | $f_{01}$ | 0 | $f_{03}$ | 0.107973 |
| $k_{dg}$ | 0.038047 | $R_1$ | 0.985341 | $R_3$ | 2.003963 |
| $k_{db}$ | 0.022915 | $n_1$ | 500.0286 | $n_3$ | 78.21552 |
| $k_{sr}$ | 0.121137 | $f_{02}$ | 0.004300 | PSNR | 36.91055 |

| Material Name | fruitwood-241 | $k_{db}$ | 0.012252 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.016596 | $\alpha_2$ | 0.260382 |
| $k_{dr}$ | 0.039844 | $k_{sg}$ | 0.015615 | $\alpha_3$ | 0.094987 |
| $k_{dg}$ | 0.026524 | $k_{sb}$ | 0.014755 | PSNR | 29.95628 |

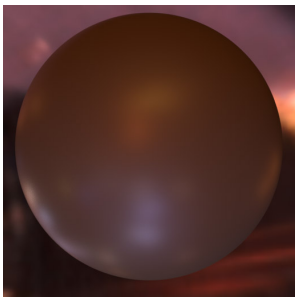
| Material Name | fruitwood-241 | $k_{db}$ | 0.007769 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.013965 | $\alpha_2$ | 0.237405 |
| $k_{dr}$ | 0.035268 | $k_{sg}$ | 0.013229 | $\alpha_3$ | 0.089704 |
| $k_{dg}$ | 0.022004 | $k_{sb}$ | 0.012590 | PSNR | 30.63603 |

**Rendered Images**

Reference image

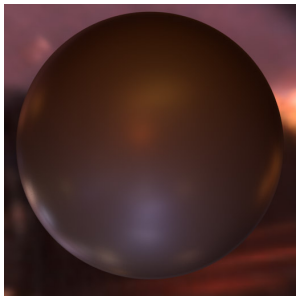


Ashikhmin-Shirley
(PSNR=41.51187)

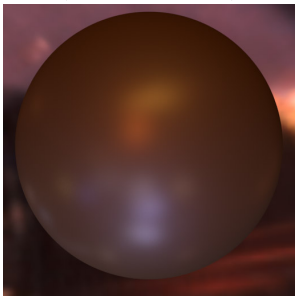


Cook-Torrance
(PSNR=42.82529)

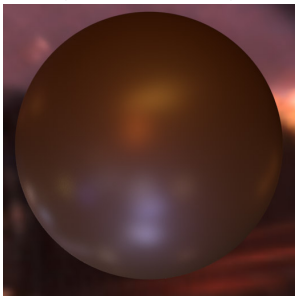
Edwards et al.
(PSNR=36.91055)



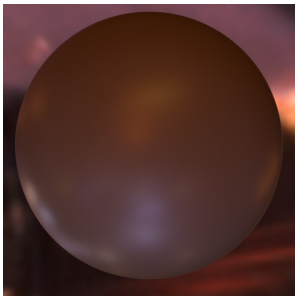
Lawrence et al.
(PSNR=29.40209)



Ward
(PSNR=29.95628)

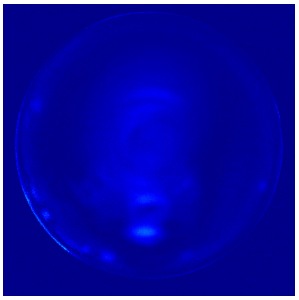


Ward-Duer
(PSNR=30.63603)

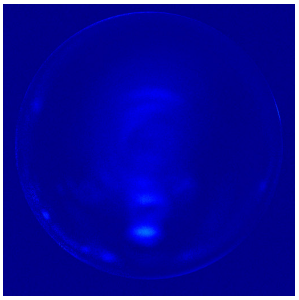


Our factored model
(PSNR=42.50193)

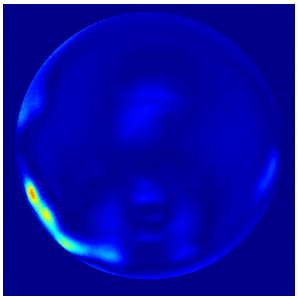
**Difference Images**



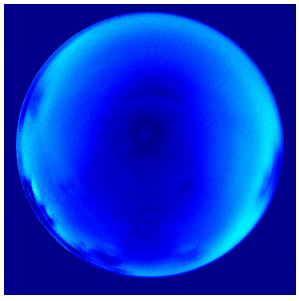
Ashikhmin-Shirley



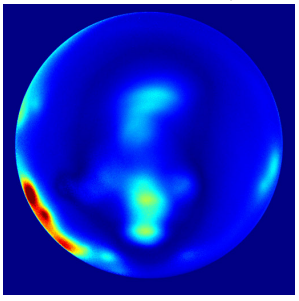
Cook-Torrance



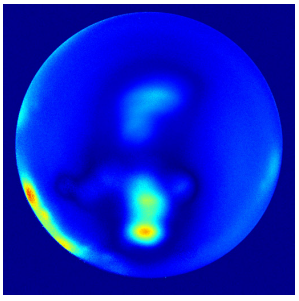
Edwards et al.



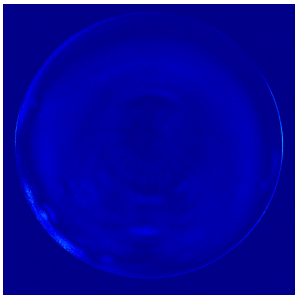
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: gold-metallic-paint

**Fitted Parameters/PSNR**

| Material Name | gold-metallic-paint | $k_{sr}$ | 0.095173 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.064821 | $n_2$ | 13.51918 |
| $k_{dr}$ | 0.012394 | $k_{sb}$ | 0.023332 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.003461 | $f_{01}$ | 0.999999 | $n_3$ | 6.242788 |
| $k_{db}$ | 0 | $n_1$ | 54.18483 | PSNR | 31.38160 |

| Material Name | gold-metallic-paint | $k_{sr}$ | 0.016017 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.010907 | $m_2$ | 0.314351 |
| $k_{dr}$ | 0.034075 | $k_{sb}$ | 0.003990 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.018242 | $f_{01}$ | 0.999999 | $m_3$ | 0.395875 |
| $k_{db}$ | 0.000929 | $m_1$ | 0.163078 | PSNR | 31.68605 |

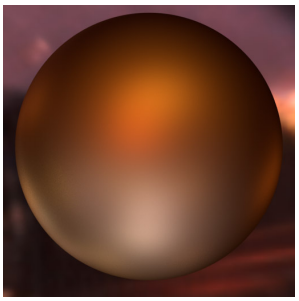
| Material Name | gold-metallic-paint | $k_{sg}$ | 0.180409 | $R_2$ | 2.285812 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.061884 | $n_2$ | 49.99182 |
| $k_{dr}$ | 0.022420 | $f_{01}$ | 0.049867 | $f_{03}$ | 0.405929 |
| $k_{dg}$ | 0.010113 | $R_1$ | 1.525054 | $R_3$ | 2.177543 |
| $k_{db}$ | 0.000820 | $n_1$ | 100.0028 | $n_3$ | 9.856454 |
| $k_{sr}$ | 0.264513 | $f_{02}$ | 0.435724 | PSNR | 32.99036 |

| Material Name | gold-metallic-paint | $k_{db}$ | 0 | $\alpha_1$ | 0.173325 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.132758 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0 | $k_{sg}$ | 0.090954 | $\alpha_3$ | 0.434850 |
| $k_{dg}$ | 0 | $k_{sb}$ | 0.030906 | PSNR | 26.86548 |

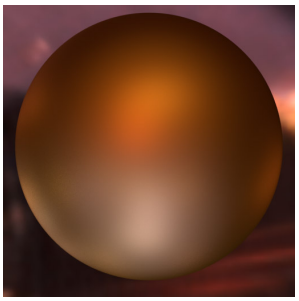
| Material Name | gold-metallic-paint | $k_{db}$ | 0.001040 | $\alpha_1$ | 0.407611 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.076391 | $\alpha_2$ | 0.174346 |
| $k_{dr}$ | 0.034520 | $k_{sg}$ | 0.052009 | $\alpha_3$ | 0.407611 |
| $k_{dg}$ | 0.018575 | $k_{sb}$ | 0.019028 | PSNR | 31.72941 |

**Rendered Images**

Reference image

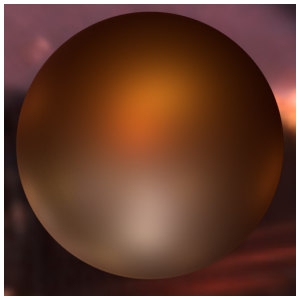


Ashikhmin-Shirley
(PSNR=31.38160)



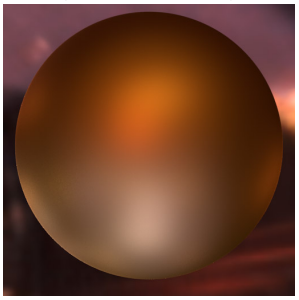
Cook-Torrance
(PSNR=31.68605)

Edwards et al.
(PSNR=32.99036)



Lawrence et al.
(PSNR=33.95720)

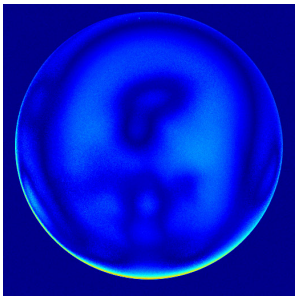
Ward
(PSNR=26.86548)



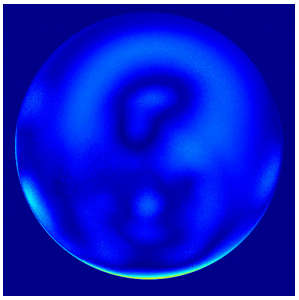
Ward-Duer
(PSNR=31.72941)

Our factored model
(PSNR=38.57361)

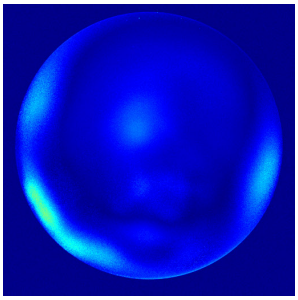
**Difference Images**



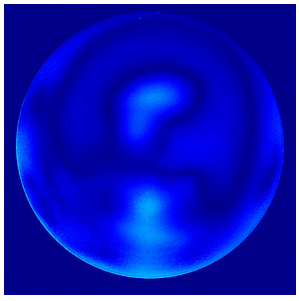
Ashikhmin-Shirley



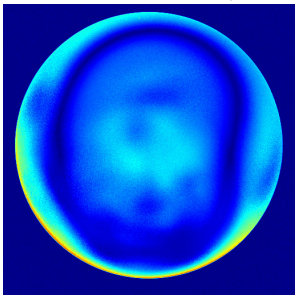
Cook-Torrance



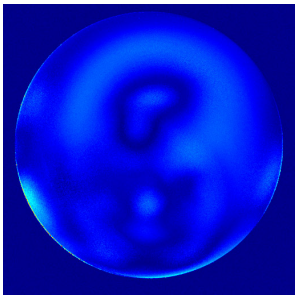
Edwards et al.



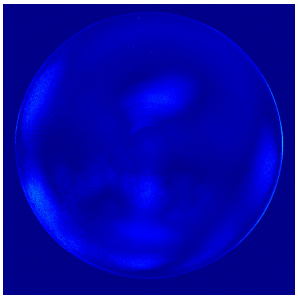
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: gold-metallic-paint2

**Fitted Parameters/PSNR**

| Material Name | gold-metallic-paint2 | $k_{sr}$ | 0.064027 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.055451 | $n_2$ | 121.8059 |
| $k_{dr}$ | 0.109143 | $k_{sb}$ | 0.056094 | $f_{03}$ | 0.012394 |
| $k_{dg}$ | 0.092820 | $f_{01}$ | 0.085913 | $n_3$ | 2085.604 |
| $k_{db}$ | 0.061419 | $n_1$ | 15773.05 | PSNR | 22.80907 |

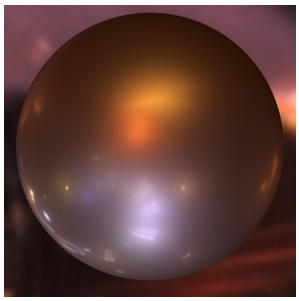
| Material Name | gold-metallic-paint2 | $k_{sr}$ | 0.022277 | $f_{02}$ | 0.007591 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.020004 | $m_2$ | 0.001992 |
| $k_{dr}$ | 0.081671 | $k_{sb}$ | 0.019272 | $f_{03}$ | 0.055467 |
| $k_{dg}$ | 0.066153 | $f_{01}$ | 0.999999 | $m_3$ | 0.014263 |
| $k_{db}$ | 0.038342 | $m_1$ | 0.153439 | PSNR | 26.12984 |

| Material Name | gold-metallic-paint2 | $k_{sg}$ | 0.083634 | $R_2$ | 0.051600 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.082260 | $n_2$ | 5.273783 |
| $k_{dr}$ | 0.082400 | $f_{01}$ | 0.021783 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.068456 | $R_1$ | 0.126697 | $R_3$ | 3.066630 |
| $k_{db}$ | 0.038976 | $n_1$ | 378.1257 | $n_3$ | 210.1439 |
| $k_{sr}$ | 0.095092 | $f_{02}$ | 0.013226 | PSNR | 26.68763 |

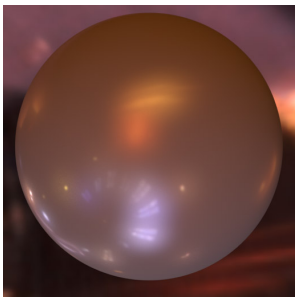
| Material Name | gold-metallic-paint2 | $k_{db}$ | 0.090907 | $\alpha_1$ | 0.082507 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.015045 | $\alpha_2$ | 0.082507 |
| $k_{dr}$ | 0.140239 | $k_{sg}$ | 0.013132 | $\alpha_3$ | 0.013288 |
| $k_{dg}$ | 0.119538 | $k_{sb}$ | 0.012109 | PSNR | 20.06930 |

| Material Name | gold-metallic-paint2 | $k_{db}$ | 0.088308 | $\alpha_1$ | 0.082822 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.011777 | $\alpha_2$ | 0.082822 |
| $k_{dr}$ | 0.138600 | $k_{sg}$ | 0.010221 | $\alpha_3$ | 0.012815 |
| $k_{dg}$ | 0.118269 | $k_{sb}$ | 0.009933 | PSNR | 20.07076 |

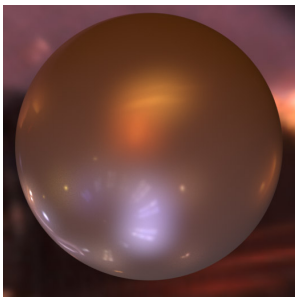
**Rendered Images**



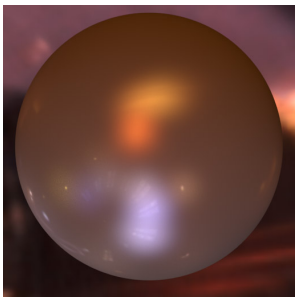
Reference image



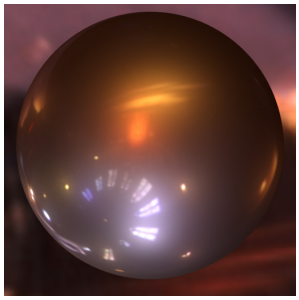
Ashikhmin-Shirley
(PSNR=22.80907)



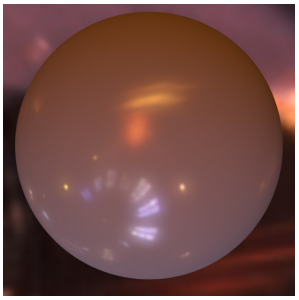
Cook-Torrance
(PSNR=26.12984)



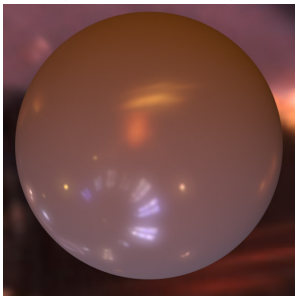
Edwards et al.
(PSNR=26.68763)



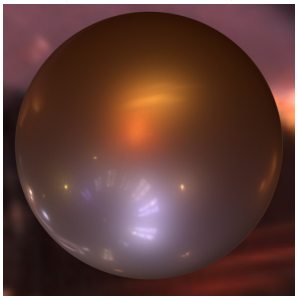
Lawrence et al.
(PSNR=31.50862)



Ward
(PSNR=20.06930)

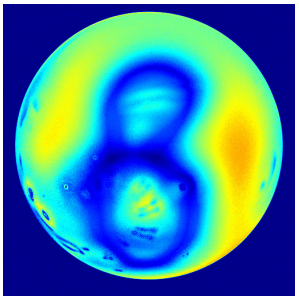


Ward-Duer
(PSNR=20.07076)

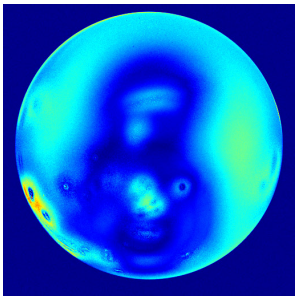


Our factored model
(PSNR=38.43023)

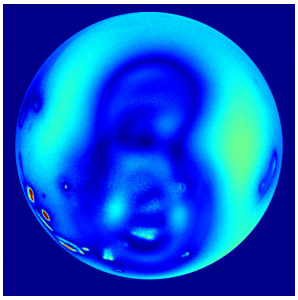
**Difference Images**



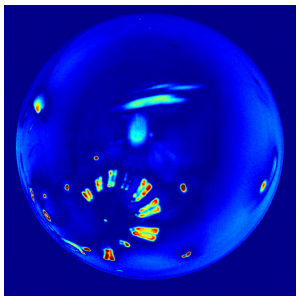
Ashikhmin-Shirley



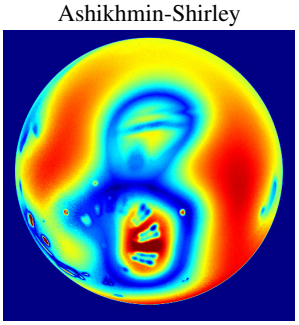
Cook-Torrance



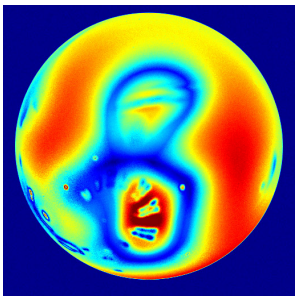
Edwards et al.



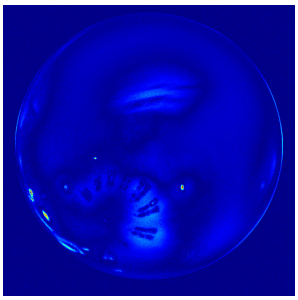
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: gold-metallic-paint3

**Fitted Parameters/PSNR**

| Material Name | gold-metallic-paint3 | $k_{sr}$ | 0.057695 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.045392 | $n_2$ | 618.6426 |
| $k_{dr}$ | 0.108201 | $k_{sb}$ | 0.025724 | $f_{03}$ | 0.763566 |
| $k_{dg}$ | 0.074190 | $f_{01}$ | 0.100809 | $n_3$ | 7348.320 |
| $k_{db}$ | 0.037666 | $n_1$ | 243890.7 | PSNR | 21.56816 |

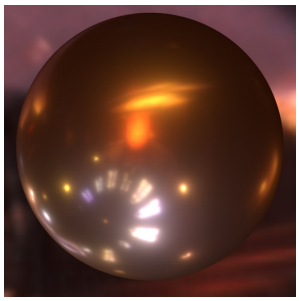
| Material Name | gold-metallic-paint3 | $k_{sr}$ | 0.013795 | $f_{02}$ | 0.833701 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.010845 | $m_2$ | 0.017734 |
| $k_{dr}$ | 0.105298 | $k_{sb}$ | 0.006147 | $f_{03}$ | 0.126871 |
| $k_{dg}$ | 0.071969 | $f_{01}$ | 0.999999 | $m_3$ | 0.003259 |
| $k_{db}$ | 0.036399 | $m_1$ | 0.060662 | PSNR | 21.82084 |

| Material Name | gold-metallic-paint3 | $k_{sg}$ | 0.101518 | $R_2$ | 0.514671 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.056563 | $n_2$ | 1584.391 |
| $k_{dr}$ | 0.108052 | $f_{01}$ | 0.608030 | $f_{03}$ | 0.008078 |
| $k_{dg}$ | 0.074971 | $R_1$ | 1.040652 | $R_3$ | 0.003887 |
| $k_{db}$ | 0.038863 | $n_1$ | 406.8558 | $n_3$ | 2.786221 |
| $k_{sr}$ | 0.130499 | $f_{02}$ | 0.180269 | PSNR | 21.22627 |

| Material Name | gold-metallic-paint3 | $k_{db}$ | 0.041178 | $\alpha_1$ | 0.035131 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.046298 | $\alpha_2$ | 0.038673 |
| $k_{dr}$ | 0.111591 | $k_{sg}$ | 0.035792 | $\alpha_3$ | 0.009418 |
| $k_{dg}$ | 0.078201 | $k_{sb}$ | 0.019699 | PSNR | 21.14606 |

| Material Name | gold-metallic-paint3 | $k_{db}$ | 0.049356 | $\alpha_1$ | 0.031977 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.026279 | $\alpha_2$ | 0.031977 |
| $k_{dr}$ | 0.134720 | $k_{sg}$ | 0.020598 | $\alpha_3$ | 0.008016 |
| $k_{dg}$ | 0.095275 | $k_{sb}$ | 0.011764 | PSNR | 19.48245 |

**Rendered Images**

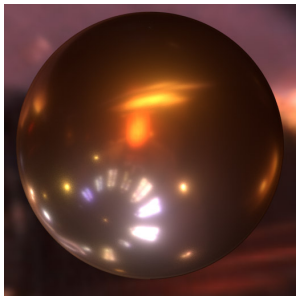


Reference image

Ashikhmin-Shirley
(PSNR=21.56816)

Cook-Torrance
(PSNR=21.82084)

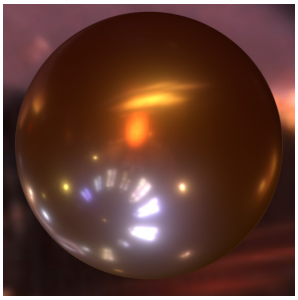
Edwards et al.
(PSNR=21.22627)



Lawrence et al.
(PSNR=35.83481)

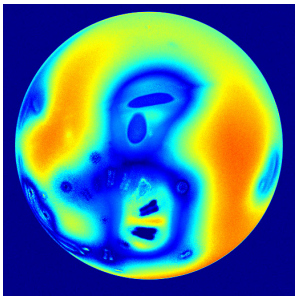
Ward
(PSNR=21.14606)

Ward-Duer
(PSNR=19.48245)

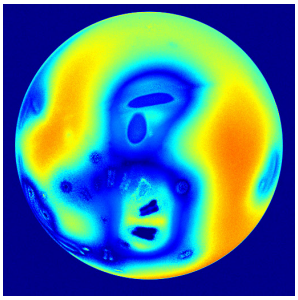


Our factored model
(PSNR=32.85134)

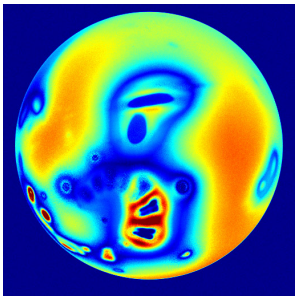
**Difference Images**



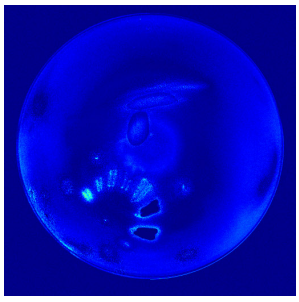
Ashikhmin-Shirley



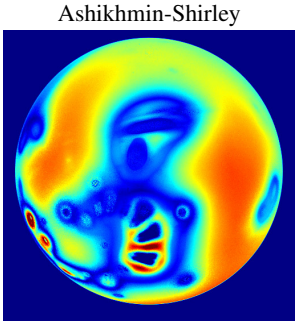
Cook-Torrance



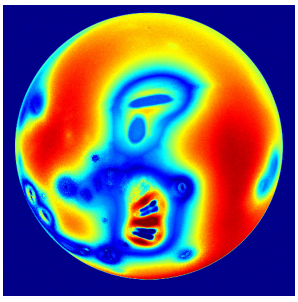
Edwards et al.



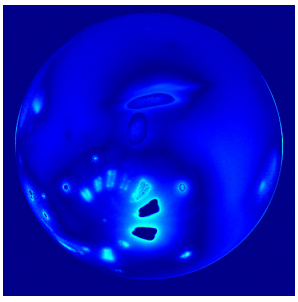
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: gold-paint

**Fitted Parameters/PSNR**

| Material Name | gold-paint | $k_{sr}$ | 0.052822 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.043434 | $n_2$ | 9.770113 |
| $k_{dr}$ | 0.153136 | $k_{sb}$ | 0.028188 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.080244 | $f_{01}$ | 0.512604 | $n_3$ | 21.05486 |
| $k_{db}$ | 0.021028 | $n_1$ | 87.65079 | PSNR | 36.44028 |

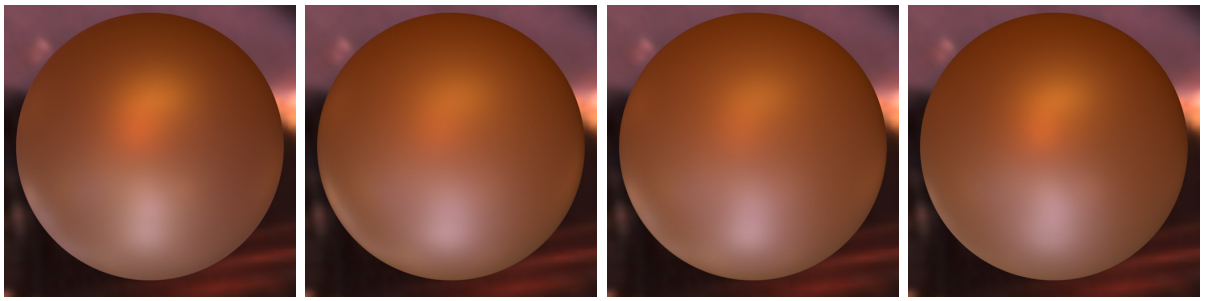
| Material Name | gold-paint | $k_{sr}$ | 0.008380 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.006910 | $m_2$ | 0.373302 |
| $k_{dr}$ | 0.161780 | $k_{sb}$ | 0.004534 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.087157 | $f_{01}$ | 0.831948 | $m_3$ | 0.289865 |
| $k_{db}$ | 0.025000 | $m_1$ | 0.143325 | PSNR | 36.49769 |

| Material Name | gold-paint | $k_{sg}$ | 0.109957 | $R_2$ | 0.699388 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.069879 | $n_2$ | 11.70696 |
| $k_{dr}$ | 0.151241 | $f_{01}$ | 0 | $f_{03}$ | 0.768832 |
| $k_{dg}$ | 0.079559 | $R_1$ | 0.819796 | $R_3$ | 10.63834 |
| $k_{db}$ | 0.021640 | $n_1$ | 128.0681 | $n_3$ | 434.7993 |
| $k_{sr}$ | 0.135211 | $f_{02}$ | 0.147876 | PSNR | 36.79577 |

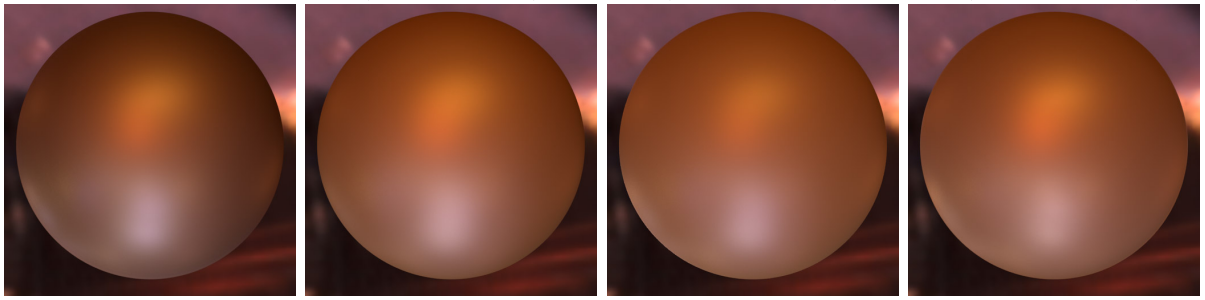
| Material Name | gold-paint | $k_{db}$ | 0.017772 | $\alpha_1$ | 0.485298 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.072630 | $\alpha_2$ | 0.174250 |
| $k_{dr}$ | 0.136194 | $k_{sg}$ | 0.058183 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.068675 | $k_{sb}$ | 0.034990 | PSNR | 33.90714 |

| Material Name | gold-paint | $k_{db}$ | 0.025497 | $\alpha_1$ | 0.383160 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.036849 | $\alpha_2$ | 0.158544 |
| $k_{dr}$ | 0.162557 | $k_{sg}$ | 0.030385 | $\alpha_3$ | 0.383160 |
| $k_{dg}$ | 0.087795 | $k_{sb}$ | 0.019906 | PSNR | 36.37196 |

**Rendered Images**

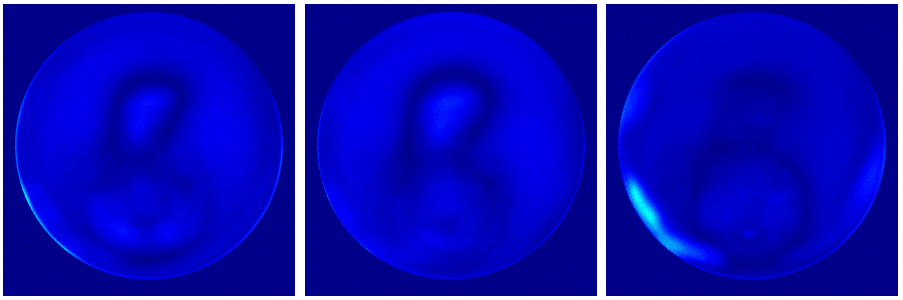


Reference image | Ashikhmin-Shirley (PSNR=36.44028) | Cook-Torrance (PSNR=36.49769) | Edwards et al. (PSNR=36.79577)

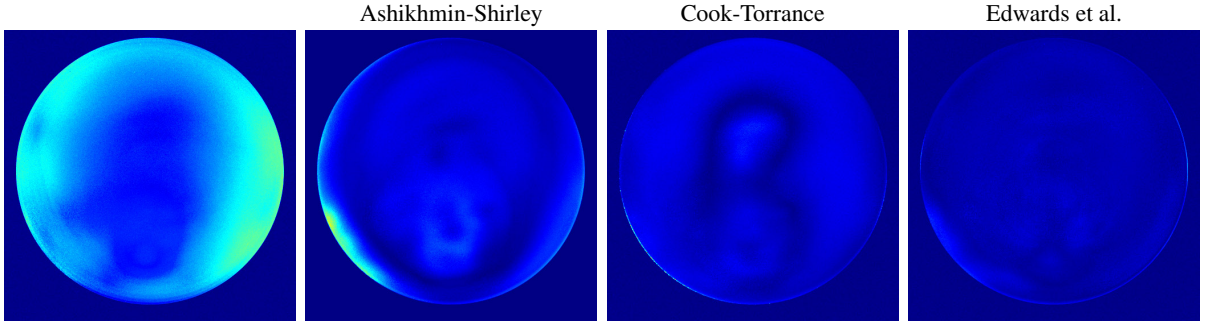


Lawrence et al. (PSNR=25.98337) | Ward (PSNR=33.90714) | Ward-Duer (PSNR=36.37196) | Our factored model (PSNR=40.23611)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: gray-plastic

**Fitted Parameters/PSNR**

| Material Name | gray-plastic | $k_{sr}$ | 0.063598 | $f_{02}$ | 0.029713 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.059940 | $n_2$ | 1321.047 |
| $k_{dr}$ | 0.102257 | $k_{sb}$ | 0.058949 | $f_{03}$ | 0.144295 |
| $k_{dg}$ | 0.103058 | $f_{01}$ | 0.053865 | $n_3$ | 235.6570 |
| $k_{db}$ | 0.096414 | $n_1$ | 7430.884 | PSNR | 39.29905 |

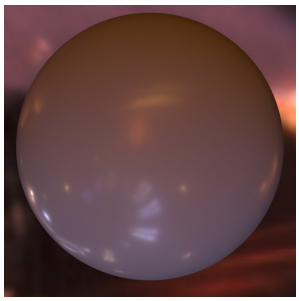
| Material Name | gray-plastic | $k_{sr}$ | 0.014765 | $f_{02}$ | 0.055114 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.013917 | $m_2$ | 0.015993 |
| $k_{dr}$ | 0.102474 | $k_{sb}$ | 0.013688 | $f_{03}$ | 0.034336 |
| $k_{dg}$ | 0.103262 | $f_{01}$ | 0.142381 | $m_3$ | 0.036893 |
| $k_{db}$ | 0.096614 | $m_1$ | 0.088725 | PSNR | 39.10830 |

| Material Name | gray-plastic | $k_{sg}$ | 0.075373 | $R_2$ | 0.241877 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.074254 | $n_2$ | 97.11179 |
| $k_{dr}$ | 0.106115 | $f_{01}$ | 0.002902 | $f_{03}$ | 0.084189 |
| $k_{dg}$ | 0.106694 | $R_1$ | 0.184932 | $R_3$ | 1.062705 |
| $k_{db}$ | 0.099972 | $n_1$ | 500.6113 | $n_3$ | 197.2099 |
| $k_{sr}$ | 0.079973 | $f_{02}$ | 0.026655 | PSNR | 36.77162 |

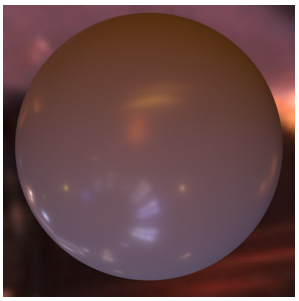
| Material Name | gray-plastic | $k_{db}$ | 0.094889 | $\alpha_1$ | 0.107744 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.008180 | $\alpha_2$ | 0.050754 |
| $k_{dr}$ | 0.100341 | $k_{sg}$ | 0.007690 | $\alpha_3$ | 0.016544 |
| $k_{dg}$ | 0.101294 | $k_{sb}$ | 0.007463 | PSNR | 34.47930 |

| Material Name | gray-plastic | $k_{db}$ | 0.091937 | $\alpha_1$ | 0.105751 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.007134 | $\alpha_2$ | 0.047177 |
| $k_{dr}$ | 0.097324 | $k_{sg}$ | 0.006721 | $\alpha_3$ | 0.015897 |
| $k_{dg}$ | 0.098416 | $k_{sb}$ | 0.006579 | PSNR | 35.75974 |

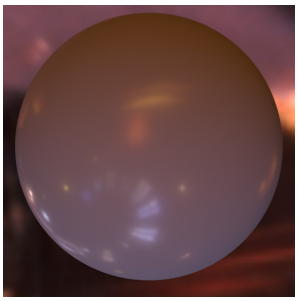
**Rendered Images**



Reference image

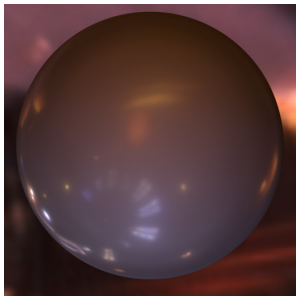


Ashikhmin-Shirley
(PSNR=39.29905)

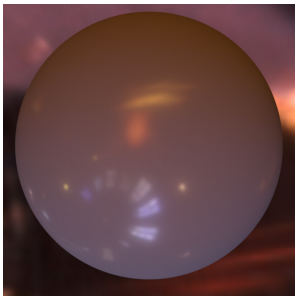


Cook-Torrance
(PSNR=39.10830)

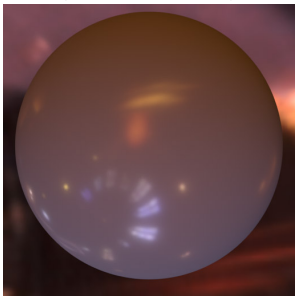
Edwards et al.
(PSNR=36.77162)



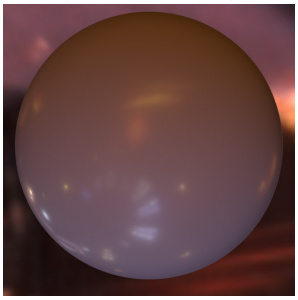
Lawrence et al.
(PSNR=24.95354)



Ward
(PSNR=34.47930)

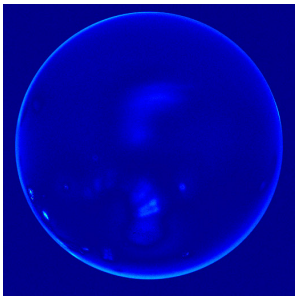


Ward-Duer
(PSNR=35.75974)

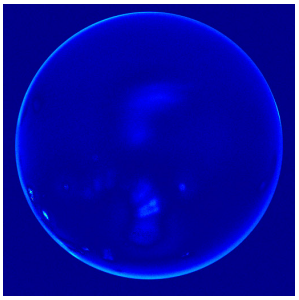


Our factored model
(PSNR=44.56899)

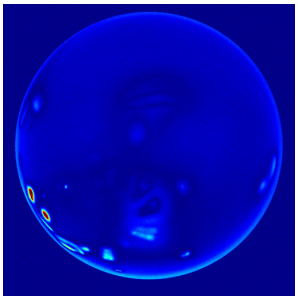
**Difference Images**



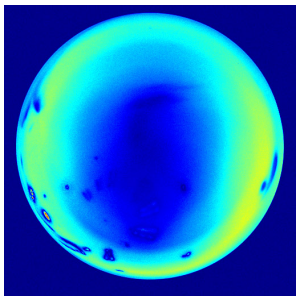
Ashikhmin-Shirley



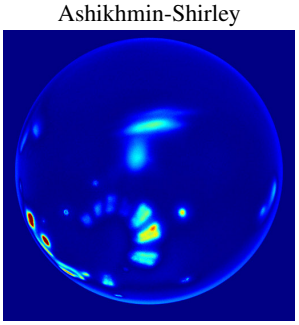
Cook-Torrance



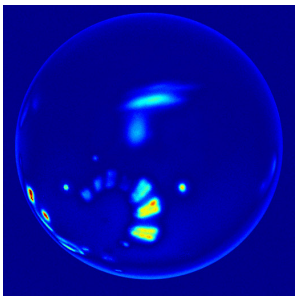
Edwards et al.



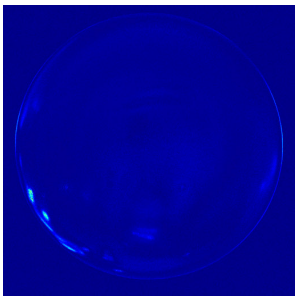
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: grease-covered-steel

**Fitted Parameters/PSNR**

| Material Name | grease-covered-steel | $k_{sr}$ | 0.043922 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.040339 | $n_2$ | 3073.587 |
| $k_{dr}$ | 0.041306 | $k_{sb}$ | 0.037505 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.042691 | $f_{01}$ | 0.175600 | $n_3$ | 630.2191 |
| $k_{db}$ | 0.045511 | $n_1$ | 78801.77 | PSNR | 21.59187 |

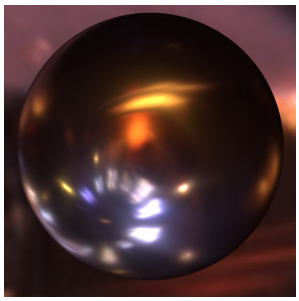
| Material Name | grease-covered-steel | $k_{sr}$ | 0.011648 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.010706 | $m_2$ | 0.062908 |
| $k_{dr}$ | 0.035944 | $k_{sb}$ | 0.009953 | $f_{03}$ | 0.124948 |
| $k_{dg}$ | 0.037696 | $f_{01}$ | 0.999999 | $m_3$ | 0.004164 |
| $k_{db}$ | 0.040874 | $m_1$ | 0.024141 | PSNR | 22.40913 |

| Material Name | grease-covered-steel | $k_{sg}$ | 0.049019 | $R_2$ | 0.471914 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.045329 | $n_2$ | 197.5066 |
| $k_{dr}$ | 0.020764 | $f_{01}$ | 0.158152 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.024407 | $R_1$ | 0.154558 | $R_3$ | 1.194935 |
| $k_{db}$ | 0.029018 | $n_1$ | 268.2956 | $n_3$ | 189.0947 |
| $k_{sr}$ | 0.053680 | $f_{02}$ | 0.999999 | PSNR | 25.01986 |

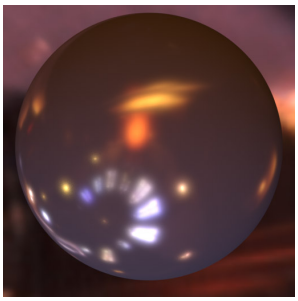
| Material Name | grease-covered-steel | $k_{db}$ | 0.039441 | $\alpha_1$ | 0.042520 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.046462 | $\alpha_2$ | 0.042520 |
| $k_{dr}$ | 0.032706 | $k_{sg}$ | 0.042225 | $\alpha_3$ | 0.012329 |
| $k_{dg}$ | 0.035742 | $k_{sb}$ | 0.039074 | PSNR | 22.77946 |

| Material Name | grease-covered-steel | $k_{db}$ | 0.052328 | $\alpha_1$ | 0.045751 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.028795 | $\alpha_2$ | 0.045751 |
| $k_{dr}$ | 0.049198 | $k_{sg}$ | 0.026361 | $\alpha_3$ | 0.012619 |
| $k_{dg}$ | 0.050182 | $k_{sb}$ | 0.024561 | PSNR | 20.52568 |

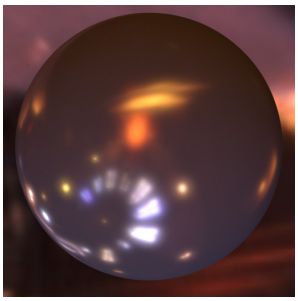
**Rendered Images**



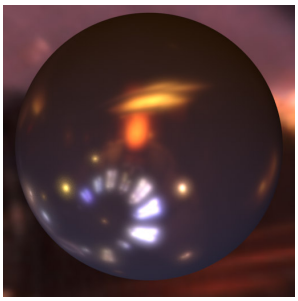
Reference image



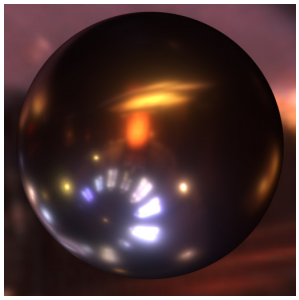
Ashikhmin-Shirley
(PSNR=21.59187)



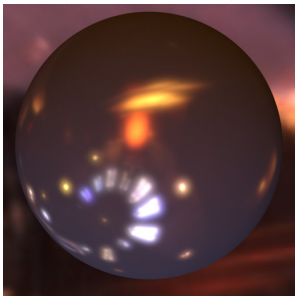
Cook-Torrance
(PSNR=22.40913)



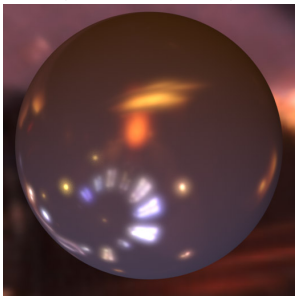
Edwards et al.
(PSNR=25.01986)



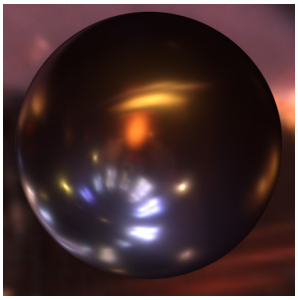
Lawrence et al.
(PSNR=31.96941)



Ward
(PSNR=22.77946)

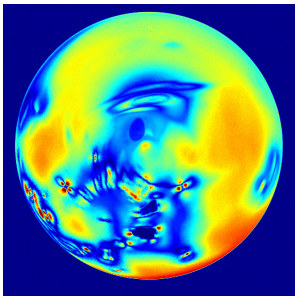


Ward-Duer
(PSNR=20.52568)

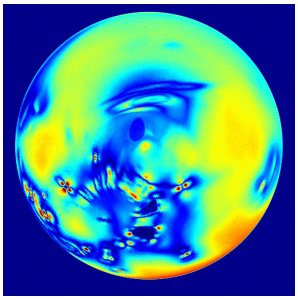


Our factored model
(PSNR=32.07312)

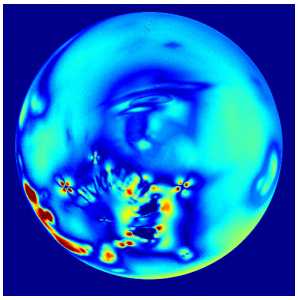
**Difference Images**



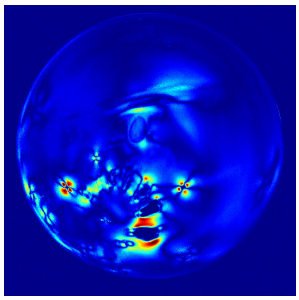
Ashikhmin-Shirley



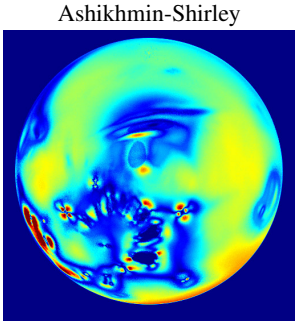
Cook-Torrance



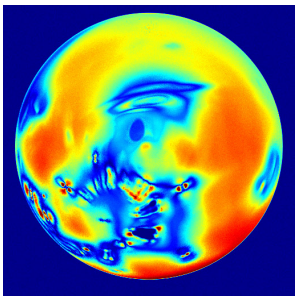
Edwards et al.



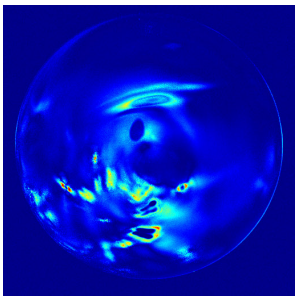
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: green-acrylic

**Fitted Parameters/PSNR**

| Material Name | green-acrylic | $k_{sr}$ | 0.215565 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.187675 | $n_2$ | 33.28998 |
| $k_{dr}$ | 0.013863 | $k_{sb}$ | 0.210673 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.074072 | $f_{01}$ | 0.066367 | $n_3$ | 33.28998 |
| $k_{db}$ | 0.038209 | $n_1$ | 8463.158 | PSNR | 35.21293 |

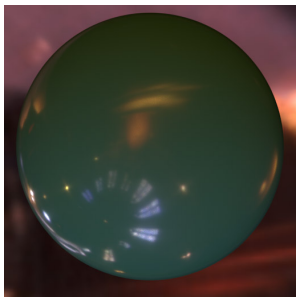
| Material Name | green-acrylic | $k_{sr}$ | 0.021144 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.018382 | $m_2$ | 0.021836 |
| $k_{dr}$ | 0.017685 | $k_{sb}$ | 0.020552 | $f_{03}$ | 0.149678 |
| $k_{dg}$ | 0.077419 | $f_{01}$ | 0 | $m_3$ | 0.012400 |
| $k_{db}$ | 0.042027 | $m_1$ | 0.021836 | PSNR | 36.65733 |

| Material Name | green-acrylic | $k_{sg}$ | 0.242111 | $R_2$ | 0.863154 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.272390 | $n_2$ | 100.1929 |
| $k_{dr}$ | 0.009408 | $f_{01}$ | 0.017108 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.070562 | $R_1$ | 0.183802 | $R_3$ | 27.86978 |
| $k_{db}$ | 0.034218 | $n_1$ | 499.9600 | $n_3$ | 8.422834 |
| $k_{sr}$ | 0.283136 | $f_{02}$ | 0.032373 | PSNR | 34.60515 |

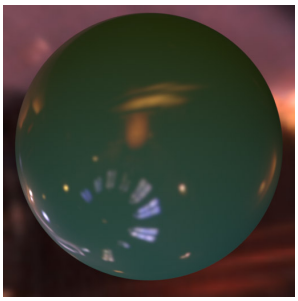
| Material Name | green-acrylic | $k_{db}$ | 0.034543 | $\alpha_1$ | 0.063399 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.011692 | $\alpha_2$ | 0.016883 |
| $k_{dr}$ | 0.008406 | $k_{sg}$ | 0.010404 | $\alpha_3$ | 0.008874 |
| $k_{dg}$ | 0.068847 | $k_{sb}$ | 0.010639 | PSNR | 28.21543 |

| Material Name | green-acrylic | $k_{db}$ | 0.007432 | $\alpha_1$ | 0.114251 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.021211 | $\alpha_2$ | 0.012461 |
| $k_{dr}$ | 0 | $k_{sg}$ | 0.018826 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.044069 | $k_{sb}$ | 0.019965 | PSNR | 25.13088 |

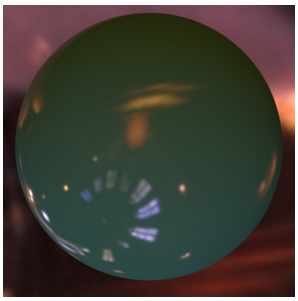
**Rendered Images**



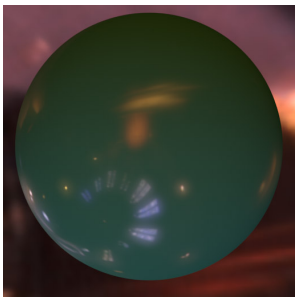
Reference image



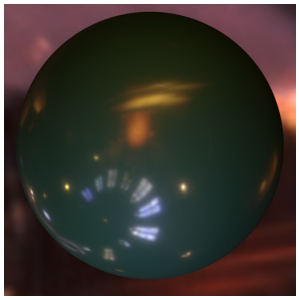
Ashikhmin-Shirley
(PSNR=35.21293)



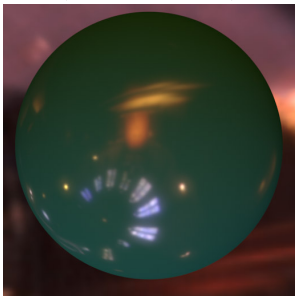
Cook-Torrance
(PSNR=36.65733)



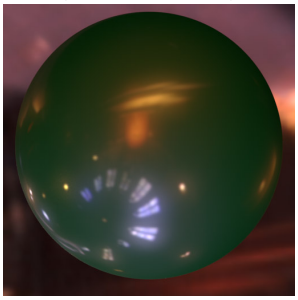
Edwards et al.
(PSNR=34.60515)



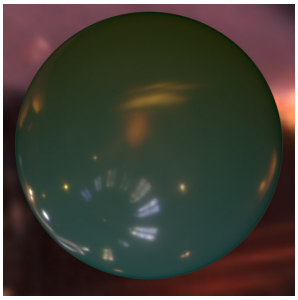
Lawrence et al.
(PSNR=25.84666)



Ward
(PSNR=28.21543)

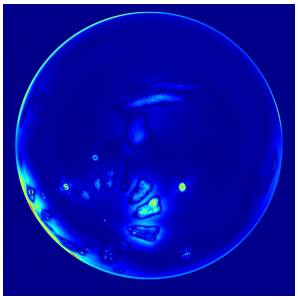


Ward-Duer
(PSNR=25.13088)

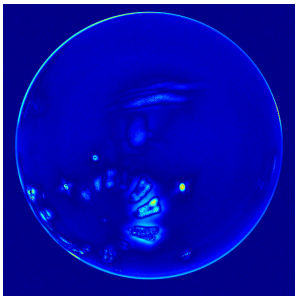


Our factored model
(PSNR=39.51563)

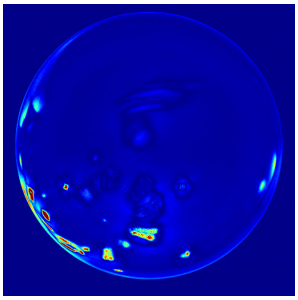
**Difference Images**



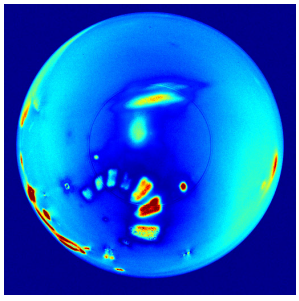
Ashikhmin-Shirley



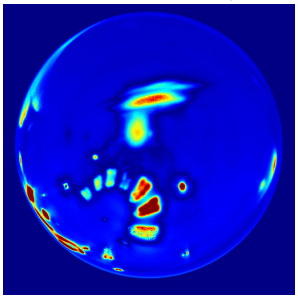
Cook-Torrance



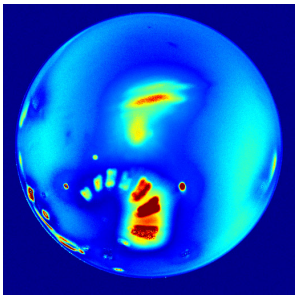
Edwards et al.



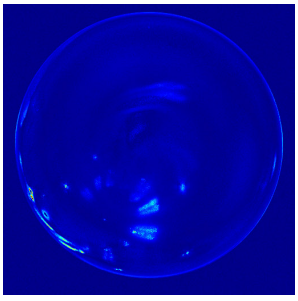
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: green-fabric

**Fitted Parameters/PSNR**

| Material Name | green-fabric | $k_{sr}$ | 0.108146 | $f_{02}$ | 0.114991 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.154421 | $n_2$ | 5.086753 |
| $k_{dr}$ | 0.032585 | $k_{sb}$ | 0.177036 | $f_{03}$ | 0.652458 |
| $k_{dg}$ | 0.024016 | $f_{01}$ | 0.003189 | $n_3$ | 0 |
| $k_{db}$ | 0.028993 | $n_1$ | 5.018502 | PSNR | 43.55704 |

| Material Name | green-fabric | $k_{sr}$ | 0.016933 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.024348 | $m_2$ | 0.725243 |
| $k_{dr}$ | 0.038439 | $k_{sb}$ | 0.027824 | $f_{03}$ | 0.212966 |
| $k_{dg}$ | 0.032228 | $f_{01}$ | 0.090382 | $m_3$ | 0.999999 |
| $k_{db}$ | 0.038487 | $m_1$ | 0.395134 | PSNR | 39.41698 |

| Material Name | green-fabric | $k_{sg}$ | 0.073560 | $R_2$ | 4.000681 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.083779 | $n_2$ | 49.93899 |
| $k_{dr}$ | 0.048550 | $f_{01}$ | 0.000149 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.046798 | $R_1$ | 1.893640 | $R_3$ | 2.111722 |
| $k_{db}$ | 0.055162 | $n_1$ | 100.0266 | $n_3$ | 9.965544 |
| $k_{sr}$ | 0.051404 | $f_{02}$ | 0.077297 | PSNR | 40.13325 |

| Material Name | green-fabric | $k_{db}$ | 0.049837 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.006041 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.045339 | $k_{sg}$ | 0.008716 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.042110 | $k_{sb}$ | 0.009916 | PSNR | 35.04630 |

| Material Name | green-fabric | $k_{db}$ | 0.046189 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.005539 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.043049 | $k_{sg}$ | 0.007920 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.038936 | $k_{sb}$ | 0.009031 | PSNR | 35.65640 |

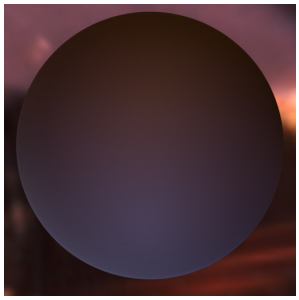
**Rendered Images**

Reference image

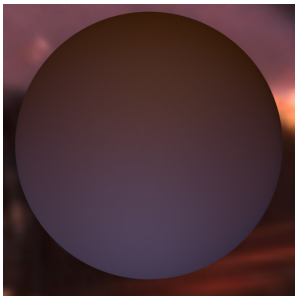
Ashikhmin-Shirley
(PSNR=43.55704)

Cook-Torrance
(PSNR=39.41698)

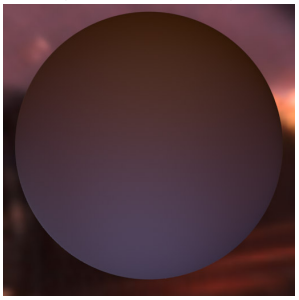
Edwards et al.
(PSNR=40.13325)



Lawrence et al.
(PSNR=28.77530)



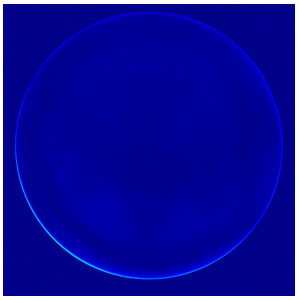
Ward
(PSNR=35.04630)



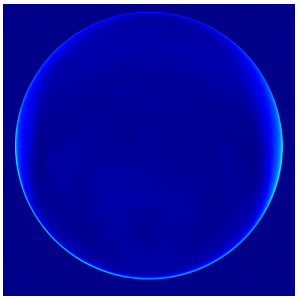
Ward-Duer
(PSNR=35.65640)

Our factored model
(PSNR=46.40413)

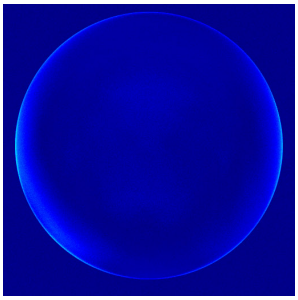
**Difference Images**



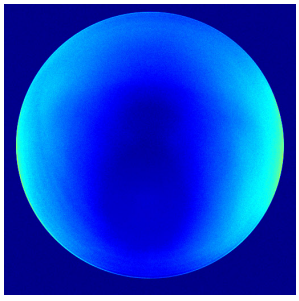
Ashikhmin-Shirley



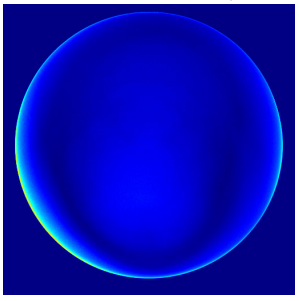
Cook-Torrance



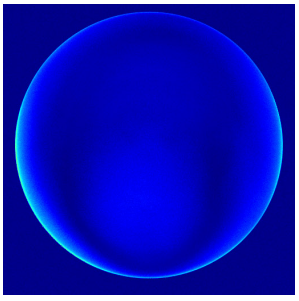
Edwards et al.



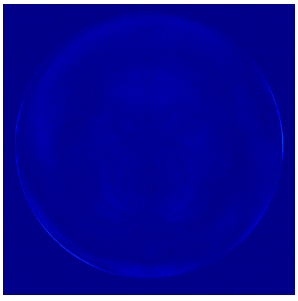
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: green-latex

**Fitted Parameters/PSNR**

| Material Name | green-latex | $k_{sr}$ | 0.043914 | $f_{02}$ | 0.937746 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.048980 | $n_2$ | 0 |
| $k_{dr}$ | 0.066126 | $k_{sb}$ | 0.029346 | $f_{03}$ | 0.998344 |
| $k_{dg}$ | 0.101079 | $f_{01}$ | 0.659402 | $n_3$ | 0 |
| $k_{db}$ | 0.044863 | $n_1$ | 7.042539 | PSNR | 39.82589 |

| Material Name | green-latex | $k_{sr}$ | 0.005130 | $f_{02}$ | 0.602481 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.005703 | $m_2$ | 0.357057 |
| $k_{dr}$ | 0.074190 | $k_{sb}$ | 0.003426 | $f_{03}$ | 0.331320 |
| $k_{dg}$ | 0.110166 | $f_{01}$ | 0.673287 | $m_3$ | 0.611375 |
| $k_{db}$ | 0.050264 | $m_1$ | 0.999999 | PSNR | 38.18579 |

| Material Name | green-latex | $k_{sg}$ | 0.088784 | $R_2$ | 4.956295 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.052421 | $n_2$ | 49.70075 |
| $k_{dr}$ | 0.084289 | $f_{01}$ | 0.015768 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.121333 | $R_1$ | 2.919111 | $R_3$ | 3.247337 |
| $k_{db}$ | 0.057142 | $n_1$ | 100.1171 | $n_3$ | 9.490793 |
| $k_{sr}$ | 0.079581 | $f_{02}$ | 0.218245 | PSNR | 40.67233 |

| Material Name | green-latex | $k_{db}$ | 0.055579 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.013529 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.081241 | $k_{sg}$ | 0.014838 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.118268 | $k_{sb}$ | 0.008573 | PSNR | 36.77321 |

| Material Name | green-latex | $k_{db}$ | 0.055196 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.009591 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.081307 | $k_{sg}$ | 0.010634 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.118128 | $k_{sb}$ | 0.006307 | PSNR | 38.63119 |

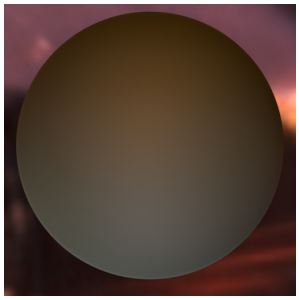
**Rendered Images**

Reference image

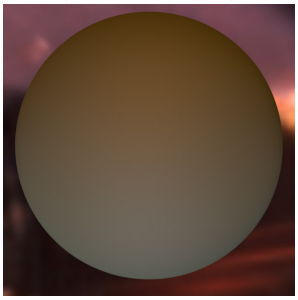
Ashikhmin-Shirley
(PSNR=39.82589)

Cook-Torrance
(PSNR=38.18579)

Edwards et al.
(PSNR=40.67233)



Lawrence et al.
(PSNR=25.42532)

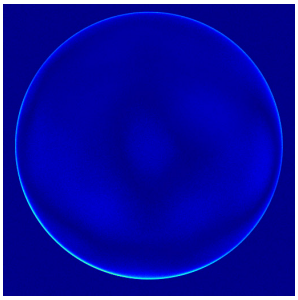


Ward
(PSNR=36.77321)

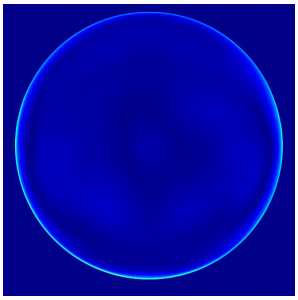
Ward-Duer
(PSNR=38.63119)

Our factored model
(PSNR=43.16040)

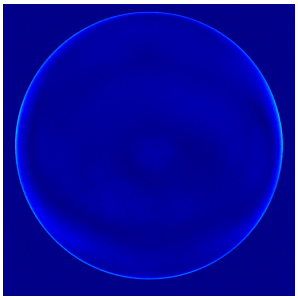
**Difference Images**



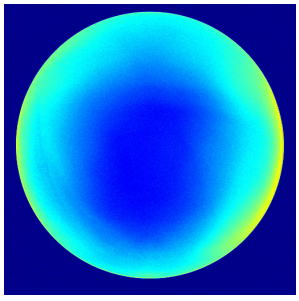
Ashikhmin-Shirley



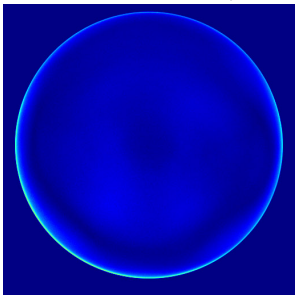
Cook-Torrance



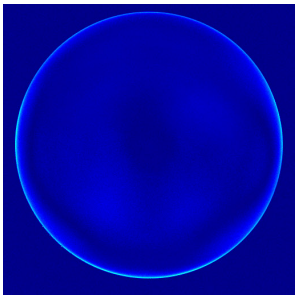
Edwards et al.



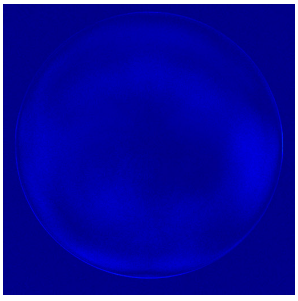
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: green-metallic-paint

**Fitted Parameters/PSNR**

| Material Name | green-metallic-paint | $k_{sr}$ | 0.082925 | $f_{02}$ | 0.419253 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.128824 | $n_2$ | 18.89905 |
| $k_{dr}$ | 0 | $k_{sb}$ | 0.135160 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.026770 | $f_{01}$ | 0.197277 | $n_3$ | 0 |
| $k_{db}$ | 0.035261 | $n_1$ | 97.05833 | PSNR | 31.61924 |

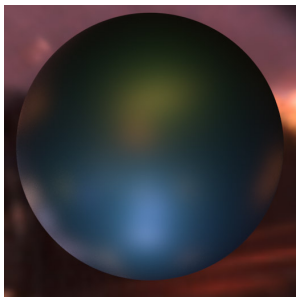
| Material Name | green-metallic-paint | $k_{sr}$ | 0.008711 | $f_{02}$ | 0.450585 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.013383 | $m_2$ | 0.135881 |
| $k_{dr}$ | 0 | $k_{sb}$ | 0.014039 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.029059 | $f_{01}$ | 0.738750 | $m_3$ | 0.132271 |
| $k_{db}$ | 0.037675 | $m_1$ | 0.301650 | PSNR | 32.11981 |

| Material Name | green-metallic-paint | $k_{sg}$ | 0.138476 | $R_2$ | 0.279394 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.145447 | $n_2$ | 2.544604 |
| $k_{dr}$ | 0 | $f_{01}$ | 0 | $f_{03}$ | 0.440285 |
| $k_{dg}$ | 0.028660 | $R_1$ | 0.663086 | $R_3$ | 3.973452 |
| $k_{db}$ | 0.037175 | $n_1$ | 101.1373 | $n_3$ | 97.71700 |
| $k_{sr}$ | 0.088405 | $f_{02}$ | 0.060018 | PSNR | 30.46973 |

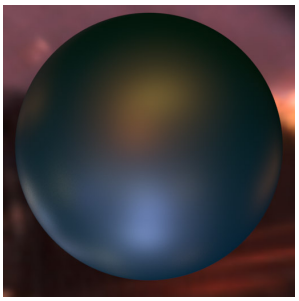
| Material Name | green-metallic-paint | $k_{db}$ | 0.019161 | $\alpha_1$ | 0.145765 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.025123 | $\alpha_2$ | 0.344853 |
| $k_{dr}$ | 0 | $k_{sg}$ | 0.046366 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.012095 | $k_{sb}$ | 0.049075 | PSNR | 28.50402 |

| Material Name | green-metallic-paint | $k_{db}$ | 0.032529 | $\alpha_1$ | 0.278984 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.016659 | $\alpha_2$ | 0.134544 |
| $k_{dr}$ | 0 | $k_{sg}$ | 0.026756 | $\alpha_3$ | 0.411982 |
| $k_{dg}$ | 0.024322 | $k_{sb}$ | 0.028140 | PSNR | 32.39587 |

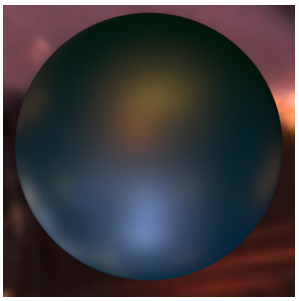
**Rendered Images**



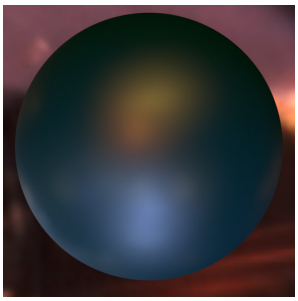
Reference image



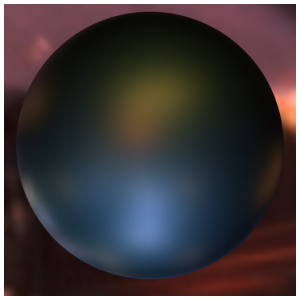
Ashikhmin-Shirley
(PSNR=31.61924)



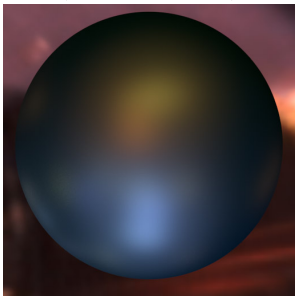
Cook-Torrance
(PSNR=32.11981)



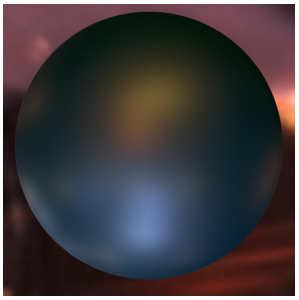
Edwards et al.
(PSNR=30.46973)



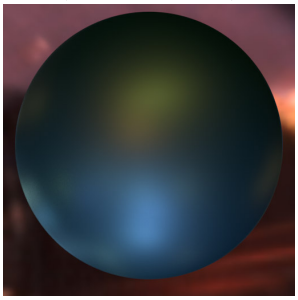
Lawrence et al.
(PSNR=35.03383)



Ward
(PSNR=28.50402)

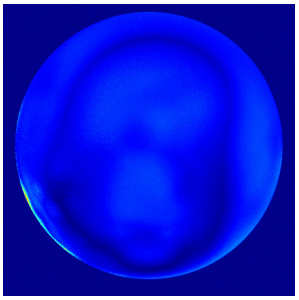


Ward-Duer
(PSNR=32.39587)

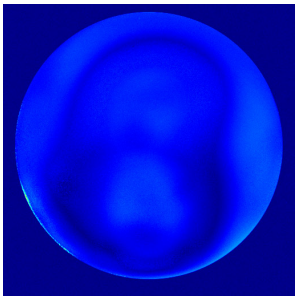


Our factored model
(PSNR=34.92847)

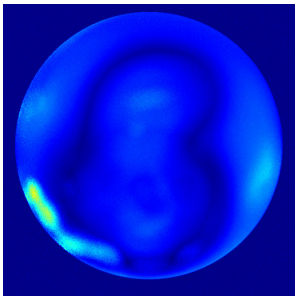
**Difference Images**



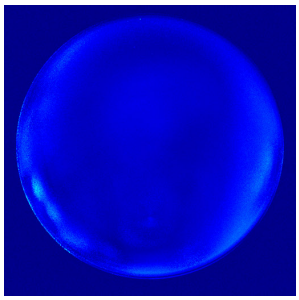
Ashikhmin-Shirley



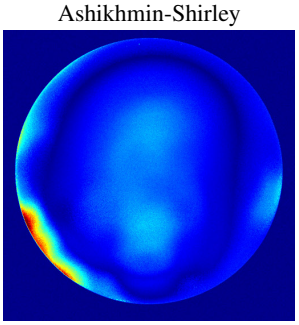
Cook-Torrance



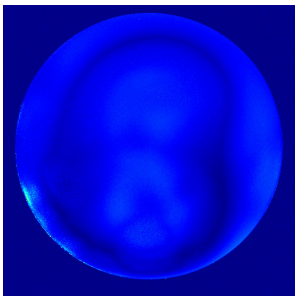
Edwards et al.



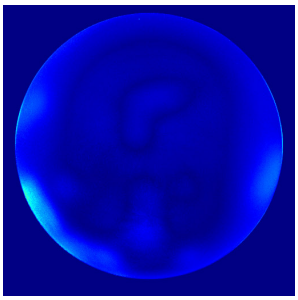
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: green-metallic-paint2

**Fitted Parameters/PSNR**

| Material Name | green-metallic-paint2 | $k_{sr}$ | 0.033114 | $f_{02}$ | 0.245074 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.056079 | $n_2$ | 915.3513 |
| $k_{dr}$ | 0.007566 | $k_{sb}$ | 0.038870 | $f_{03}$ | 0.245069 |
| $k_{dg}$ | 0.026951 | $f_{01}$ | 0.051963 | $n_3$ | 6131.623 |
| $k_{db}$ | 0.012156 | $n_1$ | 114915.8 | PSNR | 27.20830 |

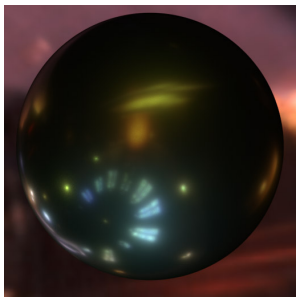
| Material Name | green-metallic-paint2 | $k_{sr}$ | 0.007291 | $f_{02}$ | 0.500265 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.012525 | $m_2$ | 0.048776 |
| $k_{dr}$ | 0.003530 | $k_{sb}$ | 0.008586 | $f_{03}$ | 0.038016 |
| $k_{dg}$ | 0.019584 | $f_{01}$ | 0.223211 | $m_3$ | 0.003128 |
| $k_{db}$ | 0.007338 | $m_1$ | 0.014184 | PSNR | 30.54521 |

| Material Name | green-metallic-paint2 | $k_{sg}$ | 0.074510 | $R_2$ | 0.032539 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.051069 | $n_2$ | 2.100239 |
| $k_{dr}$ | 0.006886 | $f_{01}$ | 0.032744 | $f_{03}$ | 0.294398 |
| $k_{dg}$ | 0.025381 | $R_1$ | 0.103382 | $R_3$ | 1.118442 |
| $k_{db}$ | 0.011314 | $n_1$ | 296.1214 | $n_3$ | 447.0931 |
| $k_{sr}$ | 0.043418 | $f_{02}$ | 0.086581 | PSNR | 26.97808 |

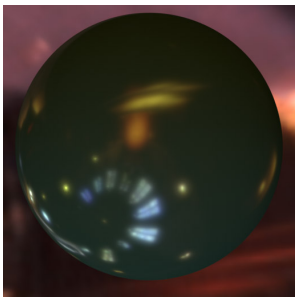
| Material Name | green-metallic-paint2 | $k_{db}$ | 0.011321 | $\alpha_1$ | 0.031743 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.008319 | $\alpha_2$ | 0.042651 |
| $k_{dr}$ | 0.007773 | $k_{sg}$ | 0.016769 | $\alpha_3$ | 0.009595 |
| $k_{dg}$ | 0.021613 | $k_{sb}$ | 0.010273 | PSNR | 27.10851 |

| Material Name | green-metallic-paint2 | $k_{db}$ | 0.011224 | $\alpha_1$ | 0.035355 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.006502 | $\alpha_2$ | 0.035355 |
| $k_{dr}$ | 0.006870 | $k_{sg}$ | 0.011481 | $\alpha_3$ | 0.009357 |
| $k_{dg}$ | 0.024431 | $k_{sb}$ | 0.007672 | PSNR | 27.67328 |

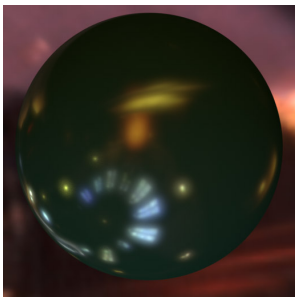
**Rendered Images**



Reference image

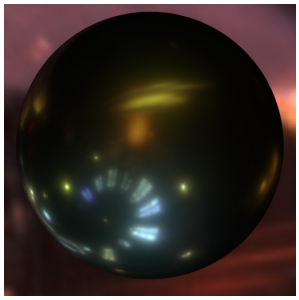


Ashikhmin-Shirley
(PSNR=27.20830)

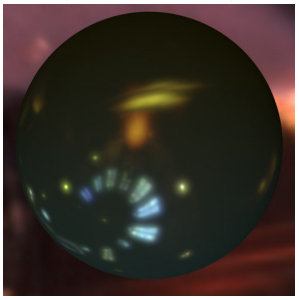


Cook-Torrance
(PSNR=30.54521)

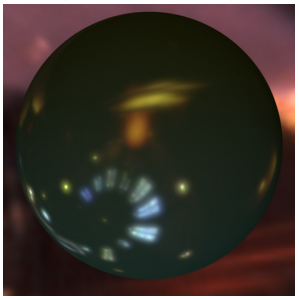
Edwards et al.
(PSNR=26.97808)



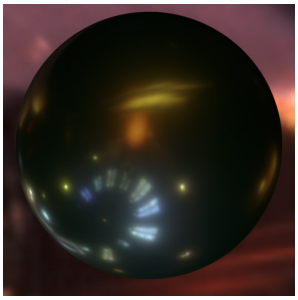
Lawrence et al.
(PSNR=36.47470)



Ward
(PSNR=27.10851)

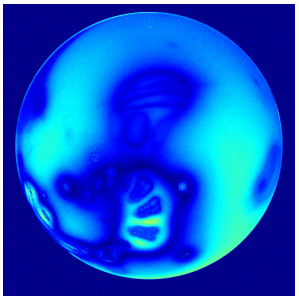


Ward-Duer
(PSNR=27.67328)

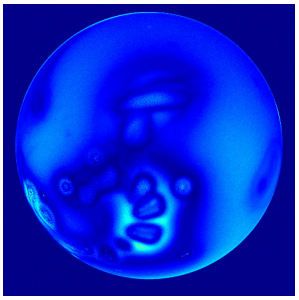


Our factored model
(PSNR=37.77368)

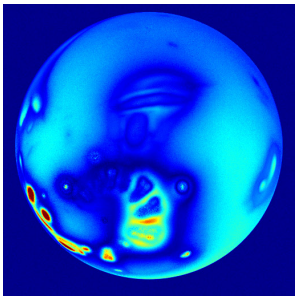
**Difference Images**



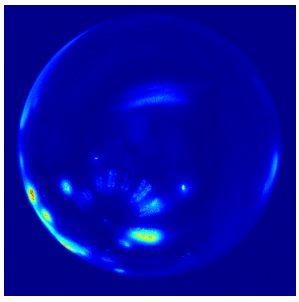
Ashikhmin-Shirley



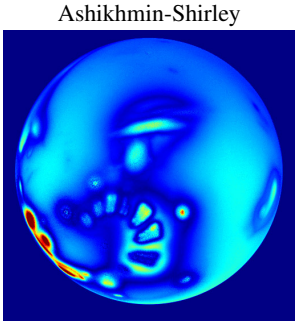
Cook-Torrance



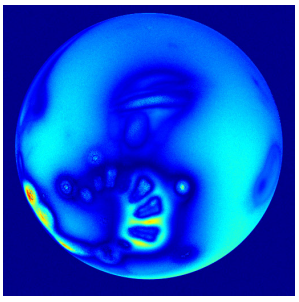
Edwards et al.



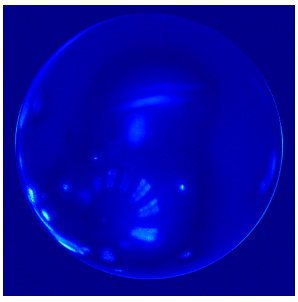
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: green-plastic

**Fitted Parameters/PSNR**

| Material Name | green-plastic | $k_{sr}$ | 0.053242 | $f_{02}$ | 0.072569 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.049303 | $n_2$ | 11403.25 |
| $k_{dr}$ | 0.015298 | $k_{sb}$ | 0.049492 | $f_{03}$ | 0.014127 |
| $k_{dg}$ | 0.083278 | $f_{01}$ | 0.023825 | $n_3$ | 2565.091 |
| $k_{db}$ | 0.091439 | $n_1$ | 224446.3 | PSNR | 38.36686 |

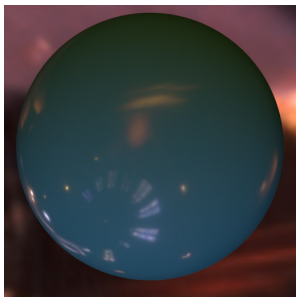
| Material Name | green-plastic | $k_{sr}$ | 0.012991 | $f_{02}$ | 0.072440 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.012027 | $m_2$ | 0.013062 |
| $k_{dr}$ | 0.015219 | $k_{sb}$ | 0.012071 | $f_{03}$ | 0.024522 |
| $k_{dg}$ | 0.083206 | $f_{01}$ | 0.017099 | $m_3$ | 0.002995 |
| $k_{db}$ | 0.091369 | $m_1$ | 0.028536 | PSNR | 38.38451 |

| Material Name | green-plastic | $k_{sg}$ | 0.039393 | $R_2$ | 0.014653 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.039190 | $n_2$ | 0.947066 |
| $k_{dr}$ | 0.016163 | $f_{01}$ | 0.035424 | $f_{03}$ | 0.072564 |
| $k_{dg}$ | 0.084098 | $R_1$ | 0.113519 | $R_3$ | 0.273852 |
| $k_{db}$ | 0.092316 | $n_1$ | 521.3240 | $n_3$ | 164.1180 |
| $k_{sr}$ | 0.042680 | $f_{02}$ | 0.005245 | PSNR | 35.57720 |

| Material Name | green-plastic | $k_{db}$ | 0.091377 | $\alpha_1$ | 0.015565 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.003332 | $\alpha_2$ | 0.015565 |
| $k_{dr}$ | 0.015221 | $k_{sg}$ | 0.003049 | $\alpha_3$ | 0.004703 |
| $k_{dg}$ | 0.083286 | $k_{sb}$ | 0.003093 | PSNR | 34.62541 |

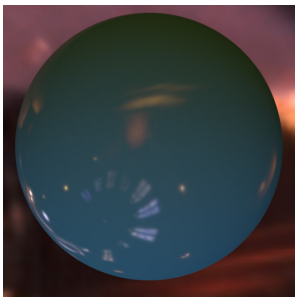
| Material Name | green-plastic | $k_{db}$ | 0.087767 | $\alpha_1$ | 0.025789 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.003926 | $\alpha_2$ | 0.015822 |
| $k_{dr}$ | 0.011251 | $k_{sg}$ | 0.003579 | $\alpha_3$ | 0.006959 |
| $k_{dg}$ | 0.079693 | $k_{sb}$ | 0.003618 | PSNR | 35.51074 |

**Rendered Images**



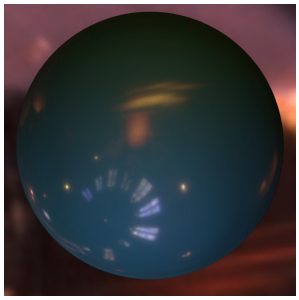
Reference image

Ashikhmin-Shirley
(PSNR=38.36686)



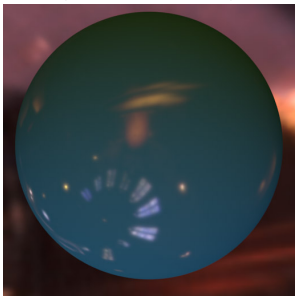
Cook-Torrance
(PSNR=38.38451)

Edwards et al.
(PSNR=35.57720)

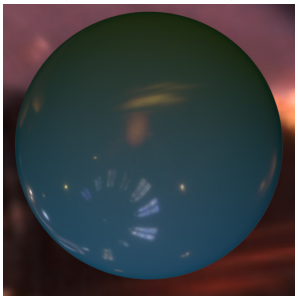


Lawrence et al.
(PSNR=26.68649)

Ward
(PSNR=34.62541)

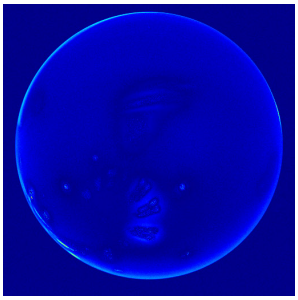


Ward-Duer
(PSNR=35.51074)

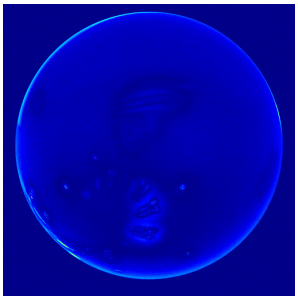


Our factored model
(PSNR=40.12791)

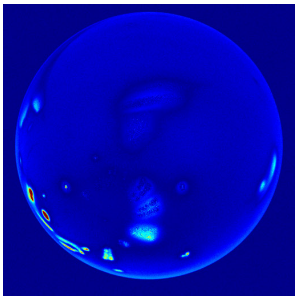
**Difference Images**



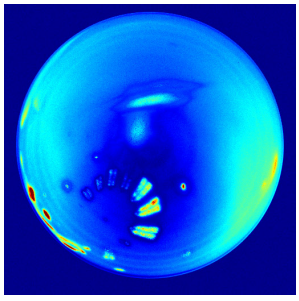
Ashikhmin-Shirley



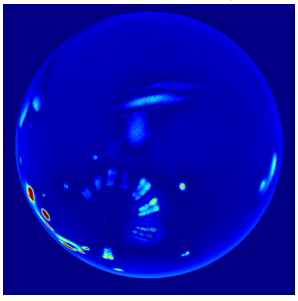
Cook-Torrance



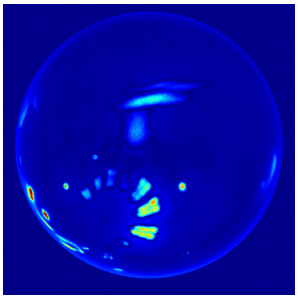
Edwards et al.



Lawrence et al.



Ward



Ward-Duer

Our factored model

**Material Name**: hematite

**Fitted Parameters/PSNR**

| Material Name | hematite | $k_{sr}$ | 0.045230 | $f_{02}$ | 0.363597 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.043473 | $n_2$ | 6190.986 |
| $k_{dr}$ | 0.018430 | $k_{sb}$ | 0.046676 | $f_{03}$ | 0.117470 |
| $k_{dg}$ | 0.018631 | $f_{01}$ | 0.015339 | $n_3$ | 102743.0 |
| $k_{db}$ | 0.019269 | $n_1$ | 1509286. | PSNR | 25.69588 |

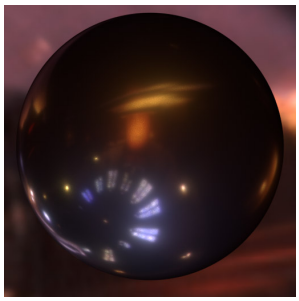
| Material Name | hematite | $k_{sr}$ | 0.011737 | $f_{02}$ | 0.010234 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.011265 | $m_2$ | 0.000881 |
| $k_{dr}$ | 0.019069 | $k_{sb}$ | 0.012108 | $f_{03}$ | 0.120932 |
| $k_{dg}$ | 0.019275 | $f_{01}$ | 0.326933 | $m_3$ | 0.004294 |
| $k_{db}$ | 0.019937 | $m_1$ | 0.017685 | PSNR | 25.41547 |

| Material Name | hematite | $k_{sg}$ | 0.079047 | $R_2$ | 0.110063 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.085005 | $n_2$ | 217.7363 |
| $k_{dr}$ | 0.019143 | $f_{01}$ | 0.007303 | $f_{03}$ | 0.153820 |
| $k_{dg}$ | 0.019483 | $R_1$ | 0.003410 | $R_3$ | 0.317948 |
| $k_{db}$ | 0.020148 | $n_1$ | 1.906463 | $n_3$ | 120.4071 |
| $k_{sr}$ | 0.082898 | $f_{02}$ | 0.079726 | PSNR | 25.08091 |

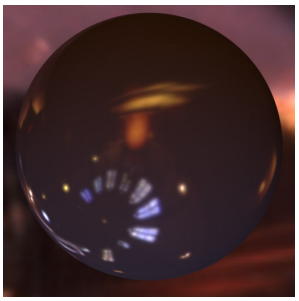
| Material Name | hematite | $k_{db}$ | 0.023923 | $\alpha_1$ | 0.014436 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.008316 | $\alpha_2$ | 0.014436 |
| $k_{dr}$ | 0.022571 | $k_{sg}$ | 0.007999 | $\alpha_3$ | 0.003639 |
| $k_{dg}$ | 0.022598 | $k_{sb}$ | 0.008412 | PSNR | 24.06828 |

| Material Name | hematite | $k_{db}$ | 0.022707 | $\alpha_1$ | 0.014955 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.006678 | $\alpha_2$ | 0.003826 |
| $k_{dr}$ | 0.021373 | $k_{sg}$ | 0.006390 | $\alpha_3$ | 0.014955 |
| $k_{dg}$ | 0.021544 | $k_{sb}$ | 0.006755 | PSNR | 24.53163 |

**Rendered Images**



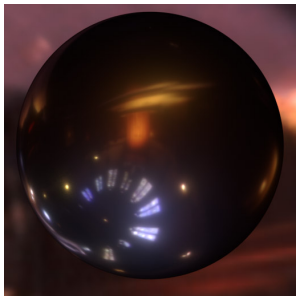
Reference image



Ashikhmin-Shirley
(PSNR=25.69588)

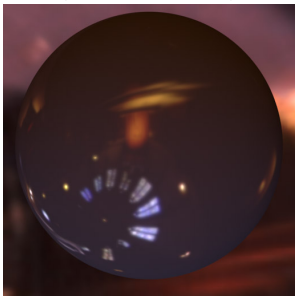
Cook-Torrance
(PSNR=25.41547)

Edwards et al.
(PSNR=25.08091)

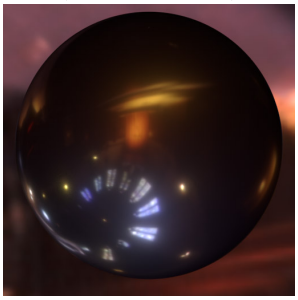


Lawrence et al.
(PSNR=38.67507)

Ward
(PSNR=24.06828)

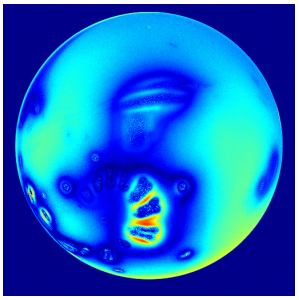


Ward-Duer
(PSNR=24.53163)

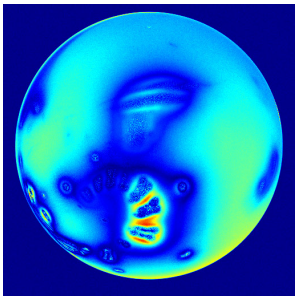


Our factored model
(PSNR=38.87075)

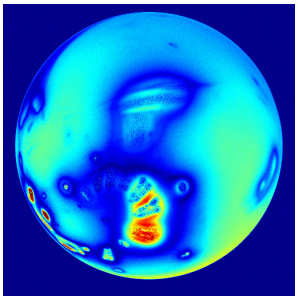
**Difference Images**



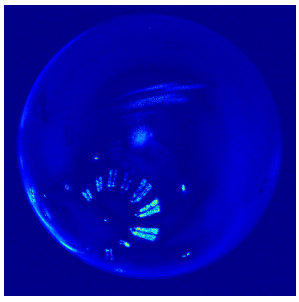
Ashikhmin-Shirley



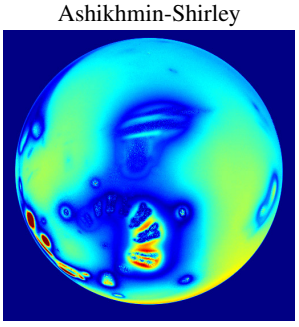
Cook-Torrance



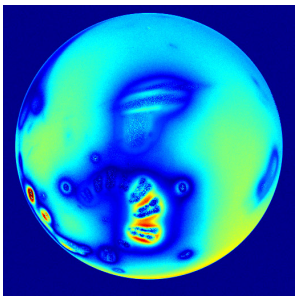
Edwards et al.



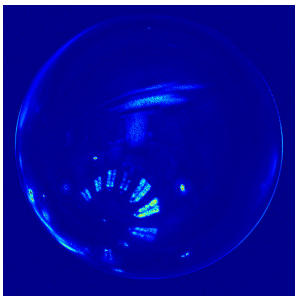
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: ipswich-pine-221

**Fitted Parameters/PSNR**

| Material Name | ipswich-pine-221 | $k_{sr}$ | 0.158291 | $f_{02}$ | 0.029516 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.156143 | $n_2$ | 26.78649 |
| $k_{dr}$ | 0.042725 | $k_{sb}$ | 0.155830 | $f_{03}$ | 0.306272 |
| $k_{dg}$ | 0.008561 | $f_{01}$ | 0.084089 | $n_3$ | 0.707588 |
| $k_{db}$ | 0 | $n_1$ | 60.81644 | PSNR | 38.62302 |

| Material Name | ipswich-pine-221 | $k_{sr}$ | 0.029836 | $f_{02}$ | 0.079756 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.029428 | $m_2$ | 0.157469 |
| $k_{dr}$ | 0.044458 | $k_{sb}$ | 0.029382 | $f_{03}$ | 0.074954 |
| $k_{dg}$ | 0.010273 | $f_{01}$ | 0.126250 | $m_3$ | 0.285386 |
| $k_{db}$ | 0 | $m_1$ | 0.999999 | PSNR | 38.95397 |

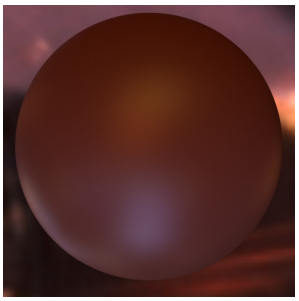
| Material Name | ipswich-pine-221 | $k_{sg}$ | 0.094799 | $R_2$ | 1.446394 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.094865 | $n_2$ | 99.46754 |
| $k_{dr}$ | 0.056778 | $f_{01}$ | 0 | $f_{03}$ | 0.154313 |
| $k_{dg}$ | 0.022403 | $R_1$ | 1.616537 | $R_3$ | 1.616160 |
| $k_{db}$ | 0.010144 | $n_1$ | 500.1060 | $n_3$ | 33.01540 |
| $k_{sr}$ | 0.095978 | $f_{02}$ | 0 | PSNR | 35.88097 |

| Material Name | ipswich-pine-221 | $k_{db}$ | 0 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.019103 | $\alpha_2$ | 0.152536 |
| $k_{dr}$ | 0.043370 | $k_{sg}$ | 0.018674 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.009458 | $k_{sb}$ | 0.018611 | PSNR | 28.45535 |

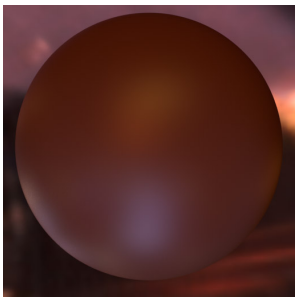
| Material Name | ipswich-pine-221 | $k_{db}$ | 0 | $\alpha_1$ | 0.144692 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.012746 | $\alpha_2$ | 0.304427 |
| $k_{dr}$ | 0.043547 | $k_{sg}$ | 0.012477 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.009591 | $k_{sb}$ | 0.012431 | PSNR | 30.36378 |

**Rendered Images**

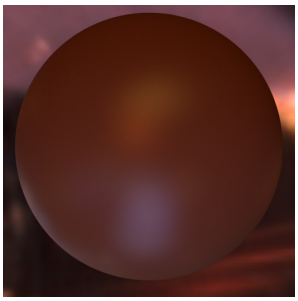
Reference image



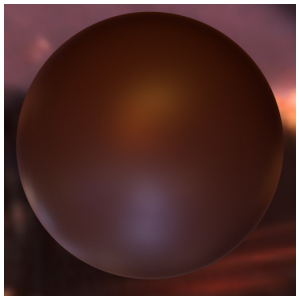
Ashikhmin-Shirley
(PSNR=38.62302)



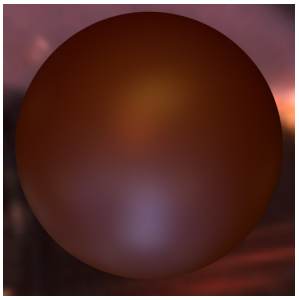
Cook-Torrance
(PSNR=38.95397)



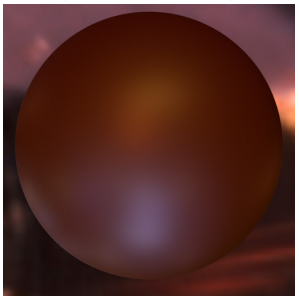
Edwards et al.
(PSNR=35.88097)



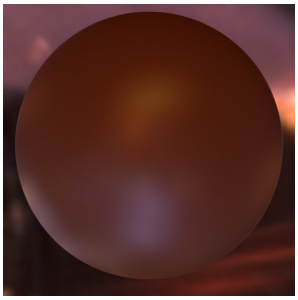
Lawrence et al.
(PSNR=30.75863)



Ward
(PSNR=28.45535)

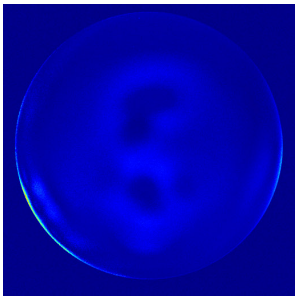


Ward-Duer
(PSNR=30.36378)

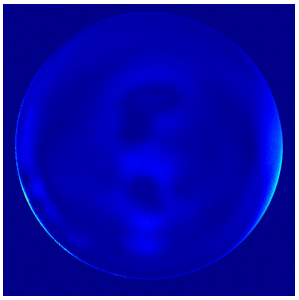


Our factored model
(PSNR=42.18089)

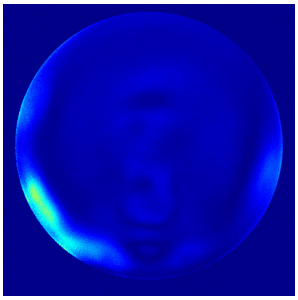
**Difference Images**



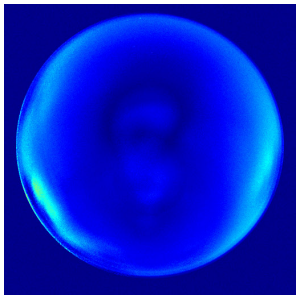
Ashikhmin-Shirley



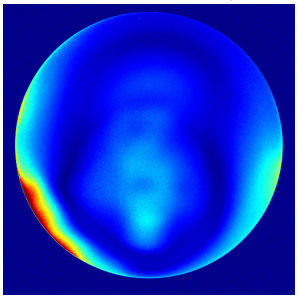
Cook-Torrance



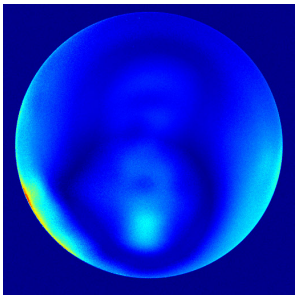
Edwards et al.



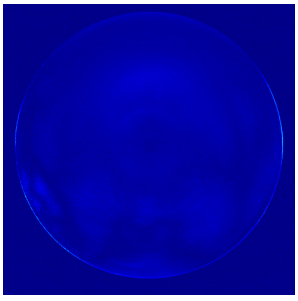
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: light-brown-fabric

**Fitted Parameters/PSNR**

| Material Name | light-brown-fabric | $k_{sr}$ | 0.122916 | $f_{02}$ | 0.792868 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.082348 | $n_2$ | 0 |
| $k_{dr}$ | 0.034054 | $k_{sb}$ | 0.071036 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.009583 | $f_{01}$ | 0 | $n_3$ | 4.922857 |
| $k_{db}$ | 0.005129 | $n_1$ | 4.922870 | PSNR | 45.97444 |

| Material Name | light-brown-fabric | $k_{sr}$ | 0.021316 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.014686 | $m_2$ | 0.785395 |
| $k_{dr}$ | 0.042872 | $k_{sb}$ | 0.012643 | $f_{03}$ | 0.154258 |
| $k_{dg}$ | 0.015294 | $f_{01}$ | 0.018622 | $m_3$ | 0.999999 |
| $k_{db}$ | 0.010069 | $m_1$ | 0.403654 | PSNR | 39.55132 |

| Material Name | light-brown-fabric | $k_{sg}$ | 0.038520 | $R_2$ | 9.335349 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.032996 | $n_2$ | 49.75174 |
| $k_{dr}$ | 0.051141 | $f_{01}$ | 0.000500 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.020993 | $R_1$ | 1.975759 | $R_3$ | 0.778003 |
| $k_{db}$ | 0.014981 | $n_1$ | 100.4358 | $n_3$ | 1.027159 |
| $k_{sr}$ | 0.055973 | $f_{02}$ | 0 | PSNR | 39.80084 |

| Material Name | light-brown-fabric | $k_{db}$ | 0.014243 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.002377 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.050053 | $k_{sg}$ | 0.001851 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.019962 | $k_{sb}$ | 0.001475 | PSNR | 35.99450 |

| Material Name | light-brown-fabric | $k_{db}$ | 0.012237 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.003590 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.046546 | $k_{sg}$ | 0.002547 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.017690 | $k_{sb}$ | 0.002136 | PSNR | 35.32609 |

**Rendered Images**

Reference image

Ashikhmin-Shirley
(PSNR=45.97444)

Cook-Torrance
(PSNR=39.55132)

Edwards et al.
(PSNR=39.80084)

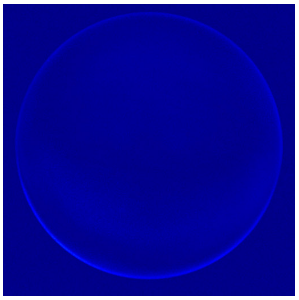
Lawrence et al.
(PSNR=29.09250)

Ward
(PSNR=35.99450)

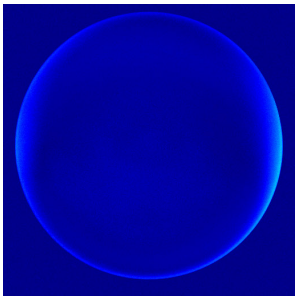
Ward-Duer
(PSNR=35.32609)

Our factored model
(PSNR=47.84692)

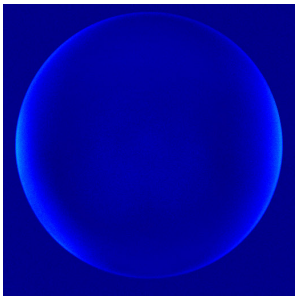
**Difference Images**



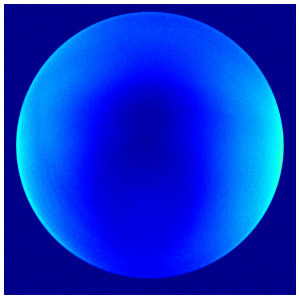
Ashikhmin-Shirley



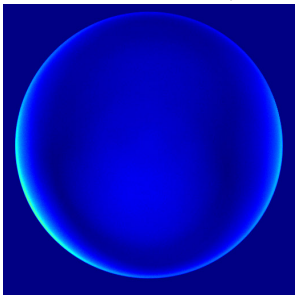
Cook-Torrance



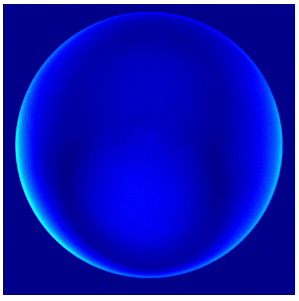
Edwards et al.



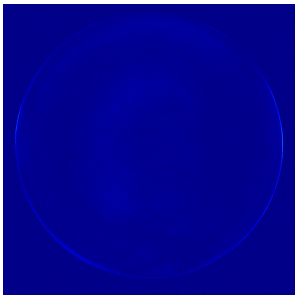
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: light-red-paint

**Fitted Parameters/PSNR**

| Material Name | light-red-paint | $k_{sr}$ | 0.124116 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.109081 | $n_2$ | 19.38844 |
| $k_{dr}$ | 0.410255 | $k_{sb}$ | 0.114165 | $f_{03}$ | 0.303847 |
| $k_{dg}$ | 0.032025 | $f_{01}$ | 0.108582 | $n_3$ | 2.433810 |
| $k_{db}$ | 0 | $n_1$ | 20.91715 | PSNR | 39.06594 |

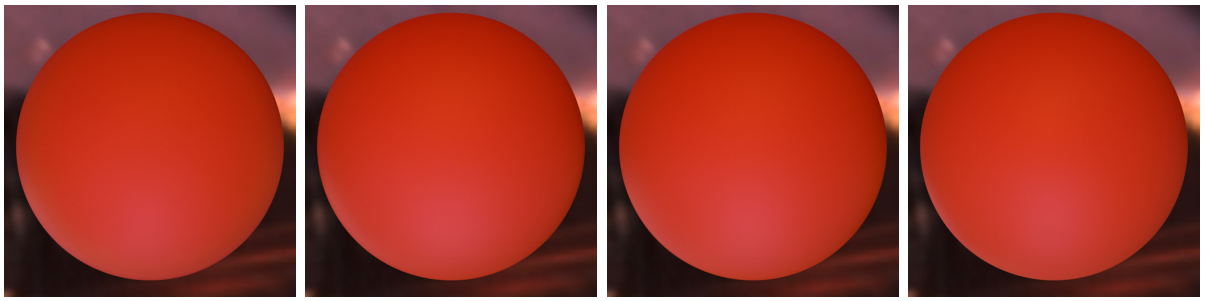
| Material Name | light-red-paint | $k_{sr}$ | 0.022107 | $f_{02}$ | 0.137737 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.019691 | $m_2$ | 0.394012 |
| $k_{dr}$ | 0.411878 | $k_{sb}$ | 0.020611 | $f_{03}$ | 0.064498 |
| $k_{dg}$ | 0.033153 | $f_{01}$ | 0.140409 | $m_3$ | 0.230044 |
| $k_{db}$ | 0 | $m_1$ | 0.921838 | PSNR | 39.38106 |

| Material Name | light-red-paint | $k_{sg}$ | 0.072945 | $R_2$ | 2.546311 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.076318 | $n_2$ | 99.97406 |
| $k_{dr}$ | 0.422889 | $f_{01}$ | 0 | $f_{03}$ | 0.174686 |
| $k_{dg}$ | 0.042716 | $R_1$ | 2.487683 | $R_3$ | 1.821787 |
| $k_{db}$ | 0.009526 | $n_1$ | 499.9989 | $n_3$ | 10.66934 |
| $k_{sr}$ | 0.080344 | $f_{02}$ | 0.017903 | PSNR | 39.77448 |

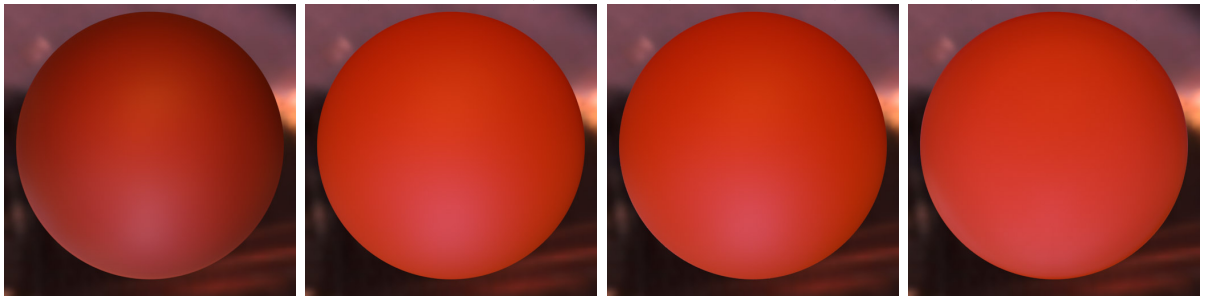
| Material Name | light-red-paint | $k_{db}$ | 0.002717 | $\alpha_1$ | 0.266218 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.015667 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.414099 | $k_{sg}$ | 0.012018 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.037975 | $k_{sb}$ | 0.013833 | PSNR | 33.22318 |

| Material Name | light-red-paint | $k_{db}$ | 0.001108 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.011643 | $\alpha_2$ | 0.243758 |
| $k_{dr}$ | 0.413137 | $k_{sg}$ | 0.009758 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.035535 | $k_{sb}$ | 0.010649 | PSNR | 34.32784 |

**Rendered Images**

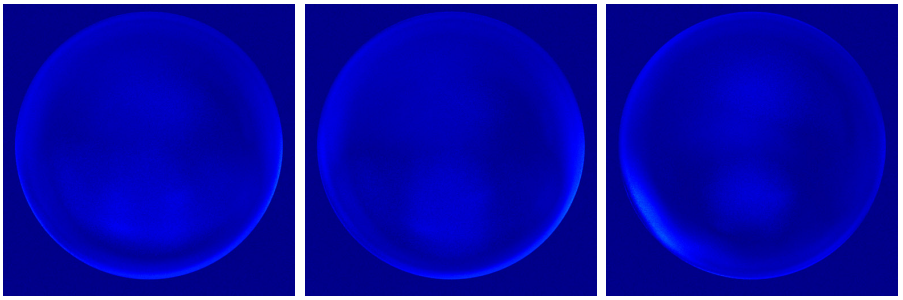


Reference image | Ashikhmin-Shirley (PSNR=39.06594) | Cook-Torrance (PSNR=39.38106) | Edwards et al. (PSNR=39.77448)

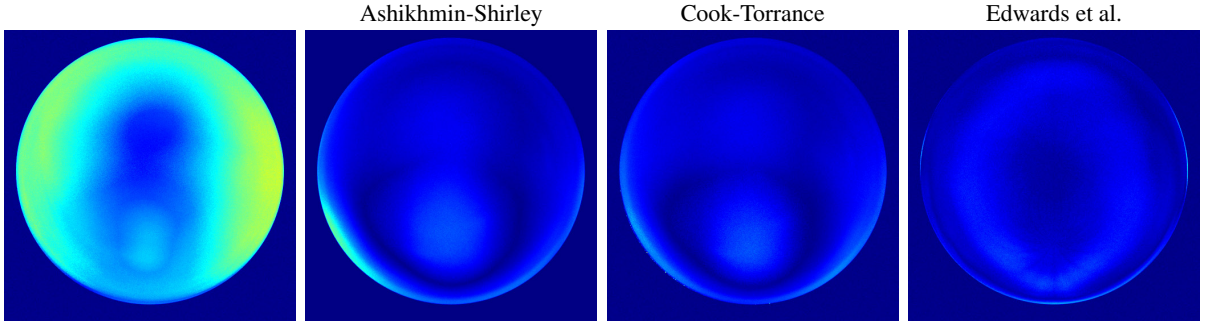


Lawrence et al. (PSNR=21.63495) | Ward (PSNR=33.22318) | Ward-Duer (PSNR=34.32784) | Our factored model (PSNR=35.72718)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: maroon-plastic

**Fitted Parameters/PSNR**

| Material Name | maroon-plastic | $k_{sr}$ | 0.054998 | $f_{02}$ | 0.034829 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.050095 | $n_2$ | 2297.633 |
| $k_{dr}$ | 0.196795 | $k_{sb}$ | 0.051126 | $f_{03}$ | 0.092706 |
| $k_{dg}$ | 0.035746 | $f_{01}$ | 0.026538 | $n_3$ | 11021.26 |
| $k_{db}$ | 0.032369 | $n_1$ | 247975.0 | PSNR | 37.26974 |

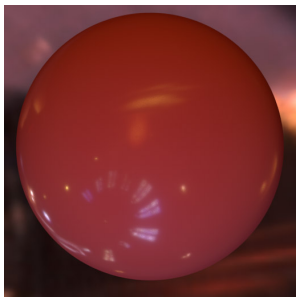
| Material Name | maroon-plastic | $k_{sr}$ | 0.013353 | $f_{02}$ | 0.093299 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.012159 | $m_2$ | 0.013281 |
| $k_{dr}$ | 0.196701 | $k_{sb}$ | 0.012409 | $f_{03}$ | 0.027380 |
| $k_{dg}$ | 0.035664 | $f_{01}$ | 0.038655 | $m_3$ | 0.002844 |
| $k_{db}$ | 0.032285 | $m_1$ | 0.029939 | PSNR | 37.27638 |

| Material Name | maroon-plastic | $k_{sg}$ | 0.040176 | $R_2$ | 0.014129 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.040954 | $n_2$ | 0.488329 |
| $k_{dr}$ | 0.198312 | $f_{01}$ | 0.036891 | $f_{03}$ | 0.103604 |
| $k_{dg}$ | 0.037143 | $R_1$ | 0.106670 | $R_3$ | 0.266005 |
| $k_{db}$ | 0.033804 | $n_1$ | 525.4225 | $n_3$ | 151.9591 |
| $k_{sr}$ | 0.044197 | $f_{02}$ | 0.010746 | PSNR | 35.32108 |

| Material Name | maroon-plastic | $k_{db}$ | 0.033124 | $\alpha_1$ | 0.015849 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.003968 | $\alpha_2$ | 0.015849 |
| $k_{dr}$ | 0.197799 | $k_{sg}$ | 0.003645 | $\alpha_3$ | 0.004611 |
| $k_{dg}$ | 0.036593 | $k_{sb}$ | 0.003770 | PSNR | 34.84309 |

| Material Name | maroon-plastic | $k_{db}$ | 0.029539 | $\alpha_1$ | 0.019434 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.004456 | $\alpha_2$ | 0.019434 |
| $k_{dr}$ | 0.193660 | $k_{sg}$ | 0.003968 | $\alpha_3$ | 0.006543 |
| $k_{dg}$ | 0.033152 | $k_{sb}$ | 0.004113 | PSNR | 36.12397 |

**Rendered Images**

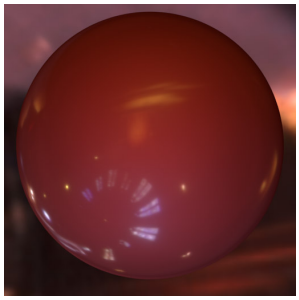


Reference image

Ashikhmin-Shirley
(PSNR=37.26974)

Cook-Torrance
(PSNR=37.27638)

Edwards et al.
(PSNR=35.32108)



Lawrence et al.
(PSNR=24.79360)

Ward
(PSNR=34.84309)

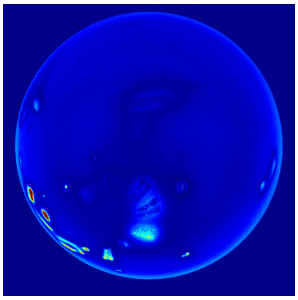
Ward-Duer
(PSNR=36.12397)

Our factored model
(PSNR=39.77534)

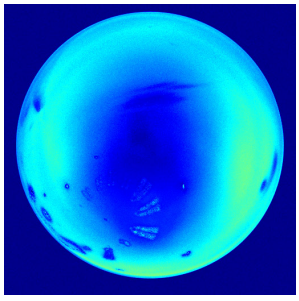
**Difference Images**

Ashikhmin-Shirley

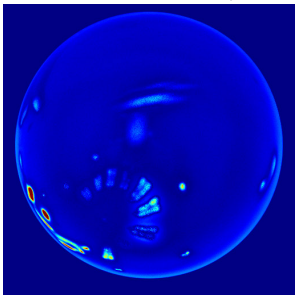
Cook-Torrance



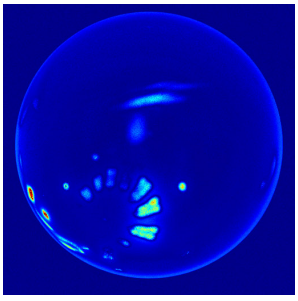
Edwards et al.



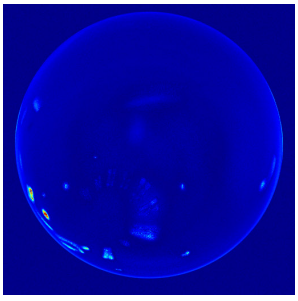
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: natural-209

**Fitted Parameters/PSNR**

| Material Name | natural-209 | $k_{sr}$ | 0.267437 | $f_{02}$ | 0.341784 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.257719 | $n_2$ | 0.267404 |
| $k_{dr}$ | 0.074711 | $k_{sb}$ | 0.243472 | $f_{03}$ | 0.037065 |
| $k_{dg}$ | 0.015422 | $f_{01}$ | 0.053454 | $n_3$ | 10.94079 |
| $k_{db}$ | 0 | $n_1$ | 63.12097 | PSNR | 36.39227 |

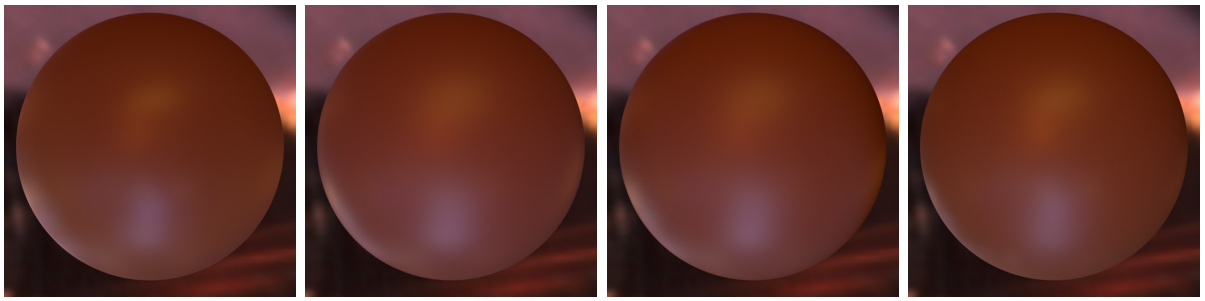
| Material Name | natural-209 | $k_{sr}$ | 0.044144 | $f_{02}$ | 0.058679 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.042586 | $m_2$ | 0.155165 |
| $k_{dr}$ | 0.077184 | $k_{sb}$ | 0.040235 | $f_{03}$ | 0.067052 |
| $k_{dg}$ | 0.017763 | $f_{01}$ | 0.149860 | $m_3$ | 0.328207 |
| $k_{db}$ | 0 | $m_1$ | 0.999999 | PSNR | 36.61009 |

| Material Name | natural-209 | $k_{sg}$ | 0.136111 | $R_2$ | 2.924809 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.128974 | $n_2$ | 53.81915 |
| $k_{dr}$ | 0.095706 | $f_{01}$ | 0.034402 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.035614 | $R_1$ | 1.763803 | $R_3$ | 1.796531 |
| $k_{db}$ | 0.012400 | $n_1$ | 97.83042 | $n_3$ | 589.4791 |
| $k_{sr}$ | 0.140963 | $f_{02}$ | 0.103678 | PSNR | 34.02990 |

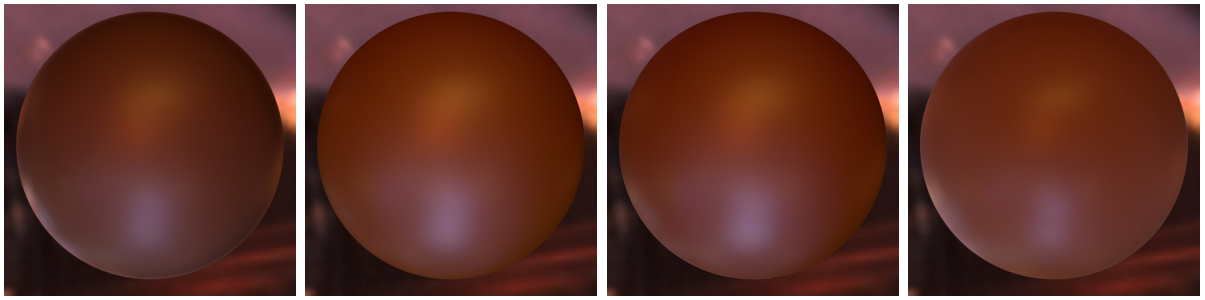
| Material Name | natural-209 | $k_{db}$ | 0.000715 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.022170 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.082523 | $k_{sg}$ | 0.020993 | $\alpha_3$ | 0.151753 |
| $k_{dg}$ | 0.023522 | $k_{sb}$ | 0.020040 | PSNR | 27.53935 |

| Material Name | natural-209 | $k_{db}$ | 0 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.018782 | $\alpha_2$ | 0.151186 |
| $k_{dr}$ | 0.076711 | $k_{sg}$ | 0.017894 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.017786 | $k_{sb}$ | 0.016900 | PSNR | 29.04678 |

**Rendered Images**

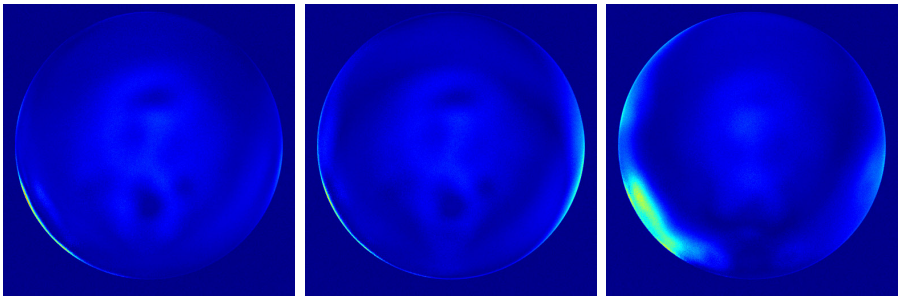


Reference image | Ashikhmin-Shirley (PSNR=36.39227) | Cook-Torrance (PSNR=36.61009) | Edwards et al. (PSNR=34.02990)

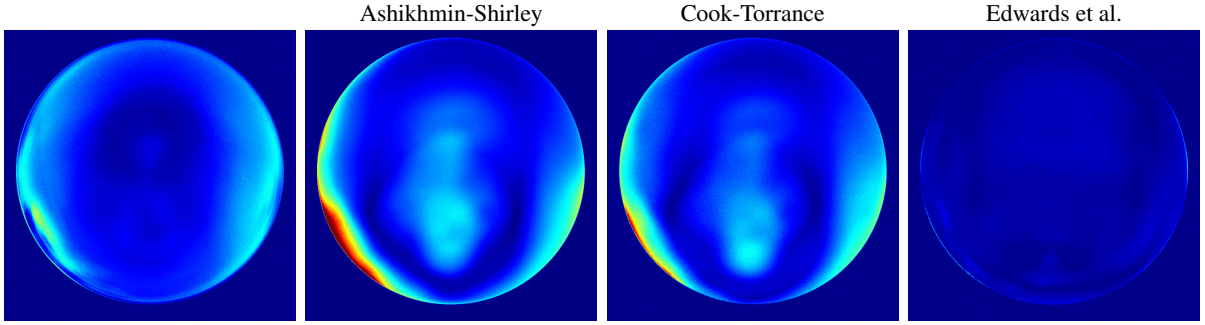


Lawrence et al. (PSNR=28.69284) | Ward (PSNR=27.53935) | Ward-Duer (PSNR=29.04678) | Our factored model (PSNR=41.55712)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: neoprene-rubber

**Fitted Parameters/PSNR**

| Material Name | neoprene-rubber | $k_{sr}$ | 0.076284 | $f_{02}$ | 0.459105 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.074434 | $n_2$ | 6.471751 |
| $k_{dr}$ | 0.241396 | $k_{sb}$ | 0.070338 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.202976 | $f_{01}$ | 0.135441 | $n_3$ | 59.75383 |
| $k_{db}$ | 0.163439 | $n_1$ | 86.85870 | PSNR | 42.49612 |

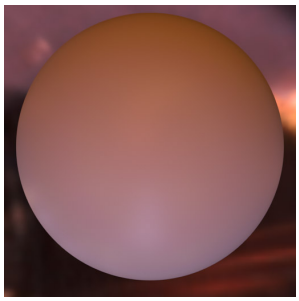
| Material Name | neoprene-rubber | $k_{sr}$ | 0.014780 | $f_{02}$ | 0.086509 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.014417 | $m_2$ | 0.127051 |
| $k_{dr}$ | 0.244275 | $k_{sb}$ | 0.013668 | $f_{03}$ | 0.129270 |
| $k_{dg}$ | 0.205793 | $f_{01}$ | 0.279026 | $m_3$ | 0.199706 |
| $k_{db}$ | 0.166020 | $m_1$ | 0.495691 | PSNR | 42.32453 |

| Material Name | neoprene-rubber | $k_{sg}$ | 0.106616 | $R_2$ | 1.527879 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.100887 | $n_2$ | 50.02870 |
| $k_{dr}$ | 0.222639 | $f_{01}$ | 0 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.184824 | $R_1$ | 0.777669 | $R_3$ | 6.990707 |
| $k_{db}$ | 0.146225 | $n_1$ | 101.5811 | $n_3$ | 24.95834 |
| $k_{sr}$ | 0.109613 | $f_{02}$ | 0.082382 | PSNR | 42.71140 |

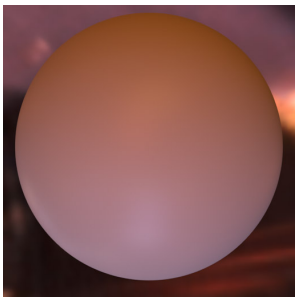
| Material Name | neoprene-rubber | $k_{db}$ | 0.165010 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.018460 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.242777 | $k_{sg}$ | 0.018510 | $\alpha_3$ | 0.152006 |
| $k_{dg}$ | 0.203558 | $k_{sb}$ | 0.016827 | PSNR | 39.45735 |

| Material Name | neoprene-rubber | $k_{db}$ | 0.163308 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.013988 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.241391 | $k_{sg}$ | 0.013822 | $\alpha_3$ | 0.144760 |
| $k_{dg}$ | 0.202602 | $k_{sb}$ | 0.012957 | PSNR | 41.26005 |

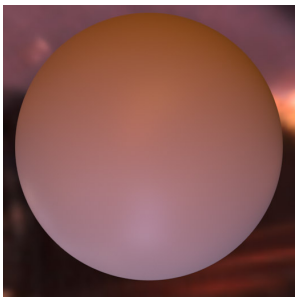
**Rendered Images**



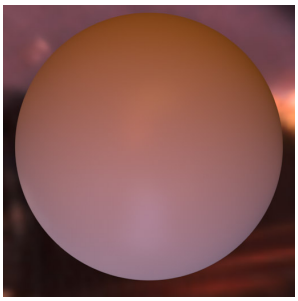
Reference image



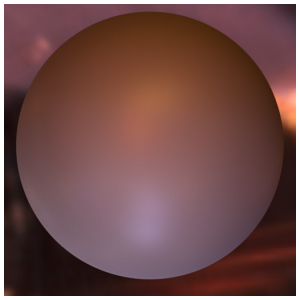
Ashikhmin-Shirley
(PSNR=42.49612)



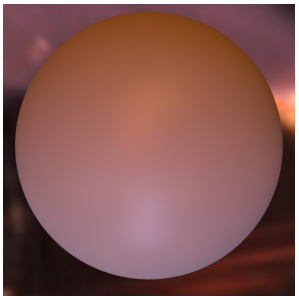
Cook-Torrance
(PSNR=42.32453)



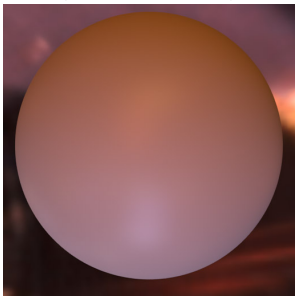
Edwards et al.
(PSNR=42.71140)



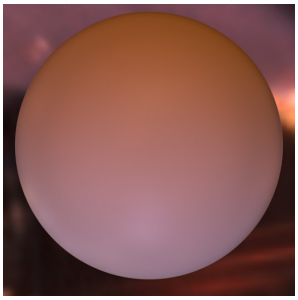
Lawrence et al.
(PSNR=21.56621)



Ward
(PSNR=39.45735)

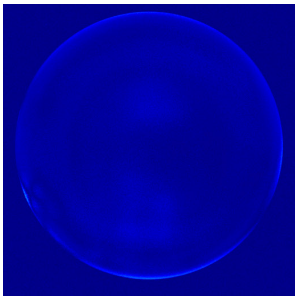


Ward-Duer
(PSNR=41.26005)

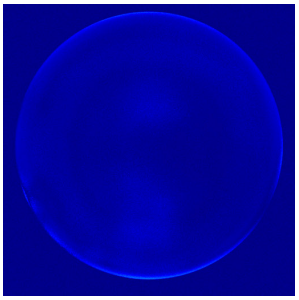


Our factored model
(PSNR=38.73367)

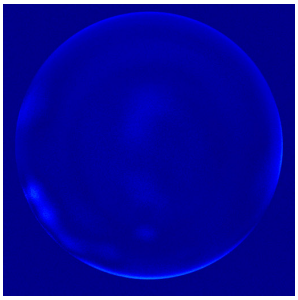
**Difference Images**



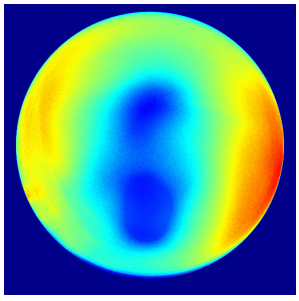
Ashikhmin-Shirley



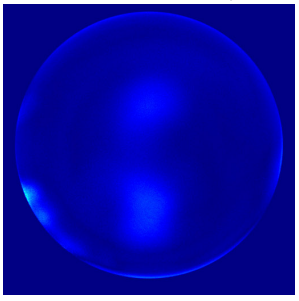
Cook-Torrance



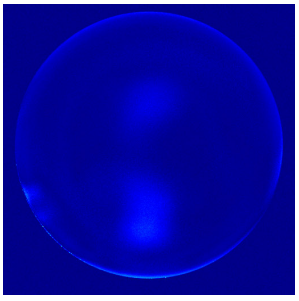
Edwards et al.



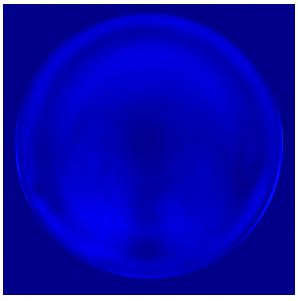
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: nickel

**Fitted Parameters/PSNR**

| Material Name | nickel | $k_{sr}$ | 0.094697 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.086196 | $n_2$ | 964.7400 |
| $k_{dr}$ | 0.017302 | $k_{sb}$ | 0.076741 | $f_{03}$ | 0.937116 |
| $k_{dg}$ | 0.013125 | $f_{01}$ | 0.191016 | $n_3$ | 178.1200 |
| $k_{db}$ | 0.010788 | $n_1$ | 3740.599 | PSNR | 30.50246 |

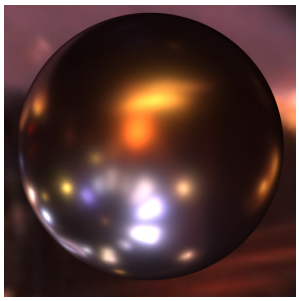
| Material Name | nickel | $k_{sr}$ | 0.021295 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.019392 | $m_2$ | 0.043505 |
| $k_{dr}$ | 0.022778 | $k_{sb}$ | 0.017271 | $f_{03}$ | 0.200294 |
| $k_{dg}$ | 0.018040 | $f_{01}$ | 0.999999 | $m_3$ | 0.022737 |
| $k_{db}$ | 0.015112 | $m_1$ | 0.095784 | PSNR | 27.82064 |

| Material Name | nickel | $k_{sg}$ | 0.323957 | $R_2$ | 4.601750 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.288635 | $n_2$ | 12208.00 |
| $k_{dr}$ | 0.030986 | $f_{01}$ | 0 | $f_{03}$ | 0.349747 |
| $k_{dg}$ | 0.025269 | $R_1$ | 2.040292 | $R_3$ | 9.496610 |
| $k_{db}$ | 0.021497 | $n_1$ | 17208.00 | $n_3$ | 7207.998 |
| $k_{sr}$ | 0.355194 | $f_{02}$ | 0.132654 | PSNR | 24.18461 |

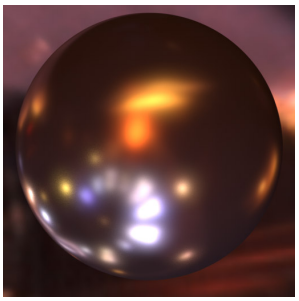
| Material Name | nickel | $k_{db}$ | 0.004090 | $\alpha_1$ | 0.031854 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.097487 | $\alpha_2$ | 0.113642 |
| $k_{dr}$ | 0 | $k_{sg}$ | 0.086165 | $\alpha_3$ | 0.063490 |
| $k_{dg}$ | 0.000421 | $k_{sb}$ | 0.074509 | PSNR | 28.19816 |

| Material Name | nickel | $k_{db}$ | 0.014432 | $\alpha_1$ | 0.104181 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.064322 | $\alpha_2$ | 0.061021 |
| $k_{dr}$ | 0.019974 | $k_{sg}$ | 0.058242 | $\alpha_3$ | 0.030938 |
| $k_{dg}$ | 0.016417 | $k_{sb}$ | 0.051601 | PSNR | 28.62560 |

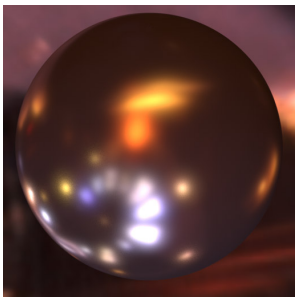
**Rendered Images**



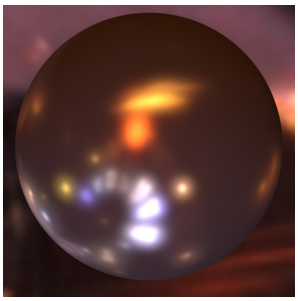
Reference image



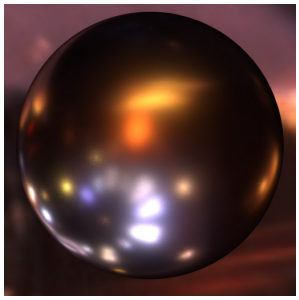
Ashikhmin-Shirley
(PSNR=30.50246)



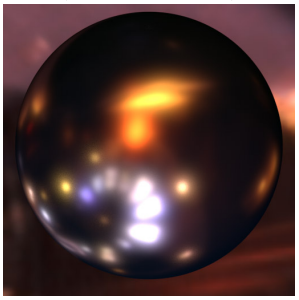
Cook-Torrance
(PSNR=27.82064)



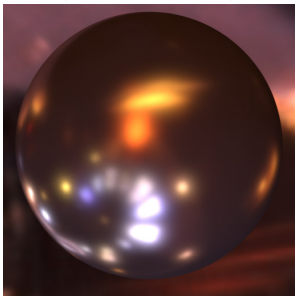
Edwards et al.
(PSNR=24.18461)



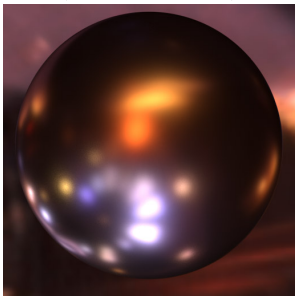
Lawrence et al.
(PSNR=34.65224)



Ward
(PSNR=28.19816)

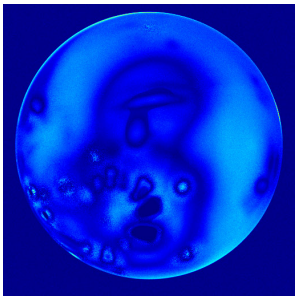


Ward-Duer
(PSNR=28.62560)

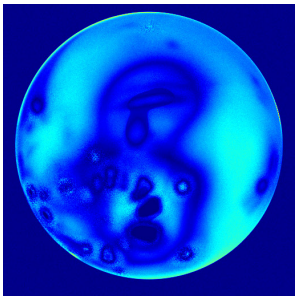


Our factored model
(PSNR=37.87757)

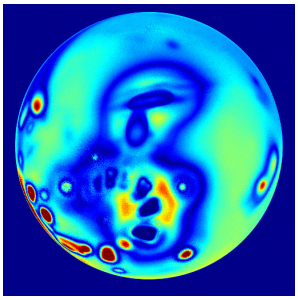
**Difference Images**



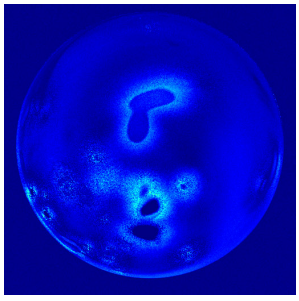
Ashikhmin-Shirley



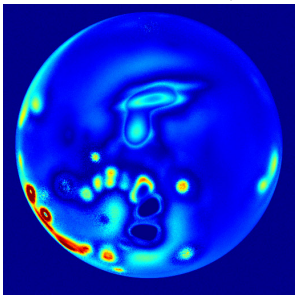
Cook-Torrance



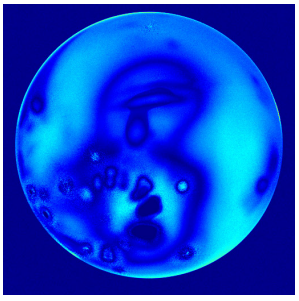
Edwards et al.



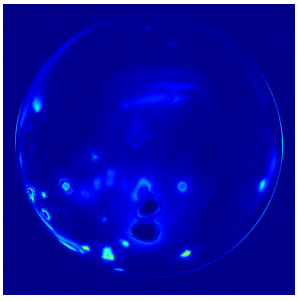
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: nylon

**Fitted Parameters/PSNR**

| Material Name | nylon | $k_{sr}$ | 0.082277 | $f_{02}$ | 0.130632 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.077323 | $n_2$ | 167.2302 |
| $k_{dr}$ | 0.196058 | $k_{sb}$ | 0.064202 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.200630 | $f_{01}$ | 0.007602 | $n_3$ | 1.827137 |
| $k_{db}$ | 0.185781 | $n_1$ | 1819.635 | PSNR | 30.71999 |

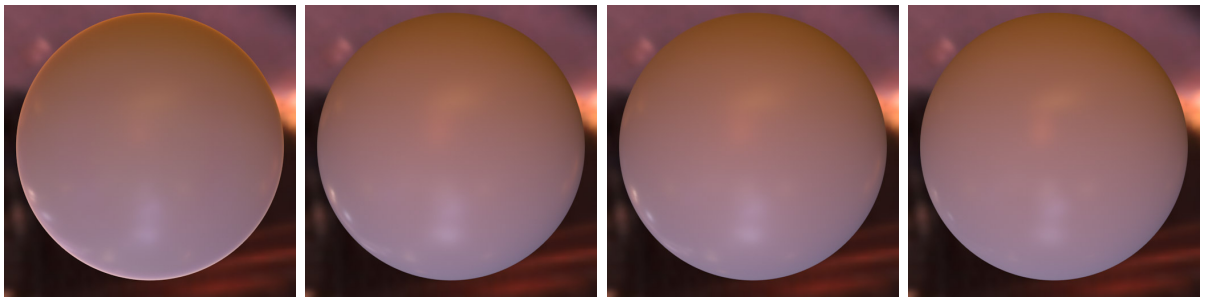
| Material Name | nylon | $k_{sr}$ | 0.016167 | $f_{02}$ | 0.178120 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.015201 | $m_2$ | 0.246817 |
| $k_{dr}$ | 0.219473 | $k_{sb}$ | 0.012638 | $f_{03}$ | 0.105121 |
| $k_{dg}$ | 0.222626 | $f_{01}$ | 0.004958 | $m_3$ | 0.084453 |
| $k_{db}$ | 0.204025 | $m_1$ | 0.029506 | PSNR | 30.93361 |

| Material Name | nylon | $k_{sg}$ | 0.068567 | $R_2$ | 1.415648 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.058004 | $n_2$ | 101.1831 |
| $k_{dr}$ | 0.227653 | $f_{01}$ | 0.006279 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.230488 | $R_1$ | 0.842525 | $R_3$ | 0.602687 |
| $k_{db}$ | 0.210414 | $n_1$ | 249.8042 | $n_3$ | 1173.513 |
| $k_{sr}$ | 0.074150 | $f_{02}$ | 0.117293 | PSNR | 30.82957 |

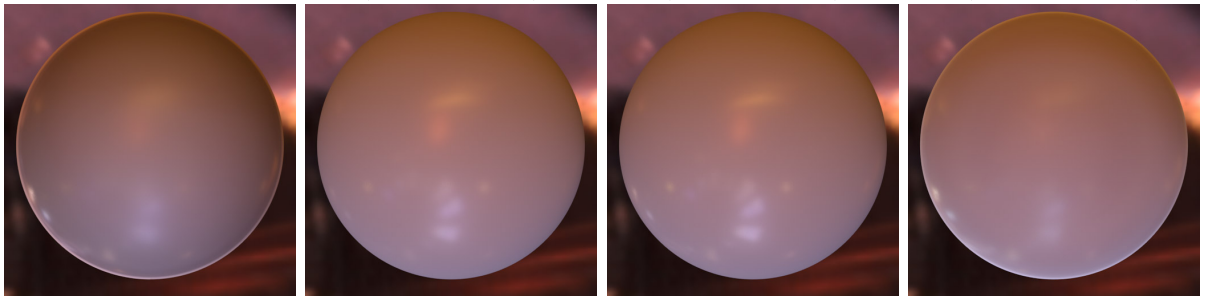
| Material Name | nylon | $k_{db}$ | 0.205861 | $\alpha_1$ | 0.151313 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.007699 | $\alpha_2$ | 0.151312 |
| $k_{dr}$ | 0.222996 | $k_{sg}$ | 0.007158 | $\alpha_3$ | 0.042228 |
| $k_{dg}$ | 0.226104 | $k_{sb}$ | 0.006471 | PSNR | 29.80179 |

| Material Name | nylon | $k_{db}$ | 0.204540 | $\alpha_1$ | 0.135351 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.006489 | $\alpha_2$ | 0.135351 |
| $k_{dr}$ | 0.220710 | $k_{sg}$ | 0.005992 | $\alpha_3$ | 0.036182 |
| $k_{dg}$ | 0.224090 | $k_{sb}$ | 0.005236 | PSNR | 30.10448 |

**Rendered Images**

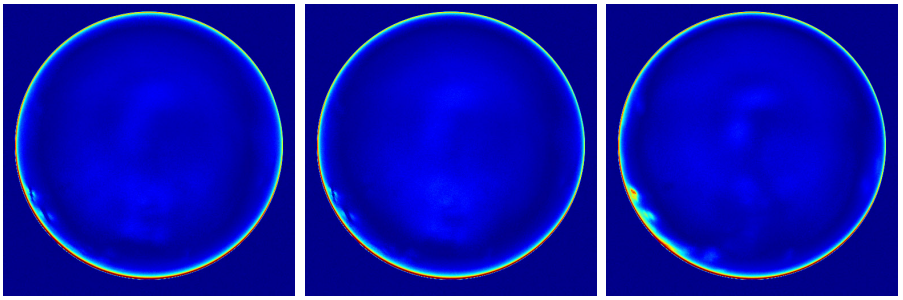


Reference image | Ashikhmin-Shirley (PSNR=30.71999) | Cook-Torrance (PSNR=30.93361) | Edwards et al. (PSNR=30.82957)

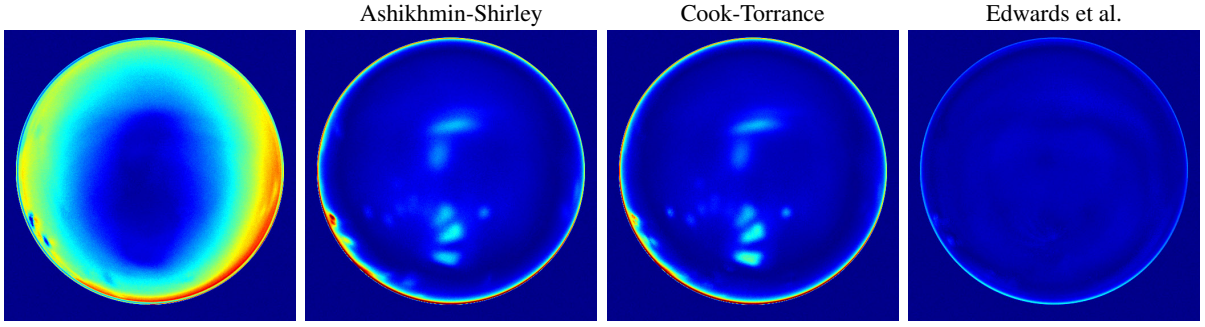


Lawrence et al. (PSNR=23.71988) | Ward (PSNR=29.80179) | Ward-Duer (PSNR=30.10448) | Our factored model (PSNR=38.02530)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: orange-paint

**Fitted Parameters/PSNR**

| Material Name | orange-paint | $k_{sr}$ | 0.153508 | $f_{02}$ | 0.278560 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.120424 | $n_2$ | 5.113014 |
| $k_{dr}$ | 0.403845 | $k_{sb}$ | 0.116735 | $f_{03}$ | 0.017254 |
| $k_{dg}$ | 0.128078 | $f_{01}$ | 0.037396 | $n_3$ | 0 |
| $k_{db}$ | 0 | $n_1$ | 23.21399 | PSNR | 38.59299 |

| Material Name | orange-paint | $k_{sr}$ | 0.018197 | $f_{02}$ | 0.175679 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.014575 | $m_2$ | 0.396213 |
| $k_{dr}$ | 0.405983 | $k_{sb}$ | 0.014127 | $f_{03}$ | 0.057797 |
| $k_{dg}$ | 0.129319 | $f_{01}$ | 0.189714 | $m_3$ | 0.232132 |
| $k_{db}$ | 0 | $m_1$ | 0.704803 | PSNR | 38.81097 |

| Material Name | orange-paint | $k_{sg}$ | 0.065592 | $R_2$ | 2.972082 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.063943 | $n_2$ | 99.98564 |
| $k_{dr}$ | 0.409264 | $f_{01}$ | 0 | $f_{03}$ | 0.373514 |
| $k_{dg}$ | 0.132331 | $R_1$ | 2.699550 | $R_3$ | 2.611340 |
| $k_{db}$ | 0.002217 | $n_1$ | 499.9980 | $n_3$ | 9.924244 |
| $k_{sr}$ | 0.083620 | $f_{02}$ | 0.027765 | PSNR | 38.62159 |

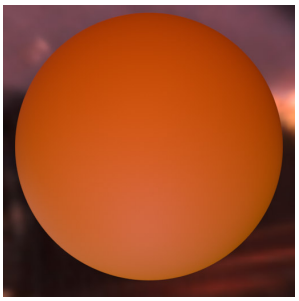
| Material Name | orange-paint | $k_{db}$ | 0.001164 | $\alpha_1$ | 0.396910 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.022017 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.402079 | $k_{sg}$ | 0.012530 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.133235 | $k_{sb}$ | 0.013617 | PSNR | 34.26673 |

| Material Name | orange-paint | $k_{db}$ | 0.001417 | $\alpha_1$ | 0.292391 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.012745 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.406726 | $k_{sg}$ | 0.009176 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.132000 | $k_{sb}$ | 0.009181 | PSNR | 35.97857 |

**Rendered Images**

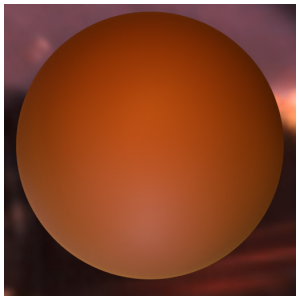
Reference image

Ashikhmin-Shirley
(PSNR=38.59299)

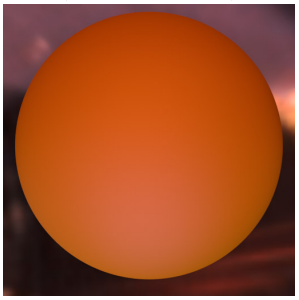


Cook-Torrance
(PSNR=38.81097)

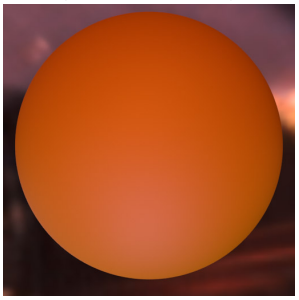
Edwards et al.
(PSNR=38.62159)



Lawrence et al.
(PSNR=21.24908)



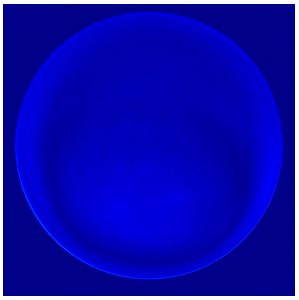
Ward
(PSNR=34.26673)



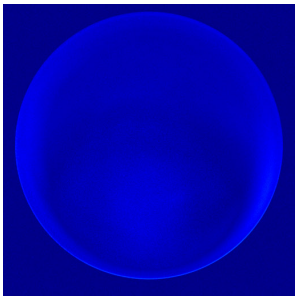
Ward-Duer
(PSNR=35.97857)

Our factored model
(PSNR=36.40926)

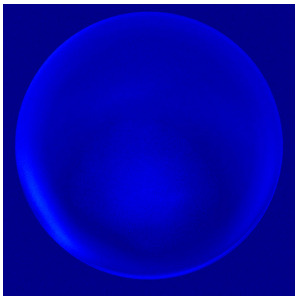
**Difference Images**



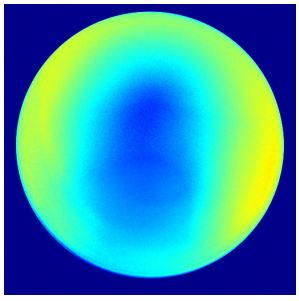
Ashikhmin-Shirley



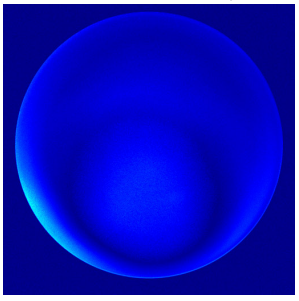
Cook-Torrance



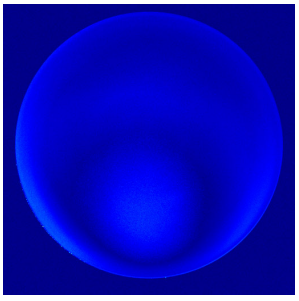
Edwards et al.



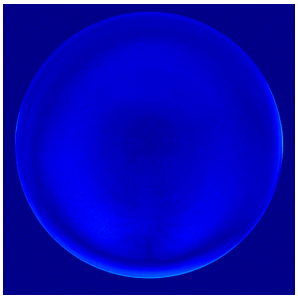
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: pearl-paint

**Fitted Parameters/PSNR**

| Material Name | pearl-paint | $k_{sr}$ | 0.049410 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.042298 | $n_2$ | 13.21418 |
| $k_{dr}$ | 0.185383 | $k_{sb}$ | 0.029787 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.163936 | $f_{01}$ | 0.999999 | $n_3$ | 13.21388 |
| $k_{db}$ | 0.136880 | $n_1$ | 52.11056 | PSNR | 37.89362 |

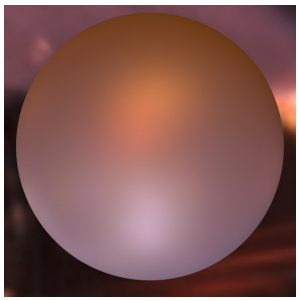
| Material Name | pearl-paint | $k_{sr}$ | 0.008909 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.007645 | $m_2$ | 0.167078 |
| $k_{dr}$ | 0.194807 | $k_{sb}$ | 0.005429 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.171809 | $f_{01}$ | 0.999999 | $m_3$ | 0.333813 |
| $k_{db}$ | 0.141932 | $m_1$ | 0.333813 | PSNR | 37.80389 |

| Material Name | pearl-paint | $k_{sg}$ | 0.111354 | $R_2$ | 2.290913 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.076895 | $n_2$ | 99.73722 |
| $k_{dr}$ | 0.181453 | $f_{01}$ | 0 | $f_{03}$ | 0.886550 |
| $k_{dg}$ | 0.161436 | $R_1$ | 1.866557 | $R_3$ | 2.670810 |
| $k_{db}$ | 0.136394 | $n_1$ | 500.0143 | $n_3$ | 25.99355 |
| $k_{sr}$ | 0.131279 | $f_{02}$ | 0.197901 | PSNR | 38.44424 |

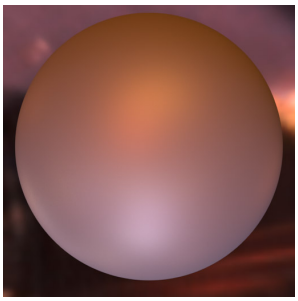
| Material Name | pearl-paint | $k_{db}$ | 0.127930 | $\alpha_1$ | 0.460016 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.082350 | $\alpha_2$ | 0.190920 |
| $k_{dr}$ | 0.164599 | $k_{sg}$ | 0.069505 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.147674 | $k_{sb}$ | 0.047323 | PSNR | 34.31150 |

| Material Name | pearl-paint | $k_{db}$ | 0.142097 | $\alpha_1$ | 0.377275 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.041775 | $\alpha_2$ | 0.178512 |
| $k_{dr}$ | 0.195141 | $k_{sg}$ | 0.035843 | $\alpha_3$ | 0.377275 |
| $k_{dg}$ | 0.172102 | $k_{sb}$ | 0.025472 | PSNR | 37.48589 |

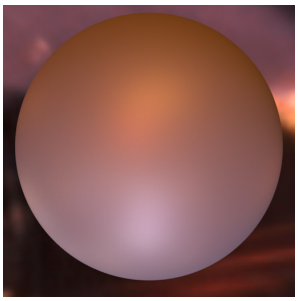
**Rendered Images**



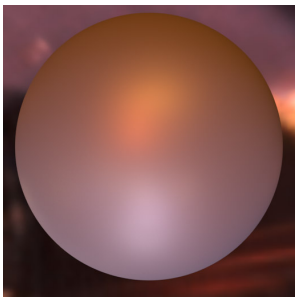
Reference image



Ashikhmin-Shirley
(PSNR=37.89362)

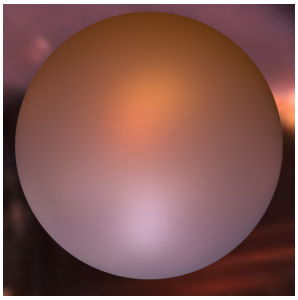


Cook-Torrance
(PSNR=37.80389)

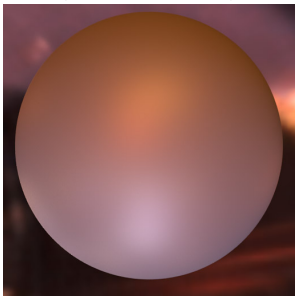


Edwards et al.
(PSNR=38.44424)

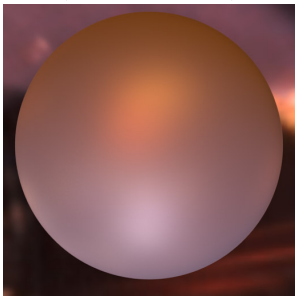
Lawrence et al.
(PSNR=23.53363)



Ward
(PSNR=34.31150)

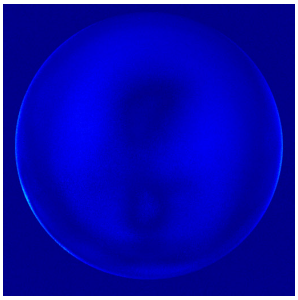


Ward-Duer
(PSNR=37.48589)

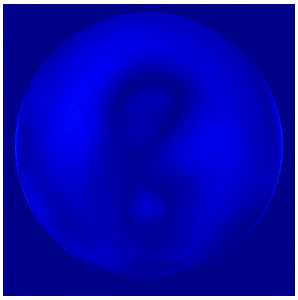


Our factored model
(PSNR=40.85558)

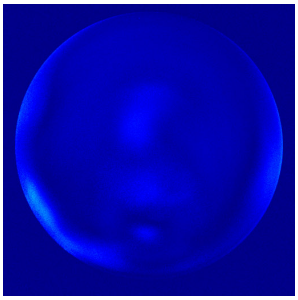
**Difference Images**



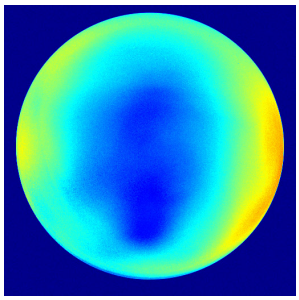
Ashikhmin-Shirley



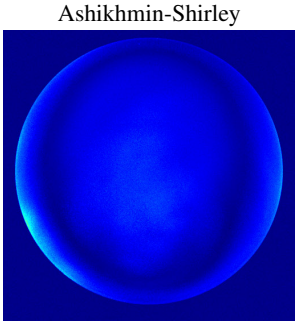
Cook-Torrance



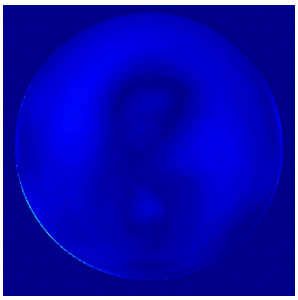
Edwards et al.



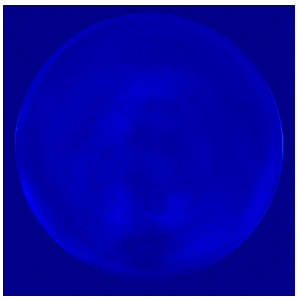
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: pickled-oak-260

**Fitted Parameters/PSNR**

| Material Name | pickled-oak-260 | $k_{sr}$ | 0.055251 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.055651 | $n_2$ | 18.44003 |
| $k_{dr}$ | 0.132427 | $k_{sb}$ | 0.054293 | $f_{03}$ | 0.478796 |
| $k_{dg}$ | 0.096610 | $f_{01}$ | 0.304049 | $n_3$ | 4.391309 |
| $k_{db}$ | 0.080248 | $n_1$ | 70.17973 | PSNR | 39.48200 |

| Material Name | pickled-oak-260 | $k_{sr}$ | 0.010079 | $f_{02}$ | 0.258178 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.010176 | $m_2$ | 0.446810 |
| $k_{dr}$ | 0.137139 | $k_{sb}$ | 0.009939 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.101301 | $f_{01}$ | 0.363709 | $m_3$ | 0.326501 |
| $k_{db}$ | 0.084799 | $m_1$ | 0.158045 | PSNR | 39.60136 |

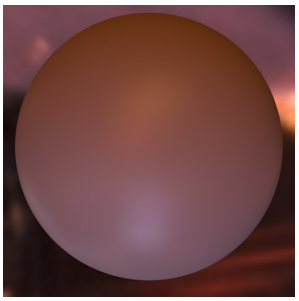
| Material Name | pickled-oak-260 | $k_{sg}$ | 0.067680 | $R_2$ | 5.365001 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.066298 | $n_2$ | 254.7388 |
| $k_{dr}$ | 0.143528 | $f_{01}$ | 0.096506 | $f_{03}$ | 0.000125 |
| $k_{dg}$ | 0.107708 | $R_1$ | 0.439194 | $R_3$ | 1.196395 |
| $k_{db}$ | 0.091007 | $n_1$ | 5.848549 | $n_3$ | 154.2914 |
| $k_{sr}$ | 0.066865 | $f_{02}$ | 0.159958 | PSNR | 39.22026 |

| Material Name | pickled-oak-260 | $k_{db}$ | 0.080368 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.018118 | $\alpha_2$ | 0.135553 |
| $k_{dr}$ | 0.132402 | $k_{sg}$ | 0.018173 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.096702 | $k_{sb}$ | 0.017710 | PSNR | 37.13451 |

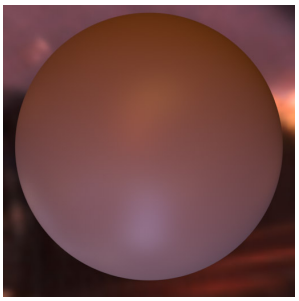
| Material Name | pickled-oak-260 | $k_{db}$ | 0.083376 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.010684 | $\alpha_2$ | 0.280199 |
| $k_{dr}$ | 0.135664 | $k_{sg}$ | 0.010779 | $\alpha_3$ | 0.135976 |
| $k_{dg}$ | 0.099828 | $k_{sb}$ | 0.010522 | PSNR | 39.16359 |

**Rendered Images**

Reference image

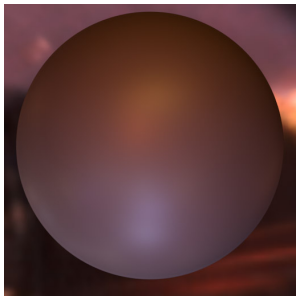


Ashikhmin-Shirley
(PSNR=39.48200)

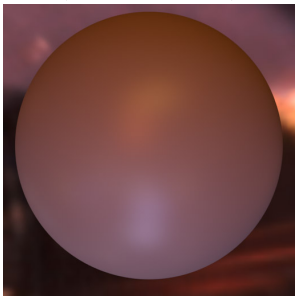


Cook-Torrance
(PSNR=39.60136)

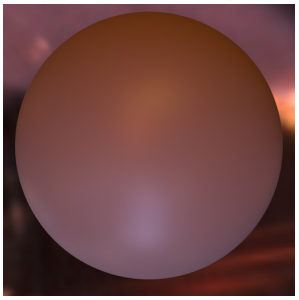
Edwards et al.
(PSNR=39.22026)



Lawrence et al.
(PSNR=23.64813)



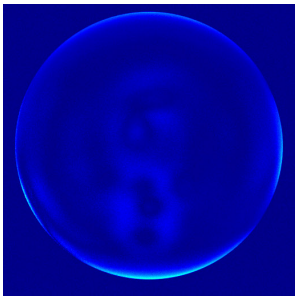
Ward
(PSNR=37.13451)



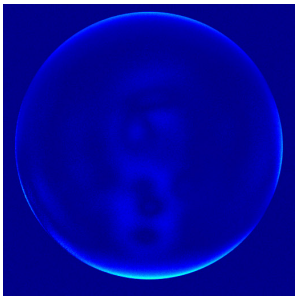
Ward-Duer
(PSNR=39.16359)

Our factored model
(PSNR=40.47611)

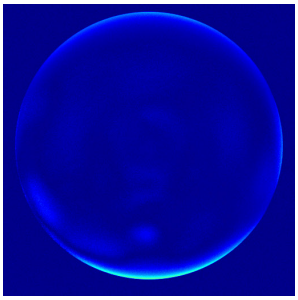
**Difference Images**



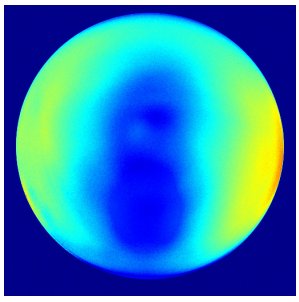
Ashikhmin-Shirley



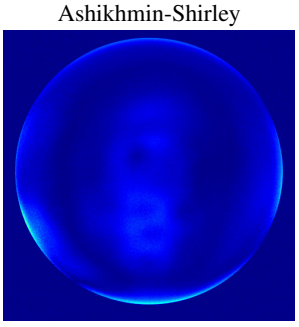
Cook-Torrance



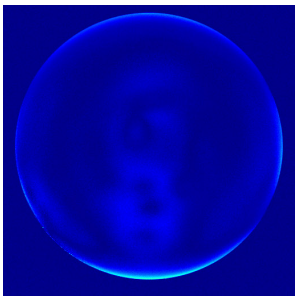
Edwards et al.



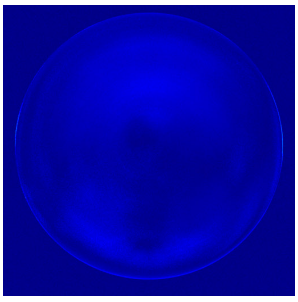
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: pink-fabric

**Fitted Parameters/PSNR**

| Material Name | pink-fabric | $k_{sr}$ | 0.142706 | $f_{02}$ | 0.124380 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.147046 | $n_2$ | 3.796324 |
| $k_{dr}$ | 0.234789 | $k_{sb}$ | 0.154945 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.171872 | $f_{01}$ | 0.999999 | $n_3$ | 0 |
| $k_{db}$ | 0.175308 | $n_1$ | 0 | PSNR | 41.80308 |

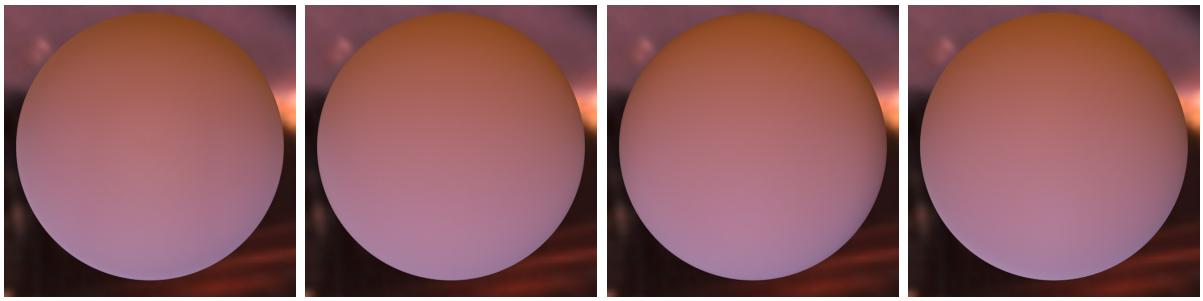
| Material Name | pink-fabric | $k_{sr}$ | 0.010758 | $f_{02}$ | 0.330983 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.010853 | $m_2$ | 0.999999 |
| $k_{dr}$ | 0.253822 | $k_{sb}$ | 0.010515 | $f_{03}$ | 0.999988 |
| $k_{dg}$ | 0.192426 | $f_{01}$ | 0.225604 | $m_3$ | 0.999999 |
| $k_{db}$ | 0.200718 | $m_1$ | 0.318539 | PSNR | 36.59859 |

| Material Name | pink-fabric | $k_{sg}$ | 0.155522 | $R_2$ | 8.759933 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.143156 | $n_2$ | 49.74342 |
| $k_{dr}$ | 0.289405 | $f_{01}$ | 0.027719 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.228008 | $R_1$ | 3.380878 | $R_3$ | 5.661182 |
| $k_{db}$ | 0.235606 | $n_1$ | 100.2123 | $n_3$ | 18.61107 |
| $k_{sr}$ | 0.148473 | $f_{02}$ | 0 | PSNR | 38.30912 |

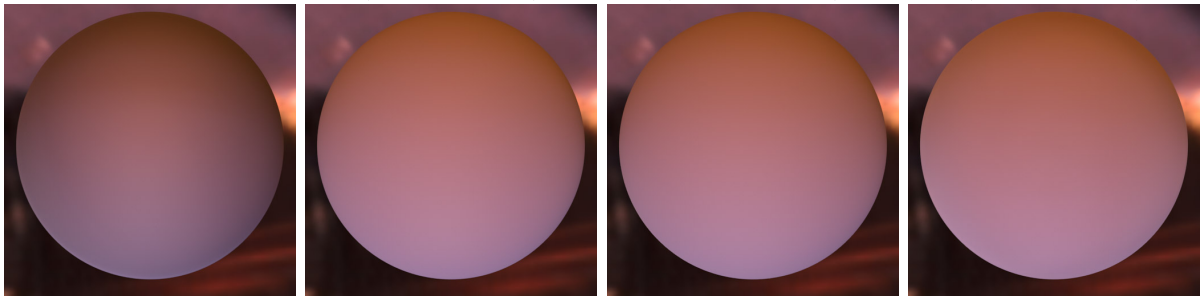
| Material Name | pink-fabric | $k_{db}$ | 0.238415 | $\alpha_1$ | 0.301631 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.008698 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.285050 | $k_{sg}$ | 0.007484 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.225797 | $k_{sb}$ | 0.003536 | PSNR | 35.88379 |

| Material Name | pink-fabric | $k_{db}$ | 0.231351 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.009658 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.279782 | $k_{sg}$ | 0.009088 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.219828 | $k_{sb}$ | 0.006592 | PSNR | 35.96642 |

**Rendered Images**

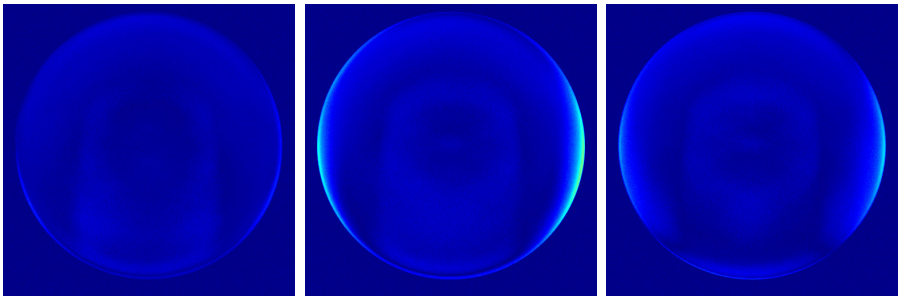


Reference image | Ashikhmin-Shirley (PSNR=41.80308) | Cook-Torrance (PSNR=36.59859) | Edwards et al. (PSNR=38.30912)

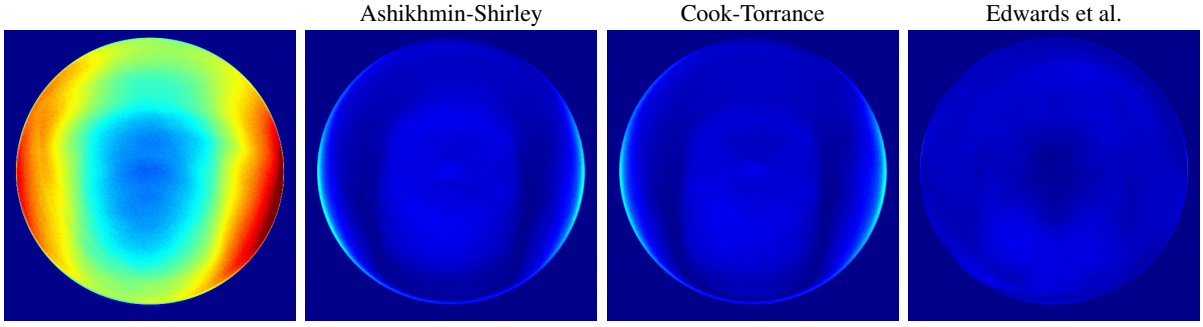


Lawrence et al. (PSNR=20.72656) | Ward (PSNR=35.88379) | Ward-Duer (PSNR=35.96642) | Our factored model (PSNR=37.96204)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: pink-fabric2

**Fitted Parameters/PSNR**

| Material Name | pink-fabric2 | $k_{sr}$ | 0.111780 | $f_{02}$ | 0.966638 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.068751 | $n_2$ | 3.864674 |
| $k_{dr}$ | 0.193284 | $k_{sb}$ | 0.063648 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.039167 | $f_{01}$ | 0.999999 | $n_3$ | 0 |
| $k_{db}$ | 0.030872 | $n_1$ | 0 | PSNR | 39.85579 |

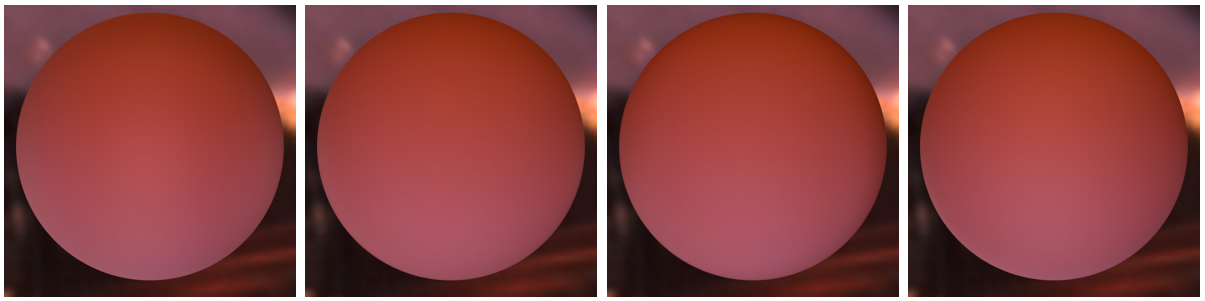
| Material Name | pink-fabric2 | $k_{sr}$ | 0.009847 | $f_{02}$ | 0.641011 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.006065 | $m_2$ | 0.999999 |
| $k_{dr}$ | 0.214626 | $k_{sb}$ | 0.005581 | $f_{03}$ | 0.999989 |
| $k_{dg}$ | 0.052233 | $f_{01}$ | 0.999999 | $m_3$ | 0.999999 |
| $k_{db}$ | 0.043219 | $m_1$ | 0.416345 | PSNR | 36.89384 |

| Material Name | pink-fabric2 | $k_{sg}$ | 0.098383 | $R_2$ | 5.617416 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.087412 | $n_2$ | 49.68080 |
| $k_{dr}$ | 0.246361 | $f_{01}$ | 0.007554 | $f_{03}$ | 0.202900 |
| $k_{dg}$ | 0.072830 | $R_1$ | 2.809374 | $R_3$ | 1.434282 |
| $k_{db}$ | 0.062955 | $n_1$ | 100.2178 | $n_3$ | 1.875046 |
| $k_{sr}$ | 0.166577 | $f_{02}$ | 0.152832 | PSNR | 37.40262 |

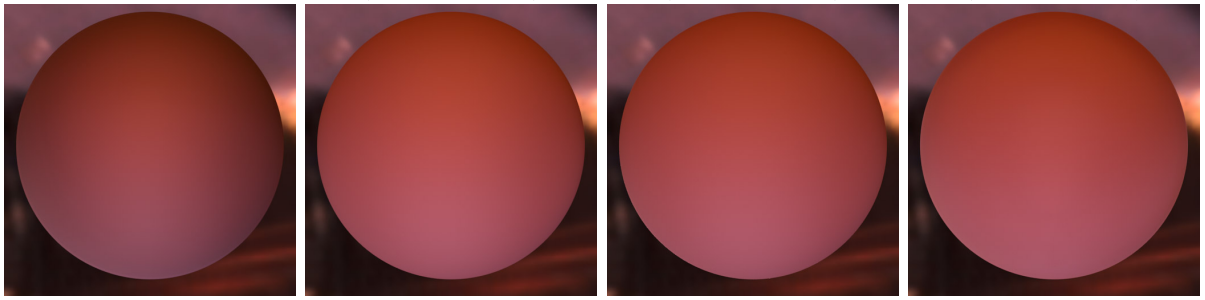
| Material Name | pink-fabric2 | $k_{db}$ | 0.066284 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.031346 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.246827 | $k_{sg}$ | 0.016698 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.075491 | $k_{sb}$ | 0.014102 | PSNR | 35.04437 |

| Material Name | pink-fabric2 | $k_{db}$ | 0.064420 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.021152 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.248955 | $k_{sg}$ | 0.012434 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.074471 | $k_{sb}$ | 0.011044 | PSNR | 36.70059 |

**Rendered Images**

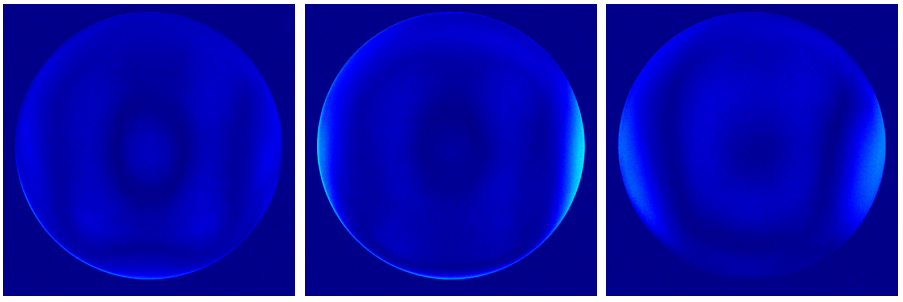


Reference image | Ashikhmin-Shirley (PSNR=39.85579) | Cook-Torrance (PSNR=36.89384) | Edwards et al. (PSNR=37.40262)

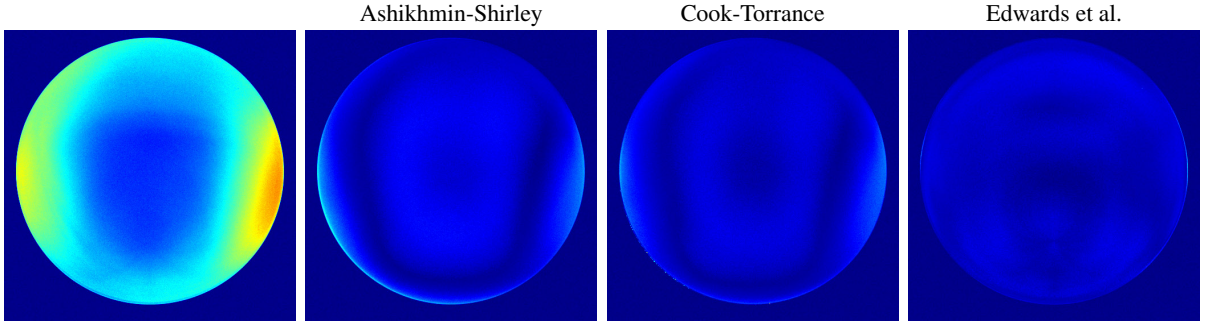


Lawrence et al. (PSNR=23.46437) | Ward (PSNR=35.04437) | Ward-Duer (PSNR=36.70059) | Our factored model (PSNR=37.73140)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: pink-felt

**Fitted Parameters/PSNR**

| Material Name | pink-felt | $k_{sr}$ | 0.113476 | $f_{02}$ | 0.936009 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.110953 | $n_2$ | 2.969968 |
| $k_{dr}$ | 0.241050 | $k_{sb}$ | 0.101473 | $f_{03}$ | 0.999983 |
| $k_{dg}$ | 0.153220 | $f_{01}$ | 0.492288 | $n_3$ | 0 |
| $k_{db}$ | 0.138662 | $n_1$ | 0 | PSNR | 36.87619 |

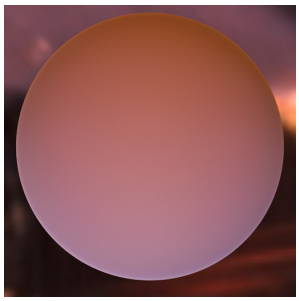
| Material Name | pink-felt | $k_{sr}$ | 0.015549 | $f_{02}$ | 0.338638 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.015163 | $m_2$ | 0.999999 |
| $k_{dr}$ | 0.261271 | $k_{sb}$ | 0.013681 | $f_{03}$ | 0.538978 |
| $k_{dg}$ | 0.173143 | $f_{01}$ | 0.478030 | $m_3$ | 0.999999 |
| $k_{db}$ | 0.157595 | $m_1$ | 0.428444 | PSNR | 35.49792 |

| Material Name | pink-felt | $k_{sg}$ | 0.171548 | $R_2$ | 7.229960 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.140259 | $n_2$ | 49.80056 |
| $k_{dr}$ | 0.282357 | $f_{01}$ | 0.008074 | $f_{03}$ | 0.346064 |
| $k_{dg}$ | 0.193930 | $R_1$ | 3.028460 | $R_3$ | 3.155459 |
| $k_{db}$ | 0.179468 | $n_1$ | 100.0165 | $n_3$ | 9.584360 |
| $k_{sr}$ | 0.176980 | $f_{02}$ | 0 | PSNR | 37.34565 |

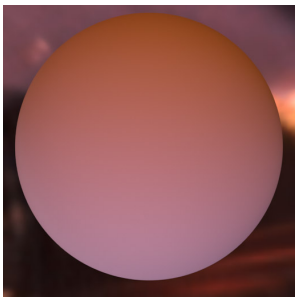
| Material Name | pink-felt | $k_{db}$ | 0.191560 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.024207 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.288575 | $k_{sg}$ | 0.022095 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.201757 | $k_{sb}$ | 0.013733 | PSNR | 34.65217 |

| Material Name | pink-felt | $k_{db}$ | 0.186444 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.016916 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.289146 | $k_{sg}$ | 0.016127 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.201009 | $k_{sb}$ | 0.012542 | PSNR | 35.74458 |

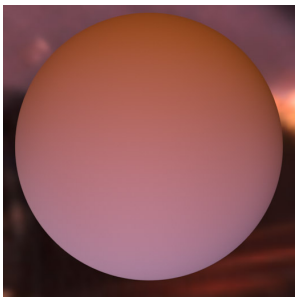
**Rendered Images**



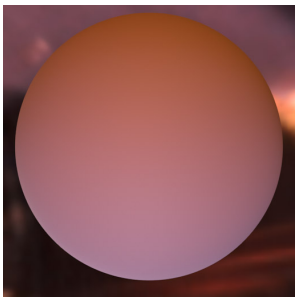
Reference image



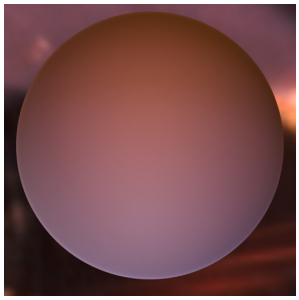
Ashikhmin-Shirley
(PSNR=36.87619)



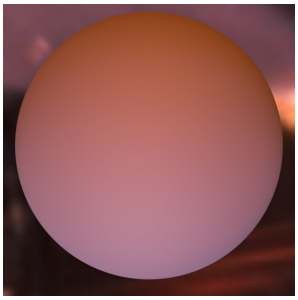
Cook-Torrance
(PSNR=35.49792)



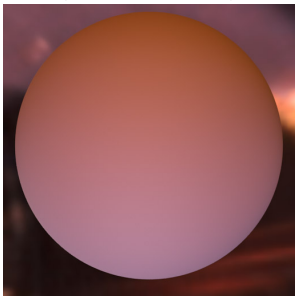
Edwards et al.
(PSNR=37.34565)



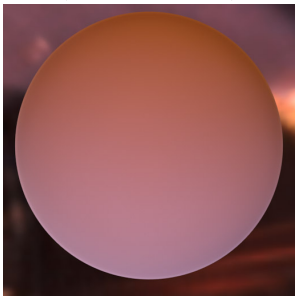
Lawrence et al.
(PSNR=21.73083)



Ward
(PSNR=34.65217)

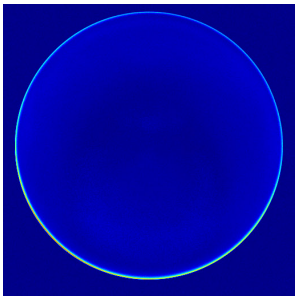


Ward-Duer
(PSNR=35.74458)

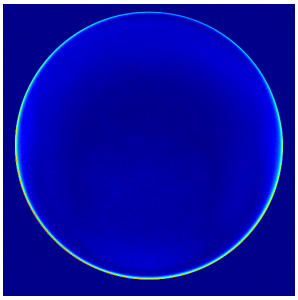


Our factored model
(PSNR=39.48701)

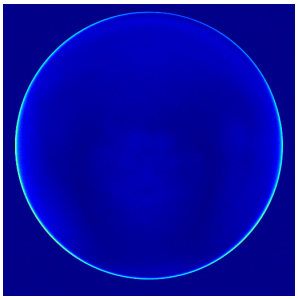
**Difference Images**



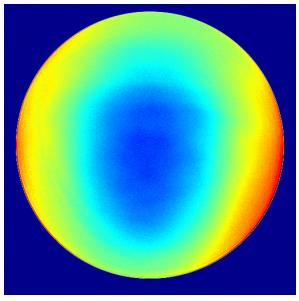
Ashikhmin-Shirley



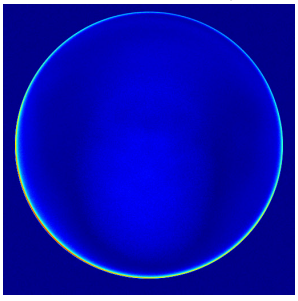
Cook-Torrance



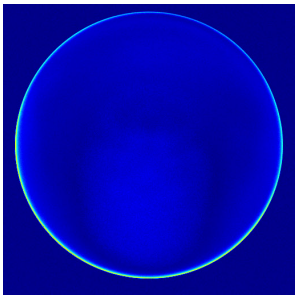
Edwards et al.



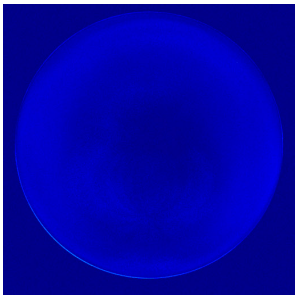
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: pink-jasper

**Fitted Parameters/PSNR**

| Material Name | pink-jasper | $k_{sr}$ | 0.036250 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.033368 | $n_2$ | 1865.190 |
| $k_{dr}$ | 0.207442 | $k_{sb}$ | 0.033840 | $f_{03}$ | 0.242962 |
| $k_{dg}$ | 0.128914 | $f_{01}$ | 0.137320 | $n_3$ | 700.0623 |
| $k_{db}$ | 0.102413 | $n_1$ | 11479.68 | PSNR | 35.23956 |

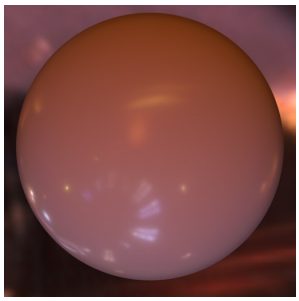
| Material Name | pink-jasper | $k_{sr}$ | 0.008534 | $f_{02}$ | 0.141579 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.007858 | $m_2$ | 0.012895 |
| $k_{dr}$ | 0.207517 | $k_{sb}$ | 0.007966 | $f_{03}$ | 0.251640 |
| $k_{dg}$ | 0.128979 | $f_{01}$ | 0 | $m_3$ | 0.051861 |
| $k_{db}$ | 0.102484 | $m_1$ | 0.031874 | PSNR | 35.18424 |

| Material Name | pink-jasper | $k_{sg}$ | 0.057835 | $R_2$ | 0.043800 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.058672 | $n_2$ | 2.814972 |
| $k_{dr}$ | 0.209593 | $f_{01}$ | 0.018340 | $f_{03}$ | 0.110744 |
| $k_{dg}$ | 0.130903 | $R_1$ | 0.091371 | $R_3$ | 1.148011 |
| $k_{db}$ | 0.104426 | $n_1$ | 139.1768 | $n_3$ | 354.4386 |
| $k_{sr}$ | 0.062883 | $f_{02}$ | 0.031453 | PSNR | 34.53462 |

| Material Name | pink-jasper | $k_{db}$ | 0.102008 | $\alpha_1$ | 0.060759 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.006906 | $\alpha_2$ | 0.033441 |
| $k_{dr}$ | 0.206831 | $k_{sg}$ | 0.006429 | $\alpha_3$ | 0.011289 |
| $k_{dg}$ | 0.128200 | $k_{sb}$ | 0.006369 | PSNR | 34.21463 |

| Material Name | pink-jasper | $k_{db}$ | 0.100055 | $\alpha_1$ | 0.060694 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.005841 | $\alpha_2$ | 0.034156 |
| $k_{dr}$ | 0.204806 | $k_{sg}$ | 0.005404 | $\alpha_3$ | 0.011700 |
| $k_{dg}$ | 0.126409 | $k_{sb}$ | 0.005417 | PSNR | 35.07673 |

**Rendered Images**

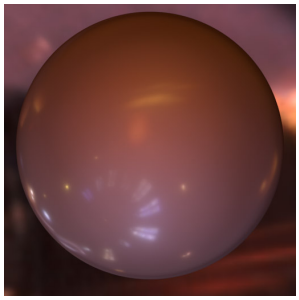


Reference image

Ashikhmin-Shirley
(PSNR=35.23956)

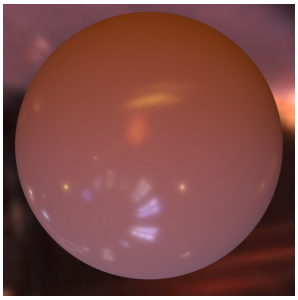
Cook-Torrance
(PSNR=35.18424)

Edwards et al.
(PSNR=34.53462)

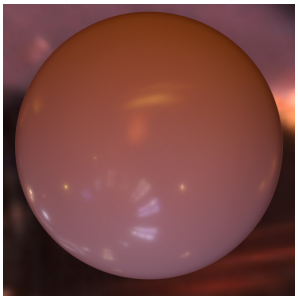


Lawrence et al.
(PSNR=23.17317)

Ward
(PSNR=34.21463)

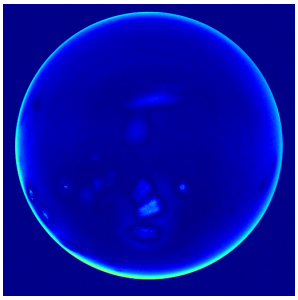


Ward-Duer
(PSNR=35.07673)

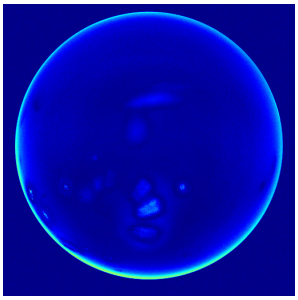


Our factored model
(PSNR=42.10834)

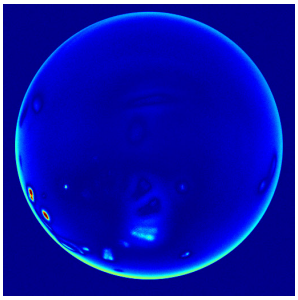
**Difference Images**



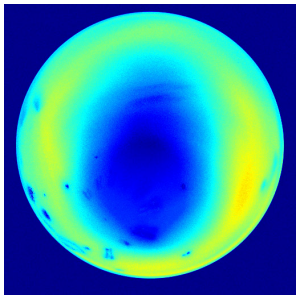
Ashikhmin-Shirley



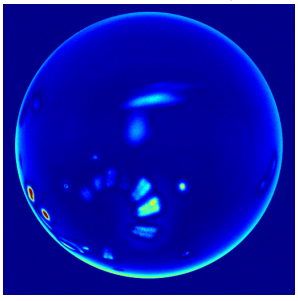
Cook-Torrance



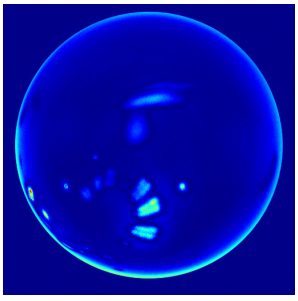
Edwards et al.



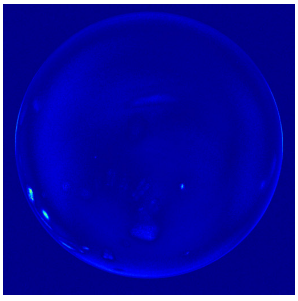
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: pink-plastic

**Fitted Parameters/PSNR**

| Material Name | pink-plastic | $k_{sr}$ | 0.118772 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.086255 | $n_2$ | 0 |
| $k_{dr}$ | 0.336736 | $k_{sb}$ | 0.087921 | $f_{03}$ | 0.604349 |
| $k_{dg}$ | 0.063457 | $f_{01}$ | 0.011212 | $n_3$ | 1.267807 |
| $k_{db}$ | 0.039083 | $n_1$ | 41.71585 | PSNR | 35.91631 |

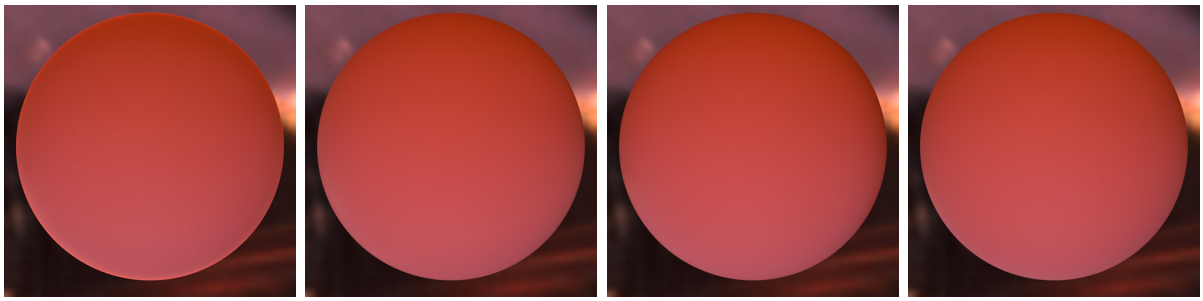
| Material Name | pink-plastic | $k_{sr}$ | 0.014989 | $f_{02}$ | 0.170776 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.011109 | $m_2$ | 0.374785 |
| $k_{dr}$ | 0.347815 | $k_{sb}$ | 0.011357 | $f_{03}$ | 0.007993 |
| $k_{dg}$ | 0.070949 | $f_{01}$ | 0.734597 | $m_3$ | 0.171185 |
| $k_{db}$ | 0.046638 | $m_1$ | 0.999999 | PSNR | 34.91128 |

| Material Name | pink-plastic | $k_{sg}$ | 0.072853 | $R_2$ | 5.379597 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.072489 | $n_2$ | 99.92846 |
| $k_{dr}$ | 0.376581 | $f_{01}$ | 0 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.092226 | $R_1$ | 2.766341 | $R_3$ | 2.172657 |
| $k_{db}$ | 0.068559 | $n_1$ | 500.0241 | $n_3$ | 6.236414 |
| $k_{sr}$ | 0.097617 | $f_{02}$ | 0.068685 | PSNR | 35.66248 |

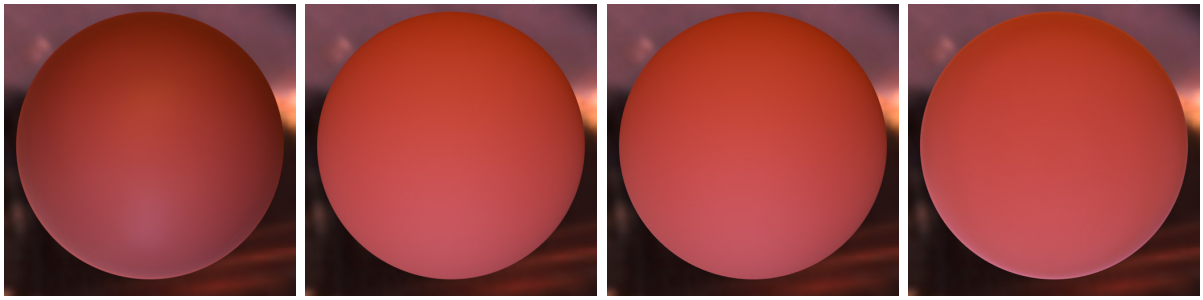
| Material Name | pink-plastic | $k_{db}$ | 0.062129 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.009013 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.373091 | $k_{sg}$ | 0.009451 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.086041 | $k_{sb}$ | 0.009613 | PSNR | 33.59844 |

| Material Name | pink-plastic | $k_{db}$ | 0.058948 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.010494 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.365556 | $k_{sg}$ | 0.008367 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.083008 | $k_{sb}$ | 0.008563 | PSNR | 33.97209 |

**Rendered Images**

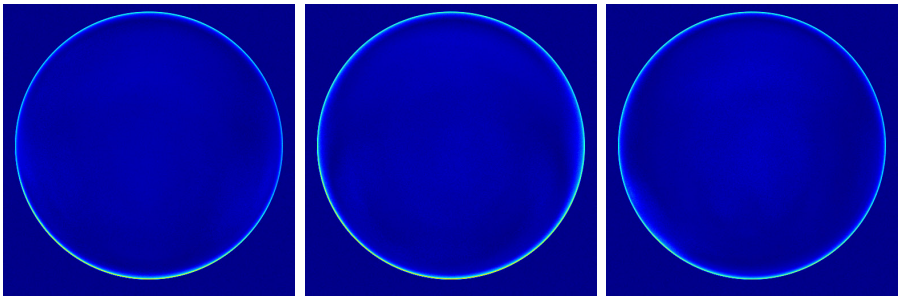


Reference image | Ashikhmin-Shirley (PSNR=35.91631) | Cook-Torrance (PSNR=34.91128) | Edwards et al. (PSNR=35.66248)

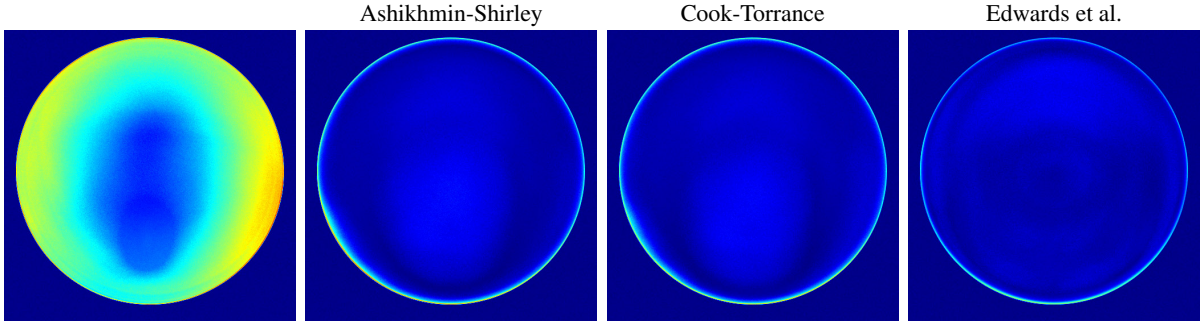


Lawrence et al. (PSNR=21.89073) | Ward (PSNR=33.59844) | Ward-Duer (PSNR=33.97209) | Our factored model (PSNR=36.45522)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: polyethylene

**Fitted Parameters/PSNR**

| Material Name | polyethylene | $k_{sr}$ | 0.164834 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.152218 | $n_2$ | 0.478252 |
| $k_{dr}$ | 0.171645 | $k_{sb}$ | 0.135639 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.189099 | $f_{01}$ | 0.067433 | $n_3$ | 0.478199 |
| $k_{db}$ | 0.193932 | $n_1$ | 14.49629 | PSNR | 31.66915 |

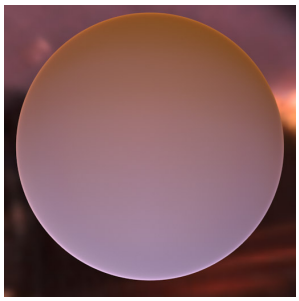
| Material Name | polyethylene | $k_{sr}$ | 0.024758 | $f_{02}$ | 0.277349 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.022970 | $m_2$ | 0.999999 |
| $k_{dr}$ | 0.188302 | $k_{sb}$ | 0.020472 | $f_{03}$ | 0.636349 |
| $k_{dg}$ | 0.204159 | $f_{01}$ | 0.214687 | $m_3$ | 0.999999 |
| $k_{db}$ | 0.207338 | $m_1$ | 0.338837 | PSNR | 30.33522 |

| Material Name | polyethylene | $k_{sg}$ | 0.343418 | $R_2$ | 13.65550 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.295164 | $n_2$ | 99.68546 |
| $k_{dr}$ | 0.237653 | $f_{01}$ | 0.032974 | $f_{03}$ | 0.025441 |
| $k_{dg}$ | 0.250856 | $R_1$ | 9.887120 | $R_3$ | 4.334452 |
| $k_{db}$ | 0.249676 | $n_1$ | 500.0134 | $n_3$ | 9.836749 |
| $k_{sr}$ | 0.385073 | $f_{02}$ | 0 | PSNR | 34.10819 |

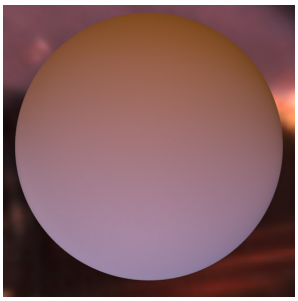
| Material Name | polyethylene | $k_{db}$ | 0.246659 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.018079 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.239223 | $k_{sg}$ | 0.020404 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.246632 | $k_{sb}$ | 0.017070 | PSNR | 29.49114 |

| Material Name | polyethylene | $k_{db}$ | 0.241302 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.017468 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.230723 | $k_{sg}$ | 0.017598 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.240946 | $k_{sb}$ | 0.015048 | PSNR | 29.99706 |

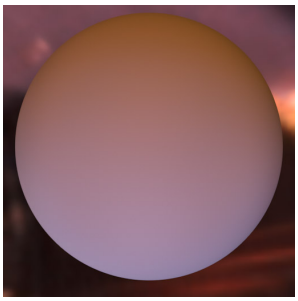
**Rendered Images**



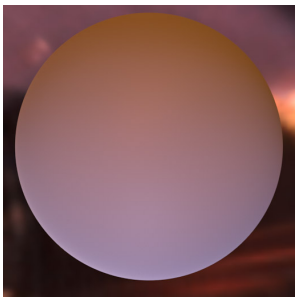
Reference image



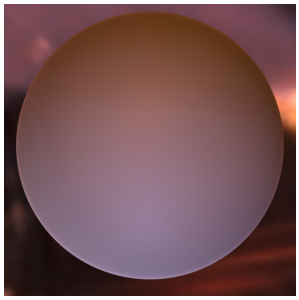
Ashikhmin-Shirley
(PSNR=31.66915)



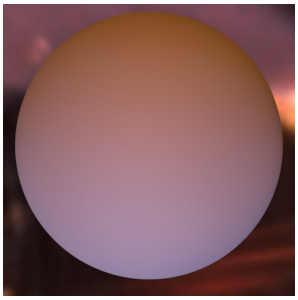
Cook-Torrance
(PSNR=30.33522)



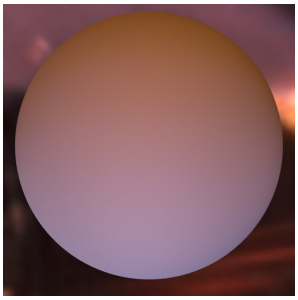
Edwards et al.
(PSNR=34.10819)



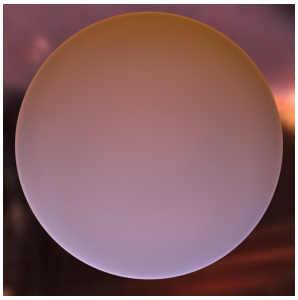
Lawrence et al.
(PSNR=22.29603)



Ward
(PSNR=29.49114)

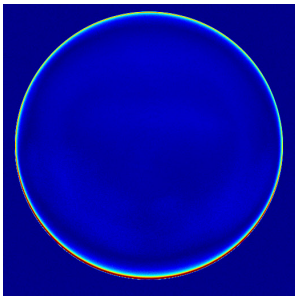


Ward-Duer
(PSNR=29.99706)

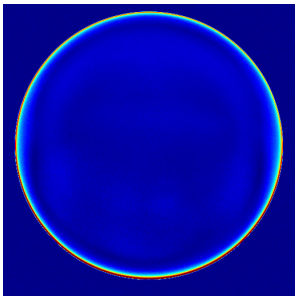


Our factored model
(PSNR=38.60353)

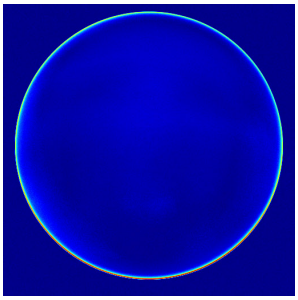
**Difference Images**



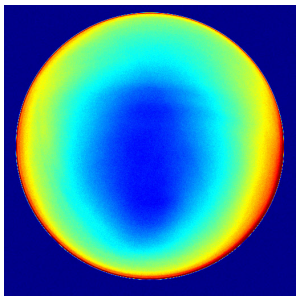
Ashikhmin-Shirley



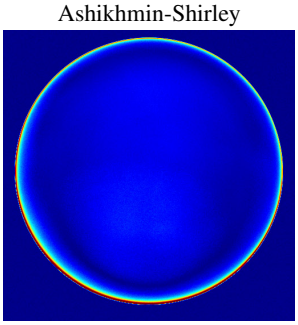
Cook-Torrance



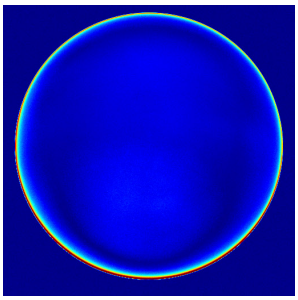
Edwards et al.



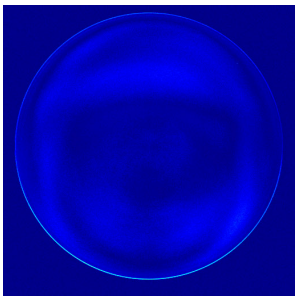
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: polyurethane-foam

**Fitted Parameters/PSNR**

| Material Name | polyurethane-foam | $k_{sr}$ | 0.088194 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.061683 | $n_2$ | 0.152825 |
| $k_{dr}$ | 0.051706 | $k_{sb}$ | 0.057262 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.014527 | $f_{01}$ | 0.020352 | $n_3$ | 0.152827 |
| $k_{db}$ | 0.006929 | $n_1$ | 0.186667 | PSNR | 42.08240 |

| Material Name | polyurethane-foam | $k_{sr}$ | 0.008876 | $f_{02}$ | 0.497367 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.006182 | $m_2$ | 0.999999 |
| $k_{dr}$ | 0.063407 | $k_{sb}$ | 0.005642 | $f_{03}$ | 0.553219 |
| $k_{dg}$ | 0.022786 | $f_{01}$ | 0.095986 | $m_3$ | 0.999999 |
| $k_{db}$ | 0.014880 | $m_1$ | 0.393607 | PSNR | 36.03919 |

| Material Name | polyurethane-foam | $k_{sg}$ | 0.077972 | $R_2$ | 14.72810 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.074407 | $n_2$ | 99.55680 |
| $k_{dr}$ | 0.084094 | $f_{01}$ | 0.011891 | $f_{03}$ | 0.000025 |
| $k_{dg}$ | 0.037534 | $R_1$ | 11.43859 | $R_3$ | 1.611958 |
| $k_{db}$ | 0.028202 | $n_1$ | 500.0484 | $n_3$ | 0 |
| $k_{sr}$ | 0.123500 | $f_{02}$ | 0 | PSNR | 40.54757 |

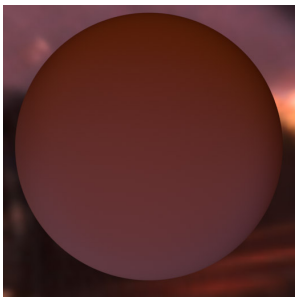
| Material Name | polyurethane-foam | $k_{db}$ | 0.030177 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.002919 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.085476 | $k_{sg}$ | 0.001189 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.039266 | $k_{sb}$ | 0.000889 | PSNR | 35.22541 |

| Material Name | polyurethane-foam | $k_{db}$ | 0.027742 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.003762 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.082365 | $k_{sg}$ | 0.002206 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.036754 | $k_{sb}$ | 0.001951 | PSNR | 35.03398 |

**Rendered Images**

Reference image

Ashikhmin-Shirley
(PSNR=42.08240)



Cook-Torrance
(PSNR=36.03919)

Edwards et al.
(PSNR=40.54757)

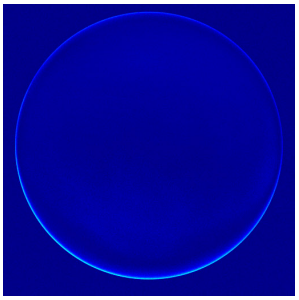
Lawrence et al.
(PSNR=27.87576)

Ward
(PSNR=35.22541)

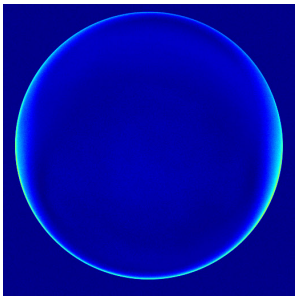
Ward-Duer
(PSNR=35.03398)

Our factored model
(PSNR=43.42601)

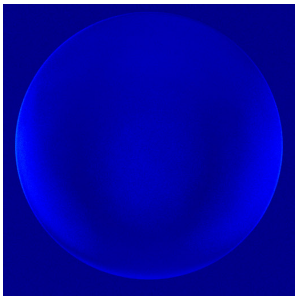
**Difference Images**



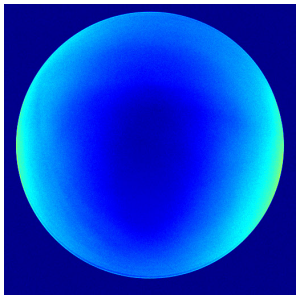
Ashikhmin-Shirley



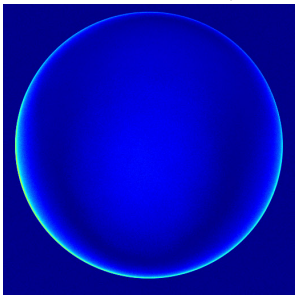
Cook-Torrance



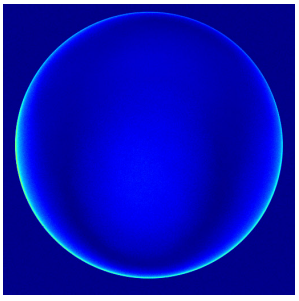
Edwards et al.



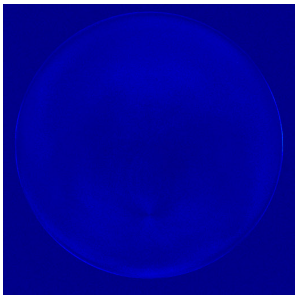
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: pure-rubber

**Fitted Parameters/PSNR**

| Material Name | pure-rubber | $k_{sr}$ | 0.064455 | $f_{02}$ | 0.039139 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.061098 | $n_2$ | 45.87277 |
| $k_{dr}$ | 0.274578 | $k_{sb}$ | 0.054986 | $f_{03}$ | 0.757762 |
| $k_{dg}$ | 0.240096 | $f_{01}$ | 0 | $n_3$ | 3.959819 |
| $k_{db}$ | 0.200886 | $n_1$ | 76.89818 | PSNR | 42.53172 |

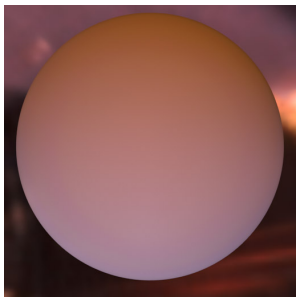
| Material Name | pure-rubber | $k_{sr}$ | 0.012843 | $f_{02}$ | 0.118882 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.012174 | $m_2$ | 0.246956 |
| $k_{dr}$ | 0.278706 | $k_{sb}$ | 0.011036 | $f_{03}$ | 0.003526 |
| $k_{dg}$ | 0.244009 | $f_{01}$ | 0.393197 | $m_3$ | 0.132283 |
| $k_{db}$ | 0.204266 | $m_1$ | 0.604046 | PSNR | 42.30524 |

| Material Name | pure-rubber | $k_{sg}$ | 0.072653 | $R_2$ | 1.878090 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.064887 | $n_2$ | 49.97412 |
| $k_{dr}$ | 0.278095 | $f_{01}$ | 0 | $f_{03}$ | 0.496471 |
| $k_{dg}$ | 0.243150 | $R_1$ | 0.845282 | $R_3$ | 3.132959 |
| $k_{db}$ | 0.203789 | $n_1$ | 100.0292 | $n_3$ | 9.735787 |
| $k_{sr}$ | 0.075691 | $f_{02}$ | 0.026603 | PSNR | 43.05757 |

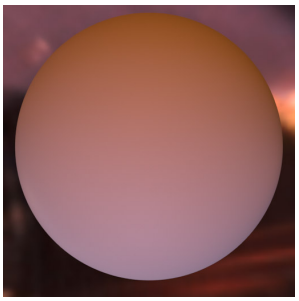
| Material Name | pure-rubber | $k_{db}$ | 0.209830 | $\alpha_1$ | 0.259794 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.012845 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.282550 | $k_{sg}$ | 0.012811 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.246716 | $k_{sb}$ | 0.009503 | PSNR | 40.71537 |

| Material Name | pure-rubber | $k_{db}$ | 0.208284 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.009017 | $\alpha_2$ | 0.205669 |
| $k_{dr}$ | 0.282641 | $k_{sg}$ | 0.008817 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.247175 | $k_{sb}$ | 0.007443 | PSNR | 41.39358 |

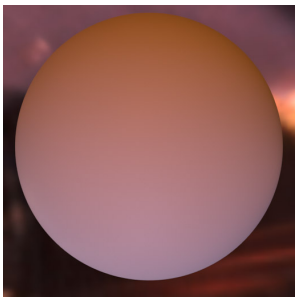
**Rendered Images**



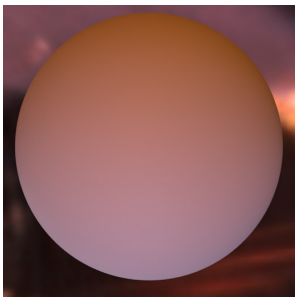
Reference image



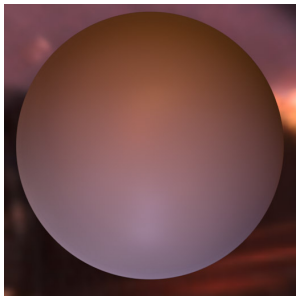
Ashikhmin-Shirley
(PSNR=42.53172)



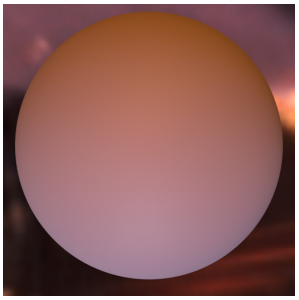
Cook-Torrance
(PSNR=42.30524)



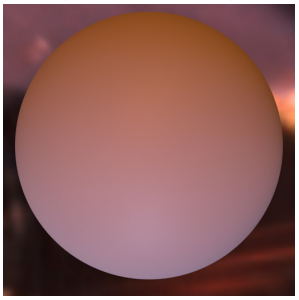
Edwards et al.
(PSNR=43.05757)



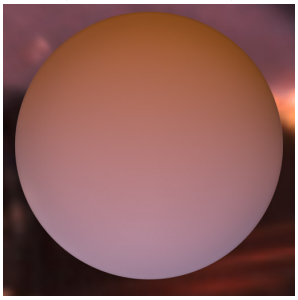
Lawrence et al.
(PSNR=20.93348)



Ward
(PSNR=40.71537)

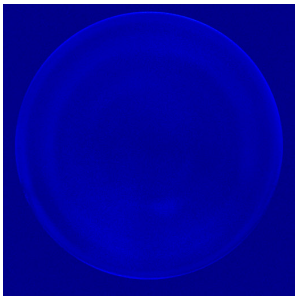


Ward-Duer
(PSNR=41.39358)

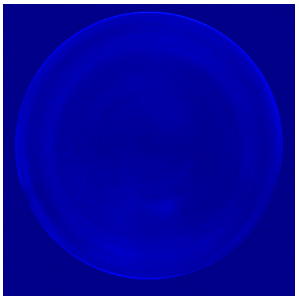


Our factored model
(PSNR=40.10928)

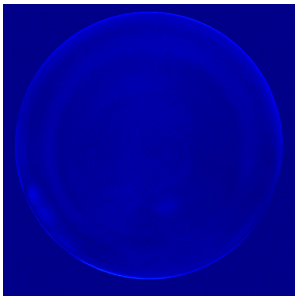
**Difference Images**



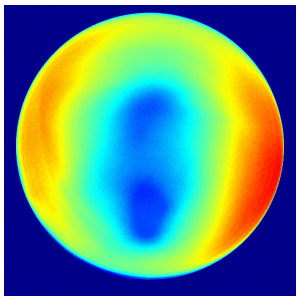
Ashikhmin-Shirley



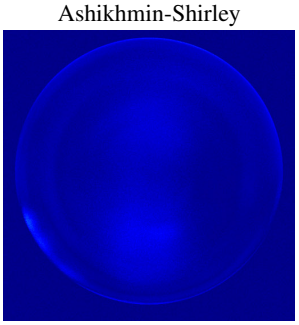
Cook-Torrance



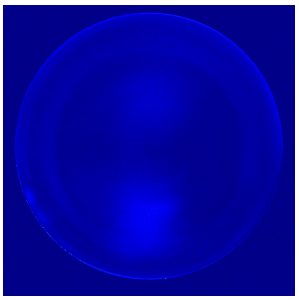
Edwards et al.



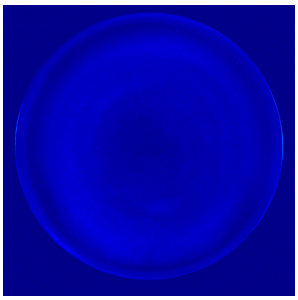
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: purple-paint

**Fitted Parameters/PSNR**

| Material Name | purple-paint | $k_{sr}$ | 0.123864 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.122339 | $n_2$ | 138.6298 |
| $k_{dr}$ | 0.280603 | $k_{sb}$ | 0.120533 | $f_{03}$ | 0.071254 |
| $k_{dg}$ | 0.030825 | $f_{01}$ | 0.066820 | $n_3$ | 67.82963 |
| $k_{db}$ | 0.029787 | $n_1$ | 554.6206 | PSNR | 38.59139 |

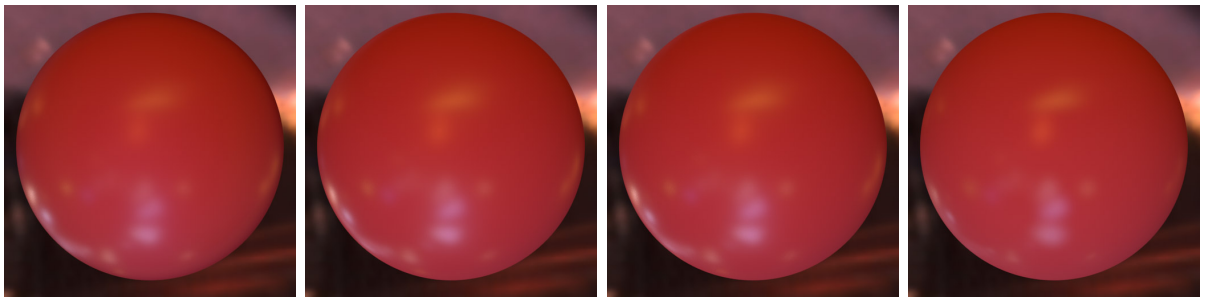
| Material Name | purple-paint | $k_{sr}$ | 0.025586 | $f_{02}$ | 0.063186 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.025276 | $m_2$ | 0.164482 |
| $k_{dr}$ | 0.280876 | $k_{sb}$ | 0.024913 | $f_{03}$ | 0.023142 |
| $k_{dg}$ | 0.031090 | $f_{01}$ | 0.066580 | $m_3$ | 0.105732 |
| $k_{db}$ | 0.030042 | $m_1$ | 0.055584 | PSNR | 38.46112 |

| Material Name | purple-paint | $k_{sg}$ | 0.112168 | $R_2$ | 0.307455 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.110588 | $n_2$ | 101.1560 |
| $k_{dr}$ | 0.284991 | $f_{01}$ | 0.001563 | $f_{03}$ | 0.091969 |
| $k_{dg}$ | 0.035137 | $R_1$ | 1.143147 | $R_3$ | 1.444913 |
| $k_{db}$ | 0.034026 | $n_1$ | 499.9660 | $n_3$ | 158.0590 |
| $k_{sr}$ | 0.113382 | $f_{02}$ | 0 | PSNR | 35.76979 |

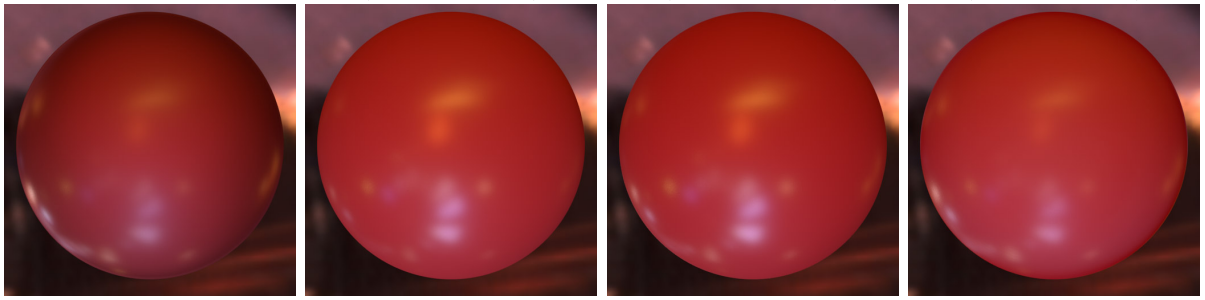
| Material Name | purple-paint | $k_{db}$ | 0.021789 | $\alpha_1$ | 0.457793 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.014605 | $\alpha_2$ | 0.139615 |
| $k_{dr}$ | 0.271899 | $k_{sg}$ | 0.014094 | $\alpha_3$ | 0.055424 |
| $k_{dg}$ | 0.022835 | $k_{sb}$ | 0.013955 | PSNR | 31.45300 |

| Material Name | purple-paint | $k_{db}$ | 0.016701 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.012899 | $\alpha_2$ | 0.134578 |
| $k_{dr}$ | 0.266937 | $k_{sg}$ | 0.012629 | $\alpha_3$ | 0.055599 |
| $k_{dg}$ | 0.017602 | $k_{sb}$ | 0.012466 | PSNR | 31.79276 |

**Rendered Images**

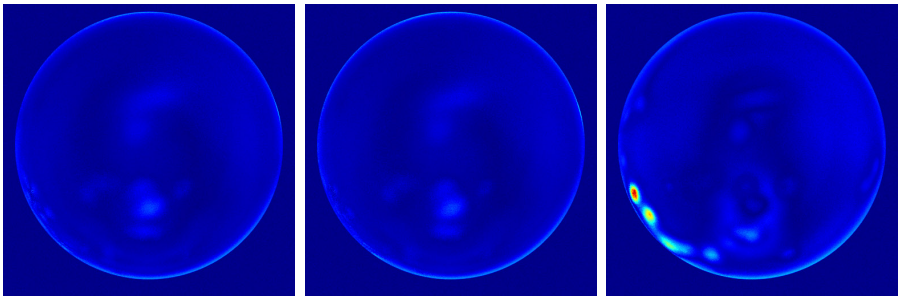


Reference image | Ashikhmin-Shirley (PSNR=38.59139) | Cook-Torrance (PSNR=38.46112) | Edwards et al. (PSNR=35.76979)

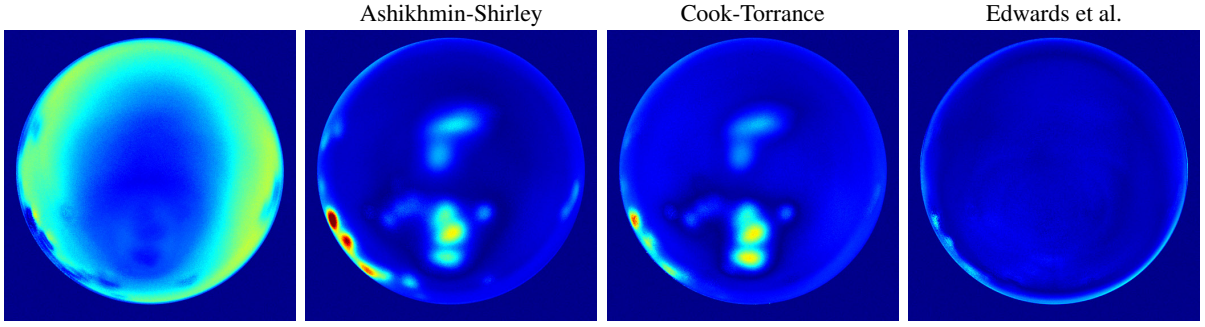


Lawrence et al. (PSNR=23.23894) | Ward (PSNR=31.45300) | Ward-Duer (PSNR=31.79276) | Our factored model (PSNR=36.16200)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: pvc

**Fitted Parameters/PSNR**

| Material Name | pvc | $k_{sr}$ | 0.093853 | $f_{02}$ | 0.085715 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.089560 | $n_2$ | 153.3461 |
| $k_{dr}$ | 0.032374 | $k_{sb}$ | 0.086998 | $f_{03}$ | 0.049535 |
| $k_{dg}$ | 0.036309 | $f_{01}$ | 0.015622 | $n_3$ | 502.7857 |
| $k_{db}$ | 0.040499 | $n_1$ | 3286.259 | PSNR | 40.27261 |

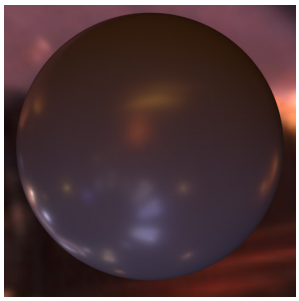
| Material Name | pvc | $k_{sr}$ | 0.022222 | $f_{02}$ | 0.015293 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.021203 | $m_2$ | 0.024334 |
| $k_{dr}$ | 0.031962 | $k_{sb}$ | 0.020612 | $f_{03}$ | 0.081073 |
| $k_{dg}$ | 0.035917 | $f_{01}$ | 0.058425 | $m_3$ | 0.125499 |
| $k_{db}$ | 0.040107 | $m_1$ | 0.060063 | PSNR | 40.80411 |

| Material Name | pvc | $k_{sg}$ | 0.084567 | $R_2$ | 0.293499 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.081849 | $n_2$ | 78.12154 |
| $k_{dr}$ | 0.037187 | $f_{01}$ | 0 | $f_{03}$ | 0.089586 |
| $k_{dg}$ | 0.041001 | $R_1$ | 0.265308 | $R_3$ | 1.284725 |
| $k_{db}$ | 0.045093 | $n_1$ | 504.0959 | $n_3$ | 295.7861 |
| $k_{sr}$ | 0.089486 | $f_{02}$ | 0 | PSNR | 34.17046 |

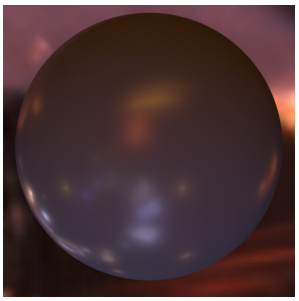
| Material Name | pvc | $k_{db}$ | 0.038186 | $\alpha_1$ | 0.112642 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.008843 | $\alpha_2$ | 0.080497 |
| $k_{dr}$ | 0.029451 | $k_{sg}$ | 0.008314 | $\alpha_3$ | 0.027146 |
| $k_{dg}$ | 0.033779 | $k_{sb}$ | 0.008007 | PSNR | 30.83384 |

| Material Name | pvc | $k_{db}$ | 0.035223 | $\alpha_1$ | 0.098135 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.007670 | $\alpha_2$ | 0.073996 |
| $k_{dr}$ | 0.026272 | $k_{sg}$ | 0.007226 | $\alpha_3$ | 0.024431 |
| $k_{dg}$ | 0.030748 | $k_{sb}$ | 0.006975 | PSNR | 31.89466 |

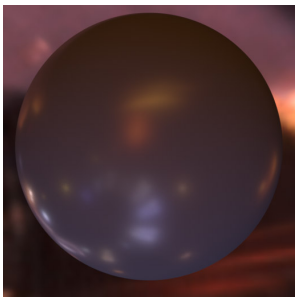
**Rendered Images**



Reference image

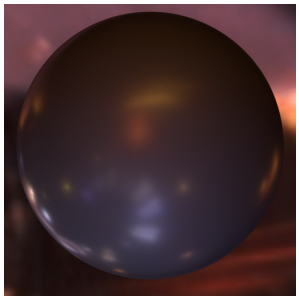


Ashikhmin-Shirley
(PSNR=40.27261)

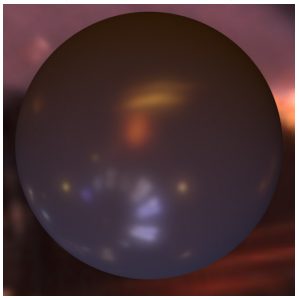


Cook-Torrance
(PSNR=40.80411)

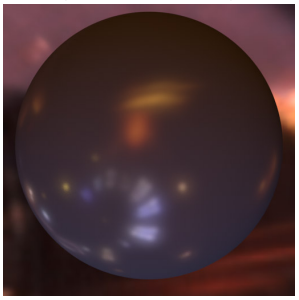
Edwards et al.
(PSNR=34.17046)



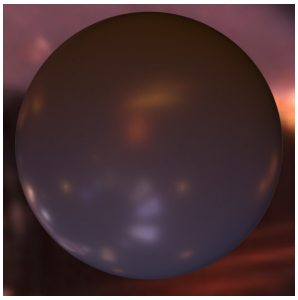
Lawrence et al.
(PSNR=30.03758)



Ward
(PSNR=30.83384)

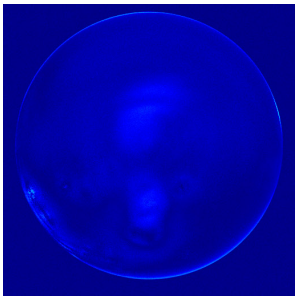


Ward-Duer
(PSNR=31.89466)

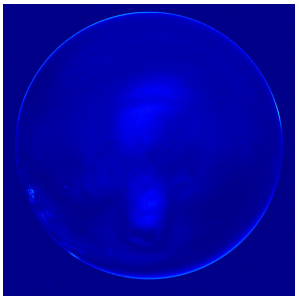


Our factored model
(PSNR=41.39534)

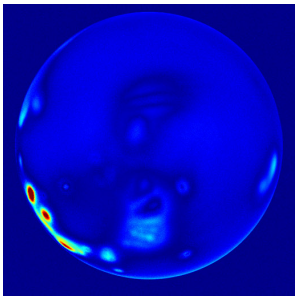
**Difference Images**



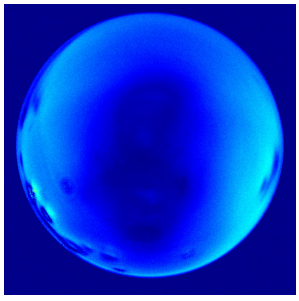
Ashikhmin-Shirley



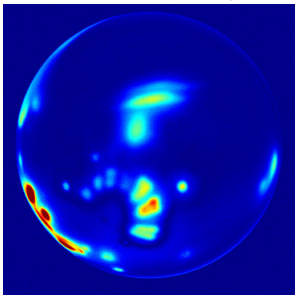
Cook-Torrance



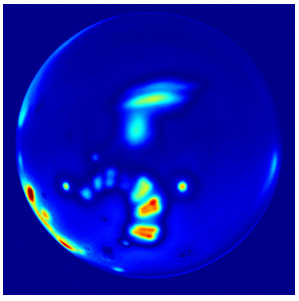
Edwards et al.



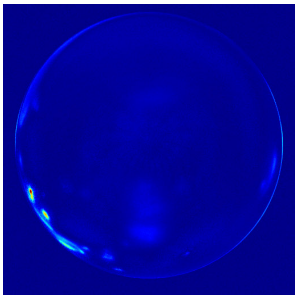
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: red-fabric

**Fitted Parameters/PSNR**

| Material Name | red-fabric | $k_{sr}$ | 0.047610 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.014846 | $n_2$ | 2.005828 |
| $k_{dr}$ | 0.184976 | $k_{sb}$ | 0.012110 | $f_{03}$ | 0.801127 |
| $k_{dg}$ | 0.021404 | $f_{01}$ | 0.185464 | $n_3$ | 6.380992 |
| $k_{db}$ | 0.005103 | $n_1$ | 13.84983 | PSNR | 39.67026 |

| Material Name | red-fabric | $k_{sr}$ | 0.005210 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.001634 | $m_2$ | 0.490279 |
| $k_{dr}$ | 0.184623 | $k_{sb}$ | 0.001339 | $f_{03}$ | 0.264282 |
| $k_{dg}$ | 0.021245 | $f_{01}$ | 0.333565 | $m_3$ | 0.695604 |
| $k_{db}$ | 0.004938 | $m_1$ | 0.261668 | PSNR | 40.11290 |

| Material Name | red-fabric | $k_{sg}$ | 0.026953 | $R_2$ | 5.120151 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.022487 | $n_2$ | 49.90640 |
| $k_{dr}$ | 0.187690 | $f_{01}$ | 0.010608 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.022310 | $R_1$ | 2.049646 | $R_3$ | 2.417964 |
| $k_{db}$ | 0.005697 | $n_1$ | 100.0089 | $n_3$ | 10.00267 |
| $k_{sr}$ | 0.087097 | $f_{02}$ | 0.396538 | PSNR | 42.29674 |

| Material Name | red-fabric | $k_{db}$ | 0.005445 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.022384 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.183323 | $k_{sg}$ | 0.006523 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.021488 | $k_{sb}$ | 0.005113 | PSNR | 38.67968 |

| Material Name | red-fabric | $k_{db}$ | 0.005627 | $\alpha_1$ | 0.442628 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.013815 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.186596 | $k_{sg}$ | 0.004249 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.022020 | $k_{sb}$ | 0.003455 | PSNR | 40.85303 |

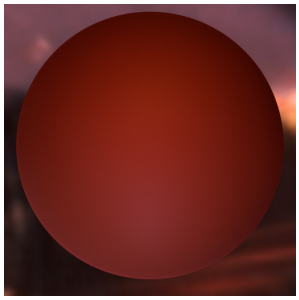
**Rendered Images**

Reference image

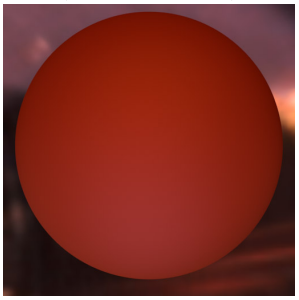
Ashikhmin-Shirley
(PSNR=39.67026)

Cook-Torrance
(PSNR=40.11290)

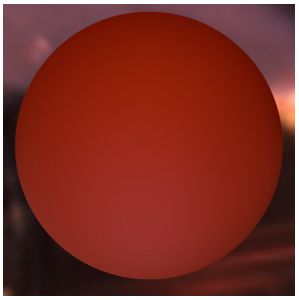
Edwards et al.
(PSNR=42.29674)



Lawrence et al.
(PSNR=24.66507)



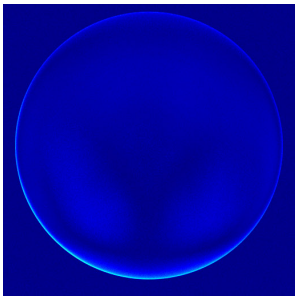
Ward
(PSNR=38.67968)



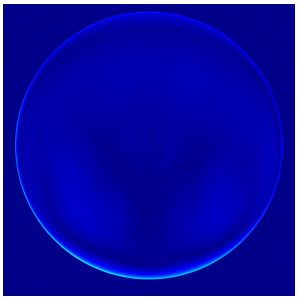
Ward-Duer
(PSNR=40.85303)

Our factored model
(PSNR=40.90798)

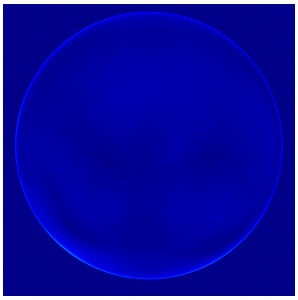
**Difference Images**



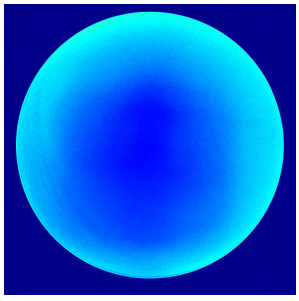
Ashikhmin-Shirley



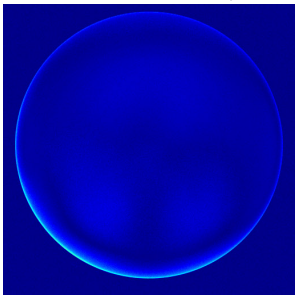
Cook-Torrance



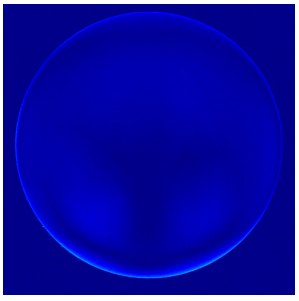
Edwards et al.



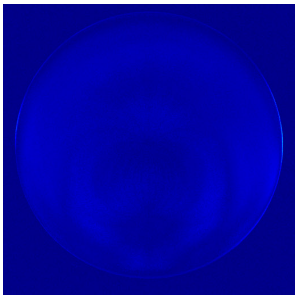
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: red-fabric2

**Fitted Parameters/PSNR**

| Material Name | red-fabric2 | $k_{sr}$ | 0.289103 | $f_{02}$ | 0.415803 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.070309 | $n_2$ | 0.383935 |
| $k_{dr}$ | 0.099841 | $k_{sb}$ | 0.066458 | $f_{03}$ | 0.424086 |
| $k_{dg}$ | 0.008291 | $f_{01}$ | 0 | $n_3$ | 0.383715 |
| $k_{db}$ | 0 | $n_1$ | 4.250619 | PSNR | 42.05655 |

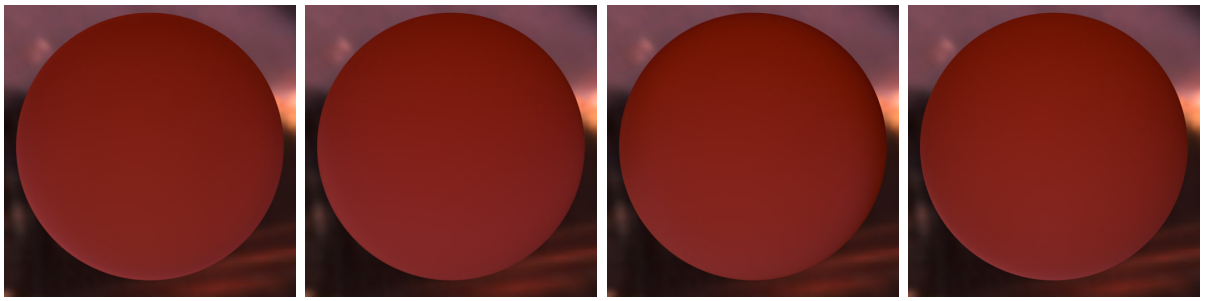
| Material Name | red-fabric2 | $k_{sr}$ | 0.032485 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.007970 | $m_2$ | 0.959779 |
| $k_{dr}$ | 0.114248 | $k_{sb}$ | 0.007484 | $f_{03}$ | 0.461518 |
| $k_{dg}$ | 0.011698 | $f_{01}$ | 0.065000 | $m_3$ | 0.999999 |
| $k_{db}$ | 0.001138 | $m_1$ | 0.385741 | PSNR | 38.17594 |

| Material Name | red-fabric2 | $k_{sg}$ | 0.038373 | $R_2$ | 6.428373 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.036436 | $n_2$ | 49.85335 |
| $k_{dr}$ | 0.151836 | $f_{01}$ | 0.007845 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.020903 | $R_1$ | 2.739655 | $R_3$ | 3.013556 |
| $k_{db}$ | 0.009763 | $n_1$ | 100.0074 | $n_3$ | 9.798912 |
| $k_{sr}$ | 0.154964 | $f_{02}$ | 0.009066 | PSNR | 40.20362 |

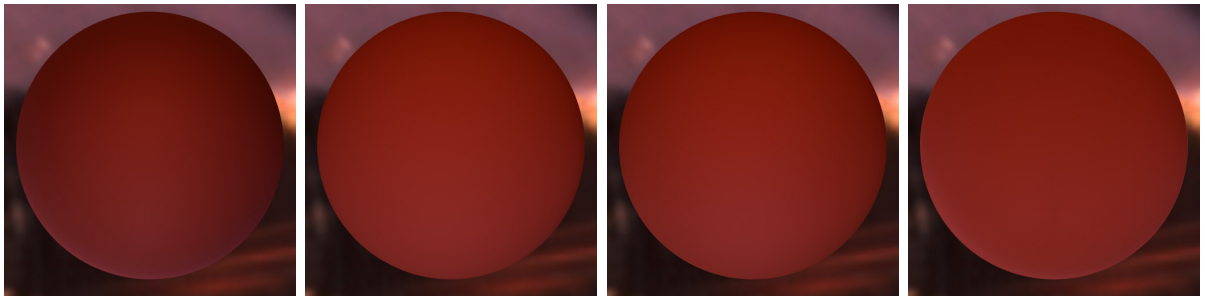
| Material Name | red-fabric2 | $k_{db}$ | 0.009904 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.008232 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.148483 | $k_{sg}$ | 0.001989 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.020137 | $k_{sb}$ | 0.001228 | PSNR | 35.30953 |

| Material Name | red-fabric2 | $k_{db}$ | 0.008044 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.009384 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.141971 | $k_{sg}$ | 0.002295 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.018512 | $k_{sb}$ | 0.001881 | PSNR | 35.18221 |

**Rendered Images**

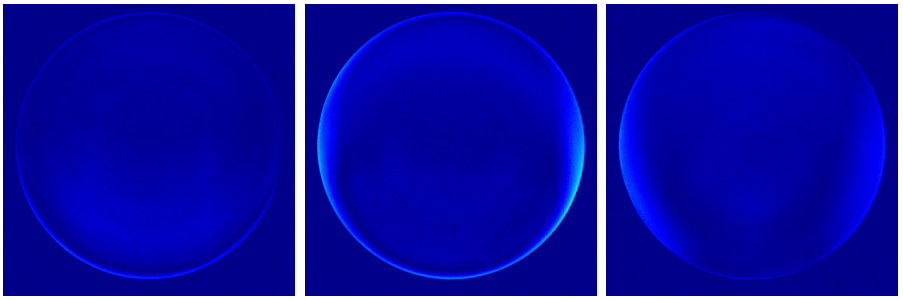


Reference image | Ashikhmin-Shirley (PSNR=42.05655) | Cook-Torrance (PSNR=38.17594) | Edwards et al. (PSNR=40.20362)

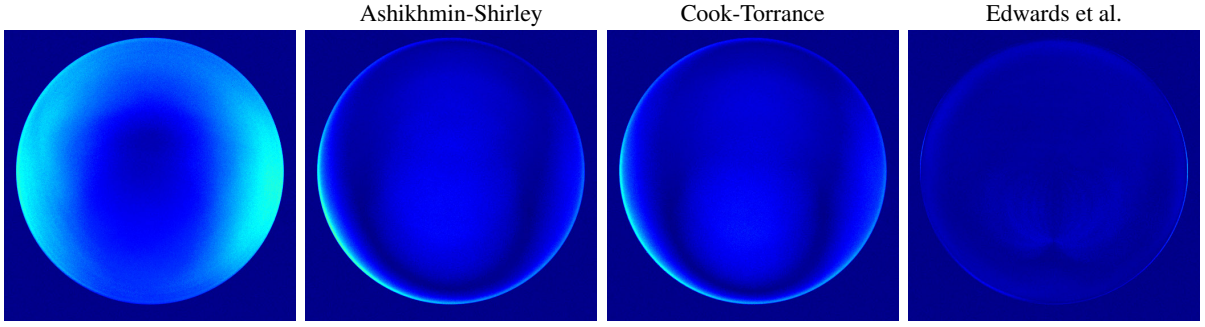


Lawrence et al. (PSNR=26.61874) | Ward (PSNR=35.30953) | Ward-Duer (PSNR=35.18221) | Our factored model (PSNR=42.53336)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: red-metallic-paint

**Fitted Parameters/PSNR**

| Material Name | red-metallic-paint | $k_{sr}$ | 0.061890 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.014382 | $n_2$ | 5267.464 |
| $k_{dr}$ | 0.085529 | $k_{sb}$ | 0.010395 | $f_{03}$ | 0.154373 |
| $k_{dg}$ | 0.010830 | $f_{01}$ | 0.039672 | $n_3$ | 111632.8 |
| $k_{db}$ | 0.004381 | $n_1$ | 309564.2 | PSNR | 22.19083 |

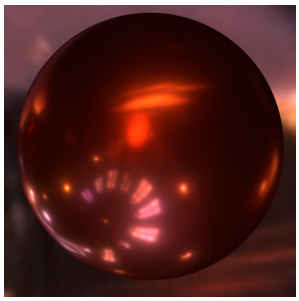
| Material Name | red-metallic-paint | $k_{sr}$ | 0.011516 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.002656 | $m_2$ | 0.015493 |
| $k_{dr}$ | 0.058910 | $k_{sb}$ | 0.001912 | $f_{03}$ | 0.218788 |
| $k_{dg}$ | 0.004818 | $f_{01}$ | 0.999999 | $m_3$ | 0.003445 |
| $k_{db}$ | 0.000099 | $m_1$ | 0.051117 | PSNR | 25.28538 |

| Material Name | red-metallic-paint | $k_{sg}$ | 0.014331 | $R_2$ | 0.180518 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.010090 | $n_2$ | 182.8884 |
| $k_{dr}$ | 0.067357 | $f_{01}$ | 0.053742 | $f_{03}$ | 0.880075 |
| $k_{dg}$ | 0.007899 | $R_1$ | 0.050528 | $R_3$ | 0.749795 |
| $k_{db}$ | 0.002633 | $n_1$ | 252.3558 | $n_3$ | 261.5811 |
| $k_{sr}$ | 0.065710 | $f_{02}$ | 0.485004 | PSNR | 23.75499 |

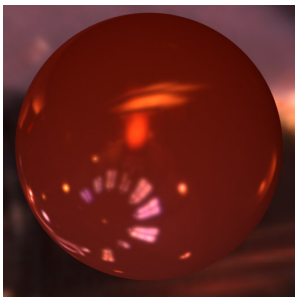
| Material Name | red-metallic-paint | $k_{db}$ | 0.006051 | $\alpha_1$ | 0.023352 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.036292 | $\alpha_2$ | 0.023352 |
| $k_{dr}$ | 0.079524 | $k_{sg}$ | 0.007331 | $\alpha_3$ | 0.006499 |
| $k_{dg}$ | 0.011813 | $k_{sb}$ | 0.004855 | PSNR | 22.46231 |

| Material Name | red-metallic-paint | $k_{db}$ | 0.005487 | $\alpha_1$ | 0.022218 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.023218 | $\alpha_2$ | 0.022218 |
| $k_{dr}$ | 0.090376 | $k_{sg}$ | 0.005306 | $\alpha_3$ | 0.005716 |
| $k_{dg}$ | 0.012216 | $k_{sb}$ | 0.003799 | PSNR | 21.74726 |

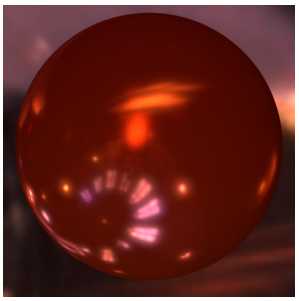
**Rendered Images**



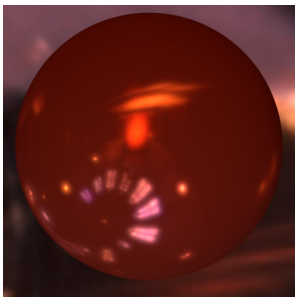
Reference image



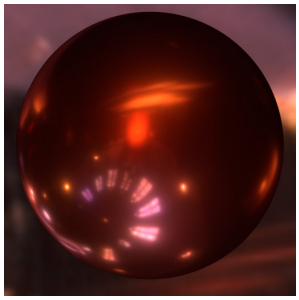
Ashikhmin-Shirley
(PSNR=22.19083)



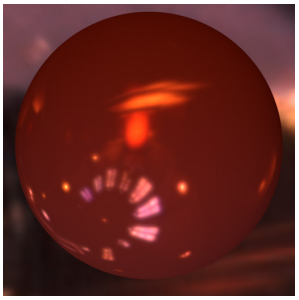
Cook-Torrance
(PSNR=25.28538)



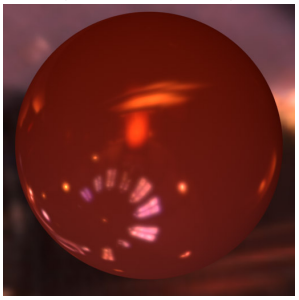
Edwards et al.
(PSNR=23.75499)



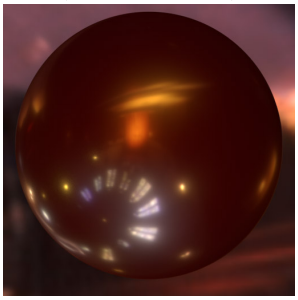
Lawrence et al.
(PSNR=36.44042)



Ward
(PSNR=22.46231)

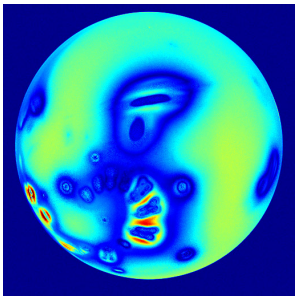


Ward-Duer
(PSNR=21.74726)

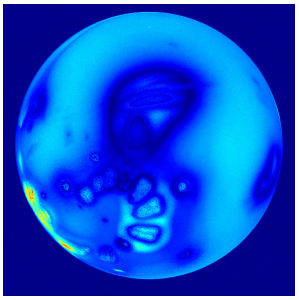


Our factored model
(PSNR=26.53240)

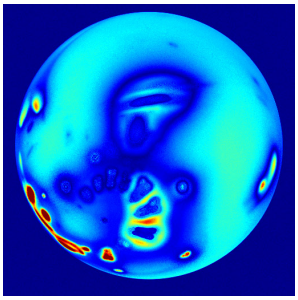
**Difference Images**



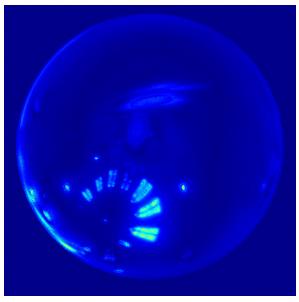
Ashikhmin-Shirley



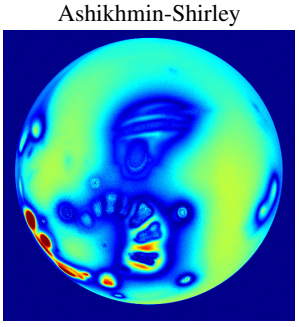
Cook-Torrance



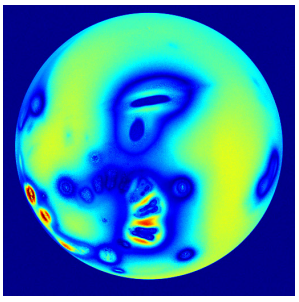
Edwards et al.



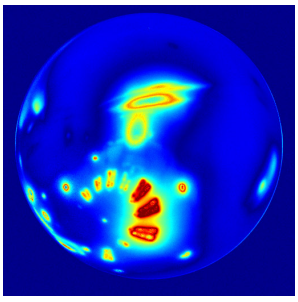
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: red-phenolic

**Fitted Parameters/PSNR**

| Material Name | red-phenolic | $k_{sr}$ | 0.039386 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.041647 | $n_2$ | 3186.436 |
| $k_{dr}$ | 0.171194 | $k_{sb}$ | 0.040031 | $f_{03}$ | 0.165596 |
| $k_{dg}$ | 0.027763 | $f_{01}$ | 0.121721 | $n_3$ | 1007.696 |
| $k_{db}$ | 0.012882 | $n_1$ | 15866.18 | PSNR | 34.98475 |

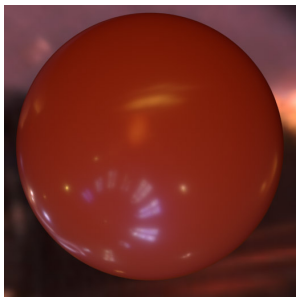
| Material Name | red-phenolic | $k_{sr}$ | 0.009336 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.009875 | $m_2$ | 0.025360 |
| $k_{dr}$ | 0.171500 | $k_{sb}$ | 0.009493 | $f_{03}$ | 0.120764 |
| $k_{dg}$ | 0.028083 | $f_{01}$ | 0.168969 | $m_3$ | 0.010752 |
| $k_{db}$ | 0.013189 | $m_1$ | 0.040980 | PSNR | 34.68129 |

| Material Name | red-phenolic | $k_{sg}$ | 0.064849 | $R_2$ | 0.157264 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.062803 | $n_2$ | 101.9483 |
| $k_{dr}$ | 0.171199 | $f_{01}$ | 0.007821 | $f_{03}$ | 0.113945 |
| $k_{dg}$ | 0.027961 | $R_1$ | 0.137743 | $R_3$ | 0.888090 |
| $k_{db}$ | 0.012983 | $n_1$ | 499.9519 | $n_3$ | 253.0008 |
| $k_{sr}$ | 0.062280 | $f_{02}$ | 0.042900 | PSNR | 33.69877 |

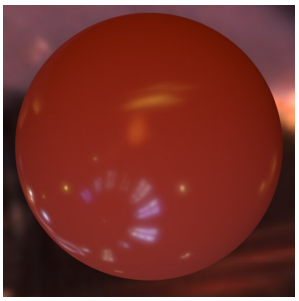
| Material Name | red-phenolic | $k_{db}$ | 0.009212 | $\alpha_1$ | 0.028790 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.007842 | $\alpha_2$ | 0.076738 |
| $k_{dr}$ | 0.166542 | $k_{sg}$ | 0.007545 | $\alpha_3$ | 0.010820 |
| $k_{dg}$ | 0.024424 | $k_{sb}$ | 0.007470 | PSNR | 33.71264 |

| Material Name | red-phenolic | $k_{db}$ | 0.006843 | $\alpha_1$ | 0.029078 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.006534 | $\alpha_2$ | 0.083077 |
| $k_{dr}$ | 0.164555 | $k_{sg}$ | 0.006522 | $\alpha_3$ | 0.010923 |
| $k_{dg}$ | 0.021844 | $k_{sb}$ | 0.006392 | PSNR | 35.48158 |

**Rendered Images**



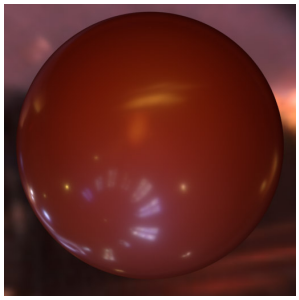
Reference image



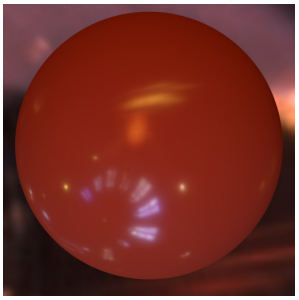
Ashikhmin-Shirley
(PSNR=34.98475)

Cook-Torrance
(PSNR=34.68129)

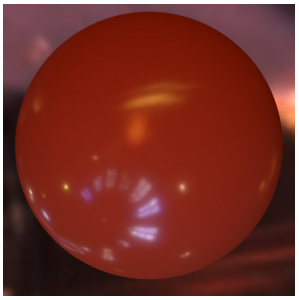
Edwards et al.
(PSNR=33.69877)



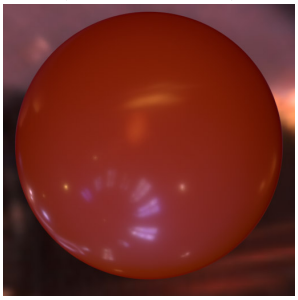
Lawrence et al.
(PSNR=25.48256)



Ward
(PSNR=33.71264)

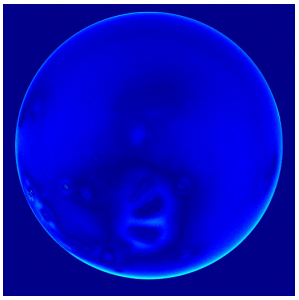


Ward-Duer
(PSNR=35.48158)

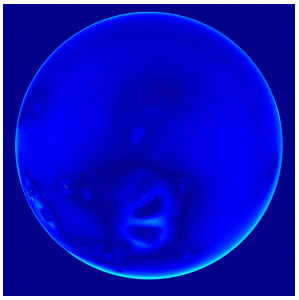


Our factored model
(PSNR=36.76010)

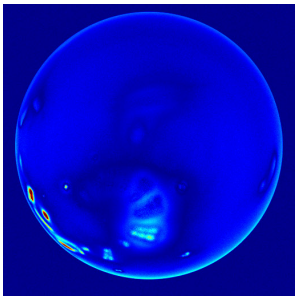
**Difference Images**



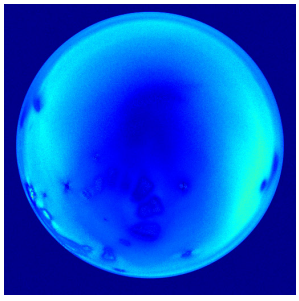
Ashikhmin-Shirley



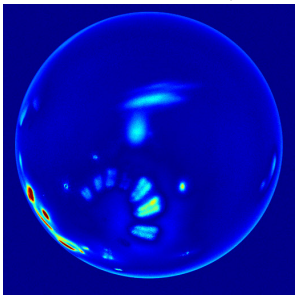
Cook-Torrance



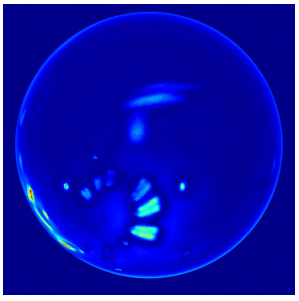
Edwards et al.



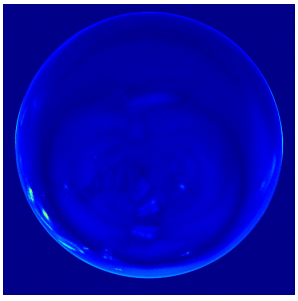
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: red-plastic

**Fitted Parameters/PSNR**

| Material Name | red-plastic | $k_{sr}$ | 0.156103 | $f_{02}$ | 0.518786 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.147194 | $n_2$ | 0.524851 |
| $k_{dr}$ | 0.248736 | $k_{sb}$ | 0.144891 | $f_{03}$ | 0.123708 |
| $k_{dg}$ | 0.029997 | $f_{01}$ | 0 | $n_3$ | 32.80325 |
| $k_{db}$ | 0 | $n_1$ | 16.12819 | PSNR | 36.58667 |

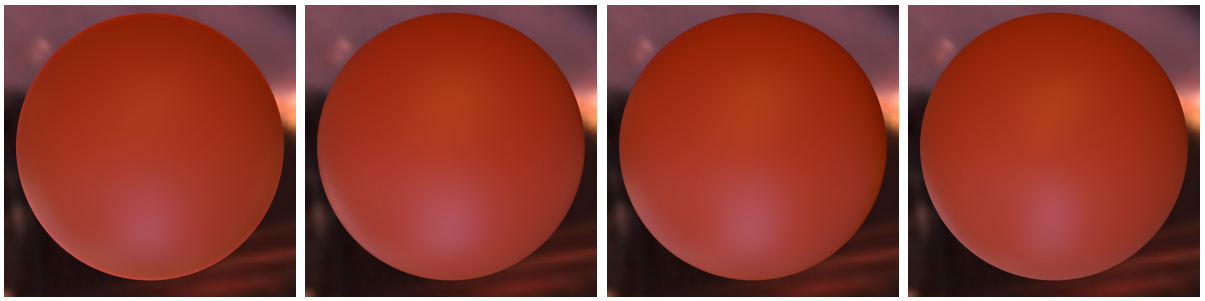
| Material Name | red-plastic | $k_{sr}$ | 0.026967 | $f_{02}$ | 0.120149 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.025339 | $m_2$ | 0.210137 |
| $k_{dr}$ | 0.250462 | $k_{sb}$ | 0.024928 | $f_{03}$ | 0.237793 |
| $k_{dg}$ | 0.031743 | $f_{01}$ | 0.067837 | $m_3$ | 0.999999 |
| $k_{db}$ | 0 | $m_1$ | 0.359196 | PSNR | 36.24502 |

| Material Name | red-plastic | $k_{sg}$ | 0.129747 | $R_2$ | 3.048692 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.127470 | $n_2$ | 99.98641 |
| $k_{dr}$ | 0.264586 | $f_{01}$ | 0 | $f_{03}$ | 0.108895 |
| $k_{dg}$ | 0.045090 | $R_1$ | 2.511239 | $R_3$ | 3.533595 |
| $k_{db}$ | 0.012181 | $n_1$ | 499.9980 | $n_3$ | 9.885275 |
| $k_{sr}$ | 0.138603 | $f_{02}$ | 0.085120 | PSNR | 36.65945 |

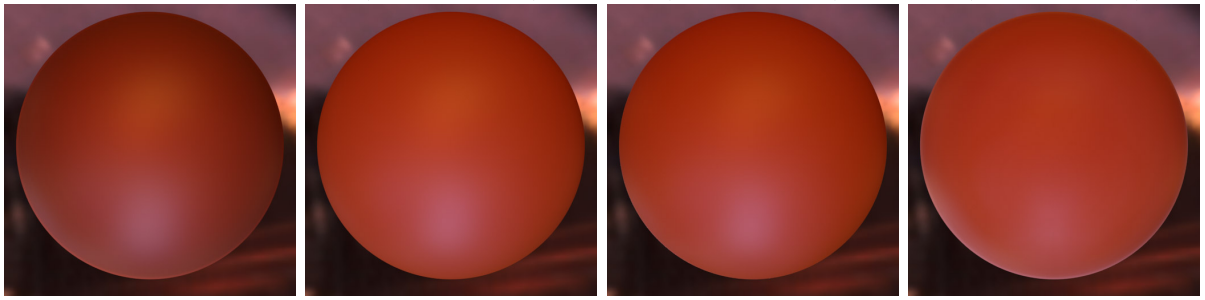
| Material Name | red-plastic | $k_{db}$ | 0.006736 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.017549 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.259568 | $k_{sg}$ | 0.016634 | $\alpha_3$ | 0.191674 |
| $k_{dg}$ | 0.040080 | $k_{sb}$ | 0.016687 | PSNR | 31.09829 |

| Material Name | red-plastic | $k_{db}$ | 0.003764 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.014488 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.255761 | $k_{sg}$ | 0.013600 | $\alpha_3$ | 0.190541 |
| $k_{dg}$ | 0.036751 | $k_{sb}$ | 0.013468 | PSNR | 32.06482 |

**Rendered Images**

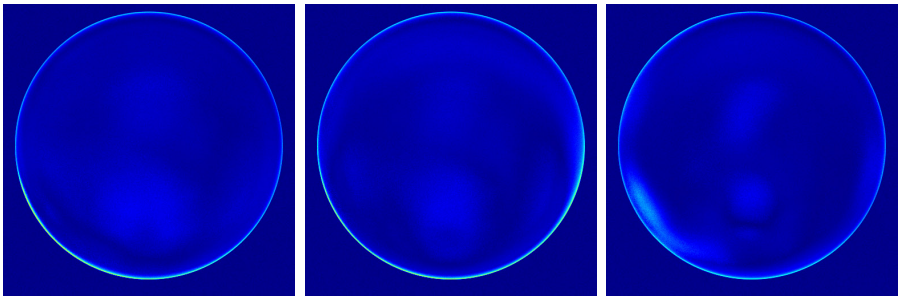


Reference image | Ashikhmin-Shirley (PSNR=36.58667) | Cook-Torrance (PSNR=36.24502) | Edwards et al. (PSNR=36.65945)

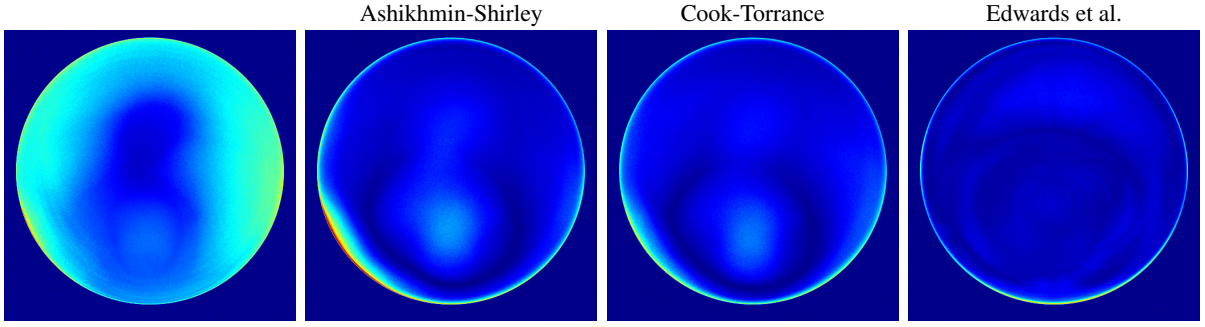


Lawrence et al. (PSNR=24.08890) | Ward (PSNR=31.09829) | Ward-Duer (PSNR=32.06482) | Our factored model (PSNR=35.54471)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: red-specular-plastic

**Fitted Parameters/PSNR**

| Material Name | red-specular-plastic | $k_{sr}$ | 0.049770 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.045225 | $n_2$ | 3474.096 |
| $k_{dr}$ | 0.251459 | $k_{sb}$ | 0.053212 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.037842 | $f_{01}$ | 0.143568 | $n_3$ | 3501.405 |
| $k_{db}$ | 0.015977 | $n_1$ | 17316.47 | PSNR | 36.07175 |

| Material Name | red-specular-plastic | $k_{sr}$ | 0.012144 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.011041 | $m_2$ | 0.023899 |
| $k_{dr}$ | 0.251516 | $k_{sb}$ | 0.013006 | $f_{03}$ | 0.144965 |
| $k_{dg}$ | 0.037888 | $f_{01}$ | 0 | $m_3$ | 0.010608 |
| $k_{db}$ | 0.016021 | $m_1$ | 0.023899 | PSNR | 36.02971 |

| Material Name | red-specular-plastic | $k_{sg}$ | 0.057529 | $R_2$ | 0.010993 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.068347 | $n_2$ | 0.454297 |
| $k_{dr}$ | 0.253580 | $f_{01}$ | 0.036749 | $f_{03}$ | 0.029750 |
| $k_{dg}$ | 0.039671 | $R_1$ | 0.139094 | $R_3$ | 0.555577 |
| $k_{db}$ | 0.018061 | $n_1$ | 500.0000 | $n_3$ | 916.0000 |
| $k_{sr}$ | 0.062267 | $f_{02}$ | 0 | PSNR | 33.82495 |

| Material Name | red-specular-plastic | $k_{db}$ | 0.018494 | $\alpha_1$ | 0.012977 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.003004 | $\alpha_2$ | 0.012977 |
| $k_{dr}$ | 0.253348 | $k_{sg}$ | 0.003046 | $\alpha_3$ | 0.003483 |
| $k_{dg}$ | 0.038854 | $k_{sb}$ | 0.002988 | PSNR | 32.96679 |

| Material Name | red-specular-plastic | $k_{db}$ | 0.004899 | $\alpha_1$ | 0.111734 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.007000 | $\alpha_2$ | 0.019914 |
| $k_{dr}$ | 0.240270 | $k_{sg}$ | 0.006378 | $\alpha_3$ | 0.009068 |
| $k_{dg}$ | 0.027625 | $k_{sb}$ | 0.007170 | PSNR | 30.33861 |

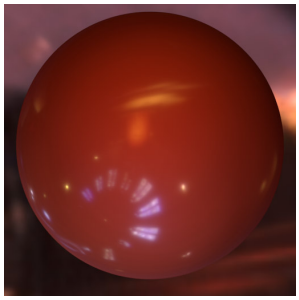
**Rendered Images**

Reference image

Ashikhmin-Shirley
(PSNR=36.07175)

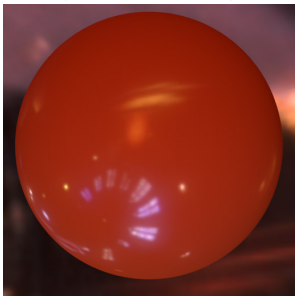
Cook-Torrance
(PSNR=36.02971)

Edwards et al.
(PSNR=33.82495)



Lawrence et al.
(PSNR=23.00942)

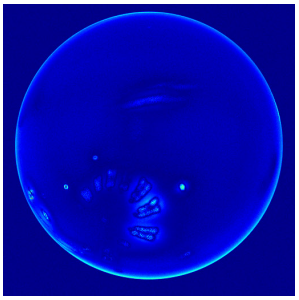
Ward
(PSNR=32.96679)



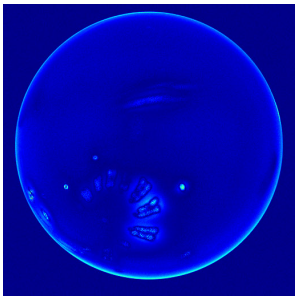
Ward-Duer
(PSNR=30.33861)

Our factored model
(PSNR=35.67335)

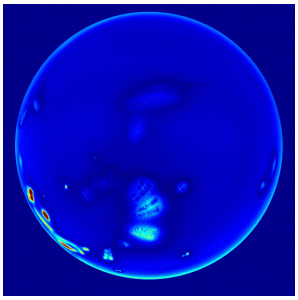
**Difference Images**



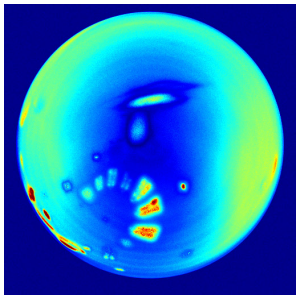
Ashikhmin-Shirley



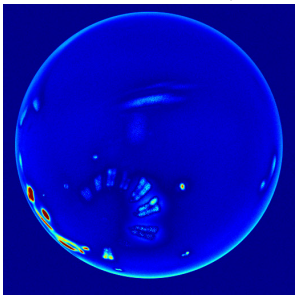
Cook-Torrance



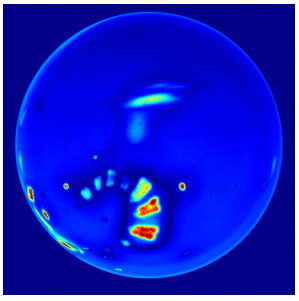
Edwards et al.



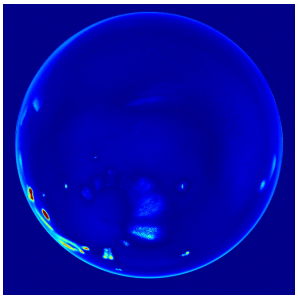
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: silicon-nitrade

**Fitted Parameters/PSNR**

| Material Name | silicon-nitrade | $k_{sr}$ | 0.056899 | $f_{02}$ | 0.152604 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.052006 | $n_2$ | 13687.55 |
| $k_{dr}$ | 0.011134 | $k_{sb}$ | 0.062899 | $f_{03}$ | 0.098223 |
| $k_{dg}$ | 0.009836 | $f_{01}$ | 0.048446 | $n_3$ | 2457.033 |
| $k_{db}$ | 0.007751 | $n_1$ | 235633.4 | PSNR | 34.13769 |

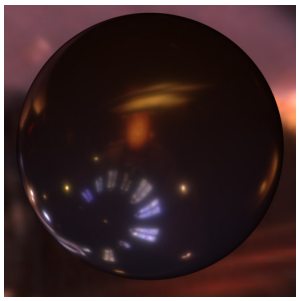
| Material Name | silicon-nitrade | $k_{sr}$ | 0.013807 | $f_{02}$ | 0.049516 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.012620 | $m_2$ | 0.002903 |
| $k_{dr}$ | 0.010984 | $k_{sb}$ | 0.015257 | $f_{03}$ | 0.104268 |
| $k_{dg}$ | 0.009699 | $f_{01}$ | 0.155016 | $m_3$ | 0.028850 |
| $k_{db}$ | 0.007594 | $m_1$ | 0.011917 | PSNR | 34.32620 |

| Material Name | silicon-nitrade | $k_{sg}$ | 0.052751 | $R_2$ | 0.014349 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.062859 | $n_2$ | 0.648353 |
| $k_{dr}$ | 0.013824 | $f_{01}$ | 0.055205 | $f_{03}$ | 0.147951 |
| $k_{dg}$ | 0.012211 | $R_1$ | 0.111649 | $R_3$ | 0.371845 |
| $k_{db}$ | 0.010872 | $n_1$ | 519.6750 | $n_3$ | 243.3520 |
| $k_{sr}$ | 0.057364 | $f_{02}$ | 0.028320 | PSNR | 29.57482 |

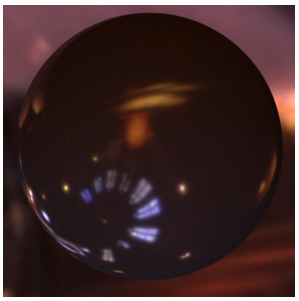
| Material Name | silicon-nitrade | $k_{db}$ | 0.010467 | $\alpha_1$ | 0.015012 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.006894 | $\alpha_2$ | 0.015012 |
| $k_{dr}$ | 0.013790 | $k_{sg}$ | 0.005972 | $\alpha_3$ | 0.004270 |
| $k_{dg}$ | 0.012992 | $k_{sb}$ | 0.007721 | PSNR | 29.23228 |

| Material Name | silicon-nitrade | $k_{db}$ | 0.006954 | $\alpha_1$ | 0.017544 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.006827 | $\alpha_2$ | 0.017544 |
| $k_{dr}$ | 0.009151 | $k_{sg}$ | 0.006046 | $\alpha_3$ | 0.005422 |
| $k_{dg}$ | 0.008589 | $k_{sb}$ | 0.007068 | PSNR | 33.56268 |

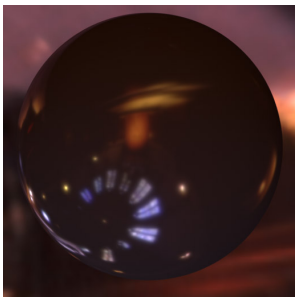
**Rendered Images**



Reference image

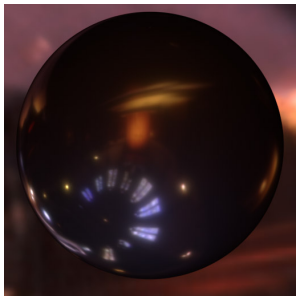


Ashikhmin-Shirley
(PSNR=34.13769)



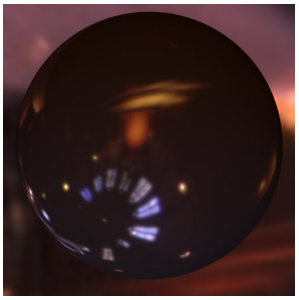
Cook-Torrance
(PSNR=34.32620)

Edwards et al.
(PSNR=29.57482)

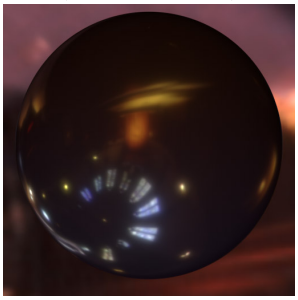


Lawrence et al.
(PSNR=36.00485)

Ward
(PSNR=29.23228)

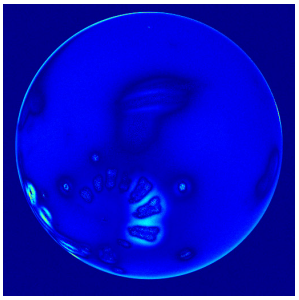


Ward-Duer
(PSNR=33.56268)

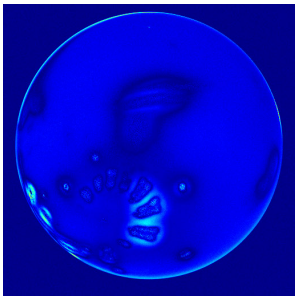


Our factored model
(PSNR=39.04593)

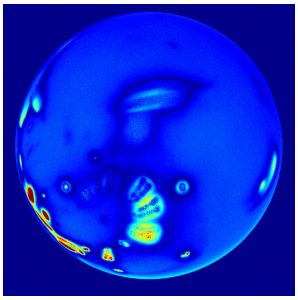
**Difference Images**



Ashikhmin-Shirley

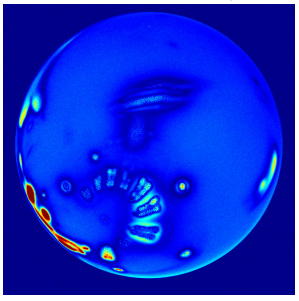


Cook-Torrance

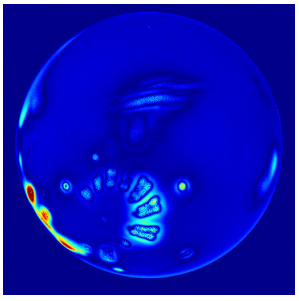


Edwards et al.

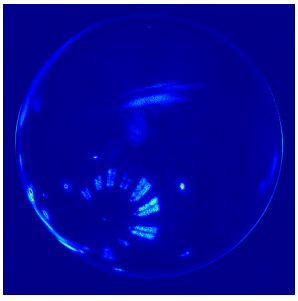
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: silver-metallic-paint

**Fitted Parameters/PSNR**

| Material Name | silver-metallic-paint | $k_{sr}$ | 0.091924 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.089731 | $n_2$ | 22.75560 |
| $k_{dr}$ | 0.016297 | $k_{sb}$ | 0.087377 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.019521 | $f_{01}$ | 0.999999 | $n_3$ | 9.184020 |
| $k_{db}$ | 0.022676 | $n_1$ | 72.54202 | PSNR | 29.28145 |

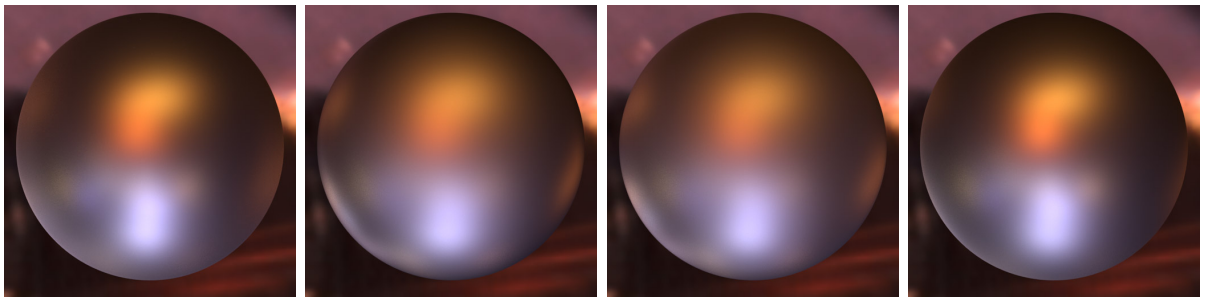
| Material Name | silver-metallic-paint | $k_{sr}$ | 0.016900 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.016503 | $m_2$ | 0.355538 |
| $k_{dr}$ | 0.032687 | $k_{sb}$ | 0.016075 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.035455 | $f_{01}$ | 0.999999 | $m_3$ | 0.261117 |
| $k_{db}$ | 0.038136 | $m_1$ | 0.146418 | PSNR | 28.90073 |

| Material Name | silver-metallic-paint | $k_{sg}$ | 0.271490 | $R_2$ | 4.787585 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.263952 | $n_2$ | 49.73169 |
| $k_{dr}$ | 0.012914 | $f_{01}$ | 0.496209 | $f_{03}$ | 0.152723 |
| $k_{dg}$ | 0.016648 | $R_1$ | 3.358015 | $R_3$ | 0.898946 |
| $k_{db}$ | 0.020183 | $n_1$ | 100.0634 | $n_3$ | 23.56284 |
| $k_{sr}$ | 0.278724 | $f_{02}$ | 0.254880 | PSNR | 32.36117 |

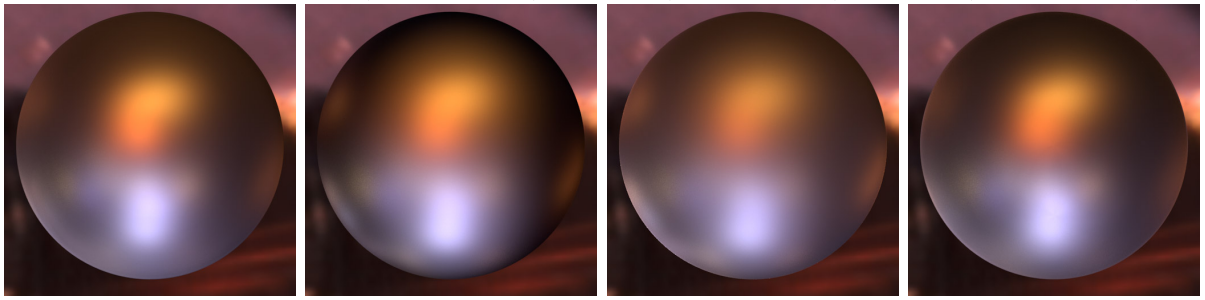
| Material Name | silver-metallic-paint | $k_{db}$ | 0.002031 | $\alpha_1$ | 0.149522 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.134204 | $\alpha_2$ | 0.307786 |
| $k_{dr}$ | 0 | $k_{sg}$ | 0.130665 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0 | $k_{sb}$ | 0.127065 | PSNR | 25.37267 |

| Material Name | silver-metallic-paint | $k_{db}$ | 0.038383 | $\alpha_1$ | 0.301423 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.077477 | $\alpha_2$ | 0.153490 |
| $k_{dr}$ | 0.032950 | $k_{sg}$ | 0.075656 | $\alpha_3$ | 0.388420 |
| $k_{dg}$ | 0.035711 | $k_{sb}$ | 0.073696 | PSNR | 28.91011 |

**Rendered Images**

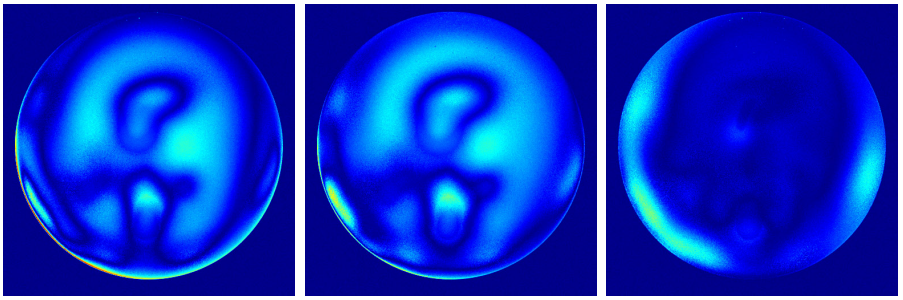


Reference image | Ashikhmin-Shirley (PSNR=29.28145) | Cook-Torrance (PSNR=28.90073) | Edwards et al. (PSNR=32.36117)

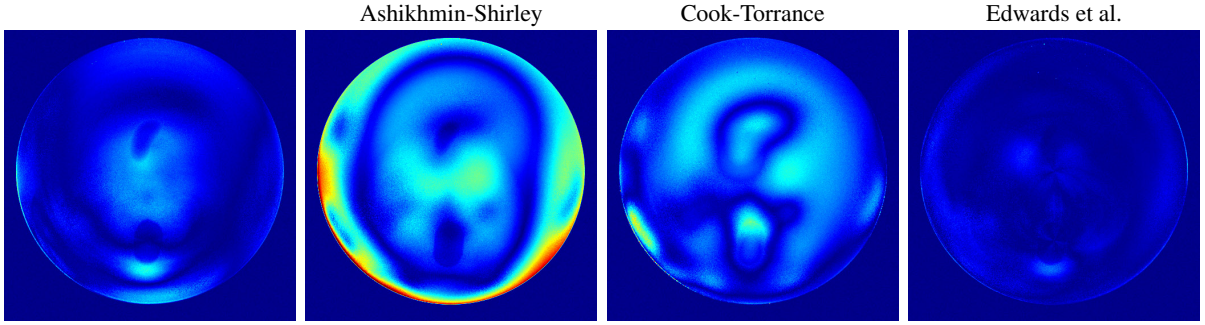


Lawrence et al. (PSNR=33.19018) | Ward (PSNR=25.37267) | Ward-Duer (PSNR=28.91011) | Our factored model (PSNR=40.19101)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: silver-metallic-paint2

**Fitted Parameters/PSNR**

| Material Name | silver-metallic-paint2 | $k_{sr}$ | 0.122624 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.111092 | $n_2$ | 5.820300 |
| $k_{dr}$ | 0.058936 | $k_{sb}$ | 0.099167 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.067302 | $f_{01}$ | 0.999999 | $n_3$ | 40.94256 |
| $k_{db}$ | 0.071773 | $n_1$ | 5.812319 | PSNR | 28.07273 |

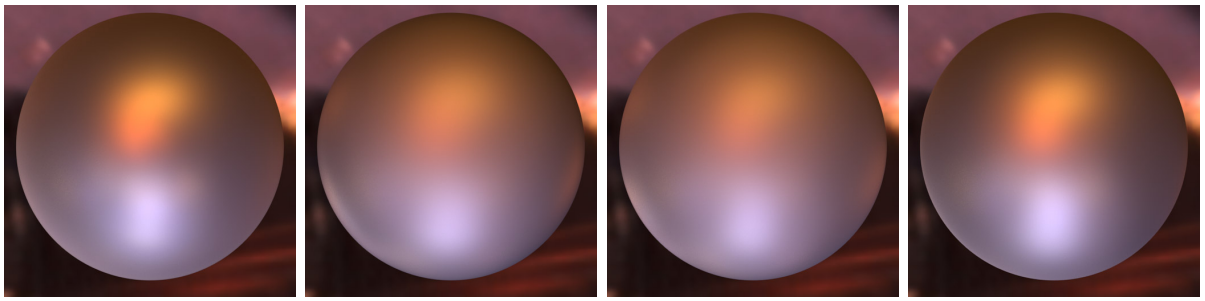
| Material Name | silver-metallic-paint2 | $k_{sr}$ | 0.018133 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.016420 | $m_2$ | 0.404201 |
| $k_{dr}$ | 0.097089 | $k_{sb}$ | 0.014635 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.101948 | $f_{01}$ | 0.999999 | $m_3$ | 0.404203 |
| $k_{db}$ | 0.102943 | $m_1$ | 0.177151 | PSNR | 27.41462 |

| Material Name | silver-metallic-paint2 | $k_{sg}$ | 0.284710 | $R_2$ | 2.141420 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.253567 | $n_2$ | 52.18945 |
| $k_{dr}$ | 0.066305 | $f_{01}$ | 0 | $f_{03}$ | 0.526807 |
| $k_{dg}$ | 0.074152 | $R_1$ | 8.770264 | $R_3$ | 1.261208 |
| $k_{db}$ | 0.078302 | $n_1$ | 99.91576 | $n_3$ | 2.688858 |
| $k_{sr}$ | 0.314536 | $f_{02}$ | 0.395126 | PSNR | 32.31536 |

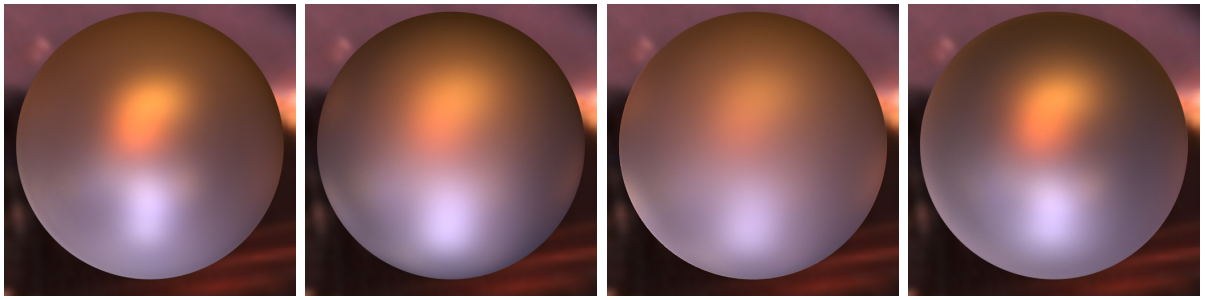
| Material Name | silver-metallic-paint2 | $k_{db}$ | 0.072513 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.152929 | $\alpha_2$ | 0.187354 |
| $k_{dr}$ | 0.058493 | $k_{sg}$ | 0.138386 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.067144 | $k_{sb}$ | 0.122951 | PSNR | 27.85402 |

| Material Name | silver-metallic-paint2 | $k_{db}$ | 0.103148 | $\alpha_1$ | 0.494716 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.091952 | $\alpha_2$ | 0.196634 |
| $k_{dr}$ | 0.097363 | $k_{sg}$ | 0.083247 | $\alpha_3$ | 0.494716 |
| $k_{dg}$ | 0.102235 | $k_{sb}$ | 0.074219 | PSNR | 27.31564 |

**Rendered Images**

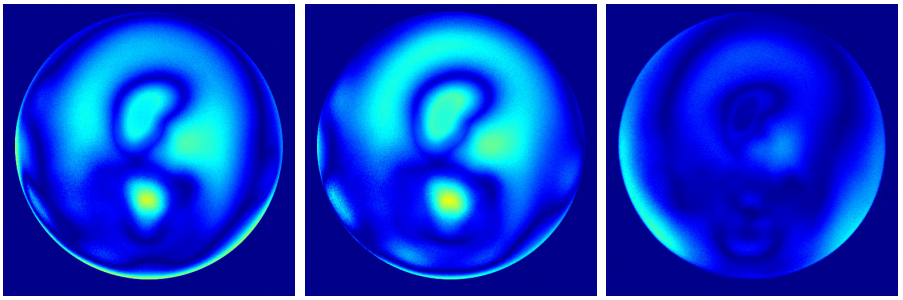


Reference image | Ashikhmin-Shirley (PSNR=28.07273) | Cook-Torrance (PSNR=27.41462) | Edwards et al. (PSNR=32.31536)

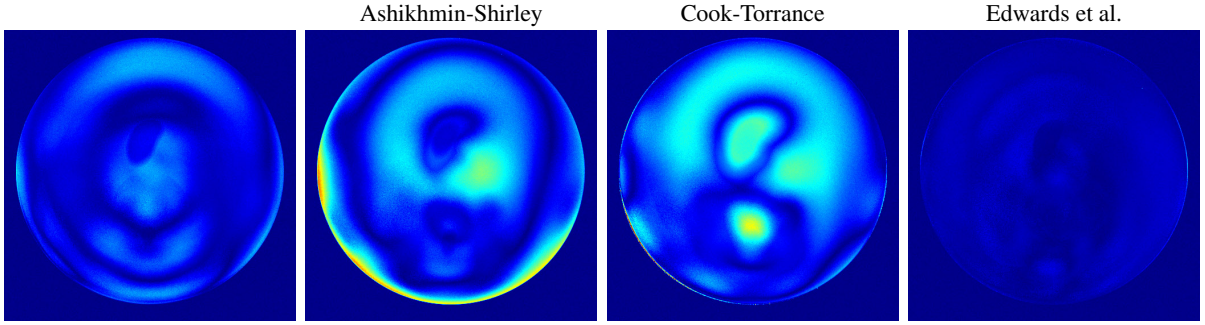


Lawrence et al. (PSNR=31.72300) | Ward (PSNR=27.85402) | Ward-Duer (PSNR=27.31564) | Our factored model (PSNR=41.20795)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: silver-paint

**Fitted Parameters/PSNR**

| Material Name | silver-paint | $k_{sr}$ | 0.059170 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.062168 | $n_2$ | 17.86136 |
| $k_{dr}$ | 0.167442 | $k_{sb}$ | 0.064315 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.134762 | $f_{01}$ | 0.512456 | $n_3$ | 17.86125 |
| $k_{db}$ | 0.115561 | $n_1$ | 93.04757 | PSNR | 36.88697 |

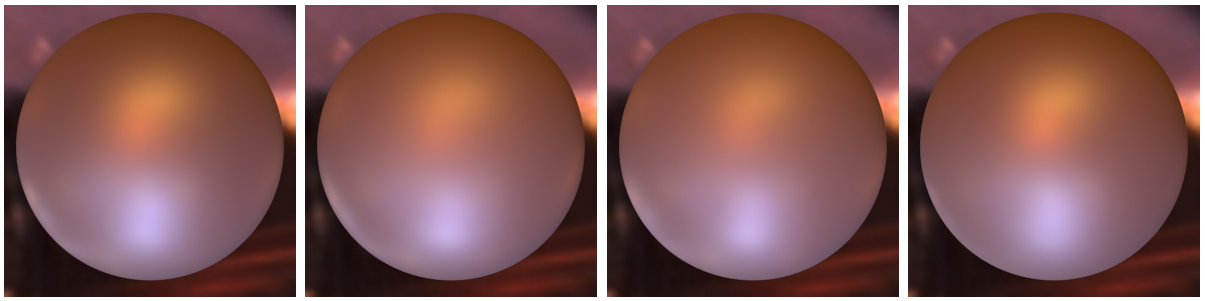
| Material Name | silver-paint | $k_{sr}$ | 0.009774 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.010268 | $m_2$ | 0.314097 |
| $k_{dr}$ | 0.175427 | $k_{sb}$ | 0.010625 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.143158 | $f_{01}$ | 0.858273 | $m_3$ | 0.314097 |
| $k_{db}$ | 0.124225 | $m_1$ | 0.141890 | PSNR | 35.64947 |

| Material Name | silver-paint | $k_{sg}$ | 0.144068 | $R_2$ | 1.678903 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.148857 | $n_2$ | 80.33218 |
| $k_{dr}$ | 0.161489 | $f_{01}$ | 0 | $f_{03}$ | 0.932868 |
| $k_{dg}$ | 0.128676 | $R_1$ | 1.370046 | $R_3$ | 5.313245 |
| $k_{db}$ | 0.109422 | $n_1$ | 500.8404 | $n_3$ | 128.0219 |
| $k_{sr}$ | 0.137312 | $f_{02}$ | 0.136622 | PSNR | 37.88355 |

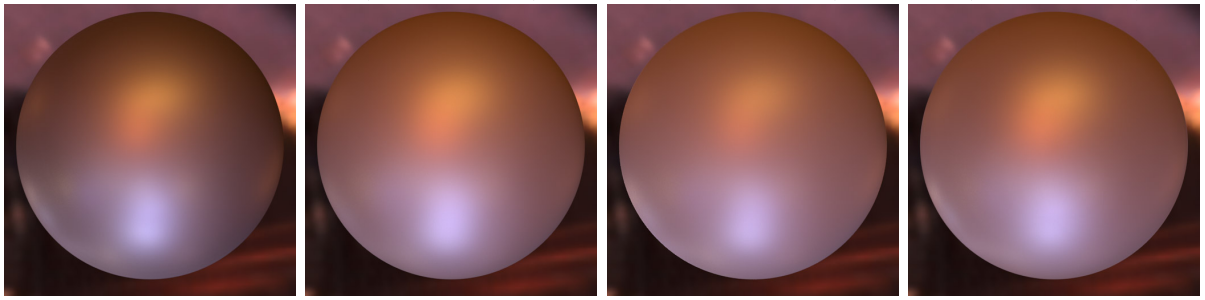
| Material Name | silver-paint | $k_{db}$ | 0.093800 | $\alpha_1$ | 0.172096 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.081153 | $\alpha_2$ | 0.399510 |
| $k_{dr}$ | 0.147882 | $k_{sg}$ | 0.085441 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.113930 | $k_{sb}$ | 0.088523 | PSNR | 33.55577 |

| Material Name | silver-paint | $k_{db}$ | 0.124463 | $\alpha_1$ | 0.361860 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.043146 | $\alpha_2$ | 0.156735 |
| $k_{dr}$ | 0.175738 | $k_{sg}$ | 0.045341 | $\alpha_3$ | 0.361860 |
| $k_{dg}$ | 0.143456 | $k_{sb}$ | 0.046946 | PSNR | 34.97818 |

**Rendered Images**

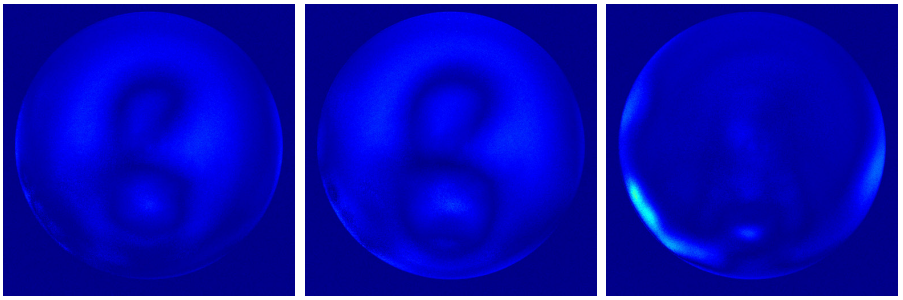


Reference image | Ashikhmin-Shirley (PSNR=36.88697) | Cook-Torrance (PSNR=35.64947) | Edwards et al. (PSNR=37.88355)

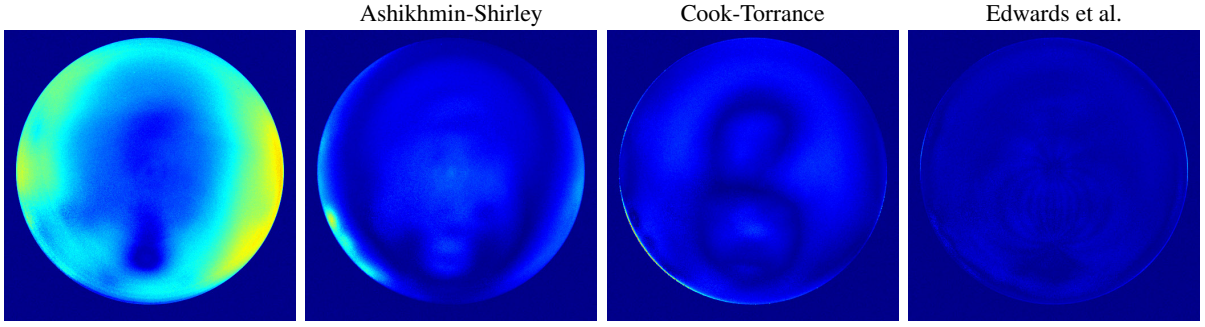


Lawrence et al. (PSNR=24.66625) | Ward (PSNR=33.55577) | Ward-Duer (PSNR=34.97818) | Our factored model (PSNR=40.68171)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: special-walnut-224

**Fitted Parameters/PSNR**

| Material Name | special-walnut-224 | $k_{sr}$ | 0.106392 | $f_{02}$ | 0.035049 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.104621 | $n_2$ | 20.70126 |
| $k_{dr}$ | 0.002930 | $k_{sb}$ | 0.101817 | $f_{03}$ | 0.132924 |
| $k_{dg}$ | 0 | $f_{01}$ | 0.188244 | $n_3$ | 33.47745 |
| $k_{db}$ | 0 | $n_1$ | 1.927020 | PSNR | 40.11623 |

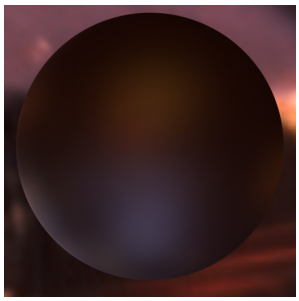
| Material Name | special-walnut-224 | $k_{sr}$ | 0.019815 | $f_{02}$ | 0.115066 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.019499 | $m_2$ | 0.201308 |
| $k_{dr}$ | 0.003348 | $k_{sb}$ | 0.018984 | $f_{03}$ | 0.118698 |
| $k_{dg}$ | 0.000100 | $f_{01}$ | 0.086051 | $m_3$ | 0.355971 |
| $k_{db}$ | 0 | $m_1$ | 0.999999 | PSNR | 42.32601 |

| Material Name | special-walnut-224 | $k_{sg}$ | 0.076480 | $R_2$ | 2.042332 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.074487 | $n_2$ | 99.91798 |
| $k_{dr}$ | 0.009970 | $f_{01}$ | 0 | $f_{03}$ | 0.189262 |
| $k_{dg}$ | 0.006623 | $R_1$ | 2.196324 | $R_3$ | 1.713432 |
| $k_{db}$ | 0.005228 | $n_1$ | 500.0023 | $n_3$ | 15.02263 |
| $k_{sr}$ | 0.077749 | $f_{02}$ | 0.020783 | PSNR | 38.11719 |

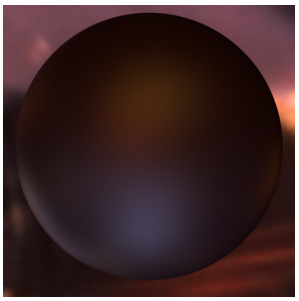
| Material Name | special-walnut-224 | $k_{db}$ | 0 | $\alpha_1$ | 0.197583 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.015638 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.001868 | $k_{sg}$ | 0.015392 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0 | $k_{sb}$ | 0.015159 | PSNR | 29.65252 |

| Material Name | special-walnut-224 | $k_{db}$ | 0 | $\alpha_1$ | 0.401023 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.010907 | $\alpha_2$ | 0.187664 |
| $k_{dr}$ | 0.001734 | $k_{sg}$ | 0.010745 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0 | $k_{sb}$ | 0.010517 | PSNR | 32.78541 |

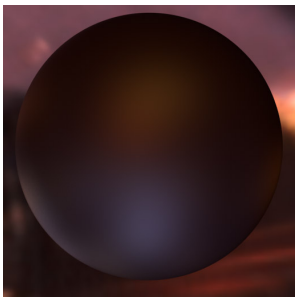
**Rendered Images**



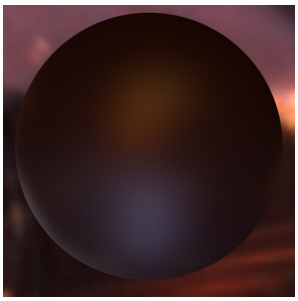
Reference image



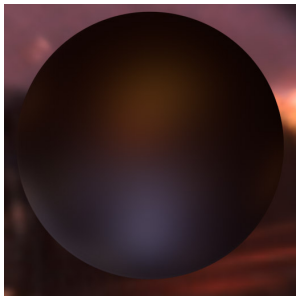
Ashikhmin-Shirley
(PSNR=40.11623)



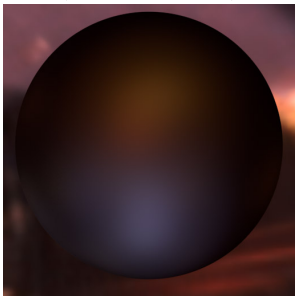
Cook-Torrance
(PSNR=42.32601)



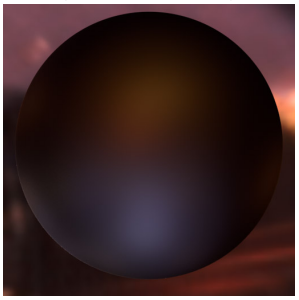
Edwards et al.
(PSNR=38.11719)



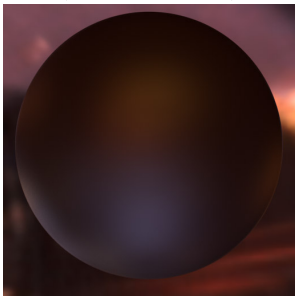
Lawrence et al.
(PSNR=36.35173)



Ward
(PSNR=29.65252)

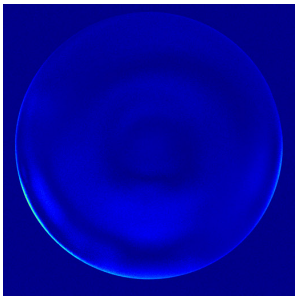


Ward-Duer
(PSNR=32.78541)

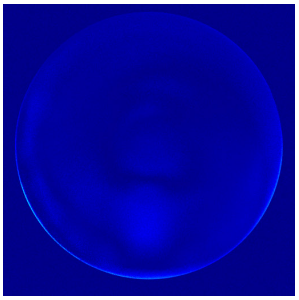


Our factored model
(PSNR=46.04748)

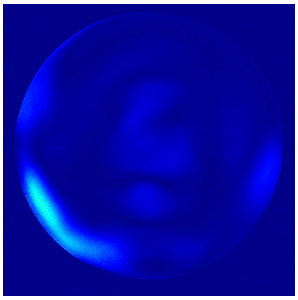
**Difference Images**



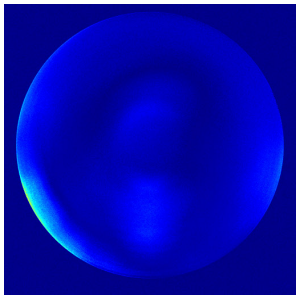
Ashikhmin-Shirley



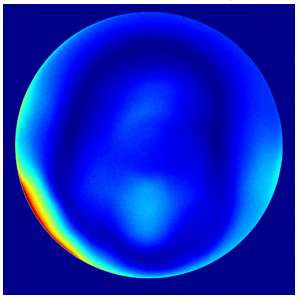
Cook-Torrance



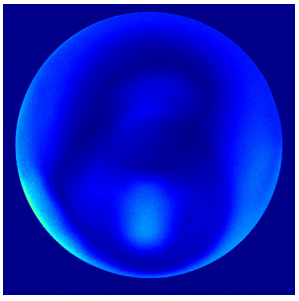
Edwards et al.



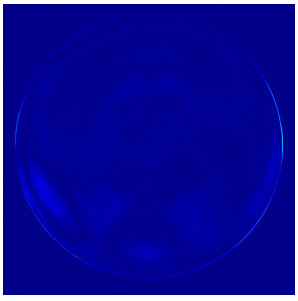
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: specular-black-phenolic

**Fitted Parameters/PSNR**

| Material Name | specular-black-phenolic | $k_{sr}$ | 0.062473 | $f_{02}$ | 0.002599 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.060293 | $n_2$ | 3240.099 |
| $k_{dr}$ | 0.004024 | $k_{sb}$ | 0.071455 | $f_{03}$ | 0.080984 |
| $k_{dg}$ | 0.003599 | $f_{01}$ | 0.023351 | $n_3$ | 12546.83 |
| $k_{db}$ | 0.003973 | $n_1$ | 304278.5 | PSNR | 35.52319 |

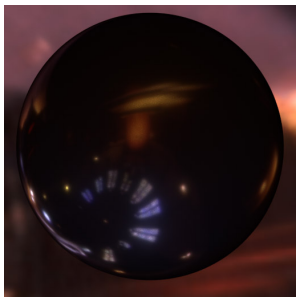
| Material Name | specular-black-phenolic | $k_{sr}$ | 0.015216 | $f_{02}$ | 0.080370 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.014681 | $m_2$ | 0.012396 |
| $k_{dr}$ | 0.003929 | $k_{sb}$ | 0.017400 | $f_{03}$ | 0.023907 |
| $k_{dg}$ | 0.003511 | $f_{01}$ | 0.006646 | $m_3$ | 0.002560 |
| $k_{db}$ | 0.003867 | $m_1$ | 0.025354 | PSNR | 35.71550 |

| Material Name | specular-black-phenolic | $k_{sg}$ | 0.046727 | $R_2$ | 0.014028 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.055835 | $n_2$ | 0.923238 |
| $k_{dr}$ | 0.004896 | $f_{01}$ | 0.034762 | $f_{03}$ | 0.078320 |
| $k_{dg}$ | 0.004499 | $R_1$ | 0.099699 | $R_3$ | 0.284227 |
| $k_{db}$ | 0.004970 | $n_1$ | 514.4874 | $n_3$ | 259.5169 |
| $k_{sr}$ | 0.048811 | $f_{02}$ | 0.003492 | PSNR | 31.92485 |

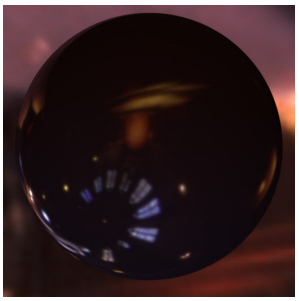
| Material Name | specular-black-phenolic | $k_{db}$ | 0.005603 | $\alpha_1$ | 0.012691 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.003264 | $\alpha_2$ | 0.012691 |
| $k_{dr}$ | 0.005026 | $k_{sg}$ | 0.003210 | $\alpha_3$ | 0.003328 |
| $k_{dg}$ | 0.004435 | $k_{sb}$ | 0.003516 | PSNR | 30.40335 |

| Material Name | specular-black-phenolic | $k_{db}$ | 0 | $\alpha_1$ | 0.017184 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.004433 | $\alpha_2$ | 0.017184 |
| $k_{dr}$ | 0 | $k_{sg}$ | 0.004165 | $\alpha_3$ | 0.006361 |
| $k_{dg}$ | 0 | $k_{sb}$ | 0.004934 | PSNR | 30.34042 |

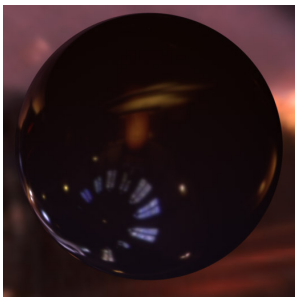
**Rendered Images**



Reference image

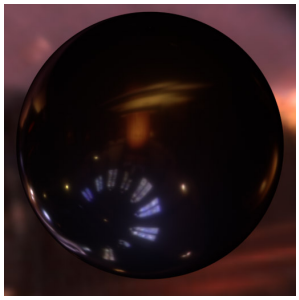


Ashikhmin-Shirley
(PSNR=35.52319)



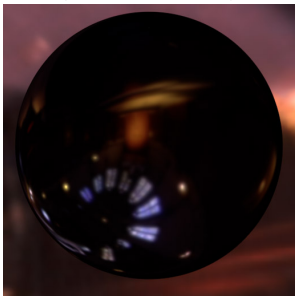
Cook-Torrance
(PSNR=35.71550)

Edwards et al.
(PSNR=31.92485)

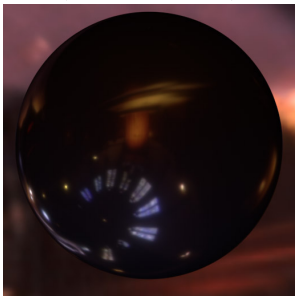


Lawrence et al.
(PSNR=37.86923)

Ward
(PSNR=30.40335)

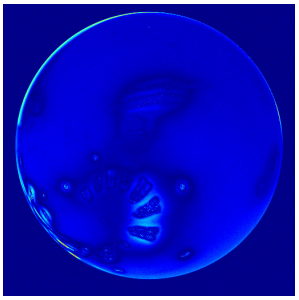


Ward-Duer
(PSNR=30.34042)

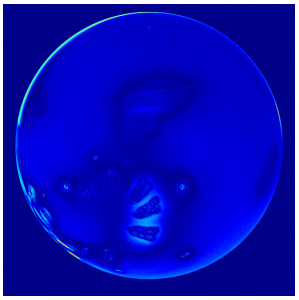


Our factored model
(PSNR=40.02345)

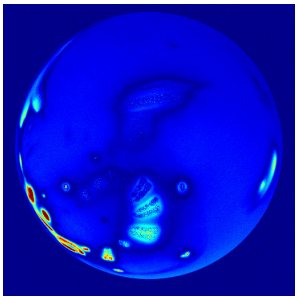
**Difference Images**



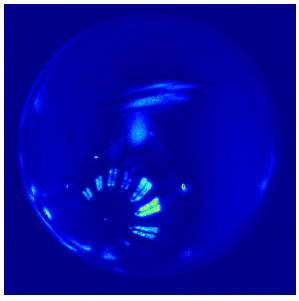
Ashikhmin-Shirley



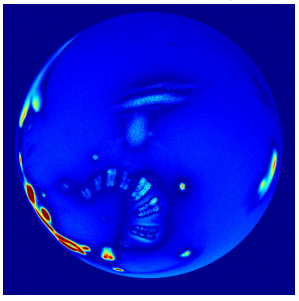
Cook-Torrance



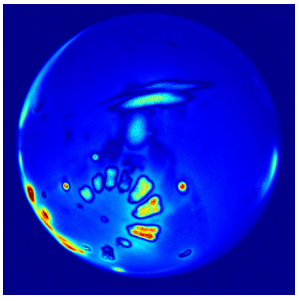
Edwards et al.



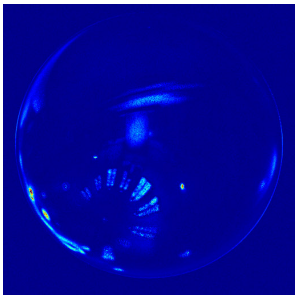
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: specular-blue-phenolic

**Fitted Parameters/PSNR**

| Material Name | specular-blue-phenolic | $k_{sr}$ | 0.068619 | $f_{02}$ | 0.022912 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.059643 | $n_2$ | 2814.400 |
| $k_{dr}$ | 0.006116 | $k_{sb}$ | 0.064929 | $f_{03}$ | 0.084657 |
| $k_{dg}$ | 0.013915 | $f_{01}$ | 0.025514 | $n_3$ | 9400.541 |
| $k_{db}$ | 0.031927 | $n_1$ | 241200.5 | PSNR | 38.34512 |

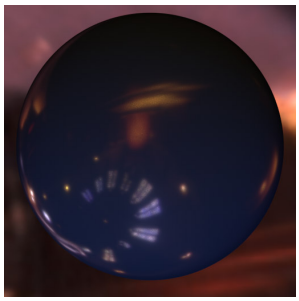
| Material Name | specular-blue-phenolic | $k_{sr}$ | 0.016758 | $f_{02}$ | 0.026254 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.014555 | $m_2$ | 0.027093 |
| $k_{dr}$ | 0.006030 | $k_{sb}$ | 0.015852 | $f_{03}$ | 0.027454 |
| $k_{dg}$ | 0.013847 | $f_{01}$ | 0.082540 | $m_3$ | 0.002983 |
| $k_{db}$ | 0.031848 | $m_1$ | 0.014549 | PSNR | 38.39409 |

| Material Name | specular-blue-phenolic | $k_{sg}$ | 0.082610 | $R_2$ | 0.212182 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.088725 | $n_2$ | 100.1921 |
| $k_{dr}$ | 0.007456 | $f_{01}$ | 0.023524 | $f_{03}$ | 0.001160 |
| $k_{dg}$ | 0.015154 | $R_1$ | 0.155416 | $R_3$ | 0.020277 |
| $k_{db}$ | 0.033395 | $n_1$ | 500.0361 | $n_3$ | 324.2401 |
| $k_{sr}$ | 0.095901 | $f_{02}$ | 0.048747 | PSNR | 34.41010 |

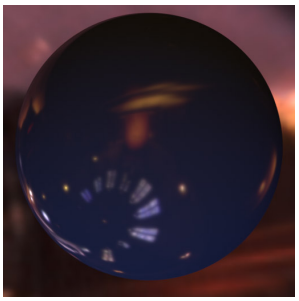
| Material Name | specular-blue-phenolic | $k_{db}$ | 0.033214 | $\alpha_1$ | 0.015803 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.004505 | $\alpha_2$ | 0.004302 |
| $k_{dr}$ | 0.007005 | $k_{sg}$ | 0.003891 | $\alpha_3$ | 0.015803 |
| $k_{dg}$ | 0.014743 | $k_{sb}$ | 0.004062 | PSNR | 32.11417 |

| Material Name | specular-blue-phenolic | $k_{db}$ | 0.027917 | $\alpha_1$ | 0.020581 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.005391 | $\alpha_2$ | 0.006754 |
| $k_{dr}$ | 0.001410 | $k_{sg}$ | 0.004616 | $\alpha_3$ | 0.020581 |
| $k_{dg}$ | 0.010027 | $k_{sb}$ | 0.004948 | PSNR | 31.39575 |

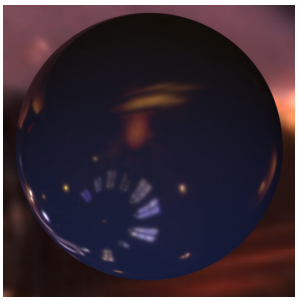
**Rendered Images**



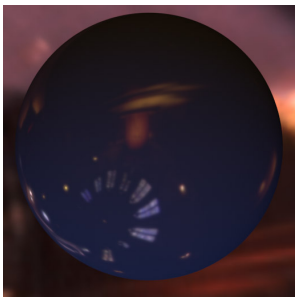
Reference image



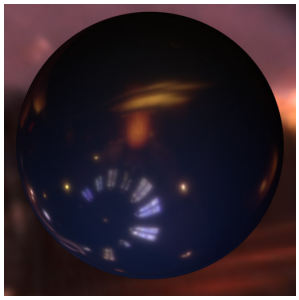
Ashikhmin-Shirley
(PSNR=38.34512)



Cook-Torrance
(PSNR=38.39409)

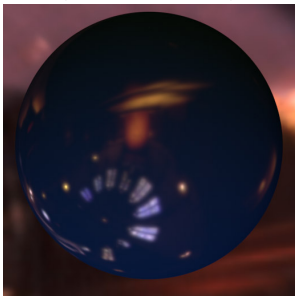


Edwards et al.
(PSNR=34.41010)

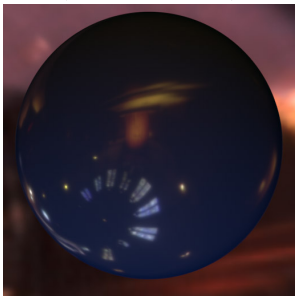


Lawrence et al.
(PSNR=29.34486)

Ward
(PSNR=32.11417)

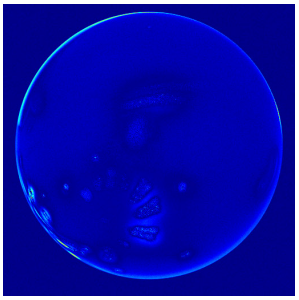


Ward-Duer
(PSNR=31.39575)



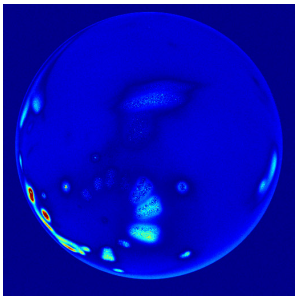
Our factored model
(PSNR=38.82533)

**Difference Images**

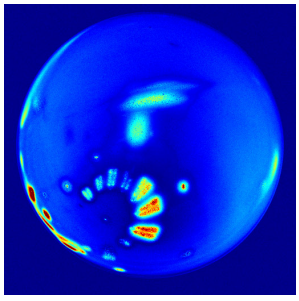


Ashikhmin-Shirley

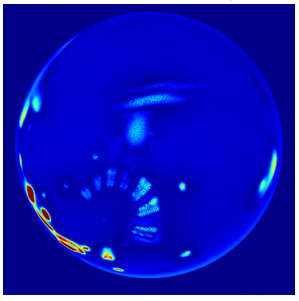
Cook-Torrance



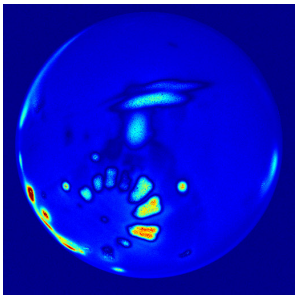
Edwards et al.



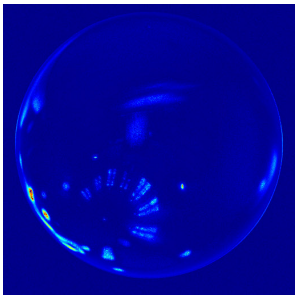
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: specular-green-phenolic

**Fitted Parameters/PSNR**

| Material Name | specular-green-phenolic | $k_{sr}$ | 0.067395 | $f_{02}$ | 0.087256 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.059888 | $n_2$ | 9109.860 |
| $k_{dr}$ | 0.008352 | $k_{sb}$ | 0.066618 | $f_{03}$ | 0.016079 |
| $k_{dg}$ | 0.026093 | $f_{01}$ | 0.026888 | $n_3$ | 2771.577 |
| $k_{db}$ | 0.022320 | $n_1$ | 244057.6 | PSNR | 38.79859 |

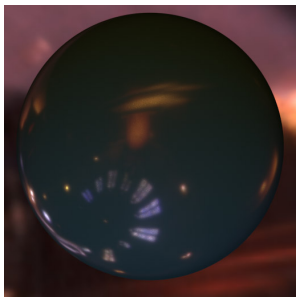
| Material Name | specular-green-phenolic | $k_{sr}$ | 0.016406 | $f_{02}$ | 0.020711 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.014577 | $m_2$ | 0.027528 |
| $k_{dr}$ | 0.008238 | $k_{sb}$ | 0.016213 | $f_{03}$ | 0.027666 |
| $k_{dg}$ | 0.025994 | $f_{01}$ | 0.086270 | $m_3$ | 0.002866 |
| $k_{db}$ | 0.022211 | $m_1$ | 0.014555 | PSNR | 38.86285 |

| Material Name | specular-green-phenolic | $k_{sg}$ | 0.045767 | $R_2$ | 0.207016 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.051305 | $n_2$ | 100.0104 |
| $k_{dr}$ | 0.009682 | $f_{01}$ | 0.038845 | $f_{03}$ | 0.002812 |
| $k_{dg}$ | 0.027311 | $R_1$ | 0.103738 | $R_3$ | 0.013947 |
| $k_{db}$ | 0.023606 | $n_1$ | 500.0256 | $n_3$ | 0.299888 |
| $k_{sr}$ | 0.051734 | $f_{02}$ | 0.099663 | PSNR | 33.95879 |

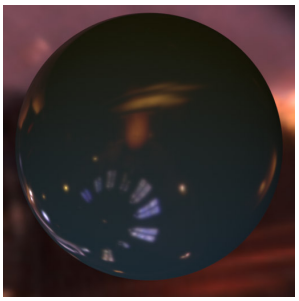
| Material Name | specular-green-phenolic | $k_{db}$ | 0.023998 | $\alpha_1$ | 0.014665 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.003920 | $\alpha_2$ | 0.014665 |
| $k_{dr}$ | 0.010121 | $k_{sg}$ | 0.003539 | $\alpha_3$ | 0.003778 |
| $k_{dg}$ | 0.027541 | $k_{sb}$ | 0.003907 | PSNR | 32.08849 |

| Material Name | specular-green-phenolic | $k_{db}$ | 0.018555 | $\alpha_1$ | 0.020053 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.005194 | $\alpha_2$ | 0.020053 |
| $k_{dr}$ | 0.003828 | $k_{sg}$ | 0.004493 | $\alpha_3$ | 0.006439 |
| $k_{dg}$ | 0.022426 | $k_{sb}$ | 0.004890 | PSNR | 32.46904 |

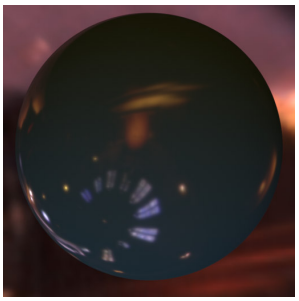
**Rendered Images**



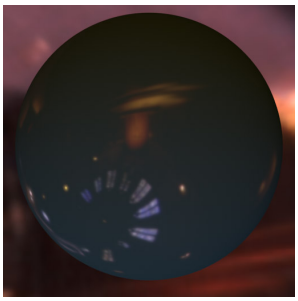
Reference image



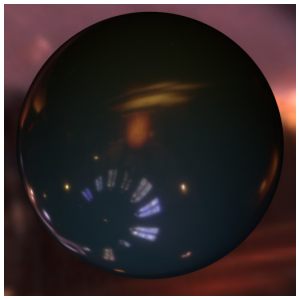
Ashikhmin-Shirley
(PSNR=38.79859)



Cook-Torrance
(PSNR=38.86285)

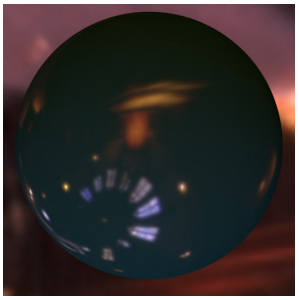


Edwards et al.
(PSNR=33.95879)

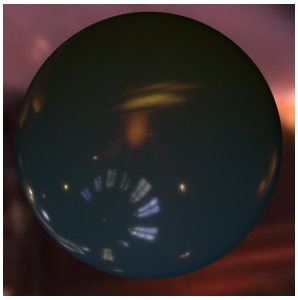


Lawrence et al.
(PSNR=31.16948)

Ward
(PSNR=32.08849)

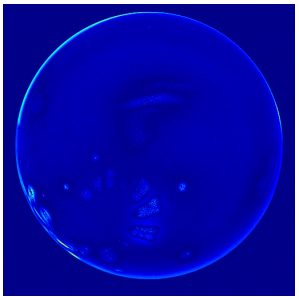


Ward-Duer
(PSNR=32.46904)

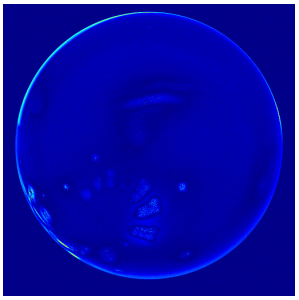


Our factored model
(PSNR=39.13792)

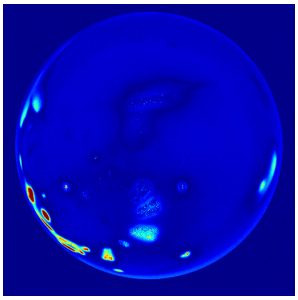
**Difference Images**



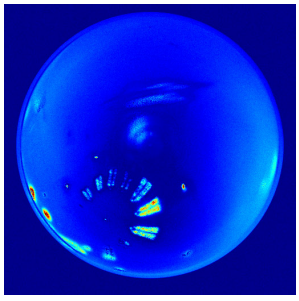
Ashikhmin-Shirley



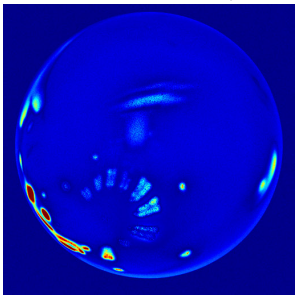
Cook-Torrance



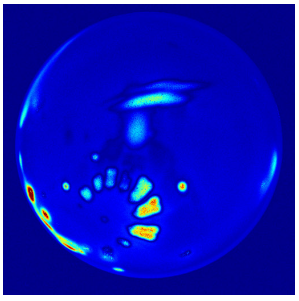
Edwards et al.



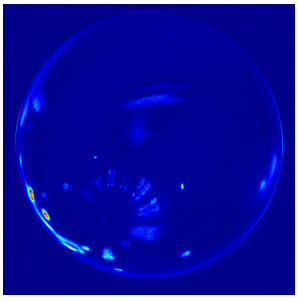
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: specular-maroon-phenolic

**Fitted Parameters/PSNR**

| Material Name | specular-maroon-phenolic | $k_{sr}$ | 0.061697 | $f_{02}$ | 0.028172 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.055435 | $n_2$ | 2452.308 |
| $k_{dr}$ | 0.155873 | $k_{sb}$ | 0.059175 | $f_{03}$ | 0.099787 |
| $k_{dg}$ | 0.026406 | $f_{01}$ | 0.025923 | $n_3$ | 9729.212 |
| $k_{db}$ | 0.006927 | $n_1$ | 292478.7 | PSNR | 38.44178 |

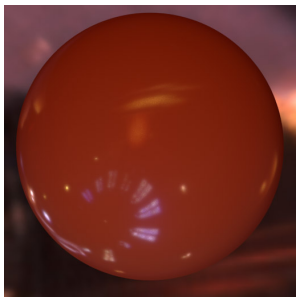
| Material Name | specular-maroon-phenolic | $k_{sr}$ | 0.014957 | $f_{02}$ | 0.026732 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.013435 | $m_2$ | 0.002613 |
| $k_{dr}$ | 0.155768 | $k_{sb}$ | 0.014341 | $f_{03}$ | 0.100116 |
| $k_{dg}$ | 0.026314 | $f_{01}$ | 0.032617 | $m_3$ | 0.014113 |
| $k_{db}$ | 0.006830 | $m_1$ | 0.029014 | PSNR | 38.41402 |

| Material Name | specular-maroon-phenolic | $k_{sg}$ | 0.042797 | $R_2$ | 0.206105 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.045787 | $n_2$ | 100.0103 |
| $k_{dr}$ | 0.157661 | $f_{01}$ | 0.038682 | $f_{03}$ | 0.006144 |
| $k_{dg}$ | 0.028046 | $R_1$ | 0.098293 | $R_3$ | 0.014257 |
| $k_{db}$ | 0.008659 | $n_1$ | 500.0275 | $n_3$ | 0.338611 |
| $k_{sr}$ | 0.047830 | $f_{02}$ | 0.111914 | PSNR | 35.35433 |

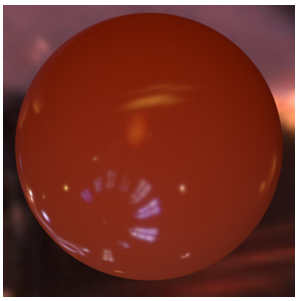
| Material Name | specular-maroon-phenolic | $k_{db}$ | 0.009355 | $\alpha_1$ | 0.014298 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.003610 | $\alpha_2$ | 0.014298 |
| $k_{dr}$ | 0.158763 | $k_{sg}$ | 0.003374 | $\alpha_3$ | 0.003547 |
| $k_{dg}$ | 0.028710 | $k_{sb}$ | 0.003617 | PSNR | 33.85280 |

| Material Name | specular-maroon-phenolic | $k_{db}$ | 0.004061 | $\alpha_1$ | 0.019878 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.004990 | $\alpha_2$ | 0.019878 |
| $k_{dr}$ | 0.152379 | $k_{sg}$ | 0.004372 | $\alpha_3$ | 0.006344 |
| $k_{dg}$ | 0.023590 | $k_{sb}$ | 0.004618 | PSNR | 34.13790 |

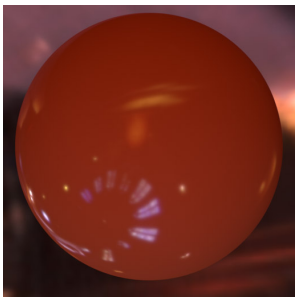
**Rendered Images**



Reference image

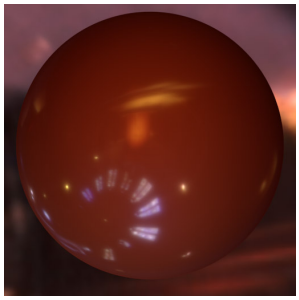


Ashikhmin-Shirley
(PSNR=38.44178)



Cook-Torrance
(PSNR=38.41402)

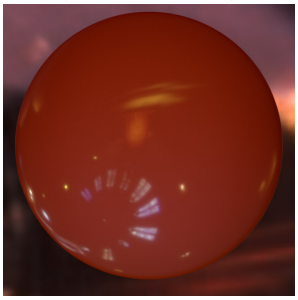
Edwards et al.
(PSNR=35.35433)



Lawrence et al.
(PSNR=23.69586)

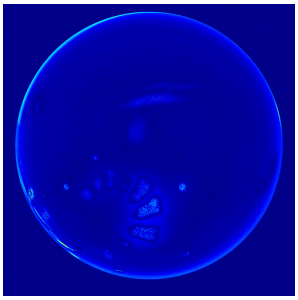
Ward
(PSNR=33.85280)

Ward-Duer
(PSNR=34.13790)

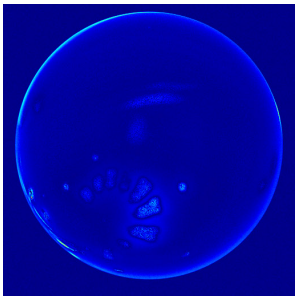


Our factored model
(PSNR=38.04757)

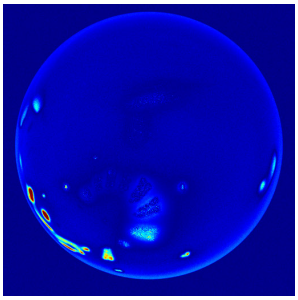
**Difference Images**



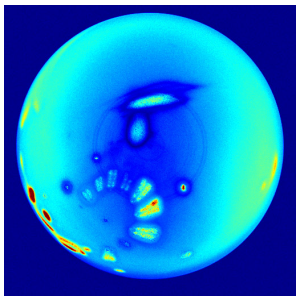
Ashikhmin-Shirley



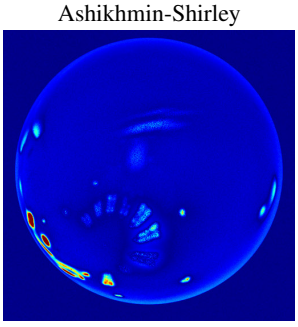
Cook-Torrance



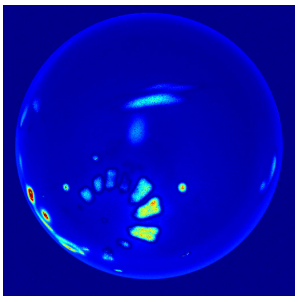
Edwards et al.



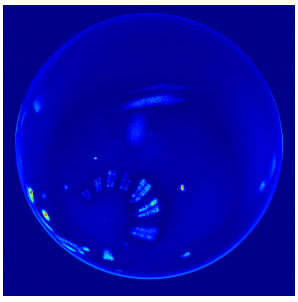
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: specular-orange-phenolic

**Fitted Parameters/PSNR**

| Material Name | specular-orange-phenolic | $k_{sr}$ | 0.049525 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.046321 | $n_2$ | 3201.905 |
| $k_{dr}$ | 0.332750 | $k_{sb}$ | 0.047255 | $f_{03}$ | 0.096174 |
| $k_{dg}$ | 0.053704 | $f_{01}$ | 0.034749 | $n_3$ | 11533.50 |
| $k_{db}$ | 0.006911 | $n_1$ | 256728.6 | PSNR | 36.48869 |

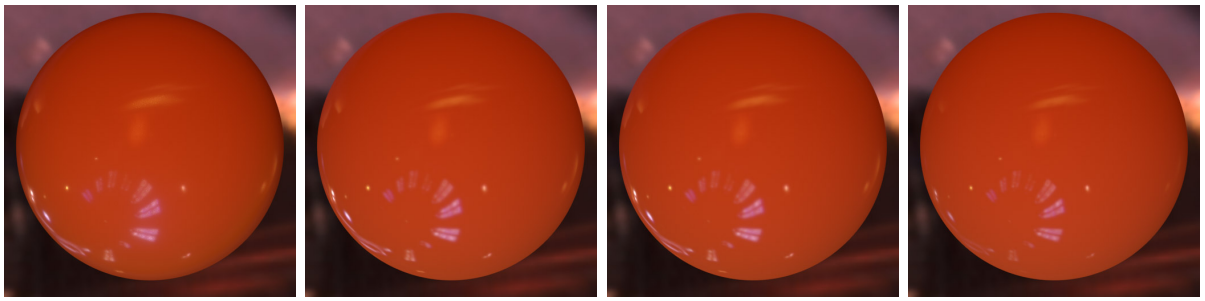
| Material Name | specular-orange-phenolic | $k_{sr}$ | 0.012077 | $f_{02}$ | 0.035542 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.011293 | $m_2$ | 0.002789 |
| $k_{dr}$ | 0.332716 | $k_{sb}$ | 0.011523 | $f_{03}$ | 0.096125 |
| $k_{dg}$ | 0.053674 | $f_{01}$ | 0.002644 | $m_3$ | 0.012972 |
| $k_{db}$ | 0.006879 | $m_1$ | 0.025478 | PSNR | 36.48478 |

| Material Name | specular-orange-phenolic | $k_{sg}$ | 0.034889 | $R_2$ | 0.171802 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.035808 | $n_2$ | 100.0522 |
| $k_{dr}$ | 0.333739 | $f_{01}$ | 0.043867 | $f_{03}$ | 0.012207 |
| $k_{dg}$ | 0.054655 | $R_1$ | 0.094968 | $R_3$ | 0.012982 |
| $k_{db}$ | 0.007842 | $n_1$ | 500.0359 | $n_3$ | 0.585707 |
| $k_{sr}$ | 0.037454 | $f_{02}$ | 0.089321 | PSNR | 34.82927 |

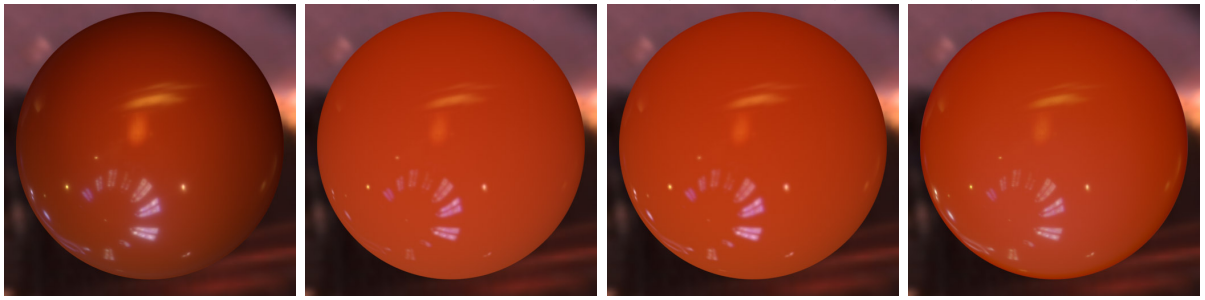
| Material Name | specular-orange-phenolic | $k_{db}$ | 0.007735 | $\alpha_1$ | 0.003269 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.003065 | $\alpha_2$ | 0.012464 |
| $k_{dr}$ | 0.333675 | $k_{sg}$ | 0.002886 | $\alpha_3$ | 0.012464 |
| $k_{dg}$ | 0.054526 | $k_{sb}$ | 0.002951 | PSNR | 34.25249 |

| Material Name | specular-orange-phenolic | $k_{db}$ | 0.004935 | $\alpha_1$ | 0.015217 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.003439 | $\alpha_2$ | 0.015217 |
| $k_{dr}$ | 0.330442 | $k_{sg}$ | 0.003123 | $\alpha_3$ | 0.004749 |
| $k_{dg}$ | 0.051819 | $k_{sb}$ | 0.003204 | PSNR | 35.53267 |

**Rendered Images**

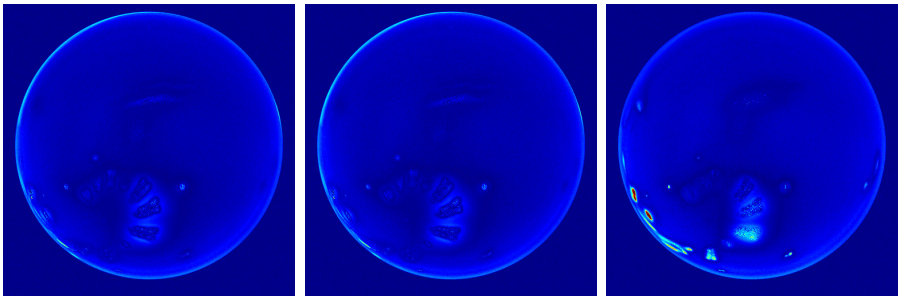


Reference image | Ashikhmin-Shirley (PSNR=36.48869) | Cook-Torrance (PSNR=36.48478) | Edwards et al. (PSNR=34.82927)

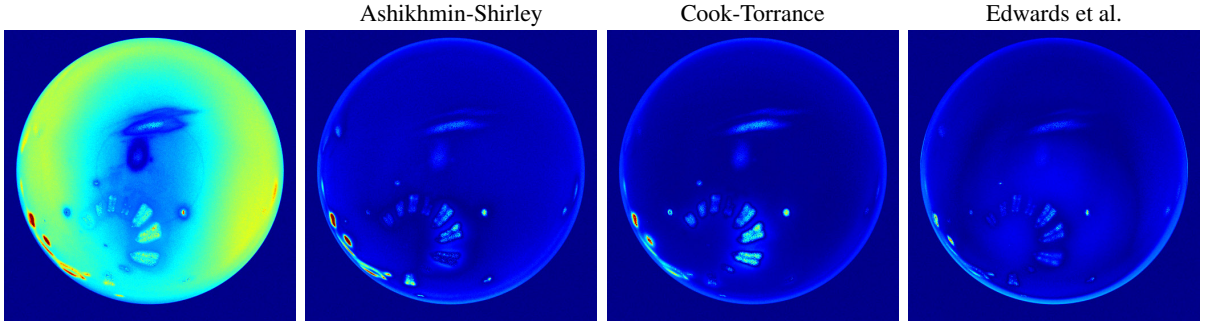


Lawrence et al. (PSNR=20.90741) | Ward (PSNR=34.25249) | Ward-Duer (PSNR=35.53267) | Our factored model (PSNR=36.22580)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: specular-red-phenolic

**Fitted Parameters/PSNR**

| Material Name | specular-red-phenolic | $k_{sr}$ | 0.068956 | $f_{02}$ | 0.021760 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.059786 | $n_2$ | 2506.074 |
| $k_{dr}$ | 0.309629 | $k_{sb}$ | 0.066371 | $f_{03}$ | 0.087410 |
| $k_{dg}$ | 0.035421 | $f_{01}$ | 0.021483 | $n_3$ | 9173.416 |
| $k_{db}$ | 0.008553 | $n_1$ | 282841.9 | PSNR | 36.57709 |

| Material Name | specular-red-phenolic | $k_{sr}$ | 0.016751 | $f_{02}$ | 0.025853 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.014519 | $m_2$ | 0.028798 |
| $k_{dr}$ | 0.309519 | $k_{sb}$ | 0.016117 | $f_{03}$ | 0.022168 |
| $k_{dg}$ | 0.035329 | $f_{01}$ | 0.087203 | $m_3$ | 0.002661 |
| $k_{db}$ | 0.008450 | $m_1$ | 0.014529 | PSNR | 36.56547 |

| Material Name | specular-red-phenolic | $k_{sg}$ | 0.045803 | $R_2$ | 0.212139 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.050419 | $n_2$ | 99.97626 |
| $k_{dr}$ | 0.311162 | $f_{01}$ | 0.035631 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.036751 | $R_1$ | 0.105084 | $R_3$ | 0.013833 |
| $k_{db}$ | 0.010103 | $n_1$ | 500.0450 | $n_3$ | 0.237167 |
| $k_{sr}$ | 0.052828 | $f_{02}$ | 0.102296 | PSNR | 34.69933 |

| Material Name | specular-red-phenolic | $k_{db}$ | 0.010302 | $\alpha_1$ | 0.015734 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.004047 | $\alpha_2$ | 0.015734 |
| $k_{dr}$ | 0.311373 | $k_{sg}$ | 0.003692 | $\alpha_3$ | 0.004226 |
| $k_{dg}$ | 0.036528 | $k_{sb}$ | 0.003863 | PSNR | 33.64649 |

| Material Name | specular-red-phenolic | $k_{db}$ | 0.004553 | $\alpha_1$ | 0.021174 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.005316 | $\alpha_2$ | 0.021174 |
| $k_{dr}$ | 0.305009 | $k_{sg}$ | 0.004513 | $\alpha_3$ | 0.007066 |
| $k_{dg}$ | 0.031692 | $k_{sb}$ | 0.004961 | PSNR | 33.31047 |

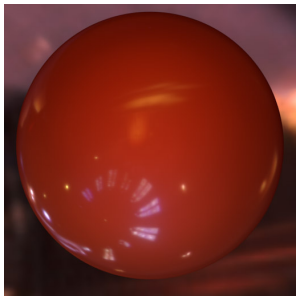
**Rendered Images**

Reference image

Ashikhmin-Shirley
(PSNR=36.57709)

Cook-Torrance
(PSNR=36.56547)

Edwards et al.
(PSNR=34.69933)



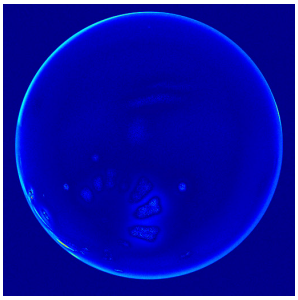
Lawrence et al.
(PSNR=23.27505)

Ward
(PSNR=33.64649)

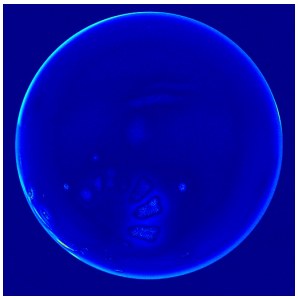
Ward-Duer
(PSNR=33.31047)

Our factored model
(PSNR=35.69960)

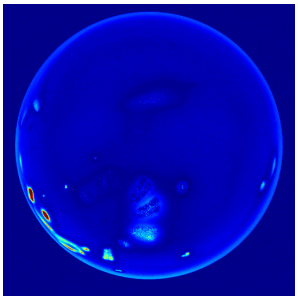
**Difference Images**



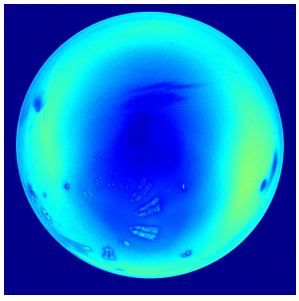
Ashikhmin-Shirley



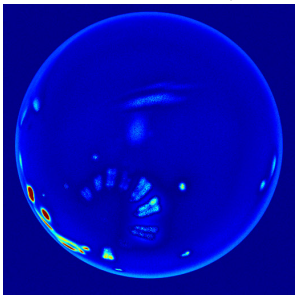
Cook-Torrance



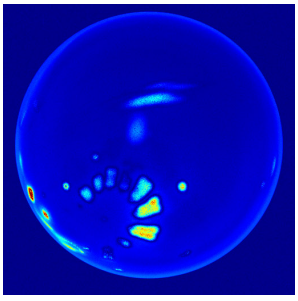
Edwards et al.



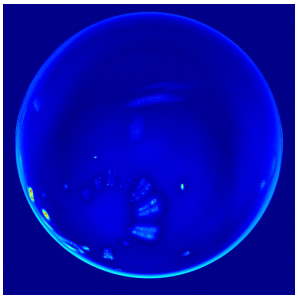
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: specular-violet-phenolic

**Fitted Parameters/PSNR**

| Material Name | specular-violet-phenolic | $k_{sr}$ | 0.063370 | $f_{02}$ | 0.006054 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.057072 | $n_2$ | 3065.894 |
| $k_{dr}$ | 0.071155 | $k_{sb}$ | 0.064283 | $f_{03}$ | 0.099157 |
| $k_{dg}$ | 0.017808 | $f_{01}$ | 0.024751 | $n_3$ | 10427.52 |
| $k_{db}$ | 0.020038 | $n_1$ | 296934.8 | PSNR | 39.57782 |

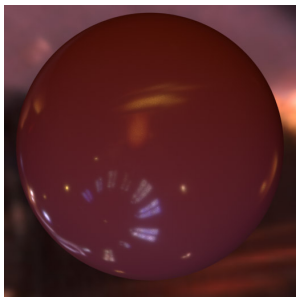
| Material Name | specular-violet-phenolic | $k_{sr}$ | 0.015415 | $f_{02}$ | 0.098114 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.013878 | $m_2$ | 0.013600 |
| $k_{dr}$ | 0.071048 | $k_{sb}$ | 0.015635 | $f_{03}$ | 0.025400 |
| $k_{dg}$ | 0.017715 | $f_{01}$ | 0.011164 | $m_3$ | 0.002592 |
| $k_{db}$ | 0.019930 | $m_1$ | 0.026105 | PSNR | 39.58574 |

| Material Name | specular-violet-phenolic | $k_{sg}$ | 0.044619 | $R_2$ | 0.189678 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.050404 | $n_2$ | 100.0163 |
| $k_{dr}$ | 0.072321 | $f_{01}$ | 0.037309 | $f_{03}$ | 0.004332 |
| $k_{dg}$ | 0.018955 | $R_1$ | 0.099907 | $R_3$ | 0.013803 |
| $k_{db}$ | 0.021304 | $n_1$ | 500.0268 | $n_3$ | 0.435042 |
| $k_{sr}$ | 0.050162 | $f_{02}$ | 0.095563 | PSNR | 35.77866 |

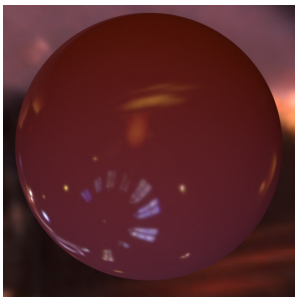
| Material Name | specular-violet-phenolic | $k_{db}$ | 0.021913 | $\alpha_1$ | 0.013765 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.003804 | $\alpha_2$ | 0.013765 |
| $k_{dr}$ | 0.072499 | $k_{sg}$ | 0.003394 | $\alpha_3$ | 0.003599 |
| $k_{dg}$ | 0.019089 | $k_{sb}$ | 0.003629 | PSNR | 34.18482 |

| Material Name | specular-violet-phenolic | $k_{db}$ | 0.016121 | $\alpha_1$ | 0.018906 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.005029 | $\alpha_2$ | 0.006435 |
| $k_{dr}$ | 0.066426 | $k_{sg}$ | 0.004386 | $\alpha_3$ | 0.018906 |
| $k_{dg}$ | 0.013964 | $k_{sb}$ | 0.004798 | PSNR | 34.63983 |

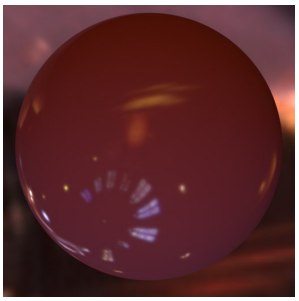
**Rendered Images**



Reference image

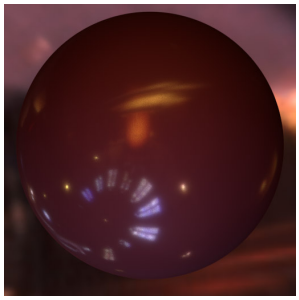


Ashikhmin-Shirley
(PSNR=39.57782)



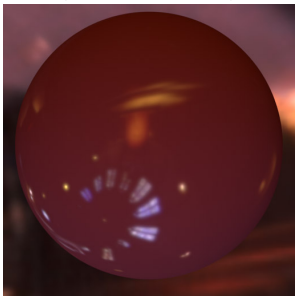
Cook-Torrance
(PSNR=39.58574)

Edwards et al.
(PSNR=35.77866)

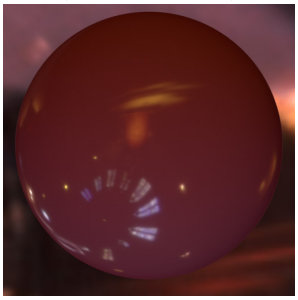


Lawrence et al.
(PSNR=25.58100)

Ward
(PSNR=34.18482)

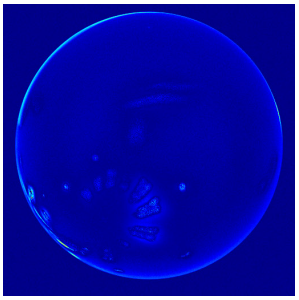


Ward-Duer
(PSNR=34.63983)



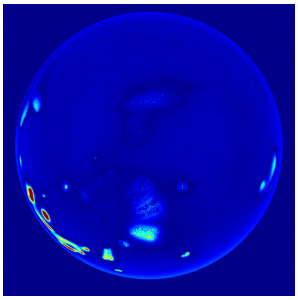
Our factored model
(PSNR=40.82002)

**Difference Images**

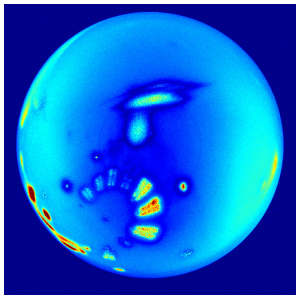


Ashikhmin-Shirley

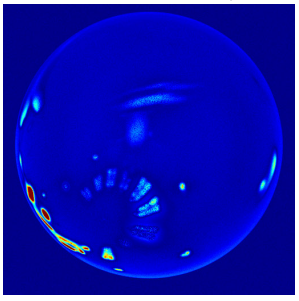
Cook-Torrance



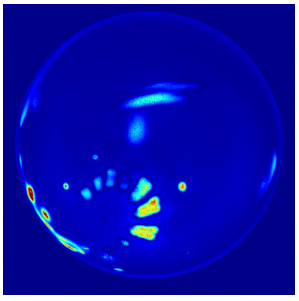
Edwards et al.



Lawrence et al.



Ward



Ward-Duer

Our factored model

**Material Name**: specular-white-phenolic

**Fitted Parameters/PSNR**

| Material Name | specular-white-phenolic | $k_{sr}$ | 0.045575 | $f_{02}$ | 0.007910 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.044584 | $n_2$ | 2537.133 |
| $k_{dr}$ | 0.283573 | $k_{sb}$ | 0.044087 | $f_{03}$ | 0.192969 |
| $k_{dg}$ | 0.227279 | $f_{01}$ | 0.084536 | $n_3$ | 11294.82 |
| $k_{db}$ | 0.125455 | $n_1$ | 215375.9 | PSNR | 34.30175 |

| Material Name | specular-white-phenolic | $k_{sr}$ | 0.011039 | $f_{02}$ | 0.015593 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.010795 | $m_2$ | 0.028681 |
| $k_{dr}$ | 0.283432 | $k_{sb}$ | 0.010678 | $f_{03}$ | 0.086955 |
| $k_{dg}$ | 0.227146 | $f_{01}$ | 0.194033 | $m_3$ | 0.003045 |
| $k_{db}$ | 0.125319 | $m_1$ | 0.013107 | PSNR | 34.29187 |

| Material Name | specular-white-phenolic | $k_{sg}$ | 0.036383 | $R_2$ | 0.174148 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.036766 | $n_2$ | 100.0835 |
| $k_{dr}$ | 0.285774 | $f_{01}$ | 0.090258 | $f_{03}$ | 0.033610 |
| $k_{dg}$ | 0.229621 | $R_1$ | 0.099545 | $R_3$ | 0.012972 |
| $k_{db}$ | 0.127525 | $n_1$ | 500.0555 | $n_3$ | 0.391714 |
| $k_{sr}$ | 0.037815 | $f_{02}$ | 0.151496 | PSNR | 33.79552 |

| Material Name | specular-white-phenolic | $k_{db}$ | 0.126767 | $\alpha_1$ | 0.012161 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.005482 | $\alpha_2$ | 0.012161 |
| $k_{dr}$ | 0.285329 | $k_{sg}$ | 0.005442 | $\alpha_3$ | 0.003229 |
| $k_{dg}$ | 0.228822 | $k_{sb}$ | 0.005477 | PSNR | 33.46913 |

| Material Name | specular-white-phenolic | $k_{db}$ | 0.125620 | $\alpha_1$ | 0.012890 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.004595 | $\alpha_2$ | 0.012890 |
| $k_{dr}$ | 0.283970 | $k_{sg}$ | 0.004545 | $\alpha_3$ | 0.003368 |
| $k_{dg}$ | 0.227520 | $k_{sb}$ | 0.004519 | PSNR | 34.22127 |

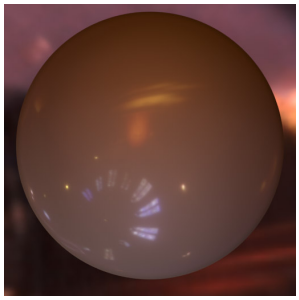
**Rendered Images**

Reference image

Ashikhmin-Shirley
(PSNR=34.30175)

Cook-Torrance
(PSNR=34.29187)

Edwards et al.
(PSNR=33.79552)



Lawrence et al.
(PSNR=16.87157)

Ward
(PSNR=33.46913)

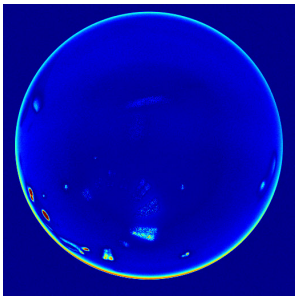
Ward-Duer
(PSNR=34.22127)

Our factored model
(PSNR=37.24647)

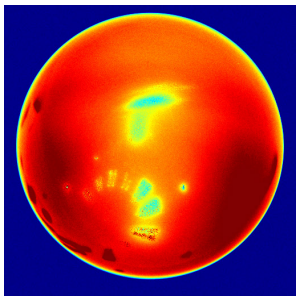
**Difference Images**

Ashikhmin-Shirley

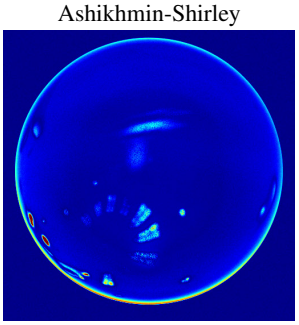
Cook-Torrance



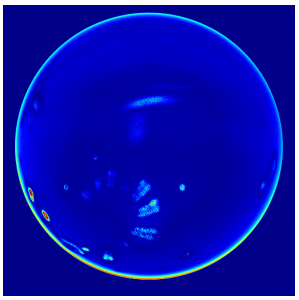
Edwards et al.



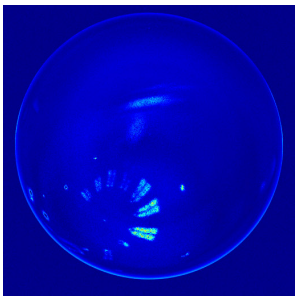
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: specular-yellow-phenolic

**Fitted Parameters/PSNR**

| Material Name | specular-yellow-phenolic | $k_{sr}$ | 0.114965 | $f_{02}$ | 0.010127 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.103997 | $n_2$ | 188622.8 |
| $k_{dr}$ | 0.312875 | $k_{sb}$ | 0.112344 | $f_{03}$ | 0.066917 |
| $k_{dg}$ | 0.136024 | $f_{01}$ | 0.000843 | $n_3$ | 6379.043 |
| $k_{db}$ | 0.013754 | $n_1$ | 5135006 | PSNR | 34.33808 |

| Material Name | specular-yellow-phenolic | $k_{sr}$ | 0.018699 | $f_{02}$ | 0.082871 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.016693 | $m_2$ | 0.015481 |
| $k_{dr}$ | 0.313550 | $k_{sb}$ | 0.018181 | $f_{03}$ | 0.020773 |
| $k_{dg}$ | 0.136755 | $f_{01}$ | 0.003302 | $m_3$ | 0.002874 |
| $k_{db}$ | 0.014463 | $m_1$ | 0.025774 | PSNR | 35.30785 |

| Material Name | specular-yellow-phenolic | $k_{sg}$ | 0.057661 | $R_2$ | 0.114915 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.063321 | $n_2$ | 81.67276 |
| $k_{dr}$ | 0.315046 | $f_{01}$ | 0.032692 | $f_{03}$ | 0.064131 |
| $k_{dg}$ | 0.138136 | $R_1$ | 0.123794 | $R_3$ | 0.061014 |
| $k_{db}$ | 0.015899 | $n_1$ | 503.6763 | $n_3$ | 8.044500 |
| $k_{sr}$ | 0.064978 | $f_{02}$ | 0 | PSNR | 34.35625 |

| Material Name | specular-yellow-phenolic | $k_{db}$ | 0.013904 | $\alpha_1$ | 0.018019 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.005162 | $\alpha_2$ | 0.018019 |
| $k_{dr}$ | 0.312411 | $k_{sg}$ | 0.004572 | $\alpha_3$ | 0.005527 |
| $k_{dg}$ | 0.135817 | $k_{sb}$ | 0.004768 | PSNR | 33.60116 |

| Material Name | specular-yellow-phenolic | $k_{db}$ | 0.009241 | $\alpha_1$ | 0.021416 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.005621 | $\alpha_2$ | 0.021416 |
| $k_{dr}$ | 0.307464 | $k_{sg}$ | 0.004891 | $\alpha_3$ | 0.007507 |
| $k_{dg}$ | 0.131688 | $k_{sb}$ | 0.005224 | PSNR | 33.38345 |

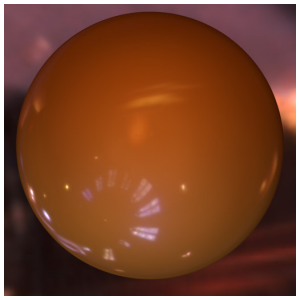
**Rendered Images**

Reference image

Ashikhmin-Shirley
(PSNR=34.33808)

Cook-Torrance
(PSNR=35.30785)

Edwards et al.
(PSNR=34.35625)



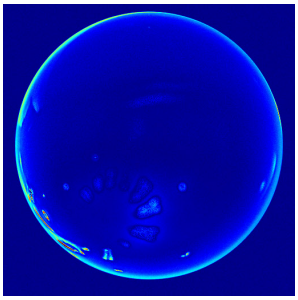
Lawrence et al.
(PSNR=22.67254)

Ward
(PSNR=33.60116)

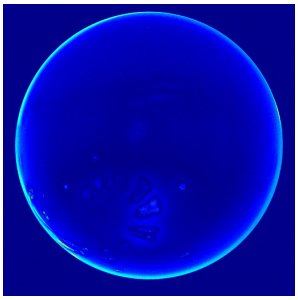
Ward-Duer
(PSNR=33.38345)

Our factored model
(PSNR=35.10905)

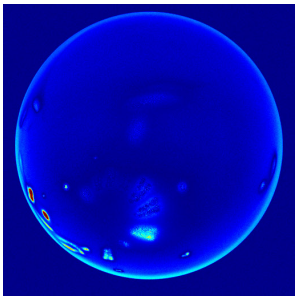
**Difference Images**



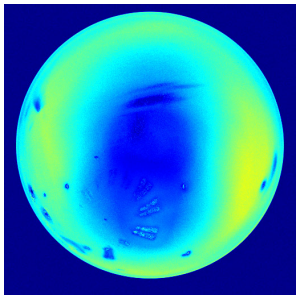
Ashikhmin-Shirley



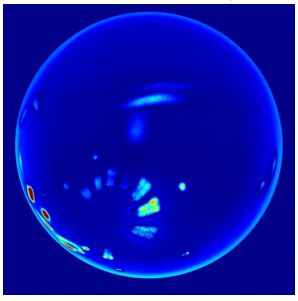
Cook-Torrance



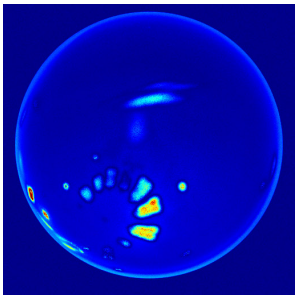
Edwards et al.



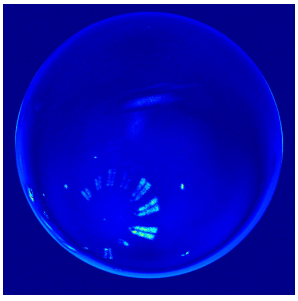
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: ss440

**Fitted Parameters/PSNR**

| Material Name | ss440 | $k_{sr}$ | 0.067204 | $f_{02}$ | 0.326766 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.058410 | $n_2$ | 4186.037 |
| $k_{dr}$ | 0.024862 | $k_{sb}$ | 0.089142 | $f_{03}$ | 0.328540 |
| $k_{dg}$ | 0.016074 | $f_{01}$ | 0.612564 | $n_3$ | 169971.5 |
| $k_{db}$ | 0 | $n_1$ | 22382.67 | PSNR | 25.13682 |

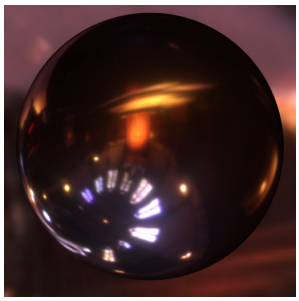
| Material Name | ss440 | $k_{sr}$ | 0.016068 | $f_{02}$ | 0.629746 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.013967 | $m_2$ | 0.009321 |
| $k_{dr}$ | 0.024835 | $k_{sb}$ | 0.021314 | $f_{03}$ | 0.339871 |
| $k_{dg}$ | 0.016042 | $f_{01}$ | 0.349343 | $m_3$ | 0.003420 |
| $k_{db}$ | 0 | $m_1$ | 0.021604 | PSNR | 25.14108 |

| Material Name | ss440 | $k_{sg}$ | 0.095949 | $R_2$ | 0.022506 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.146790 | $n_2$ | 6.556284 |
| $k_{dr}$ | 0.033218 | $f_{01}$ | 0.086096 | $f_{03}$ | 0.336810 |
| $k_{dg}$ | 0.023393 | $R_1$ | 0.088888 | $R_3$ | 0.273615 |
| $k_{db}$ | 0 | $n_1$ | 490.7297 | $n_3$ | 198.9980 |
| $k_{sr}$ | 0.110493 | $f_{02}$ | 0.229046 | PSNR | 22.71177 |

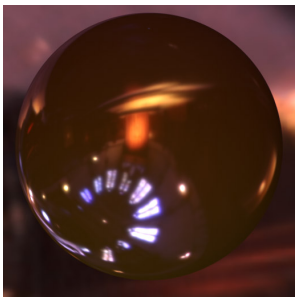
| Material Name | ss440 | $k_{db}$ | 0 | $\alpha_1$ | 0.011551 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.035629 | $\alpha_2$ | 0.003785 |
| $k_{dr}$ | 0.029617 | $k_{sg}$ | 0.030645 | $\alpha_3$ | 0.011551 |
| $k_{dg}$ | 0.020916 | $k_{sb}$ | 0.047140 | PSNR | 23.38265 |

| Material Name | ss440 | $k_{db}$ | 0 | $\alpha_1$ | 0.014110 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.027110 | $\alpha_2$ | 0.003753 |
| $k_{dr}$ | 0.028795 | $k_{sg}$ | 0.023527 | $\alpha_3$ | 0.010212 |
| $k_{dg}$ | 0.019594 | $k_{sb}$ | 0.035909 | PSNR | 24.07147 |

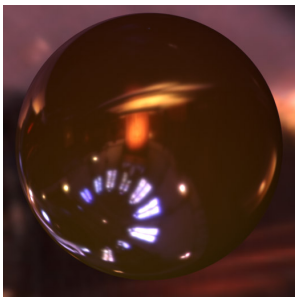
**Rendered Images**



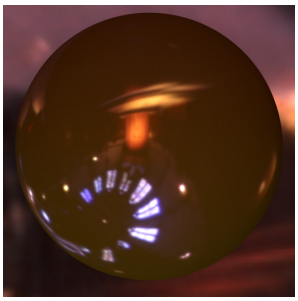
Reference image



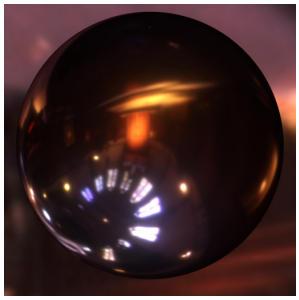
Ashikhmin-Shirley
(PSNR=25.13682)



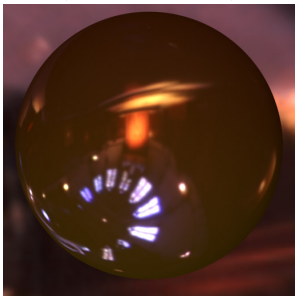
Cook-Torrance
(PSNR=25.14108)



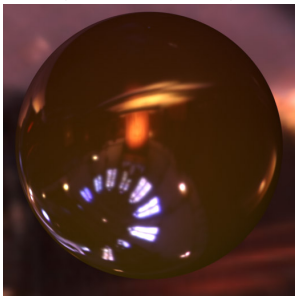
Edwards et al.
(PSNR=22.71177)



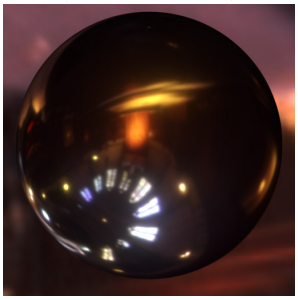
Lawrence et al.
(PSNR=37.36340)



Ward
(PSNR=23.38265)

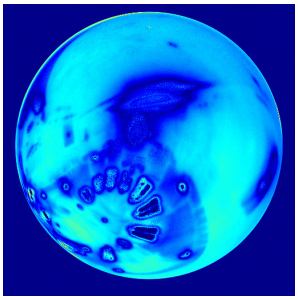


Ward-Duer
(PSNR=24.07147)

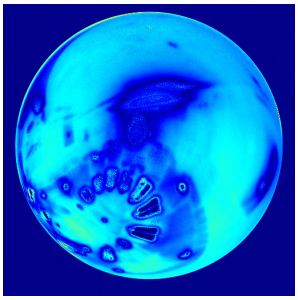


Our factored model
(PSNR=36.36064)

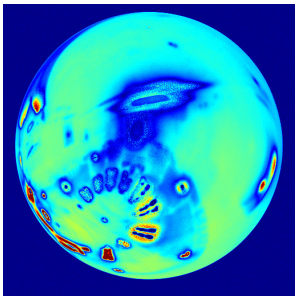
**Difference Images**



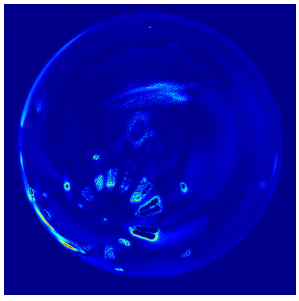
Ashikhmin-Shirley



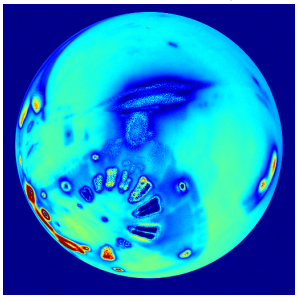
Cook-Torrance



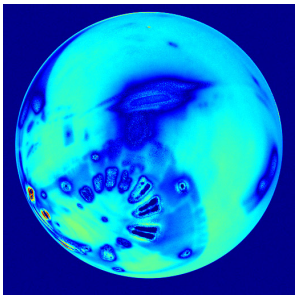
Edwards et al.



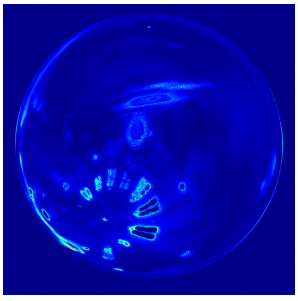
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: steel

**Fitted Parameters/PSNR**

| Material Name | steel | $k_{sr}$ | 0.185852 | $f_{02}$ | 0.122332 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.163737 | $n_2$ | 215163.2 |
| $k_{dr}$ | 0.032960 | $k_{sb}$ | 0.204325 | $f_{03}$ | 0.248879 |
| $k_{dg}$ | 0.024042 | $f_{01}$ | 0.020139 | $n_3$ | 18046.90 |
| $k_{db}$ | 0.013292 | $n_1$ | 2332755 | PSNR | 22.88113 |

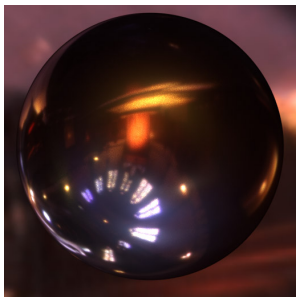
| Material Name | steel | $k_{sr}$ | 0.049336 | $f_{02}$ | 0.126803 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.043559 | $m_2$ | 0.003200 |
| $k_{dr}$ | 0.032149 | $k_{sb}$ | 0.054033 | $f_{03}$ | 0.018397 |
| $k_{dg}$ | 0.023185 | $f_{01}$ | 0.221937 | $m_3$ | 0.000884 |
| $k_{db}$ | 0.012718 | $m_1$ | 0.011114 | PSNR | 23.00434 |

| Material Name | steel | $k_{sg}$ | 0.156293 | $R_2$ | 0.012672 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.192924 | $n_2$ | 3.834743 |
| $k_{dr}$ | 0.037688 | $f_{01}$ | 0.057114 | $f_{03}$ | 0.216215 |
| $k_{dg}$ | 0.027725 | $R_1$ | 0.003256 | $R_3$ | 0.136912 |
| $k_{db}$ | 0.018727 | $n_1$ | 0.487176 | $n_3$ | 92.27279 |
| $k_{sr}$ | 0.176024 | $f_{02}$ | 0.101940 | PSNR | 21.99105 |

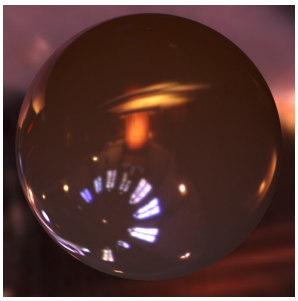
| Material Name | steel | $k_{db}$ | 0.024633 | $\alpha_1$ | 0.008490 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.030029 | $\alpha_2$ | 0.008490 |
| $k_{dr}$ | 0.041061 | $k_{sg}$ | 0.025929 | $\alpha_3$ | 0.002192 |
| $k_{dg}$ | 0.032344 | $k_{sb}$ | 0.031913 | PSNR | 21.26152 |

| Material Name | steel | $k_{db}$ | 0.018779 | $\alpha_1$ | 0.008999 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.023852 | $\alpha_2$ | 0.008999 |
| $k_{dr}$ | 0.038304 | $k_{sg}$ | 0.020550 | $\alpha_3$ | 0.002262 |
| $k_{dg}$ | 0.030095 | $k_{sb}$ | 0.026356 | PSNR | 21.99577 |

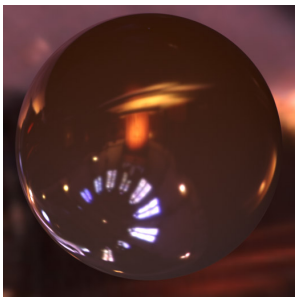
**Rendered Images**



Reference image

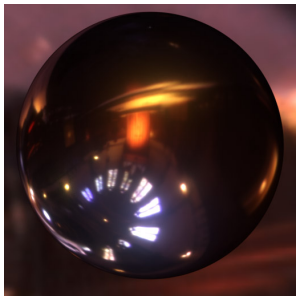


Ashikhmin-Shirley
(PSNR=22.88113)



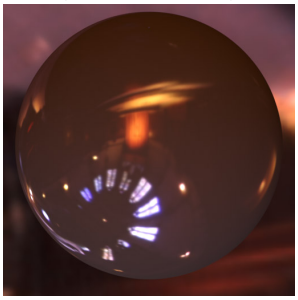
Cook-Torrance
(PSNR=23.00434)

Edwards et al.
(PSNR=21.99105)

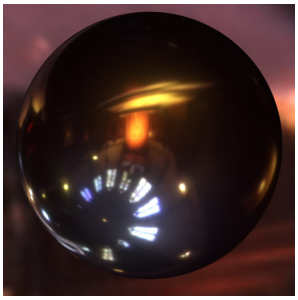


Lawrence et al.
(PSNR=34.69228)

Ward
(PSNR=21.26152)

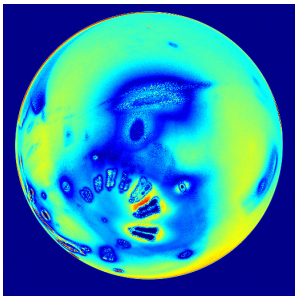


Ward-Duer
(PSNR=21.99577)

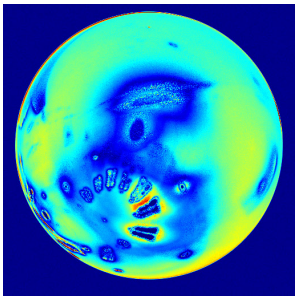


Our factored model
(PSNR=31.77657)

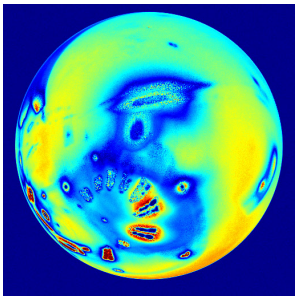
**Difference Images**



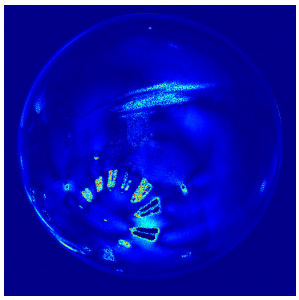
Ashikhmin-Shirley



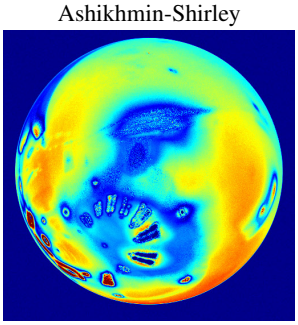
Cook-Torrance



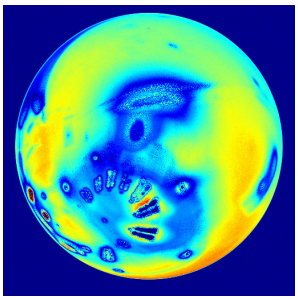
Edwards et al.



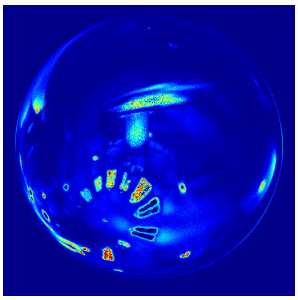
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: teflon

**Fitted Parameters/PSNR**

| Material Name | teflon | $k_{sr}$ | 0.206488 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.207874 | $n_2$ | 0 |
| $k_{dr}$ | 0.303853 | $k_{sb}$ | 0.209929 | $f_{03}$ | 0.217766 |
| $k_{dg}$ | 0.297421 | $f_{01}$ | 0.043347 | $n_3$ | 5.132384 |
| $k_{db}$ | 0.286254 | $n_1$ | 74.57317 | PSNR | 40.99699 |

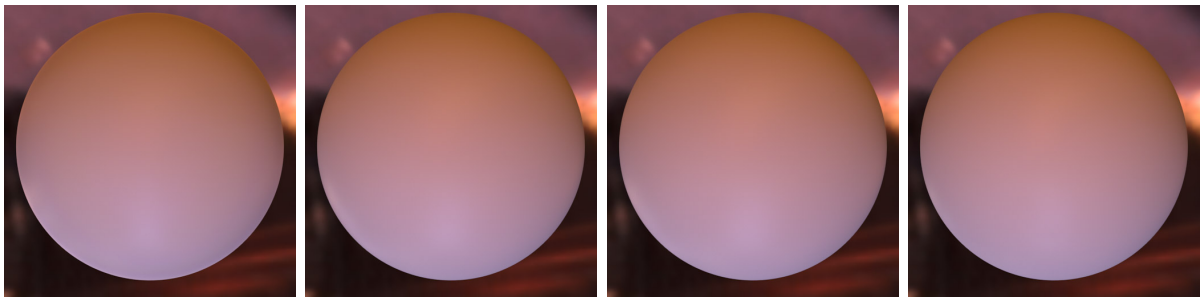
| Material Name | teflon | $k_{sr}$ | 0.022494 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.022605 | $m_2$ | 0.144411 |
| $k_{dr}$ | 0.306679 | $k_{sb}$ | 0.022822 | $f_{03}$ | 0.116708 |
| $k_{dg}$ | 0.300321 | $f_{01}$ | 0.255534 | $m_3$ | 0.170696 |
| $k_{db}$ | 0.289191 | $m_1$ | 0.533124 | PSNR | 41.30788 |

| Material Name | teflon | $k_{sg}$ | 0.137912 | $R_2$ | 1.472553 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.139877 | $n_2$ | 47.17461 |
| $k_{dr}$ | 0.279270 | $f_{01}$ | 0 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.272676 | $R_1$ | 0.787923 | $R_3$ | 6.363935 |
| $k_{db}$ | 0.261010 | $n_1$ | 104.6505 | $n_3$ | 21.71123 |
| $k_{sr}$ | 0.137000 | $f_{02}$ | 0.045924 | PSNR | 40.69270 |

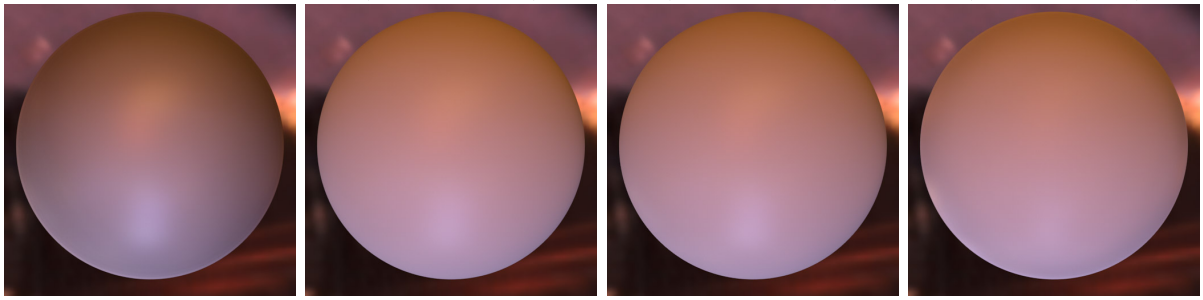
| Material Name | teflon | $k_{db}$ | 0.287953 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.018870 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.308447 | $k_{sg}$ | 0.019675 | $\alpha_3$ | 0.168859 |
| $k_{dg}$ | 0.301008 | $k_{sb}$ | 0.021128 | PSNR | 37.78950 |

| Material Name | teflon | $k_{db}$ | 0.286122 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.015188 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.305063 | $k_{sg}$ | 0.015483 | $\alpha_3$ | 0.154942 |
| $k_{dg}$ | 0.298229 | $k_{sb}$ | 0.016083 | PSNR | 39.75850 |

**Rendered Images**

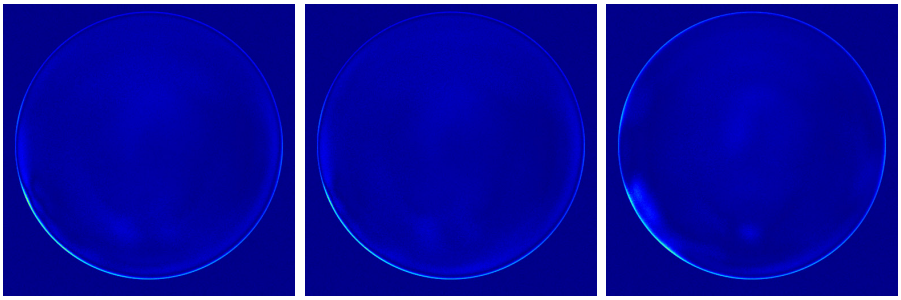


Reference image | Ashikhmin-Shirley (PSNR=40.99699) | Cook-Torrance (PSNR=41.30788) | Edwards et al. (PSNR=40.69270)

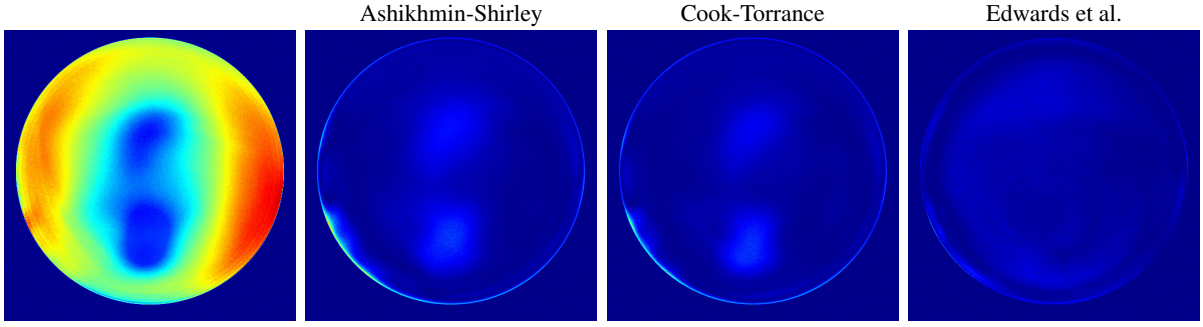


Lawrence et al. (PSNR=20.73598) | Ward (PSNR=37.78950) | Ward-Duer (PSNR=39.75850) | Our factored model (PSNR=41.99066)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: tungsten-carbide

**Fitted Parameters/PSNR**

| Material Name | tungsten-carbide | $k_{sr}$ | 0.047840 | $f_{02}$ | 0.635993 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.050521 | $n_2$ | 110218.1 |
| $k_{dr}$ | 0.026076 | $k_{sb}$ | 0.075298 | $f_{03}$ | 0.774177 |
| $k_{dg}$ | 0.009187 | $f_{01}$ | 0.050989 | $n_3$ | 12972.80 |
| $k_{db}$ | 0 | $n_1$ | 2333787 | PSNR | 24.89180 |

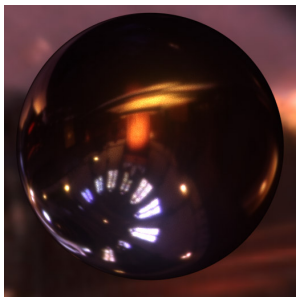
| Material Name | tungsten-carbide | $k_{sr}$ | 0.011616 | $f_{02}$ | 0.656943 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.012266 | $m_2$ | 0.004271 |
| $k_{dr}$ | 0.026096 | $k_{sb}$ | 0.018283 | $f_{03}$ | 0.052852 |
| $k_{dg}$ | 0.009213 | $f_{01}$ | 0.787193 | $m_3$ | 0.000928 |
| $k_{db}$ | 0 | $m_1$ | 0.012435 | PSNR | 24.88537 |

| Material Name | tungsten-carbide | $k_{sg}$ | 0.046641 | $R_2$ | 0.141178 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.068861 | $n_2$ | 66.51310 |
| $k_{dr}$ | 0.031513 | $f_{01}$ | 0.145996 | $f_{03}$ | 0.685879 |
| $k_{dg}$ | 0.014282 | $R_1$ | 0.003254 | $R_3$ | 0.046537 |
| $k_{db}$ | 0 | $n_1$ | 0.148218 | $n_3$ | 42.11823 |
| $k_{sr}$ | 0.043746 | $f_{02}$ | 0.621287 | PSNR | 23.13171 |

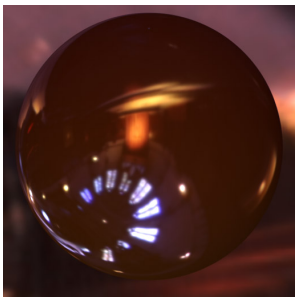
| Material Name | tungsten-carbide | $k_{db}$ | 0 | $\alpha_1$ | 0.009272 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.029319 | $\alpha_2$ | 0.002951 |
| $k_{dr}$ | 0.030443 | $k_{sg}$ | 0.030770 | $\alpha_3$ | 0.009272 |
| $k_{dg}$ | 0.014223 | $k_{sb}$ | 0.044397 | PSNR | 23.33125 |

| Material Name | tungsten-carbide | $k_{db}$ | 0 | $\alpha_1$ | 0.012043 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.022266 | $\alpha_2$ | 0.002978 |
| $k_{dr}$ | 0.030173 | $k_{sg}$ | 0.023216 | $\alpha_3$ | 0.007969 |
| $k_{dg}$ | 0.014385 | $k_{sb}$ | 0.034653 | PSNR | 23.73724 |

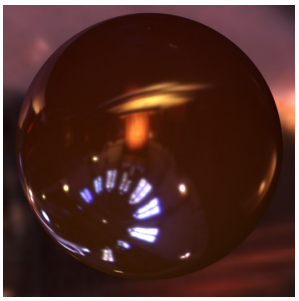
**Rendered Images**



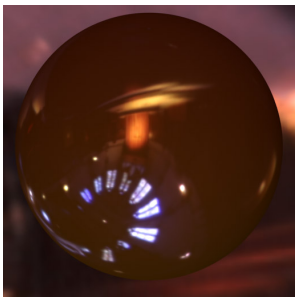
Reference image



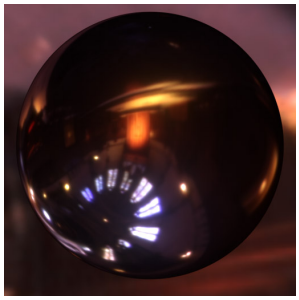
Ashikhmin-Shirley
(PSNR=24.89180)



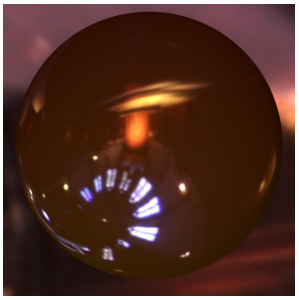
Cook-Torrance
(PSNR=24.88537)



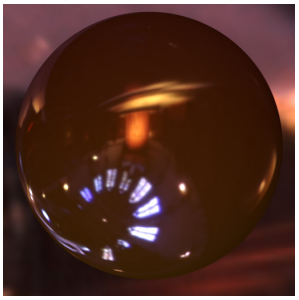
Edwards et al.
(PSNR=23.13171)



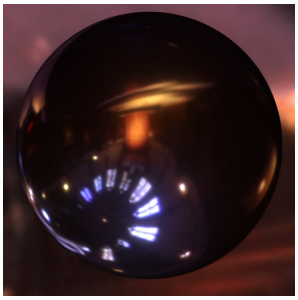
Lawrence et al.
(PSNR=38.23220)



Ward
(PSNR=23.33125)

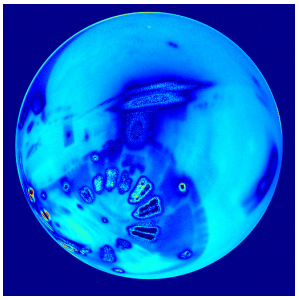


Ward-Duer
(PSNR=23.73724)

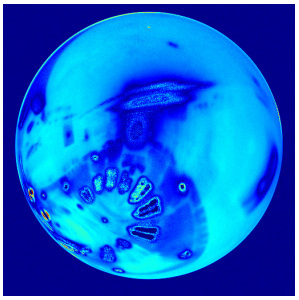


Our factored model
(PSNR=33.59939)

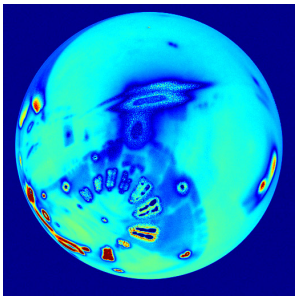
**Difference Images**



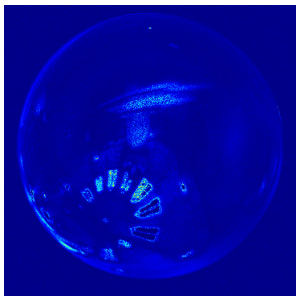
Ashikhmin-Shirley



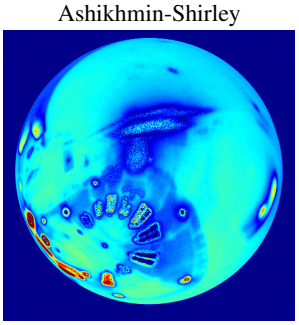
Cook-Torrance



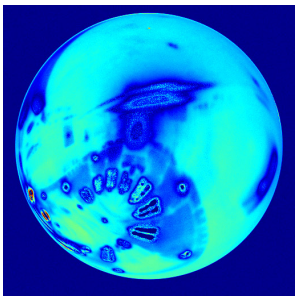
Edwards et al.



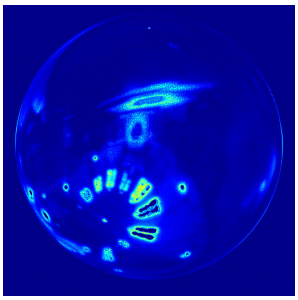
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: two-layer-gold

**Fitted Parameters/PSNR**

| Material Name | two-layer-gold | $k_{sr}$ | 0.068431 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.062823 | $n_2$ | 119.5658 |
| $k_{dr}$ | 0.104783 | $k_{sb}$ | 0.064508 | $f_{03}$ | 0.093191 |
| $k_{dg}$ | 0.088006 | $f_{01}$ | 0.022405 | $n_3$ | 6260.045 |
| $k_{db}$ | 0.056669 | $n_1$ | 228649.5 | PSNR | 23.43893 |

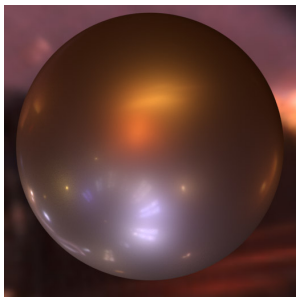
| Material Name | two-layer-gold | $k_{sr}$ | 0.016219 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.014882 | $m_2$ | 0.130492 |
| $k_{dr}$ | 0.102773 | $k_{sb}$ | 0.015269 | $f_{03}$ | 0.023861 |
| $k_{dg}$ | 0.086194 | $f_{01}$ | 0.099957 | $m_3$ | 0.002970 |
| $k_{db}$ | 0.054863 | $m_1$ | 0.017684 | PSNR | 23.57685 |

| Material Name | two-layer-gold | $k_{sg}$ | 0.075655 | $R_2$ | 1.684114 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.075645 | $n_2$ | 64.73463 |
| $k_{dr}$ | 0.087716 | $f_{01}$ | 0.039813 | $f_{03}$ | 0.068063 |
| $k_{dg}$ | 0.073640 | $R_1$ | 0.126465 | $R_3$ | 1.130377 |
| $k_{db}$ | 0.043980 | $n_1$ | 247.9041 | $n_3$ | 749.8883 |
| $k_{sr}$ | 0.083812 | $f_{02}$ | 0.999999 | PSNR | 25.79170 |

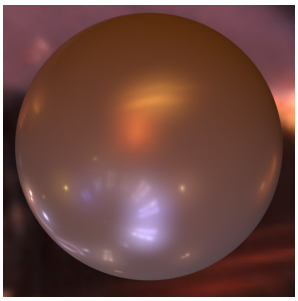
| Material Name | two-layer-gold | $k_{db}$ | 0.094584 | $\alpha_1$ | 0.070410 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.013473 | $\alpha_2$ | 0.070410 |
| $k_{dr}$ | 0.144265 | $k_{sg}$ | 0.012172 | $\alpha_3$ | 0.010775 |
| $k_{dg}$ | 0.124664 | $k_{sb}$ | 0.012367 | PSNR | 19.78573 |

| Material Name | two-layer-gold | $k_{db}$ | 0.095032 | $\alpha_1$ | 0.068653 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.009865 | $\alpha_2$ | 0.068653 |
| $k_{dr}$ | 0.144701 | $k_{sg}$ | 0.008823 | $\alpha_3$ | 0.010794 |
| $k_{dg}$ | 0.125310 | $k_{sb}$ | 0.009039 | PSNR | 19.63849 |

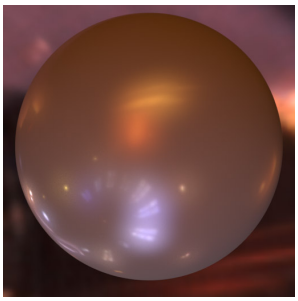
**Rendered Images**



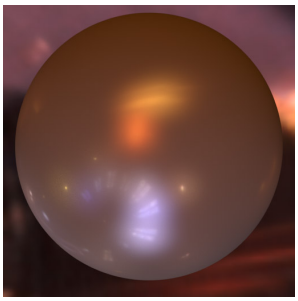
Reference image



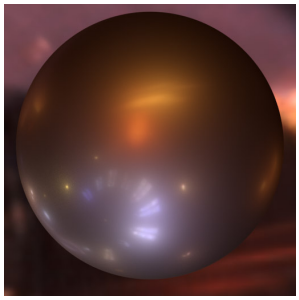
Ashikhmin-Shirley
(PSNR=23.43893)



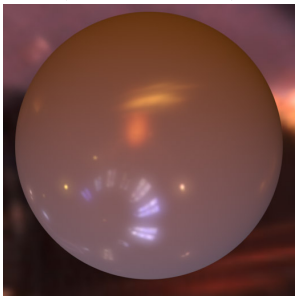
Cook-Torrance
(PSNR=23.57685)



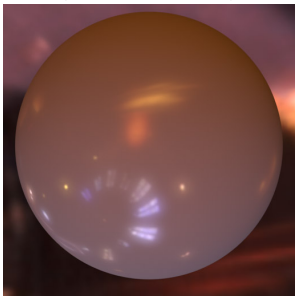
Edwards et al.
(PSNR=25.79170)



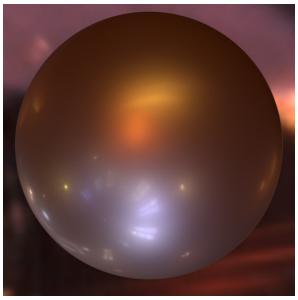
Lawrence et al.
(PSNR=29.63692)



Ward
(PSNR=19.78573)

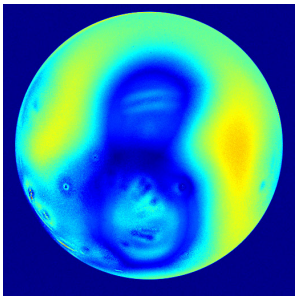


Ward-Duer
(PSNR=19.63849)

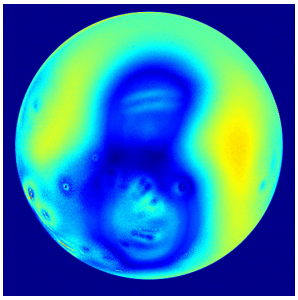


Our factored model
(PSNR=37.51388)

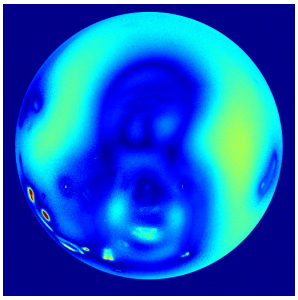
**Difference Images**



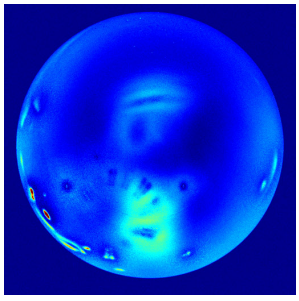
Ashikhmin-Shirley



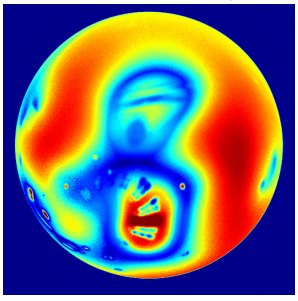
Cook-Torrance



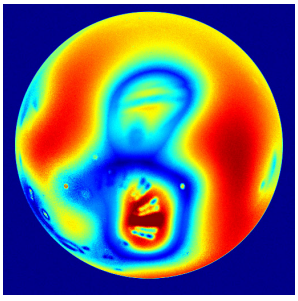
Edwards et al.



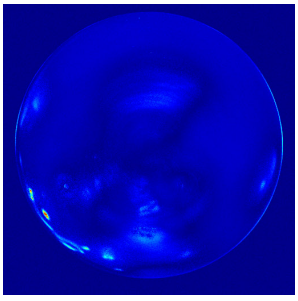
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: two-layer-silver

**Fitted Parameters/PSNR**

| Material Name | two-layer-silver | $k_{sr}$ | 0.075362 | $f_{02}$ | 0.909219 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.071802 | $n_2$ | 107.9502 |
| $k_{dr}$ | 0.062505 | $k_{sb}$ | 0.071212 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.065061 | $f_{01}$ | 0.082316 | $n_3$ | 17.48744 |
| $k_{db}$ | 0.064634 | $n_1$ | 13556.95 | PSNR | 30.70917 |

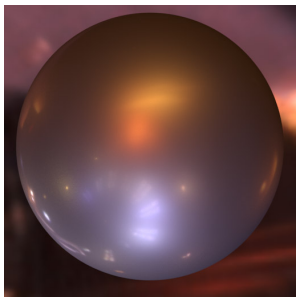
| Material Name | two-layer-silver | $k_{sr}$ | 0.017674 | $f_{02}$ | 0.678691 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.016836 | $m_2$ | 0.113538 |
| $k_{dr}$ | 0.065316 | $k_{sb}$ | 0.016711 | $f_{03}$ | 0.085565 |
| $k_{dg}$ | 0.067761 | $f_{01}$ | 0.999999 | $m_3$ | 0.011789 |
| $k_{db}$ | 0.067225 | $m_1$ | 0.296989 | PSNR | 29.66369 |

| Material Name | two-layer-silver | $k_{sg}$ | 0.093628 | $R_2$ | 0.325142 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.094262 | $n_2$ | 177.7108 |
| $k_{dr}$ | 0.088546 | $f_{01}$ | 0.017436 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.089909 | $R_1$ | 0.144081 | $R_3$ | 3.498604 |
| $k_{db}$ | 0.087957 | $n_1$ | 494.4285 | $n_3$ | 253.3008 |
| $k_{sr}$ | 0.098313 | $f_{02}$ | 0.023794 | PSNR | 27.23816 |

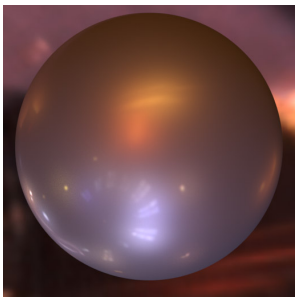
| Material Name | two-layer-silver | $k_{db}$ | 0.146941 | $\alpha_1$ | 0.086009 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.015947 | $\alpha_2$ | 0.086009 |
| $k_{dr}$ | 0.147626 | $k_{sg}$ | 0.014524 | $\alpha_3$ | 0.014318 |
| $k_{dg}$ | 0.147563 | $k_{sb}$ | 0.014174 | PSNR | 20.68873 |

| Material Name | two-layer-silver | $k_{db}$ | 0.146251 | $\alpha_1$ | 0.083894 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.011696 | $\alpha_2$ | 0.083894 |
| $k_{dr}$ | 0.148126 | $k_{sg}$ | 0.010844 | $\alpha_3$ | 0.012815 |
| $k_{dg}$ | 0.147478 | $k_{sb}$ | 0.010798 | PSNR | 20.54375 |

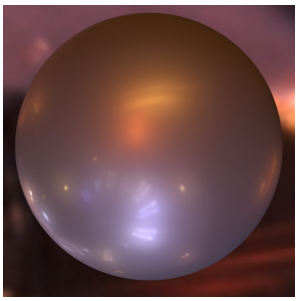
**Rendered Images**



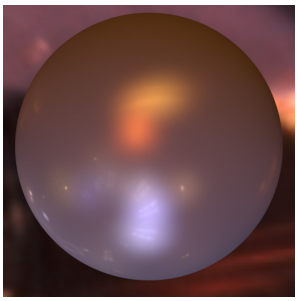
Reference image



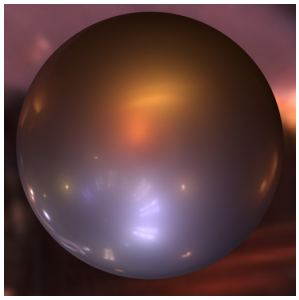
Ashikhmin-Shirley
(PSNR=30.70917)



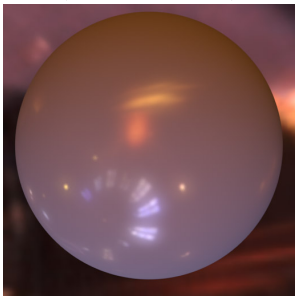
Cook-Torrance
(PSNR=29.66369)



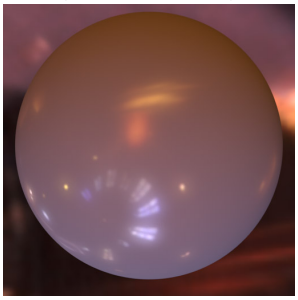
Edwards et al.
(PSNR=27.23816)



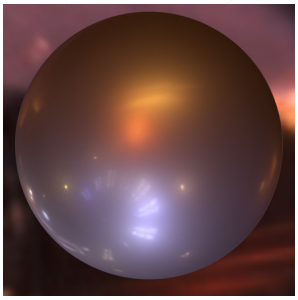
Lawrence et al.
(PSNR=31.81420)



Ward
(PSNR=20.68873)

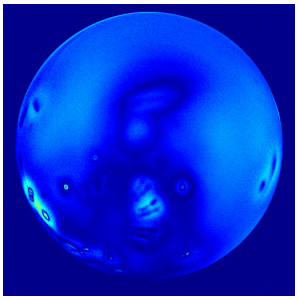


Ward-Duer
(PSNR=20.54375)

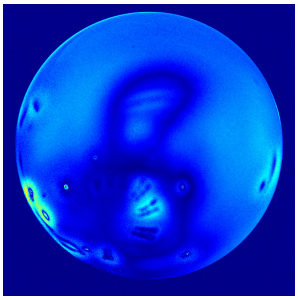


Our factored model
(PSNR=39.99408)

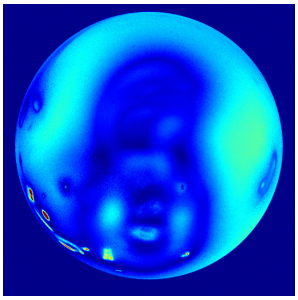
**Difference Images**



Ashikhmin-Shirley

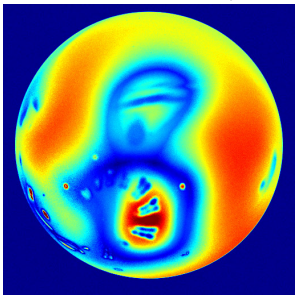


Cook-Torrance

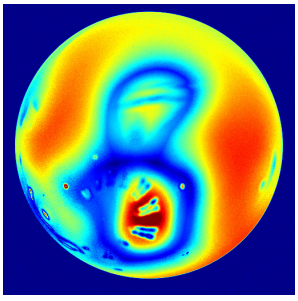


Edwards et al.

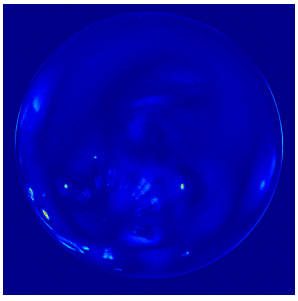
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: violet-acrylic

**Fitted Parameters/PSNR**

| Material Name | violet-acrylic | $k_{sr}$ | 0.059705 | $f_{02}$ | 0.003888 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.055849 | $n_2$ | 3521.555 |
| $k_{dr}$ | 0.064033 | $k_{sb}$ | 0.055575 | $f_{03}$ | 0.324663 |
| $k_{dg}$ | 0.021075 | $f_{01}$ | 0.096000 | $n_3$ | 173.0648 |
| $k_{db}$ | 0.046312 | $n_1$ | 17637.85 | PSNR | 29.74161 |

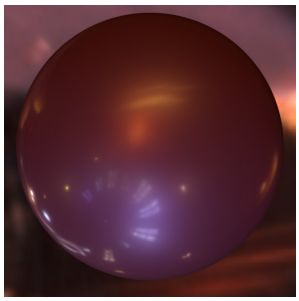
| Material Name | violet-acrylic | $k_{sr}$ | 0.019094 | $f_{02}$ | 0.044985 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.018035 | $m_2$ | 0.012437 |
| $k_{dr}$ | 0.077992 | $k_{sb}$ | 0.017845 | $f_{03}$ | 0.009769 |
| $k_{dg}$ | 0.034038 | $f_{01}$ | 0.057245 | $m_3$ | 0.002216 |
| $k_{db}$ | 0.059267 | $m_1$ | 0.031988 | PSNR | 25.44447 |

| Material Name | violet-acrylic | $k_{sg}$ | 0.086514 | $R_2$ | 0.041300 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.086173 | $n_2$ | 4.713438 |
| $k_{dr}$ | 0.058125 | $f_{01}$ | 0.017420 | $f_{03}$ | 0.293883 |
| $k_{dg}$ | 0.015255 | $R_1$ | 0.082973 | $R_3$ | 3.690874 |
| $k_{db}$ | 0.040492 | $n_1$ | 189.6160 | $n_3$ | 355.3062 |
| $k_{sr}$ | 0.091535 | $f_{02}$ | 0.020042 | PSNR | 31.32341 |

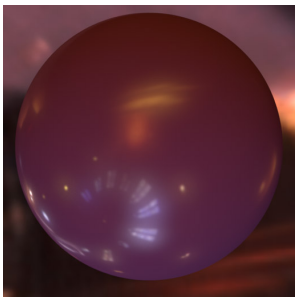
| Material Name | violet-acrylic | $k_{db}$ | 0.052349 | $\alpha_1$ | 0.032437 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.008708 | $\alpha_2$ | 0.094001 |
| $k_{dr}$ | 0.070155 | $k_{sg}$ | 0.007854 | $\alpha_3$ | 0.009546 |
| $k_{dg}$ | 0.027414 | $k_{sb}$ | 0.007945 | PSNR | 27.48083 |

| Material Name | violet-acrylic | $k_{db}$ | 0.048213 | $\alpha_1$ | 0.110862 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.008000 | $\alpha_2$ | 0.030709 |
| $k_{dr}$ | 0.065880 | $k_{sg}$ | 0.007350 | $\alpha_3$ | 0.010143 |
| $k_{dg}$ | 0.023182 | $k_{sb}$ | 0.007383 | PSNR | 28.53797 |

**Rendered Images**

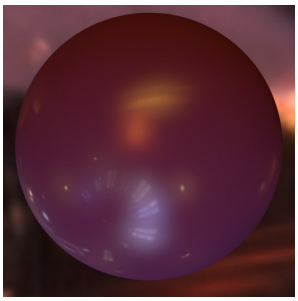


Reference image

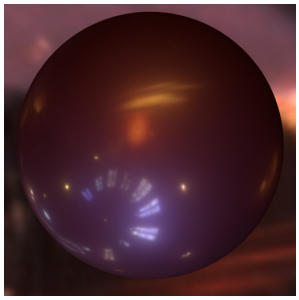


Ashikhmin-Shirley
(PSNR=29.74161)

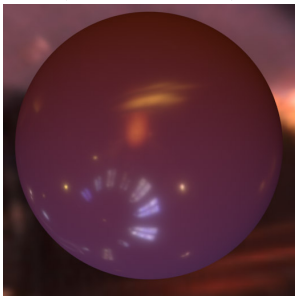
Cook-Torrance
(PSNR=25.44447)



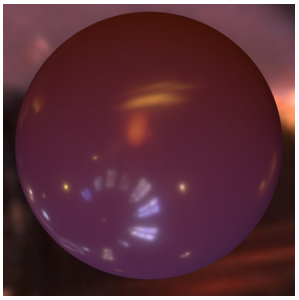
Edwards et al.
(PSNR=31.32341)



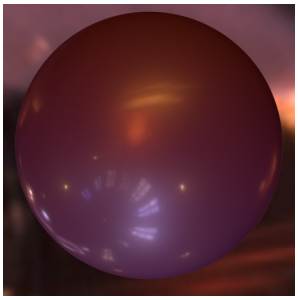
Lawrence et al.
(PSNR=27.45275)



Ward
(PSNR=27.48083)

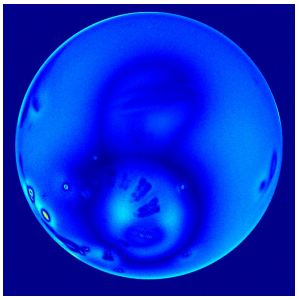


Ward-Duer
(PSNR=28.53797)

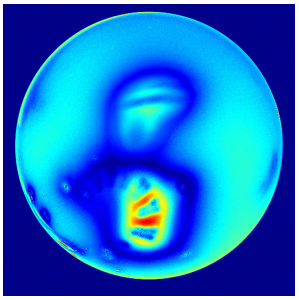


Our factored model
(PSNR=35.43399)

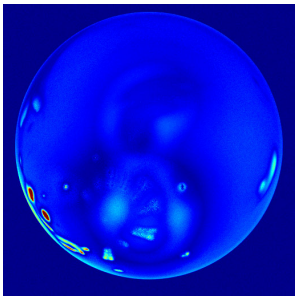
**Difference Images**



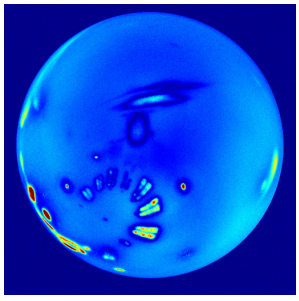
Ashikhmin-Shirley



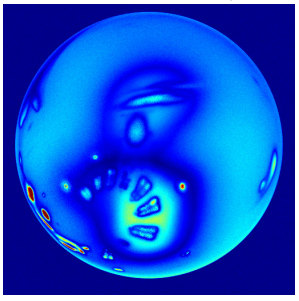
Cook-Torrance



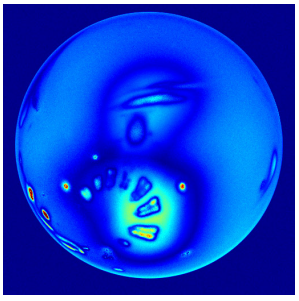
Edwards et al.



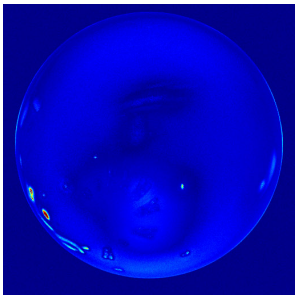
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: violet-rubber

**Fitted Parameters/PSNR**

| Material Name | violet-rubber | $k_{sr}$ | 0.064342 | $f_{02}$ | 0.499068 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.060462 | $n_2$ | 3.810063 |
| $k_{dr}$ | 0.219249 | $k_{sb}$ | 0.062601 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.032261 | $f_{01}$ | 0.114225 | $n_3$ | 0.666312 |
| $k_{db}$ | 0.096018 | $n_1$ | 74.41476 | PSNR | 42.43719 |

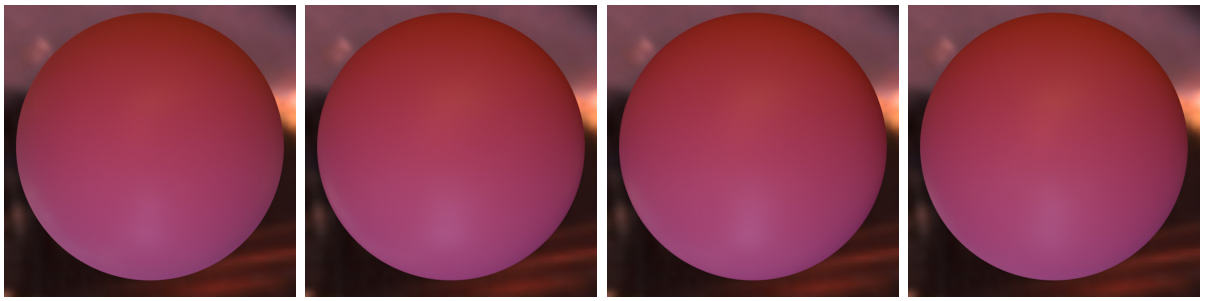
| Material Name | violet-rubber | $k_{sr}$ | 0.010353 | $f_{02}$ | 0.356745 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.009785 | $m_2$ | 0.427172 |
| $k_{dr}$ | 0.225970 | $k_{sb}$ | 0.010104 | $f_{03}$ | 0.151035 |
| $k_{dg}$ | 0.038396 | $f_{01}$ | 0.553457 | $m_3$ | 0.145359 |
| $k_{db}$ | 0.102458 | $m_1$ | 0.999999 | PSNR | 41.73785 |

| Material Name | violet-rubber | $k_{sg}$ | 0.066387 | $R_2$ | 1.727397 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.068141 | $n_2$ | 49.99045 |
| $k_{dr}$ | 0.240411 | $f_{01}$ | 0.006627 | $f_{03}$ | 0.274140 |
| $k_{dg}$ | 0.052099 | $R_1$ | 0.891840 | $R_3$ | 2.604518 |
| $k_{db}$ | 0.116716 | $n_1$ | 100.0226 | $n_3$ | 9.650782 |
| $k_{sr}$ | 0.070456 | $f_{02}$ | 0.073495 | PSNR | 41.80912 |

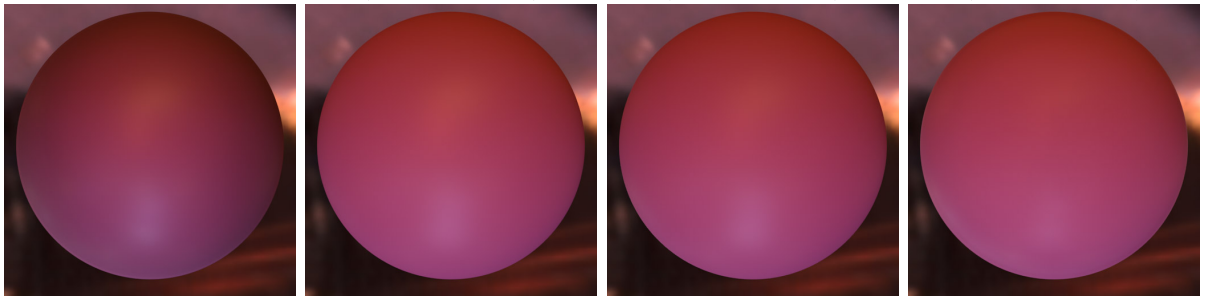
| Material Name | violet-rubber | $k_{db}$ | 0.117185 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.012466 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.239872 | $k_{sg}$ | 0.010738 | $\alpha_3$ | 0.157326 |
| $k_{dg}$ | 0.053139 | $k_{sb}$ | 0.011411 | PSNR | 37.97660 |

| Material Name | violet-rubber | $k_{db}$ | 0.115624 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.009434 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.238994 | $k_{sg}$ | 0.008641 | $\alpha_3$ | 0.156611 |
| $k_{dg}$ | 0.051292 | $k_{sb}$ | 0.008993 | PSNR | 39.92138 |

**Rendered Images**

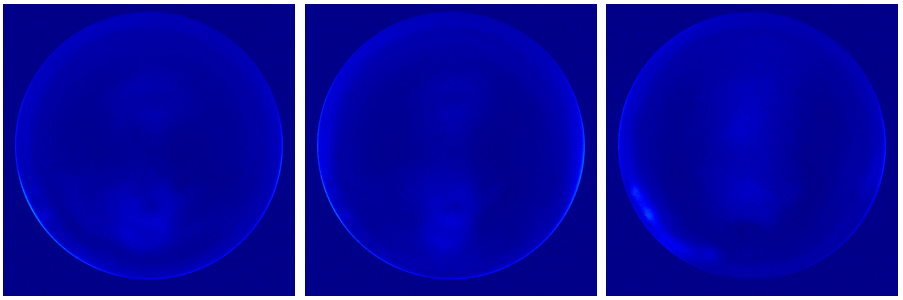


Reference image | Ashikhmin-Shirley (PSNR=42.43719) | Cook-Torrance (PSNR=41.73785) | Edwards et al. (PSNR=41.80912)

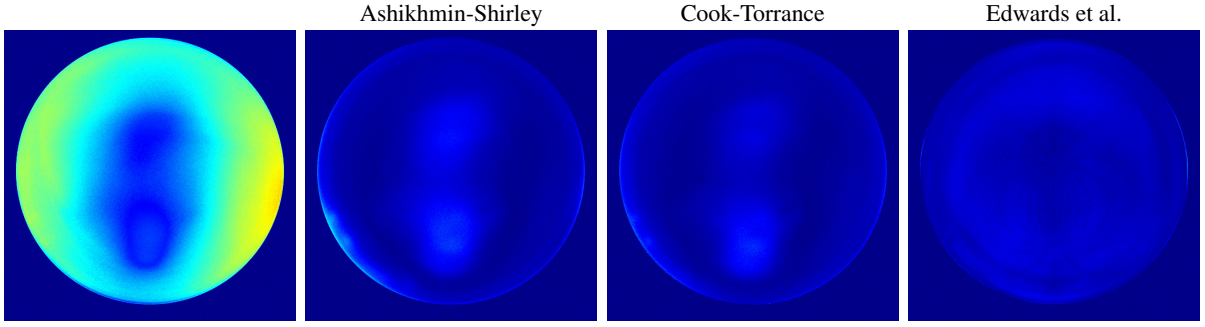


Lawrence et al. (PSNR=22.96010) | Ward (PSNR=37.97660) | Ward-Duer (PSNR=39.92138) | Our factored model (PSNR=38.59465)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: white-acrylic

**Fitted Parameters/PSNR**

| Material Name | white-acrylic | $k_{sr}$ | 0.045359 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.044350 | $n_2$ | 2758.893 |
| $k_{dr}$ | 0.322861 | $k_{sb}$ | 0.045622 | $f_{03}$ | 0.026361 |
| $k_{dg}$ | 0.306986 | $f_{01}$ | 0.118264 | $n_3$ | 2258.838 |
| $k_{db}$ | 0.265747 | $n_1$ | 15635.83 | PSNR | 36.01033 |

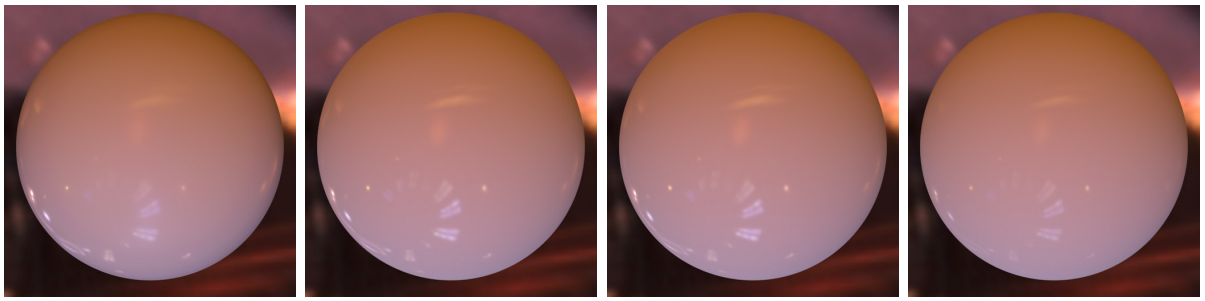
| Material Name | white-acrylic | $k_{sr}$ | 0.010873 | $f_{02}$ | 0.118827 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.010632 | $m_2$ | 0.011011 |
| $k_{dr}$ | 0.322702 | $k_{sb}$ | 0.010934 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.306829 | $f_{01}$ | 0.035296 | $m_3$ | 0.026404 |
| $k_{db}$ | 0.265587 | $m_1$ | 0.029849 | PSNR | 36.00208 |

| Material Name | white-acrylic | $k_{sg}$ | 0.059920 | $R_2$ | 0.019499 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.061309 | $n_2$ | 1.387736 |
| $k_{dr}$ | 0.324205 | $f_{01}$ | 0.023940 | $f_{03}$ | 0.045914 |
| $k_{dg}$ | 0.308262 | $R_1$ | 0.071879 | $R_3$ | 0.409044 |
| $k_{db}$ | 0.267094 | $n_1$ | 151.7632 | $n_3$ | 244.2640 |
| $k_{sr}$ | 0.060920 | $f_{02}$ | 0 | PSNR | 35.66268 |

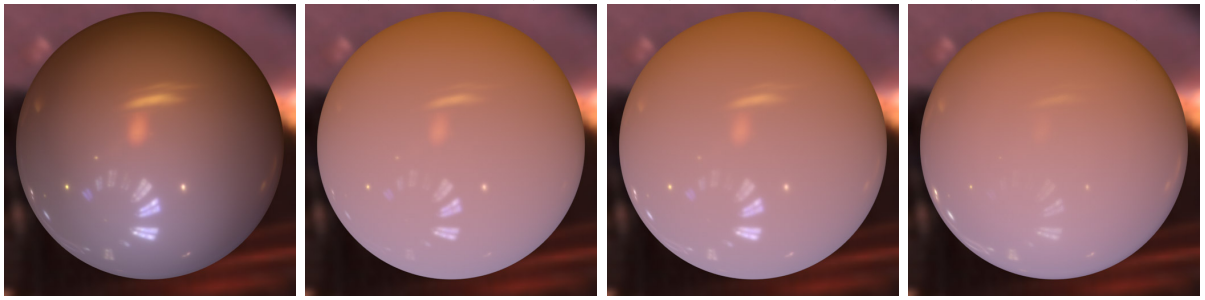
| Material Name | white-acrylic | $k_{db}$ | 0.264102 | $\alpha_1$ | 0.026330 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.004628 | $\alpha_2$ | 0.019141 |
| $k_{dr}$ | 0.320802 | $k_{sg}$ | 0.004497 | $\alpha_3$ | 0.007616 |
| $k_{dg}$ | 0.305033 | $k_{sb}$ | 0.004456 | PSNR | 35.23192 |

| Material Name | white-acrylic | $k_{db}$ | 0.258500 | $\alpha_1$ | 0.053280 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.005419 | $\alpha_2$ | 0.009491 |
| $k_{dr}$ | 0.315259 | $k_{sg}$ | 0.005259 | $\alpha_3$ | 0.020512 |
| $k_{dg}$ | 0.299664 | $k_{sb}$ | 0.005310 | PSNR | 35.52545 |

**Rendered Images**

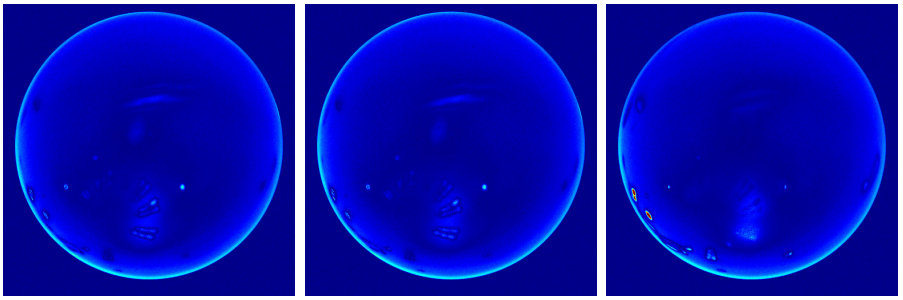


Reference image | Ashikhmin-Shirley (PSNR=36.01033) | Cook-Torrance (PSNR=36.00208) | Edwards et al. (PSNR=35.66268)

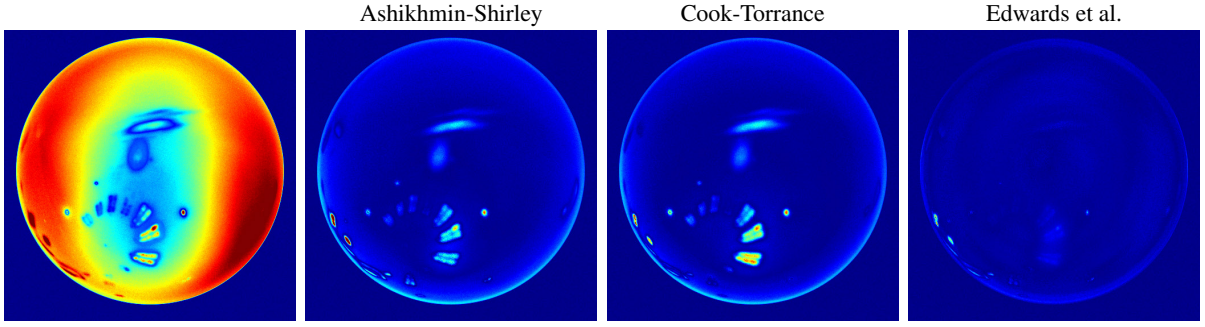


Lawrence et al. (PSNR=19.00800) | Ward (PSNR=35.23192) | Ward-Duer (PSNR=35.52545) | Our factored model (PSNR=42.28908)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: white-diffuse-bball

**Fitted Parameters/PSNR**

| Material Name | white-diffuse-bball | $k_{sr}$ | 0.094678 | $f_{02}$ | 0.236538 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.092881 | $n_2$ | 11.98419 |
| $k_{dr}$ | 0.315574 | $k_{sb}$ | 0.089511 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.267388 | $f_{01}$ | 0.074360 | $n_3$ | 71.44029 |
| $k_{db}$ | 0.171347 | $n_1$ | 132.7311 | PSNR | 39.52627 |

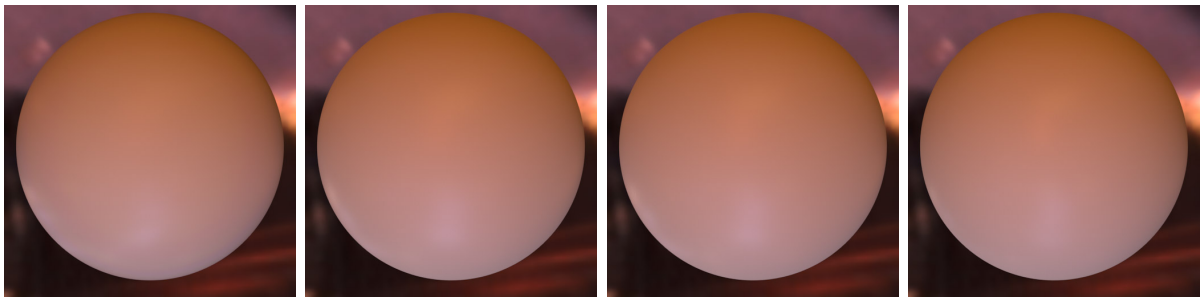
| Material Name | white-diffuse-bball | $k_{sr}$ | 0.017504 | $f_{02}$ | 0.193382 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.017155 | $m_2$ | 0.299491 |
| $k_{dr}$ | 0.318932 | $k_{sb}$ | 0.016597 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.270700 | $f_{01}$ | 0.079681 | $m_3$ | 0.160271 |
| $k_{db}$ | 0.174468 | $m_1$ | 0.108008 | PSNR | 38.88421 |

| Material Name | white-diffuse-bball | $k_{sg}$ | 0.112821 | $R_2$ | 1.258539 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.108736 | $n_2$ | 49.71966 |
| $k_{dr}$ | 0.287982 | $f_{01}$ | 0 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.240365 | $R_1$ | 0.610555 | $R_3$ | 5.698655 |
| $k_{db}$ | 0.145301 | $n_1$ | 101.9675 | $n_3$ | 17.27622 |
| $k_{sr}$ | 0.115110 | $f_{02}$ | 0.057445 | PSNR | 41.55288 |

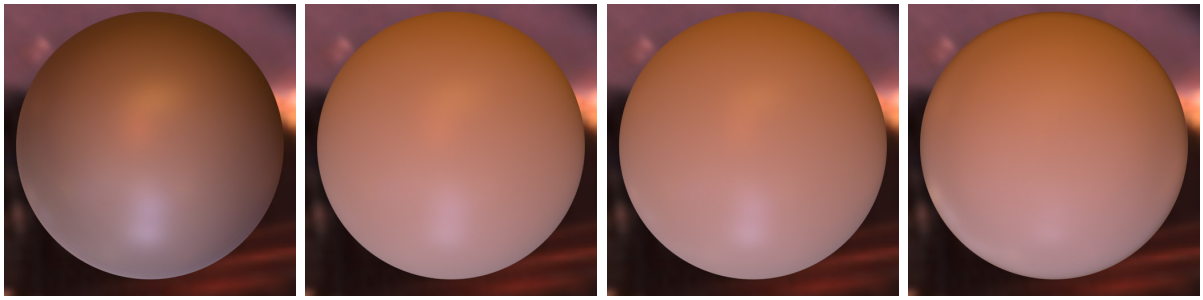
| Material Name | white-diffuse-bball | $k_{db}$ | 0.167575 | $\alpha_1$ | 0.486543 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.017081 | $\alpha_2$ | 0.486543 |
| $k_{dr}$ | 0.311442 | $k_{sg}$ | 0.017205 | $\alpha_3$ | 0.131555 |
| $k_{dg}$ | 0.262634 | $k_{sb}$ | 0.016062 | PSNR | 38.69455 |

| Material Name | white-diffuse-bball | $k_{db}$ | 0.167318 | $\alpha_1$ | 0.329201 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.011620 | $\alpha_2$ | 0.498556 |
| $k_{dr}$ | 0.311587 | $k_{sg}$ | 0.011540 | $\alpha_3$ | 0.114823 |
| $k_{dg}$ | 0.263156 | $k_{sb}$ | 0.011100 | PSNR | 39.24151 |

**Rendered Images**

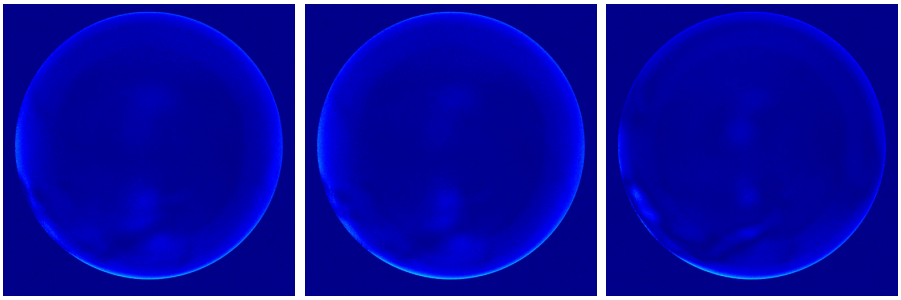


Reference image | Ashikhmin-Shirley (PSNR=39.52627) | Cook-Torrance (PSNR=38.88421) | Edwards et al. (PSNR=41.55288)

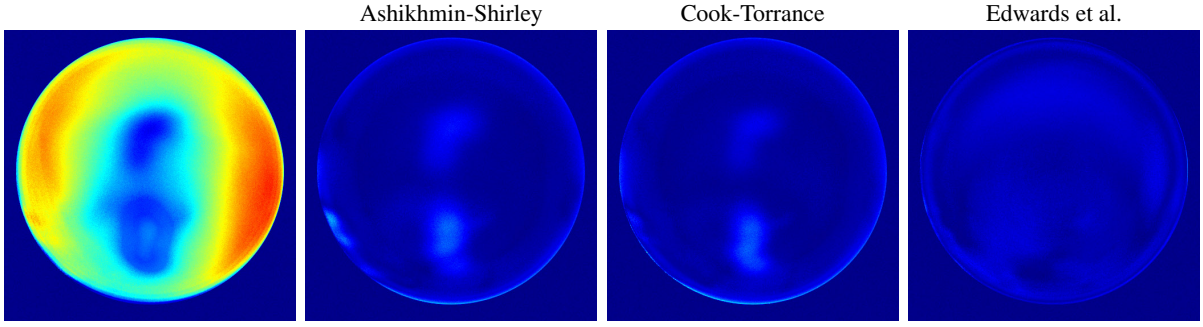


Lawrence et al. (PSNR=20.96661) | Ward (PSNR=38.69455) | Ward-Duer (PSNR=39.24151) | Our factored model (PSNR=39.49301)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: white-fabric

**Fitted Parameters/PSNR**

| Material Name | white-fabric | $k_{sr}$ | 0.077643 | $f_{02}$ | 0.430299 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.071771 | $n_2$ | 3.738544 |
| $k_{dr}$ | 0.287899 | $k_{sb}$ | 0.065589 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.193056 | $f_{01}$ | 0.999999 | $n_3$ | 0 |
| $k_{db}$ | 0.125421 | $n_1$ | 0 | PSNR | 39.12619 |

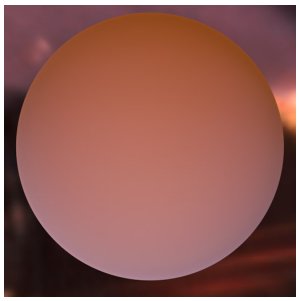
| Material Name | white-fabric | $k_{sr}$ | 0.010808 | $f_{02}$ | 0.177424 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.009526 | $m_2$ | 0.999999 |
| $k_{dr}$ | 0.299866 | $k_{sb}$ | 0.008020 | $f_{03}$ | 0.627450 |
| $k_{dg}$ | 0.205559 | $f_{01}$ | 0.323854 | $m_3$ | 0.999999 |
| $k_{db}$ | 0.138974 | $m_1$ | 0.416566 | PSNR | 37.34615 |

| Material Name | white-fabric | $k_{sg}$ | 0.113532 | $R_2$ | 6.783400 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.088113 | $n_2$ | 49.89663 |
| $k_{dr}$ | 0.318254 | $f_{01}$ | 0.017656 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.221514 | $R_1$ | 3.746839 | $R_3$ | 4.593233 |
| $k_{db}$ | 0.153303 | $n_1$ | 100.0438 | $n_3$ | 10.15235 |
| $k_{sr}$ | 0.126418 | $f_{02}$ | 0.144887 | PSNR | 39.33807 |

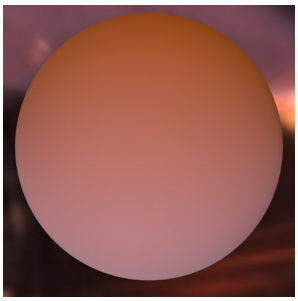
| Material Name | white-fabric | $k_{db}$ | 0.160386 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.013538 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.315620 | $k_{sg}$ | 0.009215 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.223017 | $k_{sb}$ | 0.002649 | PSNR | 37.11230 |

| Material Name | white-fabric | $k_{db}$ | 0.155364 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.009558 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.315760 | $k_{sg}$ | 0.007536 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.221209 | $k_{sb}$ | 0.004604 | PSNR | 37.38956 |

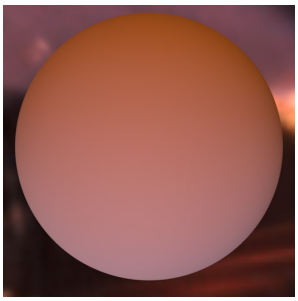
**Rendered Images**



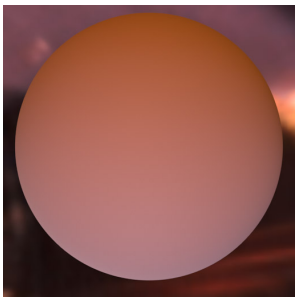
Reference image



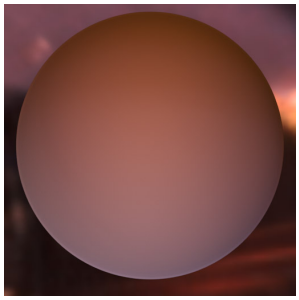
Ashikhmin-Shirley
(PSNR=39.12619)



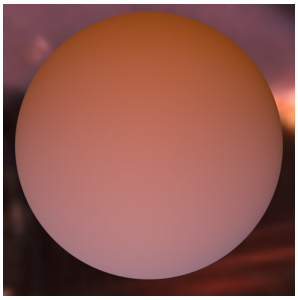
Cook-Torrance
(PSNR=37.34615)



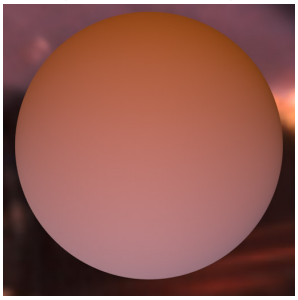
Edwards et al.
(PSNR=39.33807)



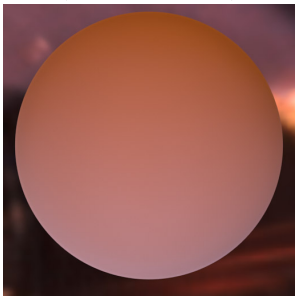
Lawrence et al.
(PSNR=20.74010)



Ward
(PSNR=37.11230)

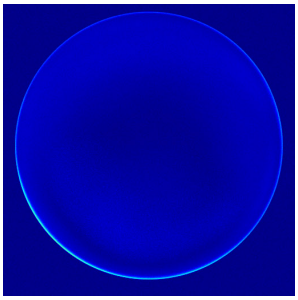


Ward-Duer
(PSNR=37.38956)

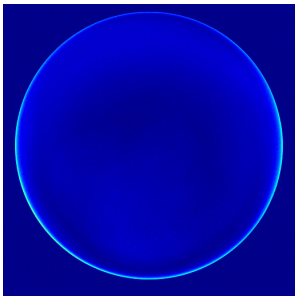


Our factored model
(PSNR=40.21137)

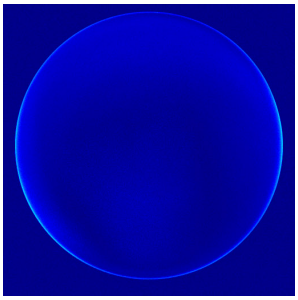
**Difference Images**



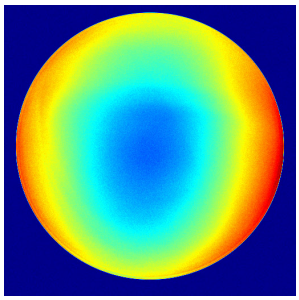
Ashikhmin-Shirley



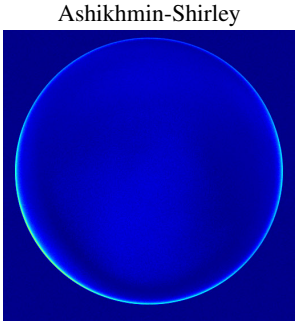
Cook-Torrance



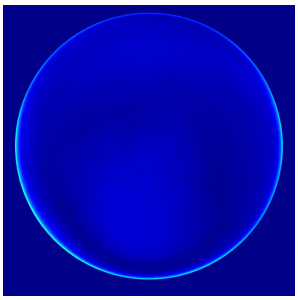
Edwards et al.



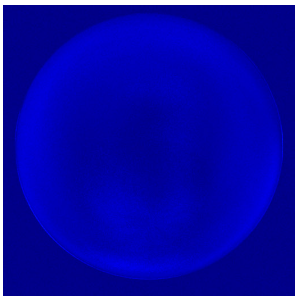
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: white-fabric2

**Fitted Parameters/PSNR**

| Material Name | white-fabric2 | $k_{sr}$ | 0.077528 | $f_{02}$ | 0.999999 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.080421 | $n_2$ | 0 |
| $k_{dr}$ | 0.056743 | $k_{sb}$ | 0.084877 | $f_{03}$ | 0.999999 |
| $k_{dg}$ | 0.050879 | $f_{01}$ | 0.999999 | $n_3$ | 0 |
| $k_{db}$ | 0.059975 | $n_1$ | 0 | PSNR | 40.80107 |

| Material Name | white-fabric2 | $k_{sr}$ | 0.026223 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.026962 | $m_2$ | 0.999999 |
| $k_{dr}$ | 0.086726 | $k_{sb}$ | 0.027982 | $f_{03}$ | 0.173571 |
| $k_{dg}$ | 0.082108 | $f_{01}$ | 0.035495 | $m_3$ | 0.999999 |
| $k_{db}$ | 0.093187 | $m_1$ | 0.999999 | PSNR | 34.88987 |

| Material Name | white-fabric2 | $k_{sg}$ | 0.254475 | $R_2$ | 15.98761 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.269038 | $n_2$ | 49.65563 |
| $k_{dr}$ | 0.094171 | $f_{01}$ | 0 | $f_{03}$ | 0.013661 |
| $k_{dg}$ | 0.089730 | $R_1$ | 24.44421 | $R_3$ | 4.850721 |
| $k_{db}$ | 0.100966 | $n_1$ | 99.43931 | $n_3$ | 21.21128 |
| $k_{sr}$ | 0.246258 | $f_{02}$ | 0 | PSNR | 36.89726 |

| Material Name | white-fabric2 | $k_{db}$ | 0.106181 | $\alpha_1$ | 0.267252 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.001189 | $\alpha_2$ | 0.267252 |
| $k_{dr}$ | 0.098601 | $k_{sg}$ | 0.001151 | $\alpha_3$ | 0.267252 |
| $k_{dg}$ | 0.094446 | $k_{sb}$ | 0.001088 | PSNR | 33.79994 |

| Material Name | white-fabric2 | $k_{db}$ | 0.103454 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.002399 | $\alpha_2$ | 0.309333 |
| $k_{dr}$ | 0.095905 | $k_{sg}$ | 0.002404 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.091671 | $k_{sb}$ | 0.002324 | PSNR | 33.67972 |

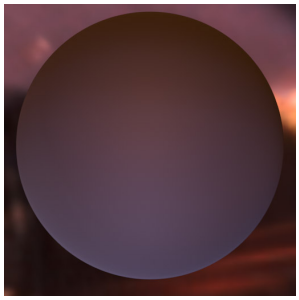
**Rendered Images**

Reference image

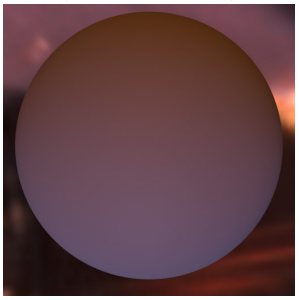
Ashikhmin-Shirley
(PSNR=40.80107)

Cook-Torrance
(PSNR=34.88987)

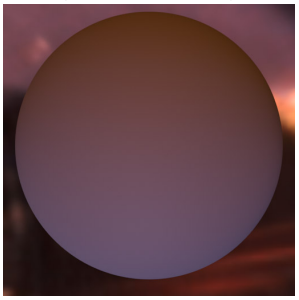
Edwards et al.
(PSNR=36.89726)



Lawrence et al.
(PSNR=24.85613)



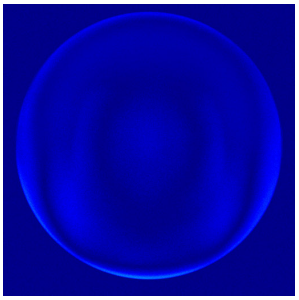
Ward
(PSNR=33.79994)



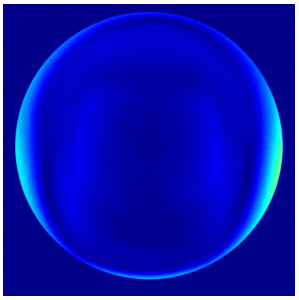
Ward-Duer
(PSNR=33.67972)

Our factored model
(PSNR=44.50326)

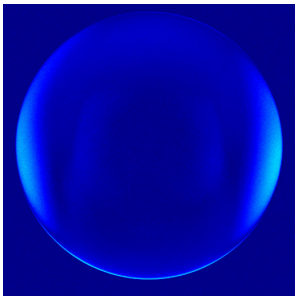
**Difference Images**



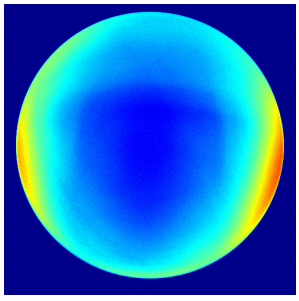
Ashikhmin-Shirley



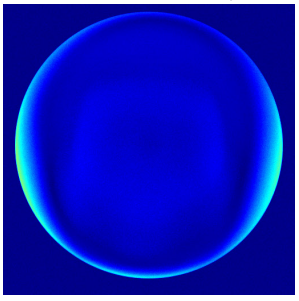
Cook-Torrance



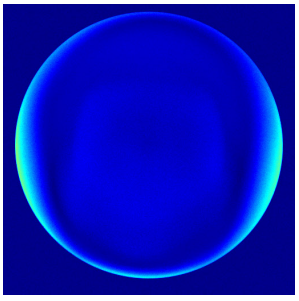
Edwards et al.



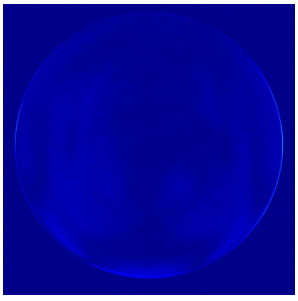
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: white-marble

**Fitted Parameters/PSNR**

| Material Name | white-marble | $k_{sr}$ | 0.055454 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.056464 | $n_2$ | 3163.487 |
| $k_{dr}$ | 0.231743 | $k_{sb}$ | 0.054618 | $f_{03}$ | 0.129891 |
| $k_{dg}$ | 0.216618 | $f_{01}$ | 0.116911 | $n_3$ | 1601.014 |
| $k_{db}$ | 0.191868 | $n_1$ | 19923.64 | PSNR | 36.32495 |

| Material Name | white-marble | $k_{sr}$ | 0.013319 | $f_{02}$ | 0.117836 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.013567 | $m_2$ | 0.009787 |
| $k_{dr}$ | 0.231773 | $k_{sb}$ | 0.013124 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.216643 | $f_{01}$ | 0.135451 | $m_3$ | 0.024781 |
| $k_{db}$ | 0.191892 | $m_1$ | 0.034527 | PSNR | 36.27182 |

| Material Name | white-marble | $k_{sg}$ | 0.089189 | $R_2$ | 0.185853 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.086297 | $n_2$ | 177.5780 |
| $k_{dr}$ | 0.232289 | $f_{01}$ | 0.005498 | $f_{03}$ | 0.081424 |
| $k_{dg}$ | 0.217158 | $R_1$ | 0.069608 | $R_3$ | 0.751782 |
| $k_{db}$ | 0.192387 | $n_1$ | 143.3265 | $n_3$ | 253.8302 |
| $k_{sr}$ | 0.087494 | $f_{02}$ | 0.046650 | PSNR | 35.69368 |

| Material Name | white-marble | $k_{db}$ | 0.185781 | $\alpha_1$ | 0.078184 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.010074 | $\alpha_2$ | 0.024940 |
| $k_{dr}$ | 0.225227 | $k_{sg}$ | 0.010152 | $\alpha_3$ | 0.010018 |
| $k_{dg}$ | 0.210207 | $k_{sb}$ | 0.009766 | PSNR | 34.33784 |

| Material Name | white-marble | $k_{db}$ | 0.182097 | $\alpha_1$ | 0.025396 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.008765 | $\alpha_2$ | 0.080238 |
| $k_{dr}$ | 0.221607 | $k_{sg}$ | 0.008858 | $\alpha_3$ | 0.010240 |
| $k_{dg}$ | 0.206488 | $k_{sb}$ | 0.008559 | PSNR | 35.30766 |

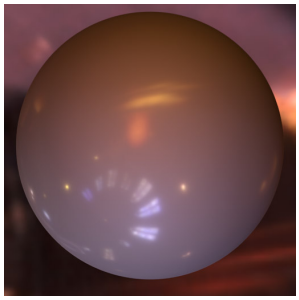
**Rendered Images**

Reference image

Ashikhmin-Shirley
(PSNR=36.32495)

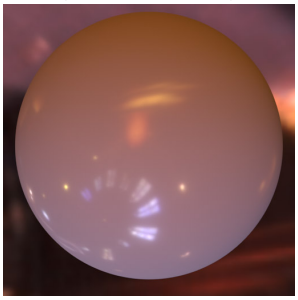
Cook-Torrance
(PSNR=36.27182)

Edwards et al.
(PSNR=35.69368)



Lawrence et al.
(PSNR=21.15359)

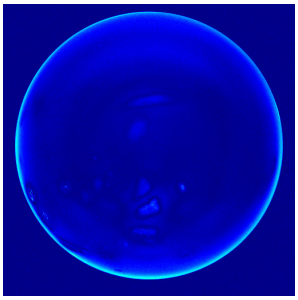
Ward
(PSNR=34.33784)



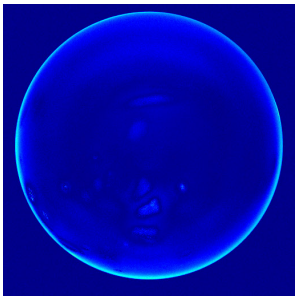
Ward-Duer
(PSNR=35.30766)

Our factored model
(PSNR=40.59265)

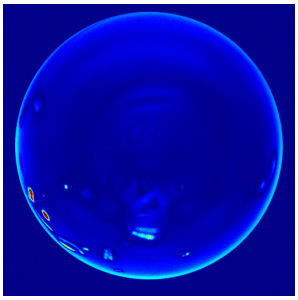
**Difference Images**



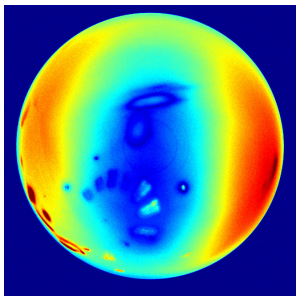
Ashikhmin-Shirley



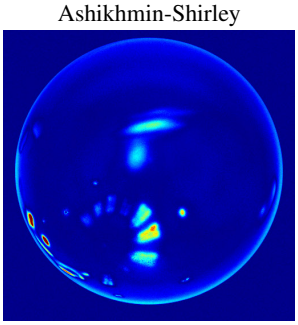
Cook-Torrance



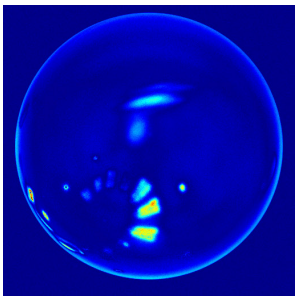
Edwards et al.



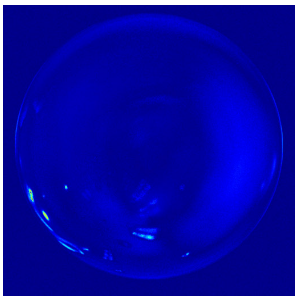
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: white-paint

**Fitted Parameters/PSNR**

| Material Name | white-paint | $k_{sr}$ | 0.175981 | $f_{02}$ | 0.026008 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.172173 | $n_2$ | 933.9826 |
| $k_{dr}$ | 0.316057 | $k_{sb}$ | 0.158444 | $f_{03}$ | 0.087252 |
| $k_{dg}$ | 0.307471 | $f_{01}$ | 0.008280 | $n_3$ | 21.10047 |
| $k_{db}$ | 0.297719 | $n_1$ | 3895.220 | PSNR | 33.83521 |

| Material Name | white-paint | $k_{sr}$ | 0.041110 | $f_{02}$ | 0.029615 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.040236 | $m_2$ | 0.044650 |
| $k_{dr}$ | 0.318464 | $k_{sb}$ | 0.037022 | $f_{03}$ | 0.055803 |
| $k_{dg}$ | 0.309818 | $f_{01}$ | 0.007744 | $m_3$ | 0.294894 |
| $k_{db}$ | 0.299882 | $m_1$ | 0.022126 | PSNR | 33.29250 |

| Material Name | white-paint | $k_{sg}$ | 0.129942 | $R_2$ | 0.031894 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.119190 | $n_2$ | 1.109295 |
| $k_{dr}$ | 0.327909 | $f_{01}$ | 0 | $f_{03}$ | 0.041359 |
| $k_{dg}$ | 0.319000 | $R_1$ | 0.109338 | $R_3$ | 1.092126 |
| $k_{db}$ | 0.308358 | $n_1$ | 137.0471 | $n_3$ | 358.4712 |
| $k_{sr}$ | 0.131931 | $f_{02}$ | 0 | PSNR | 33.15475 |

| Material Name | white-paint | $k_{db}$ | 0.295548 | $\alpha_1$ | 0.243451 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.012943 | $\alpha_2$ | 0.067393 |
| $k_{dr}$ | 0.311795 | $k_{sg}$ | 0.011992 | $\alpha_3$ | 0.023011 |
| $k_{dg}$ | 0.304660 | $k_{sb}$ | 0.010831 | PSNR | 32.64064 |

| Material Name | white-paint | $k_{db}$ | 0.288987 | $\alpha_1$ | 0.226230 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.011899 | $\alpha_2$ | 0.052758 |
| $k_{dr}$ | 0.305177 | $k_{sg}$ | 0.011360 | $\alpha_3$ | 0.020718 |
| $k_{dg}$ | 0.297604 | $k_{sb}$ | 0.010328 | PSNR | 32.60992 |

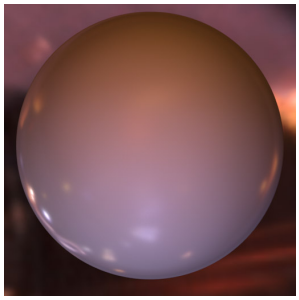
**Rendered Images**

Reference image

Ashikhmin-Shirley
(PSNR=33.83521)

Cook-Torrance
(PSNR=33.29250)

Edwards et al.
(PSNR=33.15475)



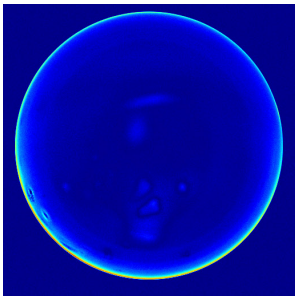
Lawrence et al.
(PSNR=20.40062)

Ward
(PSNR=32.64064)

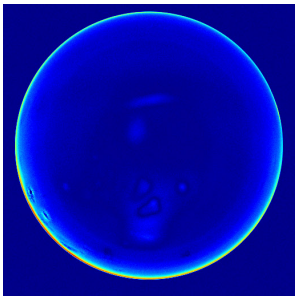
Ward-Duer
(PSNR=32.60992)

Our factored model
(PSNR=39.15472)

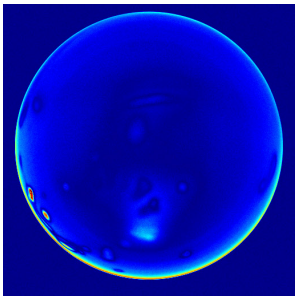
**Difference Images**



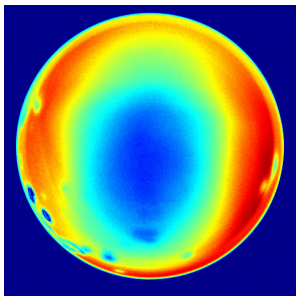
Ashikhmin-Shirley



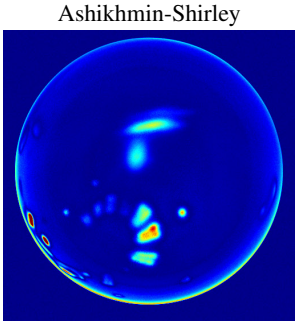
Cook-Torrance



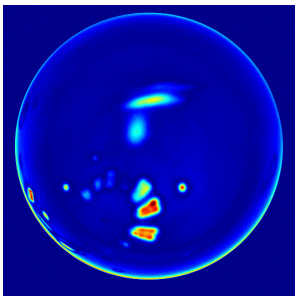
Edwards et al.



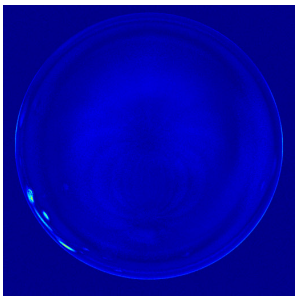
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: yellow-matte-plastic

**Fitted Parameters/PSNR**

| Material Name | yellow-matte-plastic | $k_{sr}$ | 0.131076 | $f_{02}$ | 0.055435 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.127634 | $n_2$ | 457.9019 |
| $k_{dr}$ | 0.287116 | $k_{sb}$ | 0.120819 | $f_{03}$ | 0.090240 |
| $k_{dg}$ | 0.109148 | $f_{01}$ | 0.009527 | $n_3$ | 34.24721 |
| $k_{db}$ | 0.015645 | $n_1$ | 5154.227 | PSNR | 40.16298 |

| Material Name | yellow-matte-plastic | $k_{sr}$ | 0.030218 | $f_{02}$ | 0.055699 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.029501 | $m_2$ | 0.060678 |
| $k_{dr}$ | 0.287448 | $k_{sb}$ | 0.028008 | $f_{03}$ | 0.081352 |
| $k_{dg}$ | 0.109419 | $f_{01}$ | 0.009568 | $m_3$ | 0.236713 |
| $k_{db}$ | 0.015846 | $m_1$ | 0.019079 | PSNR | 39.86016 |

| Material Name | yellow-matte-plastic | $k_{sg}$ | 0.111589 | $R_2$ | 0.055482 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.103919 | $n_2$ | 2.676937 |
| $k_{dr}$ | 0.295514 | $f_{01}$ | 0 | $f_{03}$ | 0.075451 |
| $k_{dg}$ | 0.117292 | $R_1$ | 0.080790 | $R_3$ | 1.639738 |
| $k_{db}$ | 0.023540 | $n_1$ | 84.29933 | $n_3$ | 338.8716 |
| $k_{sr}$ | 0.114280 | $f_{02}$ | 0.002109 | PSNR | 35.71823 |

| Material Name | yellow-matte-plastic | $k_{db}$ | 0.018346 | $\alpha_1$ | 0.109780 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.009449 | $\alpha_2$ | 0.071917 |
| $k_{dr}$ | 0.288096 | $k_{sg}$ | 0.008732 | $\alpha_3$ | 0.020974 |
| $k_{dg}$ | 0.111086 | $k_{sb}$ | 0.007852 | PSNR | 32.69382 |

| Material Name | yellow-matte-plastic | $k_{db}$ | 0.013018 | $\alpha_1$ | 0.120545 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.008947 | $\alpha_2$ | 0.062091 |
| $k_{dr}$ | 0.282662 | $k_{sg}$ | 0.008434 | $\alpha_3$ | 0.018760 |
| $k_{dg}$ | 0.105596 | $k_{sb}$ | 0.007723 | PSNR | 32.39386 |

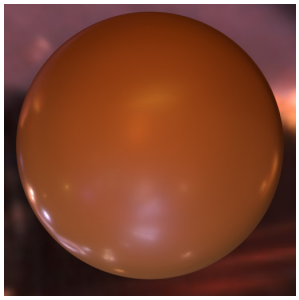
**Rendered Images**

Reference image

Ashikhmin-Shirley
(PSNR=40.16298)

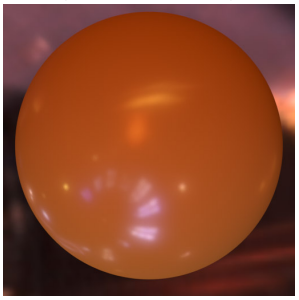
Cook-Torrance
(PSNR=39.86016)

Edwards et al.
(PSNR=35.71823)



Lawrence et al.
(PSNR=25.96730)

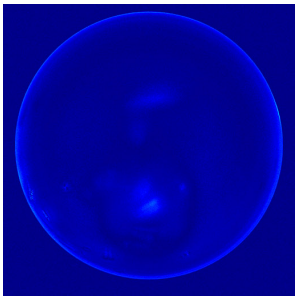
Ward
(PSNR=32.69382)



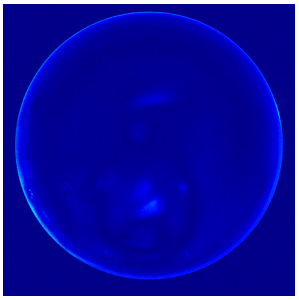
Ward-Duer
(PSNR=32.39386)

Our factored model
(PSNR=38.88591)

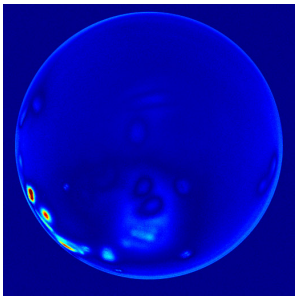
**Difference Images**



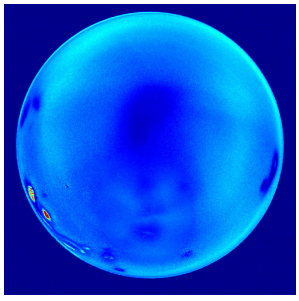
Ashikhmin-Shirley



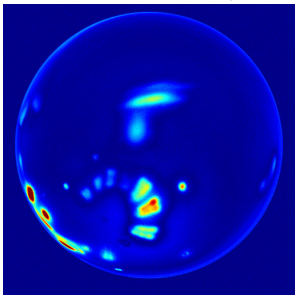
Cook-Torrance



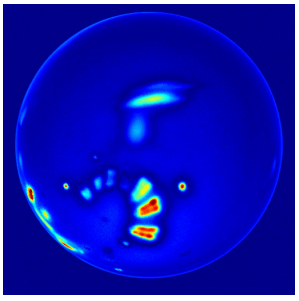
Edwards et al.



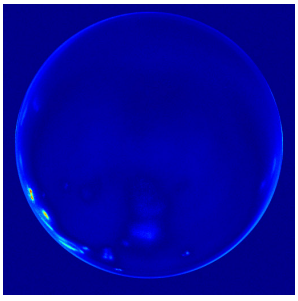
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: yellow-paint

**Fitted Parameters/PSNR**

| Material Name | yellow-paint | $k_{sr}$ | 0.125986 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.124473 | $n_2$ | 0 |
| $k_{dr}$ | 0.297158 | $k_{sb}$ | 0.110214 | $f_{03}$ | 0.220721 |
| $k_{dg}$ | 0.189138 | $f_{01}$ | 0.026065 | $n_3$ | 7.370478 |
| $k_{db}$ | 0.022167 | $n_1$ | 28.80233 | PSNR | 43.14477 |

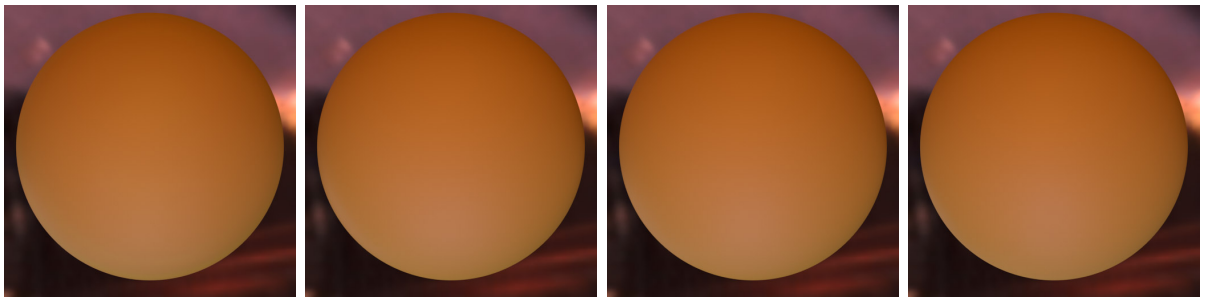
| Material Name | yellow-paint | $k_{sr}$ | 0.014969 | $f_{02}$ | 0.089270 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.014879 | $m_2$ | 0.351108 |
| $k_{dr}$ | 0.298849 | $k_{sb}$ | 0.013242 | $f_{03}$ | 0.051662 |
| $k_{dg}$ | 0.190700 | $f_{01}$ | 0.191535 | $m_3$ | 0.210404 |
| $k_{db}$ | 0.023467 | $m_1$ | 0.505390 | PSNR | 43.65423 |

| Material Name | yellow-paint | $k_{sg}$ | 0.067770 | $R_2$ | 1.879498 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.058901 | $n_2$ | 48.97342 |
| $k_{dr}$ | 0.300268 | $f_{01}$ | 0 | $f_{03}$ | 0.310217 |
| $k_{dg}$ | 0.191804 | $R_1$ | 1.077635 | $R_3$ | 3.060244 |
| $k_{db}$ | 0.024805 | $n_1$ | 100.5951 | $n_3$ | 18.64262 |
| $k_{sr}$ | 0.066955 | $f_{02}$ | 0.024035 | PSNR | 43.61659 |

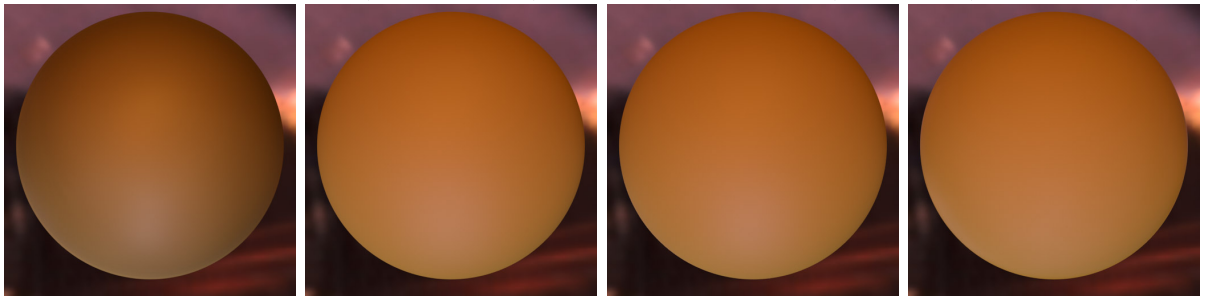
| Material Name | yellow-paint | $k_{db}$ | 0.023262 | $\alpha_1$ | 0.298620 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.014155 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.296625 | $k_{sg}$ | 0.014396 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.188017 | $k_{sb}$ | 0.011303 | PSNR | 39.00619 |

| Material Name | yellow-paint | $k_{db}$ | 0.022283 | $\alpha_1$ | 0.255970 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.009803 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.297017 | $k_{sg}$ | 0.009959 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.188438 | $k_{sb}$ | 0.008459 | PSNR | 40.72077 |

**Rendered Images**

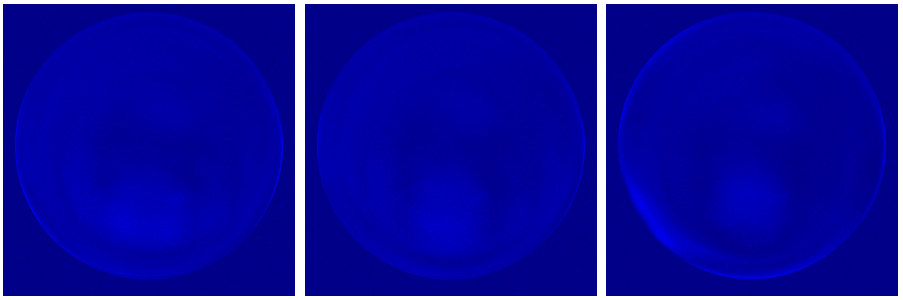


Reference image | Ashikhmin-Shirley (PSNR=43.14477) | Cook-Torrance (PSNR=43.65423) | Edwards et al. (PSNR=43.61659)

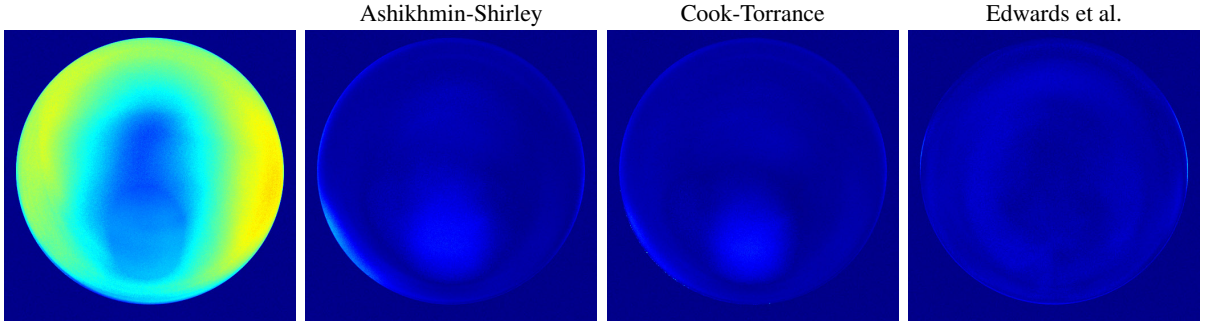


Lawrence et al. (PSNR=21.71897) | Ward (PSNR=39.00619) | Ward-Duer (PSNR=40.72077) | Our factored model (PSNR=41.30791)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model

**Material Name**: yellow-phenolic

**Fitted Parameters/PSNR**

| Material Name | yellow-phenolic | $k_{sr}$ | 0.054043 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.052254 | $n_2$ | 1655.649 |
| $k_{dr}$ | 0.297183 | $k_{sb}$ | 0.051270 | $f_{03}$ | 0.122411 |
| $k_{dg}$ | 0.213476 | $f_{01}$ | 0.108404 | $n_3$ | 668.8590 |
| $k_{db}$ | 0.102225 | $n_1$ | 9058.762 | PSNR | 33.16924 |

| Material Name | yellow-phenolic | $k_{sr}$ | 0.012702 | $f_{02}$ | 0 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.012288 | $m_2$ | 0.033839 |
| $k_{dr}$ | 0.297238 | $k_{sb}$ | 0.012047 | $f_{03}$ | 0.112137 |
| $k_{dg}$ | 0.213523 | $f_{01}$ | 0.127806 | $m_3$ | 0.014535 |
| $k_{db}$ | 0.102281 | $m_1$ | 0.052980 | PSNR | 33.11876 |

| Material Name | yellow-phenolic | $k_{sg}$ | 0.074402 | $R_2$ | 0.040181 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.073318 | $n_2$ | 2.911025 |
| $k_{dr}$ | 0.299238 | $f_{01}$ | 0.012428 | $f_{03}$ | 0.081691 |
| $k_{dg}$ | 0.215514 | $R_1$ | 0.088468 | $R_3$ | 1.265837 |
| $k_{db}$ | 0.104178 | $n_1$ | 129.1072 | $n_3$ | 565.3570 |
| $k_{sr}$ | 0.077307 | $f_{02}$ | 0.023537 | PSNR | 32.72509 |

| Material Name | yellow-phenolic | $k_{db}$ | 0.098669 | $\alpha_1$ | 0.081992 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.008142 | $\alpha_2$ | 0.033677 |
| $k_{dr}$ | 0.293509 | $k_{sg}$ | 0.007743 | $\alpha_3$ | 0.012427 |
| $k_{dg}$ | 0.210198 | $k_{sb}$ | 0.007758 | PSNR | 32.82500 |

| Material Name | yellow-phenolic | $k_{db}$ | 0.096159 | $\alpha_1$ | 0.075859 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.006959 | $\alpha_2$ | 0.032909 |
| $k_{dr}$ | 0.290883 | $k_{sg}$ | 0.006644 | $\alpha_3$ | 0.012722 |
| $k_{dg}$ | 0.207626 | $k_{sb}$ | 0.006633 | PSNR | 33.33653 |

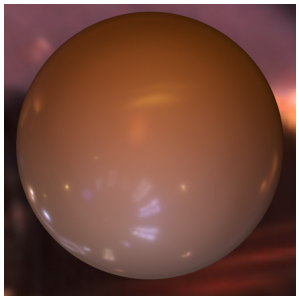
**Rendered Images**

Reference image

Ashikhmin-Shirley
(PSNR=33.16924)

Cook-Torrance
(PSNR=33.11876)

Edwards et al.
(PSNR=32.72509)



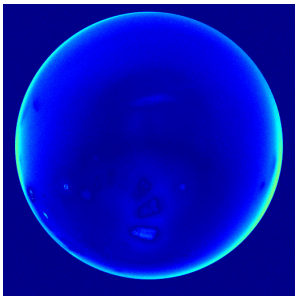
Lawrence et al.
(PSNR=22.28417)

Ward
(PSNR=32.82500)

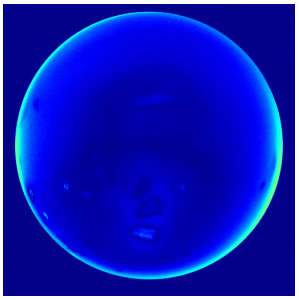
Ward-Duer
(PSNR=33.33653)

Our factored model
(PSNR=39.09060)

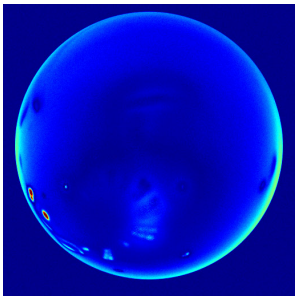
**Difference Images**



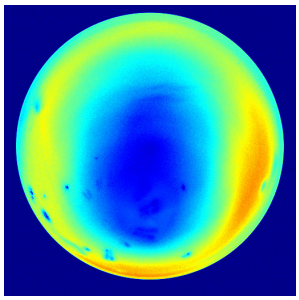
Ashikhmin-Shirley



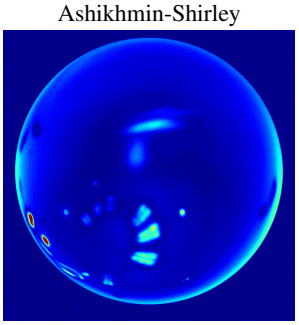
Cook-Torrance



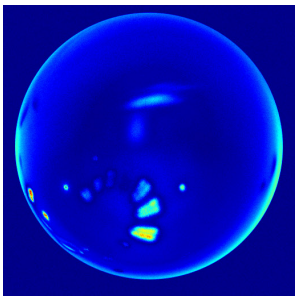
Edwards et al.



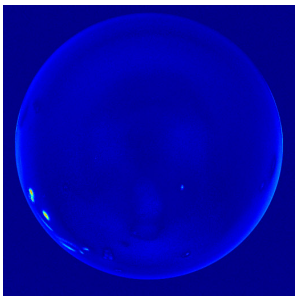
Lawrence et al.



Ward



Ward-Duer



Our factored model

**Material Name**: yellow-plastic

**Fitted Parameters/PSNR**

| Material Name | yellow-plastic | $k_{sr}$ | 0.155541 | $f_{02}$ | 0.999304 |
|---|---|---|---|---|---|
| BRDF Model | Ashikhmin-Shirley | $k_{sg}$ | 0.150765 | $n_2$ | 0.825485 |
| $k_{dr}$ | 0.202535 | $k_{sb}$ | 0.126731 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.170805 | $f_{01}$ | 0.039187 | $n_3$ | 0 |
| $k_{db}$ | 0.007435 | $n_1$ | 45.25971 | PSNR | 35.42581 |

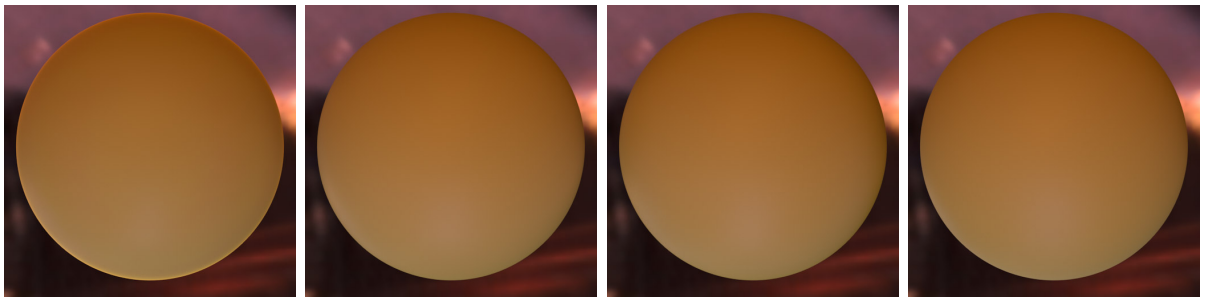
| Material Name | yellow-plastic | $k_{sr}$ | 0.019425 | $f_{02}$ | 0.163308 |
|---|---|---|---|---|---|
| BRDF Model | Cook-Torrance | $k_{sg}$ | 0.018851 | $m_2$ | 0.384329 |
| $k_{dr}$ | 0.211563 | $k_{sb}$ | 0.015800 | $f_{03}$ | 0.047452 |
| $k_{dg}$ | 0.179507 | $f_{01}$ | 0.557823 | $m_3$ | 0.165106 |
| $k_{db}$ | 0.014849 | $m_1$ | 0.999999 | PSNR | 34.68205 |

| Material Name | yellow-plastic | $k_{sg}$ | 0.114770 | $R_2$ | 3.160144 |
|---|---|---|---|---|---|
| BRDF Model | Edwards et al. | $k_{sb}$ | 0.096304 | $n_2$ | 50.00346 |
| $k_{dr}$ | 0.241226 | $f_{01}$ | 0.003458 | $f_{03}$ | 0 |
| $k_{dg}$ | 0.208261 | $R_1$ | 1.082144 | $R_3$ | 2.841200 |
| $k_{db}$ | 0.038938 | $n_1$ | 100.0287 | $n_3$ | 9.642150 |
| $k_{sr}$ | 0.117946 | $f_{02}$ | 0.086701 | PSNR | 35.60928 |

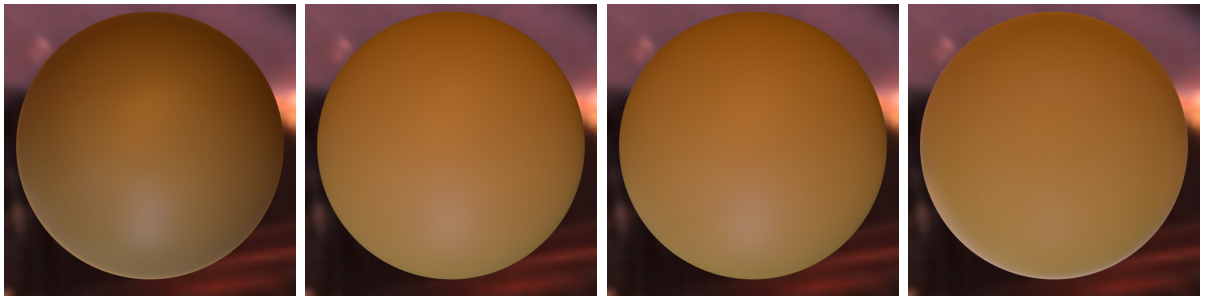
| Material Name | yellow-plastic | $k_{db}$ | 0.035989 | $\alpha_1$ | 0.190096 |
|---|---|---|---|---|---|
| BRDF Model | Ward | $k_{sr}$ | 0.010239 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.238123 | $k_{sg}$ | 0.011550 | $\alpha_3$ | 0.5 |
| $k_{dg}$ | 0.202835 | $k_{sb}$ | 0.008634 | PSNR | 32.81430 |

| Material Name | yellow-plastic | $k_{db}$ | 0.032454 | $\alpha_1$ | 0.5 |
|---|---|---|---|---|---|
| BRDF Model | Ward-Duer | $k_{sr}$ | 0.009632 | $\alpha_2$ | 0.5 |
| $k_{dr}$ | 0.233438 | $k_{sg}$ | 0.010001 | $\alpha_3$ | 0.190684 |
| $k_{dg}$ | 0.199364 | $k_{sb}$ | 0.007924 | PSNR | 33.26037 |

**Rendered Images**

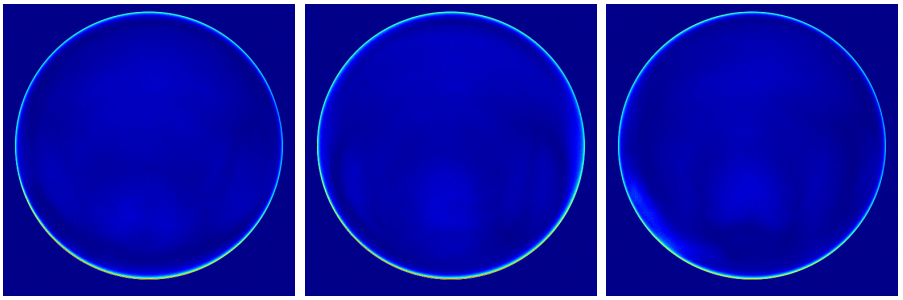


Reference image | Ashikhmin-Shirley (PSNR=35.42581) | Cook-Torrance (PSNR=34.68205) | Edwards et al. (PSNR=35.60928)

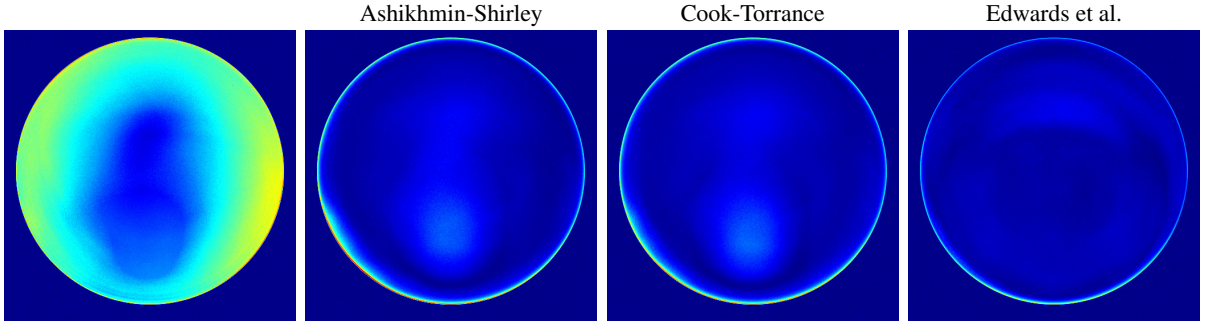


Lawrence et al. (PSNR=23.37080) | Ward (PSNR=32.81430) | Ward-Duer (PSNR=33.26037) | Our factored model (PSNR=36.88520)

**Difference Images**



Ashikhmin-Shirley | Cook-Torrance | Edwards et al.



Lawrence et al. | Ward | Ward-Duer | Our factored model