Supplementary Material
BRDF Models for Accurate and Efficient Rendering of Glossy Surfaces

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This document is supplementary to the paper "BRDF Models for Accurate and Efficient Rendering of Glossy Surfaces", submitted for publication in ACM Transactions on Graphics. In this text comparisons are made between the new proposed BRDF models and previous BRDF models, when fitted to 100 measured BRDFs. Listed below are the equations for all BRDF models used in the comparison. For a more detailed description of the models and their parameters see the paper. The rest of the document contains the parameters of the fitted BRDF models, as well as rendered sample images.

1 BRDF Models

- Smooth Surface Model, $[K_d, A, B, C, \eta]$

$$\rho = \frac{K_d}{\pi} + G' \; Q' \; S(\|D_P\|). \tag{1}$$

  where $S(f) = \frac{A}{(1+Bf^2)^C}$, $\|D_P\|$ is the length of the projected deviation vector, $G' = 1$ and $Q' = F(\theta_d; \eta)$ is the Fresnel factor*,

- Microfacet Model, $[K_d, A, B, C, \eta]$

$$\rho = \frac{K_d}{\pi} + \frac{S(\sqrt{1 - \langle \hat{H}, N \rangle})F(\theta_h; \eta)G}{\langle L, N \rangle \langle V, N \rangle} \tag{2}$$

  where $S(f) = \frac{A}{(1+Bf^2)^C}$, $G = min\big(1, \frac{2\langle N,\hat{H}\rangle\langle N,V\rangle}{\langle V,\hat{H}\rangle}, \frac{2\langle N,\hat{H}\rangle\langle N,L\rangle}{\langle V,\hat{H}\rangle}\big)$ and $F(\theta_h; \eta)$ the Fresnel factor*.

- Cook-Torrance, $[K_d, K_s, m, \eta]$

$$\rho = \frac{K_d}{\pi} + K_s \frac{DF(\theta_h; \eta)G}{\langle L, N \rangle \langle V, N \rangle} \tag{3}$$

  where $D = \frac{1}{m^2 \cos^4(\theta_h)} e^{(-\frac{\tan(\theta_h)}{m})^2}$, $G = min\big(1, \frac{2\langle N,\hat{H}\rangle\langle N,V\rangle}{\langle V,\hat{H}\rangle}, \frac{2\langle N,\hat{H}\rangle\langle N,L\rangle}{\langle V,\hat{H}\rangle}\big)$, and $F(\theta_h; \eta)$ the Fresnel factor*.

- Ashikhmin-Shirley, $[K_d, K_s, n, \eta]$

$$\rho = \frac{K_d}{\pi} + K_s \frac{(n+1)\langle N, \hat{H}\rangle^n F(\theta_h; \eta)}{8\pi \langle V, \hat{H}\rangle max\big(\langle L, N\rangle, \langle V, N\rangle\big)} \tag{4}$$

  where $F(\theta_h; \eta)$ is the Fresnel factor*.

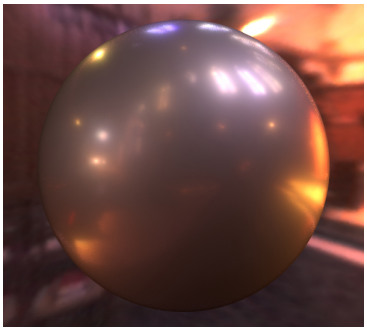
* Fresnel factor from original Cook-Torrance model (see paper for details).

2 Material Name: alum-bronze

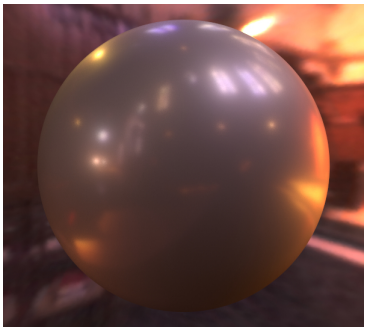
Model Parameters

Model	Fitting Metric	Model Parameters
Ashikhmin-Shirley	E_1	R: $K_d = 0.1062$, $K_s = 0.248103$ G: $K_d = 0.0815$, $K_s = 0.184284$ B: $K_d = 0.0556$, $K_s = 0.220735$ Common: $n = 6679.521974$, $\eta = 1.453599$
Ashikhmin-Shirley	E_2	R: $K_d = 0.0793$, $K_s = 0.325054$ G: $K_d = 0.0624$, $K_s = 0.240923$ B: $K_d = 0.0448$, $K_s = 0.178030$ Common: $n = 394.219256$, $\eta = 2.065733$
Cook-Torrance	E_1	R: $K_d = 0.1063$, $K_s = 0.058727$ G: $K_d = 0.0816$, $K_s = 0.043676$ B: $K_d = 0.0557$, $K_s = 0.052230$ Common: $m = 0.017044$, $\eta = 1.464929$
Cook-Torrance	E_2	R: $K_d = 0.0804$, $K_s = 0.069074$ G: $K_d = 0.0633$, $K_s = 0.051050$ B: $K_d = 0.0455$, $K_s = 0.037656$ Common: $m = 0.067645$, $\eta = 2.153631$
Microfacet Model	E_2	R: $K_d = 0.0245$, $A = 51.714552$ G: $K_d = 0.0223$, $A = 37.932695$ B: $K_d = 0.0162$, $A = 27.373094$ Common: $B = 10482.133785$, $C = 0.816737$, $\eta = 2.236525$
Smooth Surface Model	E_2	R: $K_d = 0.0096$, $A = 164.167455$ G: $K_d = 0.0113$, $A = 120.726144$ B: $K_d = 0.0085$, $A = 86.665430$ Common: $B = 16711.814477$, $C = 0.663506$, $\eta = 1.560827$

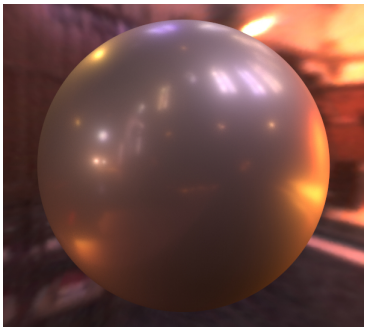
Sample Images



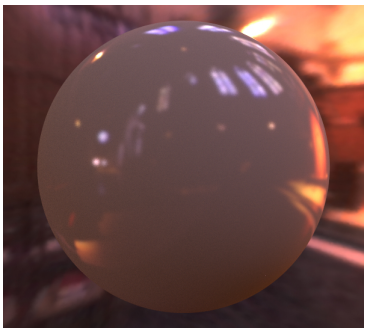
Measured BRDF



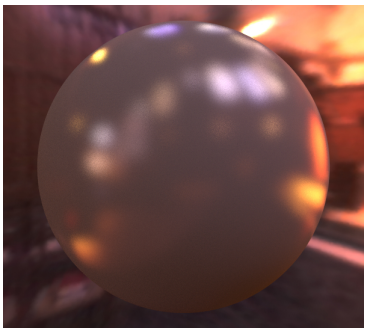
Microfacet Model, E_2



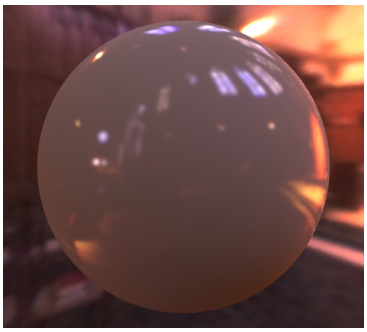
Smooth Surface Model, E_2



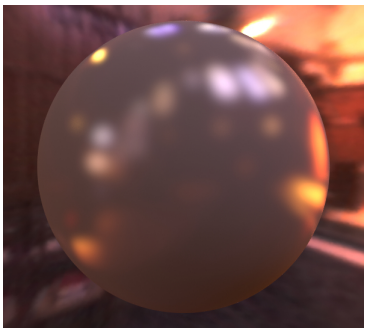
Ashikhmin-Shirley, E_1



Ashikhmin-Shirley, E_2



Cook-Torrance, E_1



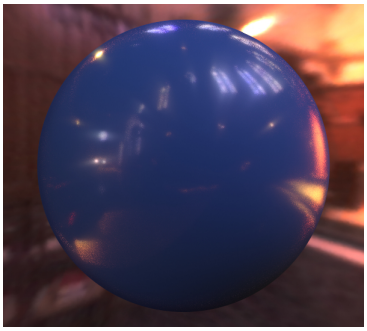
Cook-Torrance, E_2

12 Material Name: blue-acrylic

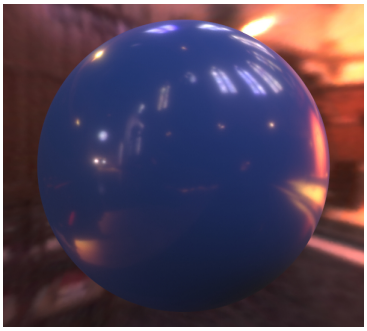
Model Parameters

Model	Fitting Metric	Model Parameters
Ashikhmin-Shirley	E_1	R: $K_d = 0.0143$, $K_s = 0.058314$ G: $K_d = 0.0382$, $K_s = 0.052768$ B: $K_d = 0.1075$, $K_s = 0.050536$ Common: $n = 50547.645224$, $\eta = 2.581124$
Ashikhmin-Shirley	E_2	R: $K_d = 0.0162$, $K_s = 0.285116$ G: $K_d = 0.0398$, $K_s = 0.255243$ B: $K_d = 0.1090$, $K_s = 0.246271$ Common: $n = 16885.918002$, $\eta = 1.287911$
Cook-Torrance	E_1	R: $K_d = 0.0143$, $K_s = 0.014513$ G: $K_d = 0.0382$, $K_s = 0.013136$ B: $K_d = 0.1075$, $K_s = 0.012580$ Common: $m = 0.006278$, $\eta = 2.583033$
Cook-Torrance	E_2	R: $K_d = 0.0162$, $K_s = 0.068770$ G: $K_d = 0.0399$, $K_s = 0.061563$ B: $K_d = 0.1090$, $K_s = 0.059387$ Common: $m = 0.010820$, $\eta = 1.293530$
Microfacet Model	E_2	R: $K_d = 0.0111$, $A = 1191.397279$ G: $K_d = 0.0351$, $A = 1099.257252$ B: $K_d = 0.1043$, $A = 1082.125405$ Common: $B = 255868.959838$, $C = 1.084736$, $\eta = 1.475061$
Smooth Surface Model	E_2	R: $K_d = 0.0123$, $A = 1094.259321$ G: $K_d = 0.0362$, $A = 1006.546586$ B: $K_d = 0.1054$, $A = 986.518119$ Common: $B = 72099.226713$, $C = 1.098781$, $\eta = 1.379266$

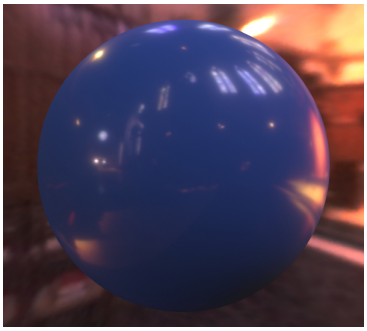
Sample Images



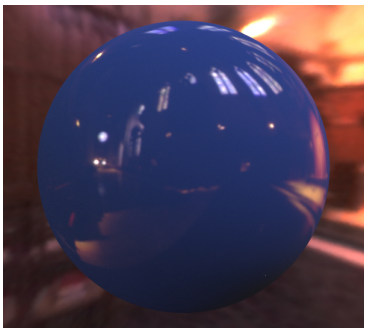
Measured BRDF



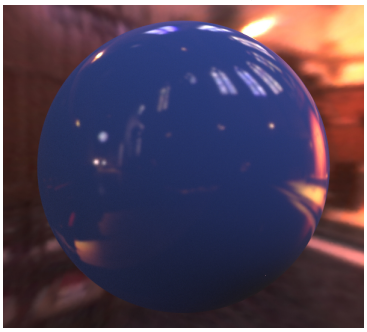
Microfacet Model, E_2



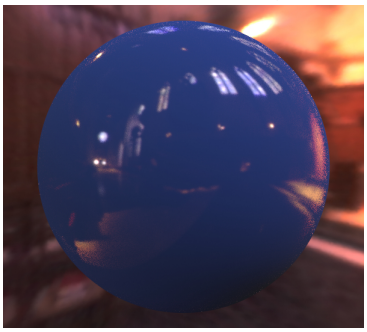
Smooth Surface Model, E_2



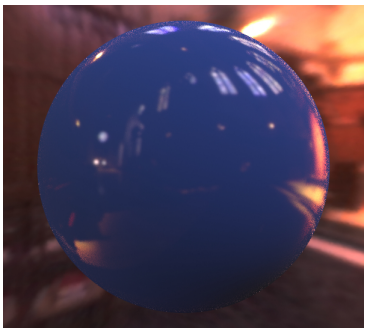
Ashikhmin-Shirley, E_1



Ashikhmin-Shirley, E_2



Cook-Torrance, E_1



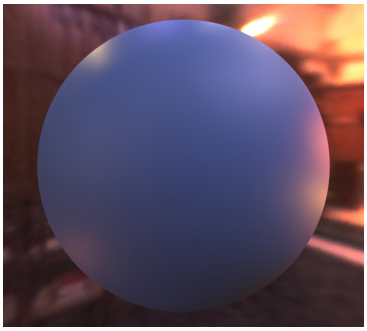
Cook-Torrance, E_2

16 Material Name: blue-rubber

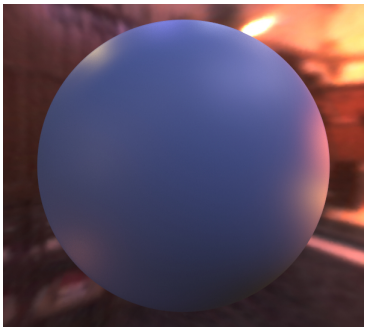
Model Parameters

Model	Fitting Metric	Model Parameters
Ashikhmin-Shirley	E_1	R: $K_d = 0.0387$, $K_s = 0.424162$ G: $K_d = 0.0774$, $K_s = 0.416356$ B: $K_d = 0.1578$, $K_s = 0.405205$ Common: $n = 27.514711$, $\eta = 1.366477$
Ashikhmin-Shirley	E_2	R: $K_d = 0.0386$, $K_s = 0.430863$ G: $K_d = 0.0773$, $K_s = 0.425432$ B: $K_d = 0.1577$, $K_s = 0.415901$ Common: $n = 26.560227$, $\eta = 1.365934$
Cook-Torrance	E_1	R: $K_d = 0.0395$, $K_s = 0.070089$ G: $K_d = 0.0782$, $K_s = 0.068735$ B: $K_d = 0.1586$, $K_s = 0.066841$ Common: $m = 0.237495$, $\eta = 1.396551$
Cook-Torrance	E_2	R: $K_d = 0.0393$, $K_s = 0.071394$ G: $K_d = 0.0780$, $K_s = 0.070466$ B: $K_d = 0.1583$, $K_s = 0.068847$ Common: $m = 0.242822$, $\eta = 1.396140$
Microfacet Model	E_2	R: $K_d = 0.0354$, $A = 1.295714$ G: $K_d = 0.0741$, $A = 1.279542$ B: $K_d = 0.1546$, $A = 1.248921$ Common: $B = 37.265716$, $C = 1.565906$, $\eta = 1.448611$
Smooth Surface Model	E_2	R: $K_d = 0.0373$, $A = 13.700771$ G: $K_d = 0.0760$, $A = 13.512093$ B: $K_d = 0.1565$, $A = 13.165095$ Common: $B = 110.766772$, $C = 0.732365$, $\eta = 1.103071$

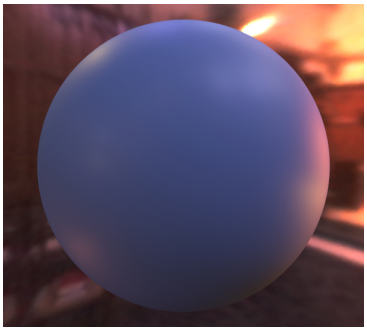
Sample Images



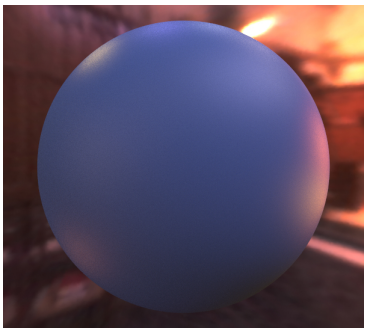
Measured BRDF



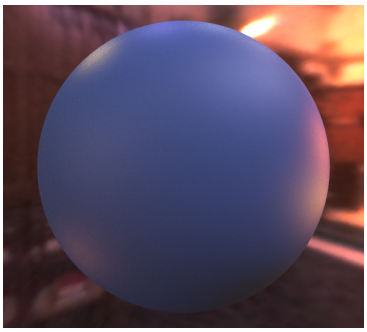
Microfacet Model, E_2



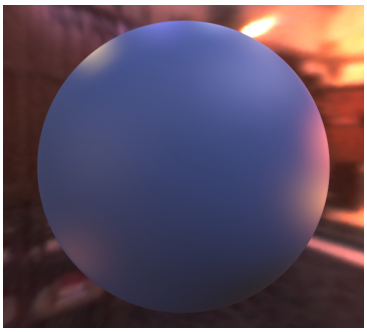
Smooth Surface Model, E_2



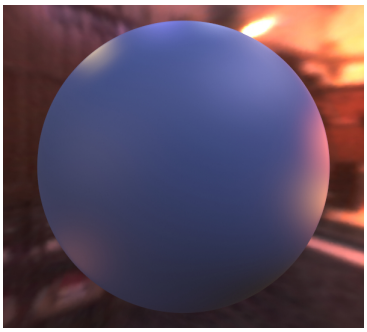
Ashikhmin-Shirley, E_1



Ashikhmin-Shirley, E_2



Cook-Torrance, E_1



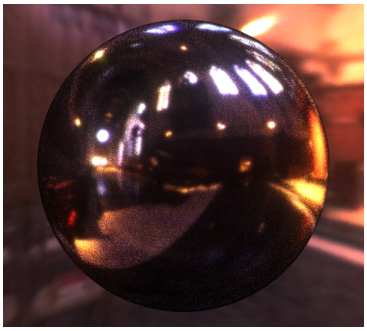
Cook-Torrance, E_2

20 Material Name: chrome

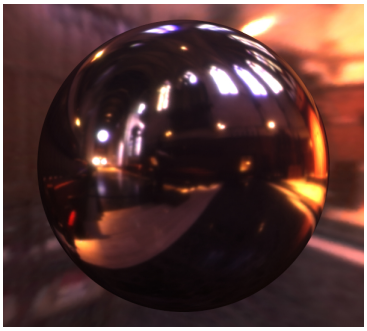
Model Parameters

Model	Fitting Metric	Model Parameters
Ashikhmin-Shirley	E_1	R: $K_d = 0.0528$, $K_s = 0.136045$ G: $K_d = 0.0243$, $K_s = 0.165195$ B: $K_d = 0.0138$, $K_s = 0.177555$ Common: $n = 67364.121723$, $\eta = 9.445841$
Ashikhmin-Shirley	E_2	R: $K_d = 0.0074$, $K_s = 0.998029$ G: $K_d = 0.0063$, $K_s = 0.765031$ B: $K_d = 0.0066$, $K_s = 0.682723$ Common: $n = 15228.047086$, $\eta = 1.754846$
Cook-Torrance	E_1	R: $K_d = 0.0522$, $K_s = 0.033449$ G: $K_d = 0.0216$, $K_s = 0.040634$ B: $K_d = 0.0084$, $K_s = 0.043689$ Common: $m = 0.005403$, $\eta = 9.457813$
Cook-Torrance	E_2	R: $K_d = 0.0074$, $K_s = 0.240845$ G: $K_d = 0.0063$, $K_s = 0.184623$ B: $K_d = 0.0066$, $K_s = 0.164773$ Common: $m = 0.011447$, $\eta = 1.772839$
Microfacet Model	E_2	R: $K_d = 0.0027$, $A = 986.846723$ G: $K_d = 0.0025$, $A = 771.035507$ B: $K_d = 0.0031$, $A = 696.134589$ Common: $B = 64661.258846$, $C = 1.905420$, $\eta = 99.999413$
Smooth Surface Model	E_2	R: $K_d = 0.0036$, $A = 901.243371$ G: $K_d = 0.0033$, $A = 704.419890$ B: $K_d = 0.0038$, $A = 639.116218$ Common: $B = 14859.786129$, $C = 1.927413$, $\eta = 9.054819$

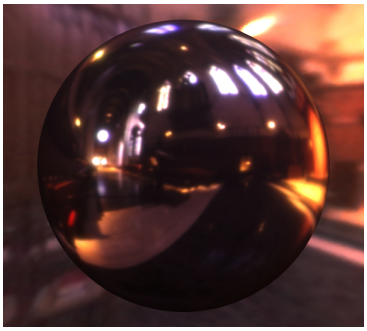
Sample Images



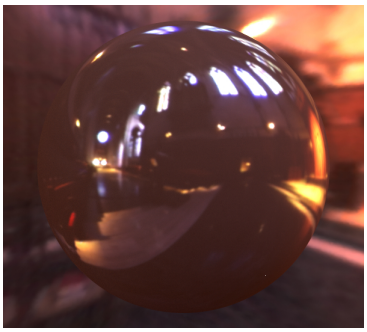
Measured BRDF



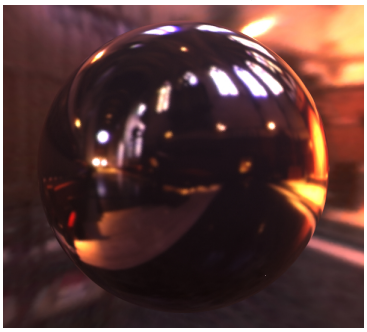
Microfacet Model, E_2



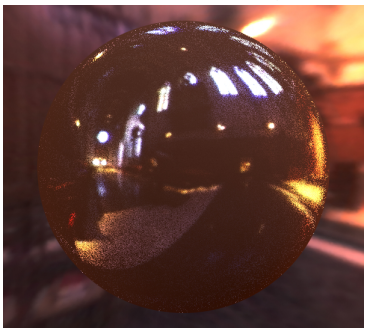
Smooth Surface Model, E_2



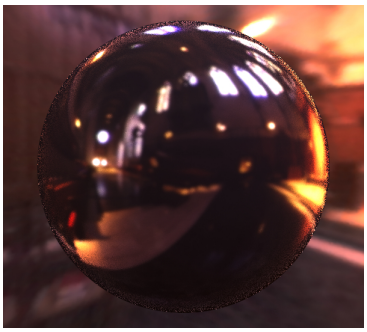
Ashikhmin-Shirley, E_1



Ashikhmin-Shirley, E_2



Cook-Torrance, E_1



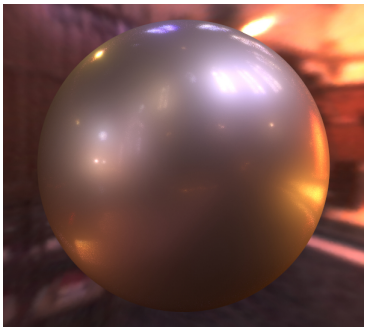
Cook-Torrance, E_2

31 Material Name: gold-metallic-paint2

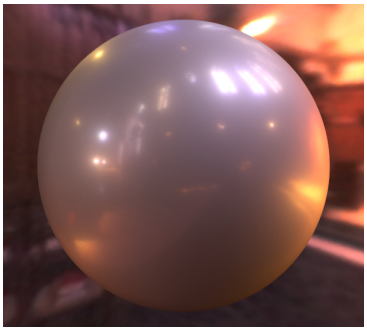
Model Parameters

Model	Fitting Metric	Model Parameters
Ashikhmin-Shirley	E_1	R: $K_d = 0.1549$, $K_s = 0.089858$ G: $K_d = 0.1292$, $K_s = 0.133079$ B: $K_d = 0.1043$, $K_s = 0.123281$ Common: $n = 75863.011892$, $\eta = 1.799335$
Ashikhmin-Shirley	E_2	R: $K_d = 0.0714$, $K_s = 0.184258$ G: $K_d = 0.0593$, $K_s = 0.162357$ B: $K_d = 0.0438$, $K_s = 0.136076$ Common: $n = 96.245600$, $\eta = 8.845464$
Cook-Torrance	E_1	R: $K_d = 0.1549$, $K_s = 0.022335$ G: $K_d = 0.1293$, $K_s = 0.033077$ B: $K_d = 0.1043$, $K_s = 0.030642$ Common: $m = 0.005121$, $\eta = 1.799976$
Cook-Torrance	E_2	R: $K_d = 0.0796$, $K_s = 0.038340$ G: $K_d = 0.0665$, $K_s = 0.033729$ B: $K_d = 0.0498$, $K_s = 0.028234$ Common: $m = 0.130189$, $\eta = 8.972796$
Microfacet Model	E_2	R: $K_d = 0.0000$, $A = 204.653573$ G: $K_d = 0.0000$, $A = 176.726904$ B: $K_d = 0.0000$, $A = 145.123515$ Common: $B = 1705396.839804$, $C = 0.621691$, $\eta = 8.599911$
Smooth Surface Model	E_2	R: $K_d = 0.0000$, $A = 494.740747$ G: $K_d = 0.0000$, $A = 428.738092$ B: $K_d = 0.0000$, $A = 353.280662$ Common: $B = 933657.850195$, $C = 0.577413$, $\eta = 2.376167$

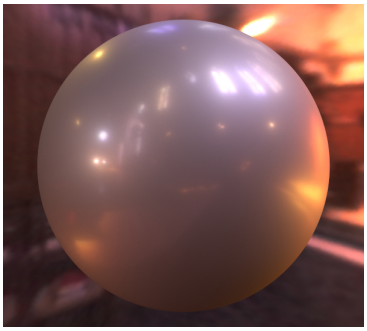
Sample Images



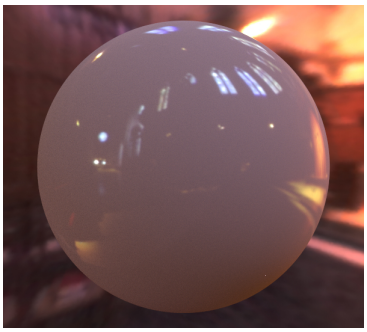
Measured BRDF



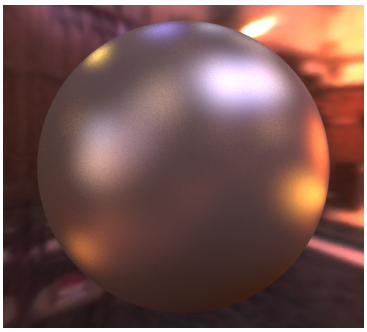
Microfacet Model, E_2



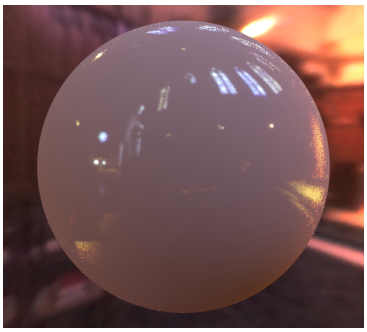
Smooth Surface Model, E_2



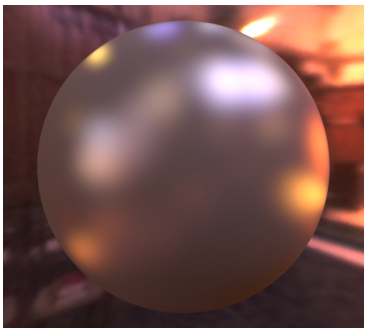
Ashikhmin-Shirley, E_1



Ashikhmin-Shirley, E_2



Cook-Torrance, E_1



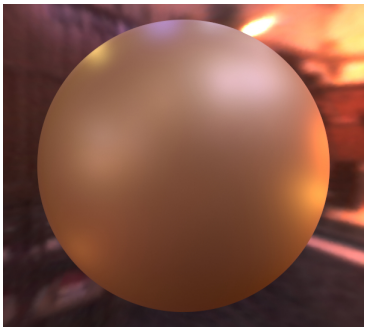
Cook-Torrance, E_2

33 Material Name: gold-paint

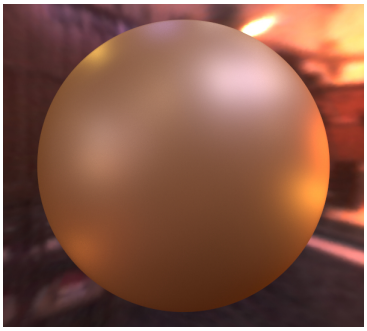
Model Parameters

Model	Fitting Metric	Model Parameters
Ashikhmin-Shirley	E_1	R: $K_d = 0.1737$, $K_s = 0.231051$ G: $K_d = 0.0979$, $K_s = 0.187356$ B: $K_d = 0.0326$, $K_s = 0.117487$ Common: $n = 39.260526$, $\eta = 4.991045$
Ashikhmin-Shirley	E_2	R: $K_d = 0.1709$, $K_s = 0.232451$ G: $K_d = 0.0965$, $K_s = 0.186871$ B: $K_d = 0.0331$, $K_s = 0.113838$ Common: $n = 37.772817$, $\eta = 5.143854$
Cook-Torrance	E_1	R: $K_d = 0.1805$, $K_s = 0.034931$ G: $K_d = 0.1032$, $K_s = 0.028448$ B: $K_d = 0.0355$, $K_s = 0.018077$ Common: $m = 0.202744$, $\eta = 7.321800$
Cook-Torrance	E_2	R: $K_d = 0.1774$, $K_s = 0.036304$ G: $K_d = 0.1017$, $K_s = 0.029288$ B: $K_d = 0.0358$, $K_s = 0.018048$ Common: $m = 0.206591$, $\eta = 7.233245$
Microfacet Model	E_2	R: $K_d = 0.1505$, $A = 1.010258$ G: $K_d = 0.0802$, $A = 0.811582$ B: $K_d = 0.0222$, $A = 0.504538$ Common: $B = 46.942557$, $C = 1.756670$, $\eta = 7.936110$
Smooth Surface Model	E_2	R: $K_d = 0.1111$, $A = 3.518634$ G: $K_d = 0.0499$, $A = 2.790004$ B: $K_d = 0.0055$, $A = 1.676939$ Common: $B = 30.415096$, $C = 0.870427$, $\eta = 1.916902$

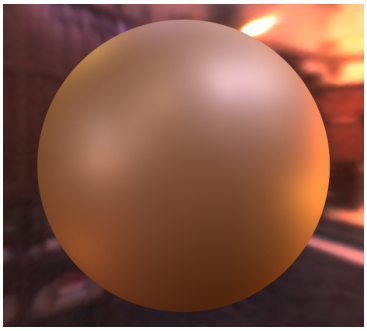
Sample Images



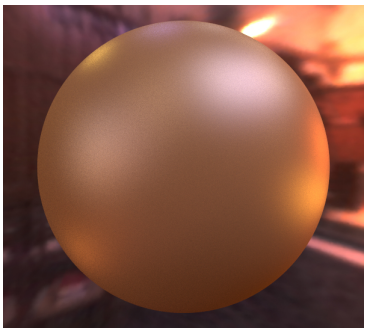
Measured BRDF



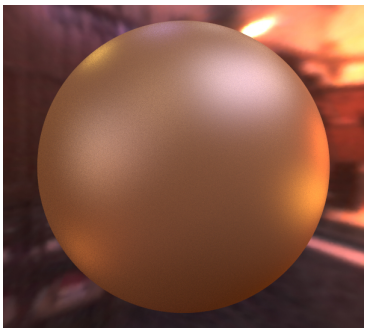
Microfacet Model, E_2



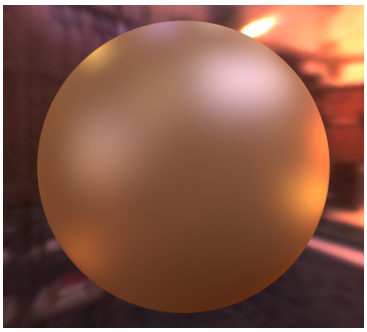
Smooth Surface Model, E_2



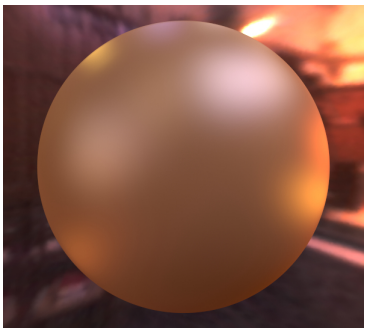
Ashikhmin-Shirley, E_1



Ashikhmin-Shirley, E_2



Cook-Torrance, E_1



Cook-Torrance, E_2