

Engineered Diffusers™

Engineered Microlens Arrays Used to Diffuse and Shape Light



Diffusers are found in many applications where a bright light source is used to create uniform illumination over a broad area. Applications include outdoor lighting, rear

projection televisions, and consumer electronic displays. Traditional ground or opal glass diffusers are inefficient and have limited capabilities when it comes to controlling the shape of the illuminated area. More modern holographic diffusers can typically be made so that round or elliptical areas are illuminated but the intensity of the illumination is usually only Gaussian within a small angular width. In addition, holographic diffusers are often limited to monochromatic applications using coherent light.

Thorlabs stocks Engineered Diffusers from RPC Photonics that have unique beam shaping characteristics and intensity distributions. Engineered Diffusers are arrays of microlenses where each microlens is independently produced. The master microlens array is produced by a laserwriting system developed by RPC Photonics. This system exposes a thick layer of photoresist point-by-point in a raster scan mode with a small focused laser beam as diagrammed in Figure 1.

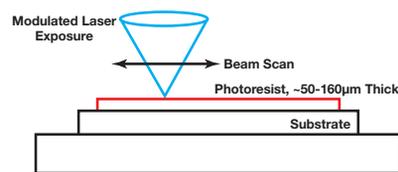


Figure 1: Diagram of the mastering process based on laserwriting.

By modulating the intensity of the laser beam as it is scanned, the degree to which the photoresist is exposed can be varied. The result of developing the photoresist is a deeply textured engineered surface, as shown in Figure 2.

Unlike uniform lens arrays, Engineered Diffusers are composed of microlenses with a variety of different sag profiles that are individually written at precise positions on the lens array. The location of each lens is randomized according to a probability distribution function that is chosen to implement the desired beam shaping properties. The randomized location of the microlenses prevents the formation of

diffraction artifacts and zero-order bright spots while also making the diffuser relatively insensitive to variations in the input beam intensity profile or the frequency of the light, which results in a diffuser that works equally well with monochromatic or broadband light. Due to the highly controlled nature of Engineered Diffusers, the specifications are listed for the design wavelength; however, deviating from that wavelength will only result in a slight variation of the divergence angle of the transmitted light.

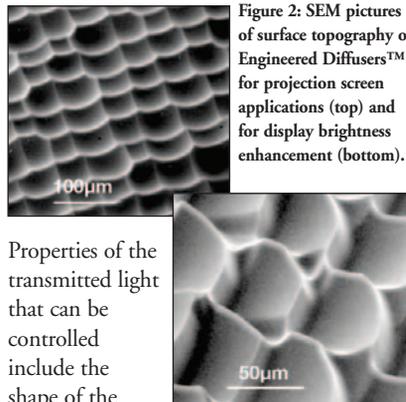


Figure 2: SEM pictures of surface topography of Engineered Diffusers™ for projection screen applications (top) and for display brightness enhancement (bottom).

Properties of the transmitted light that can be controlled include the shape of the illuminated area, divergence of the light, and the intensity distribution of the light in the illuminated area.

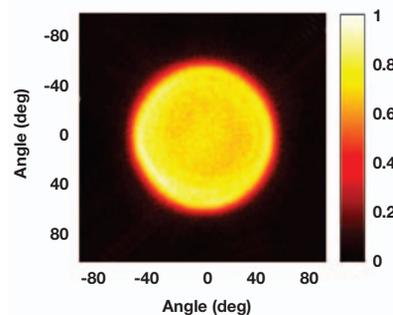
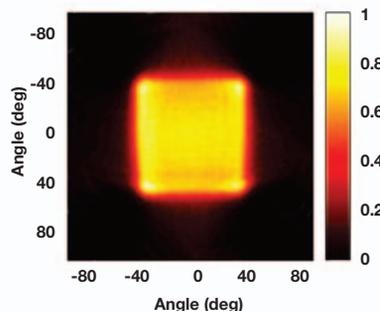


Figure 3: Measured top-hat intensity profiles for diffusers that produce a round (above) and square (below) illumination area.



In a particularly challenging application of this technology, an ideal projection screen was designed. For this application, the divergence angle in one direction was large (120° FWHM), while in the other it was narrow (40° FWHM). In addition, the near-field distribution of focal spots was controlled and the speckle pattern commonly associated with coherent light sources was avoided, all while maintaining the resolution of the projection. Figure 3 shows plots of the intensity distribution of two relatively simple Engineered Diffusers.

The flexibility of the engineered surface makes it possible to create complex diffuse illumination patterns (see Fig. 4). As a result, this technology should play an important role in devices that utilize solid-state lighting.

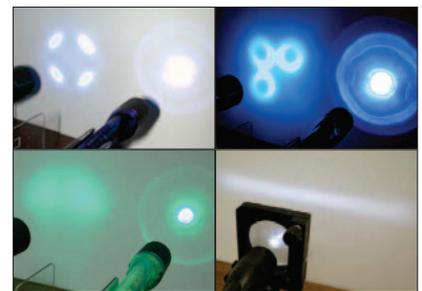


Figure 4: Beam shaping and homogenization of LED light sources with Engineered Diffusers™. For comparison, a raw illumination beam is also shown.

In addition, the achromatic properties of Engineered Diffusers allow them to be used to mix light from RGB LED arrays into a transmitted light distribution as seen in Figure 5, with a controlled color temperature, divergence, intensity distribution, and shape.

Figure 5: Achromatic performance allows for mixing of multiple wavelengths.



References

¹ D. H. Raguin, G. Michael Morris, and P. M. Emmel, Method for making optical microstructures having profile heights exceeding fifteen microns, US Patent #6,410,213 B1.

² Tasso R. M. Sales, High-contrast screen with random microlens array, US Patent # 6,700,702.

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