SSL Postings
U.S. DEPARTMENT OF ENERGY

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Full Throttle with SSL R&D

You might not know this, but the DOE SSL Program conducts a rigorous scientific peer review of all first-year DOE-funded R&D projects. These annual peer reviews are closed to the public and are conducted by top outside experts, who put the researchers through their paces and provide invaluable feedback that helps them stay on track and adjust course if necessary.

The latest peer review was held last month in Morgantown, WV, and it was exciting to get a close-up look at transformative science in action, as fundamental understanding of the physical properties and phenomena involved in solid-state lighting continues to improve. So I thought I'd give you a sampling of what these highly promising DOE-funded projects are doing to move the needle:

- Lumileds is developing a high-efficacy, high-power LED emitter to enable both industry-leading efficacy and the best possible luminaire performance in the high-brightness application space. The LED is being optimized for high drive current, high temperature operation, and a well-defined radiation profile. Efficacy improvements are being enabled by an integrated development effort, with improvements in each of the elements of the LED architecture. The epitaxy is based on advanced patterned sapphire substrate flip-chip (PSS-FC) architecture, with improvements to internal quantum efficiency and extraction efficiency. Die-level improvements include the development of a contact design that increases reflectivity with minimal penalties on forward voltage and thermal performance. Phosphor development is focusing on phosphors with reduced bandwidth to increase the luminous efficacy of radiation while maintaining high quantum efficiency and color quality. Package development is focusing on optical materials that maximize light extraction from the PSS-FC die in a radiation profile optimized for directional applications. Multiple package options are being developed to address different application needs, including a low-cost chip-scale package LED. So far, Lumileds has developed a high-brightness LED with an efficacy of 175 lm/W at a CCT of 4000K and a CRI of 70.

- North Carolina State University is addressing the issue of extracting light trapped in the OLED device. For basic OLED devices on planar glass substrates, only 17% to 25% of the generated light is extracted from the panel. This inefficiency is due to trapping of photons in the electrodes, transparent substrate, and inner layers resulting from mismatches in the index of refraction along the photon path (i.e., organic materials, anode, substrate, encapsulation layers, and air). The project is exploring the development of a corrugated substrate coupled with a low-index-of-refraction buffer layer to minimize total internal reflection. Development has focused on optimal feature pitch and depth for maximum extraction without creating current

leakage or pathways for shorting. The project is also investigating the use of a microlens array to extract light from the substrate mode. The overall goal is to achieve an extraction efficiency >70%.

- Cree is developing novel LED luminaire systems that involve a number of advancements, including light engines with discrete emitters and narrow-band downconverters enabling >200 lm/W peak efficiency, low-profile optical designs with highly uniform (≤0.003 Δu'v') near- and far-field color mixing at high (>90%) optical efficiency, novel ultra-compact color sensors providing real-time input for accurate color control (≤0.003 Δu'v'), and ultra-compact, low-cost scene sensors for accurate (<1% false-positive rate in low-light ambient) occupancy detection. The technology benefits can be applied to a broad range of luminaires with ultra-high steady-state efficiency of >170 lm/W at 3000–3500K CCT and >80 CRI (or the equivalent).

- The University of Michigan is working on eliminating plasmon losses in high-efficiency white OLED devices for lighting applications. Phosphorescent OLEDs have consistently demonstrated up to 100% internal quantum efficiency; i.e., one photon is emitted for every electron injected. However, without light-extraction techniques, approximately 80% of the emitted photons are trapped and lost inside the device. This project is combining a theoretical understanding of the fundamentals of light propagation in OLEDs with innovative experimental approaches to achieve a light-extraction efficiency of >70%. The researchers have introduced two completely new methods for light extraction that are potentially inexpensive, independent of the illumination spectrum, and compatible with existing OLED device designs. In the first year of the project, they've already achieved 60% light-extraction efficiency, with a clear sight to meeting and even exceeding all of the targets. When combined with the features of low cost, lack of wavelength dependence, and compatibility with conventional OLED designs, the technology approaches being developed are poised to revolutionize the efficiency of OLED lighting sources.

These four projects, as well as others DOE is funding, have a great story to tell about how U.S. scientific and engineering leadership are driving progress in SSL technology and adding to the body of knowledge. See the DOE website for a description of all the new projects, and stay tuned to these *Postings* and DOE's Research Highlights web section for more progress reports, and to DOE SSL Updates to hear about funding opportunity announcements and project selections.

Best regards,
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As always, if you have questions or comments, you can reach us at postings@akoyaonline.com.