

White Science

Improvements in white LED lighting technology

BY EDDIE WIEBER



White LED technology has gained enormous momentum in recent years as new ways of manufacturing, packaging and mass distribution have been developed. White LEDs have become more useful and more efficient than ever before. (Image courtesy OSRAM)



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FOR A LONG TIME the prevailing wisdom about LEDs as they pertain to the sign business was that in specific applications—like inside red-faced channel letters—LEDs were a good choice.

That is, *red* LEDs were a good choice.

As far back as 1999, red LED technology had advanced into a realm of becoming a very efficient and cost effective product—especially in applications requiring a red light: traffic signals, channel letters, center high-mount stop lights (CHMSLs) and of course, indicator lights on a thousand electronic gadgets.

White LEDs were relegated to the Romper Room of the lighting industry—cute give-away pens and flashlight key chains and lots of other specialty gifts and curios. Some research scientists gave conference talks about breakthroughs in the brightness of white LEDs, but because of extremely high costs those discoveries were slow to emerge from laboratories.

But in the search for better ways, white LED technology has gained enormous momentum. It's the demand for a general source of illumination that will meet global lumen output needs for interior commercial lighting, street lighting, residential lighting, automotive lighting, and sign and display lighting—without the energy requirements and heat output of incandescent bulbs, without hazardous materials, fragile materials or unsafe and unreliable products.

Well that's the *dream* anyway...

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Digital graphics are increasingly displayed in thin profile cabinets that use white LEDs as a backlight source. (Image courtesy Clear Corporation)



In Cape Town's Green Point Stadium the energy-efficient LEDs by OSRAM Opto Semiconductors trace wave shapes of high quality white light. (Image courtesy BEKA (Pty) Ltd)



EARLY ADOPTERS

For many years the sign industry helped push LED technology forward. For example, electronic message signs were an important breakthrough technology in the emerging days of widespread LED adoption. Today these are still an important segment of the industry. And channel letter illumination was another driver for early adoption of LEDs.

The current search for the *Holy Grail* of man-made lighting centers around finding the most pleasing, most cost-effective replacement for the incandescent light bulb. That means white, not red light. And that search is trickling now back toward the sign industry in the form of products adapted from improvements in LED technology for the general illumination market. These products will become even more useful and more

efficient as new ways of manufacturing, packaging and mass distribution emerge.

Jill Bonilla, marketing manager for SloanLED believes the focus to make white LEDs is opening the door to new benefits for the sign industry. For example, SloanLED reports its newest Great White 3 product is up to 40 percent brighter than previous versions.

"For the same price as last year, you're looking at higher performing LED modules that are brighter, more energy efficient, have a longer leg length, wider viewing angle and are available in three shades of white," she says.

Such an increase may appear sudden to the casual observer, but it's really the result of the thousands of big and small steps that have happened and still do happen as the industry's infrastructure is built.

"It's hard to pinpoint that one huge breakthrough," says Osram Sylvania's Daniel Chu. He says that from Osram's standpoint, the driving force behind it all is a combination of a little of everything—materials used in not only LED chip technology, but also materials used in packaging for the overall systems that make improvements possible.

WHITE SCIENCE

At the industry's core is enabling technology such as much more efficient Star Wars-sounding MOCVD (metal organic chemical vapor deposition) reactors made by companies such as Aixtron and Veeco; it continues with better chip structures and package designs from companies like Osram Sylvania, Nichia, Phillips and Cree; followed by better sign lighting fixtures made by companies whose advertisements for LED signage lighting are occasionally found in this magazine: SloanLED, CAO Group, GE Lumination, US LED, Agilight, Super Bright LEDs, JT LED, LED Inc., LEDtronics, Permlight, Sunfire LED and many others.

From a device material and structure standpoint, Osram Opto Semiconductors, for example, has reported significant improvement of commercially available thin GaN LEDs that produce high lumen output and efficiencies beyond 100 lumens per watt.

Chu says those advances are responsible for recent upgrades in the company's signage portfolio. He also mentions advanced metallization and electro-technology at the LED chip level and advanced packaging technology.

Chip technology is getting better. But even with a brighter chip, the entire module has to be built to work properly with that chip.

"One thing has changed for sure," says Bonilla. "People are becoming more like connoisseurs of light."

There are two leading technologies currently used for producing white light from LEDs: the RGB cluster and the blue LED chip that is coated with phosphors. The RGB cluster is used extensively in the electronic message sign industry

because in addition to white, discrete RGB levels can be controlled to produce millions of colors. But this model is generally considered to be too expensive for other sign applications such as channel letters or border lighting.

More promising is white LED technology based on blue LED chips coated with phosphors. "When you look into all this LED advancement, you have to separate the difference between the cool white LED versus the warm white LED," says Chu.

And while the prevailing wisdom points toward signage applications being mainly focused on cool white applications, warmer whites are in demand as well, as evidenced by a range of choices now available in white LEDs.

Bonilla says the demand for different shades of white for sign lighting products is behind SloanLED's decision to offer its white LEDs for sign lighting applications in three different color temperatures. Great White 3, for example, is a cool white LED and performs best in deep channel letter cans installed high up on tall buildings because the eye sees a cool white best from a distance. Warmer whites produce a pleasing softer light that is effective when used to enhance the ambiance of interior signage, where shallow channel letters are more popular.

"Sometimes a color temperature, whether cool or soft or warm, can just be a preference of the customer and how they want their image portrayed," says Bonilla.

TO INFINITY—AND BEYOND

If you think MOCVD sounds like Star Wars, then *quantum dots* probably sounds like real-life rocket science. And it is.

Quantum dots are extremely small semiconductor particles—in the range of about 2-10 nanometers—that, because of their extreme smallness, behave in strange but very predictable ways. And when quantum dot technology is combined with LED lighting technology, the results are also strange, but interesting and exciting.

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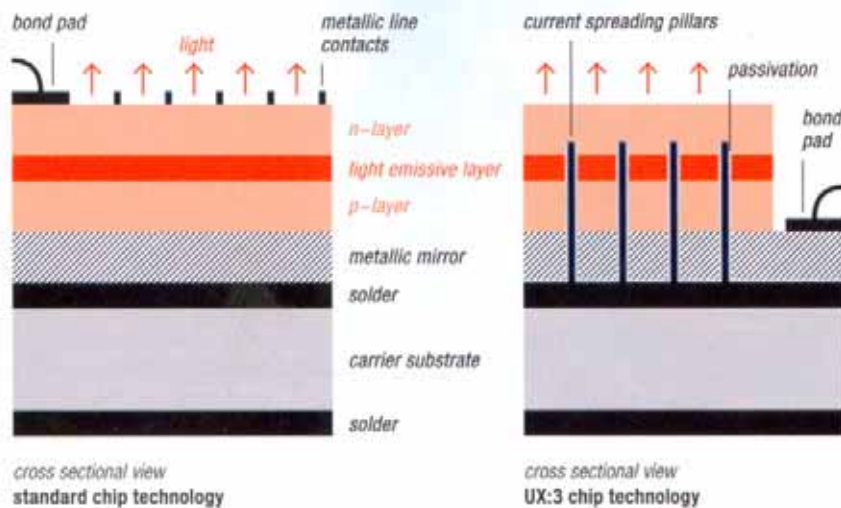
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OSRAM Opto Semiconductors — UX:3 chip technology

Source: OSRAM Opto Semiconductors



OSRAM's first generation of ThinGaN LED chips featured a metallic grid on the top of the device that reduced its active emission area and increased light absorption. The latest design remedies that deficiency by burying the n-type electrode in the epistructure. (Image courtesy OSRAM)

Commemorating the landmark's 100th anniversary in 2008, the Blue Key student group of the Colorado School of Mines in Golden, Colo. exchanged 551 incandescent lamps for blue, red and cool white LED lamps manufactured by Sylvania. The new lamps screw into the original Edison sockets.



John Ritter, the executive vice president of product development for QD Vision, a start-up company headquartered in Watertown, Mass., says companies like QD Vision are now driving the materials out of the academic environment and into the commercial environment in terms of performance and scale.

The company launched its first commercially available product for solid-state lighting with Nexus Lighting late in 2009 with plans to release other products in the near future. The lamp integrates a quantum dot optic with cool white LEDs that produces a warm white light, similar to a warm white incandescent bulb.

"There are two basic mechanisms for light emission from quantum dots," explains Ritter. The first is *photoluminescence*, which is a down-conversion process. "That means it absorbs higher energy light, which means a bluer light,

and emits lower energy, which means a redder light," Ritter says. The other light emission mechanism is *direct electro-luminescence*, which Ritter says his company is developing.

As mentioned above, the most common way that white LEDs are made is with a blue chip coated with phosphors. "There's a sweet spot for the most efficient performance of that combination," Ritter says, "but it results in a cool bluish white light. It works, but it's not a real pleasing color quality for having in an office or retail establishment."

THE QUEST FOR WARM WHITE

Thus, the push for nice warm white LEDs that emulate incandescent light bulbs. Most warm white LEDs produced today are made by coating blue LEDs with red phosphors. "It works, but it's not real efficient," says Ritter. "The problem

with using the conventional phosphors technique is that red phosphors emit into the deep red or near infrared end of the spectrum, which is not perceived by human eyesight. So to get the warm effect, some luminous efficiency is sacrificed.

"What we do is provide an alternative that allows customers who are LED lamp or fixture makers to start with a cool LED source and use quantum dots in what we call a quantum light optic that adds in that missing red component to the spectrum, but does so in a narrow band emitter. The result is to get a warm white output from an LED that's 25 or 30 percent more efficient than the conventional approach."

He says quantum dots can be made to emit anywhere in the visible spectrum. "We can pretty well dial them in to a precise color point," he says.

BACK TO THE LIGHT

Aside from lighting up rooms and signs, one of the most prevalent applications of white LEDs today is backlit displays. The biggest driver is the cell phone market, but the technology spills over into the backlighting of larger LCD displays used in television sets, computer screens and digital signage, and to a growing extent, backlit static digital prints.

It's another growth area for quantum dot technology as well because of the potential for quantum leaps in efficiency, with the bonus of having a broader color gamut. New developments using blue LEDs and green and red quantum dots becomes an ideal RGB source, according to Ritter, and results in very saturated red, green and blue colors. "That's a significant and very visible difference in the display quality," he says.

What's R&D now will soon be on store shelves. In June, LG Display unveiled a prototype LCD panel that uses quantum dot-based LEDs as the backlight source.

Ritter says QD Vision is actively developing products for LED backlighting of LCD displays, and products should be on the market in 2011. **SDG**