NOVEMBER/DECEMBER 2008

LEDs MAGAZINE®

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TECHNOLOGY AND APPLICATIONS OF LIGHT EMITTING DIODES

Solar Power
Off-grid LEDs for illumination P.22

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Standards talk in San Diego P.31

Residential
LEDs address a growing market P.44

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LEDs behind New York project P.29

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ISSUE 24

november/december 2008

Cover Story

LEDs lit the New York City Waterfalls this summer (see page 29). Commissioned by the Public Art Fund. © Olafur Eliasson, 2008. Photo: Julienne Schaer.

features

columns/departments

commentary

Residential lighting is a growing market for LEDs

I enjoyed the LEDs 2008 conference in San Diego, and not just because of the lunches outside in the sunshine. There was lots of positive talk about standards, and the progress being made by LED makers — see our report on p31. I also learned a lot about the residential lighting market, and why it's different from the commercial lighting sector — see p44 for more. LED-based residential light fixtures (RLFs) are now part of the EPA's Energy Star RLF program, which dates back to 1997. Alex Baker, EPA's Lighting Program Manager for Energy Star, spoke about RLF v4.2 at LEDs 2008, on the same day that the DOE's Energy Star criteria (SSL v1.0) went "live" — see p15. *LEDs Magazine* solicited some additional comments from Baker — see www.ledsmagazine.com/features/5/11/1 for the full version. Baker explained that the inclusion of LED light engines in RLF v4.2 is a natural extension of the RLF program, which compares measured source performance against performance thresholds applicable to all technologies; this "enables consumers to make apples-to-apples product comparisons."

Different lighting markets justify, says Baker, a different approach to measurement. "SSL v1.0 employs fixture photometric data [and] is fully appropriate for commercial, industrial and architectural lighting," he says. "However, the residential segment of the market has never conducted full fixture photometry." Testing of this type would be inappropriate and overly burdensome for RLF manufacturers, who operate within much tighter cost constraints, says Baker, asking "would luminous intensity distribution data for a Tiffany-style fixture assist a consumer with a purchasing decision?"

I've spoken with manufacturers that said they would work with RLF v4.2 rather than SSL v1.0, where they have a choice, because the EPA specification is easier to meet. Baker says this is not the case, and that the RLF v4.2 specification is "equally as stringent as the SSL v1.0 specification."

Working with the ALA and NEMA, says Baker, the RLF program has maintained a database of lamps and ballasts which exceed the program's minimum performance thresholds. RLF manufacturers use these off-the-shelf components to earn the Energy Star for their fixtures. Nearly 16,000 fixtures are currently qualified. This source-based testing philosophy has been extended to include LED light engines in v4.2. "This represents the type of off-the-shelf solution that RLF manufacturers are seeking," says Baker.

RLF v4.2 references an "ASSIST Recommends" test procedure for LED light engines. "This was developed by LED manufacturers, and is currently under review for IESNA standardization, similar to the development of LM-79 or LM-80," says Baker, adding that EPA has worked with the Lighting Research Center (LRC) to train several labs to perform the testing procedure. "EPA is confident in the strength of this testing procedure, and working with the LRC has tested several promising fixture designs," he says. "To date, we have found no fixtures capable of meeting the long-established 50 lm/W efficacy requirement."

At LEDs 2008, several voices pointed to the confusion caused by multiple Energy Star requirements for LED fixtures and called for a single, unified program. Baker says that EPA "anticipates meeting with DOE in the near future to clarify larger programmatic issues." As more fixtures are tested, the different specifications will be refined, and are expected to start to converge. But for now it looks like residential fixtures will continue to have a different route to gaining their Energy Star.

Tim Whitaker, EDITOR
twhitaker@pennwell.com

LEDs MAGAZINE

EDITOR & PUBLISHER Tim Whitaker twhitaker@pennwell.com Tel. +44(0)117 946 7262

MANAGING EDITOR Julie MacShane juliem@pennwell.com Tel. +1 603 891 9221

CONTRIBUTING EDITOR Brian Owen

SALES MANAGER (EUROPE & ASIA) Joanna Hook joannah@pennwell.com Tel. +44(0)117 946 7262

SALES MANAGER (USA) Mary Donnelly maryd@pennwell.com Tel. +1 603 891 9398

PRODUCTION DIRECTOR Mari Rodriguez

ART DIRECTOR Meg Fuschetti

ILLUSTRATOR Christopher Hipp

MARKETING COMM. MANAGER Carol Fronduto

CIRCULATION MANAGER Debbie Bouley debbieb@pennwell.com

GROUP EXHIBITS DIRECTOR Katrina Frazer katrinaf@pennwell.com

TECHNOLOGY GROUP SENIOR VICE PRESIDENT & PUBLISHING DIRECTOR Christine A. Shaw cshaw@pennwell.com Tel. +1 603 891 9178

VP OF AUDIENCE DEVELOPMENT Gloria S. Adams

CORPORATE OFFICERS

CHAIRMAN Frank T. Lauinger

PRESIDENT AND CEO Robert F. Biolchini

CHIEF FINANCIAL OFFICER Mark C. Wilmoth

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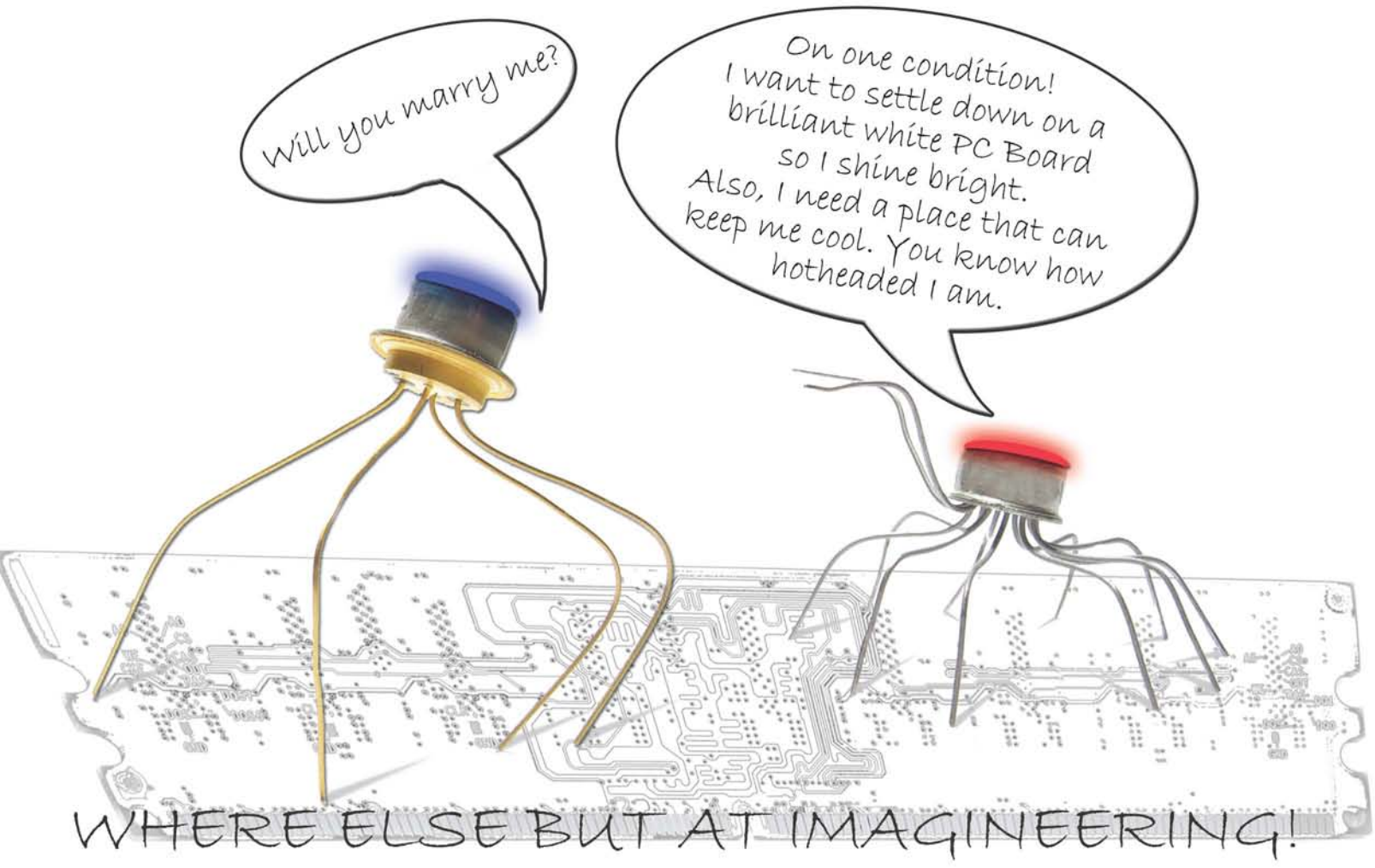

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LEDs MAGAZINE | web exclusives

Webcasts

Thermal Design for Enhanced LED Performance
Monday, November 24, 2008

JOHN PARRY, Mentor Graphics (formerly Flomerics)
STEVE TAYLOR, The Bergquist Company

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

Articles

Tesla™ simplifies LEDs for the OEM general lighting market
www.ledsmagazine.com/features/5/9/7

Vicor's flexible, accurate & efficient power solutions for LED backlighting applications
www.ledsmagazine.com/features/5/10/13

Safety-centered approach improves quality of light for petrochemical facilities
www.ledsmagazine.com/features/5/10/14

Upfront thermal simulation helps SureFire design products for life or death situations
www.ledsmagazine.com/features/5/11/2

Featured Companies & Profiles

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

Instrument Systems GmbH • TradeKey (Pvt.) Limited

Company Profiles have also been added for the following (see www.ledsmagazine.com/Profiles):

Kingsun Optoelectronic • High Power Lighting Corp • Instrument Systems

ADVERTISERS index

FEATURED event

Strategies in Light 2009

February 18-20, 2009
Santa Clara, California, USA

Strategies Unlimited and PennWell Corporation will host their 10th annual business-oriented conference and exhibition on high-brightness LEDs at the Santa Clara Convention Center. This year's conference theme focuses on Lighting the Future with LEDs. For its 10th anniversary, Strategies in Light will expand the scope of the conference by adding a separate lighting track to meet the information needs of lighting designers, specifiers and architects. *Go to www.strategiesinlight.com for more information.*

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

electronica 2008
November 11-14, 2008
Munich, Germany

Interlight Moscow 2008
December 9-12, 2008
Moscow, Russia

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

Intelligent Automotive Lighting
January 26-29, 2009
Frankfurt, Germany

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

LED Lighting Today: Tales or facts?
March 13, 2009
Naples, Italy

Lux Pacifica 2009
April 23-25, 2009
Khabarovsk, Russia

Lightfair International
May 5-7, 2009
New York City, NY, United States

OPTOmism: Photonics for the Green Revolution
May 18-20, 2009
Santa Clara, CA, United States

Display Week 2009
May 31-June 05, 2009
San Antonio, TX, United States

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

FAWOO TECHNOLOGY

New Age of LED Lamps Coming

Introducing New Halogen Type Lumidas-H LED Lamps series from FAWOO TECHNOLOGY

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[Lumidas-H 3W, 5W, 8W, 16W, 22W, 35W Lamps]

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POWER :12V AC/DC DC 0.240A (MAX 12V)
Size(mm): D50.0×H51.5
Base Type : GU5.3 / EZ10

5W Halogen PAR20 LED LAMP
POWER : DC 0.384A (MAX 12V)
Size(mm) : D70.0×H75
Base Type: EZ10 / GU5.3

8W Halogen PAR30 Style LED LAMP
POWER : AC110V AC220V DC 0.384A (MAX 12V)
Size(mm) : D95.0×H99.2
Base Type : E27 (26) / EZ10

16W Halogen PAR38 Style LED LAMP
POWER : AC 100~240V
Size(mm) : D122×H161
Base Type : E27/E40

22W Halogen PAR48 LED LAMP
POWER : AC 100~240V
Size(mm) : D152×H161
Base Type : E27/E40

35W Halogen PAR56 LED LAMP
POWER : AC 100~240V
Size(mm) : D180×H191
Base Type : E27/E40

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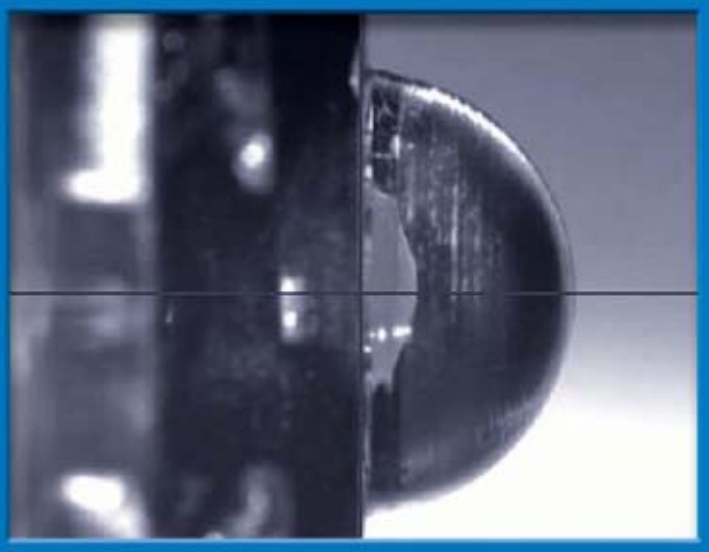
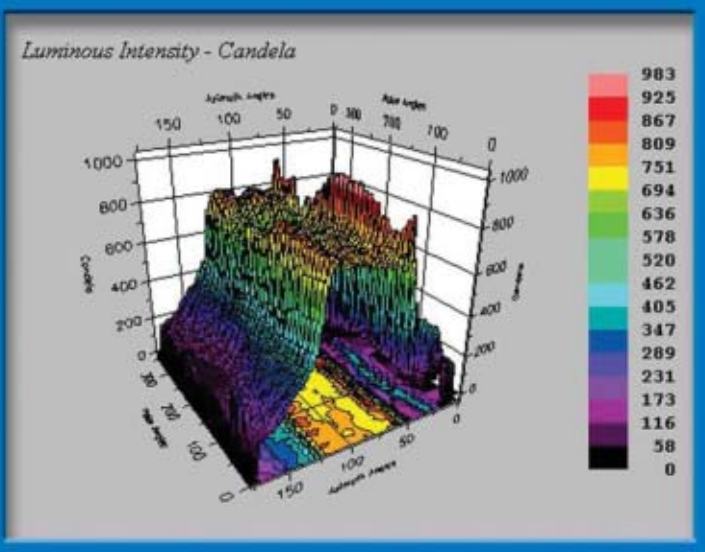
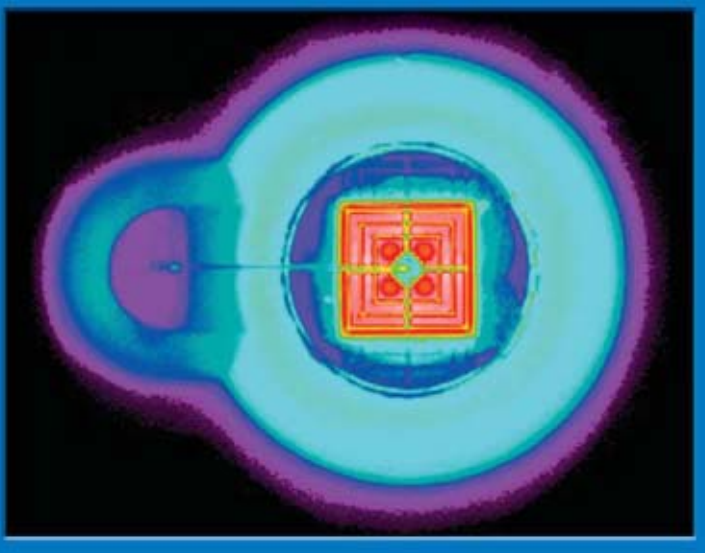


Industry Standard Near Field Models



Extensive Light Source Analysis Capabilities

Optimized For LED Measurement



Use With All Popular Optical Design Software

Let Your LEDs Shine (and Reduce Cost!) with Accurate Source Models from the SIG-400.

Whether you're designing an LED light source or an LED lighting system, accurate characterization with a near field source model is vital. These enable detailed evaluation and comparison of LED designs, and can be used with popular optical design software packages. The result is reduced development costs, elimination of rework, and confident communication of data to your customers.

The new SIG-400 Source Imaging Goniometer specifically addresses the needs of LED researchers, manufacturers and users for high accuracy die and device characterization. This fourth generation SIG-400 brings together improvements in instrument design and construction to make it easier than ever to obtain precise, accurate near-field models for small light sources.

The SIG-400 combines a 16-bit ProMetric imaging colorimeter, a high precision goniometric assembly, and SIG1.0 control and analysis software to deliver detailed, near-field source models. These Radiant Source™ Models and ProSource® software are the industry standard for describing and analyzing the near-field optical properties of light sources.

If you're manufacturing high quality LEDs or incorporating them into luminaires or other illumination systems, then you also need the best optical source models. For more information on the SIG-400, contact us at +1-425-844-0152 or visit us online.

RADIANT IMAGING

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news views

PATENTS

Osram and Philips agreement enables access to LED luminaire IP

The two largest European lighting manufacturers, Royal Philips Electronics and Osram, have concluded a patent license agreement for LED-based technology used in luminaires. Osram says that the agreement "will give the market for LED-based lighting a further boost." Philips described the agreement as "a next step in making the basic Philips LED control IP broadly available to accelerate the development of the market."

In June 2008, Philips announced a patent licensing program for LED-based luminaires (*LEDs Magazine*, Jul/Aug 08, p7). However, royalties under this program are not payable by companies that purchase all key LED luminaire components from Philips. Now, Osram has taken a license from Philips to obtain the same concession for Osram customers. In other words, LED luminaire manufacturers that use key components purchased from Osram will not be liable to pay license fees to Philips.

Osram says that these "special rights" relate not only to patents held by Philips but also to patents held by Color Kinetics and TIR Systems, which were acquired by Philips last year. According to Philips, this new arrangement also benefits Philips customers, because it includes royalty-free access to Osram LED system patents when purchasing all key components from Philips. ◄

MORE DETAILS: www.ledsmagazine.com/news/5/9/31

AUTOMOTIVE

Europe mandates DRLs for all new vehicles from 2011

To increase road safety, the European Commission (EC) has decided to introduce dedicated daytime running lights (DRLs) on all new types of motor vehicles from the year 2011 onwards. Dedicated DRLs automatically switch on when the engine is started, and substantially increase the visibility of vehicles to other road users. Compared with dipped-beam headlamps, dedicated DRLs have around 25–30% of the energy consumption, dropping to 10% when LED technology is used. A number of car makers, notably Audi, have already introduced DRLs using white LEDs. The new EC Directive, which is not yet law in all 27 member states, foresees that from 7 February 2011 onwards all new types of passenger cars and small delivery vans will need to be equipped with DRLs. Trucks and buses will follow in August 2012. ◄

MORE DETAILS: www.ledsmagazine.com/news/5/9/35

BACKLIGHTING

Dell drives transition to energy-efficient LED displays

US-based computer maker Dell says that it plans to transition all of its new laptop displays to LED backlights in the next 12 months. This, says the company, will be a major achievement in its commitment to become the "greenest" technology company on the planet. Dell estimated that at least 80 percent of its total laptop volume will be delivered with LED as the standard display backlight by the end of 2009, moving to 100 percent in 2010. At the LEDs 2008 show, John Jacobs of DisplaySearch forecast that all laptops would use LED backlights by 2015.

Effective December 15 this year, two-thirds of Dell Latitude E-Family laptops will be shipped with LED backlighting as a standard feature, as will Precision M2400 and M4400 mobile workstations. In addition to being mercury-free and highly recyclable, Dell says that LED displays deliver significant energy savings compared to cold cathode fluorescent lamp (CCFL) technology.

For example, Dell's 15-inch LED-backlit displays consume an average of 43 percent less power at maximum brightness, resulting in extraordinary cost and carbon savings. The company estimates customer savings of approximately $20 million and 220 million kWh in 2010 and 2011 combined, the equivalent of annual CO_2 emissions resulting from energy use of more than 10,000 homes. ◄

MORE DETAILS: www.ledsmagazine.com/news/5/9/33

news+views

ENTERTAINMENT

Vitec acquires Litepanels LED lighting business

The Vitec Group has acquired the business and assets of Litepanels, a manufacturer of LED-based lights for the television, broadcast, video and film industries. An initial

cash sum of around $14.5M will be followed by further payments depending on future profitability. Litepanels, based in North Hollywood, California, has developed a range of LED on-camera and stand-mounted lighting systems, backed by a strong patent portfolio, that have gained acceptance with lighting and broadcast professionals in the last few years. Litepanels was founded in 2005 by five partners with extensive experience as lighting designers or lighting directors, all of whom will stay with the company.

Back in March 2008, Litepanels, Inc announced that West Palm Beach, Florida CBS affiliate WPEC has become the first TV station in the world to use 100-percent LED lighting for illumination of its television news studio (see photo). The station chose Litepanels' 1 x 1-foot, 5600K spot fixtures to do the job, taking advantage not only of their HD-friendly light properties, but also the tremendous energy savings both in powering the lights themselves and in cooling the studios. ◄

MORE DETAILS: www.ledsmagazine.com/news/5/9/11

MARKETS

Taiwan LED companies lead demand for sapphire wafers

The market for sapphire materials in electronic applications looks set to reach $400 million by 2012, according to a report by Yole Développement. The report also says that the sapphire substrate market for electronic applications has reached a 2007 market volume of 4.61 million wafers (2-inch equivalent) for LED manufacturing, augmented by several tens of thousands of 6-inch wafers for silicon-on-sapphire (SoS) RF applications. For LED manufacturing, the sapphire business is suffering huge price pressures in the main Asian regions. With LED die-on-wafer now sold for between 2 and 3 cents, LED producers are requesting sapphire substrates down to $17 for a 2-inch wafer. This situation has forced some sapphire producers to leave these regions to focus on western countries where market prices are more attractive. Demand for 4-inch wafers is growing rapidly, along with the recent announcements of some major companies such as Osram and Showa Denko to migrate part of their production to larger diameter substrates. Plans for 6-inch nitride LED production have been announced by Samsung, and 8-inch c-plan sapphire has been demonstrated by Monocrystal, a leading supplier. Five of the top ten sapphire suppliers are in Asia, a region which accounted for 67% of revenue. Asian countries also consume a huge proportion of the total sapphire inventory, with Taiwanese companies accounting for 58% of total sales and Japanese companies accounting for a further 19%.

MORE DETAILS: www.ledsmagazine.com/news/5/10/9

OUTDOOR LIGHTING

Dellux lights road tunnel in Germany with Osram LEDs

In the fall of 2008 the "Thüringer Schmücketunnel" on the A71 autobahn in the German state of Thüringen will become the first tunnel in Germany, and the longest tunnel in Europe, to be lit with LED lighting. Trials have already commenced in one of the two tubes, which have a maximum length of 1729m and are 4.5m high

PEOPLE

Enfis: The UK-based manufacturer of high-power, intelligent LED arrays has hired Dan Polito as president of Enfis Lighting North America. Until recently, Polito was VP of marketing at Lamina Lighting, and is based in the New York/New Jersey area. Enfis expects that Polito will be ideally placed to move the company's products into lighting applications that require controllability, reliability and high lumen output from a single source.

Intematix: Jeff Lagaly, former global sales director for Cree Lighting, has been appointed VP of sales, LED lighting for Intematix Corp, the Fremont, California-based supplier of phosphors, LED components and SSL modules. At Cree, Lagaly oversaw the sales effort that introduced and drove Cree's XLamp LED line to sales in excess of $100M.

Element Labs: Barbara Nelson is to take over as CEO of Element Labs from co-founder Nils Thorjussen, who will continue as VP business development. Element Labs, a Santa Clara, California-based developer and supplier of LED video technology, says that Nelson's appointment forms part of its strategy to strengthen its core management team and further accelerate its plans for growth. Nelson was most recently CEO and chairman of NeoScale Systems.

Lynk Labs: Best known for its AC LED technology, Lynk Labs has appointed Charles Huber as the company's new VP business development. Having previously served as senior VP engineering & product management at Juno Lighting Group, Huber brings nearly 20 years of lighting industry expertise to Lynk Labs.

Everlight: Stephan Greiner is the new VP of global sales at Everlight, a manufacturer of LEDs and other opto semiconductors. Greiner will be responsible for worldwide sales strategies, and brings 13 years of experience in semiconductor sales. His last position was senior director, sales, Europe and emerging markets, at Osram Opto Semiconductors.

Permlight: Barry Williams, formerly with Nichia, has been named director, Western region OEM sales for Brillia, the light engine division of Permlight Products. Williams will be responsible for the ongoing collaboration with original equipment manufacturers in the Western region to help bring LED-based luminaires to market. ◄

and 9.5m wide. The LED luminaires are supplied by Dellux Technologies and each contains 84 Golden Dragon LEDs from Osram.

Wolfgang Medenwald, VP of business development Europe for Dellux, told *LEDs Magazine* that a total of 783 luminaires are used in the tunnel. "Each tube has 314 fixtures for the interior section, and 35 additional luminaires are used in each emergency area, where a 3-times higher luminance level is required," he said. "There are also 5 luminaires in the emergency aisle between the tubes."

The Dellux luminaires are claimed to be virtually maintenance-free, and to provide constant light output over a period of 130,000 hours (15 years). This is achieved using "degradation compensation" technology. "We have installed redundant LEDs in each luminaire to offset soiling and degradation losses," says Medenwald. "We also operate the LEDs at only 85% of their rated current to achieve greater efficiency and durability. Our patented technology allows maintenance of the required light levels for a minimum of 15 years despite the difficult conditions in the tunnel."

The LEDs can be controlled to provide the prescribed luminance levels through the tunnel during both day and night. By day the required luminance in the tunnel is 4.65 cd/m^2, while by night a value of 0.8 cd/m^2 is sufficient. The average power consumption of the luminaires is 70 W during the day and 12 W at night. Overall, compared with a lighting system based on high-intensity discharge lamps, the LED luminaires will consume at least 30% less energy, corresponding to annual savings of 10,000 kWh. ◄

MORE DETAILS: www.ledsmagazine.com/news/5/9/13

PACKAGING

Evident licenses nanocrystal patents from Philips

Evident Technologies has signed a non-exclusive licensing agreement with Philips Electronics that will enable Evident to launch a new line of low-power LEDs and LED-based products that use semiconductor

nanocrystals (also known as quantum dots) as the wavelength converter. Conventional phosphors can only yield a limited range of colors, says Evident, while semiconductor nanocrystal technology removes these color limitations. In the first commercial example, Holiday Creations/Diogen Lighting will incorporate Evident's technology into "light-strand" holiday lights in the US and Canada market. The Dot-strand lights are available in a range of "never-before-seen colors" such as peach, lime and aqua (see photo).

In related news, Evident was recently awarded US patent no. 7,399,429 covering the ability to make semiconductor nanocrystals from III-V materials, including indium gallium phosphide. ◄

MORE DETAILS: www.ledsmagazine.com/news/5/10/17

BUSINESS IN BRIEF

Cree signs with two distributors

Cree and Digi-Key have signed a global distribution agreement for Cree LEDs including the XLamp and high-brightness devices. Cree LEDs are available through Digi-Key's website and will be added to future print catalogs. In addition, Premier Farnell is to distribute the full standard portfolio of Cree LEDs, including XLamp products. These products will be distributed throughout the company's global network of companies via its multi-channel model of 35 websites, paper-based catalogues and dedicated field sales forces.

Instrument Systems reports success

Instrument Systems GmbH, a Munich, Germany company specializing in light measurement, finished the fiscal year 2007-2008 with its best results since it was established in 1986. Revenues increased by 22% to EUR 9.3 million, following on from EUR 7.6 million in the year 2006-2007. The medium-sized company is a leader in LED test & measurement.

StockerYale opens Ireland facility

StockerYale, the Salem, NH-based manufacturer of chip-on-board LED modules for industrial applications such as machine vision, has opened a state-of-the-art facility in Cork, Ireland. The facility, which will also act as an R&D center, will double the company's die placement capacity to 50,000 LEDs per day by mid 2009. The company's LED Systems business is experiencing significant growth in inspection, industrial, and security markets.

Bayer teams with LSG

Bayer MaterialScience LLC (BMS), a producer of polymers and high-performance plastics, has entered into a joint development agreement with LED lighting manufacturer Lighting Science Group (LSG). The alliance combines the lighting application and LED system integration know-how of LSG with BMS' polycarbonate resin technology. BMS has developed grades of its Makrolon polycarbonate and Bayblend PC/ABS resins specifically for demanding high-brightness LED applications. ◄

PATENTS

Nichia LED patent invalidated

On October 1, the Korea Intellectual Property Tribunal (KIPT) ruled that patent number KP 491482, (the "482" patent) owned by Nichia Corp. is invalid based on lack of inventiveness. This is the second of Nichia's patents to be invalidated by KIPT in recent months, following a similar ruling in July 2008. In October 2007, Nichia filed an infringement lawsuit based on the 482 patent and directed against Seoul Semiconductor's Z-Power P9 Series white LEDs, which contained Mvp LED chips from SemiLEDs. In order to assist its customer (Seoul), SemiLEDs decided to counter-sue so that it was also involved in the lawsuit against Nichia. ◄

MORE DETAILS: www.ledsmagazine.com/news/5/10/1

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LED Recessed Down Lights
GU10 - 4.5W

LED Cabinet Lights
MR16 - 3W

LED Track Light
MR16 - 3W

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The SEEN 2008 FALL
Catalogue is now on stage.

funding + programs

DOE Energy Star program for SSL effective from September 30

The Energy Star Solid-State Lighting program, developed by the U.S. Department of Energy (DOE) with input from various industry stakeholders, came into effect on September 30, 2008. Energy Star (www.energystar.gov) is a voluntary labelling program operating in North America that recognizes energy-efficient products in numerous categories that meet or exceed certain performance criteria.

DOE unveiled its criteria one year ago and has been making revisions, as well as educating the industry, in the intervening period. The Energy Star SSL version 1.0 criteria are based on, and intimately linked with, various industry standards such as LM-79 (photometric measurements) and C78.377 (chromaticity) – see *LEDs Magazine*, Jul/Aug 2008, p7. In fact, the Energy Star launch had to wait until another standard, LM-80, was finally approved by the Illuminating Engineering Society of North America (IESNA).

IESNA formally adopted LM-80-2008, entitled "Approved Method for Measuring Lumen Depreciation of LED Light Sources," in the final week of September. The final version of LM-80 should be published soon via IESNA's website (www.iesna.org).

With the approval of LM-80, DOE had in place all of the industry-recognized test procedures needed for qualifying products as Energy Star. DOE's next step is to help manufacturers get Energy Star qualified products to market. To help manufacturers navigate the qualification process, DOE has created a document, "Manufacturer's Guide for Qualifying Solid-State Lighting Luminaires," that can be downloaded from the DOE's SSL Program website (www.netl.doe.gov/ssl/energy_star.html). This document outlines the performance benchmarks that Energy Star qualified products must meet; identifies testing facilities approved to conduct Energy Star testing; and establishes the protocols manufacturers must follow to submit this information for approval. The Manufacturer's Guide complements Energy Star SSL Criteria v1.0, and will be updated to reflect the expansion and evolution of the program.

The news from DOE is very positive, although there is still no end in sight to the Department's dispute with the Environmental Protection Agency (EPA), which has issued conflicting and overlapping criteria covering some types of SSL fixtures (see "Energy Star Wars: the Phantom Menace" at www.ledsmagazine.com/features/5/8/2).

LM-80 and lumen depreciation

The IESNA's LM-80 standard has had a long gestation period, mainly because the industry could not agree on a unified methodology to calculate predicted life. Eventually, this was omitted. Officially, LM-80 provides methods for measurement of lumen maintenance of sources including LED packages, arrays and modules only…it does not provide guidance or make any recommendation regarding predictive estimations or extrapolation.

LM-80 says lumen maintenance, the decrease in light source output (luminous flux) as a percentage of initial output over a time period, should be measured for operation at three separate case temperatures, over at least 6000 hours, although 10,000 hours is preferable. While most manufacturers can use such measurements to extrapolate lifetimes such as L_{70} (time taken to reach a lumen maintenance of 70%) for their own devices, it proved impossible for the LM-80 authors to agree a common industry-wide technique for this type of prediction. ◄

DOE unveils Round 6 of CALiPER testing results

The latest results from the US DOE's Commercially Available LED Product Evaluation and Reporting (CALiPER) program were released at the LEDs 2008 conference on October 1 (see p31). Mia Paget, CALiPER program manager, described the results of Round 6 testing of 24 SSL products — see www.netl.doe.gov/ssl/comm_testing.htm.

The focus of Round 6 was on small replacement lamps (MR16 lamps, A-lamps, candelabra lamps, etc). A variety of luminaires were also tested, including four desk lamps, a downlight, a recessed wall fixture, and two different types of outdoor products. In addition, a number of products using traditional sources were tested for benchmarking purposes.

The results: Paget said some LED replacement products of this type "hit the bar" in terms of performance, but most on the market today do not.

"Some don't beat competing alternatives, even incandescents," she said. While some replacement lamps claim to be replacing an 80W bulb, they only match the output of a 40 W lamp. Some lamps also showed a problem with form factor, and with the quality and color appearance of the light. Many white-light lamps emitted blue, green or orange light instead.

"The very best MR16 LED lamp did not reach the minimum output of halogen lamps, but most every LED lamp exceeds the efficacy of halogen," Paget summarized

Room for optimism

Almost all of the SSL products tested did not meet the manufacturers' performance claims on the package. This is troubling since the DOE does not want a repeat of the problems encountered during the early years of CFLs, when consumers were disappointed with their performance and quality.

However, there is still plenty of room for optimism. Paget said that, according to recent CALiPER results, improvements are coming in output and efficacy of these lamps. "Of course, there is a learning curve. Many companies are still just setting their foot on the slope." ◄

funding + programs

Procurement scheme draws LEDs into public sector in UK

A hospital trust that is part of the National Health Service (NHS), the UK's public-sector health provider, is participating in a procurement scheme that should provide companies with the opportunity to supply innovative, ultra-efficient lighting (UEL) technology into this market. The Rotherham NHS Foundation Trust is undertaking a market consultation process in partnership with the Department for Business Enterprise and Regulatory Reform (BERR), the Department of Health (DH), and the NHS Purchasing and Supply Agency (PASA).

This project is one of the first to adopt the Forward Commitment Procurement (FCP) model, developed by the UK Government to hasten the market entry of innovative and sustainable technologies. FCP is described as providing "a practical mechanism to harness the power of public-sector procurement to create much needed innovative solutions for pressing environmental problems, such as climate change."

This project will accelerate the up-take of ultra-efficient lighting in the NHS, helping to realize more rapidly the environmental benefits of this technology, as well as delivering energy savings and best value to the NHS. It should also help to drive innovation and to provide a focus for the development of the supply chain.

The project is the first result of the secondment to BERR of Geoff Archenhold as an industrial advisor (see *LEDs Magazine*, Jul/Aug 2008, p13). Archenhold says that "ultra-efficient lighting" should fulfil two criteria; it should contain a light source that exhibits in excess of 100 lm/W and the fixture should have an overall efficacy of 60–80 lm/W, depending on the circuit power consumed.

Healthy lighting

The Rotherham NHS Foundation Trust has identified a requirement for smart and ultra-efficient lighting solutions for its "Future Ward" refurbishment project that will run over a 7-year period starting in 2009. The estimated value for the lighting component is £2 million. The market evaluation exercise provides the lighting supply chain with an opportunity and a framework through which it can inform and shape procurement strategy, design and specifications for advanced lighting products. This applies not only to the Future Wards program at the Rotherham, but also to other NHS refurbishment and new build projects. There are a number of other Trusts and organizations which have indicated similar requirements and interest in UEL. The scale of the market within the NHS is very substantial.

The 24/7 environment of the NHS means that lighting represents a significant percentage of electricity consumption, making it an ideal "lead market" for innovative lighting. Good lighting makes a significant contribution to creating the right environment in a hospital or clinic and can help create both an operationally effective and patient-centered healing environment. The Rotherham NHS Foundation Trust has said that it wants to achieve a step change in the patient experience, including the incorporation of "highly efficient, smart lighting systems that can deliver economical carbon reductions while at the same time contributing to a pleasant and healthy environment for both patients and staff."

A hospital in the UK has installed 300 LED external light fixtures to illuminate its car parks and access roads. The Royal Glamorgan Hospital near Cardiff, Wales, used fixtures from UK manufacturer i-Vision at a cost of just under £100,000. With estimated savings in energy and maintenance costs of over £34,000 per year, the Pontypridd & Rhondda NHS Trust, which runs the hospital, expects to see a payback period of less than 3 years. Switching to LED lighting will allow the Trust to realize carbon savings of 100 tons per year, and also reduce the need to hire access vehicles to replace faulty lamps.

MORE DETAILS: www.ledsmagazine.com/news/5/10/12

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RPCVD technology offers low-cost growth alternative for GaN-based LEDs

By eliminating ammonia and using large, low-cost substrates, a new growth technology could offer a challenging alternative to conventional MOCVD processes, writes **GILES BOURNE**.

Since the opening in July of BluGlass Ltd's pilot manufacturing plant for GaN-based LEDs, a revolutionary growth technology is now accessible to the LED industry. The installation of the Australian company's first commercial-scale mass production deposition tool at its new headquarters (see Links) means that BluGlass will be able to further test its remote plasma chemical vapor deposition (RPCVD) process under the conditions required to demonstrate the technology's full potential. BluGlass is currently in discussions with a number of major LED manufacturing groups with a view to demonstrating its unique process.

This is the culmination of 15 years' research at Sydney's Macquarie University by a team led by the technology co-founder, Scott Butcher. Commercialization work during the last two years has been undertaken by BluGlass, which trades as a company on the Australian stock exchange, under an arrangement whereby it also owns all of the relevant patents.

The groundbreaking process, developed by the university and advanced by BluGlass, allows GaN-based LEDs to be manufactured much more cheaply than with the current technology, thanks in part to the greatly reduced consumption of toxic chemicals.

What makes the company's RPCVD process unique is that the plasma source used to provide active nitrogen species is removed from the area of film growth, providing greater control over the deposition process. "The RPCVD growth of GaN has been attempted by other groups in the past without much success," says Butcher. "The breakthrough for Blu Glass has been to overcome these past problems, particularly those associated with oxygen contamination."

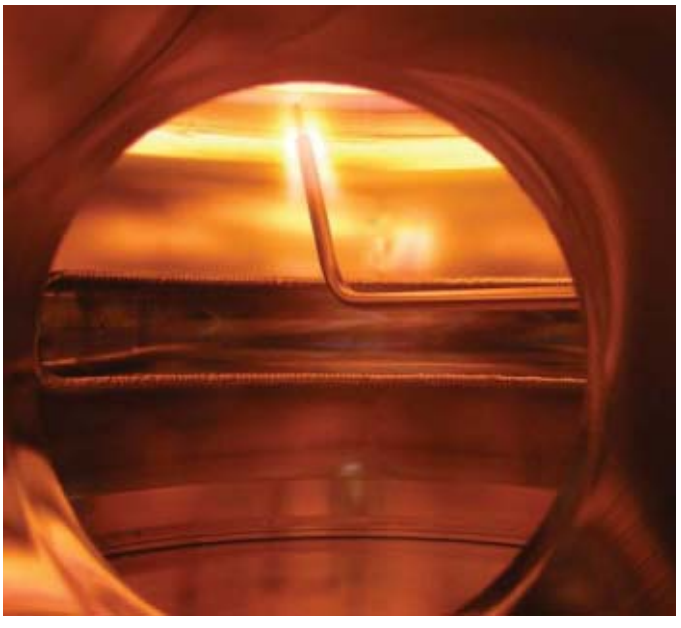

Fig. 1. Inside the BluGlass reactor, the nitrogen plasma can be seen as well as a diagnostic probe.

Source materials

Currently, the most widely used system for producing GaN-based LEDs is metalorganic chemical vapor deposition (MOCVD). This involves growing a series of GaN-based semiconductor thin films, usually on synthetic sapphire substrates, to produce a device structure. Generally speaking, temperatures of more than 1000°C are required to do this. The MOCVD process also uses large flows of highly purified ammonia vapor, in addition to metalorganic compounds, which are the source of metals (such as gallium and indium) used to create the GaN-based layers.

In contrast, RPCVD does not require the use of ammonia, but uses nitrogen gas instead. The active nitrogen species used during growth is generated in a plasma, remote from the substrate position. In MOCVD reactors, nitrogen gas itself cannot be used as a precursor for growth because it is chemically inert. The plasma, however, provides active nitrogen species by exciting the gas molecules to a higher potential energy level where they become chemically reactive.

BluGlass's process limits the concentration of high-energy ionic nitrogen species and electrons close to the film growth surface, which could be potentially damaging to the film. This is done by generating the plasma remotely. The use of remote plasma allows longer-lived, chemically-reactive neutral species that are also created in the plasma region to stimulate film growth.

"One of the main advantages of the RPCVD process, apart from eliminating expensive and environmentally unfriendly ammonia, is that the film growth can be done at very much lower temperatures," says Butcher. "High temperatures are required in MOCVD to crack the ammonia and provide sufficient nitrogen for growth to occur. In RPCVD, temperatures only need to be high enough to decompose the metalorganics used to provide the gallium and other metals that combine with the nitrogen species. A BluGlass reactor operates at as low as 550°C, half that of MOCVD."

Projected cost savings

Quite apart from providing large savings in energy and the elimination of expensive ammonia vapor, thanks to low temperature growth the BluGlass process also allows the use of

GILES BOURNE *is the CEO of BluGlass Ltd* (www.bluglass.com.au), *Silverwater, Australia.*

versatile substrates such as cheaper glass, silicon and lattice-matched, buffered substrates instead of synthetic sapphire. The company has been advancing the development of such substrates through an alliance with France's St Gobain Research.

The new BluGlass demonstration plant in Sydney is intended to quantify the cost advantages for semiconductor manufacturers that are interested in purchasing equipment from BluGlass. The company's ongoing studies show that the savings should be significant, a finding that has been supported by independent analysis.

Wright Williams & Kelly Inc. (WWK), a US-based operational cost management consultancy, has produced a report outlining the potential savings at the epi-wafer level by comparing RPCVD with conventional MOCVD processes. It assumed that 2-inch buffered glass substrates were used by BluGlass, and measured the results against similar-sized sapphire substrates that are common within the industry today. The report was based on a commercial production tool that could handle 21 individual wafers.

WWK concluded that: "The wafer-level analysis shows an overall cost saving of 48% for RPCVD, with the major cost driver being a 70% reduction in the materials and consumables costs. The largest factors in this area are a substantial reduction in substrate cost and the complete elimination of ammonia. Over a projected seven-year useful life, the operating costs for RPCVD are almost US$8 million lower than MOCVD for a single piece of equipment."

The study found that the total cost per epi-wafer using the BluGlass technology was $45.07, compared with $86.30 for MOCVD. The greatest single saving came in the use of a buffered glass substrate, which cut costs from $25 to $10 for each 2-inch wafer. Ammonia vapor costs of were completely eliminated while other process gases were slashed by 84% (see table).

Process cost comparison

Cost (US $)	MOCVD	RPCVD (BluGlass)	Savings (%) for RPCVD
Substrate	25.00	10.00	60
Ammonia gas	10.64	0.00	100
Other process gases	4.58	0.74	84
Total cost per epi-wafer	86.30	45.07	48

Cost comparison for MOCVD on 2-inch sapphire substrates vs. RPCVD using 2-inch buffered glass substrates. Source: WWK

Larger wafers

Encouraging as the WWK figures are, there remains the potential for RPCVD to deliver greater cost savings. This is partly because of the limited scope of the report, and also relates to the possibility of further advancement of BluGlass's technology.

WWK noted that MOCVD requires the installation of specialized plumbing for each reactor because ammonia is supplied as a pressurised and liquefied vapor. Also, downstream of the film growth chamber, specialized abatement equipment is also needed when using ammonia. This plumbing is not needed for RPCVD equipment. The study, however, did not quantify the savings. Additional savings could also result from the lower temperatures used in the BluGlass process.

Fig. 2. The BluGlass demonstration reactor at the company's new facility in Australia.

Another major advantage of the RPCVD technique is that it is possible to manufacture on larger substrates than the 2-, 3- or 4-inch ones commonly used by the GaN-based LED industry. Because of the high temperatures used in the MOCVD process, it has been difficult for the industry to go beyond this limit because larger substrates tend to bow and distort. In contrast, the silicon industry processes substrates that are 12 inches in diameter.

"Many thousands of devices can be processed from a single wafer, and there are huge cost advantages in processing larger wafers," says Butcher. "BluGlass has demonstrated uniform thickness deposition (with less than 2% variation) on glass substrates of 6-inch diameter to better than industry standard. We have plans to extend this to a full 12 inches." Further work is also being undertaken to determine whether this can match or exceed uniformity achieved by MOCVD.

Technology developments

The new BluGlass factory sees the installation of a fourth-generation reactor, which is more advanced than the model used for WWK's cost analysis. This reactor will be the base model for any sales that eventuate as a result of the demonstration process. Despite this advance, however, BluGlass is planning to take its technology to new levels.

Early in October, the company announced the formation of a technology council comprised of industry experts and internal BluGlass scientists to advise and oversee advancements to the semiconductor manufacturing process. It is intended that the council will also provide direction for the timely commercial delivery of the technology.

The council comprises Chennupati Jagadish, a specialist in semiconductor optoelectronics and nanotechnology, and Petar Atanackovic, an expert in the fields of CMOS, compound semiconductors and optoelectronics. They are joining two internal members from BluGlass's technical team, Conor Martin and Marie Wintrebert-Fouquet.

LINKS

BluGlass opens pilot plant to demonstrate LED growth process
www.ledsmagazine.com/features/5/10/4

Solar power drives LEDs for ge

Thanks to rapid improvements in photovoltaic and LED lighting technology, solar-powered LED lighting is now suitable for a range of illumination applications, according to **SEAN BOURQUIN** and **ANTHONY TISOT** of Carmanah Technologies.

Against a climate of rising energy costs and escalating environmental concerns, today's advanced LED technology is creating new opportunities in solar-powered area lighting. Thanks to a new generation of bright and efficient LEDs, solar-powered lighting is expanding from its role in signal lights and flashing beacons to offer a renewable energy alternative for general illumination applications.

Early applications of solar-powered LEDs

Among the earliest widespread applications of solar-powered LED technology, self-contained marine lanterns were introduced in the early 1990s as a cost-effective replacement for higher maintenance, solar-powered, tungsten-incandescent marine lights. Designed and built by Canadian manufacturer Carmanah Technologies for the United States Coast Guard, the powerful all-in-one lanterns could be transported easily, installed in minutes, and left to operate reliably for years, maintenance free.

Unlike the large mechanical lights they replaced, the new solar-powered lanterns integrated all components (including photovoltaic modules, batteries, lenses, electronic controls and sensors) within a compact and durable watertight housing. Free from external components and impervious to water damage and corrosion, the solid-state lanterns proved to be an effective and reliable alternative. Operating on low-voltage current and generating only a small amount of heat, the stand-alone units were rugged, watertight and resistant to shock, vibration, and environmental extremes.

FIG. 1. Solar-LED marine lanterns mark buoys, such as this one being towed, in all conditions.

Throughout the years, self-contained solar LED lanterns have survived prolonged submersions under ice, category-five hurricanes, collisions with cruise ships and container vessels, and in the case of one wandering buoy, a year-long 5,800-kilometer journey across the Atlantic Ocean — all while continuing to operate flawlessly. Easy to transport and deploy at a moment's notice, solar-powered LED lanterns quickly became a popular backup that could be relied upon when conventional systems failed. For example, following the devastation of Hurricane Charley in Punta Gorda, Florida in 2004, solar-powered lanterns were the only points of light on an otherwise blacked-out river.

Later, modified versions of this original design gained popularity as aviation lights for runways, taxiways and helipads; roadway flashers for school zones and pedestrian crossings; and warning flashers for line-maintenance projects and uncontrolled railway crossings. In each new capacity, this versatile technology continued to uphold the fast-growing reputation for convenience, durability and reliability. User testimonials described solar LED aviation lights continuing to work even after being hit by vehicles, or struck into an adjacent field by an aircraft propeller — one solar LED obstruction light was even

SEAN BOURQUIN *is product manager and* ANTHONY TISOT *is communications manager with Carmanah Technologies Corporation (www.carmanah.com), Victoria, BC, Canada. Tel. +1 250 380-0052.*

eneral illumination

FIG. 2. Solar-powered LED lights illuminate airfields without generators or grid power for a low maintenance, cost-effective lighting alternative.

crushed into the ground under a falling tower only to emerge fully functioning and ready for the next challenge.

Solar-LED units for general illumination

Although integrated solar-LED units proved indispensible as signal lights for a growing range of industrial applications, larger-scale general illumination applications were still a ways off. While delivering impressive results as a light source for lanterns and beacons, the combined solar-LED technology was not yet suitable for illuminating larger outdoor areas in an efficient, cost-effective manner.

For Carmanah, the next logical step was to illuminate smaller areas in remote locations such as stand-alone bus stops and transit shelters. A new generation of white, high-flux LEDs made this possible by enabling a solar-powered light source to provide a brighter and more effective, yet natural and aesthetically pleasing, output.

To further maximize efficiency, an intelligent onboard energy management capability adapted from the company's marine technology ensured each light could provide ample illumination throughout the night, in all weather, all year long. The ability to automatically monitor and manage available energy "on the fly" helped make the new bus stop lighting system a popular upgrade across North America, and notably, throughout challenging solar environments such as London, England, where Transport for London equipped transit routes with more than 3,000 user-activated illuminated bus stops and 650 transit shelter lighting systems.

As an alternative to hardwired grid-based lights, solar-powered LED lights offered a range of practical advantages, including a simple and cost-effective installation, years of reliable low-maintenance operation, and no electricity bills, ever.

Pedestrian-scale general illumination

Although proven effective as a means of illuminating smaller outdoor areas, the challenge of extending this technology to larger applications presented some considerable roadblocks. For example, to ensure a consistent level of bright and effective light, most general illumination applications would have required a level of LED efficacy (measured in lumens per watt or lm/W), that was not yet readily available. To compensate, a solar-powered LED light fixture would have required a much larger photovoltaic array, additional battery capacity, and more LEDs per fixture. While the added cost of these components would quickly make a large-scale lighting application an expensive proposition, the ungainly size and weight of these materials also presented engineering challenges affecting the mechanical, structural and design characteristics of the proposed lighting solution.

Fortunately, ongoing advances in LED technology have provided the higher-efficacy product needed to address these challenges. Combined with a range of corresponding innovations in fixture design that has enabled engineers to maximize the capability of the new LEDs through optimized thermal and optical design, the technology is now available to produce an efficient and cost-effective solar-powered area lighting solution.

FIG. 3. A durable solar-LED taxiway light continues to operate even after being run over by an airfield service truck.

New technology presents new opportunities

Along with improvements in photovoltaics, energy storage, and lighting fixture and lens design, increased LED efficacy has had a dramatic effect on reducing the overall size requirements and associated costs of a solar-powered general illumination system, making solar-LED technology a viable alternative for

larger pedestrian-scale outdoor applications.

In a recent example of community-wide "greening" with solar LED technology, the City of Kelowna in British Columbia has begun equipping parks, paths and other public spaces with 100 solar LED lighting systems. Unlike traditional lighting technology, each of the new area lights is powered by an EverGEN™ solar engine — a stand-alone energy source that's completely self-contained, with all components (including solar modules, rechargeable batteries and electronic controls) integrated within a compact pole-mounted enclosure.

In choosing suitable locations, the project team started with a list of 200 potential sites, and selected the final 100 spots based on a list of factors including technical and geographic considerations (such as access to sunlight), distribution throughout the community, functional variety, and distance from an existing power supply. The final list identified a variety of buildings, parks, trails, crosswalks, municipal facilities, parking lot kiosks and transit facilities.

A government grant is helping to support the Kelowna solar lighting project as part of the Canadian government's commitment to help communities reduce energy costs, increase energy efficiency, and develop cleaner energy technologies.

In another recent example, the Dockside Green development in Victoria, British Columbia is working with the City of Victoria to illuminate the community's harbor ferry dock and pathway access with solar-powered area lights (see Fig. 5). Each of the solar-powered lights at Dockside Green features a pole-mounted solar engine, powering a BetaLED The Edge™ light fixture (developed specifically for the company by Beta Lighting).

Thanks to the optimized industry-standard design of the BetaLED fixture, each fully-shielded solar-powered area light directs light only where needed, for an efficient, uniform output that is also "dark-sky friendly," in accordance with the International Dark-Sky Association (IDA).

While providing impressive area lighting performance from a stand-alone solar-powered device, each new lighting system is also eligible for Leadership in Energy and Environmental Design (LEED) Renewable Energy Credits. As part of the LEED Green Building Rating System™, Dockside Green's first residential phase,

FIG. 4. Solar-powered transit stop provides LED down lighting, edge-lit schedule illumination, and user-activated signal light.

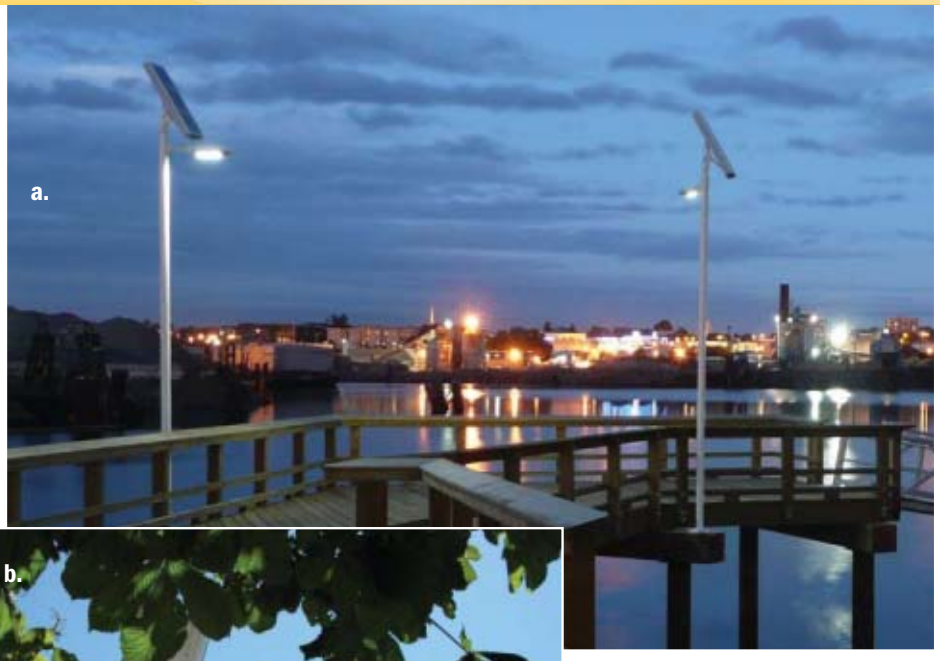

FIG. 5. (a) Solar-powered LED area lights illuminate harbour ferry dock in Victoria, British Columbia. (b) Installation of solar-LED light fixtures.

Synergy, has already been certified as built to LEED Platinum standards, with the developers targeting LEED Platinum certification for the entire 15-acre harbour front community.

While providing a convenient and versatile source of outdoor lighting for new installations, each solar-powered area light also conveys a positive environmental message, day or night, as an attractive and immediately recognizable symbol of the community's commitment to renewable energy, green technology and sustainable development.

Suitable locations for solar-powered area lighting

As solar-powered LED area lights increase in capability, they present an increasingly attractive lighting option for a range of locations. While particularly well suited to areas without access to utility power, solar lighting is also a good choice for anywhere grid-based electricity would be too costly or inconvenient to access. As a stand-alone solution, a solar-powered area light requires no trenching, cabling or connection to the electrical grid, making it an ideal solution for a growing list of pedestrian-scale applications in remote locations, green spaces or urban environments:

Area lighting: for parks, campuses, marinas, bike paths, and parking kiosks

Security lighting: for industrial sites, ports, harbors, airports and fenced perimeters

Architectural or accent lighting: for buildings, shelters, displays and landscaping

Aside from the considerable "green" appeal of implementing a solar-powered lighting solution, key incentives include freedom from utility power, quick and low-cost installation (both in rural and urban environments), versatile deployment, low maintenance, long component life, and — as a stand-alone light source that is unaffected by power outages — impressive reliability.

Although the list of potential sites for solar-powered lighting is growing fast, some locations can present specific challenges. Significant shade from buildings or trees throughout the day can affect performance, as well as distance from the equator. For example, as Los Angeles receives almost twice as much winter sun as Toronto, a solar lighting system in Toronto would require more energy collection and storage capacity (through larger panels and batteries) to compensate for less available energy during the day, and longer operating times during the night.

Fortunately, these obstacles are not insurmountable; today's solar-LED technology provides a range of built-in energy management and control capabilities — from basic on/off control, to adaptive dimming and sensing, and

advanced energy management techniques — that can help to balance the relationship between lighting requirements and available energy resources.

Some solar LED lights can be programmed to shine brightest whenever the need is anticipated to be the greatest — for example, during times of highest usage — and conserve energy outside of peak usage hours. Others may monitor environmental conditions and dynamically adjust light output to match the level of solar charging available.

In these ways, a solar LED light can utilize the available energy as efficiently as possible to ensure light is available when needed — an especially significant capability during times of low solar charging (such as low light or winter conditions) or in challenging geographic locations.

Advantages of solar-powered LED area lighting

Durable construction: Solid-state components offer greater resistance to impacts, vibration and environmental extremes.

Versatile placement: Free from grid connections, stand-alone lights can be added just about anywhere there's access to sunlight.

Low-cost installation: With no trenching, cabling or grid access required, solar LED lighting can be installed quickly and affordably, with minimal disruption to traffic flow, businesses or landscaping.

Cost-effective operation: Solar LED lighting can save money with quick implementation, low maintenance, long life, and no electricity bills, ever.

Energy efficiency: high-efficacy LEDs that efficiently convert energy to light enable solar lighting to surpass many traditional light sources for a green choice.

Dark Sky friendly: directional optics and shielding ensure light is directed only where needed.

Adjustable output: light output can be dynamically adjusted for brighter or dimmer illumination to accommodate user preferences and energy requirements. ◄

Looking ahead

At a time when technological, economic and political factors are converging to provide an unprecedented level of support for renewable energy alternatives, solar-powered area lighting is well positioned for large-scale adoption in pedestrian-level lighting applications. The continued drive towards standardization in the LED and photovoltaic industries, along with ongoing improvements in product quality, reliability and effectiveness, can do much to support the widespread adoption of this technology. Much as luminaires are validated and standardized for performance, standardization of solar LED components can help encourage the adoption of LED general lighting.

Solar-powered LED lighting has come a long way, and thanks to ongoing improvements in the efficiency and effectiveness of the key component technologies involved, it is fast becoming a popular lighting alternative for forward-thinking organizations and communities around the world.

MEAN WELL's LED / Outdoor power series include 4 distinct series and dozens of different models. These power units are suitable for various LED applications including LED street-lamps, LED lights, LED signs and other high dust/moisture installations. Most LED power supplies are in compliance with UL1310 Class 2 and EN61347-2-13 safety standards.

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

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focus on

Architecture

LEDs go with the flow in New York City waterfalls

The New York City Waterfalls public art installation, by artist Olafur Eliasson, comprises four man-made waterfalls in the New York Harbor situated along the shorelines of Lower Manhattan, Brooklyn and Governors Island. One of the key features of the waterfalls is their use of LED lighting behind the water flow to simulate the effect of moonlight. The Waterfalls range from 90 to 120-feet tall and were on view from June 26 through October 13, 2008. The project was commissioned by the non-profit Public Art Fund in collaboration with the City of New York. The lighting designer for the project was Michael Mehl of Jaros, Baum & Bolles. "Working with LEDs offered us very interesting possibilities both technically and aesthetically in realizing Eliasson's artistic vision," he said.

Photo: Moritz Wade/perceptual.de and LightWild

Each waterfall pumps 35,000 gallons of water per minute from the East River to the top of a scaffold. As the water flows over the lip of the falls it is illuminated by LED fixtures. Each waterfall utilizes a continuous row of assembled 5 foot sections of LED fixtures, with a mixture of cool and warm white LEDs controlled by 3 separate channels. The total wattage is 300W per 5 ft. section at 100% output, while the actual operating load was 15-25%, depending on the site. Light grazes the back of the water, penetrating the flow and accentuating the effect of wind gusts and water flow rate.

MORE DETAILS: www.ledsmagazine.com/news/5/10/13

G-LEC develops media façade for BMW Museum

Around 1.75 million white LEDs have been used to create a media façade inside the BMW Museum in Munich. The museum reopened in June this year, following a major four-year refurbishment. The highlight of the 25 exhibition rooms is BMW Square, where a massive LED installation transforms the walls into so-called "mediatecture". Developed by Berlin-based ART+COM in conjunction with G-LEC, a developer of LED lighting products, the installation comprises white surface-mounted LEDs pitched at 20mm on white printed circuit boards. At the heart of the system is the ability to individually control each one of the 1.75 million LEDs. Also, each PCB can be cut into pixel-sized increments in order to fit the installation tightly around the shape of the space, including bridges, archways and wall fixings. A total of 700 sq. m is covered with the circuit boards, with a major challenge being to ensure that all the LEDs were at an exact

color temperature of 5600K. The walls were then transformed into a media façade with the addition of huge panes of sand-blasted glass placed at a specified distance in front of them.

MORE DETAILS: www.ledsmagazine.com/news/5/9/29

Curved arena façade engineered with LEDs

LED lighting project designer LightWild has just completed two software-controlled architectural projects on the newly opened, 17,000-seat, O2 World Arena in Berlin, Germany. On the exterior, a massive LED installation stretches across the building's curved glass facade and inside, two lobbies glisten with thousands of controlled fluorescent and LED fixtures behind frosted acrylic lenses. Visitors to the arena are greeted by the colorful moving graphics and video effects that are driven across the installations on event nights. The LED façade is 380 feet (116 m) long by 40 feet (12 m) tall and is built on a 104-degree curve with an average radius of 213 feet (65 m). There are 117 vertical mullions spaced slightly more than 3 feet (1 m) horizontally across the façade. In all, there are 7020 LightWild Pixels installed in the vertical mullions on the façade of the arena. With 40 LEDs/Pixel, a total of 280,800 LEDs are in use on the façade.

"The curved façade presented an optical challenge more than a physical challenge. Physically, each section of glass on the facade is flat but there is a slight angle (<1°) between each section so that collectively the façade is curved. Therefore, the horizontal light from our LEDs tends to separate more than it would from a flat surface," said Randy Jones, LightWild's Director of Engineering.

MORE DETAILS: www.ledsmagazine.com/news/5/9/36

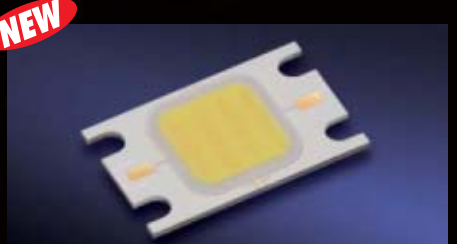
Citizen new L102 over 100 lm/W is coming soon!

New Citizen White LEDs deliver more light with less power!

NEW

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

NEW



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

NEW

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

Already in production!

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

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

Natural color Ra : 95

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

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

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

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

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

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

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Contact person : Jose Luis Garrote Tel : +34-96-192-06-34 E-mail : ventas@algsa.es

Scandinavia / Baltic states : Arrant-Light Oy www.light.fi
Contact person : Janne Makinen Tel : +358-2-2462-300 E-mail : janne.makinen@light.fi

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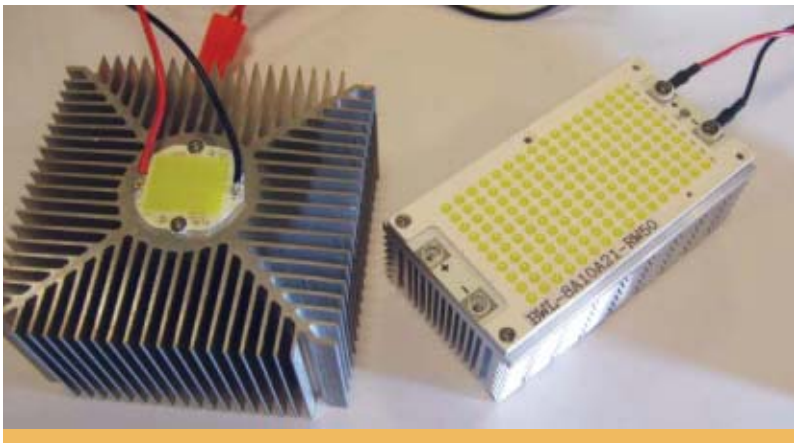
SSL standards and LED performance demonstrate great progress in San Diego

Updates on standards and on the progress made by leading LED makers, as well as advice on how to build LED luminaires and work with fixture OEMs, were among the highlights of the LEDs 2008 event. **TIM WHITAKER** and **JULIE MACSHANE** report.

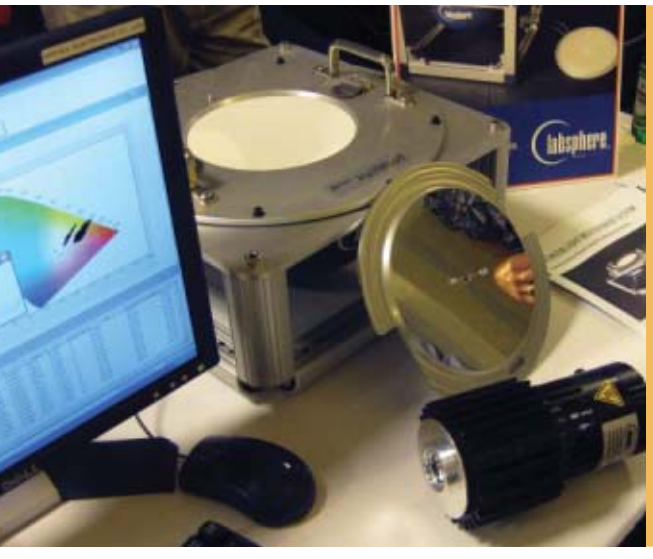
Coinciding with launch of the DOE's Energy Star criteria, the LEDs 2008 conference, held annually in October in San Diego, was always likely to have a strong component relating to standards. As described below, huge progress has been and continues to be made. The conference also benefited from some interesting discussions on the lighting marketplace — see Last Word on p44.

However, most of the opening morning was given over to representatives of some of the leading LED chip manufacturers, who described progress made in recent years, and identified areas that need attention. George Craford of Lumileds and Christian Fricke of Osram Opto Semiconductors talked about results for power LEDs that were covered in our last issue (*LEDs Magazine*, Sept/Oct. 2008, p25). Craford said that Lumileds has improved the performance of single (1 mm^2) chips by 22% since last year, while Fricke reported a 3x increase in the efficiency of blue LEDs in the last three years. Osram's ThinGaN blue has reached an optical output power of 600 mW at 350 mA (for a Dragon package with lens), corresponding to an external quantum efficiency (EQE) of more than 60% and a wall-plug efficiency of more than 50%. John Edmond of Cree said he expected his company's blue LEDs to hit an EQE of 70% towards the end of next year. Reducing droop — the fall-off in efficiency at higher current density — is a target for all these companies. Edmond pointed out that there can be 10% droop even between 50 and 350 mA, so there are substantial gains to be made if this can be reduced or eliminated. Fricke spoke about design devices with lower droop, and how new multi-quantum-well structures have reduced the occurrence of non-radiative recombinations.

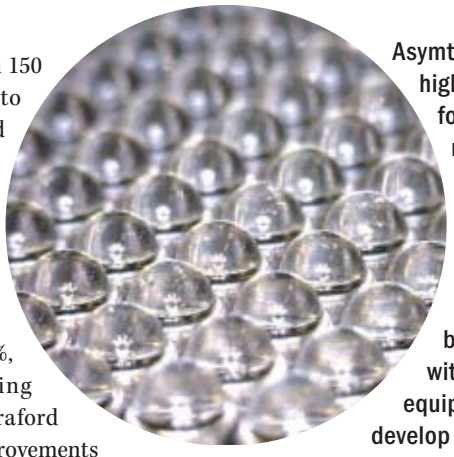
All these speakers agreed that a cool-white 150 lm/W LED at 350 mA will be a commercial reality in the not-too-distant future. Lumileds expects that a single LED at higher drive current will eventually reach the



American Bright showed various LED modules and panels built using direct die attachment (DDA) technology, including these 10 W models. At left is a light engine containing 144 LEDs (the company also showed a 100W version with 1600 LEDs), and at right is a panel containing 160 LEDs, which has a larger form factor but higher efficacy of up to 90 lm/W in cool white.
MORE DETAILS: www.ledsmagazine.com/press/16827



Labsphere showed new equipment for testing LED light engines: the forward spectral flux standard (black assembly at front) and the HalfMoon high-reflectance, diffuse-coating hemisphere with the specularly flat mirrored component (back center). The small footprint of the hemisphere lets users measure the light output of the forward-emitting sources from the center of the virtual sphere while driver electronics and thermal management reside outside the test area. The total spectral flux standard allows calibrations of spectrometer-based flux measurement systems in accordance with IESNA LM-79 recommendations.



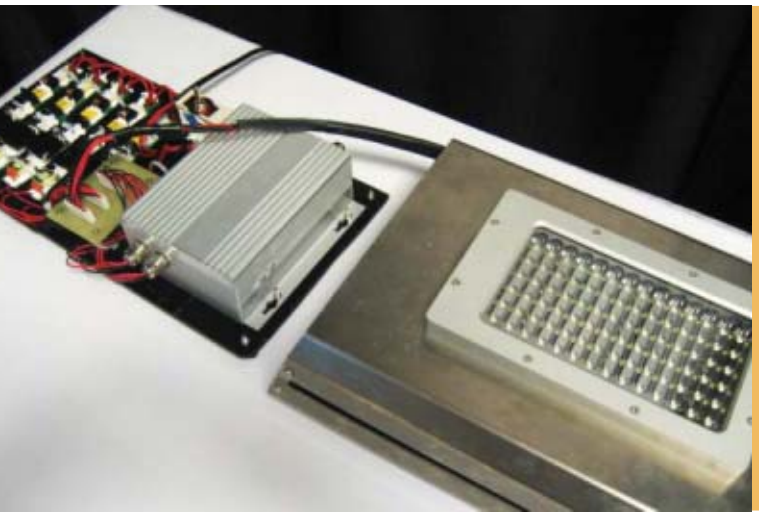
Asymtek, which supplies high-speed systems for fluid jetting of materials including silicones, promoted its partnership with Dow Corning, a silicone manufacturer. Dow Corning has been working closely with a select group of equipment partners to develop optimized production processes that are easy for LED makers to implement in their factories.

MORE DETAILS: www.ledsmagazine.com/press/16888

1000-lumen barrier with 150 lm/W efficacy. But how to get there? Edmond said that 150 lm/W could be achieved by reducing forward voltage (Vf) to 3.0 V at 350 mA, improving the chip EQE to 68%, increasing phosphor conversion efficiency to 79%, and reducing packaging losses to around 2%. Craford talked about similar improvements and said that a key target was to increase the internal quantum efficiency (IQE) to 80% at 2A drive current.

By way of contrast, Nichia's Dan Doxsee said that his company was focused on efficacy, like its competitors, but added "we can't afford to ignore the quality of light," particularly since the majority of indoor lighting applications are between 2600K and 4200K. Doxsee said that high CRI makes the best use of the electricity consumed. Nichia has developed three CRI grades of white LEDs; "high CRI" for speciality lighting has the highest Ra of 92, but the lowest efficacy. The other grades are "moderate CRI" for indoor lighting, or "typical CRI" (Ra = 70) for outdoor lighting.

On the panel session following the talks, the speakers were joined by Bill Kennedy of Toyoda Gosei, who said that his company has "de-emphasized" lighting applications and is focusing on backlighting, which is "where the money is." Kennedy speculated that many companies in the lighting market may be delaying their adoption of LEDs because they are waiting for further improvements in LED performance and/or price reduction. This, he said, was not a positive position for the LED industry. Craford, on the other hand, said that CFLs had been held back by form-fit-function, but that LEDs do not have many of the same disadvantages. "LED adoption could be a lot quicker if we do things right," he said.



On the Supertex stand was an LED streetlamp controlled by the company's HV9910B LED driver IC. Two controllers, one with power factor correction (silver box) and the other without (uncovered components), are visible at left. Supertex also said that the HV9910B driver IC was selected by the designers of two very high-profile projects in China — the Water Cube in Beijing and the 36 km Hangzhou Bay Bridge — based on overall performance and cost efficiency.

Market indicators

John Jacobs from DisplaySearch predicted that penetration of LED backlights in LCD panels larger than 10-inch diameter will approach 50% by 2015. This is largely as a result of the expected 100% penetration of LED backlights in the notebook PC market, while monitors and LCD TVs will see 13% and 11% penetration, respectively. Jacobs cited research by Intel on the notebook market, which showed that consumers place value on long battery life, as well as on machines that are thin and light. LEDs can directly influence these parameters, and the display cost is only around 15% of the total bill of materials for a notebook, so the cost of new technology can be absorbed. Also, the linear relationship between LED drive current and brightness allows significant savings when the display is dimmed, compared with incumbent CCFL technology. However, thermal management and binning are both significant challenges in the notebook segment.

Local dimming capability is a big advantage for LED backlights in LCD TVs, since this reduces motion blur and also helps to cut power consumption. Unfortunately, said Jacobs, for monitors and for LCD TVs there is nowhere to "hide" the cost of the LED backlighting unit (BLU). Compared with CCFLs, LED BLUs have a significantly higher cost structure, and add 5–6% or more of the panel price. Jacobs said that costs for CCFLs and some types of LED BLU will start to converge in late 2010, for 15.4-inch panels.

The next speaker emphasized that one important way to aid LED market growth and to establish a clear future for the industry is to "clearly disassociate high-quality lighting from toys and decorations." Kate Conway of LED Consulting said that if consumers associate LEDs only with cheap lighting, they will not want to purchase them for use in general illumination. "We need an industry-wide identity and message to emphasize the good performance, fabulous features and environmental aspects [of LED lighting]," she said.

Building light fixtures

Scott Riesebosch of CRS Electronics gave a talk entitled "Quality LED Lighting: Taking the High Road" in which he described many of the factors leading to successful luminaire design. "LED fixtures are a new breed involving thermal, electronic, and optical design," he said. "Photons and electrons are precious — don't waste either of them." Riesebosch advised the audience that, since all LEDs are not created equal, they should use well-known names to avoid IP and quality issues. They should also focus on stability and consistency from fixture to fixture, since color and light output can vary greatly. Thermal issues are vitally important, and a higher junction temperature (T_j) results in shorter life expectancy. "If you can design to a lower T_j, do

it!" he said. "Also, color rendering is crucial for many applications. Understand the needs of your market — will 75–80 be OK, or does the application need 90+?" Riesebosch concluded by saying that technical details must be on datasheets for LED luminaires/fixtures, and that these should be built and tested in accordance with the new Energy Star SSL criteria.

Speaking of Energy Star, the DOE's criteria became effective on September 30, the first full day of the conference (see p15). The DOE's Jim Brodrick was on hand to launch Energy Star and tell companies how to participate. In the main conference sessions, Alex Baker of the EPA took the opportunity to describe the alternative Energy Star criteria for LED-based residential lighting fixtures, which were unveiled in early June, sparking much controversy.

Baker's presentation explained some of the requirements of the residential market, also backed up by a later talk by Terry McGowan (see p44). Residential fixture makers, said Baker, are motivated by aesthetics, and not by performance. They generally require off-the-self sources (lamps, ballasts) and seek complete technology solutions. As they gradually gravitate towards the use of LED light engines within their fixtures, one requirement is to achieve "sparkle," which can be a problem for LEDs compared with other light sources. In the Q&A session, Scott Riesebosch told Baker that his company, a luminaire maker, was confused by the competing standards and wondered which to use. Privately, a leading fixture maker told *LEDs Magazine* they were "keeping quiet" about the EPA criteria (i.e. not being openly critical) because the EPA performance threshold was easier to achieve than the DOE version (see Commentary, p4).

Car tail-light containing LEDs from ROHM. In the main conference, Stephan Berlitz from Audi said that the main benefits of using LEDs in cars are the styling and branding possibilities, as well as functionality, for example, increasing the intensity of tail-lights in dense fog. Energy savings are expected, he said, and will not persuade customers to pay more.

Fixture OEMs

As a representative of a lighting OEM, Craig White of Progress Lighting (part of Hubbell) said that his company is "on the fence" with regard to Energy Star. "There are pros and cons associated with both EPA RLF 4.2 and DOE SSL 1.0," he said "However, we need a single Energy Star standard to qualify products for a single brand logo," adding that the dual standards are causing confusion. The DOE criteria, said White, are very good when the customer needs to understand performance. "But for decorative lighting, where light is contributing to aesthetics rather than general illumination, we

rarely get requests for performance data."

Among the main advantages of LED technology, said White, are the ability to function in low temperature environments; the absence of mercury, which is "starting to hit consumer's radar screens as an issue", and the physical size of the light source, which allows "form follows function" designs. The relative ease of achieving Dark Sky compliance is another benefit.

Osram Opto Semiconductor's black body TopLED with lens is aimed at signage applications, for example airport signs listing plane schedules. The black package surrounding the emitter results in a much higher contrast ratio and a sharper image.

White said that LED manufactures require education on what fixture OEMs need, and to understand fixture OEM development cycles. Also, fixture OEMs are challenged to keep pace with rapidly changing technology to maintain product vitality, he said. "Continual improvements in efficacy, for example, might involve changing the LEDs in a fixture, or possibly a complete redesign." Another challenge for fixture OEMs is that "an unprecedented level of technical competency is required to evaluate and select viable suppliers of components and finished goods." Marketing materials must also be updated regularly to convey performance changes. White said that his company's catalogs, which are essential for sales, are printed in two-year cycles.

Standards

Standards featured strongly in the LEDs 2008 program and (naturally) in the follow-on LED Measurement & Standards conference. In the main event, Kevin Dowling of Philips said that standards help to establish a foundation for evaluating LED fixtures. "Over time, the limitations [of the new standards] can be addressed, but standards need to emerge to allow practical experience and best practice," he said.

Standards for chromaticity (C78.377), photometric measurements (LM-79) and lumen maintenance (LM-80) have recently been adopted (see p15), but there are many more in progress. The CIE is looking at color rendition and the possibility of an alternative metric that might eventually replace color rendering index (CRI), while an ANSI group is evaluating interconnects and sockets for replaceable LED lamps and light engines. There are efforts to standardize the optical measurement of high-power LEDs (not covered by the existing CIE 127:2007), and to develop high-speed testing methods for LEDs, as well as UL 8750 addressing safety issues.

The list goes on, but this is very positive for the LED industry. As Dowling said, "Standards are beneficially driving adoption, and accelerating usage and acceptance." He also commented that "CFLs are increasingly being viewed as an interim solution" for energy-efficient lighting, which is another good sign for the LED industry.

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Robert Steele, PhD.
Conference Chair and Director of Optoelectronics
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Michael Siminovitch
Director
California Lighting Technology Center

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LEDs entertain the crowds at PLASA show

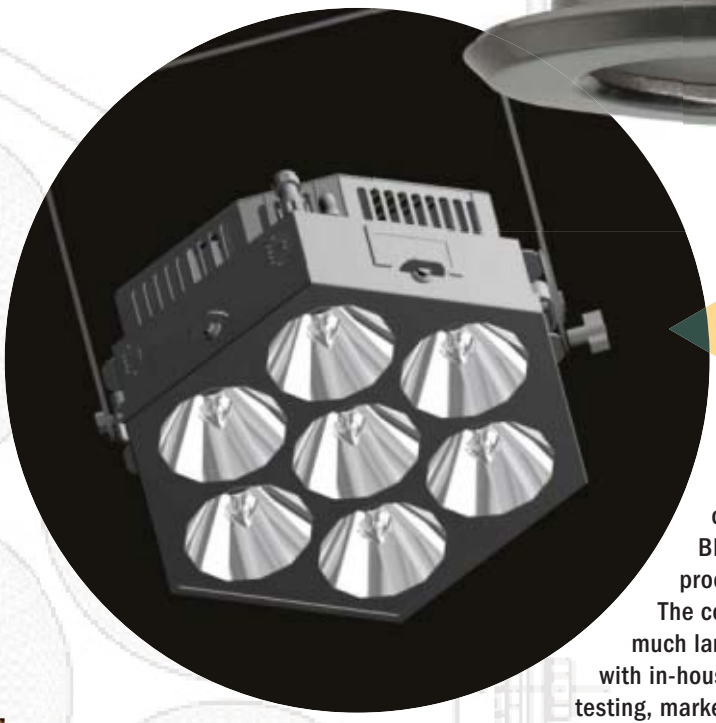
Manufacturers continue to find new ways to use LEDs for lighting and display products that are aimed at the entertainment sector. PLASA 2008 showcased some of the latest innovations, as **TIM WHITAKER** reports.

Display LED won a PLASA Award for Innovation for digiFLEX, a flexible, rubberized display (www.ledsmagazine.com/news/5/9/19). digiFLEX tiles measure 320 mm (w) x 160 mm (h) and flex smoothly horizontally and vertically. They weigh less than 6 kg per sq. m, or less than 10% the weight of a traditional LED display. With a 10 mm pixel pitch, digiFLEX produces 2000 nit of brightness.

LINK: www.digiled.com/digiFLEX

Another winner was the VaryLED A7 Zoom from JB-lighting Lichtanlagentechnik. This new luminaire found favor with the judges as a moving LED fixture with a zoom function, adding new depth to LED functionality. The VaryLED A7 Zoom contains 108 LEDs and is said to perform in the brightness range of a washlight with a 700 W discharge lamp.

LINK: www.jb-lighting.de



i-Pix shared a stand with Amptown, which makes flight cases for all i-Pix products. Following the ongoing success of Radiohead's current tour, the i-pix BB 7 (pictured) is in full production and shipping now. The company has moved to a much larger purpose-built facility with in-house production, R&D, testing, marketing and sales.

LINK: www.i-pix.uk.com

At PLASA, Robe Lighting introduced a range of new LED fixtures, including the REDWash 3-192, a moving-head wash light containing 192 RGBW Luxeon Rebel LEDs. The fixture provides a rectangular light field with manual control of beam spreads, and has different "egg crate" lens modules as optional extras. A version containing 192 white (6200K) LEDs is said to be the world's first LED moving-head strobe light.

LINK: www.robe.cz

PixelRange's impressive stand included the PixelMax Pro, a new combined wash and pixellation luminaire built with 288 RGBA Luxeon Rebel LEDs (www.ledsmagazine.com/press/16815). The fixture offers the flexibility of 18 individually controlled cells in a 3×6 matrix. This cellular configuration gives the user the ability to produce low-resolution visual effects, in addition to using the fixture as a high-power wash light with a vast color palette.

LINK: www.pixelrange.com

The Alien LED Downlight is a plug-and-play recessed LED downlight that features RGB+W color mixing for a broader range of hues including deep, saturated colors. It is available in 9 W standard (5 LEDs) or 18 W high-power (9 LEDs) versions. The IP67 rating means it's equally suited to both indoor and outdoor environments.

LINK: www.martin-architectural.com

On the Philips Color Kinetics stand was the ColorReach Powercore, a high-output RGB LED projector that is expected to go into production later this year. With an output of more than 4000 lumens, the fixture is intended to illuminate extensive facades on large buildings up to 400 feet. The 300W fixture accepts direct line voltage for easy installation, and no external power supply is required.

LINK: www.colorkinetics.com

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Steve Taylor, *Manager – Strategic Business Development*
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Market Trends and Emerging Applications in the LED Industry

SPEAKER: Robert Steele, *Director of Optoelectronics Programs, Strategies Unlimited*

Industry luminary Bob Steele delivered his forecast and outlook for the worldwide high-brightness LEDs market in this sought-after webcast. This presentation covered market trends, including a review of the developments in each of the major application areas. It also provided a market forecast through 2012.

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The Xolar RGB luminaire from Xilver has a unique modular housing with integrated heat management. Each pixel contains 12 Luxeon Rebel LEDs and is fitted with Xilver's Color Combining system. Up to 12 Xolar fixtures can be controlled and powered from the Xilver X-900 intelligent controller and power supply.

LINK: www.xilver.nl

Barco unveiled the new StudioPix pixelation luminaire (www.ledsmagazine.com/press/16835), developed by High End Systems as a smaller version of the ShowPix. The 13.5-inch diameter head of the StudioPix (right) has a circular array of sixty-one 3 W RGB LEDs, with an output of up to 11,500 RGB lumens. At left is a Showgun fixture, a projector surrounded by a ring of LEDs that can either match or complement the center beam.

LINK: www.highend.com

The EvenLED system from Brother, Brother & Sons was shown at PLASA by White Light. The 6 W RGB LED pixels create an even light distribution over a standard back-projection surface. The system is designed to replace cycloramas and backdrops lit with tungsten light sources, which are commonly used in theatres and TV studios.

LINK: www.whitelight.ltd.uk

Enfis demonstrated the color fidelity of the warm white Hi-CRI version of its Uno light engine. Elsewhere on its PLASA stand, the company demonstrated a version of its Quattro array capable of generating 12,000 lumens in white, which it described as the "world's brightest LED package." Enfis also revealed (www.ledsmagazine.com/news/5/9/14) that Dan Polito, formerly with Lamina, has been appointed president of Enfis Lighting North America.

LINK: www.enfis.com

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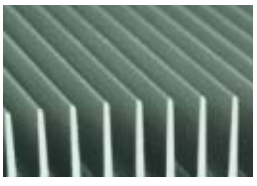

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last word

LEDs reach residential lighting market

TERRY McGOWAN, director of engineering of the **AMERICAN LIGHTING ASSOCIATION (ALA)**, says it is vital that the residential lighting market is understood by LED manufacturers.

As homeowners and builders become more aware of LED technology, it's important for LED companies to understand the residential lighting market and how it differs from the market for commercial lighting. The US residential/decorative lighting market is sizeable, with two hundred and fifteen million units sold in 2007. Revenues amounted to $4.4 billion, and growth of the market is influenced by population demographics, the health of the housing industry, competition with imports, and of course product pricing.

In the residential/decorative lighting market, small manufacturing companies and family-owned showrooms are still common, but closures and consolidations are changing the number of retail locations where uniquely-designed lighting fixtures can be purchased. Eventually, that will affect the number of different styles available.

Design is a key factor in this market — the emphasis is on decoration and appearance, not light output. Traditional classic designs remain popular and the market has historically experienced only modest technology changes over time. UL & CSA standards and compliance are critical.

The market is strongly influenced by both consumer and builder preferences and requirements. Professional specifiers are increasingly influential, but have a limited impact in contrast with the commercial lighting market. There is a trend towards energy efficiency, although only 7% of fixtures sold to homes are Energy Star rated. "Green" thinking is starting to change the market — especially with builders — and the demand for lighting fixtures using compact fluorescent lamps (CFLs) and solid-state sources is increasing. Legislation, whether at the federal or state level (for example California's Title 20 & Title 24), has been a strong driver of these changes.

In the US, electric lighting consumes 22% of all electrical energy. The breakdown for different lighting markets is 51% for commercial lighting, 27% for residential, 14% for industrial and 8% for outdoor. This means that residential lighting consumes 6% of all electrical energy used in the US. Programs now being developed seek to reduce those kilowatt-hours by 50% over the next 10 years.

However, for LED-powered lighting to be a success in the US residential lighting market, it must meet several important consumer needs that deal with the quality of the light. For example, warm white light with a color temperature of 2700–3000K is necessary. Ideally, the source should be on the black body curve (if not on the curve, then slightly below is better than above). A high CRI of 90+ and a "fat" spectral distribution, with light output in the deep red region of the spectrum, is also required.

The capability of the lamps to be dimmed is critical and absolute control of flicker (even with dimming) is essential. Ideally, a luminaire would dim to at least 1% of full output, without flicker. If the luminaire reduces CCT with light output (in the same way as incandescent lamps), that would score bonus points with consumers. So far, this kind of color modulation can't be achieved with CFLs, but is a possibility with LEDs.

For the massive inventory of luminaires with screw-based sockets, consumers and industry also require lamp retrofits that perform adequately — that is, they must have comparable light output and light quality to the products that they are supposed to replace. LED system power factor and power quality questions must also be resolved before LED systems move in quantity into multi-unit housing. Also essential is the inclusion of LED decorative residential luminaires in the Energy Star program. Consumers, retailers and manufacturers now have a 10-year history of Energy Star residential lighting fixture market development and this must continue with LED sources.

One way for manufacturers to make inroads into the residential lighting market is to submit entries into the Lighting for Tomorrow (LFT; www.lightingfortomorrow.com) competition. The objective of Lighting for Tomorrow, sponsored by the ALA, the Department of Energy (DOE) and the Consortium for Energy Efficiency (CEE), is to produce energy-efficient residential luminaires that are stylish, marketable, functional and available at prices that consumers will pay. The program started in 2003 and an SSL category was added in 2006. With over 100 SSL entries submitted for 2008, LFT is a growing influence in the market. Judges represent lighting showrooms, energy organizations, lighting designers, home builders, the media and test organizations. Winners must be UL/CSA tested and meet Energy Star requirements.

LFT has been a remarkable success in getting quality, energy-efficient residential luminaires into consumers' homes. The competition supports sponsors' efforts to save energy, drive new business for manufacturers and lighting showrooms, expand Energy Star luminaire designs, and benefit builders and green construction efforts. The 2009 LFT Competition will be announced in January, and intent-to-submit forms will be due in March 2009.

In summary, the residential/decorative lighting industry can be characterized as small and certainly different than the commercial lighting industry, but important — because everyone has a home.

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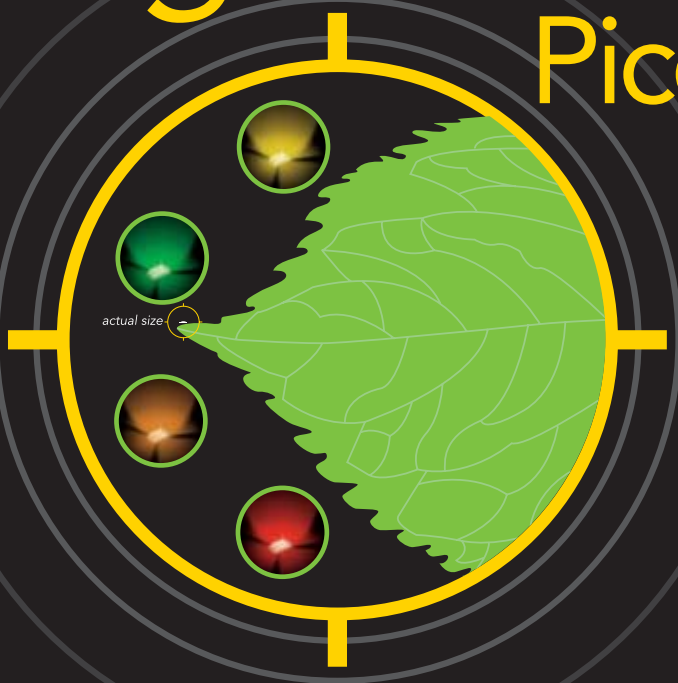

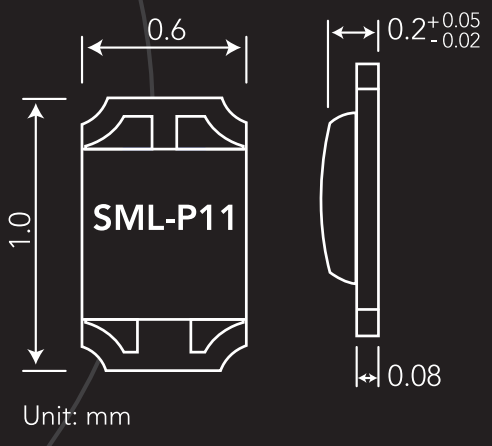

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