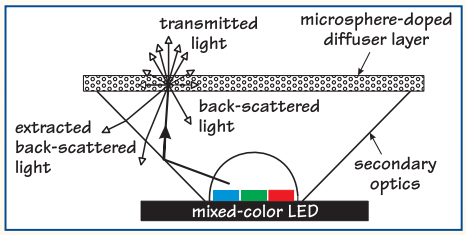
SPE Technology for Mixed-Color LEDs

One method of creating white light with LEDs is by mixing radiations in the right proportion from several different colored LEDs, such as red, green, and blue, commonly referred to as mixed-color white LEDs. Mixed-color LED systems require extra optical elements to reduce spatial color variations and create uniform white light. Optical diffusing techniques commonly used cause light loss because some portion of the light is scattered back toward the LEDs, where it is absorbed and lost.

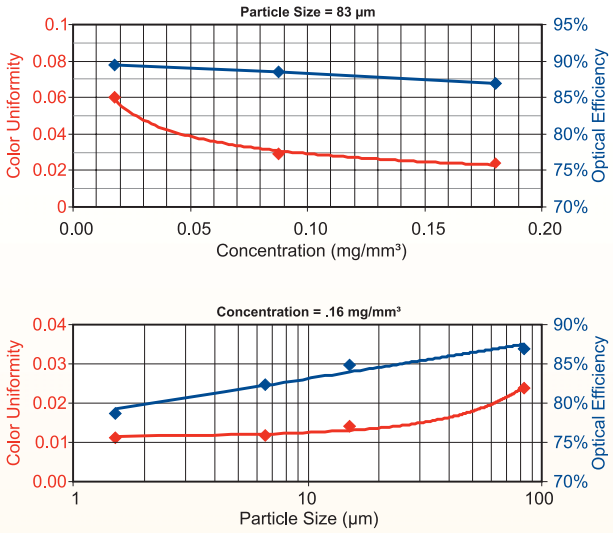
In 2004, the LRC developed scattered photon extraction (SPE™) to extract backscattered light from the phosphor layer in white LEDs to increase overall light output.



In this study, the LRC hypothesized that a new approach using SPE optics with optical diffusers could improve the spatial color uniformity of mixed-color LED systems without sacrificing much efficiency. LRC researchers combined SPE optics with a diffuser composed of epoxy resin and refractive-index-matched microspheres and investigated the effects of microsphere size and concentration on color uniformity and optical efficiency.

Experiment and simulation

The LRC built an RGB LED system with SPE optics using diffusers consisting of polymethyl methacrylate microspheres to conduct lab experiments. Color uniformity was measured with a CCD camera, and optical efficiency was measured in an integrating sphere.



Experiment results showing color uniformity and optical efficiency as a function of microsphere concentration (top) and microsphere size (bottom). Larger color uniformity values equal worse color uniformity.

Results

The experiments demonstrated that SPE optics with a microsphere-doped diffuser on the top surface:

- Increase the spatial color uniformity of the RGB LED system with high overall optical efficiency.
- Produce more uniform spatial color distribution with smaller microspheres than with larger microspheres at the same concentration. However, the system's optical efficiency with smaller spheres is lower.
- Produce more uniform spatial color distribution with higher concentrations of microspheres than with lower concentrations. However, the system's optical efficiency is lower with a higher sphere concentration.

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