LED WATCH BY JAMES BRODRICK

Organic Light Emitting Diodes (OLEDs) are LEDs with a twist. "Organic" refers to organic (carbon-based) chemicals, which form the light-generating layers in a sandwich of thin, layered materials, replacing the inorganic (non-carbon-based) chips in LEDs. The method of creating light is essentially the same, though the form is different: discrete point-like chips in LEDs vis-à-vis large sheets in OLEDs. Both technologies are poised to play different, important roles in the future of lighting. LEDs tend to be point sources, better utilized in spot and light focusing applications. OLEDs are flexible sheets, like paper, that provide more dispersed light.

The U.S. Department of Energy (DOE) is spearheading R&D efforts to improve the energy efficiency and performance of OLEDs for general illumination applications. DOE's efficacy goal for general illumination OLEDs is 100 lumens per watt in a commercial fixture by 2015. The best laboratory devices now deliver on the order of 35 lumens per watt at a reference brightness of 1,000 candela per sq m. These devices are typically small, perhaps 100 sq cm, so the light output is only a few lumens. While display backlighting products are on the market now, DOE hopes to see the first OLED *general lighting* products available by 2009.

Layered structures are perfect for flat screens, and OLEDs are already used in small screens for cell phones and 32-in. television screens. Currently, the polymer layers are sandwiched between glass plates, but soon plastic films will replace them, making OLEDs flexible. Imagine a light device that can follow curves, turn corners or cover a wall to make programmable wallpaper. Or think of OLEDs in fabrics creating "electrotextiles" that illuminate clothing, curtains or furniture. These innovative methods of delivering light will likely accelerate acceptance of this energy-saving technology, despite potentially higher initial costs.

Once they achieve the target efficiency for their prototype OLED technology, researchers at Universal Display Corp. are looking for an efficiency drop of only 30 percent over 50,000 hours.

According to Anil Duggal, advanced technology leader for organic electronics at General Electric, what's exciting about OLEDs is the chance to come up with completely new form factors. GE is currently investigating thin, flexible light sources—like wallpaper. Duggal says the reason for focusing on wallpaper right now is to make you think about paper-thin, flexible lighting materials and new methods of lighting design.

OLEDs consist of at least two layers of organic thin films between two glass electrodes. When powered up, electrons and holes (vacancies where electrons used to be) form in the organic layers. These electrons and holes later recombine and emit light in a process called "phosphorescence." The light color depends on the chemistry of organic phosphors in the layers. Combining red, green and blue phosphors into a single RGB device can produce white light.

Paul Burrows, manager of Pacific Northwest National Laboratory's Nanoscience and Nanotechnology Initiative, demonstrates future OLED general illumination technology by rolling a sheet of paper like a window shade. With this "lightbulb" of the future, you unroll the flexible film, forming a one-sq m white light panel.

CHALLENGES

Besides cost reduction, lifetime and efficiency improvements are also needed before OLEDs can be used for general illumination. DOE-funded projects are actively attacking these challenges.

Mark Thompson, chair of the Department of Chemistry at the University of Southern California, is tackling a tough problem for white OLEDs—finding a long-lifetime blue emitter. While red and green phosphorescent emitters are largely optimized, developing a long-lived phosphorescent blue emitter remains a challenge. Currently available blue phosphors last only up to 1,000 hours at best. Thinking outside the box, Thompson decided to use a long-lasting fluorescent blue with phosphorescent red and green to produce a hybrid RGB OLED having a white spectrum similar to sunlight. He has succeeded in producing a fluorescent blue emitter with a lifetime of 5,000 hours at 20 lumens per watt.

At Universal Display Corp. (UDC), researchers are focusing on getting the efficiency as high as possible, according to senior scientist Brian D'Andrade. UDC's best reported OLED efficacy to date is 45 lumens per watt, but D'Andrade is confident that they can reach DOE's 2015 target. UDC is developing new phosphorescent emitters, including longer lasting blues. Once they achieve an acceptable efficiency level, the key will be keeping the device operating at that level for a long time. D'Andrade is looking for an efficiency drop of only 30 percent over 50,000 hours.

DOE-funded researchers like Duggal, Burrows, Thompson and D'Andrade continue to strive for technology improvements that lower the cost and increase the efficiency and lifetime of OLED technology. The energy savings potential of OLED technology is significant, yet may ultimately be dwarfed by the enormous design potential, as new forms and functions offer unique lighting solutions for challenging applications.

James Brodrick is the lighting program manager at the U.S. Department of Energy, Building Technologies Program. The Department's national strategy to guide high-efficiency, high-performance, solid-state lighting products from laboratory to market draws on key partnerships with the lighting industry, research community, standards organizations, energy-efficiency programs, utilities and many other voices for efficiency.