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TECHNOLOGY AND APPLICATIONS OF LIGHT EMITTING DIODES

Standards

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OLEDs

Lighting market to take off in 2011 P.18

Lighting

Learning to ask the right questions P.15

Lightfair

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- Color :

50/80W
50/80/100W
160/200W

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LEDs MAGAZINE

ISSUE 27

may/june 2009

Cover Story

The Calculite LED Downlight from Lightolier was named Most Innovative Product of the Year at Lightfair (p2). Photos: Next Generation Luminaires competition (www.ngldc.org)

features

columns/departments

commentary

LEDs make a great show at Lightfair

During the first week of May, *LEDs Magazine* staff enjoyed the bright lights of New York City. In the case of the Lightfair International tradeshow, these were mostly LED-based lights, which dominated the event. At the Lightfair Innovation Awards, the major winners included LED-based lighting fixtures from Lightolier (part of Philips) and Peerless, an Acuity brand. The Calculite LED Downlight from Lightolier won the Most Innovative Product of the Year and is shown on the cover of this issue. LEDs from Lumileds and Luminus won Technical Innovation Awards (see www.ledsmagazine.com/news/6/5/6 for more details).

It was particularly pleasing to see that the Illuminating Engineering Society (IES) won the Judges' Citation Award, in special recognition of an innovative product at the judges' discretion, for the LM-80-08 standard "Approved Method for Measuring Lumen Maintenance of LED Light Sources." It is difficult to over-estimate the importance of standards such as LM-80 as the solid-state lighting industry continues to develop and mature. This issue features part two of an article by Kevin Dowling reviewing the current state of SSL standards, and one of the most remarkable aspects is the very long list of standards that are now in development (see p.21). Dowling is heavily involved in many of the standards activities in North America, and acknowledges that harmonization of these efforts with those in other regions around the globe will be essential to the future growth of the industry.

Another essential factor, for different reasons, is intellectual property. Recently, the Zumtobel Group signed a cross-licensing deal with Philips, so that Zumtobel is now a partner in Philips' licensing program for LED-based luminaires, and Zumtobel's customers can avoid paying licensing fees to Philips. Osram has already signed a similar deal with Philips. As well as its giant competitors, Philips is also talking to much smaller companies, firstly by trying to make sure everyone is aware of the licensing program, and then by following up with selected companies that are on its radar. The follow up appears to be along the lines of "we think some of your products are using some of our IP — we need to talk." Recipients will react in different ways. Some will like the licensing deal on offer, some will sign up reluctantly, and some will resist. Philips has a fine line to tread between appearing to be heavy handed, and wanting to extract value from its IP, which includes the patents acquired from Color Kinetics; in the US, these remain controversial (but valid nonetheless). The question of which companies are on Philips' radar is also an interesting one. Showing products at Lightfair can have all sorts of unexpected results.

IP also affects programs such as Energy Star and the L Prize. Such programs must take care that their criteria do not require a participant to use technology and IP that is owned by a single organization. We understand that the US DOE is already looking at this question with regard to LED dimming.

Our team is still sorting through piles of press releases and other material from Lightfair, but when that's done we will be preparing our extended coverage of the event for our next issue.

Tim Whitaker, EDITOR
twhitaker@pennwell.com

LEDs MAGAZINE®

GROUP PUBLISHER Shannon E. Alo-Mendosa
shannona@pennwell.com
Tel. +1 603 891 9137
EDITOR Tim Whitaker
twhitaker@pennwell.com
Tel. +44(0)117 946 7262
MANAGING EDITOR Julie MacShane
juliem@pennwell.com
Tel. +1 603 891 9221
CONTRIBUTING EDITORS Brian Owen, Hassaun Jones-Bey, Francoise von Trapp
MARKETING MANAGER Carol Fronduto-Dirksen
PRESENTATION MANAGER Cindy Chamberlin
PRODUCTION DIRECTOR Mari Rodriguez
SENIOR ILLUSTRATOR Christopher Hipp
AUDIENCE DEVELOPMENT Debbie Bouley

PennWell®

EDITORIAL OFFICES PennWell Corporation, LEDs Magazine Corporate Offices
98 Spit Brook Road, LL-1
Nashua, NH 03062-5737
Tel: +1 603 891-0123
Fax: +1603 891-0574
www.ledsmagazine.com

SALES OFFICES
SALES MANAGER (USA) Mary Donnelly
maryd@pennwell.com
Tel. +1 603 891 9398
SALES MANAGER (EUROPE) Joanna Hook
joannah@pennwell.com
Tel. +44(0)117 946 7262
SALES MANAGER (JAPAN) Manami Konishi
manami.konishi@ex-press.jp
Tel: +81 3 5645 1271
SALES MANAGER (CHINA & HONG KONG) Mark Mak
markm@actintl.com.hk
Tel: +852 2838 6298
SALES MANAGER (TAIWAN) Alice Chen
alice@arco.com.tw
SALES ADMIN (TAIWAN) Cindy Yang
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SUBSCRIPTIONS: For subscription inquiries:
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e-mail: led@omeda.com;
ledsmagazine.com/subscribe
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DATE: June 2009

PRESENTER: Vrinda Bhandarkar, Senior Market Research Analyst, Strategies Unlimited

LED Luminaire Photometry & Performance Testing

ORGINALLY BROADCAST: March 2009

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News and views from Lightfair International 2009
Including the Lightfair Daily reports
www.ledsmagazine.com/features/6/4/6

LEDiscovery...they Learned, they Engaged, they Discovered!
www.ledsmagazine.com/features/6/4/2

Advances in TRIAC dimmable drivers open way for lamp subsidies
www.ledsmagazine.com/features/6/5/8

Welland shows great LEaDership in new initiatives
www.ledsmagazine.com/features/6/5/7

Featured Companies

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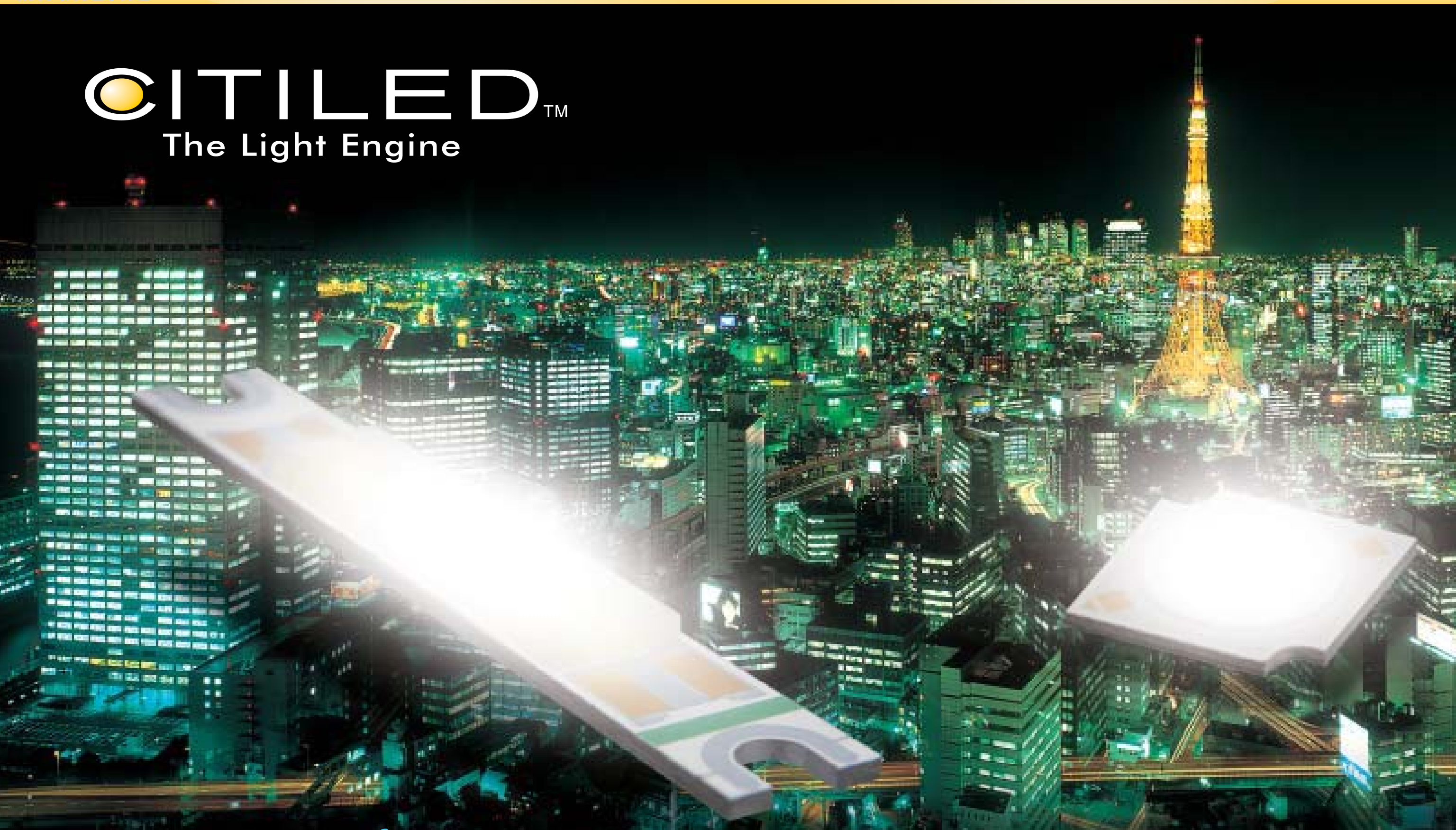

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Germany / Austria / Swizerland : Endrich Bauelemente Vertriebs GmbH
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Contact person : Clare Millard Tel : +44-1229-582430 E-mail : clare.millard@optosource.com
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Spain / Portugal : Antonio Lopez Garrido, S.A.
Contact person : Jose Luis Garrote Tel : +34-96-192-06-34
E-mail : ventas@algsa.es（for sales）／laboratorio@algsa.es（for technical assistance）
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LUMINAIRES

Zumtobel joins Philips' LED licensing program

Two of Europe's largest lighting companies, The Zumtobel Group of Austria and Royal Philips Electronics of The Netherlands, have concluded a comprehensive, worldwide, cross-licensing agreement for current and future patent rights. The deal mainly covers driver and control technologies for changing intensity and color of conventional and solid-state lighting (SSL)-based systems. Central to the agreement is Philips' LED-based luminaires licensing program, introduced in 2008 (see www.ledsmagazine.com/news/5/7/3).

The Zumtobel Group is now a qualified supplier under this licensing program, and customers of Zumtobel's OEM brands TridonicAtco and Ledon will now be exempt from paying licensing royalties to Philips. A similar arrangement was reached between Philips and Osram in September 2008.

Zumtobel Group CEO Andreas Ludwig, said that the deal had enabled his company to further exploit its outstanding technology position. "We will be continuing to invest in the expansion and exploitation » page 8

At Lightfair, Philips unveiled a 600-lumen, 8 W, A-shape LED prototype lamp capable of dimming down to 10%.

POWER LEDS

LED makers extend performance boundaries

The run-up to Lightfair saw several announcements relating to power LED performance. Cree described its new XLamp XP-G LED "the industry's brightest and highest-efficiency Lighting-Class LED" (see www.ledsmagazine.com/products/18554), although the product will not be commercially available until 3Q09. The cool white XLamp XP-G provides 139 lumens and 132 lm/W at 350 mA, and 345 lm at a current of 1 A. We assume these figures relate to the highest available bin. Cree claims that the XP-G LED has "the highest lumen density of any available lighting-class LED." The product is based on the XLamp XP family package, with dimensions of 3.45 x 3.45 mm. Cree's XR family package measure 7.0 x 9.0 mm.

Meanwhile, Philips Lumileds announced the Luxeon Rebel ES, which it described as "the world's first power LED specified for minimum 100 lm/W performance" (see www.ledsmagazine.com/press/18537). Efficacy of 100 lm/W is a great number, but not unique. The important point is » page 10

MODULES

Molex and Leviton offering LED lighting modules

Leviton, a manufacturer of electrical and electronic wiring devices for OEM lighting fixture customers, and Molex, a supplier of interconnect products, have formed a strategic alliance to supply LED lighting modules to manufacturers of commercial, industrial and residential lighting fixtures.

Leviton will use its extensive distribution and sales networks to sell Molex's newly announced Transcend Lighting Series of LED modules. This will, say the companies, help to "drive the adoption of LED light source technology to fixture manufacturers on a global scale."

The two Transcend products launched at Lightfair (the RM2 module is pictured) contain Acriche 4W AC LEDs from Seoul Semiconductor, and can be directly plugged into the AC line voltage without a converter or separate power supply. The products, offered exclusively through Leviton, are compact, interchangeable modules that are dimmable using Leviton dimmers and can connect to fixtures using Leviton GU24 base sockets.

The products are part of Molex's newly-launched SSL business unit. "The lighting market lacked a full-service integrator that answered the needs of all fixture manufacturers, regardless of size or capability," said Mike Picini, VP of solid state lighting for Molex. "Our SSL business unit leverages Molex's long-standing electrical, thermal and optical expertise, our design and development capabilities, and our experience in manufacturing high-volume, high-quality products. We developed the Transcend series to enable more rapid adoption and greater acceptance of LED lighting." ◄

MORE: www.ledsmagazine.com/news/6/5/7

news+views

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of our existing patent portfolio," he said. "As we do so, we will be banking primarily on LED technology, the widespread marketing of which will receive major new impetus from the agreement now reached with Philips."

Rudy Provoost, CEO of Philips Lighting, said that LED lighting is transforming the lighting industry. "By licensing our technology we are able to open up the full potential of new LED lighting solutions to companies and consumers, helping the SSL market to grow. I am therefore delighted that the Zumtobel Group supports our SSL licensing program." ◂

MORE: www.ledsmagazine.com/news/6/5/4

UV LEDS

Forgery detection assisted by ultraviolet devices

LED maker Seoul Semiconductor (SSC) has reached an agreement with M-Vision to license patents related to a portable fluorescent forgery detector, which uses UV LEDs to analyze documents. The technology was jointly developed by SSC's subsidiary Seoul Optodevice and Korea Minting & Security Printing Corporation (KOMSCO). As part of the licensing contract, Seoul Optodevice will receive licensing royalties from M-Vision, an industrial optical component developer, based on sales of the detector. Portable fluorescent forgery detectors are widely used for identifying forgery of bank notes, securities, passports, gift coupons, and ID cards by banks, financial companies and many other businesses. SSC expects demand for such products to significantly increase as counterfeit money raises issues around the world.

Many detectors use UV mercury lamps, but UV LEDs are advantageous in terms of lifetime, durability, output power and eco-friendliness. Existing UV mercury lamps require a low background light level, or even darkness, to detect forgeries, while UV LED-based detectors can easily identify forged documents even in bright places.

Seoul Optodevice, in partnership with US-based Sensor Electronic Technology Inc (SETI), claims to be the only company currently capable of commercial production of short-wavelength, deep-UV LEDs. ◄

MORE: www.ledsmagazine.com/news/6/4/15

FUNDING

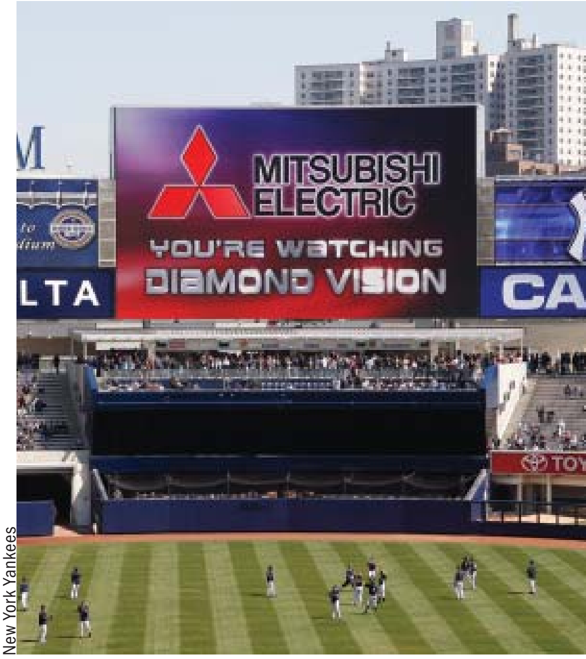
Nuventix secures $8 million

Nuventix Inc. has closed an $8 million funding round to accelerate advanced development of the company's SynJet cooling technology, which synthetic jets to achieve efficient cooling and reduce energy consumption in lighting designs. Funding will also be used to add support resources for existing and new Asian distributors as Nuventix expands its geographic reach. Braemar Energy Ventures contributed $3 million and Uniquest of Korea added $1 million. The funding closes out the company's total $18 million series C round. The company also signed an agreement with Silicon Valley Bank that makes a $4 million line of credit available to the company. Nuventix has now raised $32.5 million since its inception, and it will use the funds to add specialized engineering staff and to expand into other countries. ◄

MORE: www.ledsmagazine.com/news/6/4/11

DISPLAYS

Giant LED screen shines at New York Yankees' stadium



New York Yankees

An LED video screen from Mitsubishi Electric Diamond Vision forms the centerpiece of the New York Yankees' new stadium complex in the Bronx and is believed to be the most advanced, high-definition, sports venue display in the world. The screen is capable of showing four full HD 1080 images simultaneously, as well as text and graphics. The 8mm pixel pitch display is over 30m wide and around 18m tall, delivering 550 square metres of high-definition display area, powered by more than 8.6 million LEDs. By comparison, the scoreboard at the previous Yankee Stadium measured 7.6 x 10m with 486,400 LEDs. ◄

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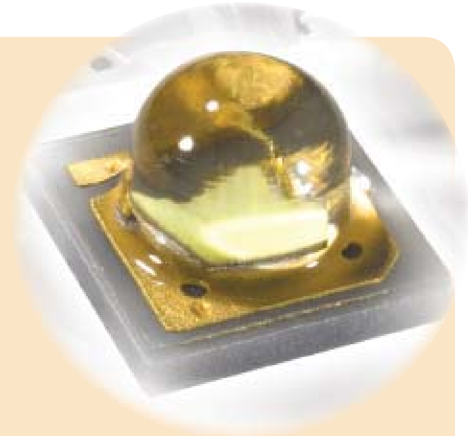
LED makers from page 7

that Lumileds has decided to specify the minimum efficacy, rather than the minimum lumen output (i.e. luminous flux in lumens). The company says it is "focusing on the performance characteristics that are most important to the lighting industry" and "simplifying LED product selection…for lighting designers." The idea is that flux binning and forward voltage (Vf) binning selections are pre-determined to deliver 100 lm/W efficacy, which means that the only remaining selection is color (i.e. correlated color temperature, CCT).

Cree has also released an RGBW multichip LED, as well as XLamp XP-E color LEDs in royal blue, blue, green, amber and red (see www.ledsmagazine.com/products/18553). The XLamp MC-E color is a multichip LED combining white, red, green and blue LED chips in a single packaged component. Cree described this as "the first of its kind in the industry" based on the inclusion of white with other colors. The difficulty comes in placing the phosphor onto the white emitter while making sure that the other chips do not come into contact with the phosphor. The MC package, measuring 7.0 x 7.5 mm, is extremely compact, and Cree says this provides design flexibility for color-changing LED applications that require high flux from a small lighting source, such as entertainment and architectural lighting.



Last, and also least in terms of size, Osram Opto Semiconductors has introduced a new power LED in a 3 x 3 mm package (see www.ledsmagazine.com/news/6/5/5). The Oslon LED (see photo) is aimed at lighting applications, such as spotlights, desk lights and ceiling floodlights. The company says the new package offers high efficacy even at high currents as well as simplified thermal management, high reliability and a beam angle of 80°C. At 350 mA, the Oslon LED has a typical brightness of 110 lm in ultra-white (5700 and 6500 K), with a maximum possible luminous flux of 130 lm at present. At 3000K, the device produces 85 lm at 350 mA with 75 lm/W efficiency, and 155 lm at 700 mA. Size-wise, the Oslon is in the same league as the Luxeon Rebel, which has a 4.5 x 3 mm footprint, and the Cree XP package.

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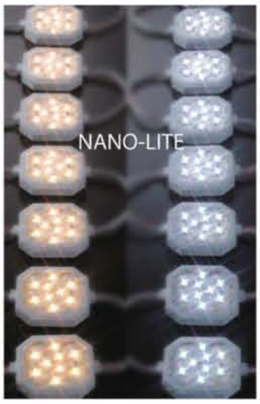

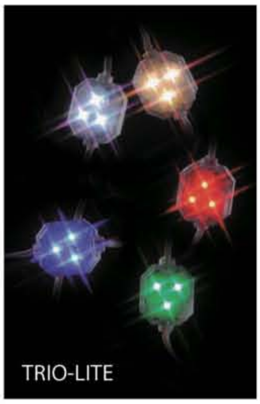

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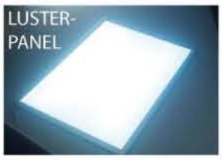

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funding + programs

Solid-state lighting projects win $26 million in DOE funding

The US Department of Energy (DOE) has announced the outcome of its Round 5 funding opportunity for Core Technology and Product Development projects, as part of its multi-year solid-state lighting (SSL) program. The selections, with a value of $26 million, are anticipated to contribute to the development of advanced SSL technologies that are much more energy efficient, longer lasting, and cost competitive. Such technologies will target a product system efficiency of 50 percent with lighting that accurately reproduces the sunlight spectrum. See www.ssl.energy.gov for more details.

Core Technology Research

With a total value of $10.4 million, selections for Core Technology Research are expected to fill key technology gaps, provide enabling knowledge or data, and represent a significant advancement in the SSL technology base. Recipients and project titles are:

- Eastman Kodak Co.: "High Efficiency Colloidal Quantum Dot Phosphors"
- Kaai Inc: "High Efficiency m-Plane LEDs on Low Defect Density Bulk GaN Substrates"
- QD Vision Inc., Massachusetts Institute of Technology: "Quantum Dot Light Enhancement Substrate for OLED Solid-State Lighting"
- Rensselaer Polytechnic Institute, Kyma Technologies: "High Efficacy Green LEDs by Polarization Controlled Metalorganic Vapor Phase Epitaxy"
- University of Florida, Lehigh University: "High Efficiency Organic Light Emitting Devices for Lighting"
- University of Florida: "Top-Emitting White OLEDs with Ultrahigh Light Extraction Efficiency"
- University of San Diego, Osram Sylvania: "Phosphors for Near UV-Emitting LEDs for Efficacious Generation of White Light"

Product Development

With a total value of $15.6 million, Product Development selections are focused on the development or improvement of commercially viable materials, devices or systems. Technical activities are focused on a targeted market application with fully defined price, efficacy and other performance parameters necessary for success of the proposed product. Recipients and project titles are:

- Cree Inc.: "SSL Luminaire with Novel Driver Architecture"
- DuPont Displays Inc.: "Solution-Processed Small-Molecule OLED Luminaire for Interior Illumination"
- Eastman Kodak Co.: "OLED Lighting Panels"
- Osram Sylvania Products Inc.: "Highly Efficient Small Form Factor LED Retrofit Lamp"
- Philips Lighting Electronics NA, Philips Research: "High Efficiency Driving Electronics for General Illumination LED Luminaires"
- Rohm and Haas Co.: "High Refractive Index Encapsulants with High Thermal and Photochemical Stabilities for High-Brightness LED Applications"
- Universal Display Corp., University of Michigan: "High Efficacy Integrated Undercabinet Phosphorescent OLED Lighting Systems"

DOE updates plans for SSL R&D

The US Department of Energy (DOE) has released the March 2009 edition of its Multi-Year Program Plan for solid-state lighting (SSL) research and development. The report provides a description of the activities the Department plans to undertake in the period of FY2009 through FY2015 to implement its SSL mission. The PDF file of the updated Plan can be downloaded from the DOE's SSL program website at www.ssl.energy.gov.

The document reviews significant R&D accomplishments in 2008, a new lighting competition announcement, and a recap of several major DOE-led government-industry meetings.

Additionally, the document provides information on current portfolio and funding opportunities, as well as an update on Congressional Appropriations for SSL as of March 2009. Funding of around $25 million is expected for FY 2009, slightly more than in the previous year (see graph at www.ledsmagazine.com/news/6/4/7).

Significant updates to the Technology Research and Development Plan include:

- revised definitions of components of a solid-state lighting luminaire to comply with IES standards
- a greater emphasis on luminaire issues in product development for both LEDs and OLEDs
- revised task structure and new priorities for core and product development tasks for both LEDs and OLEDs
- an updated list of technical, cost and market barriers.

The DOE will continue to update the Multi-Year Plan on a regular basis to incorporate new analyses, progress, and new research priorities. The DOE has also released a report on its SSL Manufacturing Workshop, held April 21-22 in Fairfax, VA. Two hundred attendees discussed various issues that influence SSL product quality and cost.

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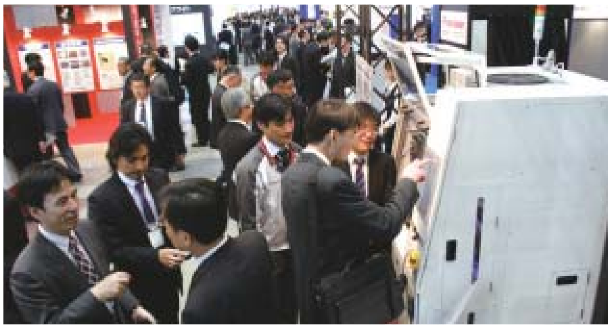

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Asking the right questions helps to educate customers and suppliers alike

Awareness and education are key aspects of market transformation, and there are now a number of tools to help improve the purchasing process, writes **BRIAN OWEN**.

I was recently the recipient to the following email. Contact details have been omitted, and punctuation has been corrected, but not the grammar:

"To whom it may concern,

I have something special to introduce to you, led street lights. I heard that you have an interest in Led lights. I've have the privilege of bringing into this country some of the best made, most efficient, flood and street led lights ever built. I've helped in the development creativity and the marketing exposure. I would like to introduce a web site to you, which has all the necessary information available, for evaluation of many applications of the led light fixtures, our specialty are our led street lights. The lights can do the talking for themselves. With your extended interest in led lamps, you will be able to recognize parking lot, street, and highway and other applications for our lights, also we have office ceiling panels very quality product. I'm hoping that you feel a need to install a sample or more, for evaluation and for consideration of larger applications. If you have any questions, please call or email…If you want samples or to see the fixture we can meet at your earliest convenience, and I will demonstrate the fixtures at your place of choice.

Thank you for this opportunity."

Following the article I wrote about the experiences of the CALiPER mystery shopper (www.ledsmagazine.com/features/5/9/1), I now feel like the mystery manufacturer has contacted me. I use the term "manufacturer" loosely, because more people are springing up in the SSL business than a broken couch. Whether manufacturer, agent, distributor or representative, it is all the same; grab some product from a far-away source, create a website and you are in the LED business overnight. In some instances, I have seen the same product on multiple websites, all claiming to be the 'manufacturer'.

In my presentations to lighting designers, specifiers and energy-efficiency organizations, I highlight some of the many resources and tools that are available to vet SSL products. The message is the same: educate the potential buyers in order to attempt to prevent purchasing pitfalls. At the same time, make the manufacturers and their channels aware of this process to put them "on notice" that the truth is out there and if they are not "bringing it" everyone will know when they are "winging it."

Ask the right questions

In 2007, in preparation for the 1st Light Canada in Toronto, I asked Scott Riesebosch of CRS Electronics to join the presentation panel and develop a list of questions that a potential buyer should ask a prospective manufacturer. As a capable manufacturer, Riesebosch knows what he is up against and definitely wants a potential customer to be able to discern the difference between truth and fiction. Since the first release, the list has been enhanced and expanded to reflect additional testing criteria and other relevant issues that are important in specifying SSL.

In 2008, I was pleased to see the release of the BetaLED/Ruud Lighting publication entitled, "LED Lighting Systems in Sustainable Building Design," which also included a list of "Questions to Ask When Specifying an LED Lighting System" (www.betaled.com/ordering.aspx). Shirley Coyle, president of Ruud Lighting /BetaLED in Canada, says there is more leg work required by lighting specifiers at this stage in applying LEDs for general lighting. "Too often the specifier or lighting designer is put in the awkward position of not having enough information to make a fair comparison between competing options — whether LED or incumbent technology," she said. "With the wide range of performance and pricing in the LED products being offered today, it is more critical than ever that anyone reviewing LED products follow a minimum process to protect his or her own reputation and to get the great performance that a well-designed LED luminaire can offer."

Recently, I had the pleasure to meet Avraham Mor of Lightswitch, a Chicago-based lighting design firm. Mor takes the questions and requirements very seriously and is not shy to let prospective SSL suppliers know it. Prior to even agreeing to a meeting or a review of products, he sends out an email in response to the supplier's request, indicating what Mor expects from the supplier. This includes testing documentation, warranty and as to whether the design allows for component replacement over time.

With the release of Energy Star for SSL 1.0 from the DOE, the availability of CALiPER testing results and most recently the Quality Advocates pledge and the Lighting Facts label, specifiers can arm themselves with more resources and tools to get through this process, which is somewhat daunting at times. Not every product can qualify for Energy Star, as the product category may not be included. Also, to be

BRIAN OWEN *is a Contributing Editor of LEDs Magazine and Program Advisor to greenTbiz, which facilitates the LED City Toronto initiative and is an Energy Star partner. He is actively involved in the development and operation of energy conservation programs for government, municipalities and utilities. Email: Brian@greenTbiz.org.*

lighting | EDUCATING BUYERS

Questions to ask the supplier

Dear...

Thank you for your email. We have a process for the review of unsolicited products. For each product that you wish us to consider or review:

1. Along with collateral or a cut sheet, please supply a photometric report from an accredited recognized testing laboratory for each product, along with an IES photometric file and completed LM-79 and LM-80 testing results.
2. Are any of your products Energy Star qualified or in process for qualification?
3. Have any of your products been CALiPER tested?
4. Have you taken the Quality Advocates pledge?
5. Are you a Lighting Facts LED Product Partner?
6. Please supply the Lighting Facts label criteria for each product.
7. For each product please answer the following questions;
    - What is the maximum junction temperature (Tj) specification (at highest ambient temp)?
    - What is the operating temperature range specification?
    - Was it salt spray tested (for outdoor fixtures) in accordance with ASTM B117? For how long?
    - What is the lumen maintenance specification?
    - What LED is inside? Is it a brand name? Was it tested according to IESNA LM-80?
    - What is the luminaire life expectancy and warranty?
    - What is the ingress protection rating?
    - What is the power factor?
    - How much power does it consume in the "off" state?
    - Does it have a UL / CSA / applicable safety mark? (Please supply the applicable file number.)
    - What is the CCT range (e.g. 3000K +/- 175K)?
    - What is the chromaticity stability over time?
    - What are the tolerances on specifications?
    - Is it a lead-free fixture / RoHS compliant?
    - Is the lumen specification for DELIVERED lumens out of the fixture?
    - Has it been tested in accordance with the IESNA LM-79 standard – absolute photometry?
    - Is the lm/W specification for FIXTURE lm/W?
8. How long has the company been in the LED business?
9. Please provide three installation or pilot references.

I look forward to receiving your documentation and responses. Upon review of your complete submission for each product, we can arrange for further discussion and the provision of a working sample to review.

Regards... ◄

tested by CALiPER, a product has to "seen" on the market and found by mystery shoppers. However, there is no excuse for a manufacturer not to take the Quality Advocates Pledge and to use the Lighting Facts labelling details on their product literature and packaging. Lighting Facts labelling details (www.lightingfacts.com) must be based upon photometric reports from qualified testing labs and the use of the label will be monitored and "policed."

In our greenTbiz and LED City Toronto programs, Chantal Brundage, program manager and I are inundated with SSL product solicitations from various points in the distribution channel. "It is important for us to ensure that reliable LED luminaires are suggested to the businesses, commercial properties and municipalities that we work with and that the suggested product will meet their lighting needs," said Brundage. For the best part, we have successfully accomplished internal vetting, but a useful procedure, which saves valuable time, was long awaited and welcomed. Besides, we can avoid some of the tiresome meetings that drain the brain, if not disintegrate it.

A measured response

So getting back to that email I received, we have taken the best that every resource or tool has to offer and prepared our response, "Questions to ask the supplier," which is shown at left. From a manufacturer's point of view, Riesebosch, who authored the list of questions, explained that inferior product will damage market transformation, as it will not deliver on the promise of ROI, energy efficiency, life expectancy, and quality of light. "It was frustrating to see people buying LED products based on price," he said. "We knew these customers were not going to be happy with their decision or their return on investment 6 to 12 months down the road when they started experiencing problems. We needed to educate potential clients so they could make more informed decisions. Creating an unbiased, education-focused 'LED procurement checklist' was one answer."

Riesebosch outlined why each of the questions and its respective answer was important. "As an Energy Star Partner, CRS is an advocate of the new Energy Star criteria for solid-state lighting. It is a big step in the right direction, but there are extra steps that can be taken to ensure a good customer experience." Examples include a requirement for a certain ingress protection rating or salt-spray testing for outdoor luminaires. Insisting on transient voltage protection and appropriate safety marks (which can be validated on the appropriate websites for UL, CSA, etc.) will help ensure safety. Asking what brand of LED is inside can also help; a recognized brand name LED is more likely to perform better and also reduces the possibility of patent infringement, which could disrupt future supply of a product.

"These questions are crucial as they directly impact the life expectancy, safety and availability/legality of a product," said Riesebosch. At the recent Energy Star Lighting Partner meeting in San Antonio, many partners agreed that a comprehensive list of applicable standards is needed. For example, standards already exist for salt spray tests, transient voltage protection ratings, and many other areas applicable to LED lighting. Having all the standards in one place would assist specifiers tremendously as they could simply reference the standards applicable to their application.

Other questions such as "How long have you been in business?" and "Do you have any references?" are directed at getting a feel for the longevity and stability of the company. After all, the warranty is useless if the company is not going to be around in 6 months. Giving people a list of "questions to ask" that they can copy and paste into documents, emails, etc. empowers them, making them more likely to buy a solid-state lighting product — and a good one at that.

It has now been several weeks since I sent a response to the original email. I have not received a reply, and I am not holding my breath in expectation of one.

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e darren.cullen@nsh.co.uk, www.nshelectronics.com

SGS

OLED lighting set to take off in 2011

As companies begin small-volume production and address various challenges, OLED lighting looks to be well-suited for a range of applications, writes **JENNIFER COLEGROVE.**

FIG. 1. EDAG, a German-based provider of engineering services, presented its vision of an environment-friendly, future-orientated vehicle at the Geneva motor show in March 2009. The "Light Car," says EDAG, will be one of the first vehicles to utilize OLED technology as an individually adaptable design and communication element. The driver can design the outlines of the car's lights to give the car a unique appearance, or individually configure his cockpit and instrument panel. The transparent tailgate can be used for car-to-car communication, for example, the braking force could be communicated to the next vehicle by means of an illuminated scale on the back of the car. Light Car video: www.edag.de/pr/web_tv/webtv/en.

Hundreds of millions of dollars have been invested in OLED lighting, especially in Europe, the US and Japan. Currently, more than 130 companies and universities, and over a dozen organizations are working on OLED lighting.

Compared with the other major lighting technologies in the market — incandescent, fluorescent, high intensity discharge (HID) lamps, LEDs and electroluminescent (EL) — OLED lighting has several advantages:

- OLED lighting devices emit from the surface, can be made flexible/rollable, and even transparent like a window or reflective like a mirror.
- OLED lighting is thin, rugged, lightweight, and has fast switch-on times, wide operating temperatures, no noise and is environmentally friendly.
- The power efficiency of OLED lighting has also improved dramatically recently.

The unique features of OLED lighting are inspiring the imagination of designers, who are exploring various OLED lighting applications: windows, curtains, automotive light, decorative lighting, and wallpaper. Figures 1-3 show some examples.

There are several potential applications for OLED lighting, including:

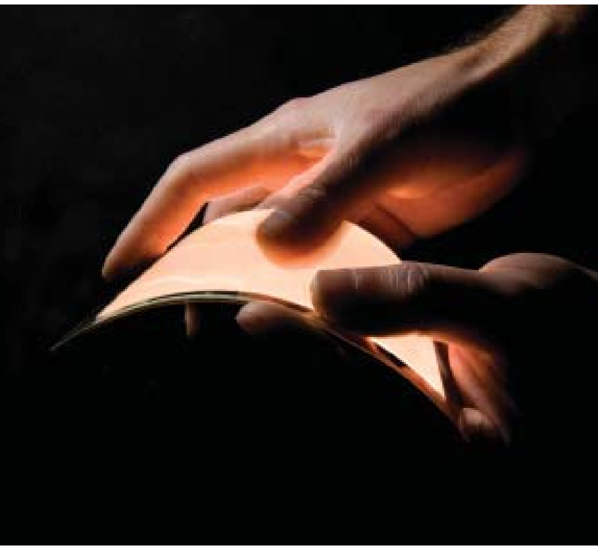


FIG. 2. A European research consortium has demonstrated the world's first large-area, flexible OLED tile that does not require ITO (indium tin oxide) as a transparent electrode, and has printed shunting lines. Agfa Materials, Philips Research and Holst Centre say that the work eliminates costly materials and lithography process steps, and represents a significant step towards low-cost, high volume and large-area manufacturing of flexible OLED lighting. More details: www.ledsmagazine.com/news/6/4/13.

FIG. 3. During Euroluce in Milan, Italy, in April, Philips premiered what it described as "the world's first OLED-based interactive lighting concepts," which were intended to demonstrate a new light ambiance and novel design possibilities. Various luminaire concepts incorporated radiant, flat OLED light panels, supplemented with power LEDs from Lumileds for the functional lighting part. "What's particularly exciting is that LEDs and OLEDs offer the possibility to create new lighting designs and experiences that weren't achievable in the past," said Rudy Provoost, CEO of Philips Lighting. More details, photos and videos: www.ledsmagazine.com/news/6/4/17.

JENNIFER COLEGROVE *is the director of display technologies with DisplaySearch (www.displaysearch.com).*

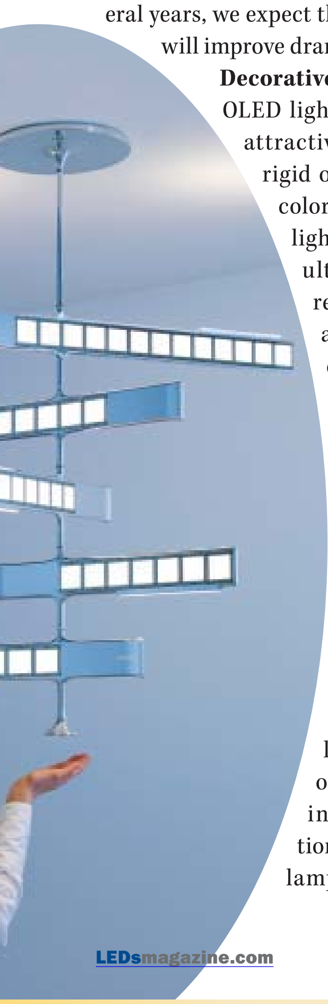
OLED display and OLED lighting comparison

Feature/specification	Display	Lighting
Luminance (cd/m^2)	150-1000	500-7000
Color criteria	Full color	Balanced white, or RGB for decorative lighting
Color specification	>100% of NTSC	CRI>80
Typical panel diagonal (cm)	2-100	5-200
Pixels	Yes	No pixel, but small tiles
Lifetime (k hours)	T_{50} is about 5-60	T_{70} needs 10-100
Efficacy (lm/W)	10-100	10-150
Backplane	Active matrix (AM) or passive matrix (PM) or segmented	Simple
Process	Typically batch	Roll-to-roll, or batch
Cost ($/m^2)	~1000 to 2000	Target 30-100
Issues	Backplane scale to large size, backplane cost, resolution/fine patterning	Uniformity and large area, high CRI, material cost, high luminance, infrastructure

Source: DisplaySearch

Automotive: OLED lighting is suitable for both internal and external automotive applications, with its thinness, light weight and power savings, and because it can be shaped for any surface. OLED's wide operating temperature could be beneficial for cold or hot weather, and it is color-tunable, so it can show red color as an external stop signal, for example. However, the automotive industry has a long design cycle.

Backlights for LCDs or other displays: Since OLED is surface lighting, this could eliminate the light guide plate, diffuser and other components that are currently used in backlights. However, the OLED would need to operate at very high brightness and color temperature, while still maintaining a long lifetime. While white OLEDs can't currently meet these requirements, over the next several years, we expect that OLED materials will improve dramatically.



Decorative/general lighting: OLED lighting can have very attractive designs, can be rigid or flexible, white or color or tunable. OLED lighting does not have ultraviolet or infrared in its spectrum, and does not generate heat during operation. Therefore OLED has a good potential for museums or other art exhibitions.

Healthcare/industrial: OLED lighting doesn't need complex and costly fixtures to build shadow-less lamps for medical or other specialty industrial applications. For shadow-less lamp application, not only high brightness but also long lifetime is needed.

Signage/advertisement: This category covers signage/advertisements that can use a direct drive backlight to light up the pictures on a plastic film one area at a time. This type of signage/advertisement looks animated, and can attract consumers' attention.

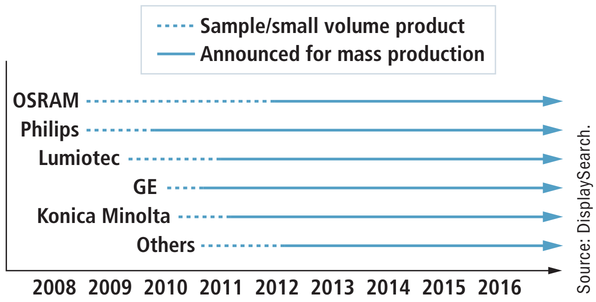


FIG. 4. OLED lighting manufacturers' roadmap.

Moving into production

Although OLED displays have been in mass production for about a decade, OLED lighting has just started sampling and small volume production. This is because OLED displays and OLED lighting face different challenges, as shown in the table. OLED displays include passive matrix (PM) and active matrix (AM) versions. The PM-OLED display market peaked in 2006, and has been declining since. PM-OLED suppliers should look into OLED lighting for new opportunities. AM-OLED displays face challenges such as the high cost of the TFT (thin-film transistor) backplane, and the need to scale to large size with fine patterning, among others.

Meanwhile, OLED lighting is facing issues such as material cost, uniformity for large area panels, high color rendering index (CRI), and an immature infrastructure. Looking into the future, the OLED lighting industry will pick up in 2011, with Philips, GE, Konica Minolta, Lumiotec and Osram entering mass production (Fig. 4). The OLED lighting market is setting the stage to take off in 2011, with OLED lighting revenues forecasted to reach $1.6 billion in 2015, reaching $6 billion by 2018, according to DisplaySearch's newly-released report, "OLED Lighting in 2009 and Beyond: The Bright Future." The report is also the source of the table and Fig. 4.

LINKS

OLED channel: www.ledsmagazine.com/OLEDs

Ingo Maurer OLED table lamp: www.ledsmagazine.com/news/5/4/12

How to pick the perfect inductor for your LED driver application

IC reference designs are a good start. But what if you want to optimize the driver inductor for size, efficiency or price?

Or evaluate newer, high performance parts that weren't available when the reference design was created?

Then you'll want to check out the new LED Design Center on the Coilcraft web site. It's filled with interactive tools that let you compare hundreds of inductors for all LED driver topologies, including SEPIC.

To start your search for the perfect LED driver inductor, mouse over to **www.coilcraft.com/LED**

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LED lighting standards and guidelines are now building on a firm foundation

Standards established in 2008 are being used in guidelines such as Energy Star criteria, and many other standards are in development on a global basis, as **KEVIN DOWLING** describes.

As discussed in an earlier article, 2008 is likely to be remembered as the Year of LED Standards, due to the publication of ANSI C78.377 (chromaticity), LM-79 (luminous flux) and LM-80 (lumen maintenance). This article covers further details on LM-80 as well as looking at various guidelines that call on the new standards. It also looks at the impressive array of standards that are currently in process.

LM-80: Lumen Maintenance

As discussed previously, the LM-80 standard describes the measurement of lumen maintenance of LED light sources including LED packages, modules and arrays (but not luminaires). Prediction of lifetime beyond the testing period is not included in the standard. The sidebar "LM-80 Test Report" shows the required data that must be supplied. These are all observable and measurable quantities, and no prediction or extrapolation is involved. The IESNA committee working on a new method, TM-21 "Lumen Maintenance Prediction," is addressing the real answer to the question of predicting the lumen maintenance of LED sources. The committee is evaluating a number of models to assess lumen maintenance, but this is far more than just a formula.

Lumen maintenance of 70% (L_{70}) is used as a typical baseline level for light output levels. There is no hard and fast rule about L_{70} but generally, over time, a difference in illuminance of about one-third is a perceptible difference. General illumination is often about maintaining a norm: consistency and 30% down is a reasonable basis for illuminance levels without compromising safety and being in line with traditional sources that also exhibit losses in this range over their relatively shorter lumen maintenance periods. L_{50} can be used for decorative lighting, but not for general illumination. Emergency lighting values are outside the scope of LM-80.

Table 1. Requirements for high efficacy LED luminaires under California's Title 24*

System power rating for LED lighting	Minimum luminaire efficacy for LED lighting
5W or less	30 lm/W
Over 5W to 15W	40 lm/W
Over 15W to 40W	50 lm/W
Over 40W	60 lm/W

*2008 Building Energy Efficiency Standards

Seasoning time, sometimes referred to as burn-in time, is a relatively short period early in the life of an LED where, in some cases, the LED light output can actually rise slightly before settling in and following lumen maintenance curves. It only represents the first few hundred hours of life, and is thought to be a type of internal annealing process. It is not always observed but, if not taken into account, can throw off extrapolation significantly. A slight rise can cause the exponential fit to predict a much longer lifetime. The model under development should take this variation into account, and the recommendation is to incorporate a seasoning time of 1000 hours. For an extrapolation method, the committee will have to evaluate the use of seasoning time. In addition, there will likely be a limit on the extrapolation factor beyond tested data. Predicting 100,000 hours with only 6000 hours of test data is statistically untenable, so a multiplier will be determined.

LM-80 Test Report – required data

- Number of LED light sources tested
- Description of LED light sources
- Description of auxiliary equipment
- Operating cycle
- Ambient conditions (airflow, temperature etc)
- Case temperature (test point temperature)
- Drive current
- Observation of failure of sources
- LED light source monitoring interval
- Measurement uncertainty
- Chromaticity shift ◂

Guidelines call on Standards

2008 Title 24: Although California is but one of the 50 states, its economy is one of the world's ten largest. Due to its high energy consumption, large population and highly active industry, California has been very progressive in tackling energy issues and, because of strong legislative » page 22

KEVIN DOWLING *is the VP of Innovation at Philips Color Kinetics (www.colorkinetics.com) and has been active in SSL for over 10 years. He founded and chairs the IES SSL Committee and the NEMA SSL Committee, and is a past chairman of the Next Generation Lighting Industry Alliance.*

Table 2. A list of the known standards being worked on today
Those published are in black; those in progress are in red.

Photometry
CIE 127-2007 (TC2-45) Measurement of LEDs
IESNA LM-79 Electrical and Photometric Measurements of SSL Products
IESNA LM-80 Method for Measuring Lumen Maintenance of LED Light Sources
CIE TC2-46 CIE/ISO LED intensity measurements
CIE TC2-50 Optical properties of LED arrays
CIE TC2-58 Luminance and radiance of LEDs
IESNA TM-21 Predicting Lumen Maintenance of LED Sources
Color
ANSI C78.377-2008 Chromaticity of SSL Products
CIE 177-2007 (TC1-62) Colour Rendering of White LED Light Sources
CIE TC1-69 Color Quality Scale (new CRI)
Photobiological Safety
IES RP-27 Photobiological Safety
IEC 60825-1-2001 Safety of Laser products (to be superceded)
CIE S009 Photobiological Safety
IEEE P1789 Recommended Practices of Modulating Current in High Brightness LEDs for Mitigating Health Risks to Viewers
Safety
ANSI C82.SSI1 Power Supply
ANSI C82.77-2002 Harmonic Emission Limits
ANSI C78.09 82 Fixture Safety Specification
FCC 47 CFR Part 15 Radio Frequency Devices
IEC SC 34A 62031:2008 LED modules - Safety
IEC SC 34C 61347-2-13:2006 - Lamp Control Gear
Part 2-13: DC or AC Control Gear for LED modules
IEC SC 34A IEC 62560 Self-Ballasted LED Lamps
IEC SC 34A [tbd] LED lamps >50 V - Safety specs
UL 8750 LED Light Sources for Use in Lighting Products
Performance
IEC SC 34C 62384 - DC or AC supplied electronic control gear for LED modules
IEC SC 34A - Performance Standard for LED Lamps
Nomenclature
IES RP-16 Nomenclature and Definitions Addendum A: SSL Definitions
IEC SC 34A - TS 62504. Terms and Definitions for LEDs and LED Modules
EMC & Other
IEC TC 34 EN 62547 LED EMC/Immunity
IEC SC77A - EN 61000-3-2 LED EMC/Harmonics
ANSI SSL2 LSD-45 Sockets & Interconnects
ANSI C82.04 Driver Safety Circuitry

programs, is the only state in the US where per capita energy consumption has remained flat over the past decade. One of the reasons is Title 24, a set of building codes that dictate energy-efficiency standards for residential and non-residential buildings (among many other topics). Title 24 dictates power density for lighting, and luminaire and source manufacturers try to meet those standards so the California market is accessible to their products.

A new version of Title 24, termed the 2008 Standards, will be effective August 1, 2009 and will continue to incorporate and update efficacy standards for LED lighting — see www.energy.ca.gov/title24/2008standards. Table 150-C in the 2008 Title 24 details the specific requirements for different power ratings (see Table 1). These values can be determined through the use of LM-79.

Energy Star: Energy Star is a US government program run by the Department of Energy (DOE) and the Environmental Protection Agency (EPA) that recognizes energy-efficient products. The DOE initiated a broad and deep program around solid-state lighting nearly 10 years ago (see www.ssl.energy.gov). The initial focus was on R&D around the semiconductors themselves, but increasingly the DOE recognized, with advice from industry, the importance of broader initiatives in demonstrations, product-level evaluation, competitions, labeling, and guidelines such as Energy Star. The DOE's Energy Star for Solid-State Lighting (version 1.0) was published in September 2007 and took effect from September 30, 2008. The latest version 1.1 incorporates additional Category A application types. The detailed guidelines can be found at www.ssl.energy.gov/energy_star.html.

Although within Category A there are a number of well-defined specific applications, the trend will be to consolidate to a single category in the future. This will likely happen as LEDs continue to improve in efficacy to the point where many if not most applications can reach 70 lm/W or more.

The EPA issue: A "hot potato" issue for LED lighting is the emergence of the EPA in Energy Star guidelines. The EPA issued the version 4.2 amendment to its Residential Lighting Fixtures criteria in June 2008 but the negative reaction from industry, utilities and NGOs was swift and strong. This issue has not been resolved at the time of writing, but the market must have this resolved effectively and quickly. The DOE has also recently released, as part of its open process, a draft of its replacement lamp Energy Star guidelines. We will have to wait and see what develops in this area.

Current and upcoming efforts

There are those who maintain that standards are a critical need for LEDs and ask "where are the standards?" As you have seen, they are already here in some cases, but what is most impressive is the list of standards that are in process today. For areas such as photometry, color, eye safety, general safety, and other categories, a list of the known in-progress standards is shown in Table 2. Those listed in black are already published and those

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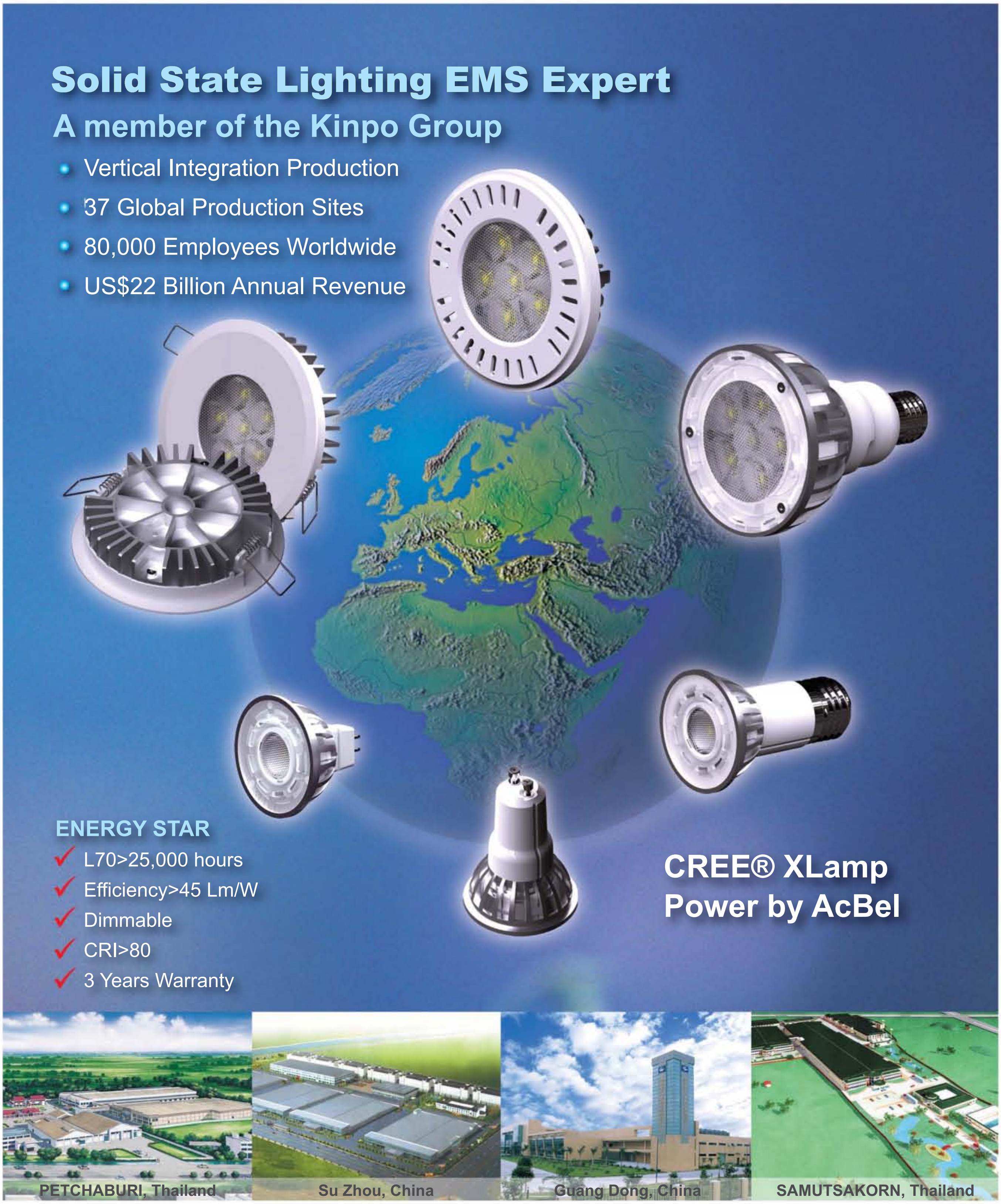

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listed in red are currently being worked on in committee.

Global harmonization

A major issue for manufacturers is that of harmonization. A worldwide coordination of efforts around LED standards will be critical. It already requires a significant investment to make one product for different markets. The various requirements of Underwriters Laboratory (North America), CE (Europe), PSE (Japan), CCC (China), the CB Scheme and others require significant design and testing efforts to meet all requirements. In some cases, different products must be designed for particular markets. This is not a new issue, but we have an opportunity with LED lighting to make new products around the world faster and easier. For national and international efforts in reducing energy use and carbon footprints, this would be a welcome scenario.

Updates to existing standards

The virtual ink is not yet dry on the three base standards that were issued in 2008, and the Energy Star guidelines for luminaires are very new, but improvement in LED technology and the results from test laboratories will allow the community to ratchet energy savings upwards, tighten specifications and even improve the measurement methods. The current standards will need to be improved and tightened. Typically, IES standards are revisited every five years, and this makes sense with mature technologies and decades-old standards. However, with LEDs continuing to evolve rapidly, this process must be more frequent.

For example, in ANSI 377.C78, the defined color temperature regions were a good start, but LEDs from within a given color temperature region can be perceptually quite different in color and tint. This should not be surprising since the regions are defined by 7-step MacAdam ellipses and then the region is expanded further by a bounding quadrilateral. This ensures that there are no gaps between adjacent regions, which helps to keep LED yields high. LED manufacturers, to their credit, are beginning to offer sub-binning within those regions and there is already work on a binning standard, but it is likely that the chromaticity regions will have to shrink or be subdivided to make sense to the end-user. Remember that a single MacAdam ellipse is the region of imperceptible change in chromaticity. A 3-step or 4-step MacAdam is typical for most light sources in real applications, and beyond those boundaries the change in color is quite noticeable.

It is also very likely that an additional metric beyond correlated color temperature (CCT) will be needed; that metric is the distance above or below the blackbody curve. This delta uv will give an indication of tint. Too far from the curve is a color. Another detail to resolve is when is a CCT

value no longer a white light source? A small and obscure note in CIE 13.3 mentions that CCT is defined only when 0.05 from the black body locus. This is a significant distance, perhaps too large.

This evolution is not new: even for fluorescent sources such as CFLs, the defined regions were and are quite large, but manufacturers eventually reduced values so the targets became quite small, i.e. within a few MacAdam steps.

Standards of form and architecture

The standards discussed so far are standards of performance, but there is a second category, perhaps just as important for a nascent technology such as LEDs, and that is standards of architecture. This can encompass standards around electrical interfaces, data protocols, and mechanical connections. Consider the wall plug, lamp socket, or the various connections on your computer. These are all standards of architecture which may even call upon other standards of performance for definition.

A friend of mine, a technical executive in Silicon Valley, told me that those without significant market share often sought standards so they could jump into the fray and conversely, standards are resisted by those in leadership positions so they can maintain proprietary platforms. The mistake in this reasoning is that market growth is often stymied without standards. In computers, chips, networks, and media this has been proven out again and again. From keyboard layouts to video formats the issue of standards has been a critical market driver once industry, trade organizations and even governments have established a common platform or architecture. In the annals of technical progress, standards are rarely mentioned as a key ingredient in market creation and growth, but they are often the essential pre-condition for large and fast-growing markets.

Future of standards

Although the economy is in an awful state, and this will affect adoption and use, LEDs are still viewed as a good opportunity to offer energy savings, good performance and more. The state of LEDs already allows many general illumination applications to be addressed in terms of technical achievement and performance level. The development and use of standards will continue apace, and costs will need to come down, but many manufacturers are addressing this now. 2009 will continue the many efforts in standardization.

LINKS

More information and images: www.ledsmagazine.com/features/6/4/1

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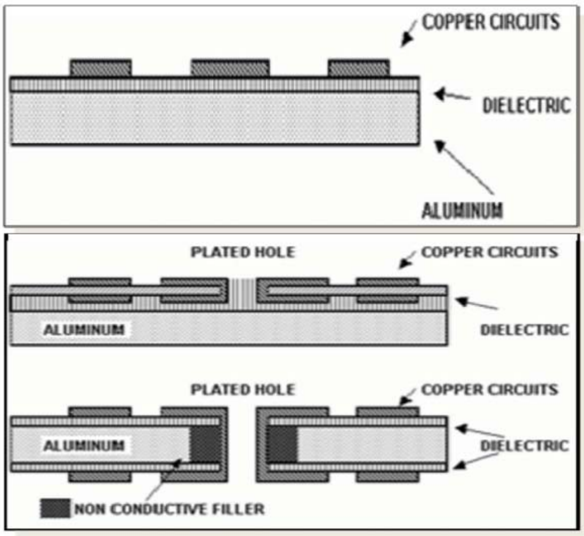

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design forum | **HIGH-CURRENT DRIVERS**

Optimized control schemes improve LED driver performance

LED DESIGN FORUM

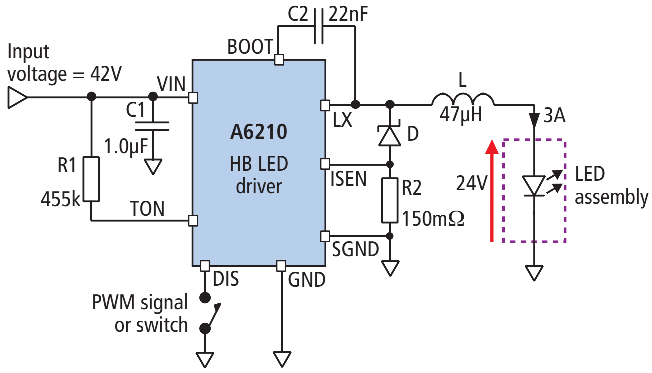
A simplified control scheme built around an optimized HB-LED driver results in rapid start-up for good dynamic brightness control and other advantages, writes **PETER TOD**.

High-brightness LEDs are being widely adopted into luminaires for the general lighting market, with a myriad of possible applications: commercial/retail downlighting, industrial, architectural, external and emergency back-up lighting to name a few. In the effort to produce more lumens in these applications, the LED driver requirements are becoming more onerous as LED currents increase. In many applications, the typical LED currents range from 350mA up to 1A, however, some of the latest LEDs require anything up to 3A.

In addition to the higher current requirements, efficiency improvements are becoming mandatory, for example through Energy Star standards. Size is often important and of course cost is always critical. To address all these requirements requires driver solutions that utilize innovative switching architectures.

The majority of LED driver solutions available on the market today are based on standard voltage-regulator architectures. Typical solutions, for example, using a fixed-frequency, current-mode-control buck converter, are far from optimum. The control schemes tend to be overly complex, often having two loops: an outer-loop to regulate the current control and an inner-loop to provide the peak current control. This control technique typically requires external compensation components as well as having the additional overhead in the silicon, which impacts cost.

Another problem is that brightness control is difficult to achieve. Most solutions rely on pulse width modulation (PWM) frequencies in excess of 200Hz to avoid flicker. A good dynamic range for brightness control requires the ability to modulate to duty cycles as low as 10%. With a 200Hz signal, this means the driver has to support the ability to turn on and off in a period of 10% × 1/200 seconds, or 0.5 ms. Most solutions have an inherent soft-start feature that is in the region of several ms, severely restricting the dynamic control range.



Simplified control scheme using an optimized driver.

The voltage in the current-control loop can be as high as 1.2V, which has a large impact on the power dissipation. For example, when driving a single LED with a forward voltage (Vf) of 3.5V, the efficiency drops by 34%, even before other losses are considered. Note also that this loss occurs across the full switching period.

Many vendors claim short-circuit and open-LED protection. While these are key protection features in boost- or buck-boost-derived topologies, they are completely unnecessary in buck-derived topologies.

The diagram shows a circuit built around the Allegro A6210, which has been specifically designed and optimized for driving high-current LEDs. With a simplified control scheme, the component count amounts to only two resistors, two capacitors, one Schottky diode (D) and the power inductor (L). An output capacitor is not required, firstly because the peak-to-peak current ripple can be as low as 10% of the maximum LED current through careful selection of the inductor value and switching frequency. This more than meets the majority of HB-LED lighting applications. Secondly, the control architecture deploys a simple inner-loop that controls the current by sensing the voltage developed across the sense resistor (R2) during the recirculation diode (D) conduction phase. No outer-loop is required, simplifying the design and removing the need for external compensation components.

A further advantage of this scheme is that the start-up restrictions of the more traditional control schemes are largely removed as the requirement for soft-start disappears. Also, the efficiency is extremely high through a sense voltage of only 183 mW, which only contributes to the power losses during the recirculation diode conduction phase.

PETER TOD *is a principal systems engineer with Allegro MicroSystems Inc. (www.allegromicro.com), headquartered in Worcester, MA, USA.*

Further reading

A more detailed version of this article with additional circuit diagrams and performance results can be viewed online at: www.ledsmagazine.com/features/6/5/6.

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Injection molding technology creates quartz glass components for UV-LEDs

A sol-gel molding process can replace the time-consuming and expensive grinding and polishing steps required to produce customized quartz-glass optics for UV-LEDs, writes **MICHAEL BAER**.

Today, almost all primary and secondary LED optics are made of well known and established materials such as PMMA (also known as Perspex or acrylic), PMMI, polycarbonate or specialty silicone. These materials satisfy the requirements of most LEDs in respect of spectral transmission and refractive index as well as temperature- and UV-A stability. Furthermore, all these materials are employed to produce large quantities of optical components via cost-effective injection molding technologies.

Due to their absorption and degradation characteristics in the spectral range below 320nm, these organic materials cannot be used as optical components for UV-LEDs. Hence, manufacturers of UV-LEDs need to work with quartz glass components. These feature very high transmission rates in the required spectral range (>90% @ 250nm — see Fig. 1) as well as excellent mechanical, temperature and long-term stability.

Until now, however, the only way to manufacture optical components from quartz glass was by using conventional diamond grinding and polishing processes. This is a result of the physical properties of quartz glass, and ultimately this leads to very expensive optical components and limits the geometrical variety of commercially available quartz glass optics.

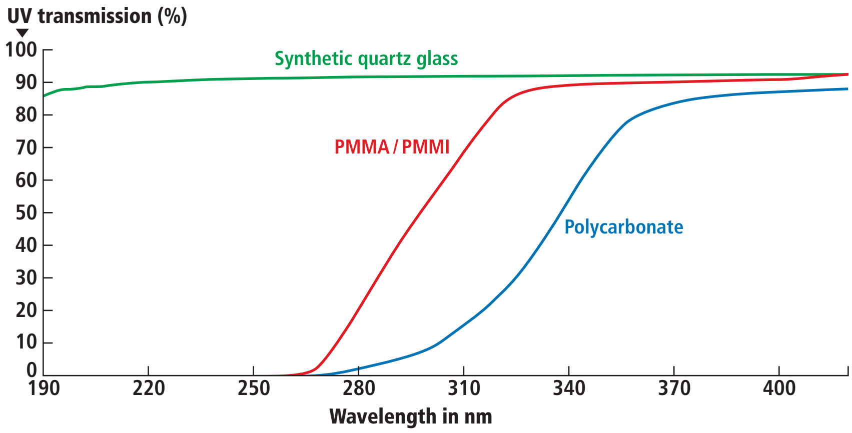


FIG. 1. UV transmission of various optical materials.

Sol-gel manufacturing process

More recently, the use of a unique sol-gel process, developed by the German company Silicaglas Ilmenau GmbH (SGIL), has enabled the manufacture of quartz glass components in their final geometry without the need for conventional refinishing. Even optically active surfaces can be manufactured in their final quality — virtually uniformly molded.

First, a liquid dispersion (sol) containing nanoscale SiO_2 particles is made via a chemical process. This dispersion is poured into suitable molds, and solidifies as a result of a chemical reaction. A solid SiO_2-gel is generated, and after removal from the mold the gel is dried. In a final densification step the gel is sintered (heated below its melting point) to produce clear synthetic quartz glass. The final quartz glass product has exactly 50% of the size of the molded gel-piece and all geometrical shapes remain identical. This high shrinkage is a result of the nanoporous structure of the gel. The pores (100–300nm) in the gel collapse during the sintering step, and the white gel becomes a transparent solid glass body.

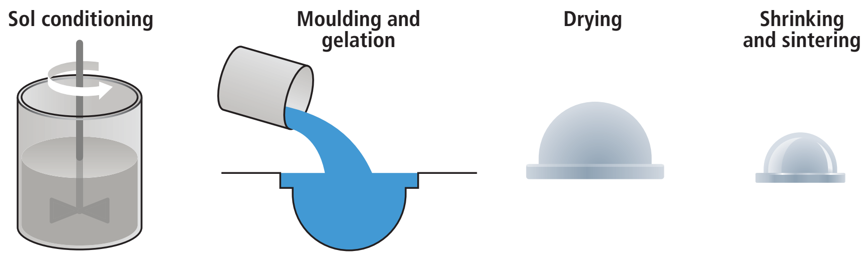


FIG. 2. Key steps in the sol-gel manufacturing process.

MICHAEL BAER *is business administration manager with SGIL Silicaglas Ilmenau GmbH (www.silicaglas.com) of Langewiesen, Germany, responsible for optical product development.*

FIG. 3. Gel body (left) and final glass lens (right) with small mounting flange to fix the lens in a housing.

The surface quality of the final glass product is strongly dependent on the quality of the molds. Geometrical defects (scratches, deformations etc) in the mold surface will be copied to the gel and can be found in the final product — proportionately 1:2 in size. Therefore, best attention has to be paid while the molds are manufactured and during the handling of the molds in the sol-gel process.

Diverse plastics (e.g. polycarbonate and polyethylene) have proved to be suitable mold materials for this process. This provides the possibility of mass production of cost-effective, disposable molds with high-quality surfaces. This eliminates the need to clean and re-use the molds, which carries the risk of scratching surfaces.

By using multi-cavity molds, larger quantities of optical components can be produced at once. For this reason, this sol-gel technology combines the advantages of an efficient mass production process — comparable to the production of plastic lenses — with the excellent properties of the quartz glass material. The process opens new approaches for the design and implementation of optical components. New designs for lenses or radiation characteristics become possible and cost effective with this new technology, as well as the implementation of mechanical features that were formerly considered impossible or too expensive to make in quartz glass. This includes spherical, aspherical and diffractive optics that can be now manufactured by the sol-gel replication technology at competitive costs.

testing | THERMAL & OPTICAL

LED system design improves with optical and thermal performance verification

The ability to quickly and easily produce accurate optical and thermal measurements for LED devices has a major positive impact on the system design process, says **JAMES PETROSKI**.

LED systems typically are designed to deliver a specified amount of light in a certain color spectrum. The designers of LED systems rely heavily on the performance specifications provided by LED manufacturers who typically rate their devices to deliver a certain number of lumens per watt at a certain color spectrum. The thermal performance of the package is also important, as well as the rate at which the light output drops as the temperature rises. If the performances differ from the manufacturers' specifications, systems builders are left with the difficult task of identifying the problem using trial and error methods and redesigning the system to compensate for the performance variations.

Traditional approaches for measuring LED performance, such as measuring optical performance with an integrating optical sphere, take considerable amounts of time and require interpretation of results that can lead to inaccuracies. A new generation of integrating test systems can reduce the time required to measure LED optical and thermal performance. This approach combines traditional thermal testing with photo detectors to automatically provide a complete optical and thermal characterization of power LEDs. Thermal metrics, as well as optical parameters such as luminous flux and efficacy, can all be measured as a function of temperature and operating current.

However, fulfilling the potential of LEDs will require dramatic shifts in the design of lighting systems, where basic technologies have not changed much in 50 years. A key difference is that conventional light sources reject most of the waste energy as infrared heat radiation, so fixtures and systems have been optimized for this mode of heat transfer. Incandescent and high-intensity discharge sources convert more than 90% of their waste energy into IR radiation, with less than 5% being lost by either convection or conduction. In contrast, in an LED system, the thermal energy is removed from the LED chip by conduction, and then leaves the system primarily by natural convection with some thermal radiation. Lighting system designers must learn to think and design for this different type of thermal system.

Lighting system design

Lighting systems are typically designed to meet optical, power and cost specifications. Common optical goals are to light an area such as a room or to provide a point source of light such as spotlight. The optical and power specifications ripple down to the performance of the individual LEDs that make up the system. When lighting an area, the primary concern is typically the number of lumens that are being generated and the efficacy. In lighting an area it may be possible to space out the lights, which reduces the thermal design challenge, while in a luminaire designed to serve as a point source the LEDs are usually close together. The power budget is in turn largely determined by the efficacy of the LED – its light output as perceived by the eye (i.e. lumens), per watt of input energy. Of course, the optical performance of an LED is highly dependent upon its thermal droop, the rate at which its light output is reduced as the temperature increases.

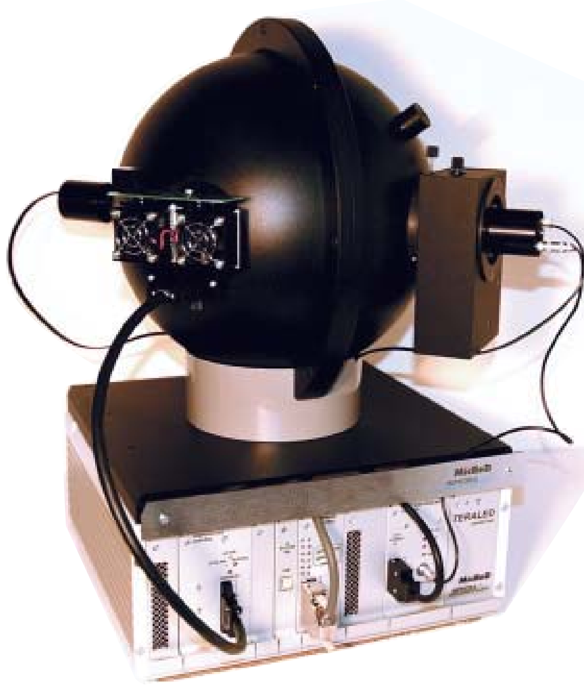


FIG. 1. Automated TERALED optical tester from Mentor Graphics.

Thermal design also plays a critical role in nearly every LED system. Excess heat can reduce the LEDs' light output, produce a color shift, and accelerate the reduction in light output over time, resulting in a shortened useful life. LEDs manufacturers often test their LEDs at a fixed junction temperature of 25°C. However, junction temperature in constant operation often rises to 60°C or higher, which can reduce light output by 10% or more below the rating.

The package design, and particularly the thermal resistance of the package, is critical to system performance. The major obstacles for the heat to leave the LED chip

JAMES PETROSKI *is a research associate with GrafTech International, based in Parma, Ohio, USA.*

are the different thermal interfaces along the junction-to-ambient heat-flow path. The LED chip is typically attached with a bond layer to a metal interconnect layer which is then attached to a ceramic substrate and an electrically isolated thermal pad; other designs have made use of a metal "thermal slug" under the die to conduct the heat. The entire package is designed to move heat away from the back of the LED chip in order to maximize optical output. Novel, improved materials, such as the graphite-based heat spreaders developed by GrafTech, can be used in applications to distribute heat evenly where weight, thickness, or volume of the thermal design must be minimized.

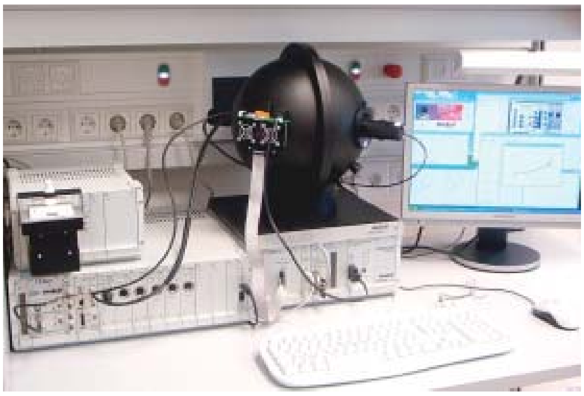
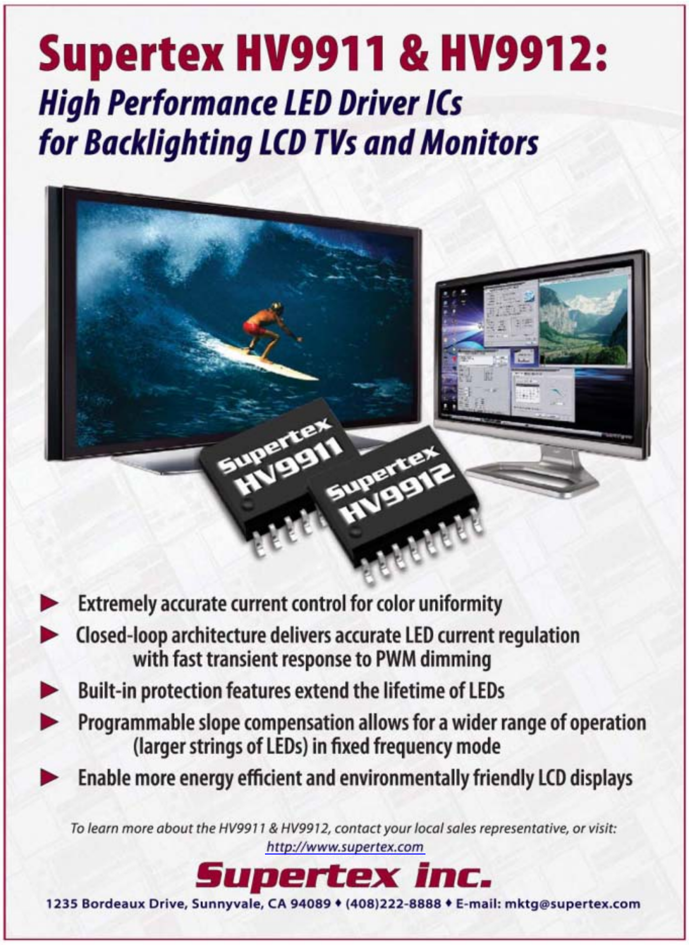


FIG. 2. Automated LED testing station combining thermal and optical test systems.

Optical performance

As someone who has designed LED systems for many years, I trust the specifications provided by device manufacturers because I know that they are doing the best job they can to deliver consistent performance. On the other hand, I have been involved in many projects where many additional weeks and months were required to track down and later correct performance problems that were traced to variances between device manufacturers' specifications and actual performance. So it should come as no surprise that I recommend asking at the early stages of the project: do the LEDs that we are planning to use actually put out the right amount of light, at the right colors, and does the package live up to our expectations in moving heat from junction to board?

In the past, measuring package thermal performance required setting up a series of thermocouples and looking for significant changes as one moved from junction to ambient. This type of testing is a bit of an art and the accuracy of the results depends on your ability to "guesstimate" junction temperature. Measuring optical performance with an integrating optical sphere is also a tricky manual task that can take a considerable amount of time and again requires the ability to guesstimate and maintain junction temperature. Fortunately, a new generation of measurement systems (see photos) has substantially reduced the time and effort required to measure optical output and thermal performance



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while increasing accuracy by providing accurate junction temperature measurements.

New approach to measurement

The new approach to thermal testing takes advantage of the fact that the temperature is proportional to the forward voltage of a specific device. After determining the forward voltage change per degree of temperature change (known as the k factor), a large current is applied to the LED and heats it. Then this current is turned off while another much smaller test current is applied for the measurement. The forward voltage is sampled very quickly as the junction cools down. The ability to monitor the voltage, and hence temperature, change with respect to time provides detailed information on how heat flows through each layer in the path from the junction outwards. This allows direct measurement of the key thermal resistances in the heat flow path such as the die-attach resistance or the submount attachment resistance.

The thermal tester can be combined with an automated optical tester (see photos) that integrates a computer-controlled filter bank, temperature-stabilized detector head, and a 300 mm diameter integrating sphere. Control software automates procedures such as measurement of photometric or radiometric emitted flux, efficiency or color coordinates as a function temperature and/or operating current. When combined thermal and radiometric measurements are performed, the thermal tester provides power for the LED under test. The thermal tester performs the thermal measurements and the evaluation of the thermal transients while the measurement sequences required for the photometric and radiometric characterization are performed by the optical tester. The optical measurements are performed under thermal steady-state conditions. Then, the LED under test is switched off and its cooling transient is measured by the thermal tester. The measured emitted optical power is then considered by the thermal tester when it calculates the thermal metrics of the LED under test.

Conclusions

The ability to quickly and easily produce accurate optical and thermal measurements of the LED device has a major positive impact on the system design process. Rather than taking the manufacturer's word for device performance, system designers can accurately measure alternative devices and base their design and sourcing decisions on real rather than promised characteristics. With a large sample size, statistics about the average and standard deviations of LED performance can be gathered and factored into a system design. System performance can be optimized to a higher level by basing simulations and design decisions on real-world data. Time to market can also be reduced in many projects by eliminating troubleshooting and redesigns required because actual LED performance did not match up specifications.

LINKS

Mentor Graphics MicReD products: www.mentor.com/micred

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PRODUCT focus

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Carclo announces new optics to support Avago and Luminus Devices

Carclo Technical Plastics, a global leader in LED optics, announces the immediate availability of 26.5mm optics and holders for the Avago Moonstone and Jade LEDs, as well as the Luminus Devices SST-90 and SSR-90 light engines. Specifically designed and optimized for these light sources, Carclo's new optics are available in plain tight and elliptical versions, as well as Carclo-exclusive frosted narrow, medium, and wide beam angles.

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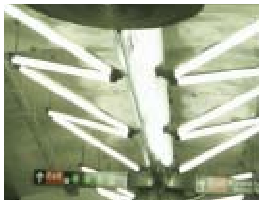

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last word

Changing times ahead for large-area LED display manufacturers

Small manufacturers of large-area LED displays should form a consortium and develop a Common Module Approach, says **PETER PIHOS**, partner of **EDG RESEARCH & CONSULTING**.

Ten years ago there were over 350 companies worldwide that manufactured large-area displays. These companies produced a variety of different technologies for specific applications. The industry demographics showed most were small, with 85% having sales less than $15 million annually. Many existed by finding a niche for their technology, such as split-flap technology for use in railway stations, or electromechanical flip-disc for the road transportation market. They also benefited from a certain degree of national protectionism.

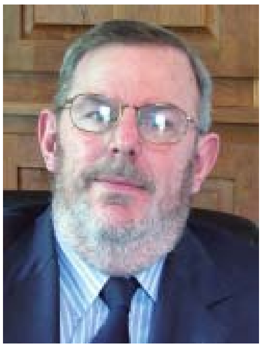
Now that LED technology has replaced other technologies, with 95% of the manufacturers selling LED technology, it is becoming more difficult to differentiate one product from the next. As a result, competing on price is becoming more prevalent. And the pricing spread between what is manufactured in China and elsewhere is substantial.

As an example, the price for a 20mm pitch, full-color system is $5200 per square meter, compared with $1800 for a similar system manufactured in China. The gap that separates manufacturers, both in performance and quality, is narrowing and in time it will be increasing more difficult to justify paying for the more expensive product.

In the past several years the majority of manufacturers have turned from actually manufacturing the total system — i.e., buying their own LEDs, populating the boards and constructing the total system in house — to relying on an OEM supplier in Asia to build to their specifications or just purchase an existing OEM's designs.

Already we are hearing some negative stories about some of the product coming from these small OEMs. Most simply do not have the resources to properly support their product. With the recent downturn in the economy I suspect these problems will only continue to increase.

Over the years my clients have shared with me their concerns about product development costs and component buying power. They simply do not have the economies of scale afforded to them like those that may be enjoyed by industry leader Daktronics with sales approaching $600 million.



So what is the small manufacturer to do as pricing continues to fall further, affecting margins and reducing profitability, which in turn reduces monies available for product development?

One solution would be to turn to an idea I initially discussed at my presentation at the Strategies in Light conference over a year ago. The idea was referred to as the "Common Module Approach" (CMA). The CMA would be basically a consortium of like-minded companies that would share the benefits of economies of scale through volume purchasing power. It would also reduce or eliminate recurrent product development costs by standardizing to product designs and, most important, offer customers a level of comfort when it comes to service and warranty issues. Additionally, it would allow the next generation of LED technology to be available to considerably more companies, rather than being the exclusive domain of current market leaders. It would level the playing field, so to speak.

It would also be beneficial for industry suppliers, especially the ones making LEDs, to have the opportunity to develop new products that are more specific to our industry, and to be able to easily reach the "long tail," which is considerable in our industry. A consortium is just the vehicle needed to exploit the opportunities that may exist.

In our most recent industry report (see link below), we discuss in more detail this concept and the rationale for companies to consider the CMA. Since the report was released in March 2009, the concept has received considerable traction and is moving forward.

I think maybe it is an idea whose time has come. It may also offer a lifeline to many of the smaller manufacturers struggling to stay in business. The key to making this work is to find a company that has the technical capabilities to develop the Common Module, the resources to assure to the consortium members that they are strong enough financially to stand behind their product and the ability to bring superior technology to market at a competitive price.

The end game would be for the consortium to be able to offer a truly differentiated product that benefits members and their customers alike.

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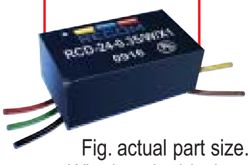
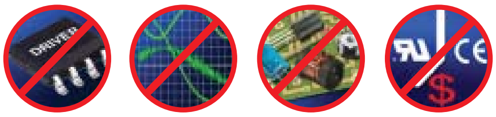


Fig. actual part size.
Wire length: 4 inches.



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