› LED and OLED Solid State Lighting: A Look Ahead

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There's a great deal of focus these days on LED replacement products, especially with the *Energy Independence and Security Act of 2007* calling for a transition to greater energy efficiency in lighting, starting in 2012.

The replacement lamp market is a huge one, and solid state lighting (SSL) products have the potential to yield significant energy savings compared with traditional replacement lamps. But solid state lighting differs from traditional lighting in fundamental ways, and thus works best with fixtures that are specifically designed for SSL sources. That means LED replacement lamps for conventional sockets can never take full advantage of SSL's considerable potential when they are used in fixtures that were designed for other lighting technologies.

The industry is very much aware of that, which is why we find more and more luminaires specifically designed for LEDs coming onto the market. And because these purpose-built products aren't bound by the same constraints that apply to traditional lighting, they offer scope for outside-the-box thinking—and for the kind of innovation that could result in lighting systems that are quite different from those we're used to. This could involve not only new form factors, but also new ways we deliver, control, and even power light.

THE CURRENT SITUATION

To understand where solid state lighting is headed, we first have to understand where the technology is right now. LEDs for general illumination have moved beyond basic R&D and have started to climb the marketing curve to widespread use.

While there are many LED lighting products out there, as a group they are of decidedly mixed quality. Many perform quite well and can compete with the incumbent technology—especially in applications such as downlights, parking-structure fixtures, 2'x2' troffer luminaires, and outdoor area lighting—but others may disappoint. Overall, however, recent progress has put the prospect of surpassing conventional lighting within sight and has created a sense of excited anticipation in the industry.

OLEDs, or organic LEDs, represent another approach to solid state lighting. Although both OLEDs and LEDs have similar potential to save energy, OLEDs have some advantages over LEDs. These include being diffuse rather than small-point light sources, which may make them more practical for general ambient lighting, as well as having broader emission spectra, which makes it easier to get good quality white light.

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Not yet commercially available for general illumination, OLEDs are used primarily in displays. Only a handful of niche OLED lighting products exist, and they're handicapped by high prices, very limited quantities, and substantial performance limitations—with no significant manufacturing taking place.

That's likely to change, as the country's first pilot OLED manufacturing facility is now gearing up in Canandaigua, New York. One of eight new DOE-funded SSL manufacturing projects aimed at reducing costs, improving product consistency, and encouraging a role for U.S. manufacturing, it will be operated by Moser Baer Technologies using technology developed by Universal Display Corporation.

OLED lighting is now at a critical stage that could be described as "make or break." It is poised between the initial core R&D that established the technology, and the development of marketable OLED lighting products. If it makes it through this transition period, OLED technology, which has tremendous potential, could offer a rich supply of innovative lighting products in the years ahead.

DEPARTMENT OF ENERGY EXPLORES CURRENT CHALLENGES

At a series of DOE roundtables held last November, industry experts discussed various issues that must be addressed if LED and OLED lighting are to progress to the next level.

For LEDs, gaining a better understanding of the major "efficacy chokes" was emphasized, with the "droop" phenomenon (whereby LEDs exhibit a significant drop in efficiency at higher currents) receiving special focus. Driver design was also cited as an opportunity for innovation, with significant energy-savings potential. Driver reliability still needs improvement, leading to a suggestion that a reasonable goal is for the entire system to last as long as the LEDs.

The question of color also was raised, with color uniformity from one luminaire to another—as well as shift over time—being noted as key areas of concern. Shrinking the payback period was described as another key to increasing market adoption.

One idea that resonated from a broader perspective at these roundtables was to

move away from the traditional means of creating and integrating light, in favor of more innovative approaches. Especially as regards integration, a modular approach to luminaire design is gaining industry attention to address concerns about maintenance and installation that have been raised by many participants at DOE events.

Significant energy savings beyond just the improvement in efficiency of light generation could be realized by moving to "smart" lighting systems that incorporate sensors and adaptive lighting controls, which would take advantage of the potential of LEDs to integrate such technology more effectively than conventional lighting can.

It was even suggested that moving the sensing system into a chip be seriously considered, because current sensing technology is bulky, expensive, limited in performance, and not designed for LEDs. And along similar lines, moving luminaire functionality itself into the chip was brought up as a way to boost efficiency.

As for OLEDs, it was emphasized that they need to develop more quickly in order to keep pace with the progress of LED lighting. The point was made that OLEDs shouldn't be designed to replace conventional lighting, or even to compete with LEDs, but that OLED manufacturers should instead focus on creating new form factors. For example, conformable diffuse lighting surfaces could offer innovative opportunities that would take advantage of OLEDs' unique characteristics.

But cost remains a major obstacle to using OLEDs in general illumination, and the need to increase brightness and improve lifetime are key challenges to realizing lower costs. Improved light extraction and uniformity will also help. And designers may need to attend to the thermal management of OLEDs as well as the light output increases. From a broader perspective, the creation of niche OLED products that offer profit at medium to low volumes was proposed to facilitate the sustainable growth of the OLED industry.

WHAT LIES AHEAD

Addressing these issues will clear the major hurdles from solid state lighting's path forward. Where, then, might that path lead?

A panel discussion at the fifth annual DOE Solid State Lighting Market Introduction Workshop, which was held last summer in Philadelphia, gave a tantalizing foretaste, as several industry experts explored where LED performance is projected to head, what new form factors are emerging, and how solid state lighting is enabling us to think differently about the way lighting is delivered as a system.

One speaker emphasized the new lighting paradigm SSL is creating, with the potential for such features as control systems that can cycle lights automatically or create on-demand lighting, or even furniture that incorporates light-emitting fibers. He said solid state lighting's adoption will be accelerated by focusing on simple plug-and-play designs for minimal-cost upgrading and design standardization of key system elements.

Both LEDs and OLEDs use direct current (dc), which has people rethinking the way solid state lighting can be powered. One alternative described at the Philadelphia workshop involves a unified dc power and communications system architecture that centralizes the LED drivers, which results in better performance, added intelligence, drive flexibility, better dimming, and easier installation. Along similar lines, another speaker described an energy-efficient, hybrid power platform for use in commercial buildings, which utilizes both alternating and direct current and integrates interior infrastructures, power, controls, and peripheral devices.

These DOE-sponsored SSL workshops, panel discussions, and roundtables are designed to provide an unbiased, vendor-neutral forum where the entire industry can come together to share knowledge and perspectives. Held on an annual basis, they generate an ongoing flow of feedback that guides DOE program planning, including development of our funding solicitations, and ensure that our planning keeps pace with the rapid evolution of the technology and marketplace.

Although that evolution has already taken SSL quite a ways, much work remains to be done. And from the look of things at this stage of the game, it seems likely that what lies ahead is not only increased energy efficiency, but whole new ways of creating, delivering, and using light.

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