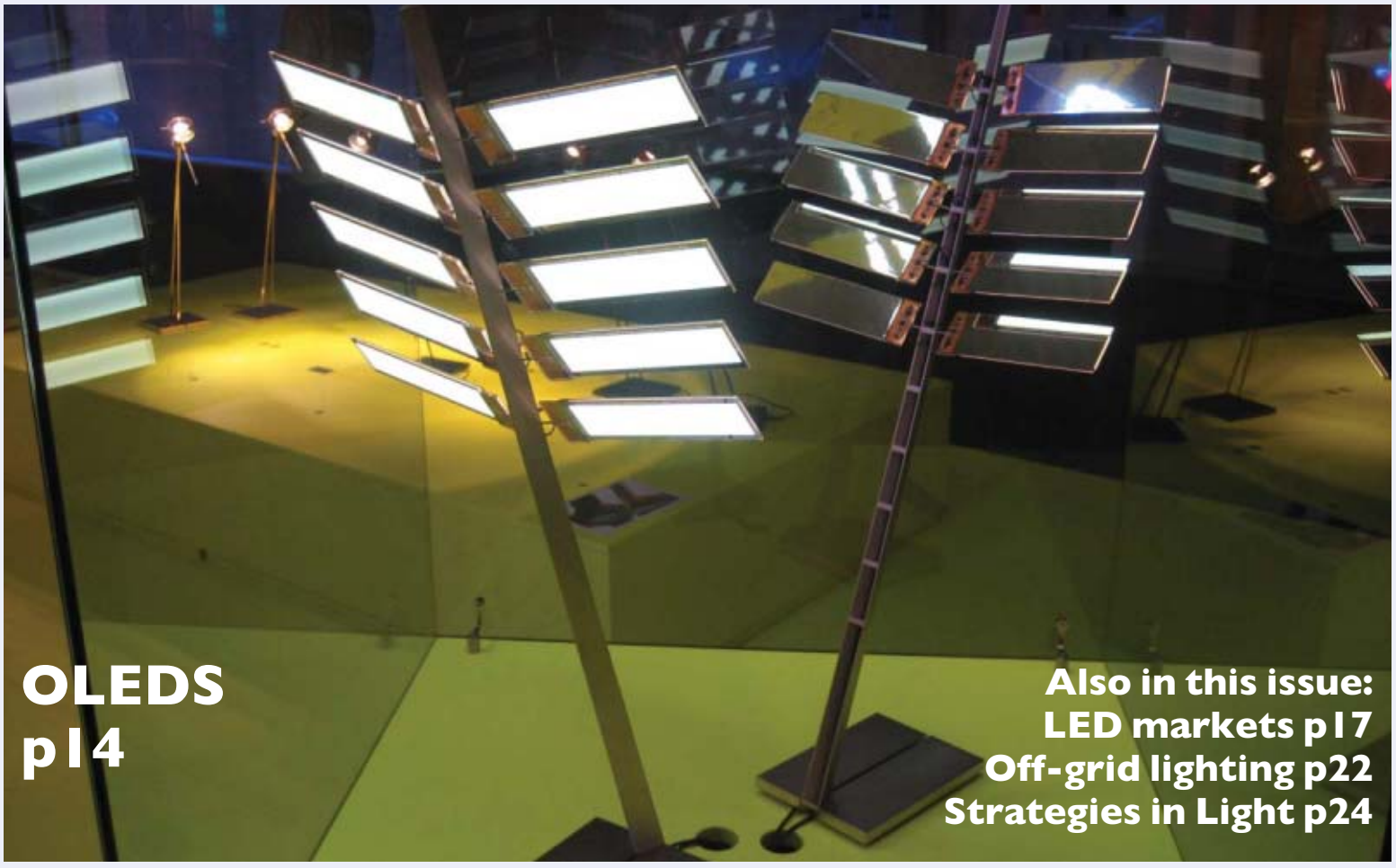
www.ledsmagazine.com

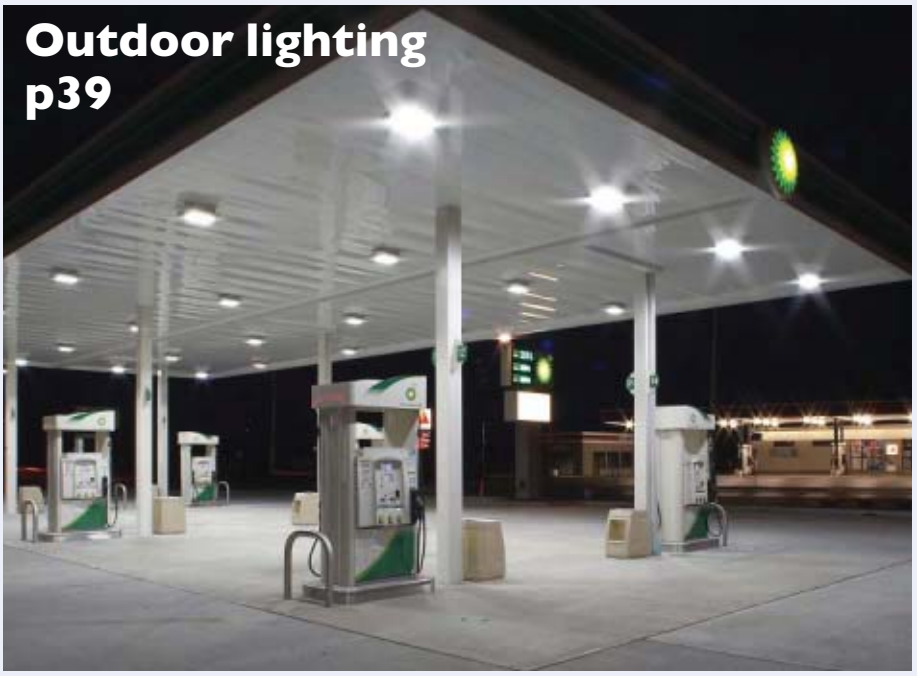
LEDs MAGAZINE™

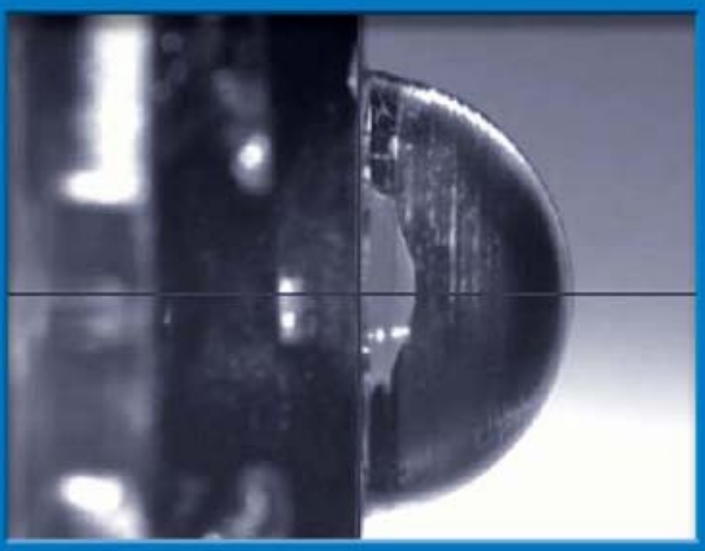
Technology and applications of light emitting diodes

Issue 20 April 2008

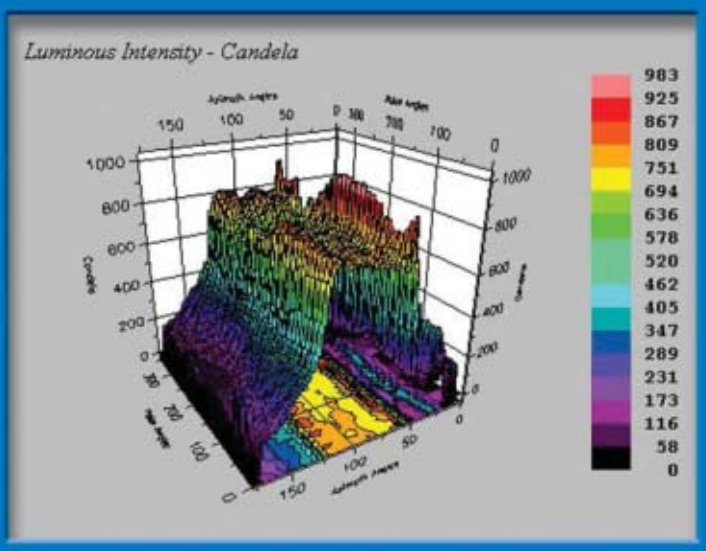
PennWell





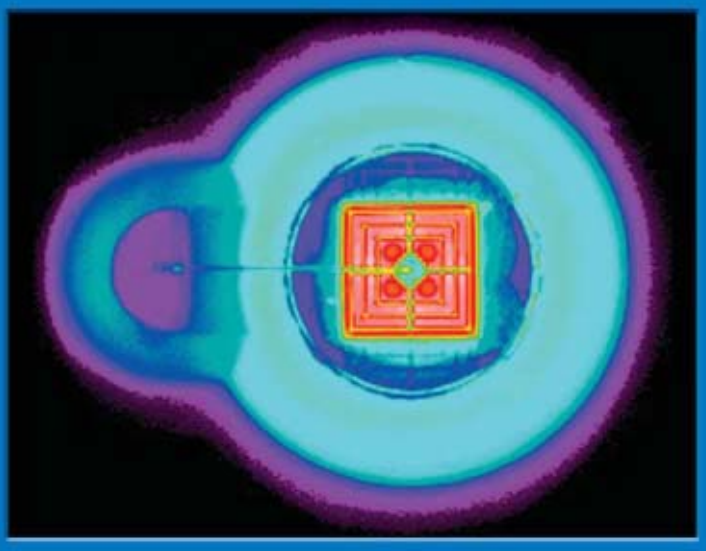


Industry Standard Near Field Models



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

www.radiantimaging.com

CONTENTS

AC provides alternate way of driving LEDs p36

We speak with Peter van Strijp, SSL veteran p20

Strategies in Light looks at new applications p24

Advertisers' Index

LEDs MAGAZINE™

Issue 20
April 2008

Editor & Publisher: Tim Whitaker
twhitaker@pennwell.com
Tel. +44 (0)117 941 5378

Managing Editor: Julie MacShane
juliem@pennwell.com

Sales Manager: Joanna Hook
joannah@pennwell.com
Tel. +44 (0)117 941 5378

US Sales: Mary Donnelly
maryd@pennwell.com
Tel. +1 603 891 9398

Studio Manager: Karl Weber

Design: Karl Weber

Production: Becky Crews

Group Publishing Director:
Christine Shaw

PennWell

***LEDs Magazine* is published by PennWell Publishing Ltd (UK)**
Warlies Park House, Horseshoe Hill,
Upshire, Essex EN9 3SR, UK
Email: info@ledsmagazine.com

Subscriptions
LEDs Magazine is available by paid subscription. Price includes 6 print issues per year plus the LED Suppliers Directory.
The electronic (PDF) version is available free of charge from our website. Visit
www.ledsmagazine.com/subscribe.
Enquiries: subscribers@ledsmagazine.com

On the cover:
Images courtesy of Ingo Maurer (main), Selador (lower left), Beta LED (lower right).

Light+Building points to growth

Since our last regular issue was published, we've attended a couple of major events in the LED calendar, including Strategies in Light, the annual industry get-together that is described in detail on page 24. One regular highlight of SIL is Bob Steele's market update and forecast, which is summarized on page 17. Bob predicted overall growth in the HB-LED market of around 20% per year between 2007 and 2012. A significant portion of this growth will occur in the Signs & Displays segment (driven by LCD backlighting using LEDs) and in Illumination. In this latter segment, Bob predicted growth of 33% annually over the next five years. Although this is a pretty healthy number, some people have suggested it could be on the low side. Peter van Strijp, formerly a senior executive with Philips Lighting, expresses this viewpoint in the article on page 20. Others have based their opinion on the rate at which applications such as outdoor lighting are expanding. But to sound a note of caution, many installations are for test and evaluation purposes, and the initial cost to purchase LED fixtures remains a barrier. Also, the US DOE test and evaluation programs described on page 10 and elsewhere suggest there is plenty of room for further improvement.

The other major event was the fifth Light+Building tradeshow in Frankfurt am Main, Germany in early April, which in addition to myself attracted a massive 164,999 visitors. Overall visitor numbers were up 22% compared with 2006, when the show was one day shorter, and there were 2173 exhibitors.

A major theme, particularly among the largest exhibitors, was energy efficiency and environmentally friendly technology. Major lighting companies such as Philips and Osram highlighted the benefits of LED technology in this respect, but - importantly - also promoted significant steps forward in other lamp technologies (sample headline: "Philips introduces world's most energy-efficient halogen lamps for the home"). The organizers issued a post-event press release in which they said; "Exhibitors in the lighting segment presented a huge variety of energy-saving lighting solutions together with the necessary control systems. And, at the same time, they cleverly combined design with technology. LED lighting was to be seen at almost every exhibition stand."

This is a slight exaggeration, and it's also worth pointing out that some manufacturers seemed to be showing LED fixtures just for the sake of having an LED fixture on their stand, rather than because they had made any commitment to the technology. One exhibit hall showcased outdoor lighting, and there were a number of manufacturers with very high quality LED fixtures such as Advanced LEDs, LEDworx, Ruud Lighting and Schréder. But there were several other manufacturers that had a range of luminaires, mostly based on other light sources, with LED luminaires thrown in almost as an after-thought.

However, this should not detract too much from what was, for LEDs in general, a great event; as well as new and interesting technologies there were many, many examples of LEDs used in real, practical, high-quality fixtures. As LED maker Cree told LEDs Magazine, in 2006 their focus was to show people that high-performance LEDs were available (which they did by filling their booth with very bright, white LED light). This time around, with much more subtlety, they exhibited lighting fixtures from their customers, to demonstrate what is being done with LEDs, right now.

With a wealth of LED lighting applications, Light+Building suggested that Bob Steele's market predictions can be achieved, and that more might be possible. However, there are still issues to be addressed, and LED makers would be wrong to suggest that penetration of the general lighting market is already a done deal.

Tim Whitaker, Editor & Publisher
twhitaker@pennwell.com

LIGHT OF THE FUTURE

Lurking high above the Siteco booth at Light+Building were several of these stylish (and faintly sinister) street lighting luminaires. The "organically flowing form" of the luminaire head is cast from aluminium and contains 86 high-power white LEDs, combined with an optical system of lenses and reflectors to meet the appropriate road lighting standards. Also included is an RGB LED optical waveguide system to provide coloured accent lighting.

LED Lamps? or Halogen Lamps?

Introducing New Lumidas-H Series from FAWOO TECHNOLOGY

- Electricty savings up to 90%
- Same brightness and Low temperature
- Long lifespan up to 50,000hrs
- Use existing fixtures
- Prices, Lowest LED Lamps in the World with above features

Hesitated because of high prices of LED lightings?

Fawoo Technology, as a Leader in the next generation LED Lighting Industry,
proudly presents the world the most affordable LED Lamps at lowest prices no one can imitate.
The superb and incomparable LED lighting,
Lumidas-H series 3W, 5W & 8W Lamps can replace 25W, 55W & 80W halogen lamps respectively.
Lumidas-H series will add more eco-friendly and energy saving benefits
to the World along with other LED series, LumiDas, LumiSheet and Lumi-M-Stick from Fawoo.

Introducing Lumidas-H 3W, 5W, 8W Lamps

MR16-GX 3W & MR16-E11 3W
for
25W Halogen lamp

70-GX 5W & 70-E11 5W
for
55W Halogen lamp

95-E27 8W
for
80W Halogen PAR30 lamp

FAWOO TECHNOLOGY
102-806 #905 Bucheon Techono-Park,364 Samjeong-dong, Ojeong-gu, Bucheon, Korea
TEL : +82-32-621-2920~3 FAX :+82-32-621-2940 E-mail : agency1017@fawoo.com / www.fawoo.com

PATENTS

Philips hits Lighting Science Group with patent lawsuit

Before Color Kinetics was acquired by Philips in June 2007, LEDs Magazine was kept very busy with news of patent lawsuits and licensing deals involving CK. Since then things have been very quiet until two recent announcements. Most significantly, CK has alleged patent infringement by LED Effects, now part of Lighting Science Group (LSG). The latter has responded with a complaint that alleges, among other things unfair business practices by Philips. This could be an interesting contest: CK started filing patents in the LED lighting space in 1997. However, LED Effects has been designing, developing and selling custom-designed, pulse-width modulation (PWM) controlled, color-changing LED fixtures and components since 1994.

On February 19, 2008, Philips Solid-State Lighting Solutions (the former CK) filed a civil lawsuit in the US District Court for the District of Massachusetts against LSG, LED Holdings and LED Effects. The assets of LED Effects, an established LED lighting manufacturer, were acquired by LED Holdings last year, and LED Holdings subsequently merged with LSG. The Philips SSLS lawsuit alleges that the defendants have infringed five related CK patents, without naming any specific products, and seeks injunctive relief.

Rather than take the licensing route (see Renaissance story, below), LSG and LED Effects responded on March 7 with a complaint filed in the Superior Court of Sacramento, CA. The complaint alleges damages, breach of the covenant of good faith and fair dealing, breach of fiduciary duty, intentional interference with economic relationship, negligent interference with economic relationship, and misappropriation of trade secrets against Philips. The complaint requests injunctive and monetary relief.

This is more than a straightforward patent infringement dispute, and there is history between the two companies. Govi Rao, now CEO and chairman of LSG, was the former GM of the North American Solid State Lighting Luminaries business of Philips. Rao moved from Philips to LED Effects around the time when Philips bought Color Kinetics.

The above-mentioned Philips SSL Luminaires business did not have the capability to develop or make its own products – this was one of the attractions to Philips of purchasing CK. Instead, Philips teamed with smaller, specialist LED companies such as LED Effects in order to win projects such as the Saks Fifth Avenue snowflakes display and the Times Square New Year's Eve ball. In fact, Philips competed with CK, using products developed and built by LED Effects.

At one stage, before it bought CK, Philips proposed a minority investment in LED Effects. At that stage, Philips' evaluation was that the CK patent portfolio would not be a threat to LED Effects' ongoing activities. Clearly, Philips SSLS now disagrees.

- More details: www.ledsmagazine.com/news/5/3/7

Philips ends spat with Renaissance

Subsequent to the LSG complaints, Philips SSLS announced it had ended litigation previously brought by Color Kinetics against Renaissance Lighting, and had licensed its worldwide patent portfolio to the Herndon, VA-based company. The deal will allow Renaissance to offer its own intelligent LED lighting products, as well as to use Philips SSLS's core technology in other new product development.

Renaissance Lighting's own patented lighting systems use a technique that blends light from multiple LEDs to produce a single source. Internal sensors are used to constantly monitor and adjust light output and color. These same sensors have the ability to activate "sleeper" LEDs that compensate for the gradual degradation of a fixture's original LEDs during their life span.

- More details: www.ledsmagazine.com/news/5/3/21

At Light+Building, Lighting Science unveiled a family of LED-based replacement lamps. The company subsequently acquired Lighting Partner BV (see www.ledsmagazine.com/news/5/4/27).

FUNDING

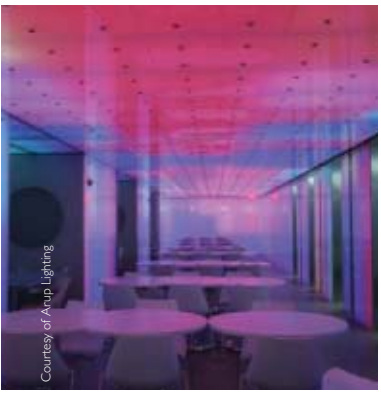
Bridgelux, Albeo, Luminus secure millions in financing

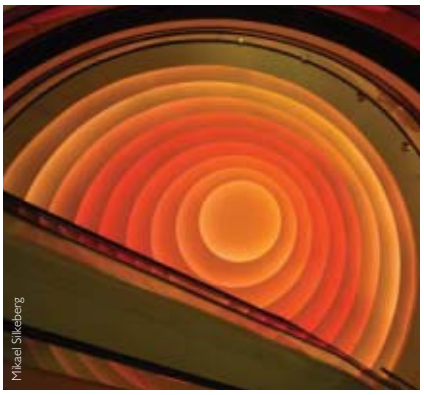
As a strong sign of health in the LED marketplace, several more companies have completed financing rounds with investment from venture capital companies. Towards the end of last year, several companies including Element Labs, Renaissance Lighting and LedEngin all completed funding rounds.

Bridgelux Inc, a fabless LED chip supplier, has completed its latest round of financing, totaling ~$40 million, made up of $30 million of private equity investment and ~$10 million of bank lines of credit. This follows a $23 million funding round announced in August 2007. Bridgelux CEO Mark Swoboda said that the funding "will enable us to rapidly expand beyond our LED chip product offerings and move aggressively into LED lighting products, expanding our market reach." This financing round was led by new investor VentureTech Alliance, while existing investors DCM, El Dorado Ventures, VantagePoint, Chrysalix Energy Venture Capital, and Harris & Harris Group participated with follow-on investments.

- More details: www.ledsmagazine.com/news/5/4/13

We've always done *spectacular*





Now we do *simple*, too

COLOR KINETICS™ PHILIPS

Our lighting transformations range from visual marvels to practical retrofits. No matter the application, Philips has the right LED lighting solution – whether to paint a city skyline with color or bring warm white accents to common interiors. We've taken LED lighting from extraordinary to extraordinarily simple.

www.colorkinetics.com

Luminus Devices, the Billerica, MA-based developer and manufacturer of very-high power LEDs, has closed a new round of financing of over $72 million and plans to use the capital to accelerate development of new products and expand into new lighting markets.

The investor syndicate was led by Boston-based Braemar Energy Ventures and included a number of other funds, notably San Francisco-based CMEA Ventures and Washington, DC-based Paladin Capital Group, which are similarly focused on energy and environmentally friendly technologies. In addition, all of Luminus' previous investors participated in the financing.

Luminus is now targeting a broader array of applications for its PhlatLight LED technology in the solid-state lighting arena. The company's PhlatLight LEDs are characterized by extremely high brightness, and are currently sold as red, green and blue chipsets. The company has yet to unveil a white LED.

- More details: www.ledsmagazine.com/news/5/3/15

Albeo Technologies, a Boulder, CO-based LED lighting manufacturer, has received a $1.5 million equity investment from a group led by Green Spark Ventures, LLC, a new Denver-based cleantech venture fund. Jeff Bisberg, Albeo Technologies' president and CEO, said that in less than 3 years the company has launched four major product lines, ramped production to ship over 20,000 units to date, and developed multiple patents. The new capital will be used for market and product expansion.

- More details: www.ledsmagazine.com/news/5/2/19

BUSINESS

Zumtobel forms single LED group, teams with Cree

Starting May 1, the beginning of its 2008/09 financial year, the Zumtobel Group will be concentrating its existing LED activities in a single unit. The Austria-based, billion-Euro lighting company says that this will create a flexible and efficient platform for its planned dynamic growth in the LED sector.

The new Zumtobel LED Division will bundle the activities of the existing LED start-ups Ledon Lighting (based in Lustenau, Austria), Lexedis Lighting (Jennersdorf) and TridonicAtco Optoelectronics (Jennersdorf), forming an expert unit within the Group with integration of all fundamental LED technologies. The new division will provide optimum support for the other Group brands, as well as marketing its capabilities in new fields of business and to new customers under the Ledon brand.

Zumtobel CEO Andreas Ludwig said that the Group's LED activities have annual sales of EUR 35 million. "The new structures will enable us to focus even more closely on LEDs as the technology of the future and help us optimize the internal process integration of LED technology over the entire value chain. All of which will boost progress towards our medium-term goal of more than EUR 100 million in LED sales."

Under the Ledon brand, the new Zumtobel LED Division will also be opening up new fields of application for LED technology, such as

furniture and showcase lighting, medical technology and light-controlled communication elements. The new division will be headed up by Roland Michal, who is succeeded as COO of TridonicAtco by Rüdiger Kofahl.

- More details: www.ledsmagazine.com/news/5/3/13
- In late April, Zumtobel acquired Italian LED company SpaceCannon - see www.ledsmagazine.com/news/5/4/28.

Zumtobel teams with Cree

Zumtobel Group and Cree have formed a close cooperation that will allow Cree's high-brightness LED chips to be used by Zumtobel. Both companies say they have the goal of driving forward the use of LED technology in the professional lighting sector. Cree has already supplied LEDs to Zumtobel; for example a new color-variable LED module from the TridonicAtco brand uses a Cree chip to generate a luminous efficacy of 80 lumens/W in the warm white range. However, this new deal should provide Zumtobel with preferential access to the best Cree chips, while Cree will benefit from a relationship with one of the major lighting manufacturers.

But where does this leave Lexedis, the joint venture between TridonicAtco and Japanese chip maker Toyoda Gosei? Lexedis has yet to introduce a higher-power white LED suitable for the lighting market, so Zumtobel is filling a noticeable gap by working with Cree. Officially, Lexedis will continue as before, under the new Ledon organization. But speculation suggests that Toyoda Gosei will not remain interested in Lexedis in the longer term.

- More details: www.ledsmagazine.com/news/5/4/10

TRAFFIC SIGNALS

Dialight installs 70,000 LED traffic signals in Florida

Programs to evaluate the energy-saving benefits of LED outdoor lighting have, rightly, attracted lots of attention over the past 12 months. LED street lighting may represent the future but this application is still in its infancy, especially when compared with programs to replace conventional traffic signals with LED fixtures. Many municipalities could already claim to be "LED cities" in the sense that they have fitted large numbers of LED traffic signal modules and are enjoying the benefits of reduced energy and maintenance costs.

A major contract was recently awarded to Dialight, who will supply 70,000 LED signals to replace traditional incandescent traffic signals throughout Miami-Dade county in Florida. Brian Todd, Dialight VP says, "LED traffic signals use 90% less energy and last ten times longer than traditional incandescent traffic signals so this contract will bring major environmental benefits to Miami-Dade County. The additional benefit of our modules is that they can be retrofitted easily into the existing enclosures of the current energy inefficient incandescent lamps."

Dialight has supplied over two million LED traffic signals across the US over the last 10 years. It is also the first company in the US to offer a comprehensive range of LED traffic signal modules that are fully compliant to the new ITE specifications. Dialight products include red, yellow and green modules using state-of-the-art high-flux LED technology.

- More details: www.ledsmagazine.com/news/5/2/23

Custom LED lamps win Brazil energy award

The Brazilian government has awarded a first-place Rational Use and Energy Conservation National Award to a project by electric power distributor Bandeirante Energia S.A. that replaced all the incandescent-based traffic lights in a Sao Paolo suburb with LED-based lamps. The project in Guarulhos involved the replacement of 5,370 incandescent bulbs used in 2,059 vehicular and pedestrian traffic lights with custom lamps using Luxeon I LEDs from Philips Lumileds.

The lamp was developed and manufactured by Meng Engenharia Ltda, a Brazilian company specializing in signaling projects. The new lamp was designed to replicate the basic shape and radiation pattern of a traditional traffic head, using seven Luxeon I LEDs and a built-in power supply per bulb as well as a standard screw-in bulb base. This design enabled fast and easy field replacement with no need for specially trained work teams. All red, green and yellow traffic lights, arrows and pedestrian signals were replaced.

The new lights are cutting the city's energy bills by approximately US$240,000 annually and reducing municipal energy consumption by 1340 megawatt hours per year.

- More details: www.ledsmagazine.com/news/5/4/7

www.sylvania.com/LED

LED system solutions *start* with SYLVANIA.

SYLVANIA, together with OSRAM Opto Semiconductors, brings you specialized LED solutions. The combined expertise of two industry leaders ensures that every detail of your LED system development is in good hands, from concept through installation and field service support. SYLVANIA's innovative business approach gives you the edge, and our system support and 5-year product warranty gives you continued confidence in our services.

For more information, call 1-800-LIGHTBULB or visit us at www.sylvania.com/LED.

OSRAM
Opto Semiconductors

SYLVANIA

PRODUCT TESTING

Round 4 of CALiPER product testing shows mixed results

The US Department of Energy (DOE) has completed Round 4 of product testing through its CALiPER program, which analyzes commercially available solid-state lighting (SSL) replacement lamps and fixtures. A summary report containing the results from Round 4 testing is available from the CALiPER program section of the DOE SSL website (www.netl.doe.gov/ssl/comm_testing.htm). In Round 4 of the testing program, 20 products were selected for testing, comprising 15 SSL replacement lamps and luminaires representing a range of applications, and five luminaires using fluorescent or halogen sources to provide benchmark comparisons.

Testing included five SSL replacement lamps (a candelabra lamp, a T8 drop-in replacement, and three MR16 lamps), two downlight products, several desk lamps and undercabinet fixtures, and a number of diverse outdoor luminaires.

The report says that a wide performance range was measured, from a wide range of product types, and care should be taken to generalize. While none of the products tested would pass Energy Star requirements for solid-state lighting, some offer very positive qualities.

However, as in earlier rounds, the greatest concern revealed by this testing was the inaccuracy of performance data presented in manufacturer product literature. "The continued practice of providing incorrect qualitative comparisons to other light sources and inappropriate quantitative performance values in manufacturer literature may mislead consumers and damage SSL market potential in the long-run," said the report.

The MR16 and candelabra lamps that were tested may fill needs in market niches (for example, for low wattage devices in decorative applications), but cannot serve as direct replacements for 20W halogen or incandescent products as claimed in marketing publications because their output levels are too low.

The three desk lamps all had higher efficacies than the halogen benchmark desk lamp that was tested in Round 2, although none of them come close to competing with the CFL Energy Star desk lamp in Round 4. Encouragingly, for the first time, one SSL desk lamp was found to have a zero off-state power draw.

The report said that the reliability of SSL products is still largely theoretical at this stage, claims of consistent color maintenance in luminaires and 50,000-hour lifetimes (or more) are only speculative. Purchasing decisions where the expected life of an SSL product is an important factor should consider product guarantees, knowledge about which LED devices are used in a product, the reputation of the manufacturer of the LED devices used in the luminaire, and the reputation of luminaire manufacturer.

• More details: www.ledsmagazine.com/news/5/2/20

• The DOE will host the "Voices for SSL Efficiency 2008" on July 9-11 in Portland, Oregon – see www.netl.doe.gov/ssl.

OUTDOOR LIGHTING

LED walkway lighting evaluated in DOE report

The DOE has published the final report from the Federal Aviation Administration (FAA) demonstration of LED walkway lighting. The report, prepared by Pacific Northwest National Laboratory (PNNL), describes energy savings of more than 25% over existing lighting, improved illuminance uniformity, and positive user feedback. The study also found that energy savings could be cost-effectively increased to 50% through a slight reduction in the existing lighting levels, while still easily meeting IESNA minimum recommended illumination levels for walkways.

Laird TECHNOLOGIES®

LED LIGHTING

global solutions :
local support

Brighter, Longer Lasting Color Control for Your LED Systems

Your LED Systems deserve the best thermal management materials with the highest rated, thermally conductive materials.

Enhance your LED Systems with Laird Technologies superior thermal products:

- Gap fillers and putties
- Phase-change materials
- Thermal greases
- Thermally conductive circuit boards
- Insulator materials
- Thermoelectric coolers

For all your LED System requirements, contact Laird Technologies at sales@lairdtech.com today!

www.lairdtech.com

In the project, part of the DOE's Gateway Program, six LED luminaires from Beta LED were installed to replace six existing high pressure sodium (HPS) luminaires mounted on 14-foot poles on a set of exterior walkways and stairs, situated between a pair of buildings and a parking lot located at the FAA William J. Hughes Technical Center in Atlantic City, NJ. Installation took place in December.

The fixture used in this project is modular, consisting of a series of "light bars" that each contain 20 LEDs. Adding (or subtracting) light bars from a given fixture increases (or decreases) both light output and final cost. The fixtures selected for this application used a 3-bar configuration to produce illuminance levels similar to the existing HPS luminaires. However, computer simulation determined that 2-bar (40-LED) luminaires would also easily provide the IESNA recommended minimum level of illumination needed for this particular walkway application (minimum average of 0.5 foot candles), while also significantly reducing the payback period.

In a scenario where the old luminaire has to be replaced with either a new HPS luminaire or an LED luminaire, the payback period for LED lighting (including both energy and maintenance costs) is reduced from 7 to 3 years in going from the 3-bar to the 2-bar LED luminaire. (The alternative is to consider the cost of fitting a new LED luminaire versus retaining the old HPS luminaire; here the payback period is much longer.)

The report says that, in the future, the dramatic pace of improvement underway in both LED chip performance and price can be expected to continue reducing the premium on LED-based products. Both of these factors will lead to further reductions in the payback periods achieved from LED retrofits.

- More details: www.ledsmagazine.com/news/5/4/5

China's first "LED City"

Tianjin Economic Development Area (TEDA) has joined the LED City™ program founded by LED maker Cree. TEDA joins Raleigh, Ann Arbor and Austin in the US and Toronto, Canada, in the program. Over the past two years, TEDA partnered with Tianjin Polytechnic University in a large, student-produced LED street lighting project. Twenty graduate students, directed by Professor Pingjuan Niu, designed, produced and installed approximately 1,500 LED streetlights. These LED fixtures were installed more than a year ago to illuminate 15 km along the university's streets.

- More details: www.ledsmagazine.com/news/5/2/26

Canadian town goes green

The Canadian government is investing CAN $500,000 in an outdoor lighting project in Kelowna, British Columbia, that uses solar-powered LED lighting. The one-year project, developed by Carmanah Technologies Corp. of Victoria, BC, will install a network of 100 self-contained, solar-powered lighting systems to light public spaces in Kelowna, including parks, pedestrian and bike trails, as well as providing accent lighting, and security and safety lighting.

"Our government is pleased to support this innovative solar-powered technology project and its potential to benefit communities across Canada and around the world," said Gary Lunn, Canada's Minister of Natural Resources. "By working in partnership with industry and communities, Canada can lead the way in reducing energy costs, increasing the use of clean energy and creating a healthier environment for Canadians."

- More details: www.ledsmagazine.com/news/5/3/14

NEWS & ANALYSIS

FUNDING

DOE funding provides $20 million for SSL projects

The U.S. Department of Energy (DOE) has announced the competitive selection of 13 projects for solid-state lighting and will provide funding valued at just over $20 million. The new selections represent the fourth round in a series seeking to examine high-priority R&D activities that will advance state-of-the-art SSL used for general illumination applications. The selected have a total value of $27.8 million, with participant cost-share.

Product development

Six selections relate to Product Development and are focused on the development or improvement of commercially viable materials, devices, or systems. Technical activities are focused on a targeted market application with fully defined price, efficacy, and other performance parameters necessary for commercial success. The total value of Product Development selections is $17.1 million; the performers will provide an average of 32% as cost-share.

In one funded project, Philips Lumileds will develop pre-production prototypes of a warm white LED that has 135 lm/W efficiency and produces 1050 lm with CCT between 2800K and 3500K and a CRI of greater than 90. Cree has received funding to develop a high-efficiency, low cost LED component capable of replacing standard, halogen, fluorescent and metal halide lamps based on the SSL system efficiency and lifetime cost savings.

GE Lumination and University of Maryland will develop an illumination-quality SSL luminaire based on LED cooling using synthetic jets combined with optimized system packaging and electronics. Osram Sylvania will develop a highly efficient integrated down lighting luminaire that minimizes thermal, optical and electronic losses and will achieve a luminous steady state output of 1300lm with 73% overall system efficiency. OLED product development has also been funded; Universal Display Corp. is leading a team that seeks to develop high efficiency OLED lighting luminaires as part of an integrated ceiling illumination system.

Core technology

Seven selections relate to Core Technology and are expected to fill key technology gaps, provide enabling knowledge or data, and represent a significant advancement in the SSL technology base. The total value of selections for Core Technology Research is $10.8 million; the performers of cooperative agreements will provide 20 % as cost-share.

Among the funded projects is one led by Crystal IS to develop GaN-ready aluminum nitride substrates for the growth of cost-effective, very low dislocation density blue LEDs. Another led by Georgia Institute of Technology will seek to understand the impact of strain, defects, polarization, and Stokes loss in relation to unique device structures upon the internal quantum efficiency of LEDs. Also, PhosphorTech Corp will develop phosphors with broad and size-tunable absorption bands, size and impurity tuned emission bands, size-driven elimination of scattering effects, and a distinct separation between absorption and emission bands.

- More details: www.ledsmagazine.com/news/5/2/10

OLEDS

First OLED luminaires are highpoint of technology and fabrication developments

OLED technology has taken several major steps forward in recent months, with the announcement of the first roll-to-roll manufactured OLED lighting devices, and the demonstration of warm-white OLEDs with an efficiency of 46 lm/W. Also, Sony has made a major investment in its OLED display manufacturing capability, and the industry has seen the first examples of OLED panels incorporated into real (but presumably very expensive) lighting fixtures.

Ingo Maurer creates first OLED luminaires

One of the highlights of the Light+Building Fair in Frankfurt in April was the demonstration by lighting designer Ingo Maurer of two luminaires built using prototype OLED lighting panels supplied by Osram Opto Semiconductors. The limited-edition table lamp, named "Early Future" (see photo), demonstrates the enormous potential of using OLEDs to create future applications with eye-catching illumination and design elements. Ingo Maurer used OLED tiles with an area of 132 x 33mm. For Maurer, unusual design is not an end in itself. "Early Future represents an important stage in the transition from abstract object to functional designer lighting," he said.

The panels for the table lamp were built using small-molecule OLED technology, while a larger, suspended luminaire used the alternative polymer approach. The table lamp demonstrated very good, uniform color when viewed directly but the color changed when viewed at a slight angle. The panels of the suspended luminaire had a distinctive greenish tinge. Even so, as intended, the fixtures effectively demonstrated the potential offered by OLEDs.

- More details: www.ledsmagazine.com/news/5/4/12

Osram develops warm-white OLED

In March, Osram reported further progress in warm-white OLED development by building a prototype panel with an efficiency of 46 lm/W, a brightness of 1000 cd/m^2 and a lifetime of more than 5000 hours. The panel measured almost 100 cm^2 with a color rendering index of 80 and CIE color coordinates of (0.46, 0.42).

Osram's results were achieved as part of the "500 lm Multi-OLED Module" project under the OPAL (Organic Phosphoresce Diodes for Applications on the Lighting Market) research consortium. This project is focusing on the optimization of the layer system comprising small molecules, in which the layers are produced by means of vacuum evaporation. In addition to Osram, this project involves Siemens Corporate Technology, the universities in Darmstadt, Braunschweig and Augsburg, and the IPMS Dresden.

By March 2009, Osram expects to be able to build a multi-panel demonstrator delivering 500 lm while consuming less than 10 W. For widespread applications it will be necessary to produce efficient OLEDs in large numbers at reasonably low cost, and this is an essential objective of the research project.

- More details: www.ledsmagazine.com/news/5/3/17

GE demonstrates OLEDs by roll-to-roll process

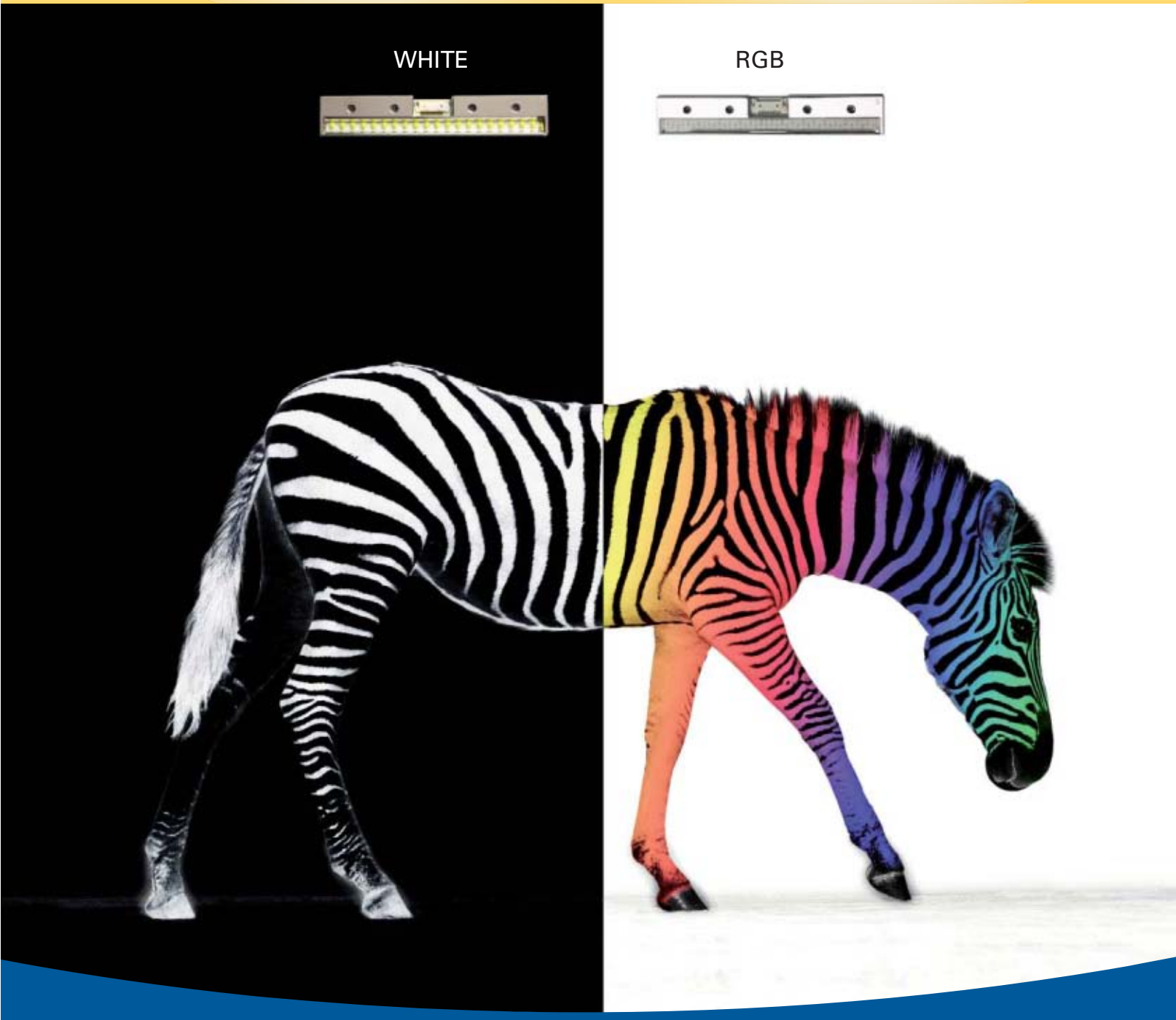
GE Global Research has demonstrated what it claims to be the world's first roll-to-roll manufactured OLED lighting devices. GE described the demonstration as a key step toward making OLEDs and other high performance organic electronics products at dramatically lower costs than what is possible today. "Researchers have long dreamed of making OLEDs using a newspaper-printing like roll-to-roll process," said Anil Duggal, manager of GE's Advanced Technology Program in Organic Electronics. "Commercial applications in lighting require low manufacturing costs, and this demonstration is a major milestone on our way to developing low cost OLED lighting devices."

- More details: www.ledsmagazine.com/news/5/3/9

Sony invests in OLEDs

Sony Corp. has unveiled plans to invest ~2 billion yen (about $203 million) to strengthen middle and large size OLED panel production technology. The company wants to position the OLED panel as "a new device capable of expanding the future potential of televisions and other AV products". In December, Sony launched its "XEL-1" 11-inch OLED TV featuring extreme thinness and superb image quality with high contrast ratio, high peak brightness, accurate color reproduction and rapid response time. Sony will reinforce its thin-film transistor (TFT) and electroluminescent (EL) layer-coating processing facilities at Sony Mobile Display Corp's Higashiura factory, and plans to implement this production technology during the FY ending March 31, 2010.

- More details: www.ledsmagazine.com/news/5/2/16



We make the Difference!

Avago RGB and White LED Modules from EBV

Many lighting applications require special light units. For such purposes Avago Technologies offers LED modules featuring compact design, outstanding heat discharge properties and very high light intensity.
Avago Technologies offers 24 Watt RGB LED modules (ADJD-MJxx) which generate virtually all the colors in the spectrum and 10.5 & 3.5 Watt warm white (ADJDYDxx) and cold white (ADJD-WDxx) LED modules. For all questions and support please just contact your local office of EBV Elektronik, Avago's leading semiconductor specialist in Europe.
Further information is also available under **www.ebv.com/avagomodules**

MAIN FEATURES:

- **Plug & Play**
- **Outstanding heat discharge properties**
- **High light intensity**
- **Long life time**
- **No soldering required**

Young Engineers | Sponsored by EBV Elektronik

Distribution was yesterday. Today is EBV.

AVAGO TECHNOLOGIES | EBV Elektronik | An Avnet Company

UK-Wiltshire, SN4 8SY | ✆ +44 (0)17 93 84 99 33 | www.ebv.com

LED market growth predicted to exceed 20% over next five years

Strategies Unlimited predicts that the LED industry is emerging from a slow growth phase, and that the total market size in 2012 will exceed $11 billion.

The market for packaged high-brightness LEDs is set to grow by 12% in 2008, according to a market update presented by Bob Steele at the Strategies in Light 2008 conference in Santa Clara, California (see page 26 for our full conference report).

Steele said that the market grew by 9.5% in 2007 to reach $4.6 billion, somewhat higher than the 6% growth seen in 2005 and 2006. In the next five years, further acceleration in growth is expected as applications outside the mobile phone market come to the fore, principally LED backlighting for LCDs, and of course solid-state illumination. Overall, Steele predicted a compound annual growth rate (CAGR) of 20% in the next five years, with a total market of $11.4 billion in 2012.

Changing applications and product mix

Steele predicted that the largest application segment in 2012, with 44% of the market, will be Signs & Displays, which includes backlighting for large LCD screens (monitors and TVs). In 2007 the largest segment was Mobile Appliances, with a 44% share. However, the largest growth in 2007 was seen in the Illumination and the Signs & Displays segments, both of which grew by over $100 million.

Between 2004 and 2007, unit shipments have increased by 26% per year to around 39 billion units, while average selling prices (ASPs) have fallen by around 16%. Overall, the product mix has shifted quite dramatically, with high power packages now accounting for 10% of the market, compared with less than 4% in 2004.

Strategies Unlimited defines high power packages as those driven by a current in excess of 150 mA. In 2007, around 39% of high-power LEDs were used in mobile applications, mainly for camera flash, while 37% were used for illumination applications.

Solid-state illumination

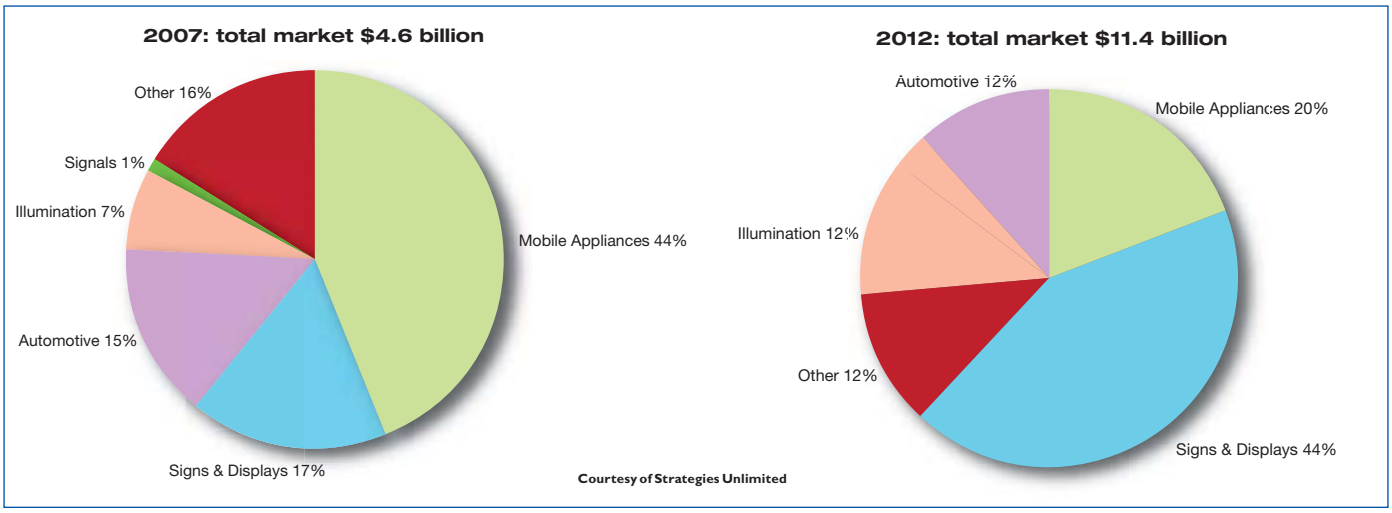
Illumination accounted for 7% of the LED market, or $330 million, in 2007, and this figure is expected to grow to nearly $1.37 billion by 2012. The Illumination segment grew rapidly in 2007, with revenue more than 60% higher than in 2006. Steele reported a lot of new activity in Asia, and many companies entering the market with new products and ideas, some of which are attracting the attention of venture capital companies. As shown by the DOE's CALiPER program, the performance of LED luminaries is highly variable, with claims frequently exceeding measured results.

The market remains highly fragmented, serving many niche applications, and prices are high for high-quality, high-efficiency luminaries. Most applications still use color, but many white-light applications are emerging, for example in the outdoor sector.

A frequently-cited requirement for the LED lighting community is to develop standards, and this effort is proceeding rapidly. The Energy Star requirements for SSL luminaries relate directly to numerous standards covering efficacy, power factor, lumen depreciation, chromaticity and safety, to mention just a few.

Steele said that energy efficiency will be the major driver for moving LED into the general lighting market. "However, this is not the only driver; products must also deliver value on a cost-of-ownership basis," he said. "Government subsidies and regulation will be important in early market development, while LED fixture efficiency and lifetime must be proven [in order] to win customer acceptance."

While some obvious challenges remain, such as high initial cost and color consistency, Steele also said that there is a need for high-efficiency light engine and fixture design, and a requirement for a widespread base of lighting fixture designers and engineers who understand LEDs.



Growth markets for LEDs. (below) White LEDs in the daytime running lights (DRLs) of the Audi A4. Future legislation mandating DRLs could have a huge effect on this market. (middle)The HP Compaq 2710p Notebook PC uses LED backlighting in its LCD screen to achieve low energy consumption and extended battery life. (right) LEDs are already used in a wide range of illumination applications. In this surgical light, high-quality white light is created using RGB mixing and sophisticated optics.

Mobile appliances and notebooks

Mobile remains the largest segment of the LED market, with a 44% share in 2007. However, the largest single application for LEDs – mobile phones – actually declined by 3.3% last year. Fortunately, applications for LEDs in mobile appliances other than phones actually increased by 21% to $264 million. Examples of such appliances include MP3 players, GPS units, portable DVD players and notebook computers.

Non-phone appliances are expected to account for 44% of the overall Mobile segment in 2012, said Steele, when notebook PCs will be the largest non-handset application (currently this is PDAs & smartphones). Steele also explained that the key application is backlighting of full-color LCD displays using white side-view LEDs. Edge-lighting of displays up to 15.4 inch diagonal requires very high performance white LEDs at the 1800-2000 mcd level. (Larger LCD panels are included in the Signs and Displays segment.)

White LED backlights are typically 1.5-2 x more expensive than a CCFL alternative, and also have a narrower color gamut. However, the key advantages of LEDs are the absence of mercury and lower energy consumption, resulting in longer battery life. Also, with LEDs having a thickness of only 0.4 mm in some cases, this enables extremely thin form factors, the ultimate example (at present) being the Apple MacBook Air.

Automotive applications

Steele predicted that the automotive market for LEDs will continue to grow steadily, roughly doubling in size from 2007 to reach around $1.4 billion in 2012. Headlamps have captured the headlines recently (see for example *LEDs Magazine* Nov/Dec 2007, p18) but this application has barely started. White daytime running lights are somewhat more widespread. In contrast, LED penetration is extremely high in some areas, such as center high-mounted stop lights and instrument panel lighting in Europe.

However, said Steele, the conversion to LEDs is not all one-way traffic. "Once a function is converted to LEDs, there is no guarantee that it will be continued in future models. LED taillights were adopted in the 2006 Honda Accord, but the 2008 model uses incandescent taillights." With around 0.5 million Accords produced per year, this had a major impact on the penetration of LEDs into the exterior lighting market.

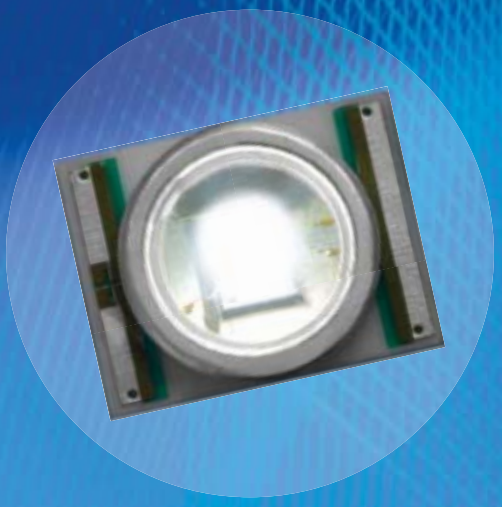
Signs, displays & LED backlights

Steele fully expects that Signs & Displays will become the largest application segment in 2012, with 44% of the total market, equal to a value of around $5 billion. That's larger than the entire HB LED market in 2007. This quite astonishing level of growth will be driven by the conversion to LED technology of backlights used in large LCD screens, principally PC monitors and TVs.

However, the conversion of LCD TV backlights to LED technology is still in its very early stages, with market penetration currently around 0.1%. Significant shipments began only towards the end of 2007. Samsung is the market leader in LCD TVs and monitors, as well as in rear-projection TVs using LED sources. For large LCD TV panels, Samsung uses direct backlighting (the LEDs are distributed across the backplane, as distinct from edge lighting), with around 1000 LEDs for a 40-inch display. Rather than using red, green and blue LEDs, Samsung uses non-standard white LEDs, in which a blue chip is combined with red and green phosphors to achieve a wide color gamut. This, said Steele, dramatically reduces control requirements compared with using RGB LEDs.

There remain many challenges to the adoption of LED backlights (which makes the market predictions even more surprising). LED backlights are currently 2-3x the cost of CCFL alternatives, which are themselves continuing to fall in price. The target is for LED prices to be reduced to within 20-30% of CCFL backlights. Also, new CCFL technology offers a wider color gamut than before, and this dilutes one of the strong arguments for shifting to LEDs. The strongest rationale for using LEDs has become the concept of local dimming to improve contrast. Because all the LEDs in the backlight can be individually controlled, specific LEDs can be dimmed in areas where the image is dark.

In summary, Steele said that CCFLs are getting better and cheaper, and cost is the main issue for LED penetration. "However, picture quality is outstanding, and high-end customers will pay a premium," he said. "Even modest penetration results in a large LED market, measured in billions of dollars."



HIGH BRIGHTNESS

HIGH EFFICACY

HIGH RELIABILITY

COLOR POINT STABILITY

50,000-HOUR LUMEN MAINTENANCE

Lighting-Class LEDs.

Cree XLamp® LEDs.






Bright + Efficient

- Luminous flux up to: 251 lumens at 1A 114 lumens at 350mA
- Efficacy up to 99 lumens per watt
- 50,000 hours at >70% lumen maintenance
- 2,600K to 10,000K CCT

Cree XLamp LED

Leading the lighting revolution. Cree XLamp LEDs deliver lighting-class performance that transforms ordinary light into bright, energy efficient light. Available in warm to cool temperature ranges, Cree XLamp LEDs are powering general illumination applications offering significant energy and maintenance cost savings.

Contact a Cree Solutions Provider or authorized distributor about your lighting-class application at www.cree.com/xlamp or call +1 919 313 5300.

CREE® LED Light

Visit us at LightFair: Cree LED Light at Booth #2635.
Cree LED lighting Solutions at Booth #1981.

Peter van Strijp, SSL veteran

For Peter van Strijp, formerly of Philips Lighting, the recent Strategies in Light event highlighted the growing momentum and increased adoption of solid-state lighting in general lighting applications.

Peter van Strijp retired on January 1, 2008 as Executive Vice President of Philips Lighting, where he was responsible for the overall Solid State Lighting strategy co-ordination and execution within Philips Lighting. He is still active in the solid-state lighting (SSL) industry, and one of his roles is as a board member of Israel-based company Oree.

LM: What were your impressions of SIL 2008?
Peter van Strijp: Let me first start by complimenting the organizers of the conference. In nearly a decade, Strategies in Light has developed into the leading conference in the LED industry. The event had more than one thousand visitors, widely distributed over the globe, the presence of almost every company that matters in the industry, as well as participation by lighting designers, government representatives and venture capitalists. It has carved itself a unique platform position in the industry.

How did SIL reflect the state of the SSL industry?
My main observation is that the adoption of LEDs in general lighting applications is gaining momentum very strongly. For me the SIL conference made this very apparent. We no longer have to give priority to other key applications to develop the technology and related cost levels....the general lighting market is already within reach. In that context I believe the market projections made by Strategies Unlimited for general illumination are on the conservative side.

What is your evidence for this?
In past years, we have heard claims that power LED technology had reached the performance levels on which the general lighting applications could convert on an economic basis to LEDs. But these claims were made by LED companies. This year [at SIL] the same assertions were made by companies active in the applications....lighting designers, fixture companies and module makers.
In past years the issues were lumen/watt, the availability of warm white, and of course price. This year I saw numerous presentations of convincing cost-of-ownership calculations by lighting fixture companies. So they are actually developing SSL-based general lighting applications.

What other positive signs did you see?
In parallel I noticed that typical industry development issues like standardization are being raised. There is a substantial industry activity on development and establishment of standards regarding performance and safety. Last but not least the massive presence of venture capitalists tells me that the economics are completing the picture....so I conclude SSL is here and now and will gain further momentum in the coming years.

What are the next steps for the SSL industry?
First of all the technology needs to be developed further so that more

applications within the general lighting industry come within reach. The tubular fluorescent lamp is the next target, now that incandescent, halogen and compact fluorescent lamps have been surpassed in lm/W. However, this will not have to wait until warm-white LEDs of over 100 lm/W are available. As soon as LED-based solutions can compete at the system level, taking into account optical efficiencies, it can start. Total conversion of the fluorescent market will of course take longer in view of economics, not so much in new installations, but in particular in the already installed fixture segment.

What challenges need to be addressed?

With the adoption in general lighting applications there will be several new challenges. The main ones are the development of industry product (interface) standards, following on from the performance and safety standardization that is currently ongoing. Just like the lighting and semiconductor industries have done in the past, the lighting industry has to develop product standards that allow economy of scale. This will go beyond the current focus on light output and color control in point light sources. We have now to solve other light-technical issues like luminous uniformity in linear and planar lighting applications without compromising on the advantages of high power LEDs. This issue is remarkably similar to some of the requirements of backlighting applications. Personally I expect that this topic will get as much attention as color consistency and light output issues.

Where can we find new opportunities?

These are numerous and will present themselves over time. There are however a number of them already visible. The first one I see is the combination of long life with the form-factor possibilities I mentioned earlier. In future we will "package lighting" differently, taking into account the elimination of light source replacement, as well architectural requirements and aesthetics that have yet to be addressed. Lighting will become part of the building infrastructure.

Another opportunity is in "controls" or "lighting system intelligence". So far all lighting controls are focused upon controlling LED physics and architectural lighting dynamics as defined by designers. The real end user– the person that is working with the installed lighting systems – hasn't been placed at the center point of industry developments. In my opinion this is the real challenge, and the company that does this best or first will be among the ultimate winners and industry leaders.

"I conclude SSL is here and now and will gain further momentum in the coming years."

What factors are required for success?

Mindset and speed.... having been in the lighting business for over 33 years, I feel I can say it. We should no longer think at the speed of the lamp industry, we all need to move to true "lighting" speed. My take-away from the SIL conference in this respect was positive... speed is picking up.

Lighting Africa helps developers of off-grid lighting systems

The International Finance Corporation aims to help suppliers establish a supply chain infrastructure in Africa for low-cost LED lighting, writes **Tim Whitaker.**

In early May, at least 400 attendees are expected in Accra, Ghana, for the Lighting Africa conference. This is the latest stage of a program that is seeking to provide access to affordable, self-contained lighting systems (usually but not exclusively LED-based) to millions of people in Africa. Specifically, the Lighting Africa program seeks to reach 250 million customers with modern, affordable lighting by 2030.

The Lighting Africa program began life as "Lighting the Bottom of the Pyramid," an initiative launched by the International Finance Corporation (IFC), the private sector investment arm of the World Bank Group (see "IFC project stimulates LED market for off-grid lighting" at www.ledsmagazine.com/news/3/10/25). IFC's Russell Sturm told LEDs Magazine that there has been "intense interest" in the program, which currently is focusing on initiatives in Ghana and Kenya. "The problem of energy access remains acute, but we have seen increasing awareness as well as recognition of the constraints, not least the required scale of investment," he says.

The IFC model is to support the development of a viable industry and supply chain for complete lighting systems, including batteries that can be recharged by solar panels or by local recharging facilities. "We are looking to fill the gaps that have been indicated to us by industry," says Sturm. Development organizations tend to have a different approach, looking first at subsidies rather than building a supply chain infrastructure. Sturm says that lots of progress has been made; for example, there is already a local program manager in place in Ghana. Central to the Lighting Africa website (www.LightingAfrica.org) is a business-to-business platform which enables problem solving, access to distribution channels and acquisition of certain key products.

Development Marketplace competition

The Lighting Africa conference provides an opportunity for program participants, funding providers, media representatives and others to meet face to face and discuss their activities and ideas. It will also see the culmination of a Development Marketplace competition, a competitive grant program that will support private enterprises in developing and delivering a wide array of modern lighting products for poor households and businesses that are not available in the marketplace today.

The competition received over 400 proposals on innovative solutions for off-grid lighting for Africa from 54 countries, including 38 African countries. The Development Marketplace's team of international assessors selected 54 projects that will present their proposals at the Lighting Africa event. Here, a panel will select between 10 and 20 winners who will receive up to $200,000 in seed funding to develop and implement their ideas.

Lighting Africa will support the winners, and all companies willing to invest time and effort and resources in the African unelectrified lighting market, by helping in areas where individual companies or teams would struggle. "This could be the development of performance standards, or explanation of tariffs, or assistance with financing," says Sturm.

According to the Lighting Africa website, currently there are 1.7 billion people worldwide without electricity. The problem is most acute in sub-Saharan Africa where over 500 million people presently lack modern energy, with rural electricity access rates as low as 2%. For the very poor, fuel-based lighting can account for 10-15% of total household income. In contrast, modern lighting can extend the working day for businesses and improve income opportunities; it can enhance educational opportunities for students (children and adults) to be able to read and study; and it removes the health-related problems caused by fuel-based lighting.

• Lighting Africa 2008 takes place May 5-8 in Accra. Visit www.lightingafrica.org for more information on the program.

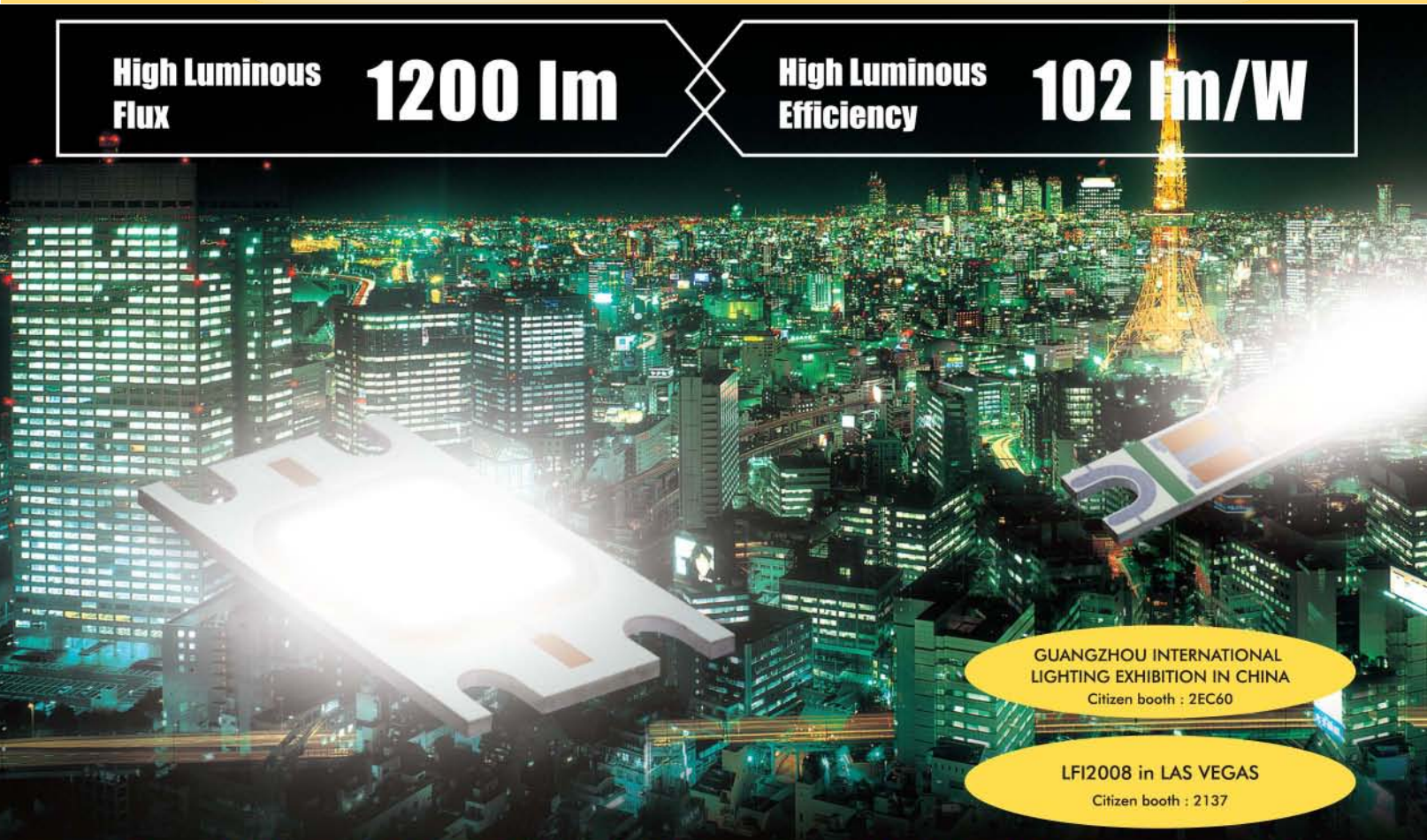
Ghana Solar Lantern project

Many groups are already involved in sustainable lighting projects for the developing world. A team led by Toby Cumberbatch of Cooper Union School of Engineering in New York City has developed LED lanterns (see photo) for communities in Northern Ghana. "We are trying to approach this task from the perspective of those at the base of the pyramid," he says. "Our goal is to work with the communities to come up with a lantern that they can produce themselves - in rural areas - and so have ownership of the device. We want to come up with a generic lighting fixture (LED, heatsink, drive electronics and optics) that can be easily assembled and placed in a chassis to suit."

To assist the project, Heatron provided Cooper Union with several dozen ELPOR® Steel Star Core LED light engines mounted with Lumileds K2 and Rebel LEDs as well as Cree Xlamp LEDs. All models produced around 80-100 lm at 350mA. Heatron also provided Cooper Union with methods and materials for mounting the ELPOR® Steel Stars.

Solar-powered lanterns built by Cooper Union Sustainability Lab for its Solar Lantern Project have been distributed to communities in Ghana. More photos at www.solarlantern.blogspot.com.

High Luminous Flux **1200 lm** | **High Luminous Efficiency** **102 lm/W**

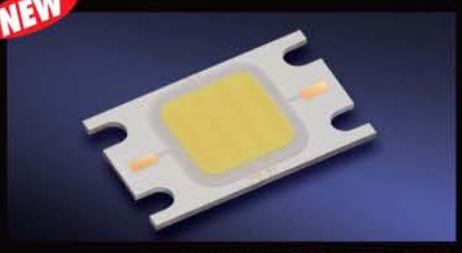


New Citizen White LEDs deliver more light with less power!

NEW

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

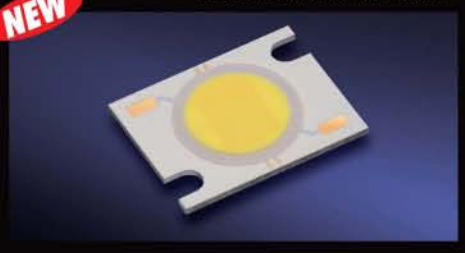
NEW



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

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

NEW

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

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

CITIZEN ELECTRONICS CO., LTD.

CITIZEN Micro HumanTech

Distributors

Germany : Endrich Bauelemente Vertriebs GmbH endrich components of life
Contact person : Frank Dembski Tel : +49-7452-600756 E-mail : f.dembski@endrich.com

Italy : Velco S.p.a. velco s.p.a.
Contact person : Paola Tonel Tel : +39-444-922-922 E-mail : info@velco-electronic.com

Netherlands : Elincom Electronics elincom electronics
Contact person : Michiel Wubs Tel : +31-10-264-0270 E-mail : m.wubs@elincom.nl

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

* Distributor in other country : researching

Request/Inquiry

E-mail : inquiry@ce.citizen.co.jp

Contact

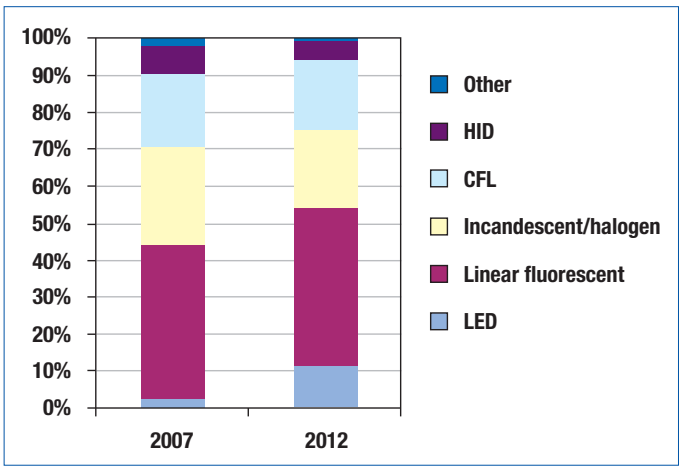
Europe	Tel : +49-69-2992-4810
North America	Tel : +1-847-619-6700
Japan	Tel : +81-3-3493-2716
Asia	Tel : +852-2793-0613
Other area	inquiry@ce.citizen.co.jp

Strategies in Light 2008 focuses on emerging LED applications

The ninth annual get-together for the LED industry highlighted the development of LED technologies and standards that are driving us into new and emerging markets, not least general illumination. **Tim Whitaker** reports from Santa Clara.

With a tagline of "Emerging Applications: Driving the LED Market Forward", the ninth annual Strategies in Light 2008 took place on February 11-13 in Santa Clara, California. The event attracted over 1000 participants from a total of 28 countries, and there were more than 50 exhibiting companies. The first day of the event was taken up with several workshops, including a full day on intellectual property, licensing, and strategy, and an afternoon session on drivers. There was also a very well-attended workshop on standards describing current progress in different areas including the new Energy Star labeling program for SSL fixtures, which is linked with and draws from many of the other current standards.

The conference itself was opened by Bob Steele of Strategies Unlimited, who gave his annual update and forecast for the HB-LED market, as summarized on pages 17-18 of this issue. By far the most enthusiastic speaker was Brian Owen, our own Canadian Columnist, who described Toronto's participation in the LED City organization and many other lighting-related programs. Brian's review of the LEDiscovery event can be found on pages 42-43.



Fixture market by source in 2007 and 2012. LEDs are expected to capture a growing portion of the total lighting market, according to Bob Smith of Cooper Lighting.

The lighting market

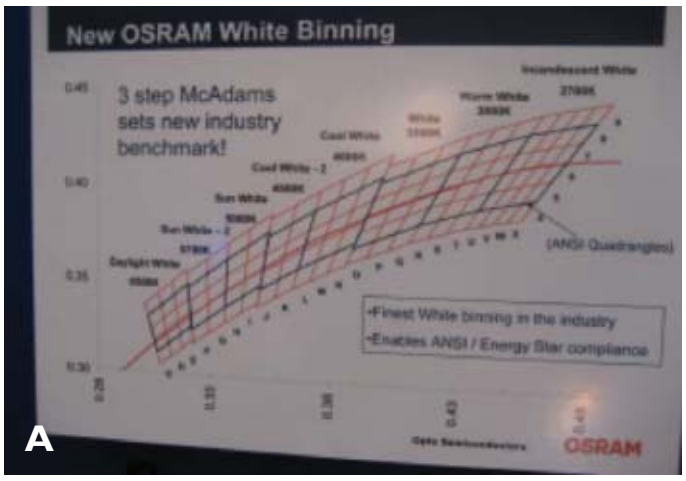
The keynote presentation at Strategies in Light 2008 was given by Bas van de Kieft, executive VP of Philips Lighting, who described Philips' ongoing commitment to solid-state lighting (SSL). "There is a very different business model for SSL versus conventional lighting; we [Philips] need to change but we are committed," said van de Kieft. "SSL won't wipe out CFLs any time soon – it depends on how quickly we can get costs down and efficiency up."

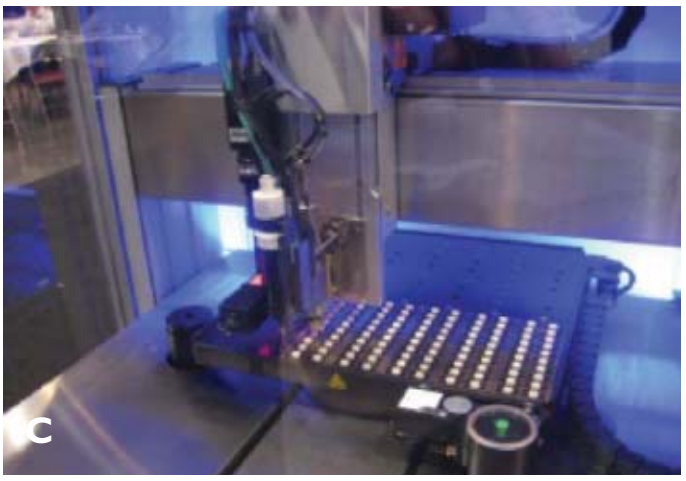
While in the past the primary motivation for lighting was "see and be seen", today there is more consideration of total cost of ownership and safety and comfort. In the future, said van de Kieft, there will be more awareness of lifestyle and health issues related to lighting, and SSL will accelerate the appearance of these trends. Globally, there is huge potential to save energy through more efficient use of lighting; this can be done with different technologies, some already available today, but there is greatest potential through the use of SSL. And, positively, such activities are backed by increasing levels of political will and general awareness.

Van de Kieft also said that Philips recognizes that a shift from hardware and lamps to luminaire systems and controls will play a crucial role in the transformation towards SSL. Luminaires and controllers enable lighting effects and bring control closer to the end user, and this in turn requires market-driven innovation to create suitable interfaces that are easy to use. In van de Kieft's words, the aim is "innovative lighting that makes sense and is simple."

In his presentation entitled "LED Technology: A Luminaire Manufacturer's Perspective," Bob Smith, director of Innovation and Advanced Engineering with Cooper Lighting, said that LED penetration in the lighting market is expected to grow significantly. However, he said, "the customer must not be over-sold or under-supplied." Smith estimated that the proportion of the lighting fixture market that uses LEDs as the source will show an increase from 2% in 2007 to 11% in 2012 (see graph, above). "However, there will still be applications where LEDs do not make sense," he said.

The influence of regulations and standards is a key factor that will drive the adoption of energy-efficient and environmentally friendly luminaires. However, said Smith, incentives could be the most impor-





Strategies in Light exhibitors: (a) Osram Opto Semiconductors unveiled a new binning scheme for white LEDs, involving 120 bins - see www.ledsmagazine.com/news/5/2/11. (b) Everlight exhibited a prototype streetlight fixture and its new 90 lm/W XcelLED high-power LEDs - see www.ledsmagazine.com/press/15934. (c) Asymtek brought one of its automated dispensing systems to the show. (d) Lynk Labs exhibited modules and fixtures powered by its hybrid AC-LED technology – see article on pages 36-37.

tant influence, since these offset higher initial product cost. "Adoption rate is a function of regulations and the value provided," he said. "Owning and operating benefits must exceed those of existing source solutions, in order to accelerate adoption rates before price parity is reached."

Smith also emphasized the benefits of joint luminaire development programs, which can streamline the process and reduce wasted effort. "Cooper wants partners to optimize performance metrics," he said. He also highlighted "voice of the customer" concerns, such as color consistency, driver lifetime and long-term product availability.

Utilities offer incentives

California has been a leader in energy efficiency for over 20 years, and has various programs that are impacting the acceptance and adoption of LED lighting in the marketplace. Mary Matteson Bryan of Pacific Gas & Electric (PG&E), a California utility company, described energy efficiency as "California's highest priority resource" – so much so that $2 billion will be spent by the state in the period from 2006 to 2008 in an effort to achieve cumulative demand reduction of over 1400MW, equivalent to 3 new 500MW power plants.

Legislation, in the form of the California Lighting Efficiency and Toxic Reduction Act, has set a goal of reducing lighting energy consumption by 50% for indoor residential, and by 25% for commercial and outdoor. Nationally, the 2007 Energy Policy Act mandates increased efficiency for general purpose lighting, defines maximum wattages, and generally requires lighting to be 30% more efficient by 2012-2014.

All this feeds into PG&E's Emerging Technologies Program (the other utility companies have similar programs), within which Bryan manages the lighting portfolio. The program's mission is to identify and assess emerging technologies, and accelerate market penetration. Among the activities are evaluation of energy savings and lighting characteristics, results of which are published at www.etcc-ca.org. Bryan's group also supports the development of incentive programs, one example being the Efficient Refrigerated Case Lighting (ERCO) scheme. This provides an upstream rebate to manufacturers of $45 per door, or $60 for higher efficiency lighting. "This [upstream rebate] results in lower cost for the customer and allows us to retain some control of which products receive incentives," said Bryan.

As well as the ERCO scheme, PG&E has a non-residential retrofit program that offers an incentive, based on calculated savings, at a

Strategies in Light provided a good opportunity to visit the LED street-lighting installation in Oakland, which uses fixtures from Beta LED and was the subject of a recent DOE demonstration report – see www.ledsmagazine.com/news/5/1/30. The photo, courtesy of Pete Strasser of the International Dark-Sky Association, shows the excellent light quality produced by the LED lights. Light trespass from conventional lighting in adjacent streets can be seen as an orange glow on the house gable in the center of the image.

rate of $0.05/kWh. Bryan explained that California's Investor-Owned Utilities (IOUs) are collaborating on the development of incentives specifically for LED lighting. "We are developing deemed rebates with stringent quality standards," she said. "We will use Energy Star labeling once available, and we encourage the lighting industry to support Energy Star." Standards-based incentives will ensure customer satisfaction and long-term energy savings.

Of course, it's not all about LEDs. "PG&E is still aggressively promoting CFL for energy efficiency, despite poor customer acceptance," said Bryan, mentioning that the DOE report on the introduction of CFLs in America (www.netl.doe.gov/ssl/072806.html) provides valuable lessons. PG&E is also looking at areas such as wireless control, daylighting, and an increased level of task lighting in offices.

Looking beyond the LED

As we all should be aware, there is more to an LED system than the LED emitter itself. Costa Politakis of Future Lighting Solutions said that LEDs are only one component of a complete lighting system. "Partnerships are critical for success in order to reduce time to market, and to enable the selection of optimized solutions and components," he said. "Another important aspect is to extract the value and determine advantages and selling features, which should inevitably include ROI and payback."

Danny Yu, VP Business Management and Strategic Marketing of Philips Lumileds, said that significant technical advancements are required in areas such as optics, power ICs and passives. "Only 'fit for purpose' LEDs and 'illumination grade' electronic components will meet the needs of the general illumination market," he said. Yu invited component manufacturers and board-level technology providers to work with LED manufacturers who understand the sys-

CONFERENCES

tem requirements of general lighting applications. "There is a huge growth opportunity for the electronics industry in general lighting, not just for the LED manufacturers," he said. "Passives and drivers must improve their ability to withstand extremes of temperature, across the range from -40°C to 85°C for outdoor applications. General illumination also requires a new generation of constant-current driver ICs that are rated for 50,000 hours. And those drivers must be engineered to feed a smoother flow of power to minimize the ripples and spikes that can affect LED performance. Even the PCB assemblies have to improve so that the board material and the solder joints will not fail in harsh exterior conditions."

Lighting applications

Improvements in the performance of power white LEDs have been instrumental in the success of outdoor lighting applications, said Mark McClear of Cree. The initial driver has been maintenance avoidance and energy savings, but there are other motivations such as light quality, uniformity, aesthetic appeal, disposal costs and safety.

McClear predicted that the next areas of success will be in indoor directional and industrial lighting, followed by indoor general illumination. Of course, this latter market has significantly different requirements from outdoor, for example the requirement for warm white (~3000K) and high CRI (>80). Lamp maintenance is not a driving factor but there is a high style content, a focus on "green" concerns and energy savings and – crucially – widely different cost expectations. Fortunately, said McClear, warm white LEDs have improved very significantly, and penetration of the lighting market will be aided by emerging SSL standards and Energy Star labeling.

SIL has been trying for several years to persuade a Boeing speaker to describe the LED lighting scheme in the new 787 Dreamliner aircraft (see www.ledsmagazine.com/features/3/6/7). Unfortunately, Eric Lindbeck started his talk with a long series of disclaimers and wouldn't give many details of the color-changing LED lighting scheme in the main cabin, which is supplied by Diehl. Even so, Lindbeck highlighted some generic end-user needs for the airline industry. The choice of LEDs instead of fluorescent lamps in a new aircraft is not a given, and is evaluated on a case-by-case basis, depending on factors including initial cost and energy draw. Further LED performance requirements are required to reduce the power demand; some phases of flight (e.g. take off) require much more power and there is barely enough to drive the LEDs. Some power LED designs require large heatsinks that add weight and increase the plane's fuel consumption, and heat produced by the LEDs also means more power used by the air conditioning systems. Also, said Lindbeck, the aircraft maker requires a reliable quality source of LEDs, ideally available over the lifetime of the plane. [Unfortunately this doesn't sit too well with LED makers that might want to concentrate on much higher-volume markets.]

Optics and phosphors

Optical design is a crucially important piece of the LED system design puzzle. As Ron Holder, president and CEO of Illumination Management Solutions (IMS) pointed out, improving optics can lead to an immediate system improvement. "By not wasting lumens, we can put more foot-candles on the task," he said. This leads to the first Optical Principle shared by Holder: "Lumens are good, but foot-candles are measured." Holder illustrated the principles by reference to two case studies; an LED MR-16 lamp and a streetlight,

Sharing the Seoul Semiconductor stand, IMS showed a street lighting product using its Light Bar concept, as well as an LED MR16 lamp with patented optics that produces up to 210 lm at 4.7 W at a color temperature of 5700K.

both of which could be seen on the Seoul Semiconductor booth in the exhibit.

The second Principle is that "Photons like to be left alone" - in other words, the design should get light to the surface/task with the least amount of interference. Holder's third Principle was "Think outside the box – literally (or: don't retrofit)." While a traditional luminaire consists of a lamp and reflector inside a box, an LED luminaire should be viewed (and built) differently, with a heatsink on one side of an interface and the LEDs and optics on the other side.

Yi-Qun Li, VP of Engineering at Intematix, gave an overview of phosphor technology, including a description of the company's new patent for yellow-green silicate phosphors with emission in the 500-575 nm range (see www.ledsmagazine.com/news/5/3/16). Li estimated that 51% of white LEDs for the general lighting market use YAG phosphor from Nichia, including Nichia's licensees such as Lumileds, Cree, Citizen and Stanley. A further 20% of white lighting LEDs use other YAG-based phosphors, and 20% use TAG phosphor technology licensed from Osram. The remaining 9%, said Li, use silicate-based phosphors supplied by Intematix.

Drivers

Several exhibitors at Strategies in Light showed new approaches to drivers, both from a technology and a commercial viewpoint. ROAL demonstrated its SignLINQ power management approach for LED signs. Generally, signs require multiple class 2 power supplies to convert AC into DC power. ROAL's approach has a Class 1 remote DC power feed that eliminates AC wiring to the sign, as well as removing the need for power supplies within the sign. For more details, see www.ledsmagazine.com/press/15907.

Among the exhibitors, Lynk Labs was particularly pleased with the response to their XyLite AC LED modules. "We had a good deal of traffic in our booth and many lighting OEMs responding to XyLite as a result of the show," said Mike Miskin, Lynk Labs' CEO. The XyLite is built around a 1.1-watt hybrid AC module, and is scalable in x and y directions (see photo, page 25).

Heatron announced that it is now offering custom power supplies (drivers) designed specifically to the requirements of high power LED assemblies. "Proper thermal management means that LED lumen maintenance and reliability are very high. The weakest link in the fixture design then becomes the driver," said Hank Zabawski, Heatron's Director of LED Technology. Drivers that are mismatched to the application yield low efficiency, power factor, overheat or simply fail to provide the appropriate output." Heatron described a driver that was designed as a replacement for a total of three independent drivers powering two LED-populated metal-core boards. Due to the configuration and compatibility of the independent drivers, overheating caused the assembly to fail UL testing. Having integrated a single custom driver from Heatron to eliminate both the overheat concerns and form factor of redundant power supplies, this product design was then able to pass UL approval. For more details, see www.ledsmagazine.com/press/15938.

Effective color mixing

Color-changeable high-power light sources can be made by mixing the light from multiple color chips, an approach which allows the removal of diffuser optics. UK company Enfis is at the forefront of this approach, using integrated temperature and optical monitoring feedback, an extremely high chip packaging density and ultra-low thermal resistance. Gareth Jones, chief technology officer of Enfis, described the key requirements for high quality lighting. "There is always a trade-off between spectral coverage [better color rendering] and luminous efficacy," he said. "High quality of white light will always mean lowering the efficacy."

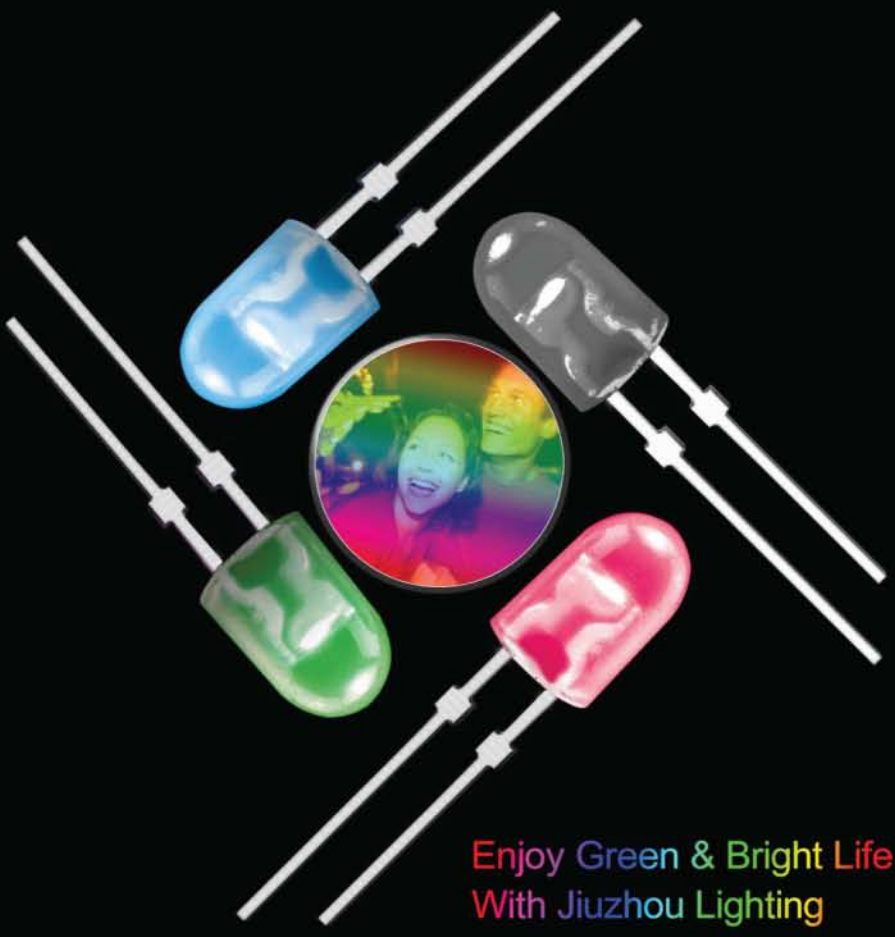
With a high packaging density of LED chips, color mixing takes place within a few mm of the source, with good color uniformity and enabling homogenous spot projection. With four different types (colors) of chip, four-channel color mixing allows easy access to all colors and white color temperatures. Jones described an array that was capable of producing 2467lm at a color temperature of 3121K with Ra=91, or alternatively 2405lm at 6473K and Ra=97. The Enfis arrays use thermal monitoring near the chip junction to provide accurate feedback and closed-loop control, so that the initial brightness can be maintained over the lifetime of the system.

FUTURE EVENTS

The tenth Strategies in Light takes place on February 18-20, 2009 in Santa Clara, California. See www.strategiesinlight.com.

Before then, the first overseas Strategies in Light will take place in Tokyo, Japan. Organized by PennWell and e.x.Press, LED Japan/ Strategies in Light will be held October 16-17, 2008.

LED Japan/Strategies in Light will bring new focus to the LED market in Japan, where there is a large number of LED manufacturers, LED users, and suppliers of equipment and materials to the LED industry. Bob Steele of Strategies Unlimited, who launched the original Strategies in Light in 2000, said "In 2007, Japan accounted for approximately 45% of the worldwide HB LED supply. Japan is home to the world's largest HB LED manufacturer, Nichia Corporation, as well as 5 of the world's top 10 HB LED suppliers. Japan is also a large market for HB LEDs, accounting for about $1 billion in HB LED consumption in 2007."



LEADING PROFESSIONAL MANUFACTORY IN
SEMICONDUCTOR LIGHTING FIELD

JIUZHOU

E-mail:overseas.led@jiuzhou.com.cn
Tel:+86-755-26947000
Fax:+86-755-26715369
Website:www.jiuzhou.com.cn
www.jz-led.com

50 YEARS JIUZHOU 1958~2008

Jiuzhou 50-years celebration!

WATCH THE WORLD WITH JIUZHOU

Theatrical lighting industry gets ready for Act Two with LED fixtures

Currently there are few good alternatives to the beam control provided by conventional lighting fixtures in the theatre. However the benefits of emerging LED products should potentially provide fixtures that are brighter, cooler, lighter, and faster to set up, says **Noah Davis.**

One of the missions of a theatrical lighting designer is to help tell the story with light. The story of the theatrical lighting industry itself is still in Act One. With movements to "ban the bulb" and shift away from incandescent sources, many people in the theatre world are wondering what will happen to its lighting industry in Act Two. It is time to shine a spotlight on the current state of theatrical lighting systems and how they may be brought up to date with LEDs.

The theatrical lighting industry was born after the invention of the electric light bulb. Prior to electricity, theatre stages were lit with gas, which often caused scenery to catch on fire. The design of the typical theatrical lighting fixture has remained largely unchanged since the1930s. The basic needs of lighting designers have not changed much either. They have always required the ability to change color, beam size, shape, intensity, and angle.

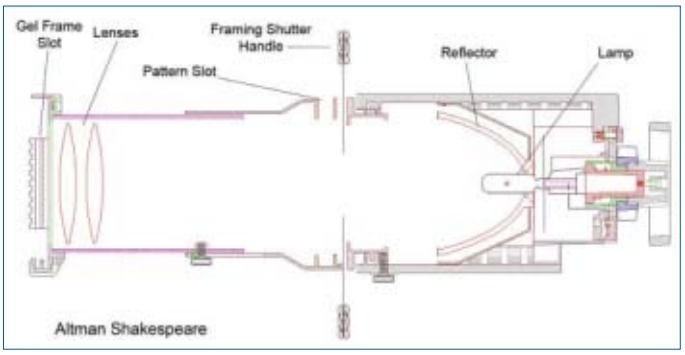


Fig. 1. In Altman's Shakespeare Leko fixture, lens tubes, which are categorized by beam spread degrees, can be swapped around to achieve a range of beam spreads from 5–90°.

Lekos and Fresnels

Most theatre productions are lit primarily with two types of fixtures. The ellipsoidal reflector spotlight, or Leko, is the most popular fixture because of its versatility. The other popular fixture is the Fresnel, a variable beam fixture that can adjust from a wide wash down to a soft but narrow spot of light, designed for shorter throws.

The Leko, named after its inventors Joseph Levy and Edward Kook, has framing shutters to change the beam shape from round to square, rectangle, triangle, etc. It also has lenses that allow the beam to be focused to a sharp edge or soft edge. A typical Leko also has an accessory slot that can accept patterns for projecting shadow images such as leaves or clouds or a custom image. The beam spread is determined by focal length. On older design fixtures, such as the Altman 360Q, a new fixture must be purchased in order to achieve a different focal length. On newer designed fixtures such as the Altman Shakespeare (Fig. 1) and the ETC Source Four, the lens tubes, which are categorized by beam spread degrees, can be swapped around to achieve a range of beam spreads from 5–90°. Models with variable focal lengths are also available with a typical range of 25–50°.

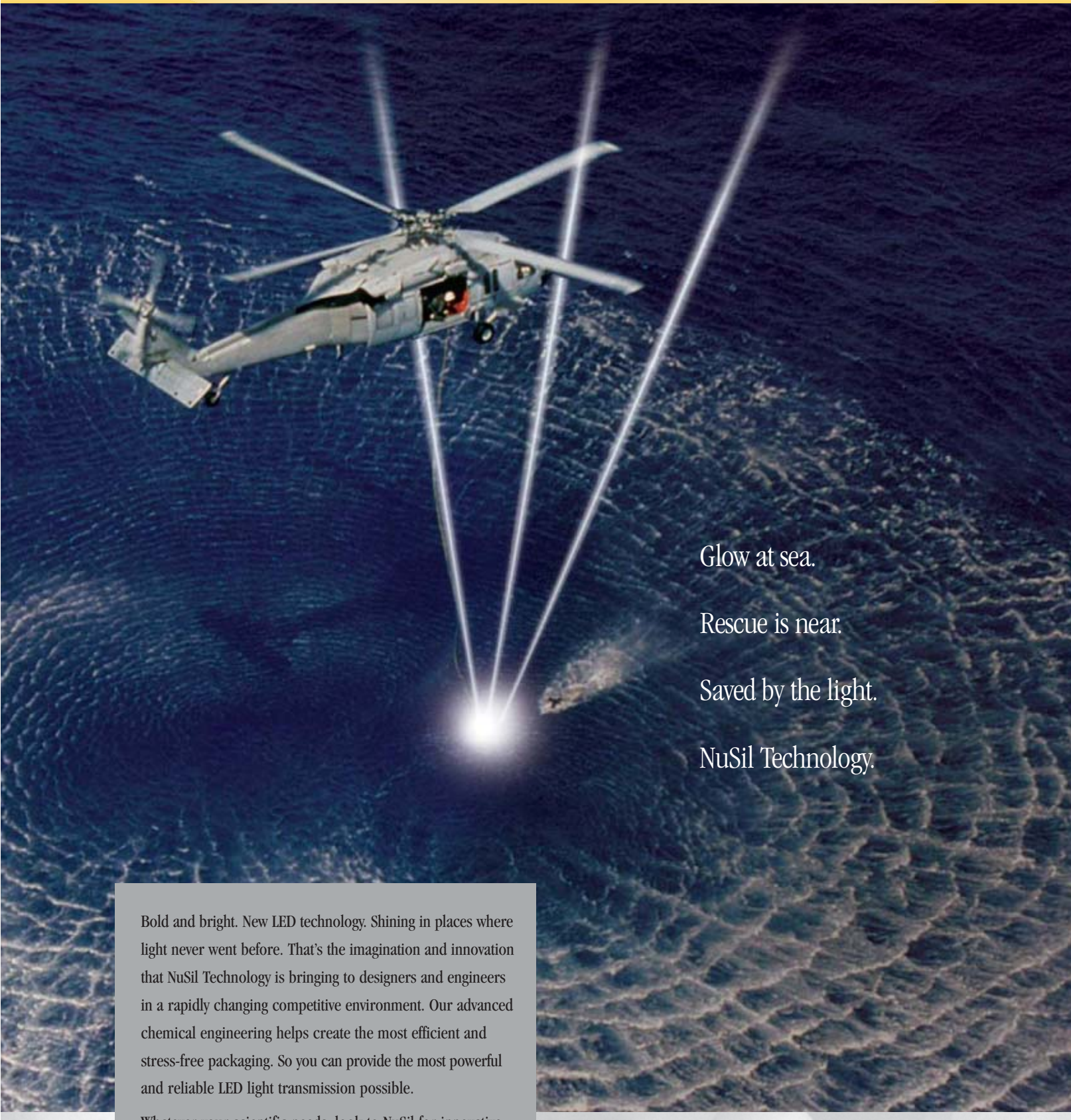
The single point light source is the key ingredient in the optical design of the Leko because this enables shadow projections and sharp-edged beams.

Color and dimmers

Color on most theatre fixtures is achieved through the use of polyester color filters in a metal frame that goes in a slot at the end of the fixture. The color filters, known as gel for their original gelatin composition, are sold in large sheets and cut down to the appropriate size for the fixture. The life of gel depends on the color saturation and the type of fixture, but it does fade over time. There are hundreds of gel colors available. Gel is designed to work with the full spectrum tungsten light sources to provide accurate, repeatable, and predictable color. Color is so important in theatre that there is special scenery paint designed to maximize the color saturation of vibrantly painted scenery lit by theatrical lights.

Theatrical dimming systems have

Fig. 2. The Chauvet Colorado wash fixture can mix red, green and blue (RGB), but does not have the gamut of colors such as pastels that are often needed for theatre.



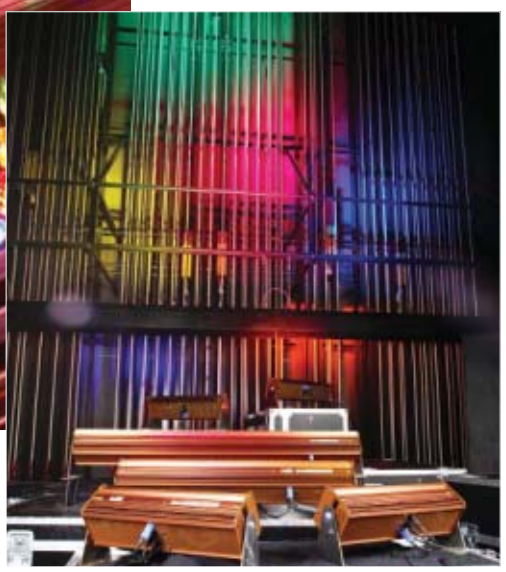
Bold and bright. New LED technology. Shining in places where light never went before. That's the imagination and innovation that NuSil Technology is bringing to designers and engineers in a rapidly changing competitive environment. Our advanced chemical engineering helps create the most efficient and stress-free packaging. So you can provide the most powerful and reliable LED light transmission possible.

Whatever your scientific needs, look to NuSil for innovative solutions. From LEDs to fiber optics, large batches to small, our Lightspan brand of products delivers precise, custom formulations and the most complete line of high-refractive index-matching adhesives, encapsulants and thermosets available. All backed by more than 25 years of engineering expertise. Follow the light to NuSil.

What? When? Where? If it's NuSil, it's no problem.

NuSil SILICONE TECHNOLOGY

What's your challenge?
www.nusil.com
Europe +33 (0)4 92 96 93 31
USA +1-805-684-8780



Figs. 3 & 4. The Selador X7 LED fixture uses a seven-color system to achieve a wide spectrum of colors that include the pastel range.

improved since their introduction. They have progressed from manually-operated lever panels to remote-controlled modular racks with IP addresses and self diagnostics. They have changed from expensive investments to really expensive infrastructure assets requiring special ventilation and wiring. A typical theatre has racks containing hundreds of dimmers that are rated between 1200–2400W at 120–240V. Theatrical lighting control systems are highly advanced. The United States Institute for Theatre Technology has worked hard to standardize the theatre industry's control protocols and plan for the future. Low voltage analog control has disappeared, while a typical lighting control system consists of Category 5 cabling, network ports and hubs, and the ability to control thousands of fixtures. Lighting controllers have also been outfitted with the latest technology such as wireless operation, touch screens, and USB ports for file saving. It is apparent that the lighting control, dimming, and distribution systems have developed much more than the fixtures themselves.

Maintenance and heat generation

The difficulties of working with theatrical lighting fixtures begin with their typical location. The lights are usually clamped to pipes that are suspended over the stage or catwalks over the audience. Once scenery is in place, it often becomes much more difficult to access the lights. On Broadway, a show can sometimes run for years. The fixtures need to be accessible for maintenance such as lamp and gel changes. The relatively short lamp life of theatre fixtures (300–1200 hrs typical) makes an LED alternative very attractive. The expense of color gel and the labor associated with changing it and managing it also make a color-changing LED fixture attractive. Convenient color changes would also give lighting designers the freedom to quickly experiment with different colors.

The lower operating temp of LEDs would make working with theatre lighting fixtures much more comfortable. One of the biggest complaints about the fixtures is the heat they generate, which is enough to cause burns and, in some cases, ignite fabric curtains. The problem of fixture surface temperature is compounded by the fact that the fixtures must be focused while they are running at full brightness and manually adjusted, sometimes while perched on top of a ladder. However, in an LED fixture, because the LED has a higher luminous efficacy, the same amount of luminous output would generate less heat.

LEDs for the theater

There have been a handful of LED fixtures developed for stage lighting, but none have the beam control that theatrical fixtures such as the Leko and the Fresnel have. There are several wash fixtures such as the Chauvet Colorado (Fig. 2) and the Elation Opti RGB that can mix red, green, and blue (RGB) but do not have the gamut of colors such as pastels that are often needed for theatre. Other than on-board dimming, the Chauvet and the Elation have few beam adjustment options. They were designed for concert and night club lighting, where precise and adjustable beam control are not as important as quick color changes and low cost. Altman has a similar fixture line called Spectra PAR with different lenses available for different beam spreads.

The only fixture currently on the market that comes close to being appropriate for theatre is the Selador X7 (Figs. 3 and 4). Selador uses a seven-color system to achieve a wide spectrum of colors that include the pastel range. They also have a variety of diffusers and secondary lenses that give lighting designers many beam-shape options. The diffusers are not as convenient as the adjustability of a Fresnel and far from the precise beam control of a Leko. The Selador X7 has a form factor similar to a strip light, a fixture designed to light up a backdrop. According to Robert Gerlach, president of Selador, the X7 was designed to maximize the current level of brightness that LEDs could deliver. The extruded aluminum body and modular electronics make it easier to manufacture different sizes of fixtures without retooling. The aluminum body has fins that act as a heat sink to keep the LEDs cool.

Altman recently unveiled a similar fixture called the Spectra Cyc. Cyc is short for cyclorama, a theatrical term for a large plain white backdrop that can be lit with different colors for different moods and settings on stage. The Spectra Cyc has an array of red, blue, green, and amber LEDs that bounce off of a reflector, helping to mix the colors together and homogenize the beam before it reaches the cyc. According to John Ryan, director of R&D for Altman, the reflector method works better at mixing the colors together than using what he calls "eyeballs" or individual optics for each LED.

Color mixing

The challenges of color mixing with LEDs are the same for theatre

as they are for architecture. The multiple color shadows or fringing, as it is sometimes called, are more apparent on 3-D objects than they are on 2-D surfaces. Since scenery typically consists of 2-D and 3-D surfaces, a LED fixture would have to have a smooth homogenous beam of light at any color.

There are novel approaches to color mixing including those patented by Osram and Bookham Optical Solutions (www.ledsmagazine.com/news/5/1/16), but they have not found their way into stage lighting applications yet. Also, there are promising new technologies such as the multi-watt array that could benefit stage lighting. Putting hundreds of small red, blue, green, and amber LED chips onto a single surface would make smooth color mixes because the different colors are so close together.

Replacing current fixtures

The ideal LED-powered theatrical lighting fixture would not just save energy; it would save labor costs in several ways. Lamp life could be extended far beyond the hour rating of a standard theatre fixture, saving lamp replacement labor and the associated troubleshooting time. If an LED fixture had a color-mixing method that could achieve the color range of gel, there would be no need for the labor expense of color changes. The heat generated by dozens of lighting fixtures would not compete as strenuously with the air conditioning, therefore saving energy costs. Another cost-saving benefit of LED fixtures is the elimination of conventional dimmers. LED fixtures could have efficient on-board dimming that only requires line voltage and a control signal.

It would be difficult to design a Leko illuminated by LEDs. The optical properties of current Lekos are based on a single point light source. Because an array of LEDs would be a planar source, a Leko with LEDs as the source of light would require a total optical overhaul. Multiple optics or a special optic that has multiple focal lengths may be necessary to collimate the light into one beam. An approach utilizing optical light pipes such as the one from Sypro Optics used for projectors may be found useful in a theatrical lighting application.

Both Selador and Altman are working on an LED stage light. Altman's Ryan says that the company has a few tricks up its sleeve, but would not reveal the method with which it is combining light output of multiple sources into one beam. Selador's Gerlach says he is currently evaluating different methods of beam collimation and color mixing as well. Both companies agree that the Fresnel would be an easier candidate for a LED overhaul. Currently, the typical Fresnel has a stationary lens and a lamp and reflector assembly that slides to adjust the beam spread. It would be easier, in theory, to mimic the softness of a Fresnel with an LED array and then add a lens or diffuser for beam adjustability.

It is apparent that the benefits of LEDs go far beyond energy savings, potentially making both designers and technicians happy with a fixture of the future, a fixture that could be brighter, cooler, lighter, and faster to set up. No one in the theatre lighting industry knows the fate of its main character, the incandescent light source, but they are looking forward to Act Two.

Further reading

A Brief Outline of the History of Stage Lighting. www.northern.edu/wild/LiteDes/ldhist.htm

LEDs to Light the Theatre by Robert Gerlach. Published in Theatre Design and Technology (TD&T), Vol. 39, No. 4, Fall 2003, pp. 11-22.

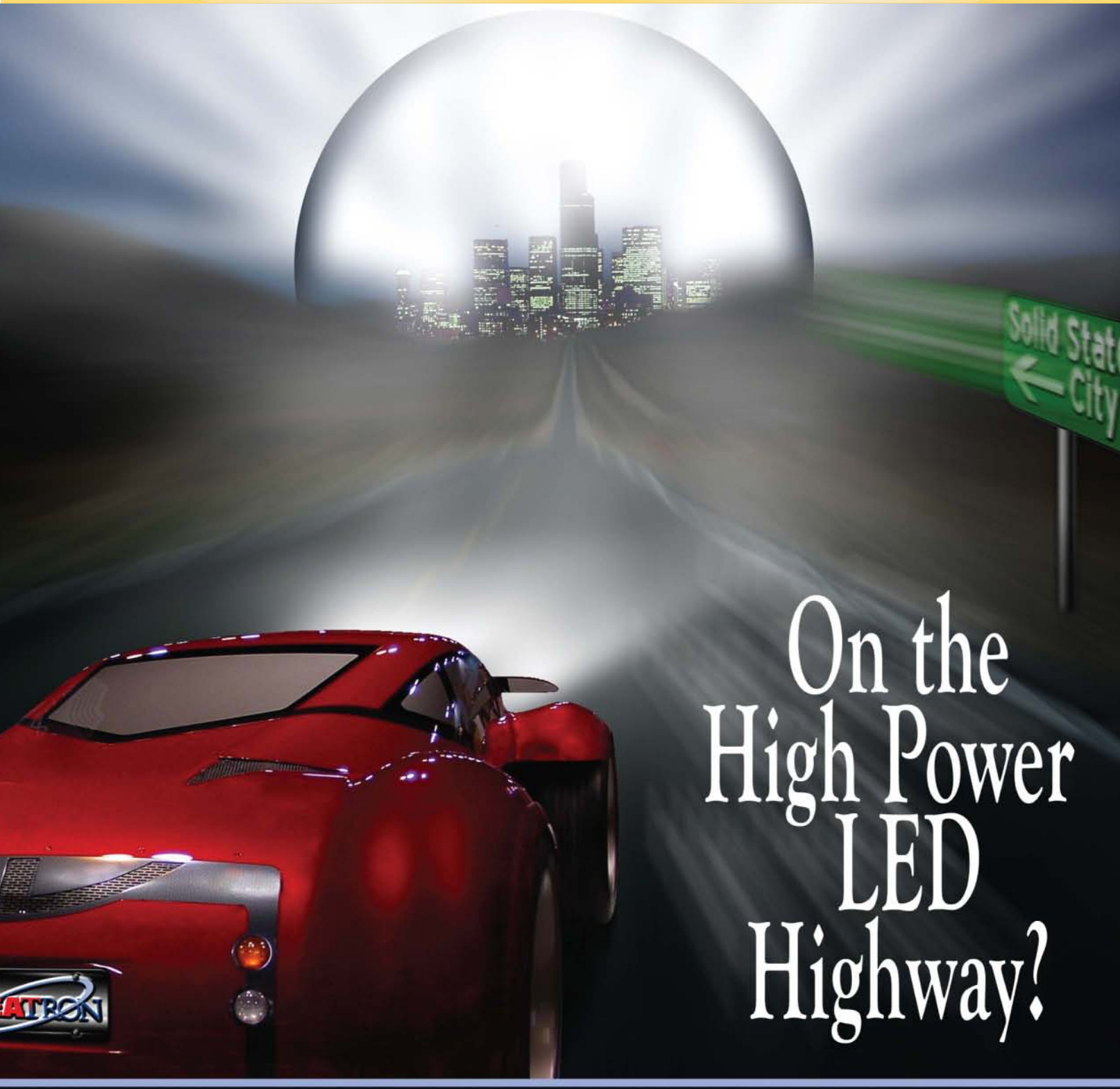
Practical DMX by Nick Mobsby, 2005 Entertainment Technology Press Ltd.

Links

Altman Stage Lighting: www.altmanltg.com
Electronic Theatre Controls: www.etcconnect.com
Selador: www.selador.net
Chauvet: www.chauvetlighting.com
Elation: www.elationlighting.com

About the author

Noah Davis (Noah_Davis@uncg.edu) is the sound and lighting shop supervisor for the Theatre Department at the U. of North Carolina, Greensboro (www.uncg.edu/the/). He received his BFA in technical theatre production from UNCG in 1995. For six years, Davis was the lighting designer for Alison Krauss and Union Station.



YES...

www.HEATRON.com/LED

+1-913-946-1377

Heatron is the quickest, most efficient and cost-effective vehicle on the road to new High Power LED product development.

- Wide range of design and development services
- Technology competencies including optics, thermal management, power sources and drivers
- Cost effective production and assembly capabilities
- In-depth industry and technology expertise

Don't make a wrong turn along the way... Let **Heatron** put you in the driver's seat to **"Solid State Lighting City".**

HEATRON

ACCELERATING THE HIGH POWER LED REVOLUTION

LIGHTFAIR INTERNATIONAL

Come visit us at
Booth #
2273
May 28-30, 2008
Las Vegas, NV

CREE LED Light | LUMILEDS | OSRAM | THE BERGQUIST COMPANY

An alternate way of driving LEDs

Several lighting manufacturers have recently incorporated AC-driven LEDs into their lighting fixtures. **Tim Whitaker** looks at this emerging technology.

Most LEDs are designed to be driven by a DC current, and LED systems are built accordingly. However, with the correct design at the device or circuit level, it is also possible to drive certain LEDs with an alternating current. One obvious advantage of this approach is the elimination of the otherwise essential AC-DC converter, which converts line (AC) voltage down to low (DC) voltage. (Note that LED replacement lamps, although plugged directly into an AC light socket, usually contain converter circuitry within the lamp so that the LEDs themselves are driven by a DC current.)

AC-driven LEDs have been available for more than a year, and lighting manufacturers are now starting to take advantage. Nexxus Lighting recently introduced what it claims is the industry's first LED floodlight for general illumination that operates directly from line voltage (i.e. 120V AC), without the need for an internal or external power supply. The SAVI™ SHO White floodlight is intended for interior and exterior applications, and contains a total of 17 Seoul Semiconductor 4-watt Acriche LEDs.

According to Nexxus, the elimination of power supplies is an important factor: these normally add cost, can have a shorter life than the LEDs and can potentially be a weak link in the system. Nexxus built the new floodlight using an existing housing for one of its other products; the AC-driven version looks the same but weighs less due to the absence of the power supply. The spec sheet shows that the floodlight has a color temperature of 5600K and operates at 68W (4W per emitter) with a total lumen output of 1394lm (equivalent to 20.5lm/W). The company says it has patents pending on the technology, and plans to launch additional direct 120V products for the commercial lighting market in 2008.

Trac 12 LED linear lighting module

Another lighting fixture using AC LEDs is the Trac 12 LED linear lighting system from Juno Lighting Group. The Juno LED modules are available in 3000K and 5000K color temperatures and operate from a 12V AC supply. Juno told LEDs Magazine that the purpose of using AC LEDs is that Juno's existing Trac 12 Lighting System is powered by 12VAC. "We wanted to use the identical infrastructure to run LEDs," said a Juno spokesperson. "Juno customers can easily convert from xenon to LED by swapping out modules."

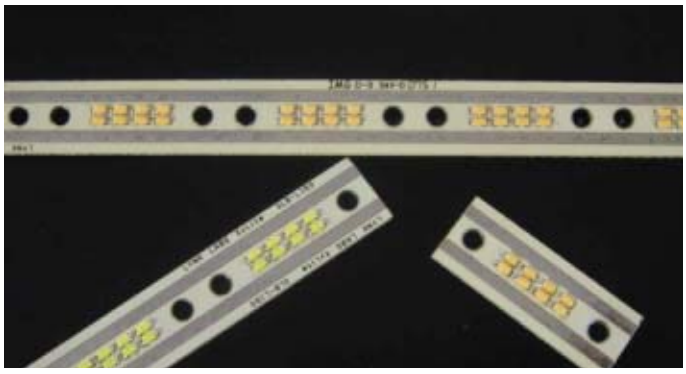
Lucifer works with Lynk

Another lighting manufacturer working with AC LEDs is Lucifer Lighting, which has incorporated devices from Lynk Labs into its PukLED under-cabinet light released in late March. The company is also using XyLite LEDs from Lynk in several products under development. The 3-watt PukLED contains 3 LEDs and has an output exceeding the company's 10W halogen Puklight. Running at 12V AC, the fixture accepts a Class II 60W electronic or magnetic transformer with the ability to power up to 18 PukLEDs.

Patrick Ward, Lucifer's VP of Research & Development, says that AC LED technology provides some major advantages relating to infrastructure. "In general, the lower component count and reduced complexity are desirable features of AC LED technology," he says. "With conventional LED fixtures, the end user routinely has to place multiple constant-current DC power supplies."

Dimming is a consistent feature in the high-end applications served by Lucifer. "With DC LEDs, dimming is problematic, requiring additional dimming modules that are not always compatible with the LED drivers," says Ward. "In contrast, AC-driven LED fixtures are compatible with more-conventional dimmers, and many fixtures can be run from the same (AC) power supply."

Lucifer's fixtures run from a 12 or 24V AC supply, allowing retrofitting in certain applications. "This also means we can maintain Class II [low voltage] safety certification, and use simpler wiring compared with line voltage applications," says Ward. A 12V or 24V system requires a step-down transformer, and this has to be sourced



Multiple 8-chip hybrid AC XyLite modules from Lynk Labs.

PukLED recessed under-cabinet light from Lucifer Lighting.

carefully to make sure it is compatible with the LED light engine.

Advantages of LEDs

In general, says Ward, Lucifer believes that LEDs have tremendous potential in lighting. "Lucifer was in at the ground floor," he says. "We've been working for several years to identify the best applications. New systems such as Lynk Labs' XyLite offer new opportunities to exploit the benefits of LEDs."

Ward says that the lighting industry is at an important juncture where designers and specifiers need to reconsider conventional lighting technologies and explore new possibilities. "The biggest issue is that lamp-configured LEDs are not the ones that function best for our applications," he says. "Application-specific LEDs are good for the fixture they're installed in, but don't open up the technology to consumers. The industry needs quality products to help build comfort levels. We also need to make installation less painful, reduce component counts and make systems more reliable."

AC LED technology

The AC-driven emitters supplied by Seoul Semiconductor and Lynk Labs are designed to use AC at the device and circuit levels, respectively. Acriche chips from Seoul comprise two parallel strings of emitters, so that different sections of the chip are illuminated during the opposite phases of the AC flow. Lynk Labs uses conventional chips supplied by Citizen, Cree, Intematix and others, and designs multichip circuits or light engines for a given AC voltage that can operate efficiently when AC is applied.

Lynk Labs' XyLite modules are driven by the company's newly patented "Hybrid AC LED" technology at the circuit and light engine design level. The XyLite modules contain 8 LED chips per circuit and are designed to operate in a notional 12V AC environment, explains Lynk Labs' Bob Kottritsch. In a "classical" AC LED circuit configuration, the 8 LEDs would be connected in an anti-parallel configuration so that 4 different LEDs were illuminated during each half of the AC cycle. "In our hybrid AC design, some of the LEDs are illuminated all the time," explains Kottritsch. "This helps to reduce the flicker that might be observed at 50 or 60 Hz." The hybrid design also improves the lumen-per-die figure for the module, and ensures that the circuit is optimized for the 12V AC environment.

The XyLite modules are designed to be used as building blocks in the X and Y directions. Lynk says these "enable luminaire and OEM manufacturers to significantly accelerate and simplify their product design strategy for almost any LED lighting application." XyLite uses very small die, which can be placed very close together and arranged into different form factors. The standard 4x2 module measures 15mm wide by 13.5mm long, and consumes only 1.1 W.

AC LEDs are not quite at the leading edge of performance, but are not far off. Seoul introduced in February a 4-watt Acriche with 80 lm/W efficiency, and expects to introduce a 100 /m/W model by the end of this year. Kottritsch acknowledges that "As individual light engines, the XyLite modules do not have the highest efficacy, compared for example to some of the best DC-driven LEDs. However, in terms of overall system (wall-plug) efficacy, they perform very well, one reason being the absence of an LED driver." Typical values are for XyLite are more than 40 lm/W for warm-white (3000K) and 65 lm/W for 5000K at the system level.

webcast

PennWell

LEDs MAGAZINE™

Upcoming Event

Essentials for Designing LED Luminaires

APRIL 29, @ 11:00 AM (EDT)

Speaker: Scott Riesebosch, President, CRS Electronics

LED light sources offer numerous potential advantages for illumination applications. However, without proper consideration of the many crucial factors affecting the long-term performance of LED luminaires in lighting applications, the design effort can be wasted. This webcast explores the essential considerations and requirements when designing LED-based luminaires, so that the end product can match customers' expectations for solid-state lighting technology.

Sponsored by:

LED Light for you
powered by OSRAM

ROHM

FUTURE EVENTS

Market Trends & Emerging Applications in the LED Industry

Thermal Design for Enhanced LED System Performance

VIEW ALL ARCHIVED EVENTS after date of play at:

www.ledsmagazine.com/webcasts

LED-illuminated gas station sees higher traffic and reduced costs

The Better Day BP gas station and convenience store in Racine, Wisconsin, is the first to feature all-exterior LED lighting, writes **Kevin Orth.**

The Better Day BP gas station in Racine, Wisconsin, has installed a total of 56 LED-based exterior lighting fixtures from Beta LED, each featuring a different number of multi-LED bars according to the desired lighting level. There are 24 fixtures (six bars each) under the canopy, and 18 four-bar wall-pack fixtures around the building. Also, there are eight 6-bar wall-packs inside and outside the carwash, three 2-bar wall-packs under each awning, and finally three 8-bar area lights, one on each pole at the entrance to the facility.

Most of us are consumers of gasoline, whether we drive an automobile or use mass transit. We are also a society insisting on convenience – fast food, quick service and easy access. These two demands have been leading the charge for the approximately 164,300 stand-alone gas stations in the United States and 115,000 combination convenience store (c-store) and gas stations.

While demand is high, regardless of pump or shelf prices, profit margins are extremely tight in these industries, requiring c-store and petroleum operators to be astute. Owners need to realize customers are often drawn to their properties because of perceptions of cleanliness, safety and a friendly atmosphere. Given how important the company's corporate identity and curbside look is to generating business, lighting choices should be carefully evaluated.

Previously thought about primarily for aesthetic purposes, lighting can have a tremendous impact on the bottom line. In an industry such as gasoline and c-store retailing, where competition is fierce and profit margins are increasingly shrinking, cost containment is vital to profitability. Advances in technology and engineering are now making it possible to use high-efficiency LED lighting for commercial applications. This new light source provides a way to reduce energy costs while still meeting properties' lighting needs.

LEDs enhance customer perceptions

Tom Tousis, owner of Better Day BP in Racine, Wisconsin, recently faced these construction decisions. When choosing exterior lighting for his new property, Tousis consulted with LED manufacturers and was impressed with the products available for his application. Although a reduction in energy costs was important to Tousis, he knew that customers' perceptions of the facility were a primary factor for increasing both traffic and revenue.

"One of the biggest problems faced by owners is how to maintain light levels and make the facility feel inviting without wasting tons of energy," Tousis said. He also noted that in addition to the tremendous energy savings, the use of LED lighting gives the station a brighter, more modern look compared to traditional high intensity discharge (HID) sources.

C-store owners are also becoming aware of the impact of the store's appearance in the minds of the customer. Many elements can make up the aesthetic appeal of a store, but equally as critical to the building materials and signage are the store's outdoor lighting elements.

High performance LED sources

The LED industry has reached breakthroughs that allow LED lumi-

Wall-mounted LED fixtures (four LED bars each) around the building at the Better Day BP.

LED lighting at the gas station is bright, uniform and welcoming, generating high traffic levels for the facility.

naires to compete with HID light sources. The viability for use of LED technology for any general lighting application begins with the performance quality of the LED source.

The two most important characteristics are luminous efficacy and color quality. Efficacies of super-bright white LEDs have increased dramatically over the last few years to a point approaching that of fluorescent sources. Today, the most efficient super-bright white LEDs have correlated color temperatures (CCT) in the 6,000K range. This high color temperature range is appropriate for roadway and general outdoor lighting applications, including parking lots, canopies and wall lights.

One of the most exciting possibilities associated with LED technology lies in the area of optical control. The source emission characteristics of LEDs are comparatively superior to the incumbent high-efficacy white light sources, based on the opportunity for precise optical control. Bare-source photometric distributions of metal halide and fluorescent lamps, although not uniformly distributed, are largely omni-directional (i.e. contained in a sphere). These source emission characteristics present challenges for optical control that reduce performance for most applications. The lack of optical control severely wastes light, particularly rampant in the U.S. where it is estimated that 30 percent of outdoor lighting is projected skyward.

Better Day BP builds sustainable future

The long life and reliability of LED light sources diminish maintenance costs and help increase profits through reduced labor and re-lamping expenses. Better Day BP is the first-ever gas station and convenience store to feature all-exterior LED lighting. Tousis has plans to be all-LED, inside and out, by spring 2008. With the canopy LED lighting alone, Tousis is saving approximately 62 percent on energy, compared with the 320W metal halide fixtures that would have been used instead.

Although Better Day BP is an independent petroleum station, the initiatives undertaken by Tousis align closely with BP's international green approach. For instance, BP has enacted a strong commitment to reduce carbon output throughout its supply chain. Through a $350 million investment, BP aims to reduce CO_2 emissions by 1 million tons per year over the next five years. On a smaller scale, using LED luminaires, Tousis will reduce his carbon emissions by approximately 30 percent and eliminate disposal of mercury found in conventional lighting sources.

According to the U.S. Department of Energy, the LED lighting technology is changing at a rapid pace. The overall efficiency performance of LED luminaires is advancing at a rate of approximately 35 percent annually, while costs are decreasing at a rate of 20 percent. LED sources have the potential to replace all existing sources used in general lighting applications today.

The changing face of retail

More and more "big-box" retailers are venturing into the petroleum and c-store market to provide customers with one-stop shopping. For example, by 2010 Home Depot (a large chain of hardware stores) plans to operate convenience stores in as many as 300 of its home centers, occupying underused portions of their parking lots. Many supermarket chains such as Albertsons, Brookshire, Kroger and Safeway are also incorporating gas pumps and c-stores into their parking lots. This provides an excellent opportunity to limit each store's carbon footprint, reduce energy costs and improve each store's perception with consumers by illuminating the parking lots with LED area lights, gas stations with LED canopy luminaires and LED wall packs on the c-stores.

LEDs solve myriad problems

With the inevitable conglomeration of gas stations, c-stores and retail outlets, efficient use of building space and land will be paramount, and the use of sustainable building materials will become increasingly important. LEDs will be able to provide the new era of stores with bright, white light that promotes a sense of welcoming and safety to consumers, while reducing energy and maintenance costs for building owners.

Tousis may be the first gas station owner to build an all-LED station, but he certainly will not be the last. As a forward-thinking entrepreneur, he has recognized the potential impact sustainable building materials can have on small businesses, specifically in the c-store and gas station industry. As more business owners jump on the bandwagon, competition will increase and push LED manufactures to continually improve the quality and sustainability of their products.

About the author

Kevin Orth is National Sales Manager for Beta LED, a manufacturing company specializing in innovative, energy-saving, high performance LED lighting products for outdoor commercial applications. Kevin may be reached at Kevin_orth@beta-kramer.com or 800-236-6800 x 3132.

Toronto leads with LEDiscovery

A group of organizations gathered at this event to discuss the future of energy-efficient LED lighting, writes **Brian Owen,** our Canadian Columnist.

As LED lighting continues to be used for outdoor public spaces, there is great value in bringing together the organizations that have already participated in such lighting programs. This was one of the aims of the LEDiscovery event, held March 25-26 in Toronto, Canada. Hosted by greenTbiz of the Toronto Association of Business Improvement Areas (TABIA) and the Toronto Atmospheric Fund (TAF), the event was a resounding success. In total, 23 manufacturers and agents of LED and adaptive lighting control technology products met over two days with close to 200 potential buyers and specifiers from the private and public sectors.

Billed as "LEDiscovery … The Future Vision of Lighting for Public Spaces — Using LED and Lighting Controls to Reduce Energy," the event was held during the week leading up to Earth Hour. Organized by the World Wildlife Fund (WWF), this event required a commitment to turn off lighting for one hour in participating cities throughout the world. Although Earth Hour was the largest controlled lighting blackout since the Edison invention itself, new technology will hopefully prevent the real thing from occurring, even under the strain of ever-increasing electricity demand. Although the best kilowatt-hour is one not used, the alternative is to explore new technologies that will drastically reduce electricity consumption. Accounting for 20% of global electricity consumption, lighting is definitely at the forefront for change, which can be achieved using LEDs and lighting control technology. Earth Hour's goal may have been "turn off the lights," but LEDiscovery's aim was "turn on the LEDs".

Front L to R: Mike Bergren, City of Ann Arbor; Daniel Howe, City of Raleigh; Chantal Brundage, greenTbiz; Andre Brix, City of Ann Arbor; Mary Pickering, Toronto Atmospheric Fund; and Michael Cavallo, Clinton Climate Initiative (CCI.) Back L to R: David Alexander, City of Welland; Peter Strasser, International Dark-Sky Association; Brian Owen, greenTbiz & LED City Toronto; and Cailey Gibson, CCI. Photo courtesy of Ben Marans.

LEDiscovery program

The first day of LEDiscovery was open to attendees from the private sector — including architects, building and business owners, commercial developers, interior designers, property managers and specifiers — who were able to view the exhibits and speak directly with representatives regarding proposed applications and questions about the technologies. Largely being a public awareness and education forum, the event included "State of the Solid State" presentations to inform attendees about technology progress and developments, as well as what to look for and what to "look out" for. One of the key and recurring items of discussion centered on regulations and standards, such as the Energy Star criteria for SSL.

The second day was by invitation and reserved for attendees from the public sector representing various agencies, boards and commissions of municipalities, as well as academic, social development, and healthcare institutions from the City of Toronto and surrounding municipalities, and also provincial government agencies. Thirteen municipalities and 30 agencies or sector organizations were represented. Manufacturers and agents were again invited to display products and make presentations to this audience in a plenary session. Attendees were then able to select manufacturers with whom they wished to have further discussion. Both manufacturers and attendees commented positively about the quality of time invested at the event. It was also observed that manufacturers were communicating with each other and quite possibly developing strategic alliances and partnerships.

LED City Summit

During LEDiscovery, greenTbiz and TABIA, who facilitate the LED City Toronto initiative, hosted the first LED City Summit sponsored by Cree. Dan Howe, Assistant City Manager of Raleigh, discussed the development of LED City and the need to understand financing to overcome first costs. Mike Bergren and Andrew Brix of Ann Arbor, Michigan, US, described their city's moratorium on public lighting, aimed at helping to keep escalating lighting operation and maintenance costs under control. While attention has shifted to LEDs, Ann Arbor has developed a "Lighting Bank Policy," where developers pay into a fund, buying credits, similar to emissions trading. This is reinvested in retrofitting existing public lighting with more efficient lighting technology, such as LEDs.

Dave Ferguson reviewed Welland, Ontario's current LED project and reported that after public consultation and surveying conducted by greenTbiz, 73% of the public were in favour of proceeding with LED street lighting. He also noted that Welland would be including LED lighting in a downtown redevelopment plan as well as in new sub-divisions through developer participation.

Michael Cavallo, Domain Director for Lighting for the Clinton Climate Initiative (CCI) described the role of the CCI and the devel-

opment of municipal purchasing initiatives with manufacturers. Peter Strasser of the International Dark-Sky Association (IDA) reminded everyone of the importance of considering light pollution and light trespass issues and was very positive with respect to LED in outdoor lighting as the technology allowed for 'dark-sky friendly' luminaire development.

LightSavers

LEDiscovery also saw the launch of LightSavers, a program developed by the Toronto Atmospheric Fund that will explore, foster, and pilot the use of efficient LED lighting and lighting controls in public spaces in order to reduce electricity consumption and greenhouse gas (GHG) emissions. Future plans of the LightSavers program include the development of a consortium of manufacturers and municipalities and their agencies to achieve these objectives. This consortium will work in partnership to test and accelerate market transformation for advanced outdoor lighting products that promise electricity reductions of 50% or more. Agencies and municipalities will be invited to participate in the development of technology pilots.

A LightSavers Symposium will be held in the Fall to bring agencies and municipalities together to discuss LED and adaptive lighting pilots that are being undertaken locally, regionally and internationally. Presenters will discuss technology, and review potential business case scenarios and innovative financing opportunities. Contact the author for further details and updates.

Manufacturers

While the focus of LEDiscovery and LightSavers is primarily LED lighting for outdoor public spaces, manufacturers displayed both indoor and outdoor products. Architects, interior designers, and property managers were able to see the LED MR16 developed by CRS Electronics of Welland, Ontario for the Palace Pier Condominium project in Toronto, the first building in North America using LEDs as its primary lighting sources in the corridors.

GO Lighting exhibited its controllable flat panel LED lighting, a great example of combining LED and intelligent lighting controls. The units can be adjusted for both brightness and color temperature. Inforesight, representing Lumecon, displayed the Relume product employed in the Welland street light installation. Electromega showed both the Leotek product installed at the Exhibition Place pilot and the Carmanah PV Solar LED luminaire installed in Phin Park (both locations in Toronto). One notable luminaire was the decorative street light from King Luminaire/Stresscrete of Burlington, Ontario. Code-named the K118R, the fixture is a decorative historical design based upon the King Luminaire Washington series. The fixture utilizes multiple arrays of LEDs to help achieve various IES distribution patterns and a unique baffle configuration to keep the up-light component below 14% as well as achieve a cut-off angle of 70 degrees to reduce glare.

About the author

Brian Owen is the Program Advisor to greenTbiz (www.greenTbiz.org), which facilitates the LED City Toronto initiative. He is actively involved in the development and operation of energy conservation programs for government, municipalities, and utilities. Email: Brian@greenTbiz.org

New constant power LED driver architecture reduces the cost for offline LED ballasts

In the fourth in a series of articles on ballasts, **Iain Mosely** describes how the constant power operation inherent in a peak-current-controlled discontinuous mode flyback converter can deliver good drive characteristics for LED applications.

For high brightness LED technology to succeed in replacing standard incandescent bulbs for high volume markets, the cost of the drive electronics required to power the LEDs must be kept to a minimum. This article, the fourth in a series discussing LED ballast design, presents a solution that exploits a novel constant power flyback converter architecture. This approach provides an ultra low cost 7W offline LED ballast that will run from 85–265Vac at 50/60Hz.

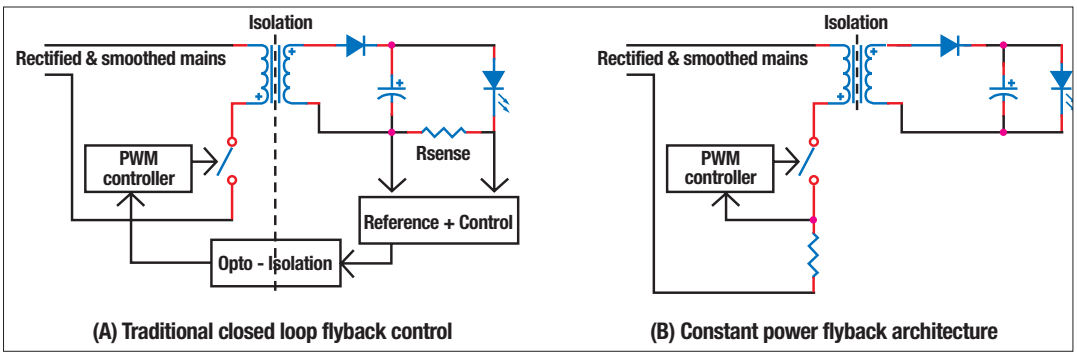


Fig. 1. Comparison of traditional a) current feedback and b) constant power flyback architectures.

Traditionally, a mains-derived, isolated, constant current ballast suitable for driving LEDs is achieved using a flyback converter operating under closed loop control (Fig. 1a). The actual LED current is measured using a sense resistor and is used to control the duty cycle of the primary side switching element. Although this gives excellent LED current regulation, the feedback circuitry requires an optocoupler, shunt reference, and sense resistor, all of which add cost and reduce overall efficiency.

The approach detailed in this article achieves very good LED current regulation by running the flyback power stage open-loop under peak-current-mode operation with the power stage running in discontinuous mode (DCM) operation (Fig. 1b). This technique results in a constant power being delivered to the LEDs, which translates into an almost constant LED current, irrespective of mains input voltage. With this approach, there is no need to sense the LED current directly or provide feedback to a primary-side controller device, which saves cost and increases efficiency.

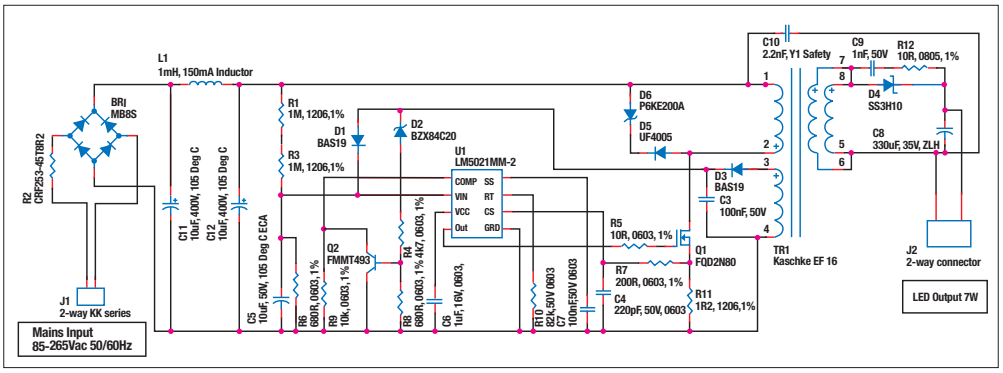


Fig. 2. A prototype unit designed to drive two series-connected Luxeon K2 LEDs used to verify the DCM constant power technique.

Theory of operation

If a flyback converter is run in DCM, the current in the transformer magnetizing inductance is allowed to fall to zero every switching cycle and a useful behavior can be exploited that is very applicable for LED loads. In DCM, the power (P_O) transferred through the converter can be approximated by the equation below.

Here, L_M is the transformer magnetizing inductance, $\hat{I}$ is the peak primary current and F_S is the flyback

DRIVERS

switching frequency. Equation 1 shows that, to a first order, the converter output power is not a function of mains input voltage if we run in DCM. Therefore, the values of L_M, $\hat{I}$, and F_S can be chosen at the design stage and result in a converter that delivers a constant output power characteristic even under variation in input mains voltage. Although an LED load requires constant current rather than constant power, most LEDs will drop a reasonably constant voltage during operation and therefore feeding them with constant power actually results in a near constant current mode operation.

$$P_O = \frac{1}{2} L_M \hat{I}^2 F_S$$

Application example

The performance that can be achieved using the DCM constant power technique was verified by construction of a prototype unit (Fig. 2) designed to drive two series-connected Luxeon K2 LEDs at 1A from an AC mains input voltage of 85–265Vac 50/60Hz.

At 1A forward current, the specified voltage drop of each K2 LED is about 3.5V, giving a total output power requirement of 7W. Choice of the power stage switching frequency and magnetizing inductance were based on ensuring that the power stage always runs in DCM with 7W output power over the full range of input voltages and that the transformer core was kept away from saturation.

The combination chosen for this example is to run with a switching frequency of 50kHz, a peak current of 0.42A and a magnetizing inductance of 1.7mH. This gives a total output power of 7.5W, which allows for the additional loss in the output rectifier, D4. Figure 3 gives the full schematic for the constant power ballast.

Tests on the prototype show that over the full range in input mains voltages, the LED current varies by only +/-9%, which is acceptable for many general lighting applications. The overall power conversion efficiency of this design, aided by removal of the secondary-side current sense resistor, peaks at 79% (Fig. 4).

Discussion

The prototype measurements show that the constant power approach can give an almost constant LED current over the full range of mains input voltages. With this open loop design approach, it is important to understand the tolerance on peak primary current, transformer magnetizing inductance, and device switching frequency since all of these parameters will influence the delivered output power level. Quantification of these parameters over temperature and production would allow the designer to assess whether this low cost approach is suitable for any particular application. In many cases, a small variation in LED current is often acceptable if the cost of the ballast can be reduced.

Conclusions

Running LEDs with constant power rather than constant current allows for a simplification of the drive circuitry required for offline ballast applications. The approach detailed in this article has shown that the constant power operation inherent in a peak current controlled DCM flyback converter can deliver good drive characteristics for LED applications.

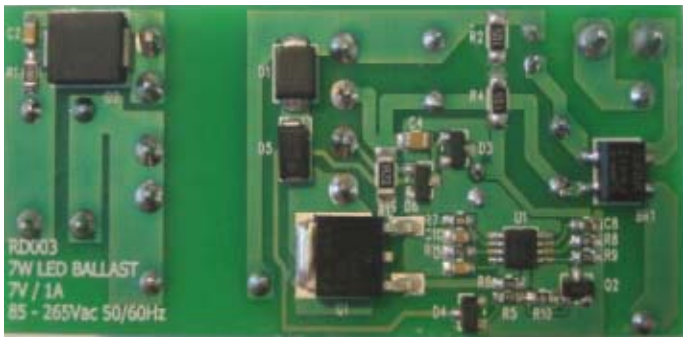


Fig. 3. The 7W offline LED constant power ballast.

Removal of the secondary-side current sense components and feedback circuitry reduces cost while simultaneously giving an increase in overall conversion efficiency. The approach used here is easily scalable in power capability through choice of the transformer magnetizing inductance, peak primary current, and switching frequency. Mains current harmonics can be reduced by using a front-end power factor correction circuit that could feed multiple converters simultaneously.

More detailed performance measurements including conducted EMI measurements taken on the 7W prototype can be found at www.convertertechnology.co.uk.

About the author

Iain Mosely (Iain.Mosely@Convertertechnology.co.uk) is technical director of Converter Technology (www.convertertechnology.co.uk), a power electronics design consultancy focused on providing class-leading solutions for many different areas of power conversion including AC/DC, DC/DC, LED lighting, and Power over Ethernet.

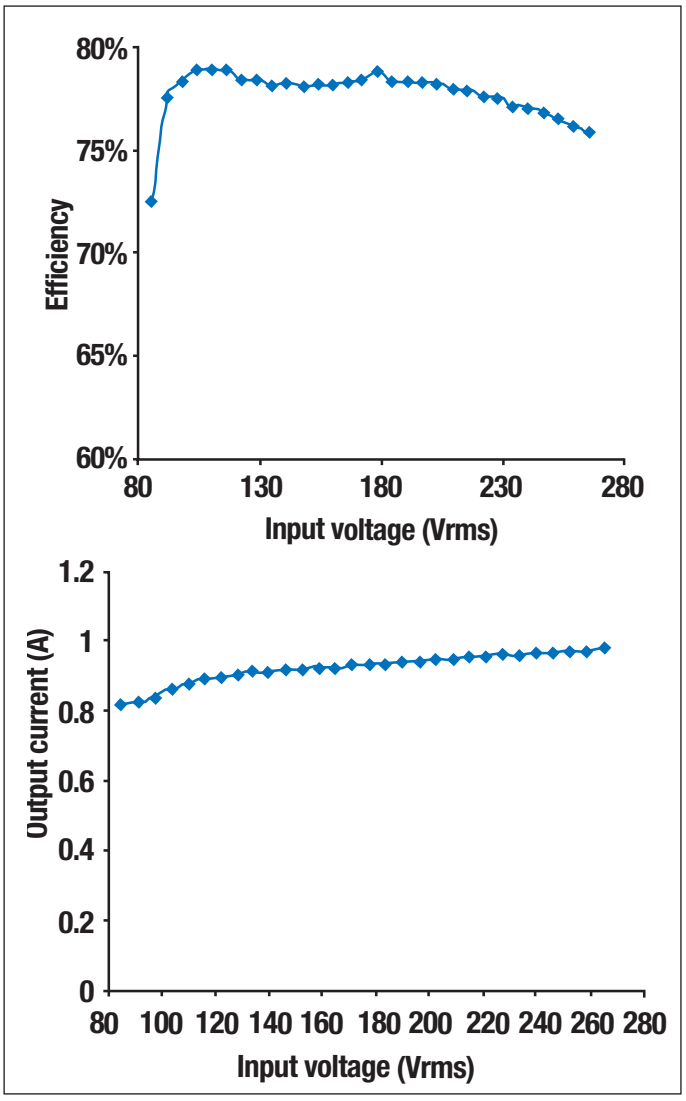


Fig. 4. 7W prototype efficiency and LED current measurements over line voltage variations.

Further reading

To read the entire series on power converters:

Part 1: Switched-mode power converters drive LEDs more efficiently, July/August 2007 p9
www.ledsmagazine.com/features/4/8/4

Part 2: Buck converter LED drive systems for automotive applications, Sept/Oct 2007 p 30
www.ledsmagazine.com/features/4/10/8

Part 3: Boost converter LED drive systems for emergency backup lighting, Nov/Dec 2007 p 34
www.ledsmagazine.com/features/4/12/12

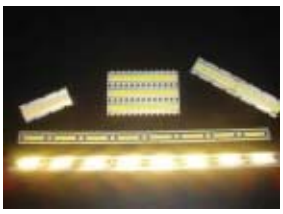
PRODUCT FOCUS

LEDs MAGAZINE

LYNK LABS INC.

XyLite™ AC LED Light Engines
Breakthrough - Simple LED Retrofit Product Design Solutions

- EFFICIENT
- SIMPLE
- NO BINNING
- NO DRIVERS



XyLite AC LED Light Engines
Plug n' Play Retrofit Solutions.

12VAC - 277 VAC Applications

LYNK LABS

Contact: Lynk Labs, Inc. Tel: 847 783 0123 Fax: 847 783 0130 Email: lynk@lynklabs.com

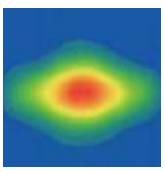
Bulb n' Ballast Solutions for LEDs

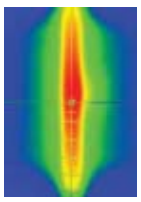
XyLite AC LED light engines accelerate and simplify LED product design and integration.

KHATOD

Always in the Front Line with Innovative Lensing Solutions

Khatod 's great attention to the Power LED Technology has led us to develop high technical products for superior lensing, qualified to meet and exceed the specific and ever changing requirements and demand of the market. Khatod presents its latest generation of lensing solutions, now on our website: Khatod.com





Tel: +39 02 66013 695
Fax: +39 02 66013 500
Email: khatod@khatod.com

FUSION OPTIX

Enabling LEDs with Advanced Diffusion Lenses

Based on our patented LightControl™ technology, Advanced Diffusion Lenses (ADL) offer a wide range of angles and diffusion properties. They homogenize light, change beam angle, lower LED count, and increase efficiency. ADLs are scratch resistant, do not stick or melt, and are easily integrated into any LED system. Our in-house rapid prototyping capabilities eliminate costly molded optics to quickly provide you with a lens of almost any shape, size, and light distribution.

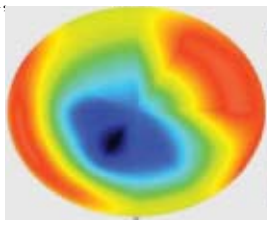
Tel: 617 649 1010
Fax: 617 649 1015
Email: sales@fusionoptix.com
Web: www.fusionoptix.com

KLA-TENCOR

P-16+ Surface Profiler

The P-16+ surface profiler provides complete, detailed two- and three-dimensional analysis of surface topography for a variety of surfaces including semiconductor wafers, C4 bumps, thin-film heads and disks, MEMS, opto- electronics, thin film/chemical coatings, biomedical devices and flat panel displays. With its intuitive menus, the P-16+ system provides measurement data such as step height, surface roughness, micro-waviness, and overall substrate form, with best in class vertical resolution, precision, and reliability.

KLA-Tencor



Contact: Brian Crawford
Tel: +1 408-875-3000
Email: brian.crawford@kla-tencor.com
Web: www.kla-tencor.com

CARMANAH TECHNOLOGIES CORP

At the Forefront Of Solar Innovation

carmanah® we put solar to work™

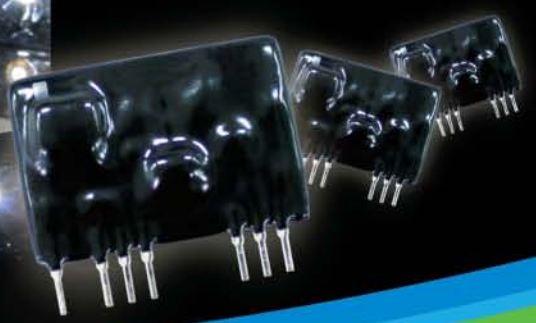
Carmanah solar area lighting combines industry-leading photovoltaic technology with advanced LED optics for an efficient and versatile lighting solution. By balancing light output with available energy resources, Carmanah solar area lighting provides consistent illumination all year long. Free from cables, wires and electrical grid access, Carmanah solar area lighting can illuminate even the most remote locations. Durable, reliable, sustainable: Carmanah solar technology is in a class all its own.

Worldwide: +1 250 380 0052
Toll-Free: 1 877 722 8877
Fax: 1 250 380 0062
Web: www.carmanahlighting.com

In North America, please contact Mary Donnelly at maryd@pennwell.com

Light it with ROHM

LEDs for Illumination



From LEDs to the drivers that power them, ROHM has the solution for next-generation illumination.

Our high brightness and low heat generating LED lighting modules incorporate unique reflector technology for superior directivity, color and brightness while our ultra-high resolution, full-color dot matrix modules and high-power, high color-rendering LEDs show objects in their true light.

For behind-the-scenes support, we offer a wide range of high-power LED drivers compatible with AC input that integrate a transformer to lighten the load and are popular in the theater, landscape, residential, commercial, and emergency sectors.

Pb Free ROHM Electronic Components | RoHS Directive Compliance | Excellence in Electronics ROHM

For catalog and product information: www.rohmelectronics.com | 1.888.775.ROHM