SEPTEMBER/OCTOBER 2008

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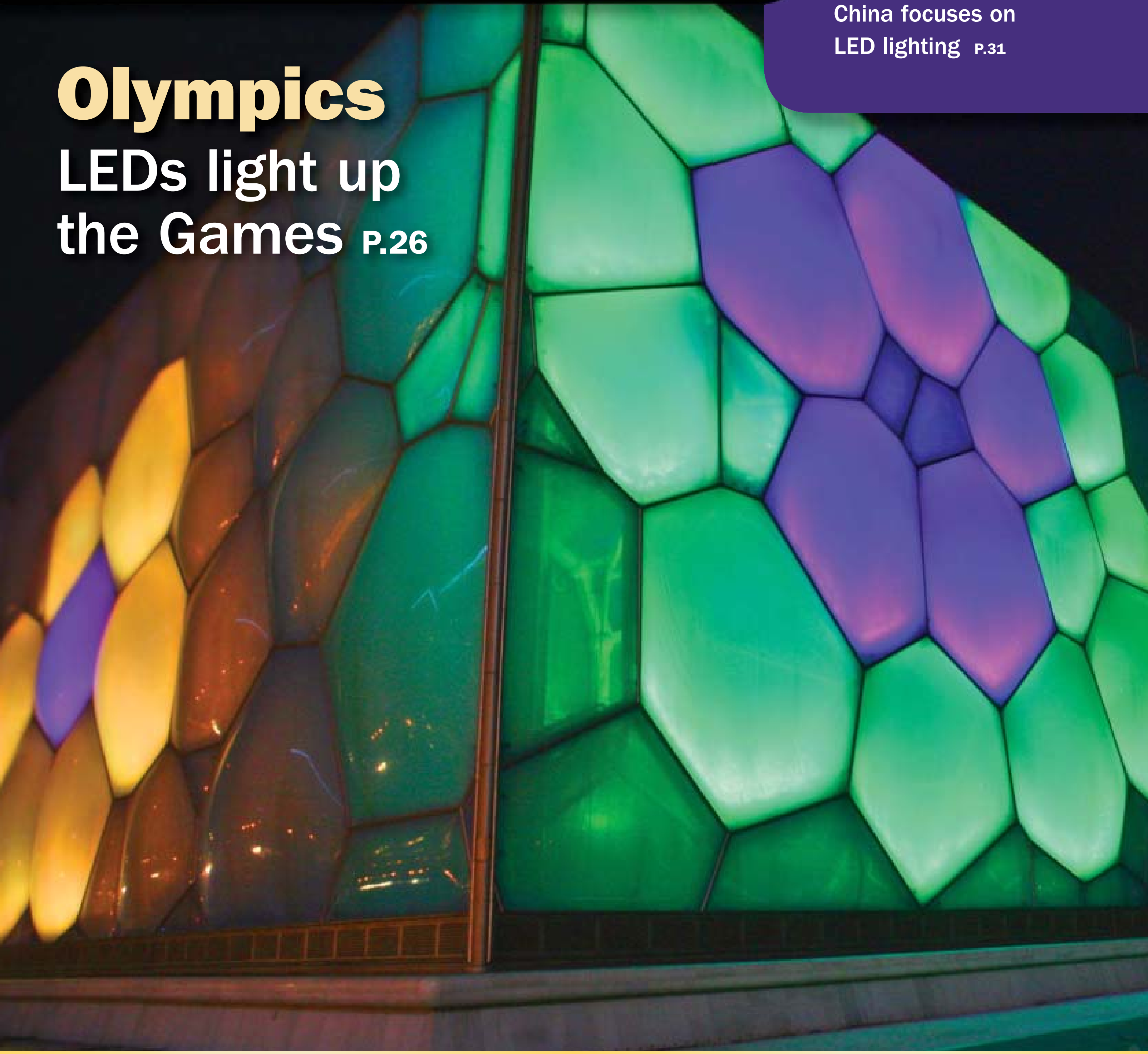
LEDs MAGAZINE®

TECHNOLOGY AND APPLICATIONS OF LIGHT EMITTING DIODES



High Luminous Flux **1200 lm**

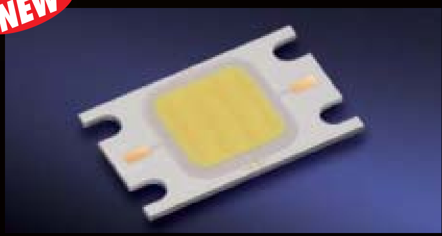
High Luminous Efficiency **102 lm/W**

New Citizen White LEDs deliver more light with less power!

NEW

CL-L190-C5N-A(5000K)
350mA : 320 lm·82 lm/W
500mA : 420 lm·70 lm/W

NEW

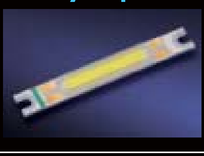


CL-L220-C16N-A(5000K)
350mA : 330 lm·102 lm/W
700mA : 630 lm·88 lm/W
1000mA : 860 lm·78 lm/W
1500mA : 1200 lm·66 lm/W

CL-L230-C10N-A(5000K)
350mA : 210 lm·91 lm/W
700mA : 560 lm·75 lm/W
1000mA : 730 lm·67 lm/W

NEW

Already in production!



CL-L102-C3N(5000K)
Typ 350mA : 245 lm·67 lm/W

CL-L102-C3L(2900K)
Typ 350mA : 150 lm·41 lm/W

CL-L102-C7N(5000K)
Typ 700mA : 540 lm·70 lm/W

CL-L102-C7L(2900K)
Typ 700mA : 330 lm·43 lm/W

Natural color Ra : 95

CL-L102-HC3N(5000K)
Typ 350mA : 190 lm·50 lm/W

CL-L102-HC3L(2900K)
Typ 350mA : 160 lm·42 lm/W

NEW

CL-654-C1N(5000K)
Typ 350mA : 96 lm·80 lm/W

CL-654-C1L(2900K)
Typ 350mA : 79 lm·65 lm/W

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LEDs MAGAZINE

ISSUE 23

september/october 2008

Cover Story

LEDs were used to illuminate the Water Cube in Beijing, a key location for the Olympic Games (see page 26). AP Photo/Natalie Behring for Cree.

features

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commentary

Time for the LED industry to come clean

Compared with CFLs, replacement LED lamps have a number of advantages and drawbacks. While CFLs have for some years been marketed as energy-efficient light sources, LED lamps are only barely starting to become a viable alternative, reflecting the current performance and cost of LED products. However, one factor may lead to the downfall of CFLs, to the ultimate benefit of LEDs. In a word: mercury. CFLs don't contain much, but it's there. Attitudes vary as to the dangers posed. There was the story of a broken CFL in a US home that resulted in a clean-up operation costing thousands of dollars. In contrast, I was recently sent four free CFLs by my UK electricity supplier. In a Q&A, the question "Should I be worried about mercury content" was answered with "No. The material involved doesn't pose a significant health problem. If a bulb breaks ventilate the room for a few minutes." The truth is somewhere between these extremes, but there's no doubt that the words "contains mercury" are not generally positive for any product. Consumer perception or legislation may eventually dictate that only zero mercury content is acceptable.

So what about LEDs? Well, there's no mercury, so that's a good start. Ideally, we would be able to say that LEDs contain no toxic materials at all and are fully recyclable, but it's not clear this is the case. In fact, there are numerous types of LED containing many different materials, albeit in small quantities. Whether or not a single LED might cause a problem is a different issue from whether a large pile of LEDs in a landfill might result in contamination of groundwater. California recently listed gallium arsenide (GaAs), a semiconductor material, as a carcinogen (see www.ledsmagazine.com/news/5/9/6). GaAs is used in some types of LED, primarily red, orange, amber and infrared devices, but it is not found at all in gallium nitride (GaN) LED chips that emit in the green, blue and UV regions and form the basis of white LEDs. This is a hugely important distinction that was beyond the understanding of one blogger who wrote: "Given the increasing usage of GaAs, the main constituent in LEDs...there may be significant environmental concerns as related to their disposal... arguments that LEDs are more environmentally friendly than fluorescent lights containing mercury may be totally specious." We can dismiss this as ill-informed rubbish, but wouldn't it be better if we had some concrete data to throw back? This is where the US DOE's Life Cycle Analysis for Solid-State Lighting will come into its own. As described on page 21, the DOE has commissioned a study looking at the energy and environmental aspects related to the manufacturing, use and disposal or recycling of LEDs and SSL products.

LED manufacturing involves numerous steps, often with low yield, that consume some pretty nasty chemicals as well as lots of energy. The cost and environmental issues are dealt with by the LED makers, and reflected in the prices they charge. But that won't satisfy the environmental lobby. So far, no-one seems able (or willing) to figure out how much energy is consumed by LED manufacturing compared with other light sources. It would be great to be able to say that LED manufacturing is more environmentally friendly, while also resulting in products that consume less energy. Let's hope the DOE study yields the right results.

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WHAT DO YOU THINK? *Comment on this editorial at http://www.ledsmagazine.com/blog*

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LEDs MAGAZINE | web exclusives

Webcasts

We are pleased to announce our next webcast:

Thermal Design for Enhanced LED Performance
October 2008

Visit www.ledsmagazine.com/webcasts for further details, or to access our archived presentations.

Articles

Jane DOE goes shopping: Experiences from the CALiPER program
www.ledsmagazine.com/features/5/9/1

LEDs: Coming soon to a street light near you
www.ledsmagazine.com/features/5/9/2

Selecting encapsulant epoxy for LED package robustness and enhancement
www.ledsmagazine.com/features/5/9/3

Company Profile: SemiLEDs Corporation
www.ledsmagazine.com/features/5/9/4

Featured Companies

A number of companies have recently been added to the LEDs Magazine website as Featured Companies. We thank these companies for their support:

Philips Lumileds Lighting • Cree Inc. • Shin-Etsu Chemical • Osram Opto Semiconductors • TerraLUX, Inc • SemiLEDs • High Power Lighting Corp.

Visit www.ledsmagazine.com/buyers/featured for details of LEDs Magazine's online partners.

ADVERTISERS *index*

FEATURED *event*

LED Japan/Strategies in Light
October 16-17, 2008
Tokyo, Japan

Strategies in Light, the leading event for the global LED industry, attracted over 1,000 attendees this year and is the largest and longest-running event in the industry. LED Japan/Strategies in Light, which will be held annually in addition to the original US event, will bring new focus to the LED market in Japan, where there is a large number of LED manufacturers, LED users, and suppliers of equipment and materials to the LED industry.

Go to www.strategiesinlight.com/ledjapan2008 for more information.

Lightsavers Symposium: Low Carbon Lighting Opportunities
October 06-07, 2008
Toronto, Ontario, Canada

Photometry and Spectroradiometry Course
October 06-08, 2008
National Physical Laboratory, Teddington, UK

Low Carbon Lighting Design
October 22, 2008
Cavendish Conference Center, London, UK

Roadmapping the LED Future
October 30, 2008
Hotel van de Valk, Eindhoven, Netherlands

LED lighting today: Tales or facts?
November 07, 2008
Naples, Italy

10th Annual OLEDs World Summit
November 10-12, 2008
Hilton Torrey Pines, CA, United States

electronica 2008
November 11-14, 2008
Munich, Germany

Interlight Moscow 2008
December 09-12, 2008
Moscow, Russia

SPIE Photonics West
January 24-29, 2009
San Jose, CA, USA

Strategies in Light 2009
February 18-20, 2009
Santa Clara, CA, United States

LED China 2009
February 28-March 03, 2009
Guangzhou, China

See www.ledsmagazine.com/events for event reports, latest updates and related news.

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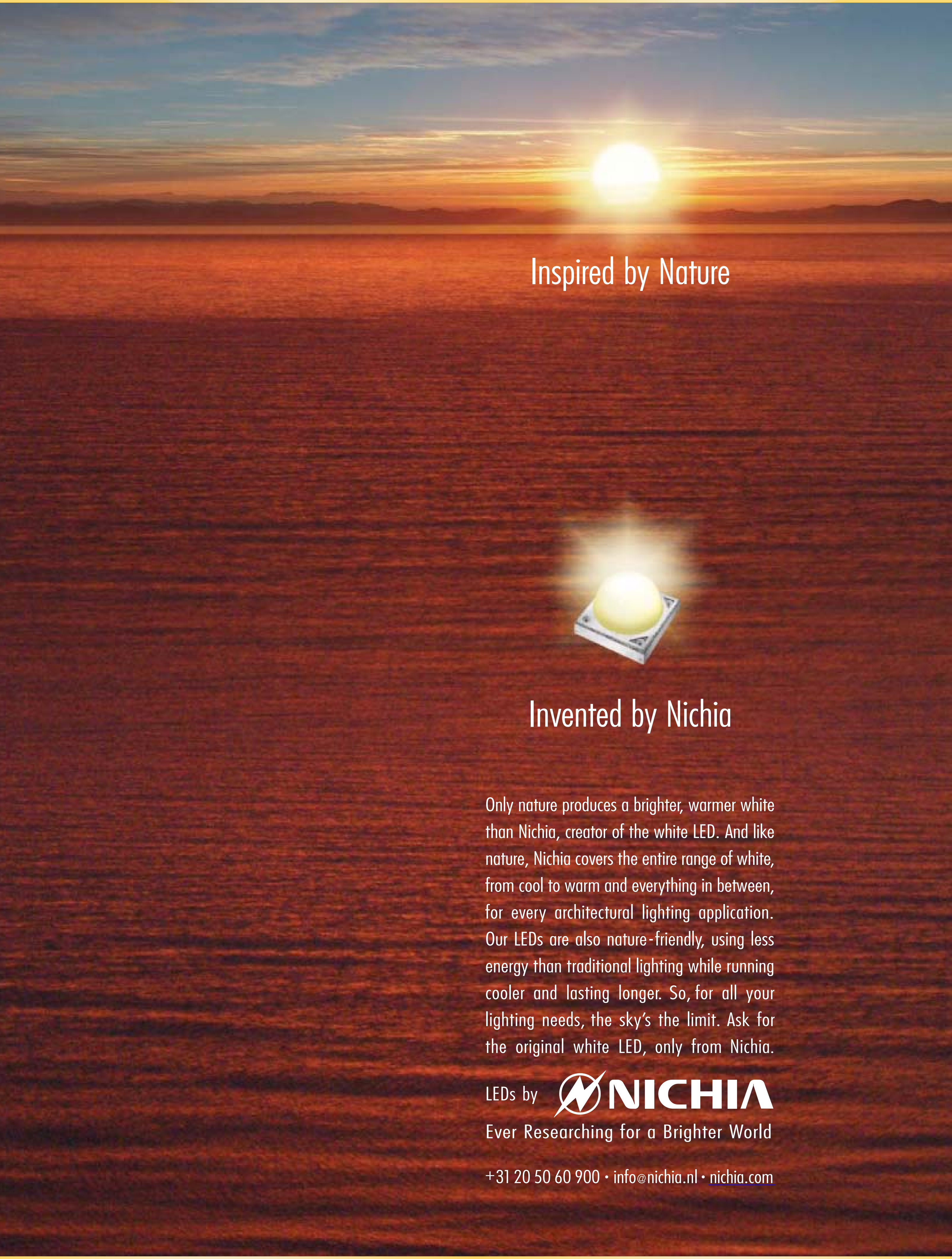
Inspired by Nature
Invented by Nichia
Only nature produces a brighter, warmer white than Nichia, creator of the white LED. And like nature, Nichia covers the entire range of white, from cool to warm and everything in between, for every architectural lighting application. Our LEDs are also nature-friendly, using less energy than traditional lighting while running cooler and lasting longer. So, for all your lighting needs, the sky's the limit. Ask for the original white LED, only from Nichia.
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news views

LIGHTING

Sharp introduces new commercial LED fixtures

Japanese manufacturer Sharp has introduced a range of new LED lighting fixtures for factories, offices and commercial spaces, which are intended to deliver high environmental performance combined with high energy efficiency and long product life. LED lighting manufactured by Sharp will be adopted as the main lighting in all plants to be located within the company's "Manufacturing Complex for the 21st Century." This facility is now under construction in Sakai City, Osaka Prefecture, and is scheduled to begin operations by March 2010. The company says this will represent the world's largest collection of LED lighting installed in buildings on this scale. Sharp says that it will be "working in the future to further expand its LED lighting business into factories, offices and commercial spaces around the globe."

Sharp has introduced 6 new downlights and 5 new oblong/square energy-efficient LED fixtures for factories, offices, and commercial spaces to the Japanese market. The four oblong overheads will have a brightness equivalent to the fluorescent lamp fixtures currently in factories, offices and commercial spaces. The square overhead is for use in conference rooms and similar spaces. Of the six circular downlights, three have a brightness equivalent to standard 150W incandescent lamps, says Sharp. All units have a design product life of 40,000 hours. ◂

MORE DETAILS: www.ledsmagazine.com/news/5/8/7

BUSINESS

Lighting Science Group acquires Lamina Lighting

LED lighting manufacturer Lighting Science Group Corp. (LSG) has acquired all of the assets of Lamina Lighting Inc., a manufacturer of high-power LED light engines and modules. Lamina Lighting was founded (as Lamina Ceramics) in 2001 as a spin-off from the Sarnoff Corp. Its light engines and multi-chip LED arrays are based on low-temperature co-fired ceramic on metal (LTCC-M) thermal management technology.

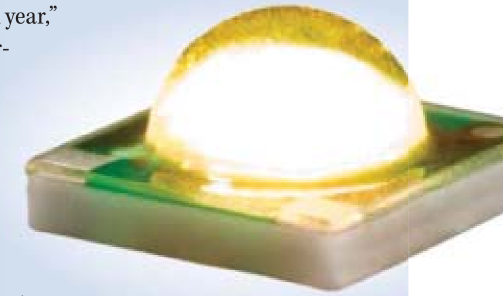
Headquartered in Westampton, NJ, Lamina is funded by five premier technology venture funds. The company has received at least $44.5 million in its financing rounds, including $7 million in April 2007 and $9 million in June 2005. Investors are not receiving a great return; LSG has paid Lamina $4.5 million in cash, and may also make "earn-out" payments to Lamina of up to $10.5 million in the second quarter of 2010, based on 2009 sales of Lamina products and components. Lamina's revenues for the first six months of 2008 were ~$2.1 million. At the same time, LSG also secured a $20 million demand line of credit with Bank of Montreal, of which $4.5 million will fund the acquisition of Lamina. ◂

MORE DETAILS: www.ledsmagazine.com/news/5/7/30

FINANCIAL

Cree reports record revenue

LED maker Cree announced record revenue of $135.9M for the quarter ended June 29, 2008, representing a 9% increase sequentially and a 22% increase compared with the same period last year. For its fiscal year ended June 29, 2008, Cree reported revenue of $493.3 million, another record figure that was 25% up on last year. However, the company's GAAP net income fell to $33.4M, or $0.38 per diluted share, from $57.M, or $0.72 per diluted share last year.



"Q4 represented a strong finish to a very successful year," said CEO and chairman Chuck Swoboda. "Revenue exceeded our previously announced guidance due to strong LED sales, which grew 11% sequentially and 27% from a year ago." In fact, Cree's LED revenue was $116.6M for the June quarter, and totaled $414M for the fiscal year.

Swoboda said that Cree has executed its strategy to transform into "a broad-based LED company with chips, components and systems that are leading the LED lighting revolution. While we recognize that there is caution in the market about the global economic environment, we remain optimistic about the year ahead as the momentum continues to build for our new products and energy-efficient lighting."

Among the drivers behind Cree's successful quarter were double-digit growth in Cree's XLamps, and the growth in LED video-screen production in China (for billboards, stadium screens etc). Swoboda said that the overall LED component revenue (i.e. packaged LEDs) for the quarter was ~30% higher than LED chip revenue.

Also during the quarter, Cree unveiled two new "lighting-class" LEDs — the XLamp XP-E and XP-C devices — with a very small footprint of 3.45 mm square by 2 mm high. Cree's XLamp XR-E LEDs have a footprint of 7 × 9 mm, with a height of 4.4 mm. The new Cree LEDs are likely to be viewed as direct competition for the Luxeon Rebel from Philips Lumileds, which has a footprint of 3 × 4.5 mm with a height of 2.1 mm. The highest-performance available bins for the new XP-E LEDs are minimum 100 lumens at 350 mA in cool white (5000 K–10,000 K) and minimum 80.6 lumens at 350 mA in warm white (2600 K–3700 K). ◂

MORE DETAILS: www.ledsmagazine.com/news/5/8/13

news+views

BUSINESS

CoolLED Ltd signs licensing agreement with Carl Zeiss

Carl Zeiss MicroImaging GmbH, a leading microscope manufacturer, has signed a licensing agreement with UK company CoolLED Ltd for the sale of the Coolled's precisExcite LED

fluorescence excitation system in the US. The license will provide microscope users in the US with access to the LED excitation technology developed by CoolLED. The precisExcite system is flexible and modular, and uses interchangeable LED array modules (LAMs) to provide excitation across the visible spectrum. precisExcite is integrated with many of the imaging software packages from microscope and imaging companies.

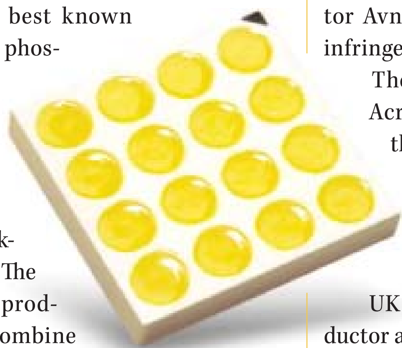
The LEDs in precisExcite are actively cooled to ensure high intensity, good stability and long lifetime. The system comprises a main unit that powers and cools the LAMs; a manual control pod; light-guides that connect the unit to a combining collimator, which then fits directly onto the microscope; and an adaptor which fits all current microscopes. Excitation of fluorophores can be achieved by selecting LAMs with the appropriate wavelength from CoolLED's range. ◂

MORE DETAILS: www.ledsmagazine.com/news/5/8/5

DEVICES

Lynk Labs enters LED device market with Tesla AC LEDs

Lynk Labs Inc, a developer of AC LED technology, is expanding its product offering and entering the LED device market with AC LED devices under the brand name Tesla AC LEDs. Lynk Labs has partnered with Intematix Corp, which is best known as a supplier of phosphor materials for LEDs, but recently introduced a range of "chip-on-ceramic" packages and arrays. The Tesla AC LED product line will combine Lynk Labs' newly-patented "hybrid AC LED" technology at the circuit and die level with Intematix' patented ceramic array packaging and phosphor technology, providing a totally integrated AC LED solution in a single SMT LED. The first Tesla LED is a 6.5 x 6.5 mm package designed to run at 1.2 W. Engineering samples are now available with volume production scheduled for late September. Tesla will be available in CCTs of 2700, 3000, 3500, 4000, 5000, 6300K with a standard CRI of 75, and High CRI in all CCTs for special orders. ◂



MORE DETAILS: www.ledsmagazine.com/news/5/7/32

PATENTS

Nichia and Seoul continue to lock horns

The patent battle between Japanese LED maker Nichia and its Korean rival Seoul Semiconductor continues. On August 18, 2008, Nichia filed a patent infringement suit in the US District Court for the Eastern District of Michigan. The complaint against Seoul and its US subsidiary, as well as its US distributor Avnet, seeks an injunction from future infringements and an award of damages.

The lawsuit once again targets Seoul's Acriche AC LED product. Nichia alleges that LEDs incorporated in Seoul's products such as Acriche infringe upon Nichia's U.S. Patent no. 6,870,191. Nichia has also filed infringement lawsuits in the US, Japan, Korea, the UK and Germany against Seoul Semiconductor and/or its subsidiaries.

Seoul Semiconductor responding quickly, saying it is "confident that the latest lawsuit by Nichia lacks merit" and that it plans to "vigorously defend" the claims. After reviewing Nichia's '191 patent, Seoul says that it believes that Nichia's lawsuit lacks merit. Seoul says the patent describes an LED substrate that is patterned with a protruded and recessed trapezoid, which is different from Seoul's products. Seoul also said that Nichia's latest lawsuit was a "misuse of the legal process."

Currently, Seoul and Nichia are engaged in twelve lawsuits throughout the world. Recently, Seoul was successful in invalidating in Korea one of Nichia's core LED patents for lack of novelty (www.ledsmagazine.com/news/5/7/31). In this latest Michigan lawsuit, Seoul will also seek to invalidate Nichia's '191 patent based on prior art.

As this issue was going to press, we learned that Nichia has been awarded the princely sum of KRW 10 million (approx. $8860) by a court in Korea for defamation by Seoul Semiconductor. The case arose after a jury verdict in the US that found that Seoul had willfully infringed four design patents owned by Nichia. Even so, Seoul disseminated the statements that "Seoul Semiconductor has substantially prevailed in the litigation" and that the products at issue are "actually non-infringing". ◂

MORE DETAILS: www.ledsmagazine.com/Patents

DEVICES

Seoul Semiconductor's new Top View LEDs have high CRI, efficacy

Seoul Semiconductor has introduced new top-view LEDs with high CRI, high efficacy and high reliability. The warm white part (CAWT722-S) has a CRI of 96 and achieves 68 lm/W, while the pure white (CWT722-S) has a CRI of 92 and produces 70 lm/W. However, it is important to note that these figures are for a drive current of 60 mA and a power consumption of 0.192 W. The light output of the pure white and warm white devices is only 13.9 and 13.1. lm, respectively. The company says that with high CRI, superior lumens per watt and long life, its new top-view LEDs "are poised to dominate the lighting market segments where high-performance light sources are a must." ◂

MORE DETAILS: www.ledsmagazine.com/news/5/7/23

OLEDS

Vitex and Novaled cooperate on OLED encapsulation

Vitex Systems, producer of thin film encapsulation technology, and Novaled, known for its organic LED technology, plan to combine the advantages of the Vitex Barix thin-film technology with Novaled's doping technology and materials, targeting very thin and high-efficiency long-lifetime OLED products. The majority of OLEDs are currently processed on glass substrates and encapsulated with glass for protection against air and moisture. The glass represents more than 90% of the device thickness. Vitex has developed an innovative thin-film encapsulation targeting ultra-thin OLED devices. ◂

MORE DETAILS: www.ledsmagazine.com/news/5/8/28

PROJECTS

LEDs crown the Comcast Center

The new Comcast Center in Philadelphia, PA, features a color-changing LED lighting system powered by Power Vector and illuminated by Winona Lighting. The tallest building in the Philadelphia skyline at 975 feet (297m), the center is designed to achieve LEED (Leadership in Energy and Environmental Design) certification from the US Green Building Council. The foyer of the Comcast Center contains the world's largest 4 mm LED wall. The top tier of the building has a lighting installation based on Winona's V-Line linear LED fixtures, which are driven and controlled by Power Vector's IRIS LED driver dimmers (shown in photo). The color-changing linear fixtures are in a down-lighting configuration and will typically display a red color to reflect Comcast's logo, but the color can be changed for holiday celebrations or other events. ◂

MORE DETAILS: www.ledsmagazine.com/news/5/7/33

news+views

ART

LEDs in close encounter on Independence Day

Residents of Gdansk, Poland were startled to see a UFO hovering in the skies over their city on July 4th. Flying up the coast, and then circling the town and dock areas, its dramatic lighting display of geometric color patterns drew immediate attention. It turned out not to be little green men from Mars, but an ambitious and inspired collaboration by New York artist Peter Coffin with London-based Cinimod Studios, and their design director Dominic Harris. The complexity and logistics involved in realizing the UFO vision are almost worthy of space flight; the mechanical, electrical and structural needs of bringing this flight together included a 6kW generator, mountain-rescue pilots and an Mi2 helicopter. Suspended fifty metres below the helicopter was the seven-meter-diameter aluminum structure of the UFO, incorporating three thousand RGB LED nodes from sponsor Philips/Color Kinetics. The inaugural flight of this piece of art coincided with the Gdansk Festival of Stars, and further "encounters" are planned in other parts of the world in the coming months. ◄

MORE DETAILS: www.ledsmagazine.com/news/5/7/24

OLEDS

Universal Display wins $1.9m award for OLED ceiling lighting

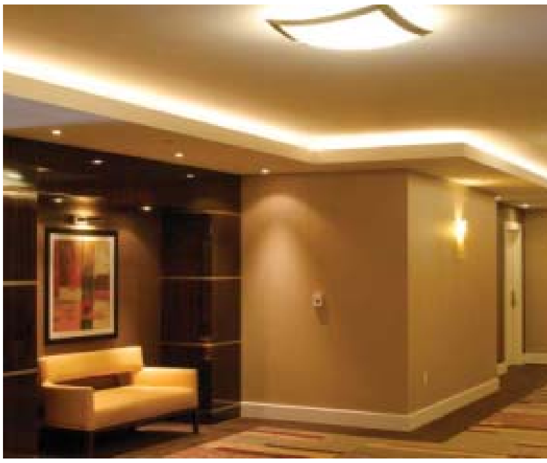
OLED developer Universal Display Corp. has won a $1.9 million, two-year contract from the US Department of Energy (DOE) to develop a ceiling-based white OLED lighting system, working with Armstrong World Industries as a key subcontractor. The companies will develop and deliver an integrated ceiling illumination system that is targeted to exceed the DOE's 2010 performance goals. The white OLED lighting panels will be designed and fabricated by Universal Display using its high-efficiency phosphorescent (PH) OLED technology, and will then be integrated by Armstrong into its TechZone open-architecture ceiling system. In addition, the team will deliver a white OLED lighting panel fabricated on a thin metallic foil substrate to demonstrate the commercial product potential of white OLEDs with a flexible form factor. ◄

MORE DETAILS: www.ledsmagazine.com/news/5/7/26

PROJECTS

Agua Caliente hotel goes green with LED lighting

LED cove lighting from Albeo Technologies is being used on 14 floors of the $300 million Agua Caliente Casino Resort Spa in Rancho Mirage, CA. Although cold cathode or neon was originally specified, Justin Knippel of Berg Electric, the electrical contractor on the job, knew that Albeo produced an LED cove lighting fixture that could meet the project's aesthetic requirements, and also save on energy and maintenance costs. "The designer had wanted a very warm feel to the hall and elevator areas and had specified » page 15



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news+views

BUSINESS AND PATENTS

Philips quarterly results

Philips said that its strong results in the 2Q08 were largely due to growth in its Lighting Division. From overall sales of EUR 6.46 B during the quarter, Lighting accounted for EUR 1.739 B, compared with EUR1.464 B in the same quarter last year. The main driver for the increase was good performance by Genlyte. Philips said that Lumileds accounted for roughly 4% of Lighting sales, which equates to ~EUR 70 M ($110 M).

Beta files 100th LED patent

Beta-Kramer, a Ruud Lighting company, says it has filed its 100th patent application relating to LED luminaires. The latest one relates to an Off-Axis Total Internal Reflection (TIR) NanoOptic; this technology will enable the KramerLED recessed series to deliver recessed downlight efficiency and optical control while maintaining specification grade 45-degree visual cutoff.

New US patents for Luminus

Power LED manufacturer Luminus Devices has received its 21st US patent for its PhlatLight technology. The company also has 120 additional patents pending in the US and foreign countries. The company's patent portfolio covers a wide range of patented technology including large-area LED devices, high-power wavelength-converting LED devices, and LED packaging technology.

ON Semiconductor acquires Catalyst

ON Semiconductor Corp. of Phoenix, AZ, and Catalyst Semiconductor, Inc. of Santa Clara, CA, have signed a definitive merger agreement. Both companies supply driver ICs for LED lighting. Catalyst shareholders will receive 0.706 shares of ON Semiconductor common stock for each share of Catalyst common stock they own. This represents an equity value of ~$115 M and an enterprise value of ~$85 M.

Sylvania LS acquires Amtech

Sylvania Lighting Services (SLS), a subsidiary of Osram Sylvania, has signed an agreement to buy the operating assets of Amtech Lighting Services from ABM Industries Inc. The transaction is expected to close prior to Oct. 31, 2008, subject to customary closing conditions.

Proceeds from the sale of the lighting business, and amounts anticipated to be realized over time from retained assets, are expected to yield Amtech ~$70-$75 M, the company reported.

SLS has worked with Amtech in the past on LED projects involving signage, dock lights, and freezer case lighting. Amtech provides services, such as the survey, design, and installation of retrofits, to more than 35,000 US locations.

The acquisition will allow SLS to expand into new local and regional markets and strengthen its presence in the banking, office and industrial markets. ◂

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an almost amber color for the lights," said Knippel. "We worked with Albeo to select the right color temperature for their LED cove lighting, and we had no trouble getting it approved." ◂

MORE DETAILS: www.ledsmagazine.com/news/5/8/9

CHIP MAKING

Luxtaltek orders Obducat system for photonic crystal LEDs

Obducat, the Sweden-based supplier of nanoimprint lithography (NIL) and electron beam lithography systems, has received an order from Luxtaltek Corp., a Tawian-based LED maker. The order is worth 22.5 MSEK ($3.55 million) and concerns one Sindre 400 system and one Sindre 60 system, to be used for mass production of photonic crystal LEDs. An agreement has also been signed concerning the supply of consumables used in the NIL systems and the potential value of this agreement is up to 80 MSEK during the next 3-5 years, in addition to the above mentioned order value. One Sindre 60 system will be delivered during September 2008, followed by the Sindre 400 system by end of 1Q09. The fully automated Sindre 400 will have production capacity of 30 wafers per hour for any wafer size between two and four inches. ◂

MORE DETAILS: www.ledsmagazine.com/news/5/8/19

PROJECTS

LED structure made of wine bottles provides a taste of Spain

Until September 14, the Expo Zaragoza 2008, Saragossa, Spain, will showcase the regional Castilla y Leon Pavillion, with a large room-size LED display by Spanish lighting company Indal. This pavilion is among hundreds of country and province displays at the show on the themes of water and sustainable development. Indal's Optical Systems Department

was in charge of most aspects of lighting for this 375 sq.m. pavilion. The structure consists of three wooden walls in the shape of a wine rack holding 30,370 bottles, with an RGB LED placed inside each bottle. To connect the LEDs together, Indal created a cable mesh to be attached to the wine rack together with electronic control systems specially designed for the occasion (each bottle has a connector). ◂

MORE DETAILS: www.ledsmagazine.com/news/5/8/4

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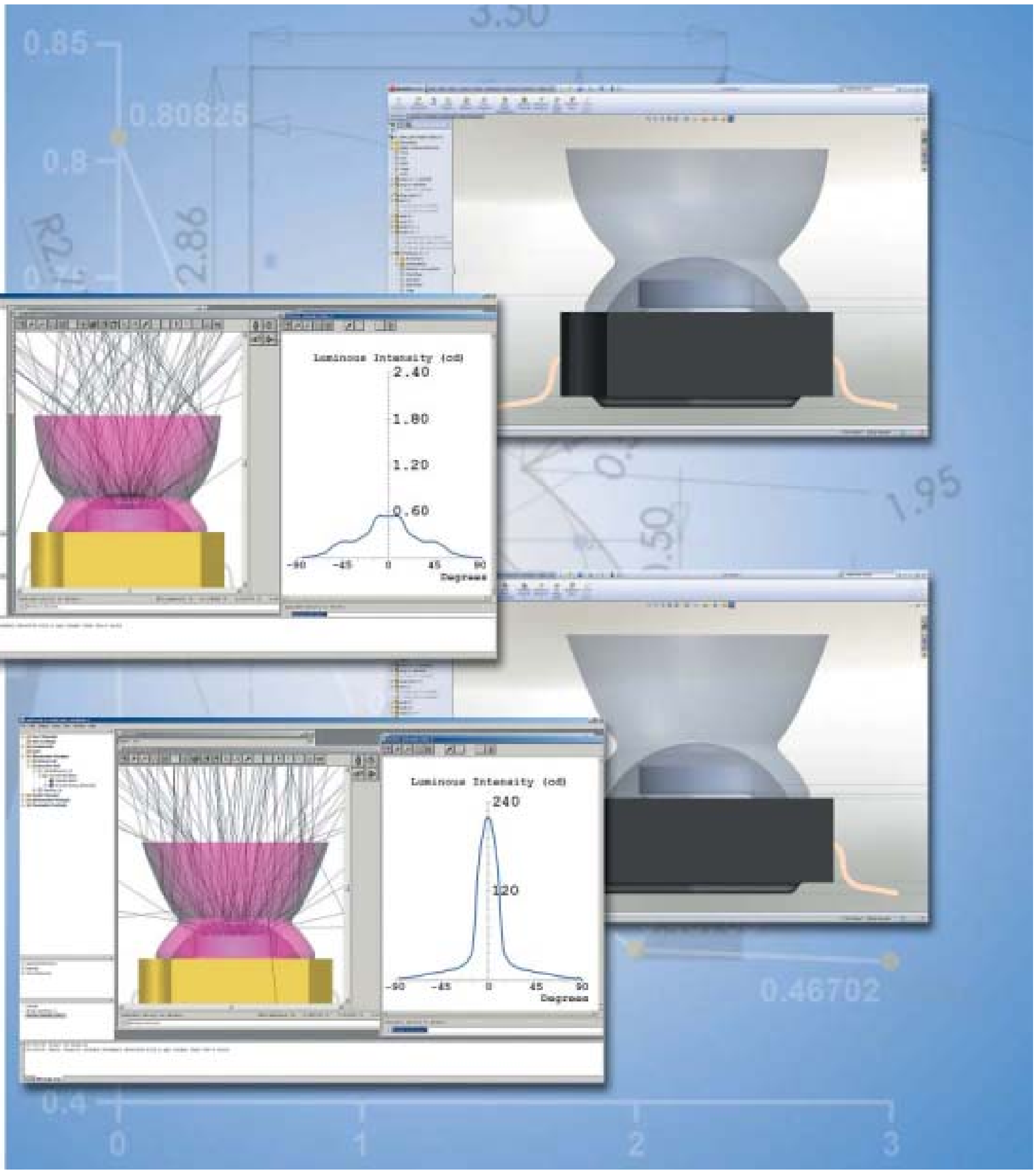

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DOE workshops create tools to build a strong SSL industry

The latest DOE workshop in Portland, OR, continued the invaluable job of communicating DOE's SSL program goals to the industry, reports **BRIAN OWEN**.

You need the right tools to do the job right. In the case of the Solid State Lighting (SSL) program run by the US Department of Energy (DOE), the workshop series has been responsible for the education of the industry, providing the tools that are necessary to deliver a strong SSL program, under the direction of Jim Brodrick, Master Craftsman. This review, which is timely because it leads up to the launch of Energy Star for SSL on September 30, 2008, will recognize the DOE for its efforts in providing an extremely valuable workshop series to the industry, including both developers and manufacturers, as well as potential buyers and specifiers of SSL.

I have been fortunate to attend the three most recent DOE SSL workshops, which have been personally interesting, productive and rewarding. The events were the "Voices for SSL Efficiency" workshops (July 2007 in Boston, MA, and July 2008 in Portland, OR), and the "Fifth Annual DOE SSL R&D Workshop" in January 2008 in Atlanta, GA. The two events in 2008 each had more than 300 attendees.

In Boston, one of the most interesting outcomes was the general consensus that LED luminaire marketing and packaging should have some form of identification of the technology, such as "LED Inside", borrowing from the highly identifiable and visible "Intel Inside" marking on computer products. In Atlanta, I had the opportunity to interview presenter Samantha LaFleur, lighting designer with Atelier Ten Environmental Designers. Asking Samantha what was the best attribute or opportunity with LED, she responded that is was the addition to the lighting designers' toolbox. To the contrary, asking her what may be the greatest negative attribute, she responded that it was the risk in liability and reputation or simply, "What if it doesn't perform...or even work at all?"

Portland workshop

At the most recent workshop, in Portland, OR, on July 9-11, more than 270 attendees were given an excellent overview of DOE programs to date, a comprehensive review of the status of Energy Star and an introduction to some of the many new programs either currently being released or in development. The only glitch in Portland was the sounding of the fire alarm system, causing an evacuation and leaving attendees to wonder whether gremlins from the Environmental Protection Agency (EPA) were playing havoc at the DOE's event.

This workshop, as in the previous two, explored how federal, state, and private-sector organizations can work together to guide market introduction of high-performance SSL products. The workshop brought together a diverse gathering of participants, including energy efficiency organizations, utilities, government, and industry, to share insights,

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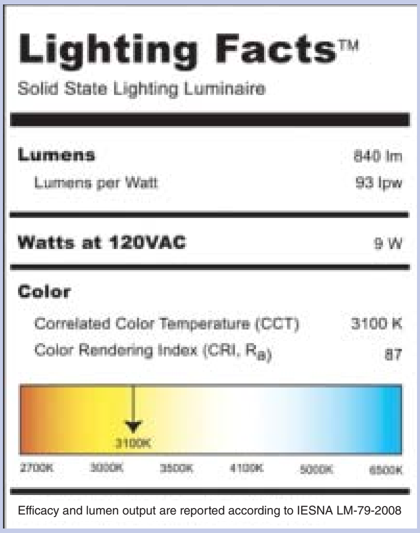
DOE and NGLIA advocate quality in SSL

A new SSL Quality Advocates initiative, developed by the US DOE and the Next Generation Lighting Industry Alliance (NGLIA), was introduced at the Portland workshop in July (see main article). The aim is to ensure that LED lighting, as it reaches the marketplace, is represented accurately, preventing a recurrence of the CFL market introduction mistakes.

"It is extremely important that early adopters of this technology have a good experience," said Jim Brodrick, who heads the DOE SSL program. While Energy Star



Draft Lighting Facts label. Courtesy of DOE / D&R International.

will help consumers distinguish between LED products, the DOE still feels that more understandable information is needed. Therefore, it is launching a voluntary product labelling program that is akin to the Food & Drug Administration (FDA) label found on food packaging. A draft version of the Lighting Facts™ label, which is subject to revision, is shown above.

Brodrick explained that participation in SSL Quality Advocates will require stakeholders to sign a voluntary SSL Quality Pledge. They will then need to affix a label either on the product or its package, or on product literature, providing essential performance information in five categories — lumen output, luminaire efficacy, power input, correlated color temperature, and color rendering index.

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ideas, and updates on the rapidly evolving SSL market.

DOE SSL portfolio manager Jim Brodrick kicked off the workshop with an overview of DOE market introduction activities. Brodrick provided a brief overview of DOE pathways to market, including CALiPER testing, Gateway demonstrations, Energy Star and the Technical Information Network.

Steven DenBaars from the University of California, Santa Barbara, followed with a tutorial on the physics behind how LEDs work, and how they differ from conventional light sources. Describing the difference between lamp efficiency and system efficiency, DenBaars noted that commercial LED fixtures are unable to achieve laboratory-device efficiency levels due to efficiency roll-off or "droop," fixture design issues, heat-sink realities, and losses due to scaling up for mass production.

Kelly Gordon of Pacific Northwest National Laboratory (PNNL) followed with a tutorial on LED applications, explaining that LED technology advances so rapidly that next generation LED products are introduced about every six months. "One year in SSL Land is like seven dog years," she summarized. With respect to the linear LED tube solution, Gordon stated that the high-performance linear fluorescent is hard to beat and that you have to know where to use LED products, such as in a new installation. She reminded the attendees to ask, "What's coming next?" and to "Think outside the bulb!"

Mike Grather of the Luminaire Testing Laboratory (LTL), focused on LED measurement and how it differs from traditional methods for measuring lighting performance. Grather explained the importance of photometric testing for LED products using absolute photometry, rather than relative photometry, because it allows more accurate measurement of the complete LED device performance versus bare lamp performance.

On Day 2 of the Portland workshop, Alan Ruud of Beta LED gave an excellent keynote address separating LED fact from fiction, and offering guidance on how to specify and evaluate LED products. Ruud advised the audience on evaluating SSL products, recommending they look for photometric performance data (using the new LM-79 standard, energy consumption or efficacy data), aesthetics, and "a warranty you can trust". Ruud declared LEDs are "ready," but warned that it is "incumbent on everyone to not settle for a luminaire that does not perform to your standards."

Daryl DeJean of Emerging Technologies Associates offered insights on customers' perspectives and needs, including accurate product data sheets and technical information, such as independent test results or Energy Star qualification where applicable. Also required are material safety data sheets, testimonials and other assessment results, warranties, and a local installation to tour where possible. He concluded by urging attendees to "keep the explanations customer-focused, using their lingo." DeJean coined a new acronym in his presentation, where LED stood for Listen, Educate and Demonstrate. This definitely illustrates the correct methodology and steps in working with the potential buyer, a lesson that should be learned by all industry personnel from the manufacturing and marketing side of the equation.

> "Specifiers should consider an SSL system's strengths and weaknesses in each application, as you would do for any other light source or luminaire." —RANDY BURKETT

Energy Star

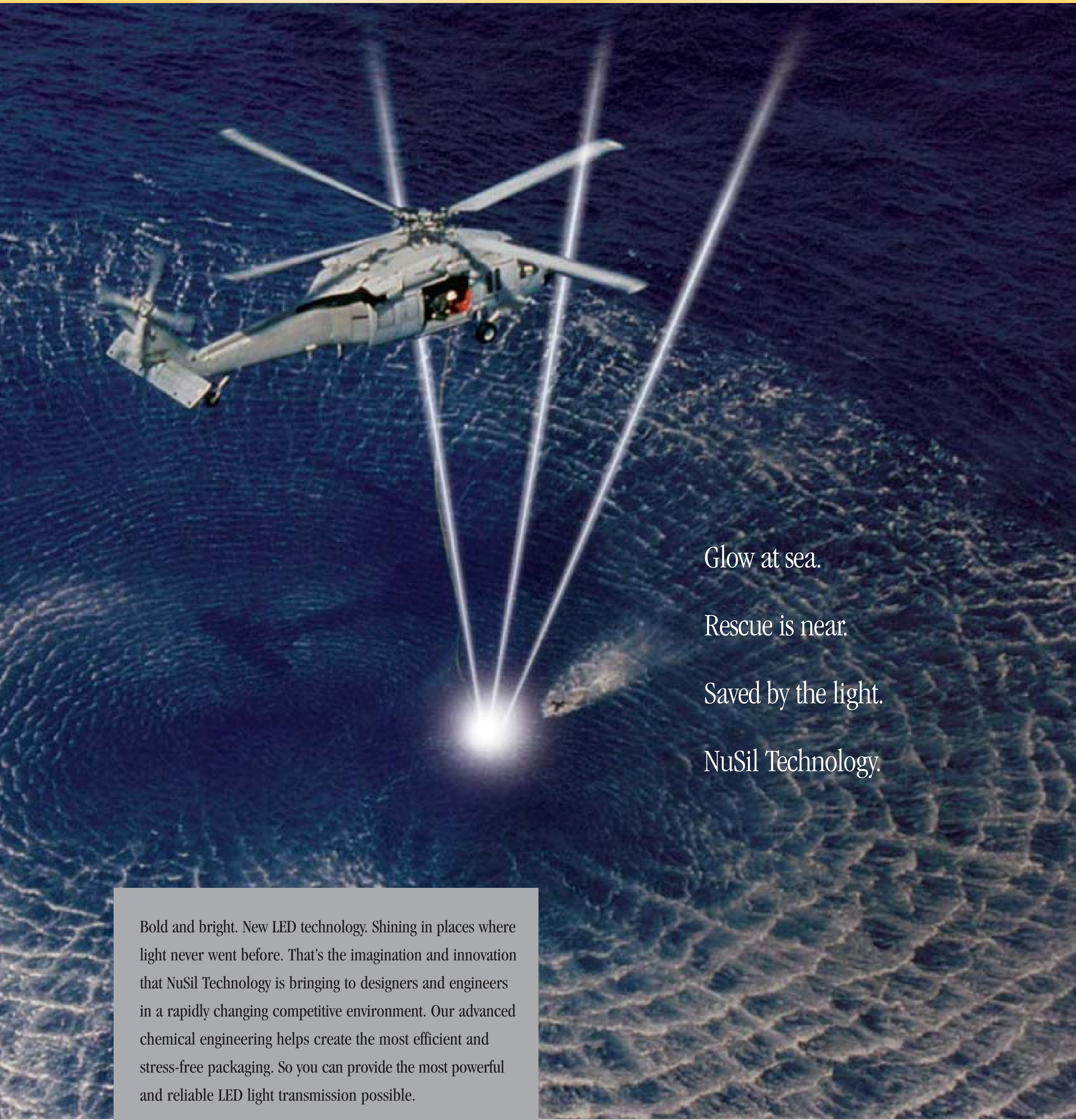
With respect to the implementation of Energy Star for SSL, Richard Karney from the US DOE shared DOE's concerns about the competing Energy Star criteria for residential luminaires issued by the EPA, stating that significant conflict and overlap exists between the two criteria. Karney stated, "There can only be one Energy Star criteria for SSL, and the DOE criteria stand as the valid guidance for SSL." Karney noted that DOE is working to resolve the issue as quickly as possible. Karney then reviewed the current status and timeline for the first Energy Star SSL products to arrive on the market starting September 30, 2008.

Derek Greenauer of D&R International then explained how to become an Energy Star partner. A manufacturer's guide and online product qualification process will be available this summer. He also discussed testing requirements, quality assurance, and other program elements designed to provide end-users with a high level of confidence in labelled products. Jeff McCullough of PNNL concluded the Energy Star session with details on DOE's plans to keep pace with rapid technology advances, referring to how DOE's transitional, two-phased approach allows early participation of a limited range of Category A products. Category B sets more rigorous performance targets, and future product advances are considered. McCullough shared DOE plans to add new product applications to Category A (see www.ledsmagazine.com/news/5/8/22), as well the proposed ratcheting of efficacy targets in a timely manner with respect to technology advancements. Unlike the EPA, the DOE will continue to engage industry in a public consultation process for feedback regarding changes to the Energy Star for SSL program.

More program notes

Mike Grather of LTL shared more on LED measurement, and reviewed new test procedures for measuring LEDs, including ANSI C78.377-2008, Specifications for the Chromaticity of Solid-State Lighting Products; IES LM-79-2008, Electrical and Photometric Measurements of Solid-State Lighting Products; and IES LM-80, Method for Measuring Lumen Maintenance for SSL Light Sources. Mia Paget of PNNL presented the latest results and analysis from round 5 of the CALiPER program, which included testing of recessed downlights, replacement lamps, task lights, and several outdoor applications. More than 100 products have been tested to date. Paget noted that while "some products do perform well, most products on the market today don't." She counselled the audience to request and understand testing when evaluating products.

Randy Burkett of Randy Burkett Lighting Design reviewed perspectives from the Lighting Designer Roundtable hosted by DOE, the International Association of Lighting Designers (IALD), and Illuminating Engineering Society (IES) in March 2008. He and other designers at the Roundtable see a strong future for SSL as a design tool, but Burkett cautions "specifiers should consider an SSL system's strengths and weaknesses in each application, as you would for any other light source or luminaire." Burkett also discussed the DOE/IES Design Guide for SSL, unveiled in draft form at the Roundtable for review » page 20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Rescue is near.
Saved by the light.
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DOE workshops from page 18 and comment. The Guide provides technical information on LED performance and design guidance for specific applications according to space and building type. The final Guide is expected to be issued by IES in late 2008.

Ruth Taylor of PNNL highlighted competitions such as the L Prize and Lighting for Tomorrow (www.ledsmagazine.com/news/5/1/23). Taylor also introduced a new commercial luminaires design competition called Next Generation Luminaires, sponsored by the DOE, IALD, and IES (www.ledsmagazine.com/news/5/6/35). The goal of both this competition and Lighting for Tomorrow is to spotlight product manufacturers who are "getting it right" and to recognize and promote high quality, energy-efficient luminaires.

As mentioned in a previous article (*LEDs Magazine,* Jul/Aug 2008, p. 14), the L Prize competition requirements include technical specifications to ensure compliance with the general requirements outlined in the 2007 US energy legislation, with additional details specified for quality, performance and mass manufacturing. As this initiative is US-funded, there is a domestic economic mandate, as manufacturers are required to be US-based companies. Interestingly, the LED die or chip must be manufactured in the United States as well. This was confirmed in a Q&A session by Jim Brodrick.

A panel presentation focused on what utility and efficiency program managers can do now to prepare for high-performance SSL products. Charlie Grist of the Northwest Power and Conservation Council next discussed balancing risks and rewards, and shared an electric utility system perspective on the economic issues of implementing SSL technologies.

Grist evaluated costs and benefits of several SSL technologies, comparing SSL to traditional sources on the basis of performance, cost-effectiveness and "the unknowns." He summarized that "mileage may vary" and that costs and benefits must be carefully calculated; one must carefully consider alternatives; and that it is essential that the audience "do their homework." Panel members shared their strategies regarding SSL initiatives. Also discussed was how utilities can benefit from and get involved with DOE's Gateway demonstration program.

Conclusions

Jim Brodrick concluded the proceedings of the workshop by asking the participants to "join the wave of opportunities to partner and participate with DOE, and shape the future of lighting." He reminded everyone to keep informed with ongoing updates on DOE SSL activities and events by registering for SSL Updates at www.netl.doe.gov/ssl.

Great stars shine bright into the night sky and Energy Star for SSL is no exception. Even with bumps in the road with respect to the recent dispute regarding the EPA's release of conflicting Energy Star criteria, the industry will overcome these growing pains and not let Energy Star become a "falling star."

On the eve of Energy Star for SSL, *LEDs Magazine* salutes the work of the DOE, one avenue being the development and progression of its workshop series. The work of the DOE has always confirmed my "Owenism" that there is no shortage of inferior product and overstated claims AND only quality standards and testing will overcome this unfortunate practice. The workshops have always identified and highlighted this, supporting the "X Files" adage, "The truth is out there…but trust no one until they earn it!" ◄

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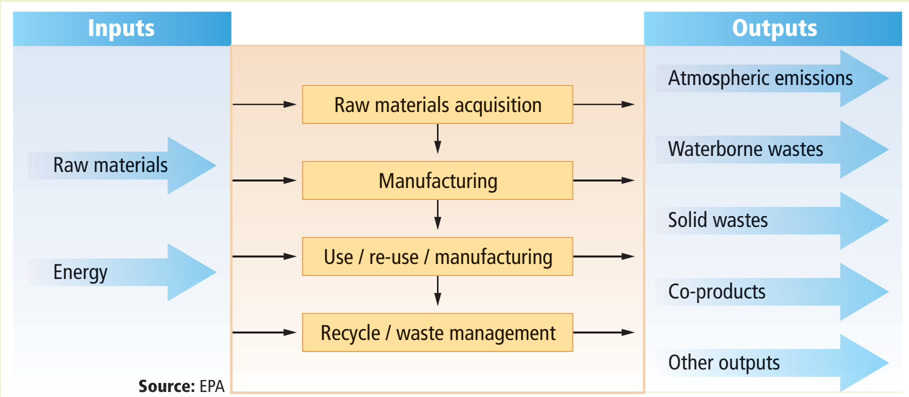
Lifecycle analysis of SSL technologies

The US DOE has commissioned a study to look at energy and environmental aspects related to the manufacturing, use, and disposal or recycling of LEDs and SSL products. The DOE's Jim Brodrick described the study as a "soup to nuts" assessment of energy and materials costs associated with SSL technology. "I view this study as an important step in understanding how the advent of SSL will have an impact on energy consumption, energy and product economics, pollution prevention, and ultimately, environmental decision-making," he said.



Stages of the product lifecycle. Courtesy of Scott Matthews / DOE / D&R International. Original diagram source: EPA.

Currently the Life Cycle Analysis study is in its first phase, under the direction of Scott Matthews, research director of the Green Design Institute at Carnegie Mellon University. The first phase, due to be completed this fall, will define the study's parameters including the identification of key energy and materials issues, the availability of relevant data, and a definition of the study's scope and boundaries. At the Portland, OR, Workshop (see main article), Matthews invited attendees to provide input on relevant data sources and concerns or issues to address. The second phase will encompass a comparison of SSL to mature lighting technologies in both the residential and commercial markets. It will begin with a valuation of raw materials and evolve through the entire product lifecycle, ending with disposal.

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GREEN PLANET

BluGlass opens pilot plant to demonstrate LED growth process

Australia's Environment Minister says that BluGlass' technology fits well with the country's intention to move towards energy-efficient lighting, reports **TIM WHITAKER**.

BluGlass, an Australian company that has developed low-cost manufacturing technology for growing GaN-based material for LEDs, has opened its new headquarters and demonstration plant at Silverwater, Sydney. The facility was opened by Peter Garrett, Australia's Federal Minister for the Environment, Heritage and the Arts.

The new pilot LED demonstration plant features BluGlass' first commercial-scale semiconductor growth system that is fitted with the company's home-grown remote plasma chemical vapor deposition (RPCVD) technology. RPCVD can be used to grow the multilayer semiconductor structures that are the starting point for the fabrication of GaN-based LEDs. Currently, commercial production of LEDs uses the metal-organic chemical vapor deposition (MOCVD) process to deposit material onto sapphire or silicon carbide substrates.

BluGlass plans to use its new plant to demonstrate "significant cost benefits" of the RPCVD process to LED device manufacturers, with the aim of winning substantial equipment supply contracts, licensing deals and royalty income.

In his speech, Garrett said that LEDs will "play an increasingly important role in the future of lighting worldwide, including in our homes. The BluGlass process is an Australian innovation, and advances in this area will make significant inroads in reducing the costs of LEDs."

Garrett said that one of the key barriers restricting the uptake of LEDs has been their cost. "And up-front cost is an important issue when it comes to deploying energy-efficient technologies," he said. "The federal government is committed to taking energy efficiency mainstream."

On June 5 this year, which was World Environment Day, Garrett announced that the planned phase-out of inefficient lighting in Australia will be brought forward to November 2008, when the importation of inefficient incandescent bulbs will be restricted.

"Our focus right now is on encouraging Australians to switch to existing efficient alternatives, like compact fluorescent lamps, but it's also on fostering innovation, and that's why the work of companies like BluGlass has the potential to become part of taking energy efficiency mainstream," said Garrett.

"This means there is going to be a huge demand for efficient lighting here and around the world in the near future. Australian innovation as represented by BluGlass is well placed to help in meeting this demand — helping to both drive our economic growth and our efforts to reduce the levels of greenhouse gas emissions."

BluGlass' pilot manufacturing reactor in operation.

An important global role

BluGlass was created from research at Sydney's Macquarie University. In 2007 the Australian Government awarded BluGlass a $5 million grant to advance its innovative technology. Also in 2007, BluGlass reported what it claimed to be the world's first blue light emission from the uniform deposition of gallium nitride on a 6-inch diameter coated glass wafer.

"Our new demonstration reactor is designed to show the world that BluGlass has a commercially viable and attractive technology," said BluGlass' chairman Mike Taverner. "We expect that among many applications, this groundbreaking Australian development will have an important global role in improving the efficiency with which we use energy in lighting, with flow-on benefits to the environment."

BluGlass recently appointed Giles Bourne as CEO after a period as interim CEO. "With the launch of our new plant, we will invite top level corporations from Asia, the US and Europe to come and see exactly what we can do," said Bourne. "We have delivered on all of our promises to investors about commercializing our technology, and we are now lifting our sales push in the global market."

BluGlass says it is already in advanced discussions with universities for orders for its pilot-scale reactors, a smaller version of its commercial technology that also incorporates its RPCVD technology. The company's plan is that customers, including commercial enterprises and universities, can buy pilot reactors to conduct their own testing. The hope is that this should speed the uptake of BluGlass' patented technology.

MORE DETAILS: www.bluglass.com.au

TIM WHITAKER *is Editor of* LEDs Magazine.


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LED chips set new R&D records

Over the summer, both Philips Lumileds and Osram Opto Semiconductors unveiled some pretty impressive lab results for power LEDs.

Two of the leading power LED chipmakers have announced "record breaking" research results for their LEDs, with values as high as 155 lm and 140 lm/W for white LEDs made using 1 mm² chips and driven at 350 mA.

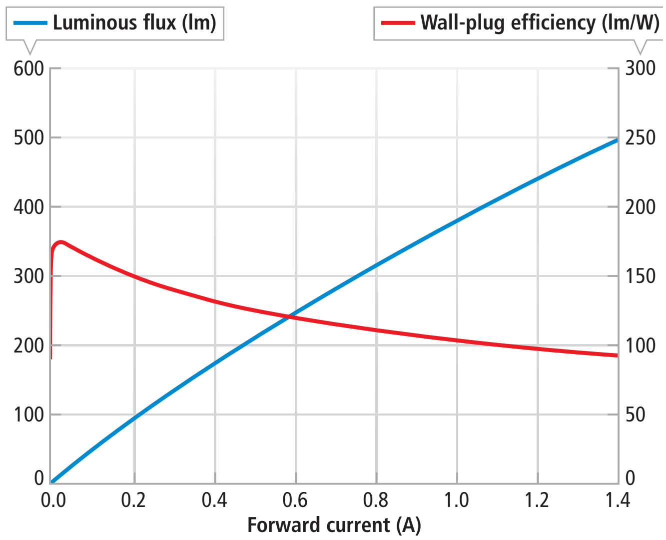
We've said this in the past in *LEDs Magazine*, but it bears repeating; these are results from superstar devices in the research lab, not from commercially available products. Our advice is this: be careful not to draw the wrong conclusions from these numbers, but recognize they are important. More than the values themselves, the results indicate the continued progress being made by LED manufacturers.

Innovation is also happening in the labs of other companies that haven't made recent announcements. And, perhaps most importantly, many of the technology enhancements that have resulted in these higher numbers will eventually move across to the next generation of production devices. Direct comparison of the numbers quoted below is not advised; wait until you can purchase production quantities of the devices and then see how they perform in your luminaire.

Osram Opto Semiconductors

Osram reported a power LED driven at 350 mA with an output of 155 lumens and 136 lm/W efficacy. The prototype white LEDs were built with 1 mm² LED chips, and had a color temperature of 5000 K, with color (x,y) coordinates at (0.349, 0.393). As shown in the graph, the LEDs can be driven at 1.4 A, and produce up to 500 lm, with a corresponding efficacy of around 90 lm/W.

Without giving away any details, the company said the key to success was a perfectly matched system of optimized chip technology, a highly advanced and extremely efficient light converter (phosphor) and a special high-performance package. Rüdiger Müller, CEO of Osram Opto Semiconductors, commented: "It was the successful combination of Osram know-how in different fields that led to these new records in efficiency and brightness. Starting with the light converter, we will be gradually moving the new developments into production." Osram says it has already applied for patents for the technologies that lie behind these records.



R&D results from power LEDs demonstrated by Osram.

Philips Lumileds

Meanwhile, back in the lab (a different one in California), Philips Lumileds has also been working hard. The company's CTO George Craford announced at the China SSL conference a range of performance highlights for white LEDs with drive currents from 350 mA to 2 A, again based on 1 mm² chips. At 350 mA, Lumileds reported an output of 138 lumens with an efficacy of 140.1 lm/W. The results were for LEDs with a CCT around 5000 K, and were pulse tests conducted under standard conditions.

Recent results from the Lumileds chip lab

Drive current (mA)	Efficiency (lm/W)	Flux (lm)	CCT (K)
350	140.1	138.0	4954
1000	111.7	339.8	5031
1500	100.0	478.8	5081
2000	86.0	562.5	5060

This is almost certainly the first example of a power LED where the numeric value for efficiency is higher than the flux value at 350 mA. Of course, this means that the power consumption is below 1 W at 350 mA. This, says Craford, is a direct result of lowering the forward voltage of the LED while maintaining high external quantum efficiency. These advances continue to positively affect the results as the test current is increased. Even at 1.5 A, the Philips Lumileds lab LEDs can achieve 100 lm/W and 479 lm from a single chip.

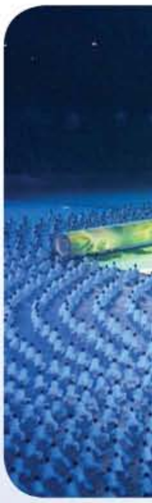
Lumileds says that delivering more light, more efficiently is key to the future of LEDs in general lighting. "Our continuous focus on epitaxy, LED chip, phosphor and packaging developments leads to innovations that have real-world impact," said Werner Goetz, director of Epitaxy Technology at Philips Lumileds. "These latest results show clear progress that will enable the solid-state lighting industry to grow and provide a more sustainable, energy efficient solution sooner than many had imagined."

focus on

Beijing Olymp

Although the Olympics had plenty of human celebrities, the real stars of the show were the LEDs. Here is a brief review of some of the places where LEDs were used, including the Beijing National Aquatics Center (Water Cube) and the Beijing National Stadium (Bird's Nest).

Rolled LED stage lighting b



During the Opening Ceremony, it was hard to miss the glowing, ever-changing scroll display on the floor of the Bird's Nest stadium. Apcus Technologies and Beijing Leyard worked together under the brand name Apcus Leyard to develop, manufacture, test and install this ground-breaking display, as well as the illuminated Olympic Rings in the stadium and other features.

For the scroll, Apcus Leyard supplied over 1300 sq. ft. of its "Ground Bar" LED product, a unique type of LED display that can be walked, danced, and even driven upon. It provides 3500 nits of brightness, and has a durable magnesium/aluminum alloy casing.

MORE DETAILS: www.ledsmagazine.com/press/16737

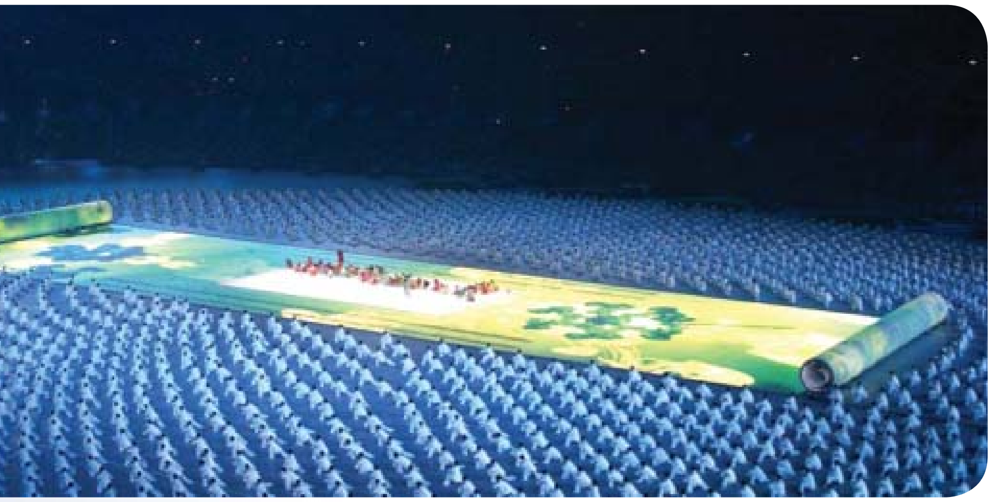
PolyBrite LED channel letters light up Bird's Nest doorways

The Borealis modular lighting system from PolyBrite International illuminates the entryways for the Beijing National Stadium with 10-ft, 2-in tall channel letters, A through L, to designate each section of the stadium. PolyBrite and Trycool Logo & Sign Products Co. in Beijing were awarded the contract to install the systems.

MORE DETAILS: www.ledsmagazine.com/news/5/8/16

ic Games

righ tens ceremony at Bird's Nest



Focus Lighting says it helped in the design of the lighting for the ribboned facade of the Olympics basketball venue, Wukesong Arena, while the façade itself was built by HOK Sports. The driving concept in the lighting design was to emulate a lotus flower by highlighting and defining each of the fragile petals.

Cree LEDs make Water Cube, Bird's Nest glow

XLamp LEDs from Cree were used to provide effects lighting for the new Water Cube and the Bird's Nest. The Water Cube, which was the home for nearly all of the 2008 Summer Olympics aquatic events, spans some 80,000 sq. m. and has ~496,000 LEDs embedded throughout the exterior of the structure.

A Cree spokesperson said that the Water Cube was designed by a consortium of companies, including Australia's PTW Architechs and Arup International Engineering Group, the China State Construction Engineering Corp, and China Construction Design International. The Australian team conceived of the bubble design, Arup Lighting executed the lighting design, and Grandar was the lighting supplier. The EFTE bubble membrane was made by a different company.

The lighting of the Bird's Nest stadium was done by Arup Lighting. The main lighting supplier was Landsky, which also custom-designed the fixtures. The exterior of the Bird's Nest stadium used ~258,000 Cree XLamp LEDs in white, amber and red colors. Cree LEDs were also used in two installations inside the Bird's Nest: the video screen behind the main stage, and the LED Ground Bar scroll lighting up the floor during the Opening Ceremony (see separate story).

MORE DETAILS: www.ledsmagazine.com/news/4/10/28

Fast facts about the Water Cube walls and lighting, courtesy of Cree

- Approximately 496,000 Cree XLamp LEDs in red, green and blue illuminate the exterior of the Water Cube.
- The Water Cube is made of 3,000 "bubbles," each with the ability to display millions of different colors.
- The Water Cube displays a different color pattern each evening. The patterns are computer-controlled. The Water Cube is programmed to display different colored designs, including ones inspired by themes including "Blooming Flowers," Rainy Day" and "Night at the Disco."
- Modules of 8-16 LEDs are integrated into the steel structure of all four walls and the roof. Each module is uniquely designed to focus the light on the individual bubbles.
- The Water Cube design was inspired by soap bubbles.
- The bubbles are made of 100,000 sq. m. of plastic that was originally developed to provide insulation for airplanes.
- Each of the bubbles in the Water Cube can resist the weight of a car. A piece of the 0.008-inch material can hold up to 300 times its own weight.
- The Water Cube's bubbles trap more heat than glass, reducing total energy requirements by 30 percent. This is the equivalent of mounting solar panels on the roof.
- Now that the games are over, the Water Cube will be converted into a multi-functional facility for sports, culture and recreation, including a café and waterslide.

More LED projects in Beijing

Panasonic, an official worldwide Olympic partner, installed 25 Astrovision LED displays at 18 Olympic Games venues. The screens had a total area of 1291 sq. m.

Neo-Neon supplied color-changing LED pathway lighting to illuminate the walkways leading into the Bird's Nest stadium, as well as other products for an LED display to entertain visitors at Festival Walk.

Chinese enterprise Shenzhen Sansun Hi-Tech Co. told *LEDs Magazine* in March that it has supplied 4 LED screens for the two highest-profile venues at the Olympics. Two P24 LED displays, at a size of 16.42 x 9.24 m or 152 sq. m (around 1636 sq. ft.), were used in the Birds Nest stadium. The two others — also P24s with a size of 6.14 x 4.61 m, or 28.3 sq. m — were installed in the Water Cube (see www.ledsmagazine.com/news/5/3/11).

LED lighting products from GE were used to light the Beijing Organizing Committee's headquarters building, and solar-powered LED street lighting fixtures were used at the Fengtai Softball Field.

Beijing Leyard installed 5 LED displays, each measuring ~100 sq. m, at the Olympic Cultural Squares in Beijing. Leyard integrated its color correction technology with Macroblock's 16-bit PWM LED driver-MBI5030 in order to achieve higher display performance and enhanced color resolution. The screens broadcast the Games live to outdoor viewers (see www.ledsmagazine.com/press/15979).

Barco provides LED screens

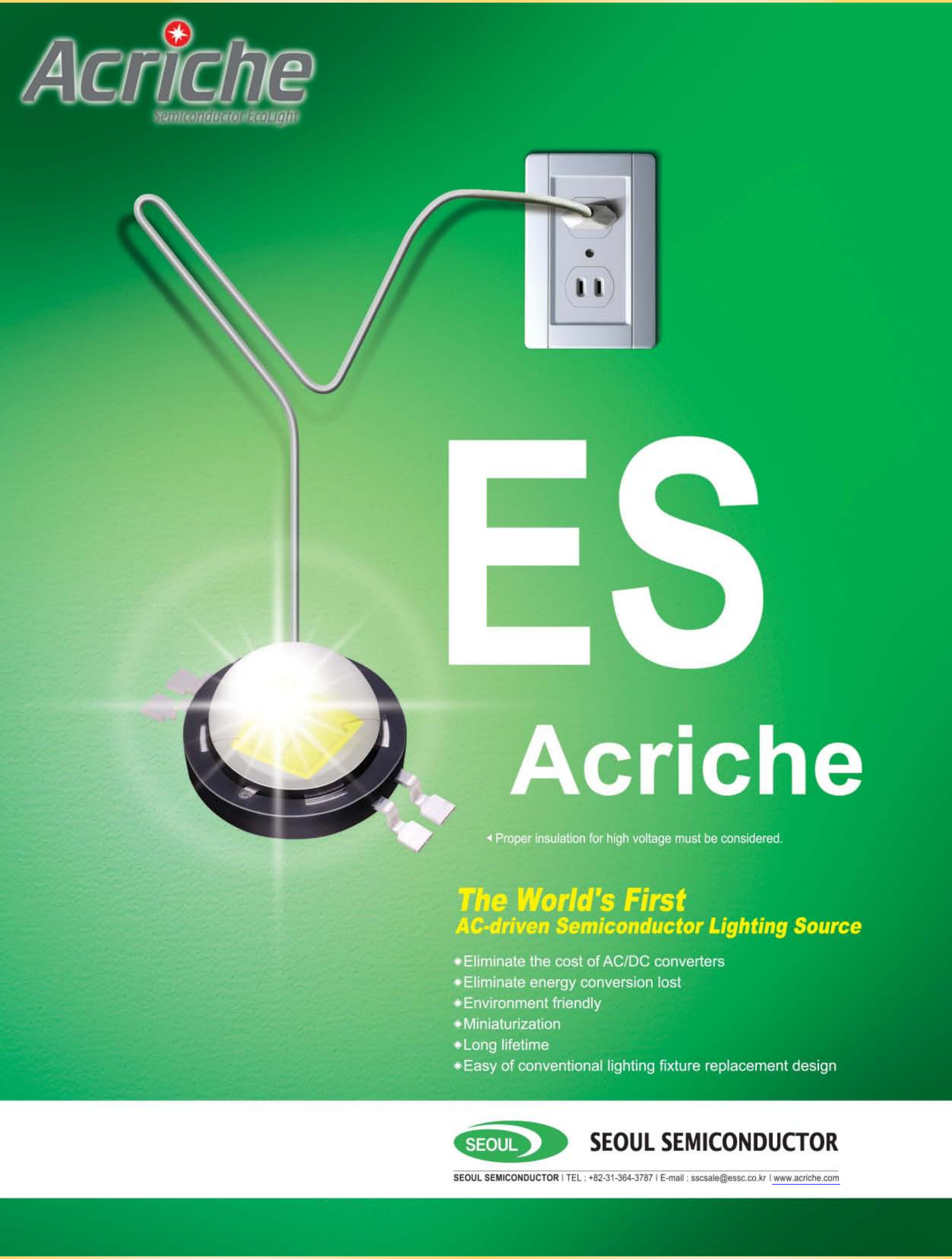
At the 12 Olympic Live Sites, Barco's LED screens made it possible for millions of Beijing people to watch the games in large groups, live and outdoors.

At the landmark Jingxin Building, China's largest outdoor LED screen, at 758 sq. m, beamed Olympic images to millions of visitors on Beijing's 3rd Ring Road. The Olympic soccer field in Shanghai was also lit up by a 391 sq. m Barco LED screen.

LED dragons illuminate fountains

Osram Opto Semiconductors and Tong Fang Co. Ltd. used Osram Golden Dragon LEDs to illuminate the elegant water fountains in Beijing's Olympic Park. These LEDs, with lens and enhanced thin-film LED components, provided the "dragon" with its characteristic golden glow. Installed in July in Beijing, the fountains are located along the north east side of the Bird's Nest and the Water Cube in Olympic Park. The 600 m long fountain is formed by thousands of tiny water jets arranged in a long, gentle curve cutting through the Olympic Park, creating a river stretching two kilometers long. The dynamic jets launch water columns as high as 6 m, creating a kind of rolling wave, like the body of a dragon as it glides through the air.

MORE DETAILS: www.ledsmagazine.com/news/5/8/14


Acriche
Semiconductor EcoLight
YES
Acriche
Proper insulation for high voltage must be considered.
The World's First
AC-driven Semiconductor Lighting Source
Eliminate the cost of AC/DC converters
Eliminate energy conversion lost
Environment friendly
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China SSL highlights national focus on solid-state lighting

At its annual forum, the Chinese LED industry showed it is addressing product quality and reliability issues, developing standards and trying to deal with patent issues, reports **ROBERT STEELE**.

The Fifth China International Forum on Solid-State Lighing (China SSL 2008) was held from July 24-26 in Shenzhen. As in previous years, the Forum was organized by the China Solid-State Lighting Alliance, with support from seven Chinese government ministries and organizations, including the Ministry of Science and Technology and the Chinese Academy of Sciences, as well as a number of domestic and foreign photonics associations such as the Chinese Optical Society, SPIE and OIDA (US), OITDA (Japan), and KAPID (Korea).

The Forum was accompanied in the Shenzhen Convention Center by an exhibition of 196 companies displaying their solid-state lighting products. Overall attendance was reported as 613 for the Forum (including 140 from overseas), and 8,212 for the exhibition (including 525 from overseas). Although there are a number of LED-related conferences and trade shows in China throughout the year, China SSL can be considered to be the premier such event as determined by its breadth of content and support by various government and professional organizations.

The Forum was preceded by a day of workshops and a short course on MOCVD technology. The workshops included "International SSL Standards and Measurements" and "Solid-State Lighting Patents". Both subjects reflect the ongoing high level of interest in China. The standards and measurements workshop included discussion of efforts in China as well as internationally to develop standards for SSL ranging from devices to systems. The workshop on patents was conducted in Chinese only, whereas all other conference events were bilingual.

ROBERT STEELE *is director of optoelectronics at market research firm Strategies Unlimited.*

Government support

The main Forum consisted of two plenary sessions plus two parallel tracks — one on Epitaxy, Chips and Equipment and one on Packaging and Applications. The beginning plenary was addressed by Cao Jianlin, the new Vice Minister of Science and Technology, who was appointed to replace the former Vice Minister Ma Songde, who recently retired, and who had addressed all previous Forums. Like Minister Ma before him, Minister Cao expressed strong support for the Chinese national solid-state lighting program and confidence in the future growth of the LED industry in China.

Photos courtesy of Scott Riesebosch, CRS Electronics

As was announced at previous Forums, the current Chinese national SSL program runs from 2006-2010, and is funded by the national government at the level of RMB350 million (~US$51 million). Also, local governments will be contributing 2–3× the amount contributed by the national government. One of the program's near-term goals is to produce a white LED with an efficacy in the 60–70 lm/W range in 2008, up from 30–40 lm/W in 2006. The program's goal for white LEDs in 2010 is 100 lm/W in production and 130 lm/W in the lab.

From the various presentations at the Forum, it is clear that the Chinese SSL industry has ambitious plans to become a major player in the world market. There is a large domestic market in China, and the bulk of the progress is in the area of applications rather than technology. Therefore, there is a strong focus on strengthening the LED technology base.

The Chinese are keenly aware of some of the product quality issues that plague the domestic SSL market at present, both at the device and system level. They clearly realize that in order to fully participate in the international SSL market, they will have to come to terms with product quality and reliability issues, develop standards that are consistent with those under development elsewhere and deal with patent issues.

At the same time, there are a number of Chinese companies exhibiting a high degree of sophistication at the SSL system and application level. This was illustrated in several presentations at the Forum on applications developed for the 2008 Beijing Olympics and planned for the Shanghai World Expo. The opening and closing ceremonies at the Olympics in August were an opportunity for the Chinese SSL industry to put its best foot forward, with a variety of colorful and spectacular effects that illustrated a high level of creative imagination as well as sophistication in control systems. The Shanghai World Expo in 2010 promises to be even more innovative in its use of solid-state lighting.

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• Built-in active PFC function	✓	✓		
• Output Voltage Range	12V~48V	9V~48V	5V~48V	5V~48V
• Constant Voltage / Consant Current	CV+CC	CV+CC	CV+CC	CV or CC
• Short Circuit / Overload Protection	✓	✓	✓	✓
• Over Voltage Protection	✓	✓	✓	✓
• Over Temperature Protection	✓	✓		
• Adjustable Output Voltage / Current	✓(150W)	✓	✓	
• Optional Dimming Function			✓	
• Protection Level	IP65 / IP67	IP64	IP64	IP67
• UL 1310 Class 2 Compliant	✓(60/100W)	✓	✓	✓
• Input / Output Connection	Cable: 18AWG, 30cm	Cable: 18AWG, 30cm	Cable: 18AWG, 30cm	Wire: 18AWG, 60cm

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Design considerations for intelligent, color-changeable LED luminaires

Purpose-designed LED modules built using chip-on-board technology are capable of demonstrating very high efficiency and high color rendering index, according to **JAMES MCKENZIE** and **MAJD ZOOROB**.

Due to soaring electricity prices and ever-growing environmental concerns about energy consumption and waste disposal, lighting is experiencing a technology revolution. In the future, LED lighting offers the promise of efficiencies exceeding 150 lm/W coupled with high color rendering index (CRI), illumination-grade luminous flux levels and long lifetimes exceeding 150,000 hours. The ideal future general lighting source should also aim to emulate the color temperature and quality of sunlight at different phases of the day.

Other benefits include dimming, high-speed switching and instant-on capability, while additional features such as color control and more recently high CRI values have dramatically diversified the possible lighting applications. Architectural, mood and decorative lighting already make widespread use of RGB LED modules to provide color-changing flexibility, but these sources have suffered from poor color fidelity (typically quantified using the CRI) and poor luminous efficiency.

When LED lighting is viewed as a replacement for illumination-grade lighting, the main drawback hindering adoption is initial cost, along with issues associated with color binning, mediocre CRI and the need to achieve a good design that can meet the promised specification targets, especially for lifetime. This article reviews typical LED lighting systems that generate white light and the associated issues with binning, the impact on manufacturers and customers, and system level approaches to help alleviate the drawbacks.

Not all white LEDs are the same

There are several different techniques to generate white light from LEDs, each with benefits and drawbacks, as shown in Fig. 1. The simplest and most efficient single-chip method is to combine a blue LED chip with a yellow phosphor, resulting in commercial LEDs that currently achieve a maximum efficiency of 100–110 lm/W at 350 mA, with a correlated color temperature (CCT) of 6500 K. However, such LEDs suffer several drawbacks, including low yield due to binning issues, which translates to increased cost for the LED module as well as longer lead times for the desired color bins. The mediocre CRI values (typically Ra = 70–80) and the CCT range of >10,000 K to around 4,500 K renders these LEDs inadequate for direct incandescent lamp replacement (which requires ~2700 K and Ra = 98–100).

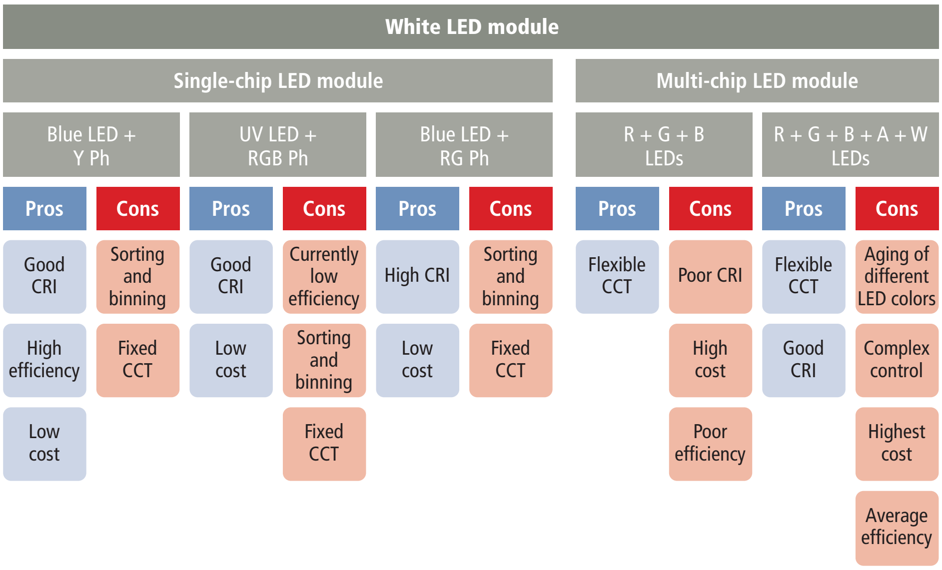

FIG. 1. The most common methods for generating white light with LEDs (Ph = phosphor, Y = yellow, R = red, G = green, B = blue, A = amber, W = white).

In some LEDs, yellow phosphors are replaced with complexes of red and green phosphors mixed to provide a broader yellow emission capable of improved matching to warmer CCT white with good CRI in the Ra = 80–90 range. Warm white LEDs at CCT of ~3000 K currently achieve state-of-the-art efficiencies of about 90 lm/W.

These systems also suffer from a fixed chromaticity color emission that cannot be modified or changed following fabrication. For many general lighting applications, this is acceptable only if the CCT and CRI are

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matched to the values achieved by incandescent or halogen lighting. However, in most cases the low color-binning yield leads to a large percentage of LED modules with undesirable color chromaticity. In order to improve color binning yield, some manufacturers such as Osram and Cree employ in situ sorting of LED die for wavelength and flux during fabrication, followed by chip-level deposition of conformal layers of phosphors to improve color uniformity, while others such as Philips Lumileds employ matched phosphor platelets positioned on the surface of the LED die.

In the case of multiple-chip LED modules (examples include PerkinElmer's Aculed and Osram's Ostar), the light from red, green and blue LEDs is mixed to provide the desired white light emission or other color schemes. These are typically only employed for projection, and architectural, decorative and mood lighting, rather than general lighting. They suffer from poor color fidelity and chromatic discrimination (typical Ra values are 70–80), due to the non-continuous superposition of narrow band RGB spectra forming the white spectrum, as well as poor overall system efficiency. More recent color-changing modules, such as those from PerkinElmer and Enfis, have increased the number of different primary colors by the addition of amber LEDs while also mixing white LEDs to improve CRI, chromaticity, color gamut and overall efficiency, and to enable the modules to function for both decorative as well as general lighting.

The primary drawback of these LED modules is that each LED semiconductor ages differently and hence tends to shift the color temperature with lifetime as well as temperature. In order to alleviate some of these problems, luminaire manufacturers such as Cree Lighting Solutions (formerly LLF Inc) and Philips (with its Lexel and Color Kinetics Intelliwhite products) have adopted system-level solutions combining both white LED modules and/or single color LEDs as well as feedback systems that continually monitor and adjust the CCT and color chromaticity.

PhotonStar LED Ltd has adopted a novel system level approach to solve some of the issues, and has implemented this at the LED module level, enabling a unified single-LED module for use in general lighting applications as well as color-changing applications. The multichip LED module employs system and die level corrective and preventative mechanisms to enable high efficiency (currently exceeding 80 lm/W at 4000 K and reaching over 100 lm/W for higher CCT) and excellent color fidelity (Ra >95) as well as ability to shift the chromaticity to suit the lighting application. It is important to note that there are no limitations in the underlying efficiency of the LED module technology and this will continue to match state-of-the-art commercial fixed wavelength white LED module efficiencies.

The ultra-low thermal resistance of the PhotonStar LED ChromaWhite LED module (<0.8 K/W) enables illumination-grade luminous flux values, while maintaining long lifetime. The multichip, high-power module enables the luminaire manufacturer to incorporate a single LED module for a broad range of lighting applications. Adopting a single module multichip technology enables an intelligent single tunable or pre-selectable lighting module in a 50% lower cost solution when compared to fixed white LED lighting solutions.

FIG. 2. Color-changing capabilities of the ChromaWhite LED module embedded in a standard PhotonStar CeilingStar5 recessed downlighter with a CCT and intensity controller box. The luminaire is running off two 9V batteries.

Binning for general illumination

LED module manufacturers experience many challenges associated with yield, as variations in LED forward voltage (V_f), luminous flux and color variation all affect the volume of product residing in a specific manufacturing chromaticity bin. Typically, manufacturers sort the resulting LED modules into approximately 3 flux bins and 8 CCT bins (subdivided into finer color bins on either side of the Planckian locus), yielding approximately 8% in each bin. This is clearly not desirable, since it causes a large stock problem and entails manufacturing large volumes to achieve adequate stock in each bin. On the customer side this also typically leads to long lead-time for specific, desirable color bins (such as warm white 3000 K and neutral white 4000 K bins) and increased price per module.

Manufacturers have invested in novel technologies to minimize the impact of the

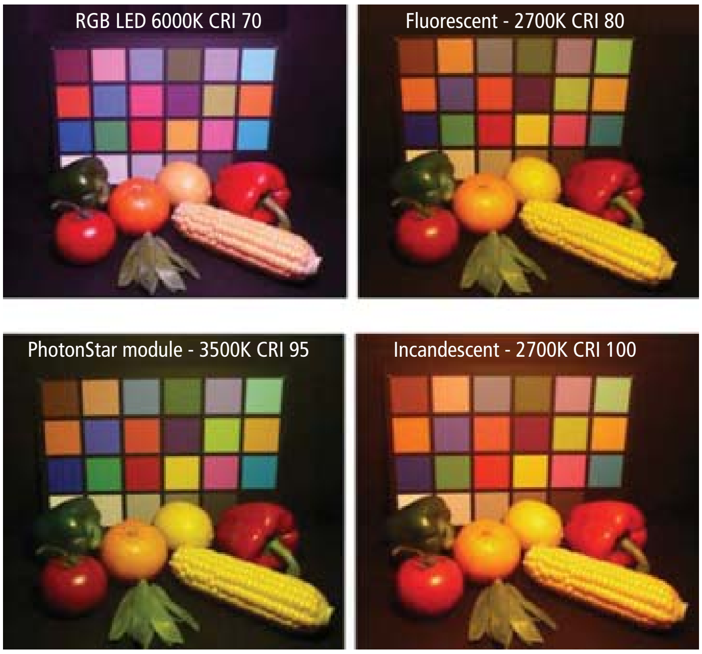
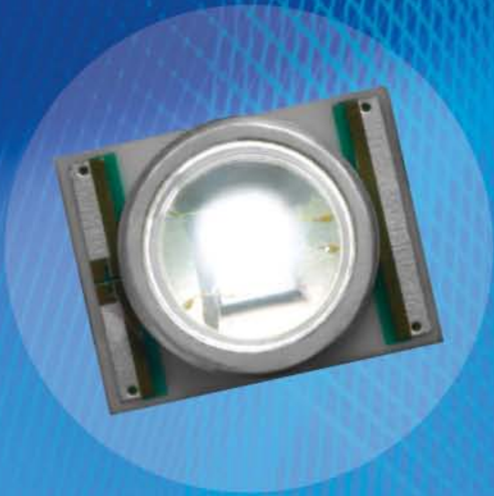


FIG. 3. Demonstrating the importance of CRI through the irradiance of colored objects using a variety of light sources.



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yield problem. However, this still does not completely eliminate color binning due to difficulties with in situ prediction of light scattering and optical thicknesses associated with deposited or attached phosphor layers. This affects the overall color chromaticity of the LED module.

PhotonStar ChromaWhite LED modules eliminate the color binning problem by employing factory pre-set LED modules locked to a desired color chromaticity using a novel, module-level, color-control approach (Figure 2). This enables the manufacture of a unified single LED module for use in most general lighting applications with customer-defined color chromaticity in proximity to the Planckian locus and in the 2500–6500 K range. The LED module may also be set for more elaborate color-changing applications. By employing proprietary color-changeable white light, it is possible to achieve luminous efficiencies greater than 80 lm/W, subject to color chromaticity, specifications typically associated with single-color white LED modules, while also having best-in-class CRI of >95.

Importance of high CRI

Figure 3 shows the importance of color rendering for general lighting applications. CRI is a quantitative measurement providing an index of the ability of a light source to reproduce colors faithfully in comparison with an ideal or natural light source. The ChromaWhite LED module provides increased content across a broad wavelength spectral range, which increases the reflectance of light matched to the surface of the objects.

The design of multiple-chip LED modules for general lighting can usually be a compromise between CRI and luminous efficiency. Increasing the spectral coverage of the light emission is typically achieved by the introduction of additional LED sources interspaced between the red, green and blue sources. This in turn reduces the overall efficiency of the system with an ROAGB LED engine having typical figures in the range of 33 lm/W (based on best-in-class commercial InGaAlP LED die).

Figure 4 highlights the efficiency and CRI of current state-of-the-art commercial light sources. The efficiency of different LED products is plotted when the modules are powered at optimum 350mA (usually around 1.15W).

Several different tunable-color LED technologies are plotted, including traditional RGB and RGBA color-changing LED modules that provide large color chromaticity tuning flexibility but poor luminous efficiency. IntelliWhite by Philips SSLS (Color Kinetics) employs the mixing of two white LEDs at different CCT temperatures to enable CCT tuning between the two white points. Values for PhotonStar ChromaWhite LED modules are based on actual in-house test results. The red area representing efficiency and CRI coverage is large due to the flexibility in color chromaticity.

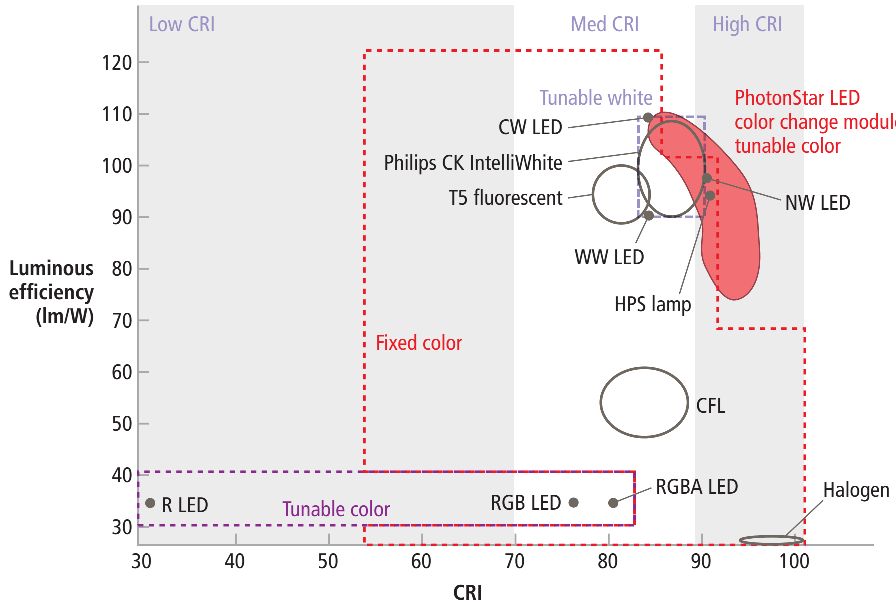

FIG. 4. Comparison of different lighting technologies. For tunable white and RGB modules, the efficiencies are based on mixing of fixed-color LEDs and are projected from commercially-available state of the art LEDs. Performance of actual commercial products may be considerably lower than shown. For LED products, lower-flux LED bins are typically selected for reduced cost and lead-time. For traditional lamps, the light output ratio is not included. (CW LED = 6500 K cool white, NW LED = 4000 K neutral white, WW LED = 2700 K warm white.)

Full spectrum approach

PhotonStar ChromaWhite LED modules provide illumination-grade lighting and the ability to modify — as well as factory pre-set — the color chromaticity within a specific color triangle as depicted by the region bounded by the solid black triangle in Figure 5. Due to the flexibility of the intelligent ChromaWhite modules, they may be configured as follows:

- Factory pre-set at a specific color chromaticity with or without active feedback for improved color lifetime performance.
- Factory set to simulate a Planckian white light source ranging between warm white (CCT = 2500 K) and daylight (CCT = 6500 K). A simple switch can control the module to travel along the Planckian locus.
- Full color tunability enabling any desired light chromaticity inside the triangle.

Thermal management and COB

Good thermal management is key to efficient, long-lifetime LED lighting. LED modules thermally de-rate with increased temperature and experience a reduction in useful lifetime. Lifetime is an exponential function of the LED junction temperature (T_j); as an example, reducing T_j by only 6°C from ~70°C to 64°C provides a 22% increase in lifetime. Assuming no modification to the heat sink, this implies that a step improvement in lifetime requires an order of magnitude improvement in the thermal resistance. The change should be from 6–8°C/W for current state-of-the-art LED modules down to ~0.6–0.8°C/W to achieve the desired 6–8°C T_j drop.

In order to achieve the desired improvement in thermal resistance, the ChromaWhite module adopts a novel chip-on-board (COB) design. The thermal solution is designed at both the board and LED chip level and achieves a thermal resistance of below 0.8 K/W. A proprietary isolation layer may also be adopted for ultra-high performance applications, reducing the thermal resistance down to < 0.3 K/W.

The adoption of low thermal resistance LED modules enables larger flexibility in designing luminaires for general lighting applications. As well as higher light output and longer lifetime, the luminaires can have smaller embedded heat sinks, a lower overall cost thermal management solution, and a larger ambient operating temperature capability.

The selection of COB as the underlying technology for ChromaWhite module products provides high packing density and the capability to use high drive currents. It also provides high accuracy chip placement and easy assembly and incorporation into existing luminaire heat sinks. COB is a flexible technology that can integrate additional embedded electronics, and is a low cost alternative to high power LED packages.

However, COB modules are typically perceived to suffer from complexity of production scaling when small to medium volumes are exceeded. In the case of lighting applications, the scaling problems are alleviated by incorporation of multiple high-power LED chips (typically 6 to 24 power chips) on a single COB module capable of generating 400–2500 lm of white light. This approach is able to generate adequate luminous flux and directly replace a lamp such as a 25W T5 fluorescent lamp, a 2 × 26 W CFL lamp or even a cluster of LED modules on an IMS board. This dramatically reduces the number of light sources to be manufactured and hence lends itself to the model of one light source per luminaire.

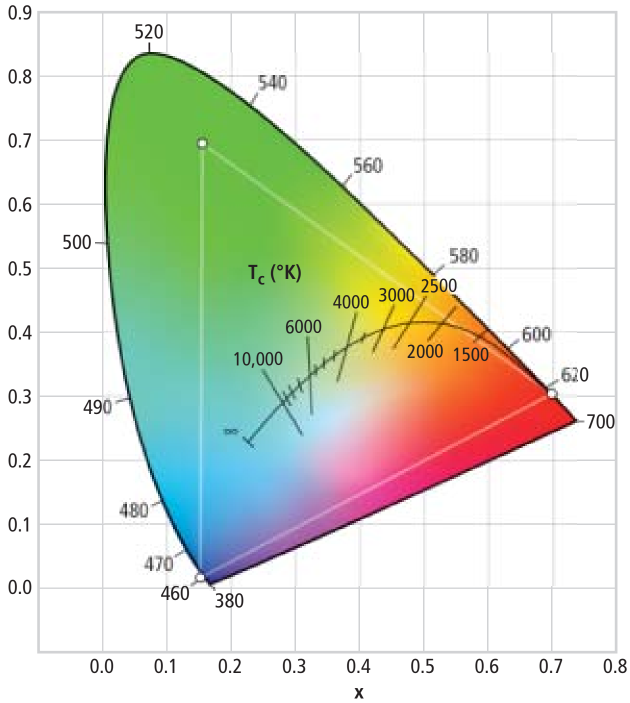

FIG. 5. The white triangle defines the color space region for the ChromaWhite module.

Proprietary optics

In order to fully benefit from the high efficiency of LED lighting, it is necessary to identify an appropriate light extraction and far-field light-shaping method from the LED module to the luminaire. Typical CFL or metal halide luminaires suffer from poor light output ratio (LOR) values (typically 55% to 75%) due to the isotropic emission nature of the light source requiring multiple reflections to re-direct the light into the desired far-field profile. By adopting board-level primary optics the ChromaWhite module dramatically minimizes the far-field angular CIE chromaticity variations as well as reducing the need for secondary optical components for general lighting applications.

Low cost LED modules for general lighting

Even though COB LED module solutions typically involve higher-cost manufacturing processes, such as special wire-bonding surface treatments, they are ideally suited for general lighting applications. The increased functionality and flexibility of the ChromaWhite modules reduces the overall cost on many levels. For example, reduced manufacturing costs are enabled by zero color binning; a reduced bill of materials results from the manufacture of one module for all color bins; and the use of multi-chip, high-power LED COB modules enables a low cost per LED die.

At the customer and system level, benefits include a minimal requirement for secondary optics due to the use of board-level optics, and the ability to use smaller, lower-cost heat sinks due to a reduced thermal luminaire load. The use of board-level LED drivers means that only simple, low-cost power supplies are required.

Due to the system level complexity and zero binning, the price per kilo-lumen for ChromaWhite LED modules can be 50% lower than for conventional single-color white LED clusters. However, when the ChromaWhite LED modules are embedded in the lighting application, the compounded benefits enable dramatically greater benefits, with up to 80% reduction in overall luminaire cost.

Conclusions

LED lighting technology has recently reached efficiency levels matching or exceeding the most efficient conventional lighting technologies. With the added benefits of superior lifetime and unlimited flexibility, LED technology is widely considered the future of intelligent lighting.

The transformation of dumb luminaires into fully color-tunable, intelligent lighting solutions opens up the design space while providing further impacts in areas of lifestyle, health and well-being. As an example, the emulation of sunrise, daylight and sunset (in both color temperature and time during the day) during the winter seasons can help in the regulation of circadian rhythms and minimization in the symptoms commonly associated with lack of sunlight such as seasonal affective disorder (SAD). The ability to adjust the CCT and boost specific wavelengths can also help in alertness and potentially benefit adult concentration in the work environment and learning in students. By providing the necessary breakthroughs in LED lighting, the PhotonStar ChromaWhite LED module, available in 1Q09, will help accelerate mass-market adoption and fulfill the future creative desires of lighting designers as well as the energy efficiency requirements of environmentalists. PhotonStar LED is currently seeking partners to explore the full potential of the technology and the applications.

LINKS

PhotonStar LED Ltd. expands, secures funding (May 2008) www.ledsmagazine.com/news/5/5/3

PhotonStar LED unveils high-efficiency CeilingStar5 downlight (Aug 2008) www.ledsmagazine.com/news/5/8/10

outdoor lighting

New York architect firm, LSG to build prototype LED streetlights

Under a $1.175M contract, OVI and LSG will produce and test 6 LED prototype streetlights for New York City, reports Julie MacShane.

The Office for Visual Interaction Inc. (OVI), an architectural lighting design firm, has been selected by The New York City Department of Design and Construction (DDC) to engineer, produce and test the winning design of the City Lights Design Competition.

The DDC created this two-stage, international competition to select a new streetlight design for New York City for the 21st century. OVI was selected for its LED-based streetlight design back in December 2004 (see "LED design wins New York City streetlight competition," www.ledsmagazine.com/features/1/12/2).

Now, following its success in the second stage of the competition, OVI has partnered with Lighting Science Group Corp. (LSG) to engineer, produce and test six prototypes of its winning design.

A NYC spokesman confirmed to *LEDs Magazine* that a sealed competitive bid was awarded by DDC on August 11, 2008, to OVI for $1.175M.

That comes out to about $195,833 per streetlight.

"We registered the contract for the prototype test in the city record, as required by law. All this is is a prototype test and when the prototype test is done, it will be entered into the city's catalog/inventory of streetlights and the city will make a determination of where it goes from there," said Scott Gastel, the Deputy Press Secretary in » page 42

FIG. 1. Mock-up of prototype NYC LED streetlight design. Courtesy of OVI/LSG.

Two US cities, two LED plans

Manassas, Virginia

The city of Manassas, VA, is hoping that new LED lights will cut down light pollution and discourage vandalism and other crimes. The city's Electric Utility is working with the city's police department to identify a "preferable neighborhood" to test out new LED streetlights, said a recent article in the city's August 2008 Utility Connection newsletter. The police want to see what effect the higher quality white lights have on vandalism, graffiti, and other crimes.

"A lot of power companies have looked at the technology and determined it's early to implement an LED program because the capital cost is so high and it's over seven years before you get payback," said Gregg Paulson, assistant director, Electric Utility, in an interview with the newsletter. "But if you look in terms of the environmental impact, that's really what's pushing it, to reduce our emissions and our carbon footprint."

Installation for the pilot starts this fall and is expected to take about three months.

Anchorage, Alaska

Anchorage mayor Mark Begich announced his city's participation in Cree's LED City program in conjunction with an energy-related initiative calling for the retrofit of all 16,000 municipal roadway lights with high-efficiency LED fixtures. Begich said that the city has allocated $2.2 million to purchase LED fixtures to change out roughly 25% of Anchorage's streetlights.

Deb Lovig, Cree LED City program manager, said that lighting is absolutely critical to daily life in Anchorage, where ~85 days a year see <9 hours of daylight. Anchorage is often cloudy during the winter, which also decreases the amount of sunlight.

Anchorage will buy LED fixtures from BetaLED, which are expected to use 50% less energy than current streetlights. This could save the city $360,000 annually at today's energy prices. The LED fixtures will be based on Cree XLamp LEDs. ◄

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the Office of Public Information for the New York City Department of Transportation.

Nothing has been said about any future installations and no determination has been made of where the test will be held, although it will be in one of the city's five boroughs, added Deputy Press Secretary Gastel.

The schedule

OVI and LSG intend to commence the engineering work this month, followed by testing of the prototypes in spring 2009 for the City Lights Streetlight project. The goal is to provide a model for widespread lighting of streets, sidewalks and parks within the city's five boroughs.

In this phase of the project, OVI and LSG will:

- fabricate working prototypes, including all necessary parts; and
- perform all testing necessary to ensure design and performance criteria are met.

There are more than 300,000 streetlights in New York City, the majority of which are based on high-pressure sodium technology. Replacing a commonly used 150W high pressure sodium lamp with the proposed LED lighting solution will reduce the energy consumption by 25-30% to an estimated 105 W per LED module, LSG says.

FIG. 2 How an LED streetlight might look in NYC with its assorted signs. Courtesy: LSG.

The design

The design challenge facing the competitors was to "create an innovative, state-of-the-art design that responds to the unique diversity of the city's architecture and urban landscape while meeting the appropriate technical performance standards".

The winning design developed by OVI combines hi-flux LED technology with state-of-art lensing optics in a small oval-shaped profile, which provides the structural framework and heat sink for the LED modules.

Linear arrays of LEDs are grouped into segments. Each segment has a primary and secondary optics system to achieve the required light distribution pattern. This modular design strategy of components allows usage and interchangeability among the various streetlight configurations.

The segmented, modular lighting design innovation for the new streetlight also streamlines fabrication and product handling, and can accommodate future generations of LED technology as these become available. ◄

City LED prototypes to be adjusted

Grand Rapids, MI, mayor George Heartwell recently commented that some of the new prototype cobra-head 35-foot LED streetlights outside his home did not spread illumination far enough back behind the pole to light the sidewalk, according to a recent article in the *The Grand Rapids Press* newspaper.

Public Works Director Patrick Bush said that he shares the mayor's concern, but believes future prototypes will perform better. In reply to the newspaper story, Bush told *LEDs Magazine*: "They forgot to mention that we said there was tremendous progress from the first generation prototypes to the second and third."

"We also pointed out that we are dealing with models from 4 different suppliers and some such as the Relume models were performing much better than others," Bush added.

"The only negative with the streetlights was that the light didn't spread behind the pole 15 feet more onto the sidewalk," said Bob Hahn, the GM of Lumecon, the national distributor for Relume Technologies. He added that Relume is planning on fixing the spread issue by deploying new prototypes to the city within 60 days.

"The City of Grand Rapids as a general rule has a very high standard for their outdoor lighting," continued Hahn. "It exceeds the IES (Illuminating Engineering Society) standards by quite a bit, by as much as 3 times the minimum requirements. They do that for safety and aesthetic reasons – they like the city to be well lit."

"I would also like to continue testing the Relume models but in a location other than Fulton Street," Grand Rapids's Bush said. "Fulton Street was the ultimate in worst case scenario. I would like to install them in a two or three lane roadway configuration to see if we can achieve better results." ◄

Relume's Grand Rapids cobra-style LED streetlights

Wireless control of LED beacons

Solar-powered LED technology provider Carmanah Technologies Corp. has partnered with Encom Wireless Data Solutions Inc. to add a wireless interface capability to its line of stand-alone solar-powered traffic beacons.

Encom technology will provide remote interface and control capabilities to add versatility and flexibility to Carmanah's solar-powered flashing beacons.

"A key benefit of a solar-powered beacon is convenience – it's easy to install, generates its own electricity, and operates automatically for years with little or no maintenance," said Richard Chesson, Carmanah VP of marketing and business development, "so how do you make it even better? We believe the answer is wireless interactivity."

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Illumination and LCD backlighting are major drivers for growth

A new report indicates healthy growth for lighting applications using LEDs, while the increasing demand for LED backlights in LCD panels is providing a boost for Taiwan's LED industry, writes **TIM WHITAKER.**

High-brightness LEDs have shown dramatic improvements in performance in recent years, as well as significant cost reduction, such that they are undergoing a period of rapid market growth in a variety of niche and general lighting applications, says a new report by Strategies Unlimited. The market research firm has analyzed the market structure for LED lighting, and the drivers that will enable HB LED technology to penetrate the lighting market, as well as the barriers to market growth. The report, entitled "The Market for High-Brightness LEDs in Lighting: Application Analysis and Forecast – 2008," also provides detailed analysis and quantitative market forecasts for 12 LED lighting applications through 2012.

In 2007, the worldwide market for HB LEDs used in lighting applications reached $337 million, up from $205 million in 2006. The majority of lighting applications used RGB LEDs in markets such as architectural lighting, channel letter signs, accent and decorative lighting and entertainment lighting. However, white LEDs accounted for 48% of the market, and this percentage will grow in selected applications such as consumer portable lighting (e.g. flashlights and headlamps) and machine vision, the report says. White LEDs have recently begun to be used on a limited basis in applications such as retail display lighting, commercial and industrial lighting and outdoor area lighting.

In the coming years, LED lighting will reach beyond single color and color-changing applications into the general illumination arena, enabling residential, commercial and off-grid applications. The LED lighting market is forecast to reach $1.65 billion in 2012, but this will represent just the first stage in the replacement by LED lighting of conventional light sources, including high-efficiency fluorescent and high-intensity discharge (HID) lamps.

TIM WHITAKER *is Editor of* LEDs Magazine.

LCD backlights are seen as a major market for LEDs. Sony's new Bravia ZX1 40-inch LCD TV has a minimum thickness of only 9.9 mm, comparable with a DVD case. This is enabled by a backlight comprising white LEDs around the edge of the screen, a unique arrangement for such a large LCD panel. **MORE DETAILS:** www.ledsmagazine.com/news/5/9/3.

Sapphire supplier sees growth

Compared with end users, companies supplying materials and equipment to LED chip manufacturers have a different perspective on the LED market. One such supplier is Rubicon, a leading manufacturer of sapphire wafers. Materials such as sapphire and silicon carbide are used, in the form of thin circular wafers, as the substrate for the deposition of semiconductor material layers. These complex layer structures are then used to make LED chips. The deposition process is known as epitaxy, and takes place in large, million-dollar pieces of equipment. The German company Aixtron is a leading supplier of epitaxial growth systems that use the metal-organic chemical vapor deposition (MOCVD) process.

In the company's recent quarterly earnings conference call, Rubicon's CEO, Raja Parvez, said that 60% of the company's revenue comes from the LED market and estimated that, overall, the LED market is expected to continue to grow at more than 20% per year over the next several years. Bill Weissman, Rubicon's CFO, added that "the company's LED revenue grew 14% year-over-year and 8% sequentially" in the second quarter as applications for LEDs continue to expand.

Parvez said that high-performance LED applications, such as large area backlight units and solid-state lighting, are growing rapidly. "LED backlight units are penetrating into the notebook computer and LCD TV market faster than expected," he said. These applications are being supported by major

LED chip manufacturers in Japan, Europe, and the US. "As a result, our sales continue to increase in these regions," said Parvez. "We are also receiving orders for 6-inch sapphire products for the LED market to support next-generation LED wafer development efforts by MOCVD equipment and LED chip manufacturers. We expect this large diameter development to ramp going forward as LED manufacturers continue to increase device performance and drive LED costs down to further penetrate lighting applications."

Parvez said that Taiwan and Korea are in early stage development for large-diameter LED chip production and therefore remain largely focused on small diameter wafers. The LED markets in Taiwan and Korea have been affected by worldwide macroeconomic conditions, causing reduced rate of growth in cell phone and small display applications. "Consequently, the rate of growth for LED applications that utilize 2-inch diameter substrates has slowed in the past quarter," said Parvez. "Slower-than-expected growth in Taiwan has increased pressure on pricing for smaller diameter products as customers strive to increase their market share."

The Philips 42PFL9803 is a 42-inch LCD TV with a backlight comprising 1152 RGB LEDs distributed across the backplane. This enables local dimming of the backlight, leading to enhanced contrast (Philips claims a contrast ratio of 2,000,000:1). The TV also uses LEDs to emit ambient light (seen on the adjacent wall) that ties in with the screen image.
MORE DETAILS: www.ledsmagazine.com/news/5/9/3.

According to Rubicon, the market in Taiwan and Korea is expected to pick up in 2009 as the demand for displays and general illumination increases, and also as liquid crystal display (LCD) manufacturers such as AU Optronics (AUO) and Chi Mei Optoelectronics (CMO) enter the LED market.

Aixtron buoyed by backlighting

Although Aixtron sells its MOCVD systems into a number of markets, the most important is the LED sector. In the first half of 2008, the company generated EUR 128.2 M (~$180 M) in revenue, of which around 74% came from equipment sales into the LED market. The company said that sales of its latest-generation, high-capacity MOCVD systems have been sustained by "long-term purchase orders from important LED market-players such as Epistar [Taiwan], Samsung [Korea] and many other » page 49

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prominent customers. With the industry's ongoing expansion of LED production capacity, these larger market players are taking the investment initiative, especially for emerging LED backlighting applications."

Aixtron also says that it has received enquiries from new, large customers in adjacent sectors, for example silicon semiconductor manufacturers that have expressed interest in investing in LED equipment so they can participate in the growth potential of the LED market. "Moreover, several Taiwanese LCD manufacturers have recently announced their vertical integration intent by placing direct purchase orders for MOCVD systems," said Aixtron's financial report.

Panel players establish LED subsidiaries

As mentioned above, AU Optronics (AUO) and Chi Mei Optoelectronics (CMO), the two major LCD panel makers in Taiwan, have both taken steps towards vertical integration within their companies for the production of LED backlight modules. In April 2008, AUO established an LED subsidiary, Lextar, to develop LEDs for LCD panel backlighting. According to Taiwan's Photonics Industry and Technology Development Association (PIDA), the company has started trial runs and is scheduled to commence operation in 2009. The company plans to purchase 5–10 MOCVD systems in the first phase, says PIDA. Meanwhile, Chi Mei Lighting Technology (CMLT), CMO's LED subsidiary, is also accelerating its development in the LED backlighting market. CMLT currently owns 10 MOCVD systems and has started production in small volumes, says PIDA, adding that the company will expand its MOCVD equipment capacity to 20 units by the fourth quarter of this year.

Taiwan's government recently gave a boost to the domestic LED industry by announcing plans to replace all the island's incandescent-type traffic lights with LED lamps in three years. Traffic signals that use LEDs consume 80–90% less energy and generally last 5–7 years, compared to just a year for a comparable incandescent light signal. The government also wants to replace all the incandescent lamps throughout the island with energy-saving lamps in four years, although this will obviously involve compact fluorescent lamps (CFLs) as well as a contribution from LED lamps.

Meanwhile, the Taiwan External Trade Development Council (TAITRA), which promotes Taiwan's foreign trade and competitiveness in world markets, says that LED sales by Taiwan-based companies "soared" during the first half of this year, helped by the Beijing Olympics and higher energy prices that are encouraging the use of lower-cost lighting.

Taiwan's LED makers reported that their sales rose 16.1% in the first half of this year to reach NT$24.2 billion (US$771.3 million), compared with NT$20.8 billion in the same period last year, according to information the companies provided to the Taiwan Stock Exchange. In addition to the beneficial effect of the Olympics, new applications such as backlights for notebook computers, as well as street lights and factory lighting, are boosting the LED market. TAITRA's press release says that Taiwan has the world's second largest LED industry with a 20% share of the global market, sitting behind Japan with a 37% share. However, forecasts suggest that Taiwan will have a 30% share of the market by 2010 as many of Taiwan's flat-panel display makers start to enter the LED business.

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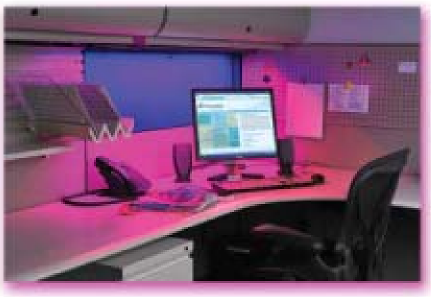

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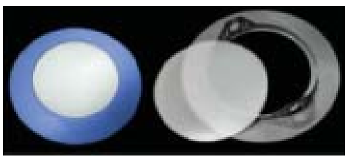

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UK incentives for LED lighting

ANDRE DOBRASZCZYK of **LIGHTHOUSE ELECTRONICS** describes how two incentive schemes will assist the penetration of LEDs into the UK lighting market.

With the imminent phase-out of incandescent lamps, and clear UK government targets to make significant energy savings over the next 10 years, a recent report commissioned by the UK's Carbon Trust identified that LEDs have the opportunity to replace the majority of light sources on this planet by 2050. Influential "energy-saving" schemes are now embracing LED technology, creating a route into the mainstream lighting markets. There are two core schemes set to revolutionize opportunities for white light LED technology penetration within the domestic and non-domestic markets.

First is the Energy Saving Recommended (ESR) scheme run by the Energy Saving Trust (www.energysavingtrust.org.uk). This has promoted energy-efficient domestic products, including lighting, with the aim of reducing domestic energy consumption. The ESR scheme has been responsible for the successful introduction of compact fluorescent lamps (CFLs) into the UK market. UK energy suppliers provide in excess of £800 million a year in subs with the aim of making new energy-saving technology affordable in this price-sensitive market.

An LED working group coordinated by the Lighting Association was established in 2007 to assess opportunities for LED technology to benefit the domestic market. The intention was to include LEDs within the ESR scheme. After much consultation, the proposed draft specification comprises two LED groups. Group 1 — Lamps with integral drivers — is aimed at replacing mains-voltage GU10 incandescent and halogen reflector lamps. Group 2 — LED lamps with non-integral drivers — covers replacements for low-voltage halogen reflector lamps.

The second scheme, the Enhanced Capital Allowance (ECA) scheme run by the Carbon Trust (www.carbontrust.co.uk), is aimed solely at the non-domestic market where energy consumption is significantly higher. This scheme promotes a broad spectrum of energy-efficient products, technologies and control systems, again with the aim of reducing energy consumption. The ECA scheme provides an incentive to the consumer within year 1 in the form of tax relief against capital expenditure. Normally such tax relief on expenditure would have to be claimed over a 3-year period. After much consultation and testing, LEDs have only recently been included within the scheme, with a focus on using LEDs to replace amenity, accent and display lighting.

So how do the schemes stack up against what is actually achievable when integrating white LEDs into lamps? It is clear that the LED market requires a measure of "best practice" to successfully put to rest the question of actual performance of a finished product. It is a fact that many LED lamps and luminaries available within the lighting market are incorrectly measured and labeled, which is causing confusion and lack of confidence in the market.

It is encouraging to see that both schemes have identified this disparity in the market and have set out criteria to ensure that all products that seek to be included within the schemes are suitably tested. Both schemes focus on the key elements associated with LED performance: photometric testing to determine whether the product is bright enough with a suitable color temperature; thermal testing to ascertain product life; electrical testing to ensure that the product is safe and meets a minimum efficiency; and life testing to ensure that the product is reliable.

The ECA scheme for LEDs specifies that the circuit efficiency of the lamp must be ≥46 lm/W for all specified lighting categories with a color rendering index Ra≥80. The lumen output from the lamp source must achieve a specified level for each category of lighting, with a forward beam light output ratio ≥0.95. All efficacy and illumination measurements are conducted after 100 hours of continuous operation and life tests completed after 4000 hours based on not less than 96% depreciation in light output. A power factor of ≥0.7 must also be achieved, with drivers meeting British safety standards.

The ESR scheme is very different and more thorough in its approach to specifying required light levels, as well as electrical specification and life testing. Light levels are expressed against individual lamp types based on achieving a minimum lumen level and peak beam candela at 1m, with specified beam angles. Color temperature is also specified. The philosophy is that the LED lamp should meet the exact lighting levels and color temperature of the lamp that is replaces, so it can be an acceptable alternative.

Specified efficacy values range from 24 lm/W for GU10 lamp replacements to 70 lm/W for exterior flood lighting. ESR also specifies a minimum product life of 15,000 hours based of 30% degradation of light, as this is more than adequate in a domestic installation. Life tests should be conducted at 100, 1000, 2000, 4000, 10,000 and 15,000 hour intervals. The ECA does not specify a minimum product life. Power factor is higher and in some instances must be ≥0.9. A classification has also been added for LEDs lamps and drivers that can be dimmed.

The schemes, although very different, share a common goal — to drive LED technology into the mainstream lighting market, providing opportunity for high volume market penetration by setting "best practice" in the industry. Will your products make the grade?

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