NOVEMBER/DECEMBER 2009

LEDs MAGAZINE®

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TECHNOLOGY AND APPLICATIONS OF LIGHT EMITTING DIODES

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Supply chain sets roadmap P.18

Connectors

The vital link for lighting P.22

Safety

Navigating the route to certification P.37

Architecture

LEDs win the Grand Prix P.14

Courtesy of Enfis Group

Superb LED Lighting by XLEDs, Korea

LED MR 16 LAMP 8W

GA1607S
8W
12V
280Lm
440Lux

LED MR 16 LAMP 4W

1605TL
4W
12V
190Lm
320Lux

LED Desk Lamp 10W

3 Color Mode
Q-200
10W
12V
1400Lux

XLEDs

Light Temptation

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Tel : 82-2-3443-5360 ext 309 Fax : 82-2-3443-5351 E-mail : info@daejindmp.co.kr

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National's new low-side, constant-current LED driver offers integrated thermal control to increase system reliability. The thermal foldback feature of National's LM3424 LED driver provides a more robust thermal design to extend the life of the LEDs, making it an ideal solution for a variety of outdoor, automotive, and indoor lighting applications.

- ✔ Online design tools
- ✔ Reference designs
- ✔ Application notes

Thermal Management

Since thermal design greatly impacts the light output and lifetime of the LEDs, a well-designed thermal system is critical. The LM3424's thermal foldback feature eliminates the need for external thermal management circuitry, allowing for a more robust and reliable thermal system and extending the life of the LEDs.

Easy to Use

With National's WEBENCH® LED Designer online tool, designers can use the LM3424's thermal foldback feature to visualize the design's behavior at user-selected LED temperature breakpoints for easy and quick development of a thermal management system.

Flexible Design

National's LM3424 LED driver, with a wide input voltage range, can be easily configured in buck, boost, buck-boost, and SEPIC topologies with minimal adjustments. Driving a maximum of 18 LEDs in one string, the LM3424 gives designers flexibility while providing up to 96% efficiency and accurate current regulation with less power and heat dissipation.

national.com/led

National Semiconductor

LEDs MAGAZINE®

ISSUE 30

november/december 2009

Cover Story

Formula One World Champion Jenson Button races past the Yas Hotel, Abu Dhabi, which is covered with an LED net from Cooper and Enfis (p.12). Photo credit: Enfis Group plc.

features

columns/departments

commentary

Nights draw in, LEDs light the road ahead

Autumn is here, the days are growing shorter and I've got my LED bike lights out of the drawer. The conference schedule has been packed in recent weeks, with the economy causing some events to struggle, while others such as Light Show West in Los Angeles were very well attended, with excellent feedback. We're pleased to say that next February's Strategies in Light 2010 (Santa Clara, CA) will be the largest in the show's history, and a strong conference program has been announced (see www.ledsmagazine.com/news/6/10/28). Also in California, utility Pacific Gas & Electric (PG&E) has removed a major roadblock for roadway lighting by including LED technology in its rate schedule (p.32). Put simply, PG&E has acknowledged the energy-efficiency benefits of LED technology, so that customers operating LED streetlights are charged less for PG&E's services and power.

In our last issue we wrote about the US DOE's Lighting Facts program, which has introduced a label for lighting performance that is similar to the Nutrition Facts labels commonly seen on food products. A great idea, but unfortunately it has been undermined first by Philips and then Osram Sylvania, who both circumvented procedures and printed their own labels (p.17). Now we hear the Federal Trade Commission is looking at a similar labeling program for all lamps, to help consumers understand exactly what they are buying. Hopefully this will get rid of some of the ridiculous comparisons that are published on lamp packaging.

Speaking of replacement lamps, it appears that the DOE's Caliper program is doing its job. We hear that Costco, a major US store, has recalled certain LED lamps after they were proven by Caliper testing to have vastly inferior performance to the values claimed by the manufacturer.

Positive news for replacement LED lamps: Cree has set new standards with its prototype A-19 lamp which has an output of 969 lm and efficacy of 102 lm/W. The 2800 K lamp has 91 CRI (p.12). In our last issue we wrote about the L Prize, which focuses on achieving performance targets for different LED lamp types. Philips has submitted a 60W-replacement prototype, which is now being evaluated. In my view, it doesn't make sense to award these lucrative prizes until the performance thresholds are reached by a lamp that is in full production. Customers don't buy prototypes. Also, the price point needs to be considered, since market transformation requires high-performance lamps that people can afford to invest in.

Finally, as this issue was going to press, we heard that GE has acquired an LED module technology from Journee Lighting (www.ledsmagazine.com/news/6/11/10). The module can be inserted into a luminaire with a simple twist-lock action, which makes the required thermal and electrical connections. Crucially, this means the module can be removed and replaced in case of failure of the LED source or drive circuitry, and it can also be upgraded as LED technology continues to evolve. As a major lighting player, GE has struggled to penetrate the mainstream market with its LED offerings, but these modules could be just what the market is looking for.

Speaking of false dawns, I'm going to go and buy a blue-LED-based light therapy box to help combat the shorter autumn days.

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LEDs MAGAZINE *online*

Webcasts

Optimizing LED Performance through Heat Management

ORIGINALLY BROADCAST: October 2009

PRESENTERS: Martin Schon, Sapa Extrusions; Mick Wilcox, Nuventix

Solid-State Lighting: Safety Certification Process and Performance Testing Measurement Techniques

ORIGINALLY BROADCAST: September 2009

PRESENTERS: Greg McKee, Labsphere
Todd Straka, Intertek

Visit www.ledsmagazine.com/webcasts to access upcoming and archived presentations.

Web Exclusive Articles

Strategically Speaking: Recent conferences in Asia highlight LED industry progress
www.ledsmagazine.com/features/6/10/12

High-efficiency lighting needs high-efficiency manufacturing
www.ledsmagazine.com/features/6/10/3

Fitted Target Efficacy metric promotes discussion
www.ledsmagazine.com/features/6/10/2

Featured Companies

The following have recently been added to the LEDs Magazine site as Featured Companies (see www.ledsmagazine.com/buyers/featured):

High Power Lighting Corp. • Instruments Systems GmbH

ADVERTISERS *index*

FEATURED *events*

Strategies in Light 2010

Strategies in Light

The Leading Events for the Global LED and Lighting Industry

February 10-12, 2010
Santa Clara, California, USA
An expanded Lighting Track and a new solid-state lighting Investor Forum will be among the highlights of SIL 2010 — see www.ledsmagazine.com/news/6/10/28 for full program details. Register by December 11 for early-bird discounts.
MORE: www.strategiesinlight.com

OLED Lighting Design Summit 2009
December 2-3, 2009
Boston, MA, United States

ForumLED
December 3-4, 2009
Lyon, France

White LEDs
December 13-16, 2009
Taipei , Taiwan

Photonics West 2010
January 23-28, 2010
The Moscone Center, San Francisco, CA, United States

The ARC Show 2010
February 03-04, 2010
Earls Court, London, United Kingdom

LED China 2010
March 02-05, 2010
Guangzhou, China

Light+Building 2010
April 11-16, 2010
Frankfurt am Main, Germany

Lighting Japan: the 2nd LED/ OLED Lighting Technology Expo
April 14-16, 2010
Tokyo Big Sight, Japan

Lightfair 2010
May 12-14, 2010
Las Vegas Convention Center, United States

LED Lighting Taiwan
June 09-11, 2010
Taipai, Taiwan

LED Expo and OLED Expo 2010
June 22-25, 2010
KINTEX, South Korea

MORE: www.ledsmagazine.com/events

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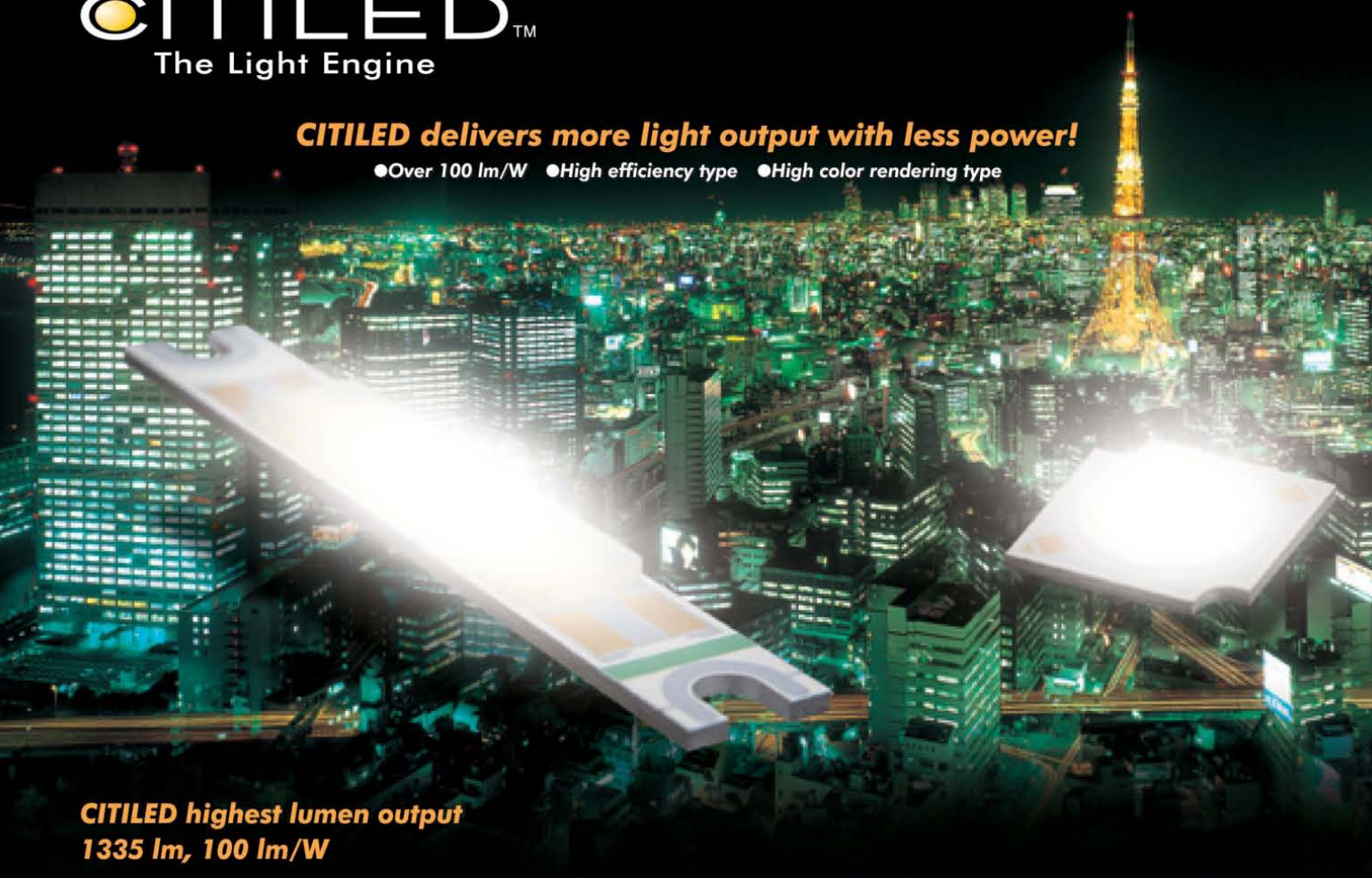
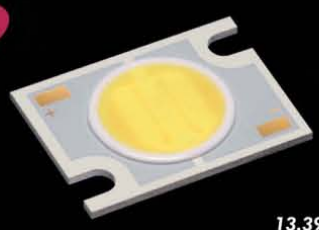


CITILED highest lumen output
1335 lm, 100 lm/W

NEW

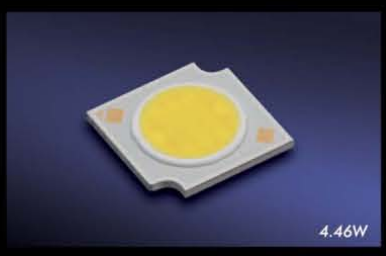


13.39W

CL-L233-C13 Series
IF:720mA
3000K(Ra85) : 900 lm・ 67 lm/W
5000K(Ra65) : 1335 lm・100 lm/W

3.26W

CL-L102-C3 Series
IF:350mA
5000K(Ra85) : 255 lm・ 78 lm/W
3000K(Ra85) : 220 lm・ 68 lm/W
5000K(Ra65) : 340 lm・104 lm/W



4.46W

CL-L251-C4 Series
IF:480mA
5000K(Ra83) : 340 lm・76 lm/W
3000K(Ra85) : 290 lm・65 lm/W
5000K(Ra65) : 425 lm・95 lm/W

▶ Please contact us for samples!

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And the market said, "Let there be LED."

LED products are the future of lighting. They are also quite complex and rapidly evolving—which is why you need a test lab like Intertek. No other lab in the world offers the same breadth of safety and performance testing services. Plus, we have labs in Europe, North America and Asia, each with a commitment to ultra-fast project turnarounds. And our engineers offer the kind of guidance that can make all the difference when it comes to getting your product to market on time.

Our industry leadership was established long ago by our founder, Thomas Edison. It's his legacy that inspires our team today as lighting reinvents itself, once again. For more information, whitepapers and webinars, please visit our website.

Intertek offers product safety certification (ETL) as well as EMC, quality, performance, environmental and energy efficiency testing services.

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news views

ARCHITECTURAL

LEDs tower above Paris, London

Two iconic towers, the Eiffel Tower in Paris and the BT Tower in London, have recently unveiled LED projects. The Eiffel Tower is celebrating its 120th anniversary, and in honor of the occasion Parisians and visitors will be able to enjoy a spectacular light display every evening until the end of the year. The dynamic lighting shows are made possible by more than 400 Ilumipod 48 IP RGBW wash lights from Iluminarc, which have been installed on the Trocadero façade of the monument.

BT, the UK-based telecom giant, has installed a huge LED information band at the top of the BT Tower, which was switched on at the start of the 1000-day countdown to the 2012 Olympic Games. The LED screen is made up of LC Plus Series™ LED panels from Martin Professional. There are 177 separate panels containing 177,000 pixels and a total of 529,750 LEDs. The LEDs are in vertical tubes, with space in between. The display covers over 280 m^2, with a circumference of 59m, and is wrapped around the Tower's 36th and 37th floors, at a height of 167m above street level. At this height the screen has to endure harsh weather conditions, including hurricane force winds. ◄

BT TOWER: www.ledsmagazine.com/news/6/11/1

EIFFEL TOWER: www.ledsmagazine.com/news/6/10/22

MANUFACTURING

Equipment sales on the rise

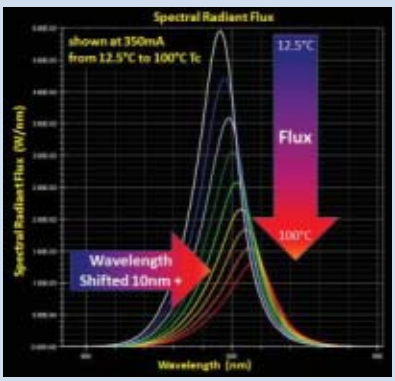
Leading vendors of MOCVD systems, which are used to grow LED epitaxial wafers, have reported positive news in their most recent financial updates. Germany-based Aixtron AG's president and CEO, Paul Hyland, said "We continue to see very healthy demand for our systems driven by an exceptionally positive response by consumers to the introduction of TV LED backlighting. Encouragingly, order and quotation activities are still continuing at a very high level and this trend seems set to continue into 2010." Similarly, John Peeler, CEO of US-based Veeco Instruments Inc., said "We have seen an unprecedented demand from LED manufacturers in China, Korea and Taiwan for our MOCVD systems as they ramp production for laptop and TV backlighting. Veeco MOCVD systems were also selected by two leading US-based LED manufacturers to ramp production for general illumination."

The US manufacturers are Philips Lumileds and Bridegelux, which both recently placed "multi-system" orders for Veeco's TurboDisc GaN MOCVD systems. Elsewhere, Sanan Optoelectronics Co. Ltd., described as the largest manufacturer of full-color LEDs in mainland China, also recently placed multiple tool »page 10

TEST

Orb Optronix systems provide advanced LED testing

As part of the design process, engineers must predict the performance of their LED system and determine if it will meet specifications at real operating temperatures and electrical drive conditions. The new ETΦ™ (ETO) family of LED characterization systems, from Orb Optronix, is capable of measuring the quantity and color of light from LEDs over a range of temperatures and electrical input power variables.



The systems feature both automated data acquisition and mature data analysis, allowing users to quickly and easily view different groupings of data in over 300 graphs. Information on how LED performance varies from LED to LED is pivotal to designing robust LED illumination systems, but this data is not readily available from LED makers. Therefore, testing multiple LED samples is critical to understanding and characterizing performance variability as a function of thermal conditions and electrical power inputs.

The ETO system, manufactured at Labsphere's facility in North Sutton, NH, is available with options for integrating sphere sizes from 6- to 76-inch; a range of source meters; and thermal platforms built for the measurement of discreet LED packages or high-power LED arrays and SSL subassemblies. ◄

MORE: www.ledsmagazine.com/press/20368

news+views

Manufacturing from page 9

orders for Veeco MOCVD systems. Simon Lin, CEO of Sanan, commented, "The addition of Veeco's high productivity MOCVD systems to our manufacturing facilities in Xiamen and Tianjin, China ensures that we can continue to increase output of our market-leading HB-LEDs. We are seeing increased demand for LEDs in such applications as general illumination, TV backlight and outdoor display."

Also in China, five Crius MOCVD systems from Aixtron have been qualified for GaN-based production at Neo-Neon International Ltd, one of the largest LED-based lighting companies in the world. The systems have a 31 × 2-inch wafer configuration. Neo-Neon's vertically-integrated approach has now resulted in a complete supply chain from epitaxy and chip processing to LED packaging and lighting applications. Ben Fan, Chairman of Neo-Neon, said that the MOCVD systems have been installed in the company's new factory complex, a five-story facility at its mainland China production plant. ◄

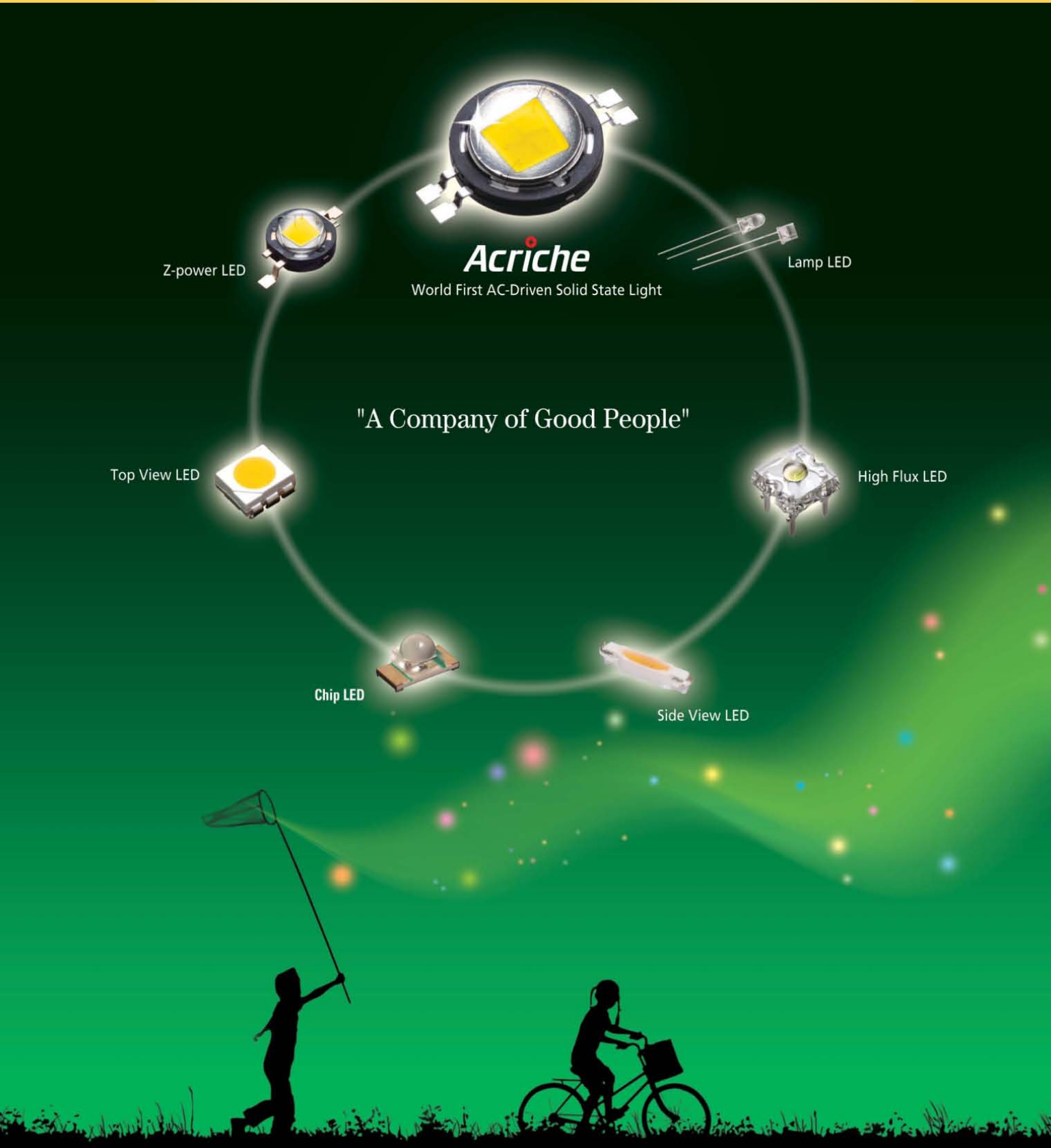
AC LEDS

Epistar and Lynk Labs ink deal

Epistar Corporation, Taiwan's largest LED epi-wafer and chip maker, has entered into a strategic equity investment and license agreement with Lynk Labs Inc., the US-based supplier of AC LED device, light engine and power supply technology (www.ledsmagazine.com/news/6/10/12). Terms of the deal were not disclosed. The companies will be developing new AC LED technology, and IP and products including single-chip and system-level solutions for the lighting industry.

Lynk Labs' technology patent and product portfolio includes fundamental core AC LED circuits that can be integrated at the chip level as well as drive methods and product- or system-level solutions. The company's first US patent, no. 7,489,086, was granted early this year.

Epistar has been developing AC LED chips since 2004 and in March 2009



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announced plans to enter the AC LED market with single-chip AC LED technology. Last year, Epistar obtained a patent license from ITRI, the Taiwan-based Industrial Technology Research Institute.

• In September, Epistar raised US$351 million in equity financing, and has settled a dispute with Philips Lumileds over AlInGaP LED technology and products (www.ledsmagazine.com/news/6/9/23).

• Also, Epistar says it has developed a technology to enable high color rendering index (CRI) and high efficacy for warm-white LEDs. The company has combined its blue and red chips in different packages (www.ledsmagazine.com/news/6/11/4). ◄

MANUFACTURING

SemiLEDs increases capacity

LED maker SemiLEDs Corporation has introduced an Aixtron MOCVD system with 7 × 4-inch configuration into its 4-inch LED wafer fab in Taiwan. SemiLEDs has shifted its mass production of its VLED products to 4-inch wafers, which it says will greatly increase production capacity to meet strong demand for high-end applications, such as street and domestic lighting. The fab will be able to produce 10 million high-power VLED chips per month when running at full capacity. At the recent ChinaSSL conference, SemiLEDs announced that its packaging customers, using I-core MvpLED chips, have achieved 120 lm/watt for cool-white LEDs running at 350mA. ◄

MORE: www.ledsmagazine.com/press/20396

REPLACEMENT LAMPS

Cree shows 102 lm/W LED A-lamp

Cree has demonstrated an A-lamp LED light bulb with an output of 969 lumens at 102 lm/W efficacy, which the company claims is the highest lumen output and efficacy reported in the industry (www.ledsmagazine.com/news/6/11/3). The light output is equivalent to that of a 65W incandescent bulb, but Cree's LED version uses only 9.5W. The demonstration A-19-style bulb features the latest Cree production XLamp® XP-G LEDs and TrueWhite Technology, a patented method of delivering warm-white light with high color rendering and efficiency. The 2800 K warm-white lamp has 91 CRI. Cree said that all data was verified by third-party testing under steady-state operating conditions.

The US government's L Prize includes a category for an LED replacement for a 60W incandescent lamp. Light output should exceed 900 lm with energy consumption of less than 10W, and efficacy of more than 90 lm/W. CRI should exceed 90 with a color temperature in the 2700–3000 K range.

It remains unclear whether Cree may plan to manufacture LED lamps in the future, or to license its technology and/or sell its LEDs to an established lamp maker.

• Cree's revenue for LED products was a record $156 million for the quarter ended September 27, 2009, a14% increase over the previous quarter.

• Cree's cool-white XLamp® XP-G LED is now commercially available. It can produce up to 367 lm when driven at 1A, at a typical efficacy of 111 lm/W. The highest-performing bin also has a standard minimum flux at 350 mA of 139 lm. The XP package size is 3.45 × 3.45 mm.

• Cree expects to add 275 jobs in North Carolina during 2009 to serve the expansion of its LED manufacturing capacity and other staffing needs at its facility in Durham, NC. ◄

ARCHITECTURAL

Enfis and Cooper provide LED veil for Yas Hotel

Anyone who saw the recent Formula One Grand Prix in Abu Dhabi could not fail to notice the color-changing LED veil covering the Yas Hotel, which is unique as the only hotel in the world to sit astride a race track. The building's visual impact is greatly enhanced by its exterior LED mesh, containing 208,800 LEDs, which resulted from a collaboration between two UK-based companies, Cooper Lighting and Enfis Group plc. The exterior consists of sweeping, curvilinear forms constructed of steel and over 5,300 pivoting diamond-shaped glass panels which are illuminated via the LED lighting system. Cooper used over 5,850 Enfis LED arrays in its lighting system. Primarily these were Enfis 4-channel UNO Plus arrays and control drivers integrated into custom-designed

A Solid-State Lighting Premium Expert

Edison Opto Corporation is a Taipei, Taiwan based global leading high power LED manufacturer. The company offers a comprehensive product line ranging from 1 Watt to 100 Watt, single-chip to multi-chip, and high flux to high CRI. The diversified product offering will cater to even the most challenging fixture designs.

Flash 2016

Recognizing the increase application of LED in mobile devices, Edison Opto offers compact SMT packaged, Flash2016, for camera flash application.

- *Type : Continuous/Pulse*
- *Flux : 50/105 lm*
- *I_F : 350/1000 mA*

New

New

High Power PLCC LED Series

- Watt : 1W
- Type : 5050 W/5050 RGB 3 in 1
- Flux(typ.) : 85lm/R-7.3 G-13.3 B-4.0lm
- I_F : 350mA/100 mA each die

Hot

Edixeon® A Series

- Watt : 1W
- Color : Cool White/Warm White
- Flux(typ.) : 110lm/75lm
- I_F : 350mA

Hot!

IP65

EdiStar Module Series

- Watt : 50W/100W
- Type : Circular/Ellipse
- Flux(typ.) : 3,000lm@50W
  5,500lm@100W
- I_F : 2,400mA@50W
  3,300mA@100W

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IP65-rated stainless-steel stanchions.

The desert climate of Abu Dhabi can reach 60°C in the summertime, creating problems for most light sources. Cooper said that the Enfis array/driver system was the only one that passed the rigorous environmental chamber trials. Enfis' technology provides the ability to control each LED array, as well as two-way communication with each driver/array combination providing real-time monitoring of fixture temperature, CCT and energy consumption. The Remote Desk Management (RDM) DMX control system was supplied by e:cue. ◄

MORE: www.ledsmagazine.com/news/6/11/2

MANUFACTURING

LG invests in LEDs

LG Group, one of Korea's largest display makers, plans to spend about 4 trillion won (about $3.34 billion) on a major plant for making liquid-crystal display (LCD) glass substrates and LEDs in Paju, Gyeonggi Province, Korea. The new, 840,000-square-meter manufacturing facility will begin producing LED components and materials in 2010, and LCD glass in 2012, and will be critical in LG's plans to exploit the sharply increasing demand for next-generation display and lighting technologies. LG Innotek, the company's LED subsidiary, will invest around 1 trillion won through 2012, and will use the new facility to produce LED BLUs and lighting components. The plant will eventually boost the company's production capabilities of LEDs by four times the current level with a focus on LED backlighting units for use in LCD televisions and monitors produced by LG Display. ◄

MORE: www.ledsmagazine.com/news/6/9/25

BUSINESS

Tyntek to acquire Ubilux

Tyntek Corp, a Taiwan-based LED chip maker, has obtained approval from its board to acquire Ubilux Optoelectronics Corp., the LED chip manufacturing arm of Powerchip Semiconductor Corp, Taiwan's second-largest computer memory chipmaker. The share-swap deal is worth about NT$2.81 billion (US$86.8 million). After the acquisition, Powerchip will become the biggest shareholder at Tyntek, and Tyntek will be the third largest LED chip maker in Taiwan, after Epistar Corp and Optotech Corp. The company has aggressive expansion plans and will increase the number of MOCVD systems to 30 units by the end of next year. ◄

MORE: www.ledsmagazine.com/news/6/10/24

OLEDS

Transparent low-profile OLED lighting panels

Osram Opto Semiconductors has developed prototype large, transparent OLED panels, that measure 17 × 17 cm^2 and have a luminous area of 210 cm^2. The panels are only a few hundred micrometers thick, and do not need separate encapsulation. The test samples were developed as part of the TOPAS research project funded by the Germany Ministry for Education and Research (BMBF). The aim of the project is

to produce 1 m^2 transparent OLED modules, and will run until 2011. Osram Opto says that in the OLED lighting market there is a clear demand for large, low-profile transparent light sources. The OLED panels can be made transparent due to new developments in electrode design and a new approach to thin-film technology. The current is distributed evenly over the active surface, which in turn leads to uniform luminance. Further development work will lead to an even thinner carrier material, and therefore to even thinner OLEDs. The new technology also simplifies the manufacturing process, whether OLEDs are produced on a small molecule or polymer basis. The next stage is to integrate the processes into a stable manufacturing operation. ◄

MORE: www.ledsmagazine.com/news/6/10/19

LICENSING

Acuity joins Philips LED luminaires licensing program

Another major lighting company, Acuity Brands Inc, has signed up for Philips' licensing program for LED-based luminaires. Acuity will gain access to Philips' patent portfolio for LED systems and controls. The deal covers worldwide sales of LED-based luminaires from all of Acuity's businesses. Acuity Brands is one of the world's leading providers of lighting fixtures and related products, with brands including Lithonia Lighting, Holophane, Peerless, Gotham and Mark Architectural Lighting. Philips has already signed licensing agreements with major players such as Osram and Zumtobel. ◄

MORE: www.ledsmagazine.com/news/6/10/21

LED PERFORMANCE

Lumileds publishes LM-80 data

Philips Lumileds is claiming to be the first power LED manufacturer to publicly publish LM-80 test report data, which describes the lumen maintenance characteristics of its white Luxeon Rebel LEDs. The report, available from its website, will be useful for luminaire manufacturers when evaluating the merits of using different LEDs for their SSL products. Lumileds is encouraging other LED makers to follow its lead. ◄

MORE: www.ledsmagazine.com/news/6/10/20

Correction:
Dialight installation

In our last issue we published an article written by Linear Technology (*LEDs Magazine*, Sept/Oct 2009, p. 49; www.ledsmagazine.com/features/6/10/9). Figure 2, which shows a refinery installation, as well as information in the section entitled "Industrial lighting," is taken without permission or acknowledgement from a case study published by Dialight (www.ledsmagazine.com/press/17997). The article also claims that a Linear IC was used in Dialight's fixtures. According to Dialight, Linear's IC is definitely not used in the luminaires pictured in Dialight's installation photo, nor are any Linear ICs used in any Dialight luminaires. *LEDs Magazine* apologizes to Dialight for publishing this material.

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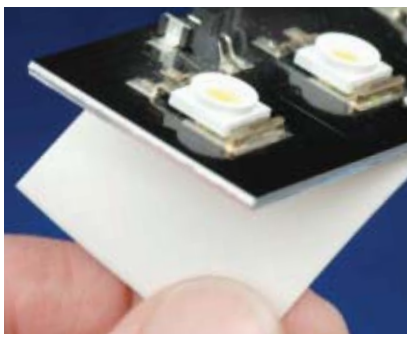

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EPA and DOE sign deal to end Energy Star Wars saga

At the end of September, the US Department of Energy (DOE) and the US Environmental Protection Agency (EPA) signed a partnership agreement that transfers the responsibilities for the Energy Star program, including solid-state lighting, from DOE to EPA. The original joint announcement (www.ledsmagazine.com/news/6/10/1) stated that the EPA would be brand manager and Agency lead for the Energy Star products program, while DOE will provide technical support in areas such as product testing and verification. The statement also resolved to develop an integrated approach to the Energy Star residential lighting program that recognizes the importance of both whole-fixture-based and light-source-based approaches for measuring lighting energy efficiency.

In mid-October, Jim Brodrick, lighting program manager for the DOE, said that it is still unclear whether the Energy Star SSL Program will continue as introduced by DOE, or if significant changes will be made by EPA (www.ledsmagazine.com/news/6/10/18). However, he said that, at the behest of the Next Generation Lighting Industry Alliance (NGLIA) and other industry stakeholders, an agreement has been reached with EPA to continue the criteria adoption process for outdoor lighting and replacement lamps.

Brodrick commented that Energy Star played "only a minor role" in the DOE's overall commercialization support efforts for SSL, which he stressed would continue. "We are in the process of expanding our Caliper, Gateway Demonstration, and Lighting Facts efforts as a way of broadening our commercialization support in an expanding industry. We will also be increasing stakeholder educational efforts, especially for those potential buyers not totally familiar with solid-state lighting," he said.

In early November, Alex Baker, Energy Star lighting program manager for the EPA, provided an update to Energy Star lighting manufacturing partners, energy efficiency program sponsors and stakeholders (www.ledsmagazine.com/news/6/11/5). Baker said that no later than November 30, 2009, DOE and EPA will release a more detailed proposal outlining anticipated Energy Star program enhancements for 2010, including a proposed approach for integrating various elements of the Energy Star lighting program.

"Among other things," said Baker's letter, "it is EPA's intention to streamline the qualification process and paperwork related to Energy Star qualification of lighting products, as part of the process of integrating potentially duplicative and overlapping specifications."

Baker also said that EPA intends to retain key elements of the DOE-developed Energy Star specifications for Solid State Lighting and Integral LED Lamps, including testing according to the IES LM-79 standard, as appropriate.

"The process to integrate the lighting specifications will be consistent with Energy Star Guiding Principles, and open to partner and stakeholder review through a series of public comment periods resulting in final version(s) that go into effect after sufficient transition time," said Baker's letter. "Until this task is complete, partners will continue to be able to qualify products using existing specifications and contracting support to the Energy Star program." ◄

Rogue lamp labels hit the shelves

In September, we reported that several Philips LED lamps were on sale in the USA with unauthorized versions of the Lighting Facts label on their packaging (www.ledsmagazine.com/news/6/9/21). The Lighting Facts label is part of the US Department of Energy's voluntary SSL Quality Advocates program, via which LED luminaire makers can "demonstrate their commitment to accurate and consistent reporting of product performance claims," to quote the DOE. Blaming an internal procedural error, Philips hurriedly joined the program and submitted the required performance data.

In October, it emerged that Osram Sylvania had also made its own Lighting Facts label for its 4W PAR16 LED lamp (www.ledsmagazine.com/news/6/10/14). This particular label lacks the standard portrait format and other features of the authorized version.

In between the Philips and Osram Sylvania incidents, the DOE commented on the Lighting Facts label program, saying that it will take "immediate action" to investigate any violations and insist on conformity with the program requirements. The DOE said anyone "who does not play by the rules" should expect to hear from DOE lawyers and the Federal Trade Commission. We have yet to hear of any outcome in this direction, but the DOE also correctly said that rogue labels undermine the very nature of the program, which is designed to protect the consumer from "getting burned" by products whose performance falls short of manufacturers' claims.

Equally important, but not covered by the Lighting Facts program, is the issue of invalid and inappropriate comparisons with existing technology. The Osram Sylvania 4W LED lamp is stated to be a replacement for a 25W lamp (of unspecified type). However, the LED lamp produces only 110 lumens—which would be pretty shoddy performance for any 25W lamp. ◄

Supply chain maps a path to bringing down the cost of LED lighting

Significant reductions could be achieved in the cost of producing LEDs, particularly if the supply chain can collaborate on an industry-wide roadmap, writes **PAULA DOE** of SEMI.

It should be possible to achieve about a 70% reduction in production costs for LED lighting by 2015. This was one conclusion reached by attendees at two US Department of Energy (DOE) workshops that looked at ways to improve solid-state lighting (SSL) manufacturing (see "SSL Manufacturing workshops"). A big part of that potential decline is projected to come from a reduction of about 85% in the cost of the packaged LED, which now accounts for some 40% of the cost of the luminaire.

However, achieving those aggressive potential reductions will likely depend, in part, on sector cooperation on an industry roadmap—and a realistic common-cost model—so those within the supply chain can figure out where to best focus their efforts. Such pre-competitive collaboration has been used effectively by the semiconductor and flat-panel display industries in the past to drive more rapid improvement in process technology.

DOE recently released an initial roadmap for HB-LED and OLED manufacturing technology. The roadmap is based on the stakeholder discussions at the workshops, and represents industry consensus on the expected evolution of SSL manufacturing, best practices, and opportunities for improvement and collaboration. "We came to some consensus on where the principal costs are, which gives us a better sense of what needs work," says Fred Welsh, Radcliffe Advisors, consultant to the DOE and one of the organizers.

DOE plans to update the roadmap next year, and also to continue work on developing a cost-of-ownership model, to better identify where the best gains from investments in improving manufacturing process would be. Such a model would allow the community to identify equipment and processes lying on the critical path and offer a more quantitative assessment of the beneficial cost impact of addressing each issue. The equipment and materials industry association SEMI, which has facilitated similar efforts in other sectors, also welcomes input on how it can best help support these efforts, says Tom Morrow, SEMI VP of global exhibitions and marketing.

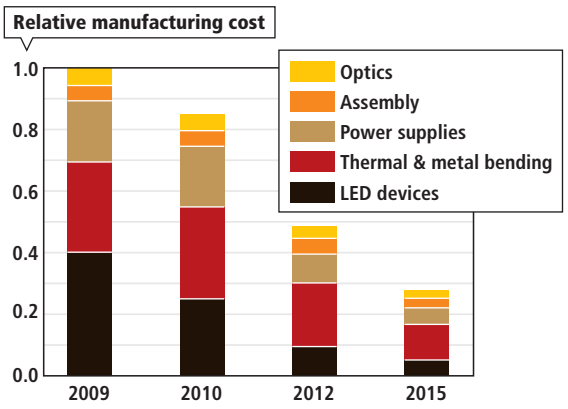

FIGURE 1. Projected luminaire cost, and potential for reduction. *Source: DOE Manufacturing Workshop.*

EQUIPMENT: Suppliers see 2–3x potential reductions

Semiconductor equipment makers say there are real options for making big improvements in process yields and productivity to bring down SSL costs, by applying learnings from other thin film manufacturing sectors and designing equipment specifically suited to this sector, with the kinds of process control and volume throughput that are now required.

"We think overall epitaxial processing cost has to come down 3×, and we see a path to be able to do that," says Jim Jenson, VP of marketing for the MOCVD business at Veeco Instruments, Inc. (Plainview, NY). He notes that progress has been made on improving the complex, multi-hour epitaxial process that grows most of the key device layers. This has included development of better uniformity and repeatability, optimized flow geometries, better temperature control, faster processing time, improved system architecture and optimized batch sizes, though it could take a few years for all these developments to get into high-volume production.

Another more radical option being considered by both established and potential new suppliers is to divide the epitaxial process into separate chambers, each optimized to the different requirements of the different layers. Typically this would use hydride vapor phase epitaxy (HVPE) for the thick GaN, though HVPE reactors will need to be made into high-volume tools. Oxford Instruments plc (Yatton, UK) recently announced the first multiwafer HVPE reactor (see www.ledsmagazine.com/press/18664).

Applied Materials, Inc. (Santa Clara, CA) reports it's making progress on possible MOCVD solutions as well. "We see techniques from IC processes used for decades that would apply," says Pat Lamey, strategic marketing and new business development for the energy and environmental solution

PAULA DOE *covers Emerging Markets for SEMI (www.semi.org), the global industry association serving the manufacturing supply chains for the microelectronic, display and PV industries.*

group. He notes that Applied's development focus is now getting feedback from customers, and is based on a combination of commonly used MOCVD processes and "some technology that's been written about for decades but never brought to production."

Lamey also says that better process control is key to improving overall LED yields and costs, because it's crucial to overall throughput and performance. "We're seeing a segment of the solid-state business with potential for significant improvement in the next half decade, and the sooner we can bring the production techniques and controls known from our other technologies and products, the faster it will move into the market place," says Lamey. "A roadmap will be particularly helpful, especially since the LED industry is transitioning from two-inch substrates to 100mm substrates."

Likely to propel the biggest jump in manufacturing productivity, however, could be the entry of some big silicon chip makers who are accustomed to doing very controlled production in very high volumes. "The customer base is evolving as new players from the IC industry enter the field," says Lamey. "Their entry will have a huge impact on manufacturing technology."

KLA-Tencor Corp. (Milpitas, CA) sees another potential 2× cost reduction from improvements in defect inspection and defect source analysis, says Richard Solarz, KLA-Tencor senior director of technology, as the LED industry currently lacks both appropriate inspection equipment to find the critical defects and efficient systems to figure out what's causing them. Tools developed to inspect finer features on silicon for the IC industry find a lot of defects that don't matter for LEDs, and can't find others that do. For example, they can't differentiate the problematic micropits or threading defects in sapphire from the particles that don't matter, and they can't bin the finished die by the qualities of interest. And laser-based bare wafer/film surface analysis tools in the front-end, developed for the hard-disk industry, can't talk to the image-based patterned-wafer inspection tool in the back-end, developed to inspect wafer-level chip packaging. This makes it difficult to quickly track defects back to their source.

"Now that we understand the key defect needs of many of the LED manufacturers, we have identified key changes we need to make in our tools to isolate these defects. And we need to overlay the defect maps from the tools," says Solarz. "Working with our customers, we believe that we can reduce manufacturing cost in many cases by as much as a factor of two." He sees other potential for improved yields, but only if the industry agrees on what is needed. One example, he notes, is the difference in opinion about the need for a color-quality monitor. "The answers range from solid 'yes' to solid

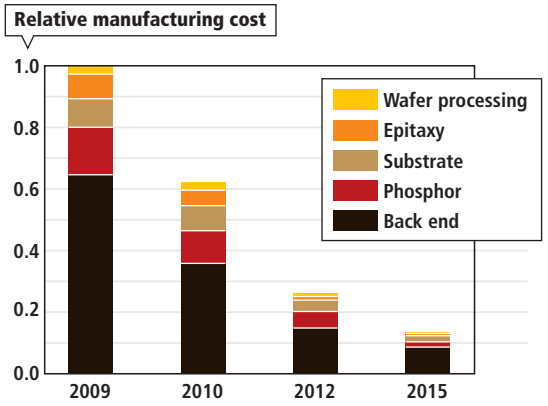

FIGURE 2. Projected packaged LED cost, and potential for reduction. *Source: DOE Manufacturing Workshop.*

SSL Manufacturing workshops

The DOE held two SSL Manufacturing workshops in 2009 (April 21–22 in Fairfax, VA, and June 24–25 in Vancouver, WA), as the start of a new initiative to enhance product consistency and quality, and to accelerate cost reductions through manufacturing improvements. More than 350 participants—chip makers, fixture and component manufacturers, and others—examined underlying issues related to materials, equipment, and other factors that influence SSL product quality and cost. The Fairfax workshop attendees identified key barriers and recommendations toward lower-cost, higher-quality SSL products, and a draft roadmap was reviewed at the Vancouver event. The final version of the roadmap represents industry consensus on the expected evolution of SSL manufacturing and is available at www.ssl.energy.gov/projects.html. ◄

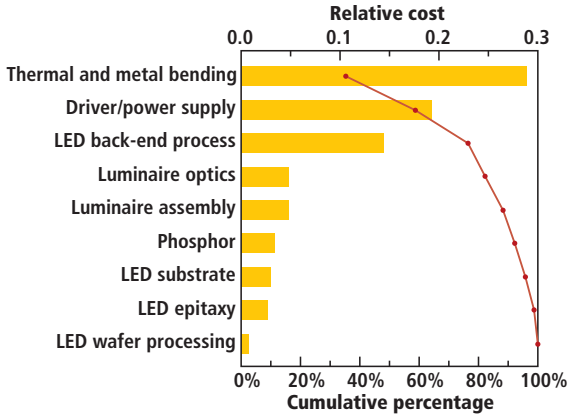

FIGURE 3. Pareto analysis of SSL manufacturing costs, projected for 2010.

'no,'" says Solarz. "People ask us for a custom tool, but if we knew everyone wanted one, we would build it."

Ultratech, Inc. (San Jose, CA) argues that there's also a clear path to a 2× reduction in lithography costs as well, by moving from mask aligners to 1× projection steppers with better yield and cost of ownership. The currently used proximity aligners start to have problems with focus and mask wear when dealing with larger wafers with more warp, argues CTO Andy Hawryluk. He notes that a 4-inch wafer typically has some 100 microns of warp, a 6-inch wafer perhaps 200 microns. So Ultratech is developing a new model of its 1× projection stepper based on an equipment platform originally used for power semiconductors, MEMS and thin-film heads, redesigned for the LED market, slated for introduction mid 2010. Designed specifically to deal with warped LED wafers, the tool can map and tilt the wafer to adjust the focus section by section, for improved yield.

EV Group (St. Florian, Austria) sees potential for improving LED efficiency by structuring the surface by nanoimprint to extract more light. Most producers are exploring the technology, reports Paul Lindner, executive technology director, though the technology is still in development, with cost of materials and throughput remaining concerns.

Wafer-level optics or packaging could also help bring down costs significantly. "With larger wafers, wafer-level packaging becomes more interesting," says Lindner, noting that 6-inch wafers are coming. "We are looking very carefully at this." If even one of the wafers were high yield, and costs were low, a wafer-level bonding process with singulation and binning at the end could be effective. Wafer-level processes for imprinting optical lenses on top of the light, based on technology developed for CMOS image sensors, might also be possible.

LED folks, meanwhile, caution the silicon guys that LEDs are an alternative universe in which core silicon assumptions about device scaling, wafer size, yield management, and automation don't necessarily apply. "If you're a CMOS guy, the first thing you should do is forget everything you know," jokes Robert Walker, principal at Sierra Ventures, noting a list of differences. For example, with some exceptions, the typical high-power LED is going to stay a single diode at sizes around 1 mm^2. Larger wafer diameters are only of modest importance when the bottleneck MOCVD chamber already produces large batches of smaller wafers.

MATERIALS: Suppliers see lower costs from larger wafers, surface treatments

Suppliers report that most of the big-name LCD makers that are now ramping toward volume production of HB-LED backlights for their own internal use are starting on 4-inch sapphire wafers instead of the more widely used 2-inch substrates, and are looking seriously at 6-inch within the next two to three years. Epitaxy reactor-chamber layout can be easily converted to take about a dozen 4-inch wafers instead of 40-plus 2-inch wafers. This will lead to some gains in yield from reducing the total edge area that's more subject to defects, but the larger gains come from just less handling of so many little parts in the rest of the process flow.

Adoption of 4-inch sapphire wafers will be widespread in 2010, reports Sunil Pahtak, VP of engineering with Rubicon Technology (Franklin Park, IL), who notes that 6-inch wafers are already in pilot volumes, will start production in 2010, and see widespread adoption by 2011–2012. Rubicon has shipped more than 30,000 epi-polished 6-inch substrates in the last two years. Prices for the larger wafers have looked daunting, compared to the $10 or so for 2-inch sapphire, but suppliers argue that higher volumes, and some sector agreement on standard specifications, should help bring down costs.

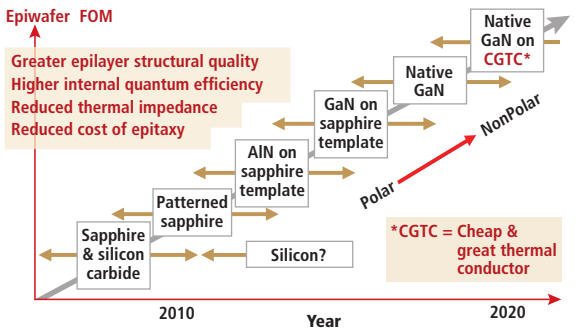

FIGURE 4. Nitride LED substrate trend prediction. *Source: Kyma Technologies.*

The next likely option is some sort of surface treatment of the sapphire to improve epi yields, or even putting the first GaN layers on the substrate separately. Better performance and better yields demands lower defect densities, requiring some solution for reducing the lattice and thermal mismatch between the substrate and the LED layers. "Bulk GaN gives a huge advantage in performance," says Keith Evans, CEO of Kyma

LINKS

Semiconductor supply chain sees big potential for cost reductions in LED manufacturing
www.ledsmagazine.com/features/6/6/9

High-efficiency lighting needs high-efficiency manufacturing Modern LED manufacturing facilities benefit from sophisticated planning and design tools, and consideration of "reduce, reuse, and recycle" options, such as the conversion of existing semiconductor facilities. This enables projects to be completed faster, with minimized environmental impact, and with an improved bottom line, writes Don Carkner, Principal Technologist with CH2M HILL, Portland, Oregon.
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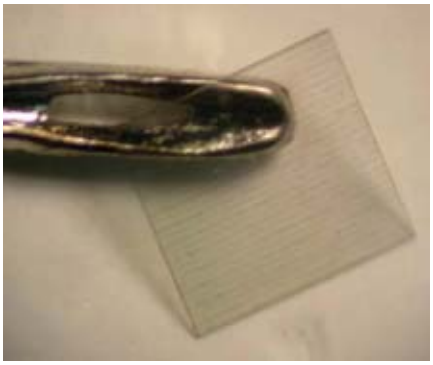

FIGURE 5. Freestanding GaN foil. (*Courtesy of Goldeneye*)

Technologies (Raleigh, NC). "But the world doesn't have much experience in making it, so we're still coming down the volume learning curve. But in the meantime there's a driving force for an intermediate solution."

The first intermediate solution now apparently getting a serious look is patterned sapphire. Texturizing the surface with different schemes of wet or dry etch improves the quality of the epi layers grown on top, for better light extraction efficiency, though why this works and how best to do it remain to be worked out. Also a possibility is adding an aluminum nitride (AlN) layer on top of the patterned sapphire, with initial results reportedly showing increased brightness and wavelength uniformity. "We strongly suspect this may bring down costs too," says Evans, "since it can eliminate some of the MOCVD steps." The AlN-coated sapphire can be ramped more quickly to the appropriate temperature and needs no buffer layer, so the epi process can skip straight to high-temperature deposition of the GaN, improving throughput of the reactor. Deliveries of these substrates are expected in 2010.

Then there's the more radical alternative of putting a GaN surface on the sapphire, then taking away the sapphire and using just the freestanding GaN foil alone as the substrate for growing the LED layers. Goldeneye (Carlsbad, CA) grows a 30-micron layer of GaN by HVPE, then removes it by laser lift-off. These thin GaN foils measuring a centimeter square (see Fig. 5) can be very quickly ramped to growth temperature and cooled back down, allowing an epi growth cycle as fast as 30 minutes, claims Scott Zimmerman, Goldeneye VP of technology. The company has just taken delivery of its first reactor redesigned specifically for this kind of rapid cycling.

The European semiconductor research consortium IMEC, meanwhile, is working on controlling thermal mismatch of GaN grown on silicon, by monitoring the growth in situ and doing careful stress engineering. "GaN on Si is the option that offers the best cost reduction possibilities in the end compared to any other choice," argues Marianne Germain, GaN program manager for IMEC. "Si is the only substrate that allows for large wafer diameters and lower substrate cost." IMEC claims to have reduced defects to about the same level as on sapphire, by using several intermediate layers of AlGaN and silicon nitride (SiN) between the Si and the GaN.

Connectors: the vital link fo

Taking the time to select the correct connector technology for a specific lighting technology can pay dividends, writes **RONALD WEBER.**

Solid-state lighting technology, in particular using high-power LEDs, is quickly entering the lighting mainstream. Connectors play a pivotal—yet often neglected—role in these new lighting applications, and connector selection needs to be given the same thought and consideration as is given to thermal, optical, and electrical issues at the early design stage. Selecting the best connector for a lighting application is a matter of matching application requirements to available connectors, with proper consideration given to performance and costs.

Connectors and solid-state lighting

Our concern here is with connector technology and the ways it can help (or hinder) making lighting more affordable and easier to apply and use. Connectors remain a critical part of a lighting system, but are often left to the end of the development cycle. This lack of foresight can result in fewer choices and higher costs (including cost of materials, cost of assembly, and cost of upkeep). Integrating connector selection into early design phases opens options, gives more choice, and often lowers costs.

Not only is it important to consider connectors early in the design to gain the widest array of options, it's equally important to understand some of the basics of connector technology to allow informed decisions about various options and tradeoffs. The connectors shown in Fig. 1, for example, are low-profile, surface-mount (SMT), two-position connectors designed for use in PCB-based LED strings, lighting controls, and other applications that can benefit from an easy poke-in wire termination to the PCB. The connector speeds assembly and routine maintenance of lighting systems through an application-specific design.

The basic connector consists of a housing and contacts used to create a separable electromechanical interface. The physical elements common to all connectors (see Fig. 2) are the housing design and material, the contact design and material, and the contact plating system. Depending on its design, the basic connector can be used for wire-to-wire, board-to-board, and wire-to-device/board connections.

Contact basics

The purpose of the contact interface is to establish and maintain a reliable, yet separable low-resistance connection. Electrically, the contact exerts a spring force to achieve the normal force required to achieve the low resistance. Mechanically, the contact must exert sufficient spring force to maintain normal forces over the life of the specific application. It must accommodate vibrations and other mechanical and environmental disturbances to maintain a long-term, stable, and reliable interface.

The design of the contact interface and bulk contact must be properly selected to stay cool for the rated current it will carry. To keep the interface resistance low, the contact's surface must resist the formation of nonconductive films, corrosion, and other effects. Plating over the base material guards against corrosion and other environmental deterioration. While spring properties and

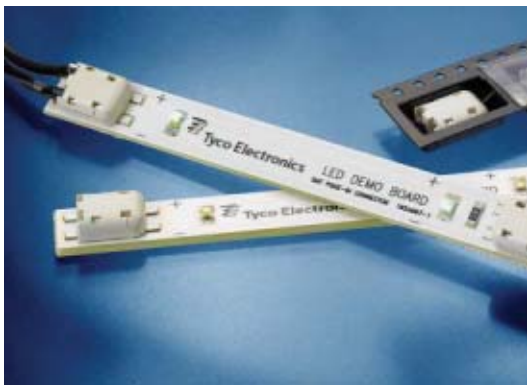

FIGURE 1. Connectors specifically designed for LED applications can lower design and assembly costs.

normal force are mainly a function of the base contact material, they work in conjunction with the plating system to provide an electrically stable connector.

Contact materials and platings

The contacts used in a connector system are at the heart of what makes a connector work. Proper material selection for the end application is always challenging as it is a compromise between cost, mechanical performance, electrical performance, and physical size constraints. Most contacts use a copper alloy of some sort, with brass arguably the most common material. Contact platings can be broadly categorized into two groups: noble pure gold or gold alloy and non-noble materials. Noble platings such as pure gold or gold alloy do not corrode or oxidize, while non-noble platings—typically tin, nickel, and silver—are subject to corrosion under the right conditions. A more detailed discussion of contact materials and platings can be found in the longer version of this article (see www.tycoelectronics.com/products/lighting).

Electrical concerns

The two most fundamental electrical criteria for any connector system are the voltage and current level. Traditionally, anything 1 amp or less and under 10°C temperature

RONALD WEBER *is the Global Technical Market Manager, Lighting with Tyco Electronics* (www.tycoelectronics.com/lighting).

r lighting system design

rise is considered a signal connector. Due to tight contact spacings, signal connectors are not well suited to higher voltage applications (typically above 48 volts). Although signal contacts have an inherent low-current rating, higher currents can be carried through these connectors by using multiple contact positions in parallel; however, the manufacturer should be contacted to obtain the appropriate derating factors for the contacts when paralleled. Similarly, higher voltage ratings are sometimes obtained by skip-loading contacts i.e. populating every third or fourth contact position to increase the distance between contacts.

Power contacts can be characterized as having current ratings greater than 1 amp and greater than 10°C temperature rise in use. Power connectors are typically larger and have fewer contacts since adequate contact material is needed to carry current without significant joule heating of the contact body. Multiple contact interface points are desirable since they provide parallel paths that serve to minimize interface resistance and decrease joule heating at the interface. Since power contacts sometimes

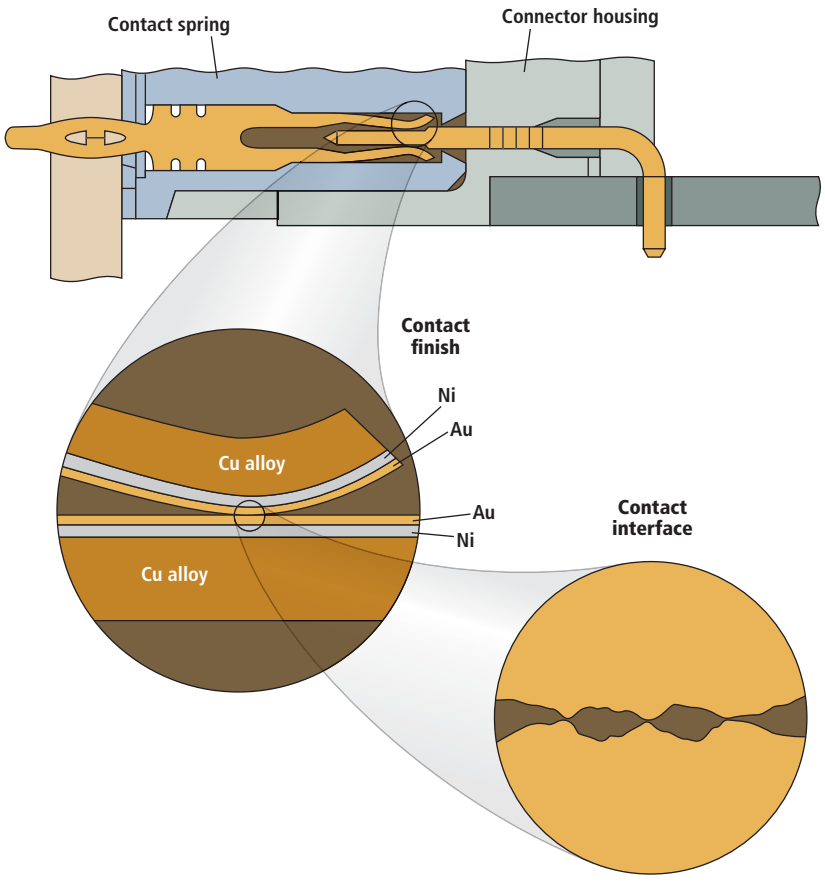

FIGURE 2. A separable connection includes a housing, contact, and contact plating.

Number	Protection Against	
	1st Digit	2nd Digit
0	No special protection	No special protection
1	Objects greater than 50 mm in diameter; hands and other large body parts	Dripping water
2	Objects greater than 12.5 mm in diameter; fingers	Vertically dripping water
3	Objects greater than 2.5 mm in diameter	Sprayed water
4	Objects greater than 1.0 mm in diameter	Splashed water
5	Dust sufficient to interfere with operation of the equipment	Water projected from a nozzle
6	All dust (dust tight)	Heavy seas or powerful jets of water
7		Immersion
8		Complete, continuous submersion in water

FIGURE 3. IP sealing levels. EN 60529 outlines an international classification system for the sealing effectiveness against both objects (tools, dust, fingers) and moisture. This classification system uses the letters IP (for *Ingress Protection*) followed by two digits. The first digit refers to protection from physical objects; the second digit deals with moisture. Most unsealed connector systems, therefore, have an inherent IP20 rating.

operate at higher voltages, contacts are spaced further apart to meet agency separation requirements.

Housings and environmental concerns

The connector housing provides a number of very important functions. Fundamentally, the housing provides environmental protection and electrical insulation between adjacent contacts and between the contact and the outside world. This insulation is usually verified and stated as a voltage in the Dielectric Withstand Voltage (DWV) rating for the connector.

A properly-designed housing holds the contacts in one half of a connector in correct relationship with the contacts in the mating half to provide trouble-free mating and unmating. It also fixes the spacing between contacts and defines the creep (electrical tracking distance over surfaces) and clearance (linear "line-of-sight" distance) between contacts.

The environmental protection provided by the housing can prevent contaminants (both solid and liquid) from getting into the connector interface, and also prevents inadvertent physical contact with the electrical contacts. The connector's level of sealing typically adheres to the well-recognized IP levels (see Fig. 3). When dealing with elevated voltages (usually above 48 volts), most safety standards require design features to prevent accidental physical contact with the electrical contact. In this case, contacts are recessed to some extent and often shrouded as a mechanical barrier to contact.

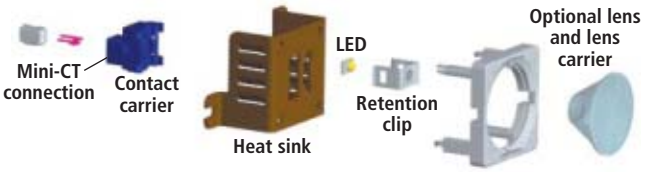

FIGURE 4. High-intensity LED holder combines thermal, mechanical, and electrical management into a single, easy-to-use system.

Choosing a connector

Electrical, mechanical, and environmental performance requirements must be identified and considered to select the best connector for an application. Electrically, the connector must be compatible with the continuous levels of current and voltage. In addition, transient and surge conditions that may occur over the life of the product need to be identified.

Mechanical considerations include form-factor issues such as physical size, mating direction, and how the connectors are held together after mating. The connector must also be evaluated for the degree in which it can withstand mechanical abuse, such as vibration, shock, and the like.

Environmentally, the connector must withstand both application temperature ranges and processing temperatures (such

as those experienced during reflow soldering of surface-mount connectors). The application environment will define additional needs, such as sealing, ability to withstand solvents or salt spray, high altitudes, or other extremes. In outdoor applications, UV exposure capability is critical to reliable, long-term connector performance.

Thermal considerations

While signal applications typically do not require thermal management, power contacts have a maximum current rating, usually based on a 30°C temperature rise on the contact. In high-intensity LED applications, the LEDs themselves generate enough heat to require careful consideration to thermal management. Integrating thermal management into a system often poses unique system packaging challenges since most of the new high-intensity LEDs are small and are often packaged as surface-mount devices (SMD). Integrating the connector system in among the LEDs, circuit boards, optics and thermal devices is often quite challenging if left to the end of the design process. Early evaluation of the interconnect options provides for a more tightly integrated, optimized solution that can make assembly and, if needed, repair much more efficient.

New interconnections must also address the special needs of solid-state lighting, including higher operating temperatures and the ability to provide housings in specific colors so the connector blends into the visible parts of the lighting designer's fixture. It is often very desirable to use circuit board-mounted connectors with softened edges to minimize shadowing and the possibility of partially occluding the light output of the low-profile surface-mount LEDs.

The next step in connectors

Current LED lighting design methodology usually incorporates one or more LEDs onto a circuit board, usually metal-clad for thermal reasons, since it is well known that LEDs perform better when operating at lower temperatures. This assembly is then integrated into the lighting fixture. However, throwing out conventional logic that mandates a circuit board in the system, one could combine a heat sink into the electromechanical design of the connector to create a thermoelectric connector that mates directly to the LED.

An example is the high-intensity LED holder that Tyco Electronics designed for use with a high-intensity LED (see Fig. 4). The holder combines a small footprint and low profile with a snap-together contact system for both direct electrical and thermal connections directly to the LED. Without the need for solder, thermal adhesives, or metal-clad PCBs, application is simple, cost effective, and expands mounting options beyond the planar constraints of circuit boards. As an added benefit, replacement of a faulty

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LED or changing colors is equally straightforward since all it entails is removing the retention clip, removing the LED, and replacing it with a new one. The basic holder kit includes a contact carrier and an LED retention clip used to secure the LED to the carrier. The module-to-cable interface is a standard two-position Tyco Electronics' Mini CT post and receptacle connection that further facilitates plug-and-play operation.

Standards and approvals

Naturally, any connector must meet agency requirements for any region of the world in which it is used. Regulatory agencies like UL and CSA in North America and IEC, TUV, and VDE in Europe have requirements to provide for safe application of a product. Selecting components that have already gone through the approval process speeds design and simplifies approval of the final product. Given the global nature of the lighting market, the designer must confirm components meet all regional or local requirements. Being cognizant of the connector agency requirements, as well as those needed by the end application, is critical to the successful selection and integration of the appropriate connector system.

Cost

The acquisition cost of the connector is one thing, yet applied cost is quite another. Newer generations of application-specific connectors for lighting can reduce the cost of engineering, manufacturing, warranty and maintenance. One key to realizing these savings is to understand connector basics and to integrate connector selection into the overall design process.

New solid-state lighting systems with their inherent longevity demand equally robust connector systems. The LEDs, thermal solution, optics, and packaging comprise a considerable part of the overall cost of the lighting system. The connector is usually a small part of the overall cost and is often specified without adequate consideration and balancing of cost versus performance. It makes little sense to scrimp on the one component that your entire fixture relies on for power. Without a reliable and appropriate connector system, the lighting fixture, however well designed and esthetically pleasing it is, becomes a dull, static (and unlit) non-functional object d'art.

A checklist of requirements can be useful when selecting a connector. The full text of this article includes a detailed checklist (see www.tycoelectronics.com/products/lighting). Keep in mind that connector manufacturers typically have product specifications as well as application specifications available, so be sure to ask the supplier for help in your selection process. Spend some time and consideration selecting the appropriate proven connector system for the application, even if it costs a little more. It will pay dividends in the long run.

conferences | JAPAN & CHINA

Strategically Speaking: Recent conferences in Asia highlight LED industry progress

Two recent LED conferences—one in Japan and the other in China—illustrate how the LED industry continues to move forward, even in the midst of a worldwide recession that has caused substantial downturns in other industries, writes **BOB STEELE**.

LED Japan/Strategies in Light, organized by Strategies Unlimited and PennWell, was held in Yokohama on September 16-17. The most pleasant surprise at this event was the growth in attendance over last year's event, held in October in Tokyo. Total attendance (including the conference and associated exhibits) nearly doubled, from 2,700 in 2008 to 5,300 in 2009. Likewise the number of exhibitors increased from 45 to 67 (more details at www.ledsmagazine.com/news/6/10/3). This occurred in a year in which the GDP of Japan declined in the first half by 7.95% from 2008. Clearly something interesting is happening to attract this kind of attendance in a very depressed economic environment.

Although Japan has long been a major center of HB LED component manufacturing (accounting for 44% of world supply in 2008), it is a relative latecomer in the adoption of LED lighting, compared to, say, the US, Europe and China. However, that situation is beginning to change, as a number of major (and many smaller) companies in Japan enter the market with well-engineered and well-designed lighting products.

The LED lighting pioneer in Japan has been Panasonic Electric Works (formerly known as Matsushita Electric Works), a well-established supplier of lighting products. The company introduced its first LED lighting products several years ago, and in 2009 is still the largest supplier. More recently Toshiba Lighting and Sharp have entered the market with a wide variety of LED luminaire products as well as replacement lamps.

Regarding the latter, it seems that these companies are beginning to target the consumer market (in addition to the professional lighting market, which is the focus of most LED lighting suppliers at present). In Akihabara, the Tokyo electronics retail district, a large number of shops prominently display retrofit lamps from Sharp and Toshiba, claiming light output equivalent to 40W and 60W incandescent lamps. Retail prices are in the neighborhood of $40.

Other Japanese companies active in the LED lighting market including Ushio, one of the country's largest lamp manufacturers, as well as Odelic, Daiko Electric, Yamada Shomei, Yamagiwa, Iwasaki Electronics, and several others that are just beginning to enter the market in 2009.

As a country with high electricity prices, as well as a strong focus on energy efficiency and the need for reduction in greenhouse gas emissions, it is not surprising that Japan has begun the move to solid-state lighting in earnest. Because the country already has wide adoption of highly efficient fluorescent lighting, it is understandable that it has waited until the efficiency of LEDs has reached the point where they are competitive with fluorescent sources to begin the adoption of LED lighting.

There are a number of regulatory moves under way to promote the adoption of LED lighting, although the details are not yet clear (at least to an outsider). The focus is on facilities that use lighting on a 24-hour-per-day basis, such as factories, convenience stores, gas stations, and the like. As one example, a Lawson's convenience store in central Tokyo has converted all of its overhead fluorescent lighting to LEDs.

ChinaSSL

The 6th China International Forum on Solid-State Lighting (ChinaSSL 2009), held in Shenzhen on October 14-16, showed similar attendance trends to LED Japan. Attendance increased from 621 in 2008 to 1,087 in 2009. Organized by the China Solid-State Lighting Alliance (CSA), and supported by the China Illuminating Engineering Society, the China Association of Lighting Industry, and the Ministry of Science and Technology, among other organizations and government ministries, this is arguably the most important LED-related conference among the many held in China each year.

China's enthusiasm for solid-state lighting seems to only increase from year to year. A steady stream of new companies is entering the market, at all levels of the supply chain, from epitaxy and chips to lighting fixtures,

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Panasonic has introduced the Everleds range of replacement LED lamps.

mostly funded by private investment, but with some government support as well.

The most recent statistics, reported by Wu Ling, General Secretary of the CSA, and others at the conference, there are now more than 1,000 LED packaging companies in China (although many of them are very small, with more than 80% of them having investment of less than RMB 10 million (US$1.4 million). Perhaps more surprising is the number of epitaxy and chip companies, estimated to number more than 60 by the end of 2009.

Equally impressive is the figure of approximately 240 MOCVD reactors expected to be installed (or at least on order) by the end of 2009. However, looking at the number of epi/chip companies relative to the number of reactors results in a figure of approximately four reactors per company. Compared with the more massive reactor populations installed or planned by competitors in the US, Europe, or elsewhere in Asia, it seems likely that some consolidation among the various Chinese chip companies will be required to achieve economies of scale and to refine large-volume manufacturing processes, as has happened over the past few years in Taiwan.

In addition to the chip and packaging companies, there are also several thousand LED application companies in China. The exact number is hard to determine, and in fact it is growing on a weekly basis. According to CSA data, the total LED applications revenue in China in 2008 was RMB 45 billion (US$ 6.5 billion), up 50% over 2007, with the largest applications being architectural lighting and display.

In addition to this domestic market, Chinese system companies are also active in production for the export market as well. This provides and important market opportunity for foreign HB LED suppliers, as the Chinese exporters are becoming more sensitive to quality, especially for lighting products, and thus many of them are using imported LEDs from Cree, Lumileds, Osram and other foreign suppliers to achieve performance and reliability levels that are not available from domestic LED manufacturers.

LED streetlights continue to be a focus of the Chinese national solid-state lighting effort. In the past, individual cities have taken the lead, installing many thousands of streetlights per city in a number of cases (the best estimate of the cumulative total through the end of September 2009 is 200,000). Vendors were usually chosen from the local region, and product quality was often poor, with many early failures reported.

A new streetlight program, initiated at the national level, will involve 21 cities, each of which is expected to install at least 10,000 LED streetlights. There will be a much greater emphasis on quality, and performance standards will have to be met as part of the bidding process. While in the past suppliers were all based in mainland China, in the new program bidding will be open to suppliers from Taiwan as well.

The total potential number of streetlights that could be installed under this program could be up to 1 million. However, the timeframe over which this could happen is still uncertain. At this point the program is still in the discussion phase, and no installations have yet taken place. In the meantime, many cities continue to install LED streetlights on their own, and a dozen others are clamoring to join the program.

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Outdoor LED lighting benefits from PG&E efforts, but health concerns are surfacing

The California utility PG&E has added LED lighting to its rate schedule, but people are starting to discuss whether cool-white lighting is a great idea. **BRIAN OWEN** and **TIM WHITAKER** report.

A significant obstacle to the adoption of LED street lighting has been overcome through the efforts of Pacific Gas & Electric (PG&E), the California-based utility. PG&E has removed a major roadblock for roadway lighting in its new rate schedule, which recognizes and acknowledges the financial benefits of LED technology. The Electric Schedule "LS-2 – Customer-Owned Street and Highway Lighting" (see www.pge.com/tariffs/ers.shtml) lists the rates charged by PG&E for different lamp types, and is the sum of the facility charge and the energy charge. Monthly facility charges include the costs of owning, operating and maintaining the various lamp types and size. Crucially, because LS-2 now lists LEDs at a separate lamp type, it reflects the energy savings of LED compared to other lighting technologies. LS-2 is applicable to lighting installations which illuminate streets, highways, and other outdoor ways and places where the customer is a governmental agency and owns the lighting fixtures, poles and interconnecting circuits.

Although LS-2 was effective May 1, 2009, there was no mention of it at September's IES Street and Area Lighting Conference (SALC), where the announcement would have surely captured the attention of all in attendance, since everyone in the industry has recognized this as a major barrier. PG&E leadership has set an example for utilities across North America and created a path for municipalities to follow. It also offers a vehicle for dialogue and discussion in dealing with their local utility when considering LED street lighting, especially when attempting to derive the associated financial benefits that demonstrate that LED makes "financial sense" in order to develop a realistic payback scenario.

Mary Matteson Bryan, lighting portfolio manager for PG&E's Emerging Technologies (ET) group, explained to *LEDs Magazine* how the new schedule was developed: "As part of PG&E's Customer Energy Efficiency department, the ET group performed a number of assessments of LED street lighting from 2007 to 2009. Evaluations of energy savings and lighting performance were positive.

"In a collaborative effort between PG&E's ET group, its Lighting Energy Efficiency program staff, and the PG&E Street and Area Lighting group, PG&E began efforts to incorporate LED street lighting as a product offering to customers. In the summer of 2008, the team started strategizing on how to develop a tariff for customer-owned LED street lights. Street lights are billed a flat monthly fee based on the lamp size and wattage and an assumed 11 hours per night of operation.

"The initial issue identified was that LED street lights do not come in standard wattages or sizes. The team developed the idea to use 'wattage categories' for the LED streetlights (for instance 50–55W category). The next issue was how to validate the power (watts) of the street light in order to assign it to the correct rate schedule category. The ET team identified the recently adopted IESNA LM-79 test procedure as a means of providing a consistent, verifiable method for measuring the power of the entire LED streetlight fixture for use in assigning to a rate schedule category.

"With these basic parameters, the LED Street and Area Lighting group developed the detailed wattage categories and monthly billing rates for amendment to the current rate schedule. The rates were subsequently approved by the California Public Utilities Commission (CPUC)."

An evaluation study of solar-powered, LED-based outdoor luminaires by the Lighting Research Center showed positive results. More: www.ledsmagazine.com/news/6/10/4.

Dark-Sky says boo to blue light

The rapidly expanding use of bluish-white outdoor lighting threatens visibility at

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night and jeopardizes the nocturnal environment worldwide, according to a statement (www.ledsmagazine.com/news/6/10/8) released by the International Dark-Sky Association (IDA).

The statement says that developers of light sources should be required to refine their products to limit blue-light emission at wavelengths shorter than 500 nm. The IDA also discourages the use of bluish-white lamp sources with a correlated color temperature above 3000 K. The IDA is a US-based not-for-profit organization aiming to preserve and protect the night-time environment through environmentally responsible outdoor lighting.

The advisory notes that the "laudable" demand for energy-efficient lighting has resulted in a new generation of electric light sources such as LEDs and induction lamps that emit a cold, bluish-white light. Although LED lighting is mentioned specifically, LEDs Magazine was told by Peter Strasser, IDA managing director, that IDA is not taking an adverse position toward any specific technology.

IDA states that the bluish-white light can have significant environmental impact, causing light pollution and sky glow, as well as glare and the compromising of human vision in the aging eye. "In addition, blue light has a greater tendency to affect living organisms through disruption of their biological processes that rely upon natural cycles of daylight and darkness, such as the circadian rhythm," says the statement.

IDA published a graph showing the photopic sensitivity curve of the human eye, which peaks at 555 nm. Light in the blue portion of the color spectrum below 500 nm, such as that produced by a phosphor-converted "blue-rich" LED, has a limited usefulness to the human eye. This blue light also falls within the circadian-rhythm sensitivity curve, which peaks at around 470 nm. (It is important to note that the human eye uses scotopic vision under low-light conditions, and mesopic vision in intermediate conditions. The peak sensitivity for scotopic vision occurs at around 520 nm.)

The IDA claims that some manufacturers and government agencies are "misrepresenting the visual effectiveness of these bluish-white light sources, and the environmental impacts are not being considered." Because of this, the IDA is encouraging government and other concerned parties to support additional scientific research on this subject, stating "Research will help to understand fully the impact of bluish-white light, and guide the evolution of lighting technology to protect human health and the nocturnal environment while providing safe and efficient outdoor lighting." An IDA white paper on this subject is expected soon.

LRC's Unified System of Photometry

Researchers at the Lighting Research Center (LRC), Troy, NY, have demonstrated in multiple field tests that, by using what they describe as a Unified System of Photometry, a street lighting system can be designed to reduce

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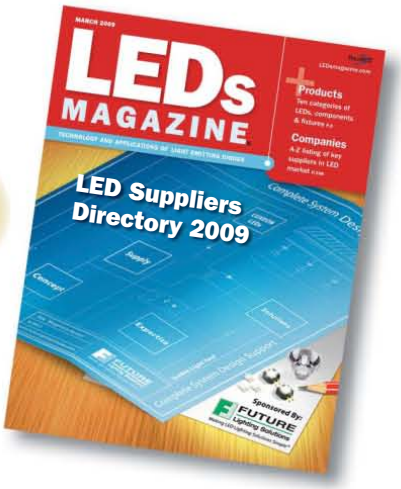

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energy use while maintaining or improving perceptions of visibility, safety, and security.

The Unified System of Photometry provides an objective method for optimizing the spectrum of a light source, while minimizing energy use and at the same time maintaining good visibility. The system was designed to characterize light at any level, including the mesopic level where both rods and cones operate (see below).

"In nighttime conditions, the human eye is more sensitive to short-wavelength light," said LRC Director of Energy Programs Peter Morante. "By replacing traditional, yellowish high-pressure sodium (HPS) lights with 'cool' white light sources, such as induction, fluorescent, ceramic metal halide, or LEDs, we can actually reduce the amount of electric power used for lighting while maintaining or even improving visibility in nighttime conditions."

The eye has two types of visual receptors in the retina, namely cones and rods. The current system of photometry—the measurement of visible light in terms of human perception—

A recent scientific paper confirmed that exposure to a low level of blue light can be as effective in treating symptoms such as mood swings and low energy levels as exposure to the intense bright white light that is used in traditional light therapy. This enables the use of smaller, portable, LED-based devices, such as this Philips product. More: www.ledsmagazine.com/press/20343.

is based on how different cones respond to different wavelengths. Cones are the dominant visual receptor under photopic (daylight) lighting conditions, while rods function primarily under very dim (scotopic) conditions.

According to Morante, it is necessary to redefine the luminous efficacy functions needed for nighttime applications where electric lighting is used, and both rods and cones contribute to vision (mesopic conditions). The LRC's Unified System of Photometry was designed to characterize light at any level, including the mesopic level.

LRC Director Mark Rea says researchers around the world are also concluding that the current system of photometry could use some updating to better characterize light source performance under nighttime conditions. Rea says that the International Commission on Illumination (CIE) will be releasing its own form of unified photometry for outdoor lighting. See www.ledsmagazine.com/news/6/11/8 for more references on this subject.

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Navigating the product safety certification process for solid-state lighting products

With proper planning, it is possible to efficiently navigate the testing and certification waters and launch high-quality LED products into the rapidly changing lighting market, writes **TODD STRAKA**.

Product safety compliance is a legal requirement worldwide, and is a necessity when introducing new solid-state lighting products into different markets. In the USA, according to the requirements of the Occupational Safety & Health Administration (OSHA), electronic equipment is deemed to be safe for use in the workplace if it is listed by a Nationally Recognized Testing Laboratory (NRTL; see www.osha.gov/dts/otpca/nrtl/index.html). NRTLs are qualified, third-party organizations that meet the requirements mandated by OSHA under 29 CFR section 1910.7 to perform independent safety testing and product certification.

The process of conducting product certification can be broken down into several steps. First, a review of the product's construction and design is performed, which includes careful evaluation of specific product information, including the bill of materials, applicable ratings of the individual components and materials, product design drawings, and spacing and dimensional requirements. From the review of all submitted information, it is then possible to determine the appropriate testing that will be required to sufficiently satisfy the requirements stated in the applicable standard(s).

Next comes the actual product testing phase, which is performed in accordance with the requirements of the applicable standard(s). Such tests may include temperature, electrical, dielectric, strain relief, environmental (wet location), and mechanical tests, among others. Step three includes the creation and issuance of the formal test report and "authorization to mark" (ATM), which grants the manufacturer permission to label the product with the applicable safety mark from an NRTL (an example would be the ETL Listed mark from Intertek).

Finally, the manufacturer must agree to participate in the NRTL's follow-up services program. This typically involves an initial audit of the manufacturing facility, as well as periodic manufacturing facility inspections to ensure consistent design, production, and labeling of the product. It is also necessary to maintain and update files to remain current with the latest revision of the applicable standards.

Standard	Product Type
Fixed Luminaires	
UL 1598 CSA C22.2 # 250	Luminaires
UL 1573	Stage & studio lighting
UL 1574	Track lighting
Portable Luminaires	
UL 153	Portable electric lamps
UL 1993	Self-ballasted lamps and lamp adapters
Specialty Luminaires	
UL 48	Electric signs
UL 676	Underwater lighting fixtures
UL 844	Fixtures for use in hazardous locations
UL 924	Emergency lighting and power equipment
UL 1786	Nightlights
UL 1838	Low-voltage landscape lighting systems
UL 1994	Low-level path marking and lighting systems
UL 2108	Low-voltage lighting systems
UL 2388	Flexible lighting products
Power Supplies	
UL 1012	Power units other than Class 2
UL 1310	Class 2 power units

These product safety standards still apply for LED lighting, but evaluations are now conducted incorporating UL 8750 – Safety Standard for LED Lighting.

Product safety standards

Existing lighting safety standards still apply for LED lighting, but evaluations are now conducted incorporating UL 8750 Safety Standard for LED Lighting. The requirements found in UL 8750 are intended to supplement those found in the existing standards that relate to lighting (see table). For example, UL 1993 covers self-ballasted lamps and lamp adapters, and now includes replacement LED lamps. The third edition, published in August 2009, added requirements covering LED driver circuitry, and added requirements and limits for LED light sources. UL 1993 is now harmonized with ANCE (Mexico) and CSA (Canada).

UL 8750 covers LED equipment that is an integral part of a luminaire, including LED drivers, controllers, arrays, modules and packages. The first edition of UL 8750 was released in May 2009, and a revised version was published in September. After a further comment period, the final standard is expected to be published before the end of 2009.

In North America, product safety standards are published by organizations such as the American National Standards Insti-

TODD STRAKA is Director – Lighting Services with Intertek (www.intertek.com), Cortland, NY.

tute (ANSI), the National Fire Protection Association (NFPA), Underwriters Laboratories (UL) and Canadian Standards Association (CSA), after gaining industry-wide consensus. NTRLs (such as Intertek, UL, and CSA) are authorized to evaluate and certify products according to these standards. Each NTRL issues its own safety certification mark, which is an equally valid indication of compliance with the standard(s).

Efficiently navigating the process

When beginning the safety certification process, it is important to first consider where you intend to sell your products. Thinking globally from the outset may save a considerable amount of time and cost for the manufacturer in the long run. Another tip is to design with compliance in mind, which means involving your certification partner at the R&D and design phases of your product's life cycle. Doing so may minimize potential compliance issues and improve time to market. During the product design phase, it is necessary to be mindful of the main safety concerns with LED lighting, which include the risk of electric shock, risk of fire, and also biological hazards. For electric shock, UL 1310 covers Class 2 power supplies, which operate at 24V or below and offer reduced shock and fire hazard. UL 1012 covers power supplies other than Class 2, which must comply with standard insulation and accessibility requirements. Generally, it is necessary to enclose (or create a barrier to) live parts to prevent physical contact. It is also necessary to insulate live parts with appropriately rated materials, and to utilize appropriate spacings for live and accessible parts.

The risk of fire arises because of heat production within LEDs. Thermal dissipation is dependent on the ambient temperature and the thermal path design. It is necessary to take into account the proximity and spacing of LEDs, the material and design of the diffuser if appropriate, the type of enclosure utilized and its flame ratings, and the installation scenario.

In terms of biological hazards, exposure to ultraviolet wavelengths (100–400 nm) is a concern. The US and Canada currently do not have mandatory standards or regulations in this respect. However, organizations such as IESNA, ANSI, CIE, and IEC are actively evaluating these effects.

Another consideration is to identify as many product variations as possible. This will allow products of similar design and construction to be grouped into product families, which may help to minimize the total number of samples required for evaluation and testing, and in turn lower the total project certification and testing fees.

Finally, as LED technology continues to advance rapidly, it is advisable to tap into industry resources to help you keep pace with ever-changing product safety and performance standards. There are many valuable educational resources available, including industry meetings and events, standards development committees, trade publications and online resources.

Performance testing

As LED products continue to seek widespread adoption in the marketplace, it is also important to remain mindful of your specific product's performance levels. Some NTRLs have the capability to also carry out product performance testing. Three major standards related to LED lighting were released in 2008: IESNA LM-79-08, ANSI C78.377-2008, and IESNA LM-80-08.

IESNA LM-79-08 covers electrical and photometric testing of SSL devices, and applies to both LED luminaires and LED light sources to be used in retrofit or replacement scenarios. It does not cover LED modules, LED packages, or individual LEDs. LM-79 is based on absolute, rather than relative, photometry, and includes the measurement of total luminous flux (lumens), luminaire efficacy (lm/W), color (chromaticity, CCT, CRI), and intensity distribution. ANSI C78.377-2008 applies to general indoor lighting applications. It covers the chromaticity of SSL products and specifies recommended chromaticity (color) ranges for white LEDs, including correlated color temperature (CCT) values for SSL products such as LED luminaires and integrated LED lamps.

A Type C high-speed mirror goniophotometer for luminaire testing.

IESNA LM-80-08 covers the measurement of lumen maintenance for LED light sources and applies to LED arrays, packages, and modules only. It does not apply to luminaires. LM-80 provides a test method to measure L70, the time taken for the light output to fall to 70% of its original value. Testing is carried out at three different case temperatures over a minimum of 6,000 hours with lumen measurements taken at 1,000-hour intervals. However, it is important to note that this standard does not provide guidance regarding predictive estimations or extrapolation of product life; this will be addressed by IES TM-21-xx, which is currently under development.

Another example of performance testing might include Ingress Protection (IP) testing according to IEC 60529. This ensures that the product's enclosure will withstand varying degrees of moisture and dust intrusion should it be placed in an environment where it will be exposed to such elements (see page 23).

LINKS

"Solid-State Lighting: Safety Certification Process and Performance Testing Measurement Techniques" Originally broadcast: September 2009 www.ledsmagazine.com/features/6/9/1

LED lighting standards and guidelines are now building on a firm foundation www.ledsmagazine.com/features/6/6/7

ANNOUNCING

Strategies in Light® Europe

The Leading Events for the Global LED and Lighting Industry

September 28-29, 2010 · Frankfurt, Germany · Sheraton Frankfurt Hotel & Towers, Conference Center

Event Overview:

The Large and Growing Global HB LED and Lighting Market

For 10 years, Strategies in Light® Conference & Expo has grown to be the premier annual forum for presenting current commercial developments in high-brightness LEDs and most recently, lighting. Celebrating its 10th anniversary in 2009, Strategies in Light drew record-breaking attendance of more than 2,000 indicative that the interest in LED technology and markets remains undiminished and the long-term fundamentals for the LED and lighting industry remain strong. In 2008 to meet the demand for the large and growing HB LED and lighting market in Japan, LED Japan Conference & Expo/Strategies in Light® successfully debuted to more than 2,700 participants. This year's 2009 event in Japan exceeded 5,300 total participants.

Join Us at Strategies in Light Europe

Strategies in Light Europe will focus on the LED industry supply chain, which results in products such as LED lighting fixtures (luminaires) and replacement lamps; automotive lighting; high-definition LED displays; backlighting for screens in TVs and laptops; and mobile devices, among others.

Discussions will cover LED systems and end products, LED light-engines and modules and the LEDs themselves, as well as critical components such as drivers and controllers, optics, thermal management and test and measurement. Speakers will focus on issues such as critical challenges and barriers to adoption; regulatory issues and standards; government support and funding; technology updates and roadmaps; financing, and the competitive landscape.

Europe has a robust LED applications environment, ranging from automotive lighting to outdoor signage to solid-state lighting. Moreover, all elements of the HB LED vertical supply chain are represented in Europe, ranging from substrates, to process materials and chemicals, to manufacturing equipment.

Whether you are a supplier, an LED manufacturer trying to reach new customers, a designer looking for new product information, or a buyer exploring the latest technologies, Strategies in Light Europe can help achieve your objectives.

WHO WILL ATTEND

- LED lighting manufacturers
- Lighting designers, specifiers and architects
- LED product designers
- LED & lighting specialists working with:
  - Mobile Appliances
  - Signs and Displays
  - Automotive Lighting
  - Signals
  - Illumination
  - Electronic Equipment
- LED makers and distributors
- Energy-efficiency organizations
- Corporate R&D staff
- Government regulators and policy-makers
- Financial analysts, investment bankers, and venture capitalists

APPLICATIONS INCLUDE

- General lighting/illumination
- Architectural and decorative lighting
- Mobile devices
- Outdoor lighting
- Signs and displays
- Automotive lighting
- Signals
- Backlighting

WHO WILL EXHIBIT

- LED manufacturers
- Component distributors
- Driver and controller manufacturers
- Test & measurement providers
- LED lighting manufacturers
- Design software suppliers
- Equipment and materials suppliers
- Thermal management and optics suppliers
- Module and light-engine vendors

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FOR MORE INFORMATION ON THE EVENT, PLEASE CONTACT:

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Putting the Smart Phone in control: using apps in embedded systems to control LED lighting

An iPhone app has been developed to control a low-cost, two-wire, low-voltage LED color lighting system in the home, explains **CARL MATTHEWS**.

There is an iPhone app that allows you to use it as a spirit level or even drink beer from it—but have you ever considered using it to control the lights in your home or office? ML Electronics (MLE), a specialist design house, decided there was no reason why not, and wrote an app to prove it when they built a new LED lighting control system.

The iPhone and other smart phones are equipped with popular standard wireless communications protocols (such as WLAN and Bluetooth) and benefit from open software architectures with support for third-party software development, so in truth there is no reason why they can't be used as a control module.

ML Electronics designers embarked on the development of a low cost, two-wire home LED lighting control system as a reference design to help us explore opportunities for using control technology to make our designs more sustainable. The design brief was to develop a low-voltage LED color lighting system that could be retrofitted into existing standard housings as a replacement for, or enhancement to, conventional lighting.

The system was required to use only two wires both for the low-voltage power supply and the control signals. In addition to allowing the system to be programmed using standard interfaces such as a PC over Ethernet, the designers set themselves the challenge of creating an iPhone application as an alternative. The project also demonstrates the efficacy of an innovative Power Line Control (PLC) protocol that runs over a 24V DC power line.

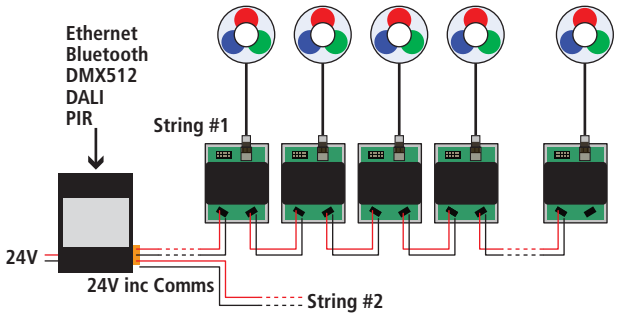

FIGURE 1. ML Electronics' LED lighting control system in serial configuration.

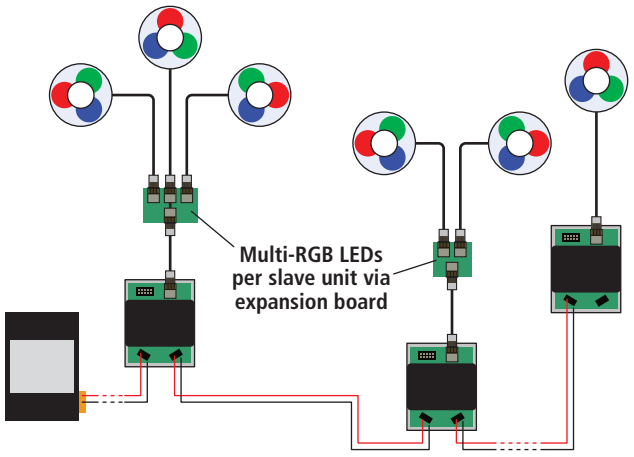

FIGURE 2. ML Electronics' LED lighting control system in multi-control scheme.

Hardware architecture

The system is operated using one or more master controllers that address a number of slaves, and each slave controls clusters of three RGB/white LEDs. The master can be controlled via Ethernet, Wireless LAN (Wi-Fi), Bluetooth, DMX512, DALI, or any custom control interface.

The slaves are connected to the master using a two-wire, low-voltage (24 volt) supply, and each slave is capable of controlling the color and brightness of up to 50 watts of LED illumination from data command signals superimposed on the power line. A master unit injects control data onto the low-voltage supply line controlling the slaves using the MLE PLC protocol. Each master can control two "strings," each with 16 slaves. These strings can be wired in parallel, so that each slave produces the same colors, or in series, allowing slaves to produce different output colors if desired. No earth is required, and there are no separate control lines, fully meeting the design brief.

The iPhone application

The iPhone app fully exploits the "fun" side of the user interface, with touch-sensitive sliders to set different color levels. It also uses the accelerometer feature to create random shake effects and to offer a tilt control as an

CARL MATTHEWS *is a Senior Software Engineer with ML Electronics Ltd., Salisbury, UK (www.ml-electronics.co.uk).*

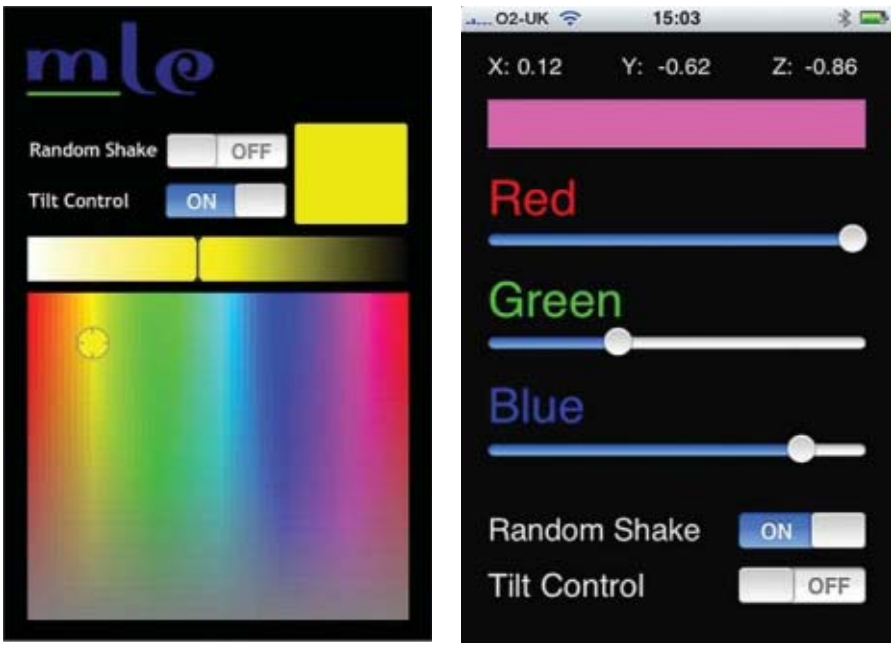

FIGURE 3. Screen shots of the iPhone app.

alternative to the sliders. Color wheel combinations were also available.

To carry out the development, the designers registered as an iPhone App Developer—providing access to development support from Apple, such as API's and example code. Before taking an iPhone App to market, there is the necessary step of registering it with the Apple iStore. Although it is an additional piece of work that needs to be completed, it brings the benefit of opening up the iStore as a marketing gateway to a huge base of potential customers. There are an estimated 21 million iPhones in the world and an additional 45 million iPod Touch devices, and Apple's App Store has seen over 1.5 billion downloads. It is also, by the way, a condition of the iPhone warranty that it is only used with duly registered software.

Other Smart Phone options

We also considered extending the application to other smartphone environments. Symbian is the biggest target, with close to 50% market share today—and rather more of the installed base. The Blackberry is the next biggest player, and Windows Mobile–based devices are also very popular. An emerging alternative is Google with the Android OS.

The only real way of writing one application that could be used on all of these is to design a web-based application so that any device capable of web browsing would be able to use it. However, this approach would eliminate the opportunity to implement the "cool" features of our iPhone app.

Conclusion

The project has exceeded expectation with the final electronics being smaller and more power-efficient than anticipated. This means that the integration into standard domestic space envelopes and housings will be a viable option. A second area that exceeded expectation is the interest we have gained from partners and customers, with two engagements to date to further develop the technology. The LED partnership is in early stages but the innovation is developing our business in different directions. We are also looking at using smart phones as control devices on other projects.

PRODUCT *focus*

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last word

Really Big LEDs will enable the next phase of LED lighting

"RBLEDs" will enable the widespread adoption of LEDs in general lighting applications, says **KEITH WARD**, president and CEO of **LUMINUS DEVICES**.

It's been more than 45 years since the first practical LED was created in a US corporate research lab. Since then millions of LEDs have been used in thousands of lighting applications, and LEDs are becoming commonplace in many applications—from street lights to medical equipment to smartphones.

Until now, virtually every application has deployed small LEDs (1 × 1 mm chip size or less) either as a single light source (indicator lights, microdisplays) or as arrays of large numbers of small LEDs (flat-panel TVs, display lighting, video walls). That's because most conventional LEDs, for all their advantages, provide fairly meager light output. Typical LEDs provide around 70–100 lm/W, depending on color temperature. While this easily surpasses the 15 lm/W of a 60 W incandescent bulb, and is on par with the 100 lm/W efficacy provided by fluorescent and many HID lights, individual LEDs are not typically able to generate sufficient light for most general illumination applications. Still, the advantages of LEDs have overcome the disadvantages of arranging them in arrays, and LED lighting is continuing to show up in an expanding variety of applications.

The next step in LED development aims to provide an LED that delivers 150 lm/W, nearly doubling today's typical performance. While some prototype LEDs approach this in the lab, it is an ambitious target and one that strains the capabilities of small LEDs arranged in groups. At 150 lm/W, or even at the theoretical ideal limit of around 200 lm/W, a single one-watt 1 × 1 mm LED produces a fairly modest output. Significant penetration into the general illumination market requires fixtures that deliver from hundreds to tens of thousands of lumens. While one could, in principle, build arrays of any number of 150 lm LEDs, clearly there are significant design compromises and system limitations for many lighting product applications.

The solution, as created by Luminus Devices Inc., is to develop much larger LEDs, big enough so that one LED can suffice for many applications, and so that arrays of LEDs can use far fewer, but larger, light sources. You could say that soon the industry is going to have LEDs, OLEDs and RBLEDs (Really Big LEDs). It is the RBLEDs that will enable the widespread adoption of LEDs in general lighting applications.

Over the past eight years, photonic lattice technology (PhlatLight™), developed at MIT, has been shown to enable superior light extraction from the LED chip independent of chip size. This has enabled Luminus Devices to develop LED chips that are more than to *ten times larger* than other commercial LEDs by incorporating novel, state-of-the-art processing technologies such as wafer bonding, substrate removal and advanced contact technologies. Combined with industry-leading efficacies through world class materials, this is the only LED technology able to deliver sufficient brightness to replace traditional light sources in mainstream applications.

The projector industry has been hindered by size, heat, fragility, environmental, and lamp-life problems commonly associated with mercury arc lamps. Large LEDs built on photonic lattice technology can provide ten times the brightness of projectors that use conventional LEDs. This has created a new class of small, light, ultra-portable "pocket projectors" that benefit business travelers and consumers by creating instant projection rooms anywhere, anytime. Until now, pocket projectors, or PICOs, using conventional LED technology have had limited popularity beyond niche markets because of their lack of brightness. This new, large-LED technology is rapidly coming to market in several brands of extremely bright powerful new, affordable, small projectors … and large data projectors as well.

Large, high-output LEDs will also be highly attractive in general and residential lighting applications. These LEDs provide high efficiency and a full white color palette that is neutral and warm instead of the undesirable harsh white light from yesterday's LEDs. This technology provides industry-leading lumen output and more than 50,000-hour lifespan.

The promise of LEDs in general and display lighting has been apparent for years. Until now there has been no technology that delivered the high brightness, color range, and the form factor to replace traditional light sources in mainstream applications. Now, with the advent of RBLEDs, the LED revolution has begun.

MORE: www.luminus.com

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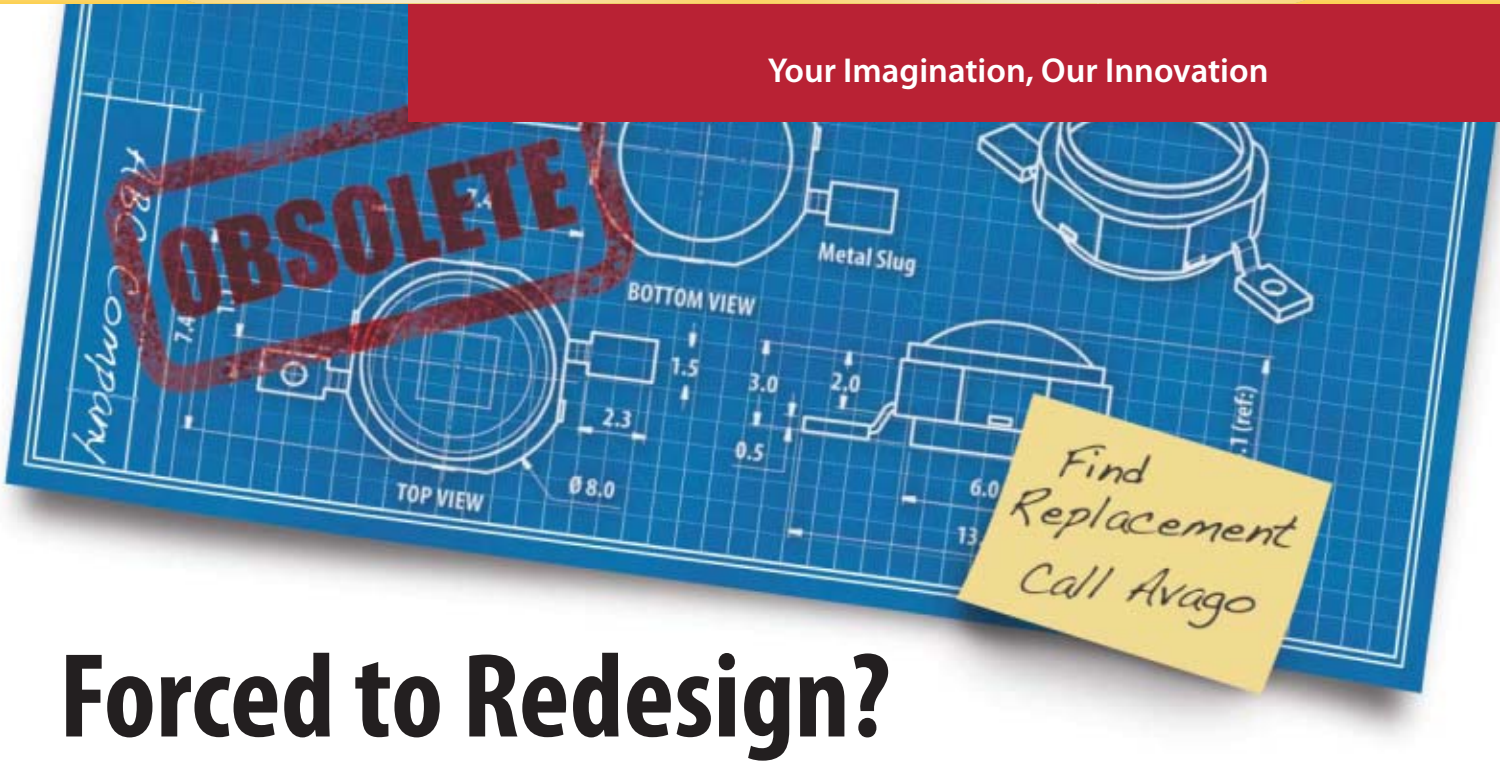

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Avago's High Power LEDs are ideal for lighting applications such as portable, contour, architectural, entertainment, decorative, outdoor, channel, and more.

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	ASMT-AW00-NSU00	1W high power	Cool white	• Better LOP
	ASMT-AW00-NTU00	1W high power	Cool white	• Better lm/W
LXHL-PM01	ASMT-AG00-NST00	1W high power	Green	• Lower thermal resistance
LXHL-PB01	ASMT-AB00-NLN00	1W high power	Blue	• Electrically isolated heatsink
	ASMT-AB00-NMN00	1W high power	Blue	
	ASMT-AB00-NMP00	1W high power	Blue	
LXHL-PR03	ASMT-AL00-NMP00	1W high power	Royal blue	
	ASMT-AL00-NNP00	1W high power	Royal blue	
LXHL-PD01	ASMT-AR00-ARR00	1W high power	Red	
LXHL-PL01	ASMT-AA00-ARR00	1W high power	Amber	
LXHL-PH01	ASMT-AH00-ARR00	1W high power	Red-Orange	

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