



LED Luminaire with Controlled Light Distribution

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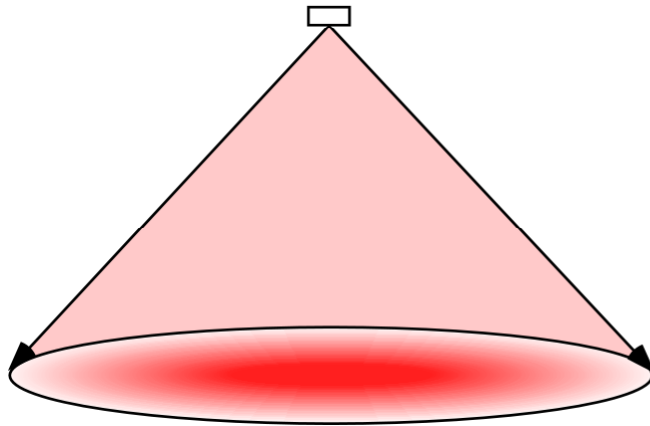
Solid State Lighting

- Finding greater use in commercial and residential applications
 - ▶ High Brightness
 - ▶ Small Size
 - ▶ Efficiency
- Light Control
 - ▶ High Brightness LEDs are Lambertian
 - ▶ Collimation tends to add structure to the light
 - ▶ Add a diffusion element
 - Ground glass, mixing rod, holographic diffuser

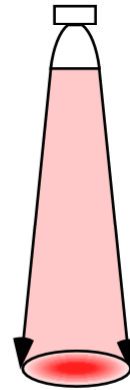
Controlled Light Distribution

- Engineered Diffuser™ redistributes the collimated LED light into any desired pattern

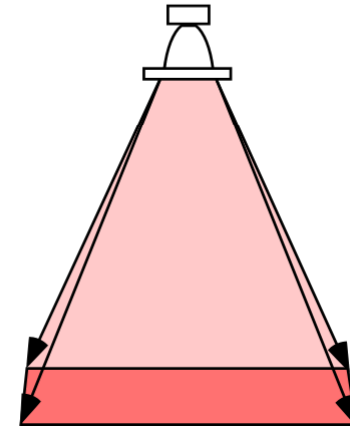
Wide-angle LED



Wide-angle LED
with Collimator

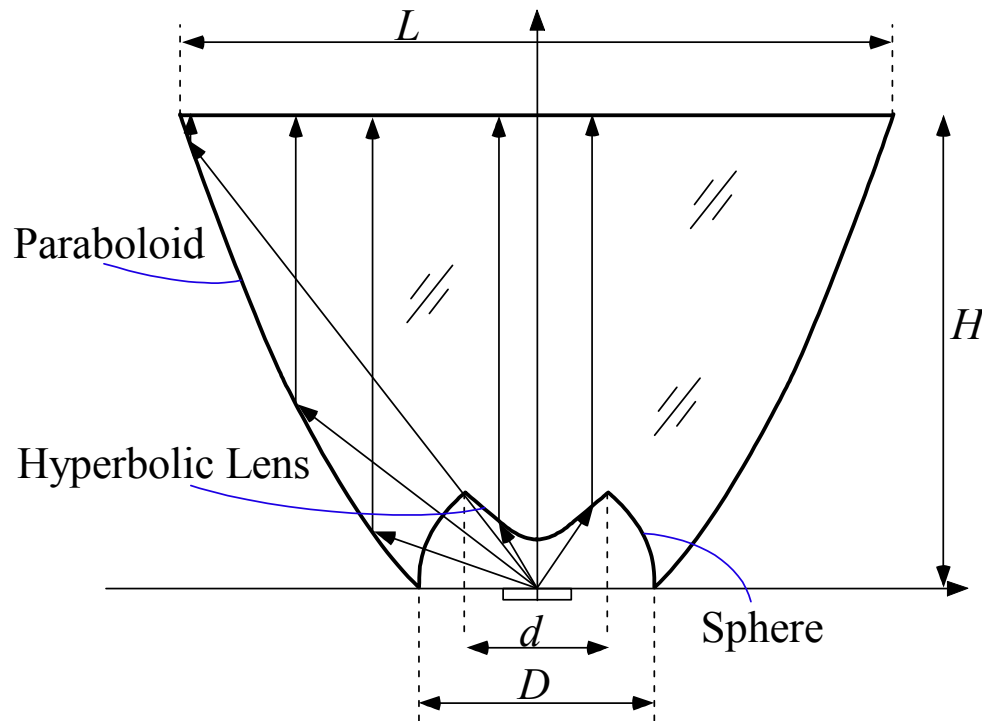


Wide-angle LED
with Collimator and
Engineered Diffuser



Collimator Design

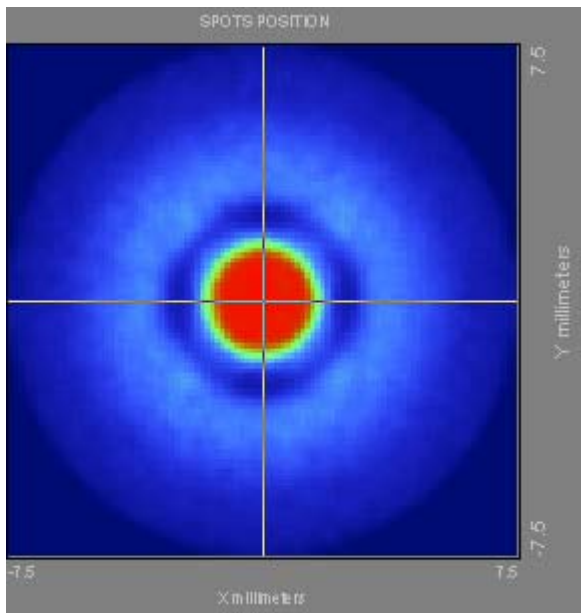
- The collimator has four surfaces that perfectly collimate a point source at the origin



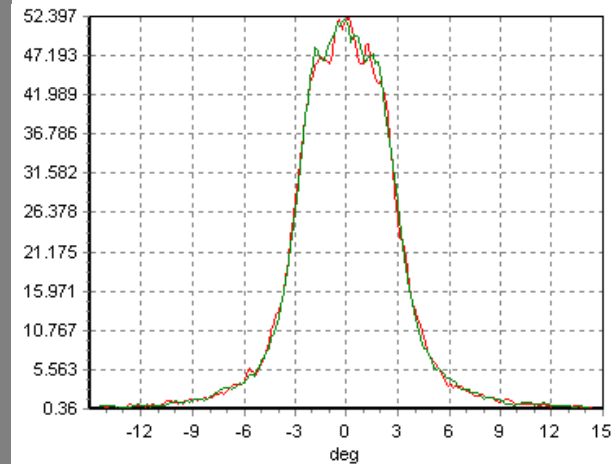
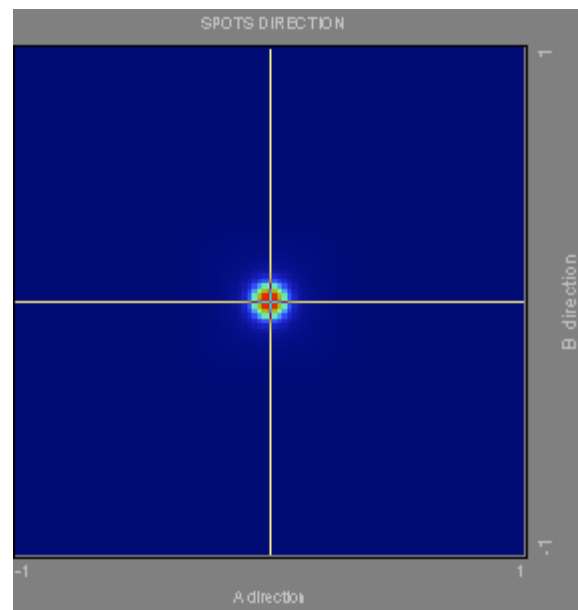
Collimator Performance

- Example: $D = 5\text{mm}$, $H = 10\text{mm}$, $n = 1.5$,
 1mm^2 LED

Spatial Distribution



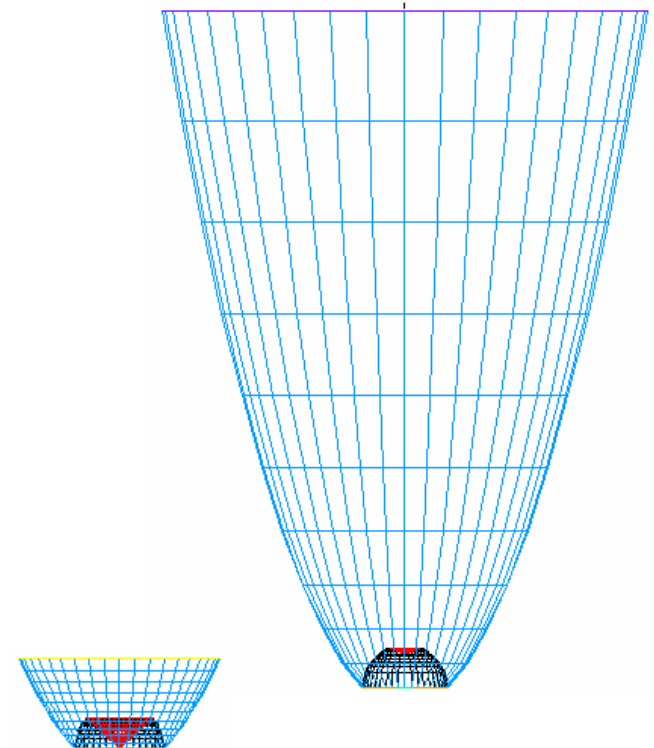
Angular Distribution



Collimator Performance

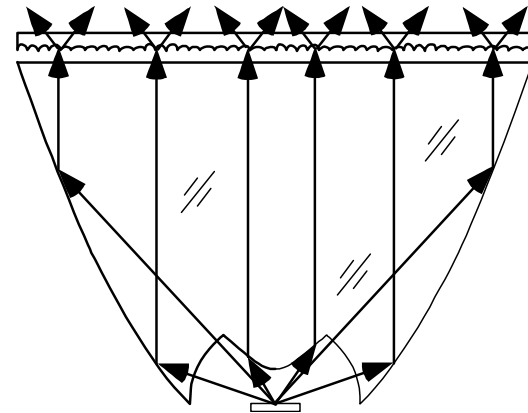
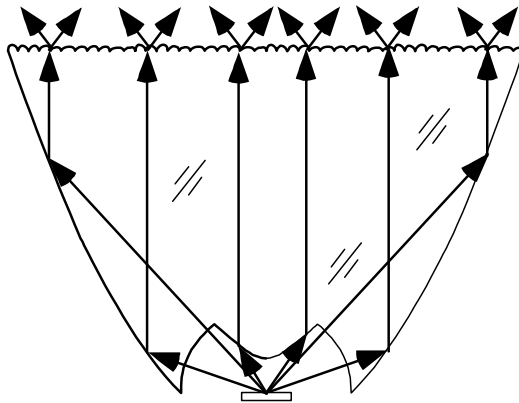
■ Example: $D = 5\text{mm}$, $n = 1.5$, 1mm^2 LED

| H | L | d | FWHM |
|------|--------|-------|------|
| 40mm | 28.7mm | 1.7mm | 2.7° |
| 20 | 20.6 | 2.3 | 4.4 |
| 10 | 15 | 3 | 6 |
| 5 | 11.2 | 3.7 | 8.5 |

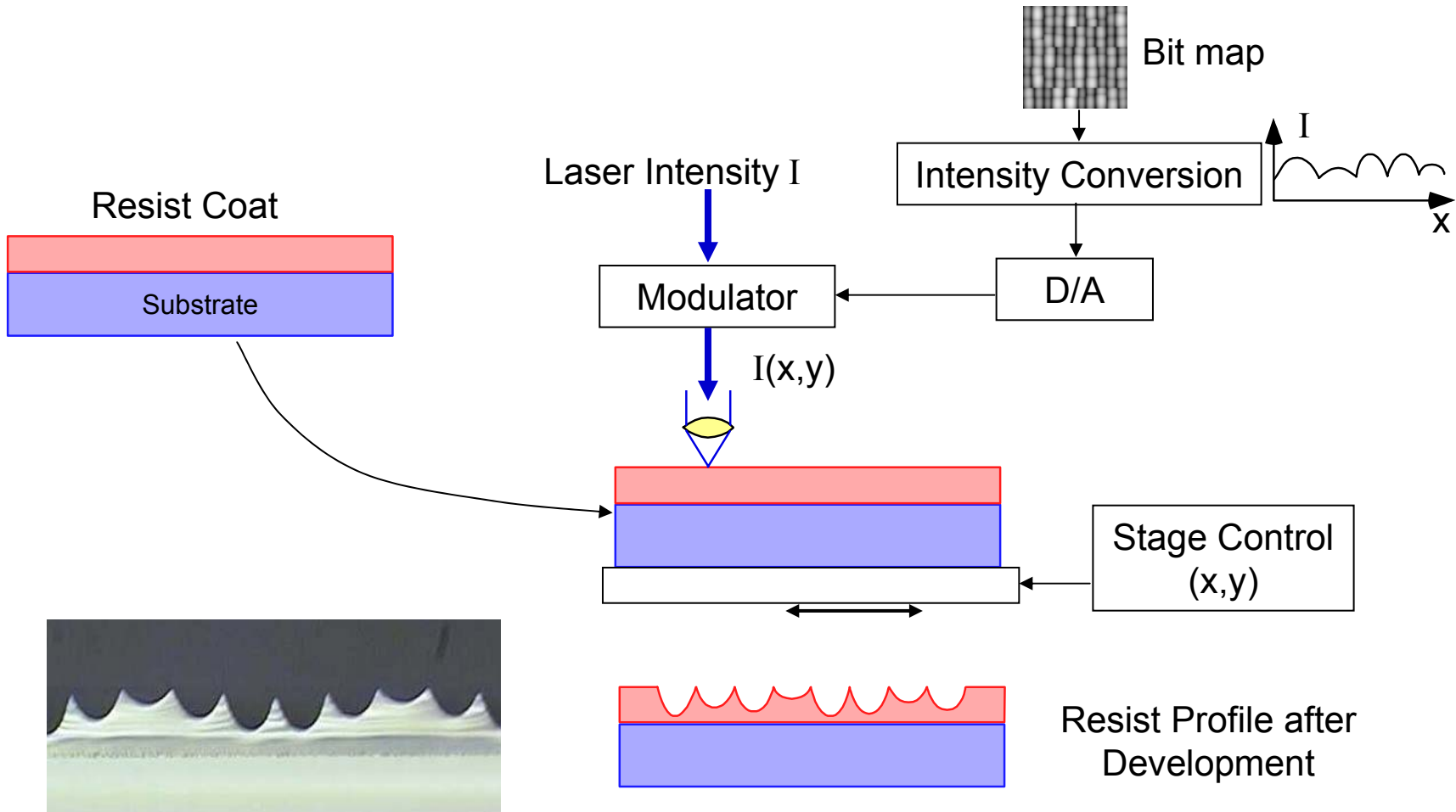


Diffuser-Collimator Combinations

- The Engineered Diffuser™ can be formed directly on the collimator or as a separate component placed above the collimator

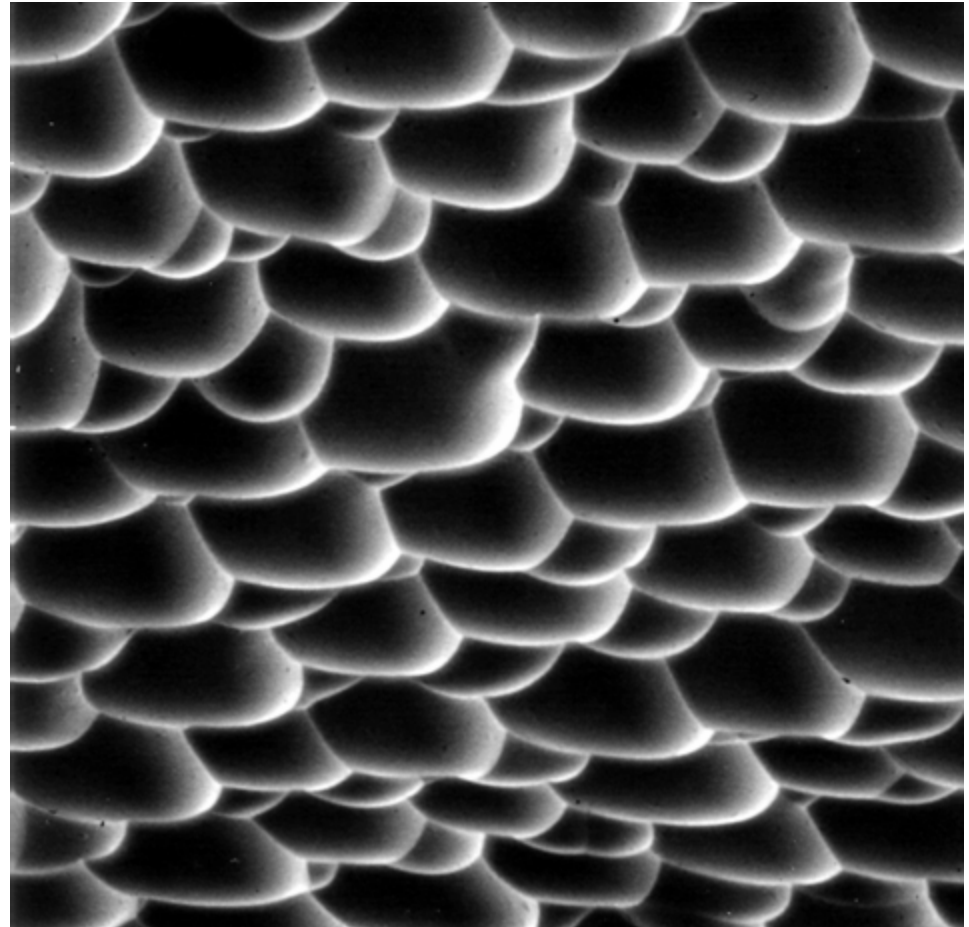


Diffuser Fabrication – Laserwriting Process



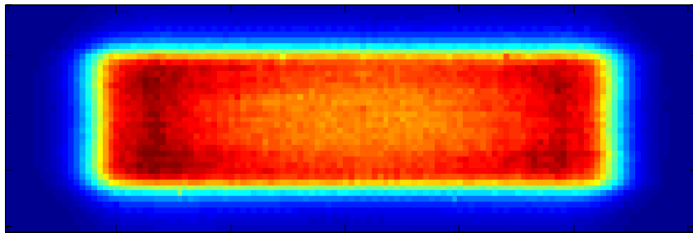
Engineered Diffusers™

- Refractive, microlens structure
- Each microlens is individually designed
- Microlens parameters are randomized to eliminate repetitive artifacts and interference effects
- Control of scatter distribution and intensity profiles
- Insensitive to wavelength
- Compatible with high volume molding and replication processes

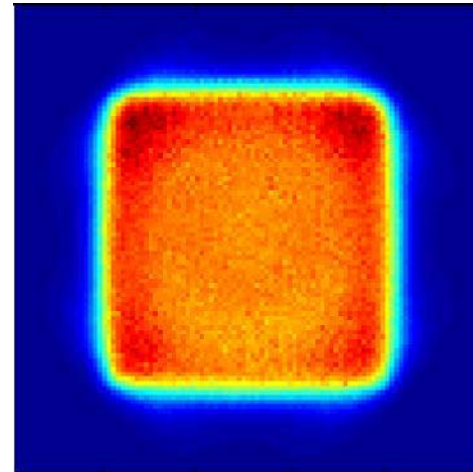


Engineered Diffuser™ Examples

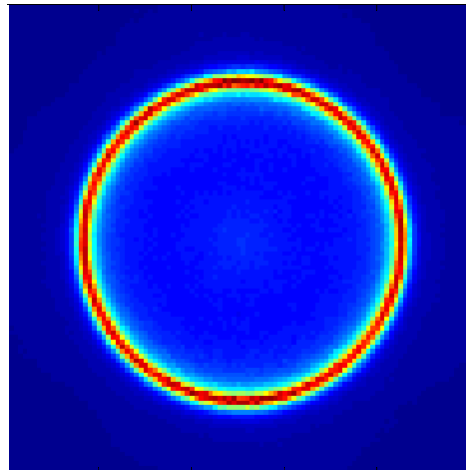
Rectangle



Square



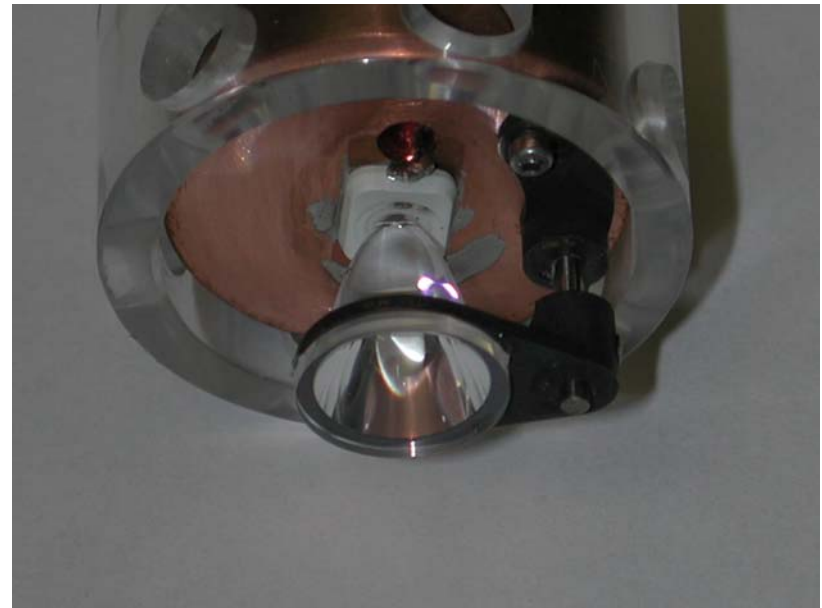
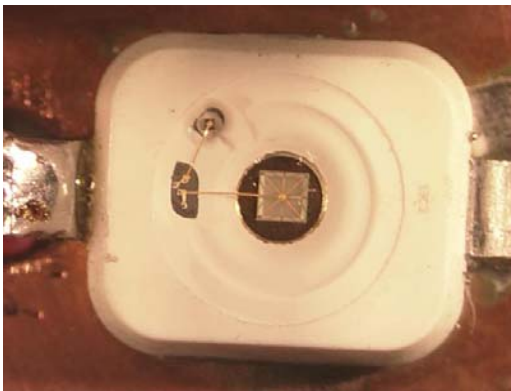
Annulus



Luminaire Example

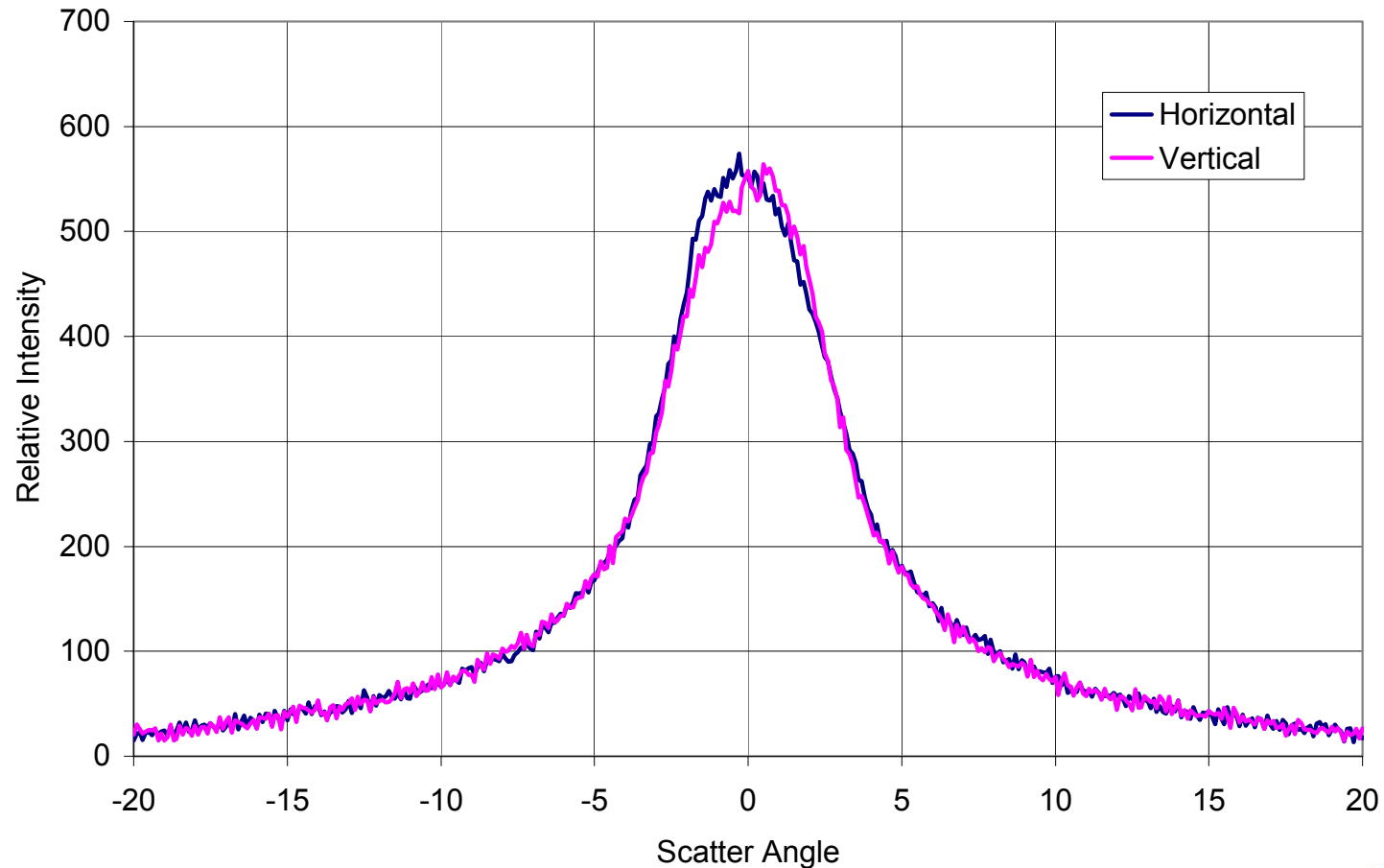
■ OSRAM Golden DRAGON[®] Green LED

- ▶ Flux of 35 lm at 500 mA
- ▶ Efficiency of 20 lm/W
- ▶ Lambertian emitter



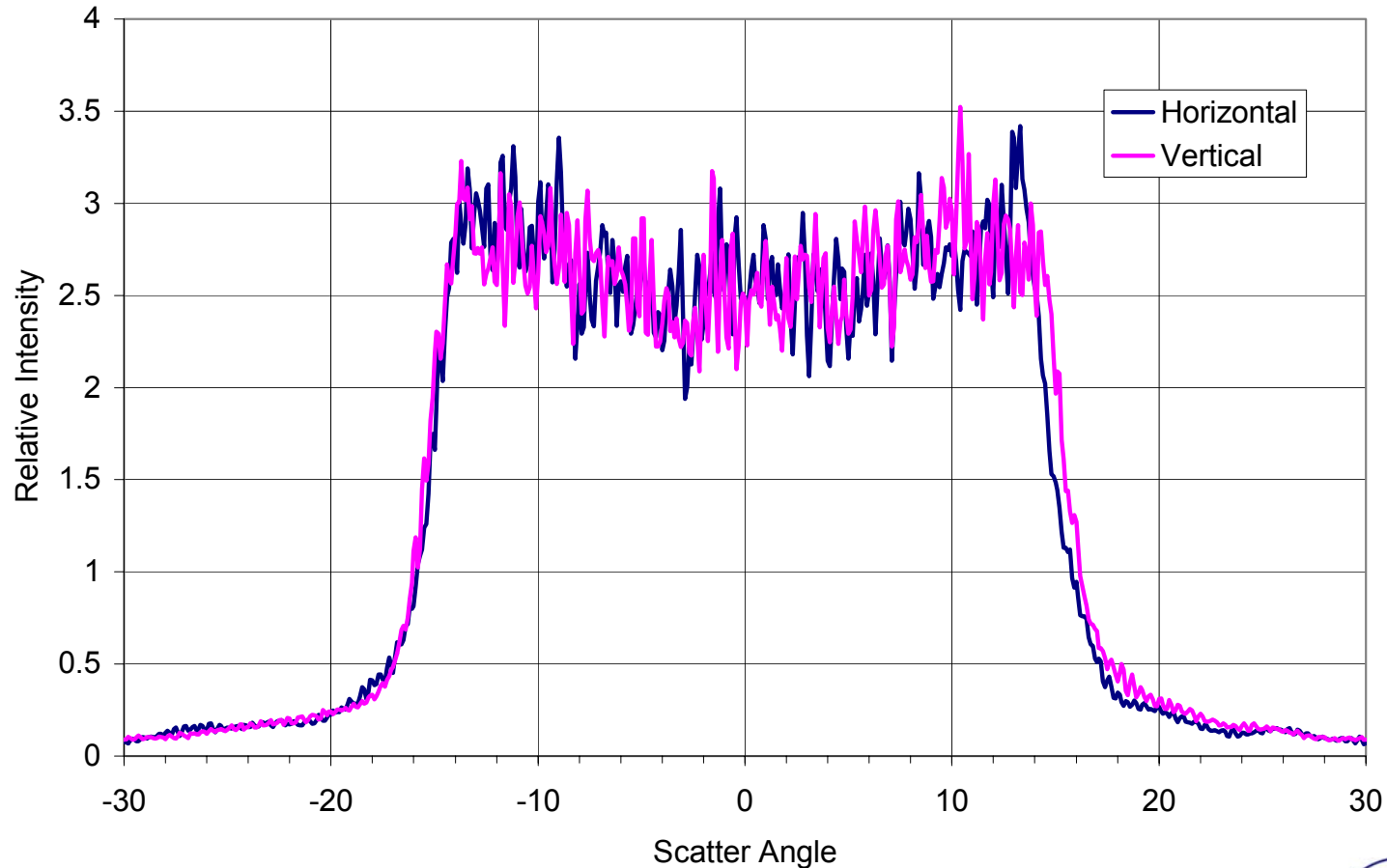
Collimation Performance of the LED

LED Divergence from Collimator



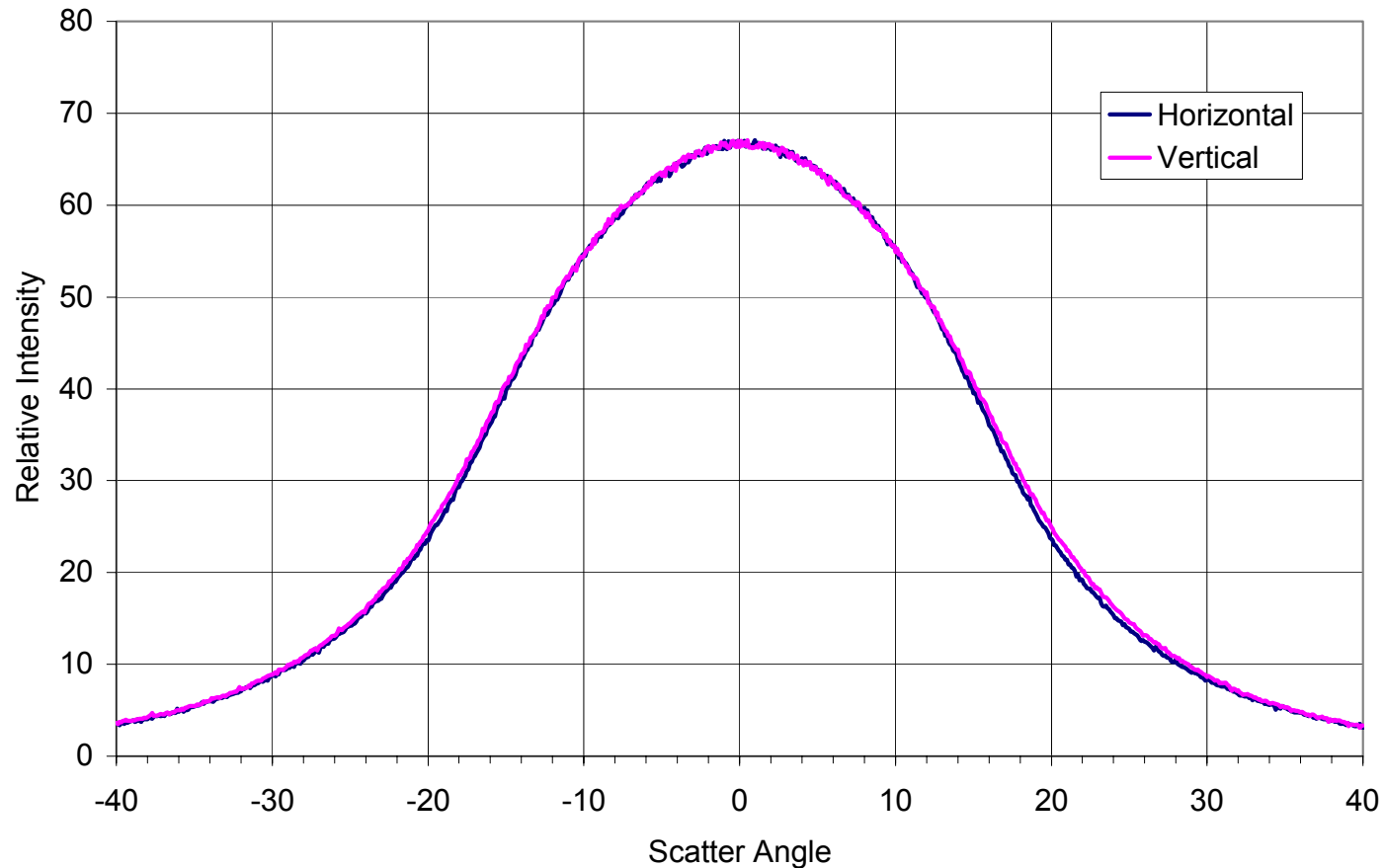
Flat-top Diffuser with Laser

Engineered Diffuser with Laser Illumination



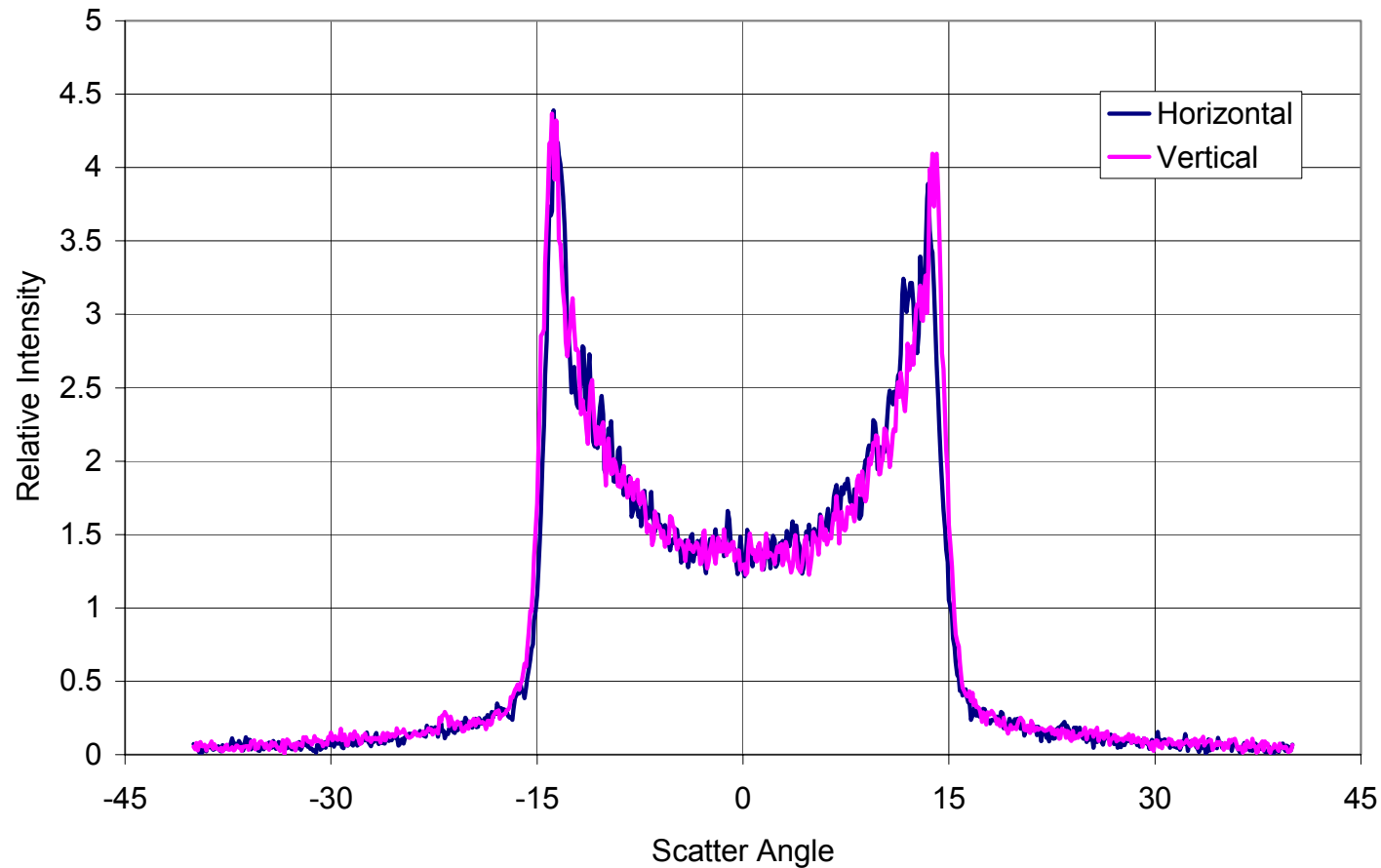
Flat-top Diffuser with LED

Engineered Diffuser with Collimated LED Illumination



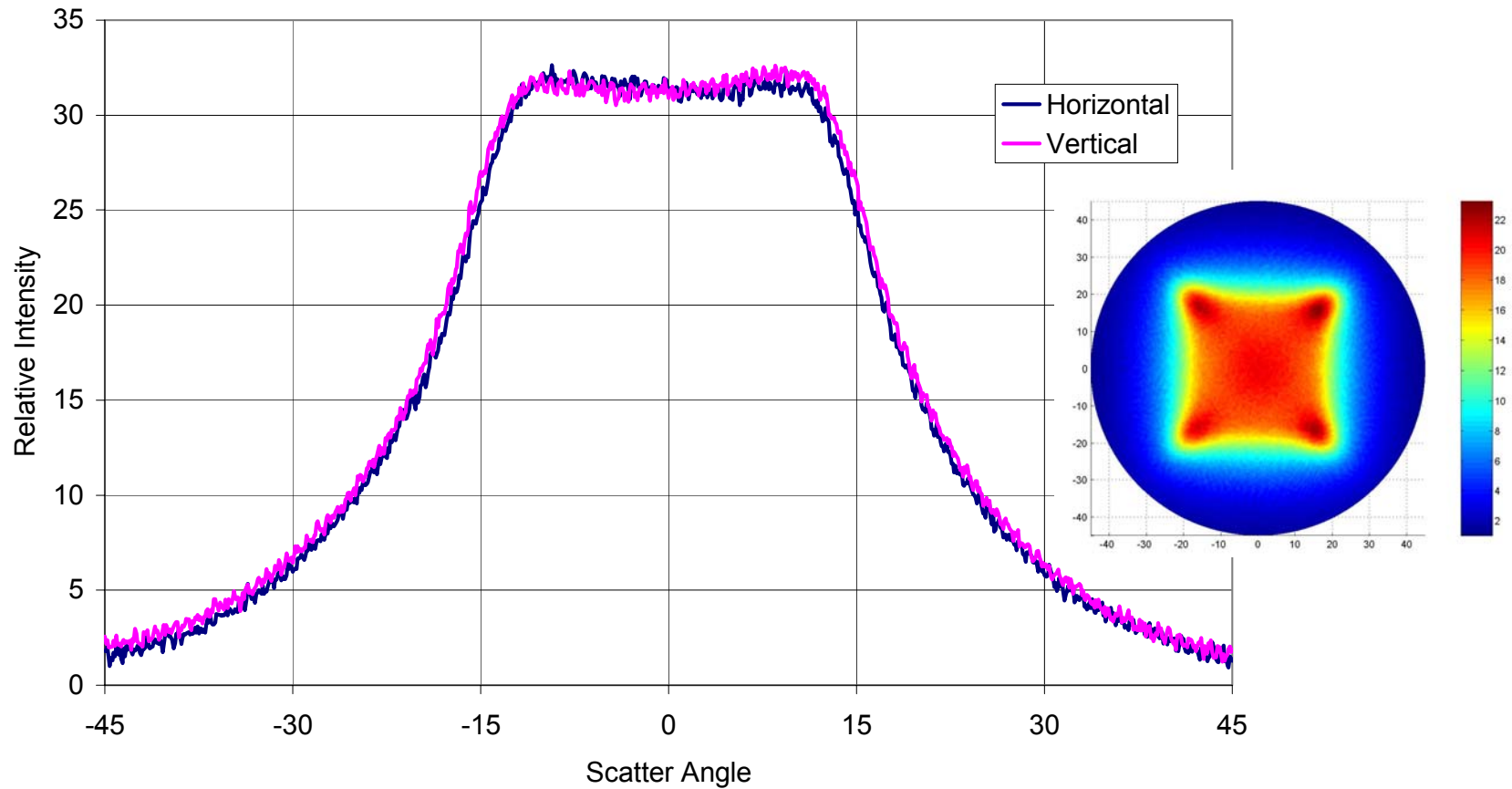
Diffuser Engineered for the LED

Engineered Diffuser with Laser Illumination



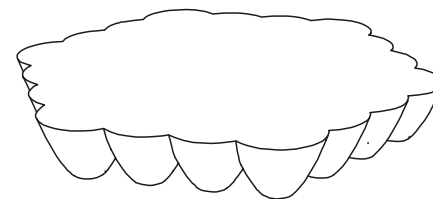
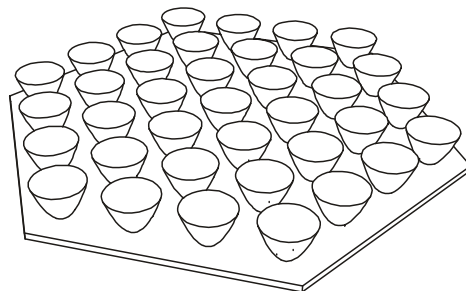
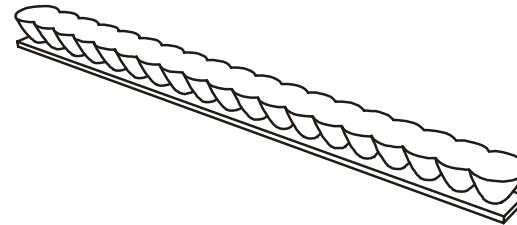
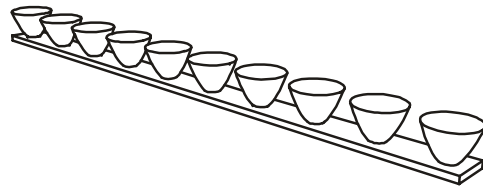
Engineered Diffuser™ with LED

LED and Collimator with Engineered Diffuser



Luminaire Configurations

■ One- and two-dimensional arrays of LEDs



Summary

- High brightness LED luminaire with controlled light distribution.
- Custom scatter distributions – round, square, rectangular, dipole, etc.
- Custom scatter profiles – flat top, Gaussian, bowl-shaped, etc.
- Low profile lighting fixture
- Single, 1-D and 2-D LED arrays