Improvements in LEDs

Though it is tough to make generalizations regarding LEDs, this lighting technology keeps getting better and better all the time.

BY EDDIE WIEBER

Eddie Wieber reports on market affairs and business trends for National Business Media and its several publications serving the graphics and automotive industries. He is a former editor of Sign Business *magazine.*

A POTENTIAL TRAP to avoid is referring to LEDs as a generic product class; as if all LEDs are equal. That would be like saying that all quarterbacks—from little league to the NCAA to the NFL—are equal. Basically, general statements concerning their reliability, longevity and performance (or lack thereof) are both misleading and inaccurate.

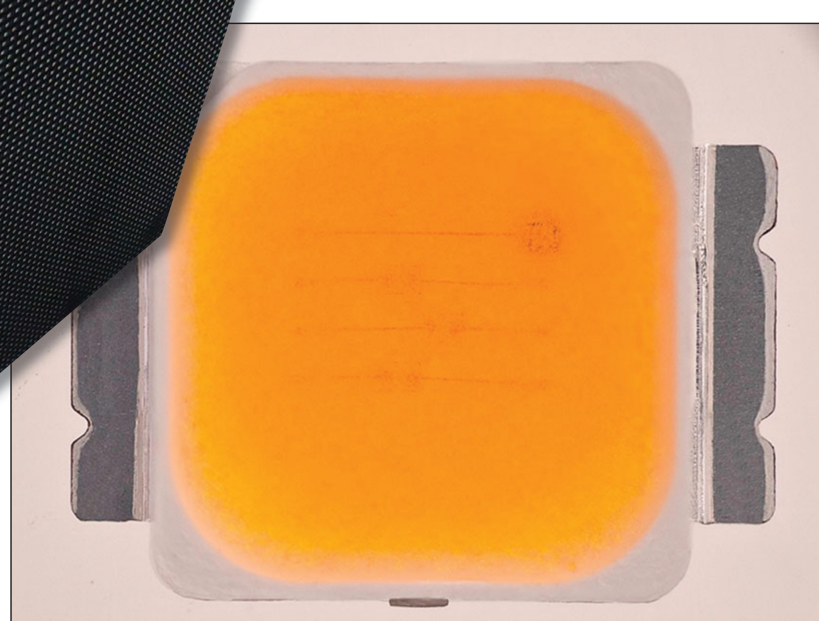
When it comes to talking about improvements in LEDs, it doesn't necessarily mean those improvements have made their way into every LED product at every price range. However, it would be accurate to say that the best LEDs, like the best quarterbacks, have come a long way since the game began. But so much for football metaphors.

The important questions are these: What's the pathway to finding the best performing LEDs? What kind of value does that represent? And what's in store in the years to come?

NEC Display Solutions of America recently announced the release of LED modules for indoor and outdoor video wall installations. (Courtesy NEC Display Solutions)

PREDICTIONS

In 1999, Dr. Roland Haitz predicted that every 10 years the amount of useful light



Cree's new XLamp MX-6S and MX-3S offer new high-voltage configurations designed for space-constrained LED lamps and bulbs. (Courtesy Cree) generated by any given LED package would be 20 times greater, while the cost-per-lumen would be 10 times less. Haitz's Law—as Haitz's observation has since become known to the LED community—follows the general historical trend of computer technology's progress of exponential improvement. Haitz's Law is an LED version of Moore's Law, which is attributed to Gordon Moore's 1965 prediction, which (simplified) stated that computer technology would increase in performance and decrease in price at an exponential rate. For a while, that is…

Both "laws" follow what mathematicians call an "S-curve," which means over time, the rate of progress eventually levels off. It's been suggested that the computer model would plateau sometime around 2015, but it's a difficult law to apply across the broad LED industry. Improvements do emerge with each succeeding generation—sometimes with the LED chips and sometimes with other components.

A PACKAGE DEAL

As alluded to earlier, all manufacturers are not equal in their improvement schedules. Neither are they equal with respect to the specific improved components, their degrees of improvement, or the costs to make improvements that are passed on to end users. That is, all LEDs available on the market are not equal in cost or performance.

So, it can be difficult to determine first of all, what has been developed through various public and private research projects; and which of those developments has made its way into the current product mix offered for general, as well as sign lighting applications.

The basic components that make up any light emitting diode are a semiconductor die (chip), a positive electrical

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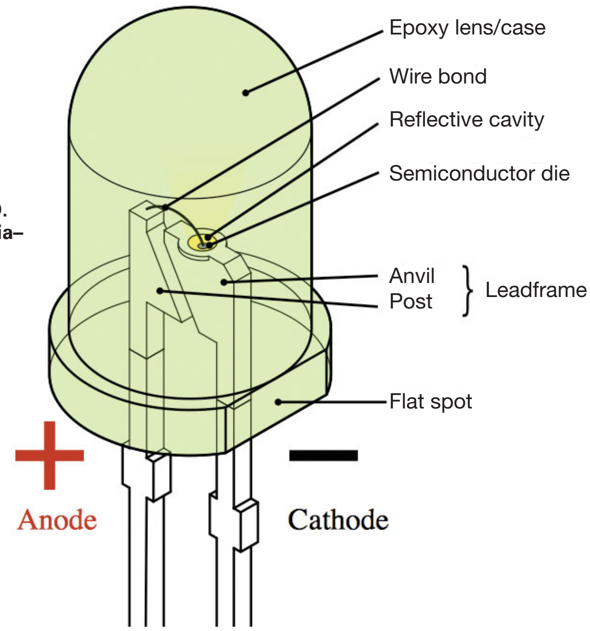
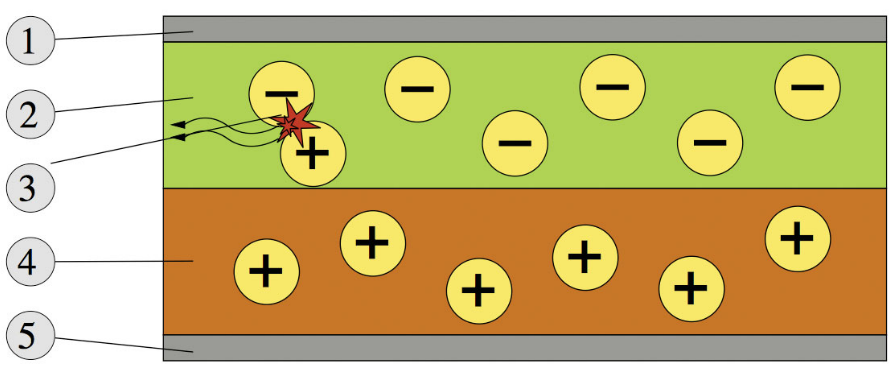


Parts of an LED. (From Wikipedia–Inductiveload)



Schematic of a bilayer OLED: 1. Cathode (−), 2. Emissive Layer, 3. Emission of radiation, 4. Conductive Layer, 5. Anode (+) (From Wikipedia–Rafał Konieczny)

contact (anode) and a negative electrical connection (cathode). Diodes are where the action is, but are only one of several components that go into the making of a light producing device. Devices also include reflectors, substrates, wires and connectors, lenses, phosphors and other coatings, heat sinks and power supplies.

As previously reported, white LED performance has significantly improved across the board in the past year and is on track to continue in the same vein for the foreseeable future. SloanLED for example reported this past spring that for the same price as a year ago, the white LED modules the company offered in 2010 are brighter and more energy efficient than their 2009 counterparts.

SloanLED also recently introduced a 24VDC wet location power supply for its LEDStripe product, which is purported to be a much more efficient system than the previous 24VAC power supply and which can be used to power previous versions of the product.

One of the historically significant and appealing features of LEDs has been their longevity. But as previously mentioned, all LEDs are not equal. When the cheerleading started in the mid- to late-1990s, LEDs were often pitted up against neon and the message to electric sign makers was about LEDs lasting for 100,000 hours. Some LEDs were capable of that kind of longevity at the time—under ideal conditions. But partially informed, misinformed and over-zealous sales people sometimes applied those numbers to all LEDs across the board, when the products they were selling were useful for only a fraction of that time. So although they didn't burn out, LEDs have gotten a bad rap–sometimes deserved, but sometimes not–for quickly fading to a point of uselessness.

RECENT INITIATIVES

Some of that has been addressed in recent initiatives such as revised Energy Star lumen maintenance requirements for solid-state luminaires or LED light engines. The standards proposed require LEDs intended for indoor use to deliver at least 91.8 percent of their initial lumen output and LEDs intended for all commercial and outdoor use to deliver at least 94.1 percent of initial lumen output after 6,000 hours of use. (The entire draft can be viewed online at *www.energystar.gov/ia/partners/product_specs/program_reqs/luminaires_draft_1.pdf*.)

Other new rules provide for "Lighting Facts" package labels—similar to food nutrition labels—that will provide information about all light sources. These labels will use more relevant metrics that will allow comparisons to different kinds of light sources to be easily made. For example, brightness would be measured in lumens instead of the traditional watt designations. The labels will also include information about operating cost, longevity, color temperature and RoHS information, such as mercury levels.

These measures are intended to require minimum performance standards on general illumination products for commercial and residential applications, but the mandates also will affect products intended for the sign industry.

OLED DEVELOPMENTS

The term Organic Light Emitting Diode (OLED) conjures up images of wavy light devices that might be found growing in a garden on Pandora, the mystical moon in James Cameron's sci-fi adventure flick, Avatar.

But the "organic" part of the term refers to the carbon-based nature of the compounds from which layers of organic semiconductor materials are made. OLED devices have been available for several years but have not yet achieved much market penetration, mainly due to extremely high manufacturing costs. But OLED technology may also be following Haitz's Law, and if so, this technology has the potential to, if not eclipse all other

The race is on for cost effective OLED devices and several global corporations are involved.

lighting technologies in the future, at least become a major player in the lighting device market.

OLEDs have some attractive features. They emit light efficiently in a large area. OLED displays don't need the filters or backlighting source that liquid crystal displays (LCDs) need because they emit their own light. OLEDs are dimmable. Some versions are flexible. Images on OLED displays have good contrast and definition. OLEDs can be made to emit warm white as well as multi-colored light. OLED displays and light sources can be packaged into extremely thin devices.

Today though, even the newest most advanced OLED products available—LG's recently announced 31" OLED television screen, Osram's Orbeos light panel and the Philips Lumiblade—are too expensive to be practical for any widespread commercial or residential applications.

But that may change soon enough.

As recently reported in MIT's Technology Review, University of Florida researchers, led by physics professor Andrew Rinzler, are working on the development of a manufacturing process in which source and drain electrodes of an OLED transistor are stacked rather than positioned side-by-side. The complex process utilizes materials such as carbon nano tubes that have only recently become available, and the result is a more efficient and less costly manufacturing process, which can contribute to further development of new devices that use even less power and that are significantly more affordable to end users.

The race is on for cost effective OLED devices and several global corporations are involved. Nano Holdings, a Connecticut-based venture capital firm that focuses on investing in nano-technology applications, partially financed the University of Florida project. Other global corporations becoming involved with OLED research and development include Universal Display Corporation, Merck, Sumitomo Chemical, Osram, Philips and DuPont Displays. DuPont Displays for example, recently announced a new printing process, in collaboration with the Japanese printer manufacturer Dainippon Screen, for manufacturing OLED displays in high enough volumes to compete with LCD technologies. And Philips Research has announced the development of an AC-powered OLED that plugs directly into a standard AC electric power supply. This development will have a significant impact on simplifying the way OLEDs are configured into lighting devices and systems in the future.

STANDARD ISSUES

The LED industry is still struggling with standards, like it always has. Partly because solid-state lighting (SSL) differs in so many basic ways from other kinds of light sources, LED products as a class have been consistently met with some

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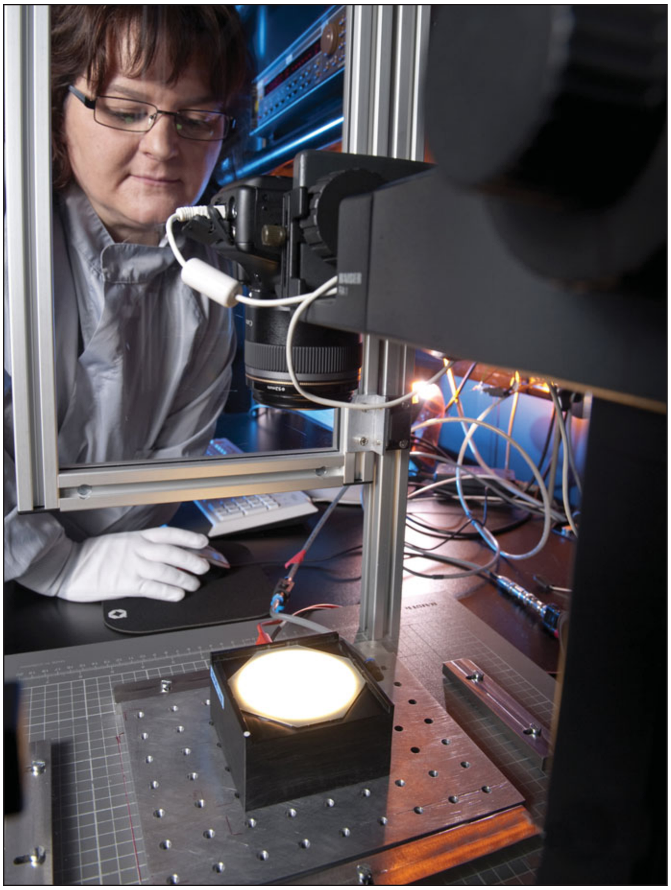
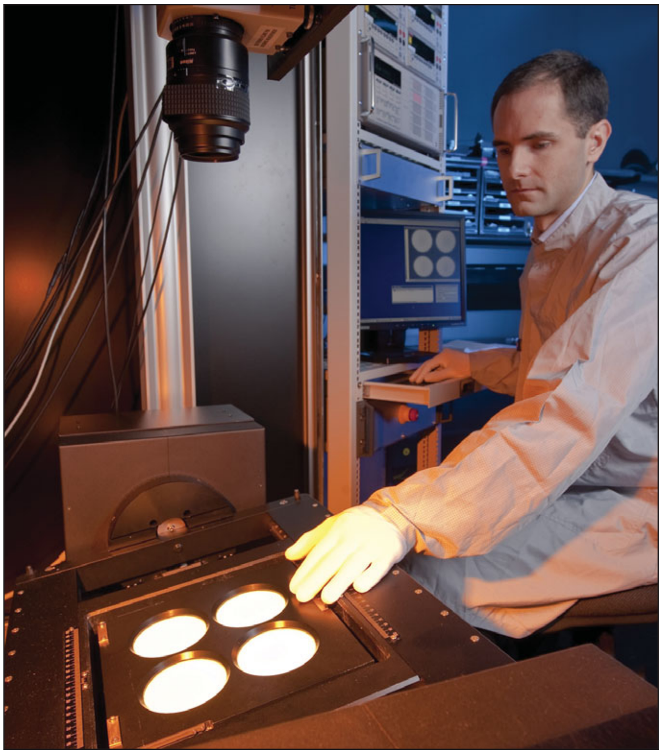
Prototype devices using the Philips Lumiblade OLED device. (Courtesy Philips Lumiblade)





Technicians observe Orbeos OLED light panels in Osram's laboratory. (Courtesy Osram)

degree of skepticism and resistance in the open market.

But one major area of resistance, the concern about credible longevity claims and other performance standards for LEDs has been addressed via the CALiPER Program: Commercially Available LED Product Evaluation and Reporting, which is administered by the United States Department of Energy (DOE). (For more information on the CALiPER program, visit *www1.eere.energy.gov/buildings/ssl/caliper.html*.)

Through the CALiPER program, tests are done to evaluate solid state lighting (SSL) products that anyone can buy on the open market. This includes any devices sold online, sold through wholesale suppliers, in department stores and other retail outlets.

To eliminate the possibility of a manufacturer pre-selecting its best samples for testing, DOE staff personnel purchase the products that are tested in the program directly from normal distribution channels.

The CALiPER program tests luminaires (e.g., packages), rather than individual LEDs, officially stating: "1) There is no industry standard test procedure for rating the luminous flux of LED devices or arrays; and 2) because LED performance is temperature sensitive, luminaire design has a material impact on the performance of LEDs used in the luminaire. For these reasons, luminaire efficacy (total lumens emitted by the luminaire divided by the total watts drawn by the luminaire's power supply) is the measure of interest for assessing energy efficiency of SSL products, as specified in LM-79."

(LM-79 is the IES Guide for Electrical and Photometric Measurement of Solid-State Lighting Products, and includes test procedures.)

Since the CALiPER program's start, DOE reports "marked improvements" overall in SSL technology. But at the same time, DOE reports a significant gap still exists in overall quality among different products and different manufacturers, as well as an overall gap between advertised claims and actual performance.

Accuracy in performance reporting is essential to the long-term health of the LED industry because the range of degrees of disparity between actual product life and claims of product life make the LED product category as a whole unreliable.

The gap essentially means some LEDs are of poor quality and some are very high quality. But the results, which are made public, will no doubt pressure manufacturers into delivering more reliable and robust products. And the best performers bear witness to the potential for a much better class of product. For example, regarding lumen depreciation, a DOE analysis reports that even though several products tested performed inadequately, "a few products show negligible lumen depreciation after more than 12,000 hours of operation–demonstrating that at least in some cases, the potential for very long SSL product life appears to be achievable." **SDG**