www.led-professional.com

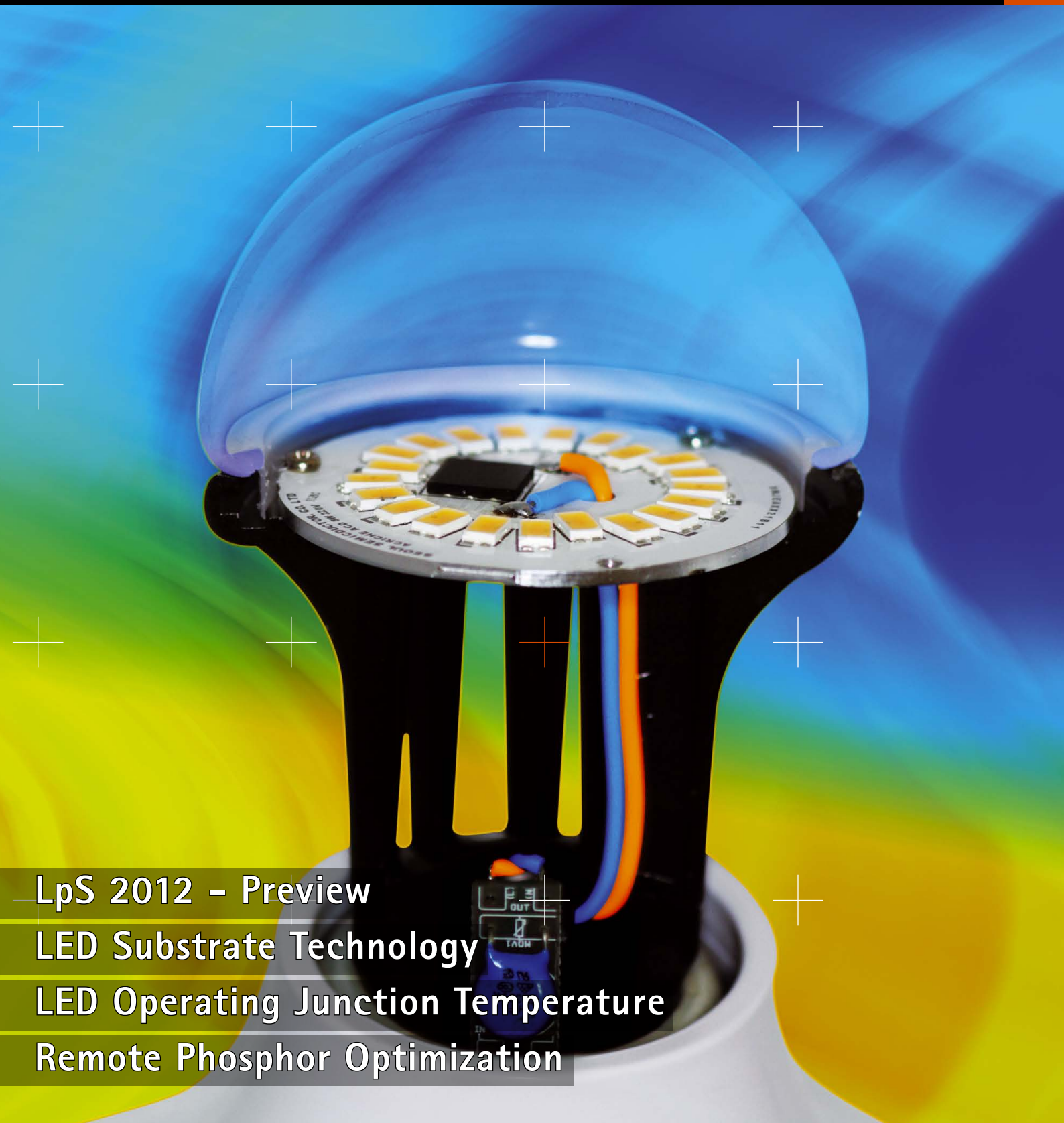
ISSN 1993-890X

# LED professional Review

LpR

*The leading worldwide authority for LED & OLED lighting technology information*

July/Aug 2012 | Issue 32



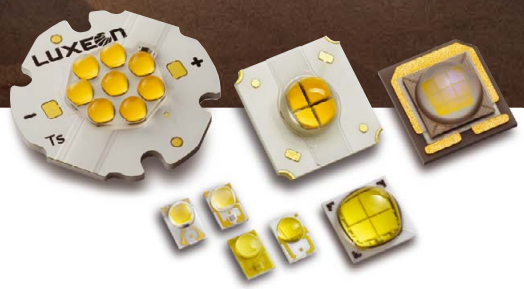
## LpS 2012 – Preview

## LED Substrate Technology

## LED Operating Junction Temperature

## Remote Phosphor Optimization


# Light that relaxes




Light by LUXEON is changing the way we light our world. The unparalleled quality of light, efficiency, and reliability enable better, more sustainable lighting solutions. LUXEON LEDs are environmentally friendly, lead-free and mercury-free, and offer the best lumen maintenance of any power LED. LUXEON LEDs are available in color temperatures and efficiency configurations that make them perfect for any of today's lighting applications.

Make the change to LUXEON and start relaxing.

**www.philipslumileds.com**

PHILIPS
LUMILEDS

PLL/LTR2-7/12

# Remote Phosphor Technology

Irradiated phosphor technologies started in the 19th century.

In 1896 Thomas A. Edison filed for U.S. Patent 865,367 for a lamp using X-rays to excite phosphor. 43 years later, General Electric offered the first commercial fluorescent lamps, using ultraviolet light in a vacuum tube to excite phosphor on glass and create visible light. 70 years later, Philips introduced the first remote phosphor LED module available on the market called Fortimo. And a few years later Intematix introduced their ChromaLit™ technology based on specific phosphor plates.

But what is a remote phosphor system by definition? Clearly it occurs when the phosphor and the LED chip are separated, which in turn causes the system behavior to be modified.

Depending on the application, the blue LED and remote phosphor approach provides a low glare system capable of up to 30% higher luminous efficacy (maximum improvement figures are: 5% light extraction, 10-15% thermal losses, 10% diffusor) in comparison to individual LEDs which require diffuse optics to properly distribute the light. A recent study showed that the effective quantum efficiency decreases with pump flux (about 0.1 %/W) but this value is negligible in comparison with the effect of an increasing phosphor temperature (about 0.03 %/K). The separation between the LED die and the phosphor prevents the phosphor from heating up, and is therefore crucial for increasing efficiency.

In addition, the mixing chamber is a main element of the remote phosphor light engine. Manufacturers such as CerFlex International, Furukawa, WhiteOptics, W.L. Gore & Associates, Light Beam or Genesis offer materials with reflectivity of up to 99.2%.

In general, the remote phosphor technology reduces the heat of the LED chip and of the phosphor. This increases the life span and improves the reliability and performance of a light engine. Remote phosphor type LEDs show high luminous efficiency and improved spatial color uniformity in comparison to proximate phosphor LEDs.

On the other hand, remote phosphor light engines are large optical light sources in relation to the individual LEDs and therefore show rigid form factors. The remote phosphor technologies have great potentials indeed, but they also need to be improved and are only applicable for well-defined, module-based applications.

You can read more about the design and optimization of remote phosphor light engines and a ray tracing software that determines the required phosphor parameters, in this issue of *LED-professional Review*.

Yours Sincerely,

Siegfried Luger
Publisher

PS: Don't forget: *LpS 2012*, 25-27 September, 2012

# Content



## Advertising Index

„More Light!“

J.W. Goethe, Philosopher

„We‘ll take care!“

Karsten Bier, CEO

RECOM

LIGHTING

Sigrun Heiden
Sigrun Heiden received the title of Mechanical Engineer where she also specialized in the subject of technical editor. She has been working as a free agent editor for the technical journal LICHT since 1994 where she works on light planning and light technology subjects.

# CLASS INSTEAD OF MASS - QUALITY MAKES THE DIFFERENCE WITH LEDS, TOO

It has been 13 years since we reported about LED light sources in general lighting for the first time in our trade journal – LICHT. If you read those articles today, you still get the sense of the pioneer spirit. Back then, the news was predominately about new efficiency records and there were even statements about a life span of up to 100,000 hours. Looking back is interesting, especially from the point of view of the topics, which also dominate trade discussions today. They are negotiated much differently, more critically and more sensitively, which corresponds with the level of technology that has now been reached. One of these subjects is the quality of LED lighting solutions. There are many different motivators. Due to intensified global competition and falling prices, profiling in the LED market is needed. Reliability, sustainability or high-end designs are values that successful brandings build on. On the other hand, the lighting technology qualities of LED products and LED based project plans are back where they belong, namely, in the focus of attention. Manufacturers with many years' experience in the lighting industry can contribute their competencies. Recently, organized companies of the German Central Committee of electrical engineering and the electronics industry of the Lighting Trade Association disclosed that the Zhaga specifications were not comprehensive enough. They want quality standards that take the life span, guarantee period, luminance, non-glaring and other characteristics of excellence into consideration. For this reason they founded the steering committee, Photonik. The committee works closely with Zhaga, taking the already approved specifications into consideration.

The pleas for high quality LED solutions in the past have completely different roots. Even the manufacturers of LED retrofit lamps repeatedly say that badly engineered products, like the ones that had to be put up with when energy saving lamps came on the market, is bad for the image and must be avoided for LEDs. In order for the technology to establish itself, its economic and lighting technology advantages have to be proven in practice. This is the only way to guarantee the acceptance of the user.

If nothing else, it is the technology based features of the LED itself that necessitate quality awareness on a brand new level. It ranges from reproducible manufacturing methods to application adequate LED selection to the correct integration of lamps. Key words like the ageing of chips and optics, color rendering, color stability and binning, thermal management and driver electronics make it clear that an interdisciplinary know-how for high quality LED lighting solutions is absolutely necessary.

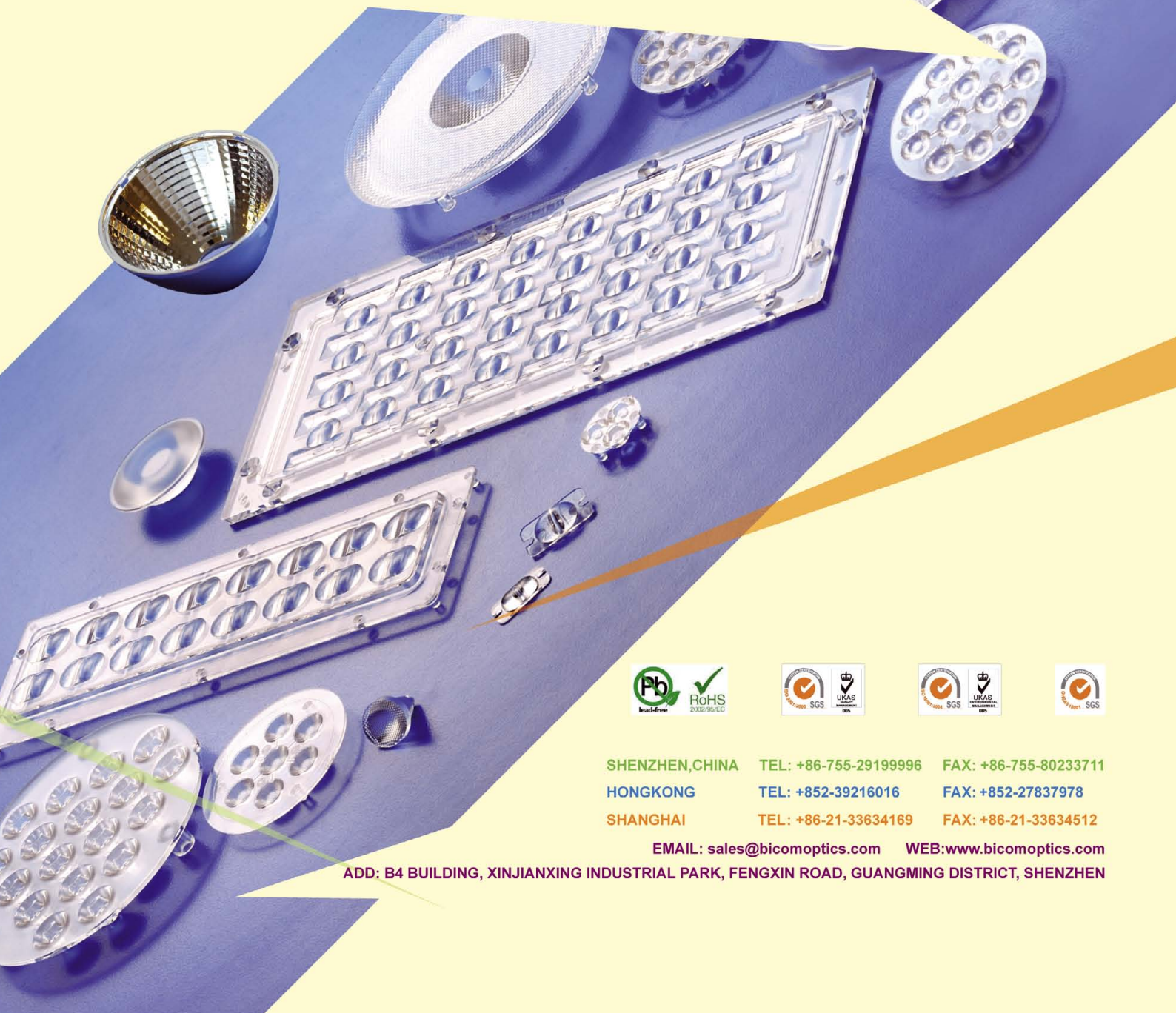
The blanket euphoria that dominated 13 years ago in relation to the luminous semiconductor is definitely over. In our opinion, there is no need for regrets because the industry news and innovation reports that are reaching our editorial office today are much, much more exciting.

S.H.

# BICOM

## Professional LED Lenses & Reflectors Manufacturer

- Provide high efficiency LED Lenses&Reflectors
- Have a lot of experience in optics field
- Develop over 100 new products monthly
- Finish a new optical design within 3 days&Trial-mould samples in 5 days
- Cooperate closely with Osram,Philips,Cree,Nichia etc.




SHENZHEN,CHINA TEL: +86-755-29199996 FAX: +86-755-80233711

HONGKONG TEL: +852-39216016 FAX: +852-27837978

SHANGHAI TEL: +86-21-33634169 FAX: +86-21-33634512

EMAIL: sales@bicomoptics.com WEB:www.bicomoptics.com

ADD: B4 BUILDING, XINJIANXING INDUSTRIAL PARK, FENGXIN ROAD, GUANGMING DISTRICT, SHENZHEN

# Toshiba to Extend Partnership with Louvre to Light up the Mona Lisa with LED

**In addition to the exterior illumination of the Louvre, in a next step, Toshiba will provide LED lighting for the Mona Lisa, the Red Rooms and Napoleon Hall**

Toshiba Corporation announced that it has reached a basic agreement with the Louvre Museum to replace part of the interior lighting of the Louvre with its own LED lighting. This is Phase 2 of a renovation project that Toshiba Corporation and the Louvre Museum have pursued in partnership since 2010. This next project phase will see renovation of LED lighting in important interior spaces of the museum. It includes specific exhibit lighting for Leonardo da Vinci's Mona Lisa, and for the Red Rooms, which display famous masterpieces such as Jacques-Louis David's Consecration of the Emperor Napoleon I and Coronation of the Empress Josephine, as well as the Napoleon Hall, the Louvre's main entrance.

As part of the project, a dedicated lighting system will be installed for the Mona Lisa, and the Red Rooms' ceiling fixtures will be converted to LED by the end of May 2013. Lighting in the Napoleon Hall is expected to be converted to LED by the first half of 2014.

Under a partnership agreement with the Louvre, Toshiba has already lit up parts of the Louvre's exterior, including I.M. Pei's Pyramid. The implementation of the second phase of the project is testament to the successful collaboration between Toshiba and the Louvre Museum in balancing environmental and aesthetic considerations during the exterior lighting renovation phase.

The installation of LED lighting for the whole of Cour Napoleon, the first phase of lighting renovation, was completed on May 12. It has taken approximately two years, since the project commenced in June 2010, for all the lighting in the Cour Napoleon to be converted to LED. Renovation of LED lighting in the Cour Carre is also scheduled to be complete in 2013.

Through the renovation of exterior lighting, Toshiba and the Louvre Museum are reducing power consumption by 73% without compromising the visual beauty of the museum. The renovation process involved repeated consultations with the Historical Monuments Committee and the Architecture and Heritage Service. This partnership has pursued artistic integrity in the LED lighting from every conceivable perspective: the shape of the fixtures, illumination brightness, color tone and installation angle, to achieve a lighting finish that respects the scenery of Paris. The fusion of French artistry with Japanese technology that Toshiba has promoted has been realized ultimately through numerous innovations. Toshiba will continue to refine its technical skills in the pursuit of the potential of LED lighting.

Toshiba perceives this project as an important example of how to extend longevity and sustain the aesthetic integrity of world heritage sites. As one of the world's foremost eco-conscious companies, Toshiba will further enhance its technical capabilities through experience gained at the Louvre, while contributing to global culture and the mitigation of environmental burdens. ■

**Part of the LED lighting replacement work, which included the Pyramid, Pyramidion and the Colbert Pavilion, was completed last December,**

## CREE XLAMP® LIGHTING-CLASS LEDs

### XLAMP XB-D LEDs

**OPTIMIZED TO DRAMATICALLY LOWER SYSTEM COST IN ALMOST EVERY LIGHTING APPLICATION**

Double the lumens per dollar

Industry's smallest lighting-class LED, delivers up to 139 lumens at 1W, 6000K, 85°C

### XLAMP XT-E LEDs

**OPTIMIZED TO REDEFINE THE INDUSTRY'S LED PRICE-PERFORMANCE CURVE**

Double the lumens per dollar

Industry's highest performance lighting-class LED, delivers up to 148 lumens at 1W, 6000K, 85°C

### XLAMP MT-G EASYWHITE® LEDs

**OPTIMIZED FOR HIGH-OUTPUT, SMALL-FORM-FACTOR, DIRECTIONAL-LIGHTING APPLICATIONS**

Now available in brighter bins, expanded CRI and color options in both 6V and 36V options

High lumen output—up to 1670 lumens at 25W, 3000K, 85°C

# CREE XLAMP LEDs ARE APPLICATION OPTIMIZED FOR LOWEST SYSTEM COST

## REVOLUTIONARY!

Cree XLamp® Lighting-Class LEDs are purposefully designed to deliver the industry's best performance and optimized specifically for distinct applications. This makes it easy to design in the brightest, most efficient LED.

Our product portfolio enables revolutionary designs for either brighter, more efficient luminaires with fewer LEDs or space saving fixtures using less LEDs.

So whether you're designing exterior wide area lighting or a tightly focused indoor directional, you can have excellent performance and lower your system cost.

**Get samples of Cree XLamp LEDs or contact a Cree Solutions Provider at cree.com or call us at +800.533.2583**

**Get Cree reference designs at cree.com/ref**

CREE®

# Daewon Innost Offers Glaxum™ Nano-Pore Silicon Substrate (NPSS) LED Arrays

Daewon Innost introduced a Glaxum™ LED Array family of Chip-On Board modules using proprietary Nano-Pore Silicon Substrate (NPSS) technology. Developed by Daewon Innost, the Glaxum arrays provide the industry's best thermal dissipation performance and are built using some of the highest efficacy, commercially available 1 Watt LED chips. Glaxum technology offers the best thermal impedance in the industry - only 0.41 degrees centigrade per watt - and by running more than 12 degrees centigrade cooler than previous top performing COB modules the Glaxum line significantly extends LED array lifetime.


**Daewon Innost's Glaxum ™ LED Array, Chip-On Board module performs at 0.41°C/Watt**

Daewon Innost today introduced the Glaxum ™ LED Array family of Chip-On Board modules. Using proprietary Nano-Pore Silicon Substrate (NPSS) technology developed by Daewon Innost, Glaxum arrays provide the industry's best thermal dissipation performance with unprecedented thermal impedance of only 0.41 degrees centigrade per Watt. They are built using some of the highest efficacy, commercially available 1 Watt LED chips.

Daewon Innost developed the NPSS technology for LED modules specifically to provide the best thermal dissipation performance available today. The LED substrate is created by applying semiconductor lithography to silicon wafers allowing for fine pitch interconnection between GaN LED chips, providing a pitch spacing of 50 microns as compared to over 300 microns with current Metal Core Printed Circuit Board (MCPCB). NPSS offers several advantages over MCPCB including superior thermal performance, higher levels of integration, and favorable scaling which will offer lower system costs as power levels increase.

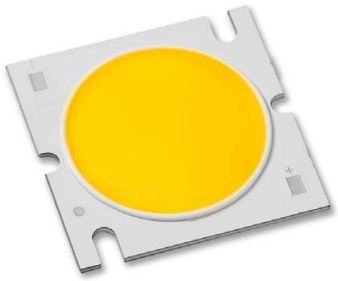
"We are delighted with the test results of our LED modules as independently tested by a leading LED chip supplier. The results demonstrate that we have surpassed the thermal performance of the best performing chip on board (COB) technology to date," said Sungyuk 'Stephen' Won, CEO of Daewon Innost. "Our Glaxum module runs over 12 degrees centigrade cooler than the previous top performing COB module. The industry rule of thumb is that each degree centigrade you can lower operating temperature translates to an extra 1000 hours of lifetime, so our cooler temperatures will provide longer life for LED arrays."

"Our business success directly depends on the reliability of our products, and thermal performance is critical for lumen maintenance. AlterLume sees the introduction of Daewon Innost's NPSS array packages as a seminal moment in LED lighting technology, and we are proud to be part of its advance in both technology improvements and cost reduction," said Dr. Brent Hermsmeier, AlterLume's CEO.

The Glaxum NPSS modules are available in models ranging from 3.5 to 100 Watts. The models with lowest thermal impedance are Glaxum-MCL-GL-WC-020-002 (warm white) and the Glaxum-MCL-GL-CC-020-002 (cool white). Tested voltage and current value of modules is 16.6 V, 1.2 A, respectively. ■

# Lextar Announces its 100-watt High Efficiency COB Products

Lextar Electronics Corp. announces its 100-watt COB LED products that have a high efficiency of 130 lm/W and low thermal resistance. In addition, Lextar's Blue Emitter with HV chip as well as high color rendering light board (CRI>95, R9>90) were on display from June 9-12 at the Guangzhou



**Lextar's new COB LED extends the available power range to 100W with an efficiency of up to 130lm/W and very low thermal resistance**

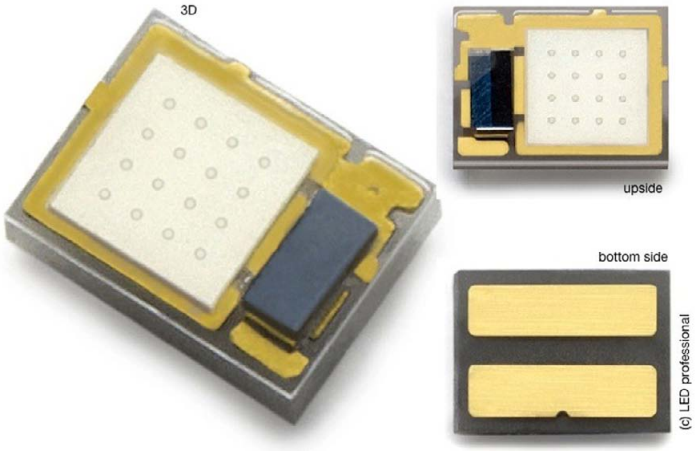
The 100-watt COB LED product has a luminous efficiency of 130 lm/W and low thermal resistance of 0.5 degrees per watt, which is more than a 70% decrease compared with most LED products. This can help simplify the thermal structure of the lamp, lower costs, as well as provide a longer lifespan. These high-power COB products are suitable for streetlights and high/low bays. In addition, Lextar will showcase full COB series including 4, 6-8, 8-15, 15-25, 30-50 and 50-100-watt products, giving the LED industry a wide range of low-to high-powered options. Also, COB products have good uniformity, no multi-shadow, low thermal resistance, and simplified fixture design.

Lextar is also promoting its Blue Emitter with HV chip that can be used with remote phosphor. It can reach a good uniformity and customers can adjust the light distribution, color temperature and color rendering to their liking. These packaging products use Lextar's own researched and manufactured HV chips, which can help with saving on electronics' spare parts and space, and increase the flexibility in finished product design, especially for small sized lamps such as jewelry lamps and candle lamps.

Expect to see Lextar's COB, PLCC and LED light module products at lighting exhibitions, all of which display Lextar's craftsmanship in advanced lighting products from its vertical integrated business model. Lextar has seen substantial results on the LED light module products that comes from its dedication on backlighting development for the past few years. The company is to continuously develop high power and value-added COB accompanied by endorsements from global brands, to market in Europe and Japan. ■

# Philips Introduces LUXEON Z

At a size that is 80% smaller than traditional power LED, the new LUXEON Z offering from Philips Lumileds is the company's smallest LED package to date. With a total footprint of just 2.2 square millimeters and high lumen output across a full spectrum of colors from 440-670 nanometers, including white, the LUXEON Z offers luminaire designers the industry's highest commercially available lumen density. In addition, the ultra-compact, non- encapsulated package of the LUXEON Z gives designers new flexibility in packaging and optical designs, helping to push the boundaries of next generation luminaire design.




**LUXEON-Z is Philips Lumiled's solution for wall-washers or moving head entertainment spotlights**

The new LUXEON Z will allow for integrated approaches that break with today's paradigms in luminaire development. Unlike other products on the market, the LUXEON Z goes beyond the constraints of a typical 2x2 multi-chip package to allow designers the ability to create specialized 2x2, 3x2 or 6x1 mono-color or multi-color luminaires. With this breakthrough, configurations are virtually limitless, and with the ability to mount as many as 250 of the high-lumen LUXEON Z in one square-inch, designers can reach new levels in lumen densities.

Simplifying development of products such as wall-washers, moving head entertainment spotlights, and even remote phosphor applications, the LUXEON Z will also give engineers in the entertainment, architectural and specialty lighting segments, a modular approach to developing products. Moreover, the non-encapsulated chips are more readily adaptable to custom optics, eliminating the need for complex, inefficient secondary lenses. The company expects that a full line of semi-custom optics will also be available in the near future.

"With the LUXEON Z, Philips Lumileds has once again reinforced its commitment to LED innovation by listening to customers and giving them the ability to create more variations of multi-chip color arrays that can take advantage of custom optics," said Rahul Bammi, VP of Product Management at Philips Lumileds. "By continuing to push the boundaries of technology with the smallest high-lumen LED package available, we are really enabling our customers to push the boundaries of luminaire development."

# New Mini Zenigata with Nominal Power of 15W Delivers up to 1550 Lumens

The new Mini Zenigata arrays of type GW5BxxxK05 provide a luminous flux between 1150 and 1550 lm (typical) with a light output of up to 99 lm/W in standard operation. The new generation of the 15 W modules is specified for a forward voltage of 39 V with a constant current of 400 mA. However, you can also operate the 15 W arrays with increased constant current of up to 440 mA to achieve a luminous flux of up to 1,650 lm. The 48 dies of the Mini Zeni of type GW5BxRxxK05 are divided electronically into a matrix of four parallel-switched series of twelve, which ensures fail-proof operation.

**Sharp's new LED modules from the new Mini Zenigata series radiate with an efficiency of up to 99 lm/W and a luminous flux of up to 1550 lm**

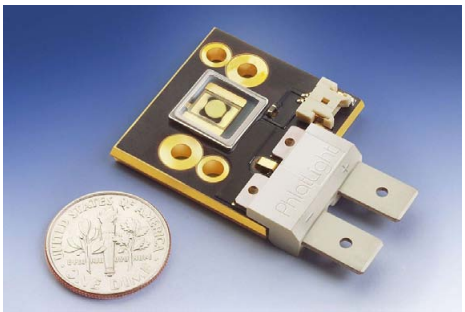
The round shape of the surface emitting light (LES) is also new in the 15 W Mini Zeni arrays. The circular LES has a diameter of 8 mm and is filled up to the edge of 48 LED dies. As a result, the new 15 W Mini Zeni modules have properties like a high-performance, point light source, which only requires simple optics (lens and reflector) contrary to multipoint light sources. Nothing has changed in the dimensions of the carrier made of technical ceramics (aluminum oxide AL2O3) of 15 mm x 12 mm x 1.6 mm, so that the new Mini Zeni arrays are completely compatible mechanically with the previous models. The lean dimensions in combination with the small, round LES also provide high design flexibility for the extremely restricted radiation angle of compact lights.

The color temperatures of the new white light LED arrays are in the range from 2,700 to 5,000 Kelvin with the shades "Natural White", "Warm White" and "Pure White". They are available in two models with CRI values of more than 80 and more than 90. The new Mini Zeni arrays also have high-quality R9 values, two binnings within MacAdam5 as well as good color consistency and stability values over time under realistic conditions (hot lumen). Thanks to the very smooth bottom side of the ceramic carrier and the already existing soldering points, the modules can be attached to an appropriate heat sink without a lot of work, thus ensuring excellent heat dissipation. The modules have a lifetime of 40,000 hours at an operating temperature of maximum 90°C. Compared to conventional halogen lamps, the LED arrays from Sharp thus have longer lives The light loss is also considerably less and is only 70% after 40,000 operating hours.

Overall, high light quality and high output with a compact shape factor are characteristic for the new 15 W Mini Zenigata LED arrays. Consequently, they are suitable for numerous applications (e.g., spot lighting) as well as for LED retrofit lamps. ■

# Luminus Devices Presents World's First Round LED

Luminus Devices announced it will be releasing a family of round LEDs that will accelerate the adoption of solid-state technology by displacing conventional light sources in high brightness lighting applications.



**According to the manufacturer, Luminus Devices, the new round big chip LED architecture will boost system-level throughput and efficiency, opening new markets to solid-state lighting**

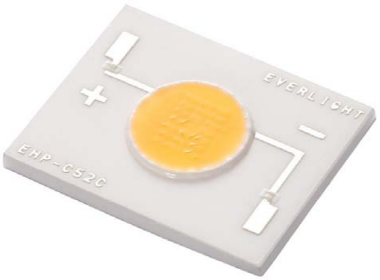
"Optical architectures of high power entertainment fixtures are frequently defined by a circular aperture, so using a traditional square LED was like putting a square peg into a round hole," said Don McDaniel, Global Marketing Director for Entertainment Lighting at Luminus. "Our new round LED increases system-level efficiency by as much as 30%, enabling our customers to use a single LED to replace a 250 W HID lamp."

Other markets and applications that will benefit from Luminus' round LED technology include medical, machine vision, portable and retail spot lighting. "There are obvious benefits to fiber coupled lighting systems," explained Chuck DeMilo, Global Director of Product Marketing, Lighting Business Group, at Luminus. "The fiber is round, the optic is round, but the LED has always been square – it was an optical mismatch. This has now been resolved with the round LED breakthrough that will enable us to replace the 300 W Xenon lamp in an application like endoscopy."

According to Luminus President and CEO Keith T.S. Ward, "We made a decision to invest significantly in R&D and operational infrastructure to revolutionize LED lighting – making the round LED concept a reality. The importance of this innovation can't be overstated, and our customers are extremely excited." ■

# Everlight Electronics Announces New C52 COB LED Series

Adding to the performance and popularity of Everlight's 6.4W and 8W Chip-on-Board (COB) LED series, one of the highest CRI and highest efficiency COBs on the market, Everlight Electronics Co., Ltd. announced the brand new and smaller C52 COB LED series which is perfectly suitable for directional and decorative applications such as MR lamps and P35 bulbs at LIGHTFAIR International 2012 in Las Vegas/USA.




**Everlight's C52 COB LED is a perfect light source for directional and decorative applications with low thermal resistance and high performance**

# Ledlink Optics, Inc.

Ledlink Optics, established in April 2008. Professional in designing and developing the secondary optics for LEDs industry.
Our company mission is to help our customers to optimise optics performance in creating solid state lighting products.
Lenses are available in a wide variety of package with numerous beam pattern options, size and application, you will find a solution at Ledlink.

## Lens

COB Lens
Convex Lens
Fresnel Lens
Hybrid Lens
Multi Lens
Oval Lens
Single Lens
Street Lighting

## Semi-Module

Thermal Conductive Plastic Semi-Module
Aluminum Semi-Module

AR111
MR 16
PAR20
PAR20 BULB
PAR30
PAR38

## Reflector

Aluminum reflector
Electroplated plastic reflector

## Just in time services by in house vertical Integration

- In house optical design
- In house mould design and manufacture
- In house mass production

## Flexibility, in terms of time and products

- Wide range of standard optics for different LEDs
- Compatible MCPCB with our standard lenses
- ODM and OEM services is available for:
  Custom secondary optics
  Custom housing components
  Semi-module product
  Custom MCPCB

LedLink

LedLink
*Linking LEDs to The Real World*

Tel:+886-2-8227-6126 Fax:+886-2-8227-6127
ledprofessional@ledlink-optics.com www.ledlink-optics.com
15F,No.655,Bannan Rd.,Chung-Ho Dist,New Taipei City,Taiwan.

For these types of applications, an LED light source must exhibit compact size, high efficiency, sufficient lumen output, high CRI, high color uniformity, and proper light distribution to maintain a comfortable and uniform lighting environment – all at consumer acceptable prices. With its new C52 COB Series, Everlight Electronics has created the other ideal LED to address major challenges posed when designing a retrofit like MR, GU or candelabra type: minimum efficiency requirements, thermal management in limited space, and complexity of design.

Everlight's COB series is a 3.7 W multi chip, ceramic substrate based LED that boasts a low thermal resistance (Rth <1.8°C/W) and superior efficacy of 100 lm/W at 3000 K CCT and high CRI (>80Ra). It will be available not only in ANSI 3000 K CCT but in all Energy Star / ANSI color temperature ranges.

Mechanically, the C52 COB series can be mounted directly on heat sink eliminating the SMT process. This provides more direct thermal dissipation, ease of assembly, and lowering of the system cost in lighting applications.

Everlight's C52 Series is using the standard DC chips configured in series and parallel to provide the most convenient driving conditions for existing driver designs. Also, with a ceramic substrate, users can have higher reliability and better thermal dissipation. The C52 Series can also achieve the low cost of industry target, >400 lm/$ for a COB LED light source. This is a superb single emission area COB LED that needs to be used. ■

## Philips Introduces the Zhaga Certified Fortimo LED Spotlight Module

Fortimo LED spotlight module (SLM) Tight Beam is the latest LED lighting innovation from Philips for retail environments. Its extremely small but powerful light emitting surface produces 1,100 lm, producing high central candela power in combination with a small reflector design. It is also the first Zhaga certified Philips LED module on the market, having been tested by Dekra-Netherlands, one of the approved Zhaga testing houses.

**Zhaga certified Fortimo LED module from Philips**

Philips' LUXEON S technology allows the Fortimo LED SLM Tight Beam to provide high light output out of the smallest possible light source. The Tight Beam module offers significant benefits in fashion retail environments as the small light source enables retailers to create a greater degree of contrast, showcasing fabrics and colors at their best, and making merchandise more attractive to customers.

Fortimo LED SLM Tight Beam offers retailers a high center beam intensity and beam uniformity. Products illuminated by a Fortimo LED SLM Tight Beam will always look bright and vivid due to its color rendering index of over 80, and perfect red rendering and color consistency.

Pim Kemps, Philips Product Manager for Spotlight LED modules, OEM Lighting Sources & Electronics: "Fortimo LED SLM Tight Beam offers retail store owners the possibility of more dramatic illumination of merchandise. This lighting solution really enables 'stopping power' as the sharp contrasts make objects appear raised out of their surrounding environments to attract maximum attention from shoppers.''

Fortimo LED SLM Tight Beam is part of the second generation of Fortimo LED spotlight systems and is commercially available.

## GT BiomeScilt Presents the Airglow One Driverless LED Light Modules

With the introduction of Airglow One, the Bremen-based company GT BiomeScilt managed its successful breakthrough in the development of energy-efficient LED light modules. Now for the first time, no additional driver is needed to operate the compact, patented LED modules in the Airglow One series. This results in the greatest possible design scope in the production and design of luminaires, together with clearly reduced costs. "Luminaire manufacturers will benefit greatly from this driverless LED technology", says Martin Hockemeyer, Managing Director of GT BiomeScilt and Managing Partner of the partner company, the Gebrüder Thiele Group. "Without the driver as an additional component, they will now be able to design lighting systems with greater efficiency and at lower costs than manufacturers still using conventional LED modules."

**GT BiomeScilt's Airglow One LED module does not need any driver for operation**

High-powered, environment-friendly solutions for shop lighting, industrial luminaires and public areas:
The energy-efficient, top quality light produced by the Airglow One LED modules means that they are simply perfect for lighting systems in public buildings, such as theatres, museums and cinemas, high-class retail complexes, outdoor areas, office buildings and commercial and industrial areas. The long service life also makes them ideal particularly in high-maintenance applications, such as street lights. Since January 2012, the high-powered modules have been available initially in two color temperature ranges with luminous fluxes of 1500, 2500 and 3500 lumen. Other product attributes include a CRI value of at least 80 and a high average service life 50,000 hours.

Future-proof platform for luminaire manufacturers:
The driverless Airglow One LED modules are compatible with heat sinks and reflectors made by well-known manufacturers, and need very little maintenance by managing without a driver. "To start with, we will be focusing initially on our key markets in Europe and the USA, in order to avoid any bottlenecks", says Hockemeyer, who is planning to expand production capacities step by step. ■

# Reflector - 824 Series from Bicom

Bicom's precision-molded 824 series reflector (77 mm diameters, 44.6 mm height) allows for rapid deployment of new lighting solutions using Citizen CLL040 and Osram E45 LEDs.

**Bicom's reflector, 824 series for Citizen CLL040**

Molded from durable polycarbonate plastic resin, the optimal optical geometric design achieved in the design process is reproduced in the molding process. The reflectors, currently available in 28 degree beam patterns, are finished in an aluminum coating with a protective lacquer finish and provide greater than 89% optical efficiency.

Molded from durable polycarbonate plastic resin, the optimal optical geometric design achieved in the design process is reproduced in the molding process. The reflectors, currently available in 28 degree beam patterns, are finished in an aluminum coating with a protective lacquer finish and provide greater than 89% optical efficiency.

Bicom's reflectors allow immediate deployment – with no tooling investment – of LED-based fixtures to replace traditional halogen or incandescent bulbs in applications where directed light is favored, such as in spotlights in retail displays, meeting rooms, or in restaurants and bars. These reflectors are also ideal for use in museums and galleries as there are no damaging UV rays or heat in the beam.

# Intematix ChromaLit Contour for 100-Watt Replacement Bulb

Intematix Corporation, a leading innovator of patented phosphors and phosphor components for high-quality LED lighting, announced the availability of ChromaLit™ Contour. Lighting manufacturers can implement ChromaLit Contour to produce 60, 75 and 100 watt-equivalent omni-directional light in an LED system. Intematix also offers A Lamp reference designs for these systems.

**ChromaLit Contour remote phosphor creates omni-directional, high-quality light, scalable to all wattages at lower cost**

Intematix's ChromaLit remote phosphor can reduce LED costs by 25% compared with conventional LED light bulb designs while offering precise color matching and exceptional light quality.

ChromaLit Contour exceeds Energy Star and China Quality Certification lighting requirements with:

- Uniform, glare-free and diffuse light
- 330 degree lighting distribution
- Standard color rendering options up to CRI 90
- Choice of color temperature from 2700 K to 5000 K
- Precise color matching

"ChromaLit Contour's remote phosphor architecture makes available in production for the first time a high performance 100-watt replacement light bulb," said Julian Carey, Senior Director of Marketing at Intematix. "With ChromaLit remote phosphor we offer our customers time-to-market advantage and lower production costs for LED light bulbs, while enabling high quality light within the constraints of light bulb sizes."

Contour is the latest in Intematix's award-winning ChromaLit line of remote phosphor products. This design trend separates the phosphor substrate from the blue LED, instead of coating the LEDs with phosphor directly. Any blue LED may be used which increases flexibility and lowers costs for lighting manufacturers.

ChromaLit Contour's shape enables internal and external convection airflow to reduce the operating temperature of the LEDs, enabling higher lumen output in constrained form factors. Like the rest of the ChromaLit line, Contour offers glare-free, diffuse light, precision color rendering and CCT, and consistent light quality. By boosting system efficacy by up to 30%, ChromaLit reduces manufacturing costs, energy consumption and total cost of ownership. ■

## Creative Materials Introduces New Adhesive for LED Lighting Applications

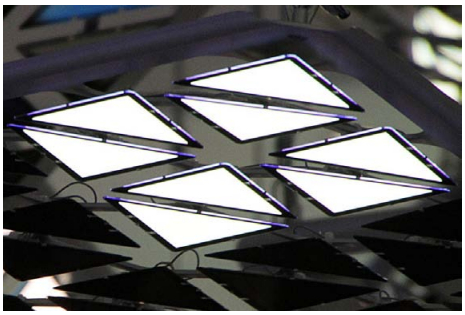
Creative Materials has developed a line of products that are customized for LED lighting applications, now including 125-35C, Syringe-dispensable Thermally Conductive Epoxy Adhesive. Formulated for use in the manufacture of LEDs, these products are highly effective as an interface between a heat-producing component and a heat-sink.

**Creative Material's new adhesives for LED lighting applications provide low-temperature curing and are highly thermally conductive**

Creative Materials' New Thermal Management Product: 125-35C Creative Materials has introduced a new product to our family of thermally conductive adhesives: 125-35C. The properties of this product are ideal for thermal management applications where precision is required in small area bonding, e.g. for bonding individual LEDs. This product is syringe-dispensable, 100-percent solids, electrically insulating and precatalyzed, featuring outstanding chemical resistance and high-temperature properties. Its thermal conductivity is >5.5 W/mK. The product cures at temperatures as low as 80°C and has a temperature range of up to 230°C. The product is flexible and stress-absorbing when bonding to mismatched substrates. Among the features of this one-component product is ease of use and minimal shrinkage during curing. ■

## New 3M™ FTB3 Barrier Film Protects Organic Electronics like OLEDs

3M's Optical Systems Division announced that its 3M™ FTB3-50 and FTB3-125 films—flexible, optically clear films that protect sensitive electronics from water vapor and oxygen—are now commercially available. Previously, these films had been sold primarily under limited research-and-development agreements. FTB3 (for flexible, transparent, barrier) film has application in a range of emerging display technologies.



**OLEDs, like all organic electronics, are very sensitive to water vapor and oxygen, hence need to be well protected**

"Many new technologies incorporate organic electronics or other components that need protection from water vapor and oxygen," explained Art Lathrop, marketing manager for 3M Optical Systems Division. "FTB3 provides superior protection from those and other contaminants while at the same time it is thinner, lighter, more flexible and more impact resistant than glass."

Lathrop noted that the film could enable new form factors for electronic devices. "FTB3 offers a unique combination of durability, flexibility, optical clarity and low weight," he said. "And it offers from two to three orders of magnitude better protection from water vapor than packaging grade barrier films."

The film has a water vapor transfer rate of less than 1x10-3 grams per square meter per day at 20°C. It also has insulating qualities that could be of interest to product developers. "Unlike metal foils, the barrier layer in FTB3 doesn't conduct electricity," explained Dr. Fred McCormick, senior research specialist within Optical Systems. "Also, it's remarkably smooth with an Ra of about 1 nanometer."

FTB3 consists of a base polyester layer (50-125 microns thick) with a very thin (less than 2.0 microns) barrier coating made up of layers of polymer and oxide.

McCormick noted that the film's flexibility allows roll-to-roll processing, which has the potential to improve manufacturing efficiencies and reduce costs. It is currently available in 300 mm-wide rolls. Wider rolls will be available in the second quarter of 2012. Additionally, 3M is developing a range of barrier films using different substrates, additional film layers, and even higher barrier performance for applications ranging from solar panels to electrophoretic, electrochromic, and OLED displays. ■

## NXP GreenChip LED Driver with Smart Digital Control

Eindhoven, Netherlands and Shanghai, China, June 11, 2012 — NXP Semiconductors N.V. (NASDAQ: NXPI) introduced the SSL21101 – the first in a new family of GreenChip™ LED driver ICs featuring Smart Digital Control (SDC) technology. Incorporating intelligent digital control within a compact analog design, the SSL21101 delivers better, more accurate system performance while reducing the bill of materials, providing an ideal solution for non-dimmable, high-performance LED applications up to 15 W.

We bring quality to light.

# Putting LEDs in the right light.

## SSL solutions from the world leader in LED measurement

**NEW:** LGS 250
Goniophotometer

Instrument Systems set the benchmark in LED testing with high-performance spectroradiometers for photometric and colorimetric measurements. Now we present another breakthrough in Solid-State Lighting with our new goniophotometers and integrating spheres.

**Find out more about our innovations for SSL:**
**www.instrumentsystems.com/ssl**

Instrument Systems
light measurement

Instrument Systems Germany · Phone: +49 89 45 49 43 0 · ssl@instrumentsystems.com · www.instrumentsystems.com

**GreenChip SSL21101 board**

The SSL21101 is a single-stage solution designed to drive LED devices in flyback or buck-boost configurations with very high efficiency – up to 90% depending on the application – and with highly accurate control of the output current. In the SSL21101, the Smart Digital Control feature offers two modes optimized for specific regional regulatory requirements. In High Power Factor mode, the PF rating is higher than 0.95 and the total harmonic distortion (THD) is limited to under 20%. The Low Ripple mode lowers the LED current ripple below 1% and makes it possible to use smaller electrolytic capacitors, enabling very compact designs.

Featuring a high level of integration and functionality in a small footprint, the SSL21101 includes a high-voltage power switch as well as a circuit that enables start-up directly from the rectified mains voltage, and is equipped with a complete set of protections. The SSL21101 enables finished applications using as few as 18 components, resulting in a very low bill of materials – in high volume, less than US $1.30 for a complete system eBOM excluding LEDs. ■

## Cirrus Logic CS163X Digital LED Driver IC

The new CS163X family provides two-channel LED color mixing capabilities while featuring the digital intelligence of TruDim™ technology for near 100% compatibility with worldwide dimmer hardware. The CS163X allows more LED bulbs to more efficiently create warm, natural light quality while also lowering the cost barrier for two-channel LED retrofit bulbs. | Best-in-class TRIAC dimmer compatibility | Dimmable to 0% of light output | Up to 30% greater efficacy than single-channel white LEDs Cirrus Logic is setting the standard for dimmer compatibility.

The CS163X family enables improved color quality at up to 30 percent greater efficacy than with single-channel white LEDs. An innovative digital architecture provides the CS163X family with the ability to control two LED strings using components typically used to control a single LED string, resulting in lower system costs compared to today's two-channel solutions. In addition, the CS163X incorporates powerline calibration technology, allowing manufacturers to calibrate bulb characteristics such as light output and color temperature by sending commands via the AC mains terminals during the final manufacturing stage. This patent-pending technology allows manufacturers to utilize LEDs with a wider variation in performance characteristics, resulting in lower LED costs while maintaining consistency in light output and color temperature from bulb to bulb.


**CS163X family of LED controllers offers up to 30% higher lumens per watt compared to single-channel drivers while providing improved color temperature quality**

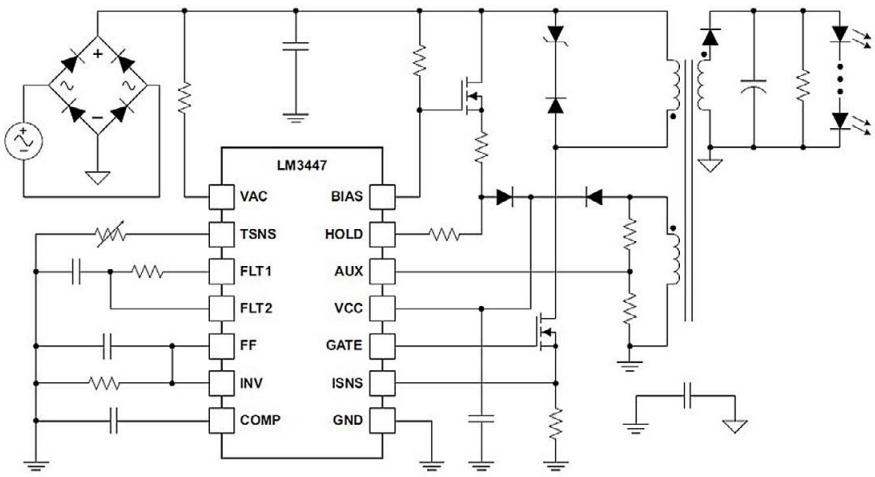
"Cirrus Logic's CS163X two-channel, TRIAC dimmable digital LED controller is a breakthrough in digital controllers and an ideal system solution for our Brilliant Mix technology," said Horst Varga, Applications Engineering, OSRAM Opto Semiconductors.

"CS163X's high level of integration and performance enables many new opportunities for the Brilliant Mix technology in LED retrofit applications requiring high color rendering index (CRI) and high efficacy. The combination of these technologies will accelerate the growth of LED bulbs that match the natural light color quality performance of today's incandescent and halogen bulbs."

Fundamental to Cirrus Logic's LED product family is the company's digital TruDim technology, which was the result of a three-year investment in TRIAC interface algorithms, LED driver topologies and system architectures. TruDim digital intelligence allows the controller to identify the type of dimmer in use and adapt its algorithm to provide smooth dimming in much the same way the consumer has come to expect from decades of using incandescent light bulbs. ■

## Industry's First LED Controller with Constant Power Regulation

Texas Instruments Incorporated introduced a new LED controller with constant power regulation. The LM3447 AC/DC LED driver includes a dimmer detect, phase decoder and adjustable hold current circuits to provide smooth and flicker-free dimming operation in off-line, isolated LED lighting applications, including A19, E26/27 and PAR30/38 bulbs, as well as can light retrofits.




**Typical application diagram of TI's new LM3447 that promises smooth, flicker-free phase-dimmable dimming**

Key features and benefits:

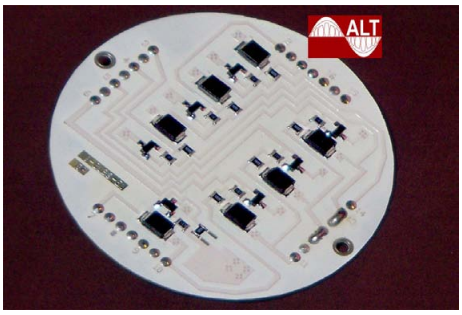
- Integrated phase dimmer decoding and dimmer detection circuitry allows for easy design and highest efficiency.
- Operates with leading edge (TRIAC) and trailing edge dimmers.
- Primary side control supports isolated lighting designs without opto-couplers.
- Constant power LED load regulation improves efficacy of LED array by compensating for LED junction temperature changes.
- Fixed frequency discontinuous conduction mode flyback topology with valley switching simplifies EMI filter design.
- Greater than 0.9 power factor correction meets all regulatory requirements.
- Thermal fold-back protects LED array from over-temperature while still providing reduced light output.
- LED open- and short-circuit protection and driver IC thermal shutdown protect lamp electronics from damage during fault conditions.

Traditional drivers use constant current control to accurately regulate LED forward current. This approach produces consistent light output or intensity from LEDs in the same bin. However, once current is applied to the LED, its solder point temperature rises, leading to a decrease in forward voltage and a drop in efficacy. Conversely, by using the new LM3447 with constant power regulation, the LED forward voltage droop over temperature is offset by an increase in LED current to maintain constant LED power. The result is up to 10-percent improvement in efficacy across the expected operating temperature range of the fixture.

The LM3447 joins TI's portfolio of off-line LED lighting controllers that include the National LM3445, the industry's first phase-dimmable LED driver with constant current control, and the TPS92310 primary side regulator for non-dimming applications.

## Monolithic High-Efficiency LED Driver

Advanced Lighting Technologies, Inc. (ALT) announced a high-efficiency and highly reliable LED lamp driver solution (LED driver) comprising no bulky, unreliable components such as capacitors, coils or EMI filters. ALT''s ultra reliable “AC LED Light Engine” consists of an LED array and ALT’s novel driver, requiring no other parts such as capacitors, coils or EMI filters except two AC power wires. ALT’s driver is compatible with all dimmers, is over 90% efficient, has a power factor greater than 0.95, and the entire driver can be integrated into a tiny 16 pin or 8 pin chip.




**ALT's AC LED Light Engine Driver Prototype PCB**

Working printed-circuit board prototypes that were unveiled at the LightFair Conference in Las Vegas demonstrate proof of concept and the technology. Because there are no reactive parts in the ALT driver circuit, the entire LED driver can be reduced to a single ASIC chip or be embedded as an IP block in a customer-specific system-on-a-chip.

The ALT driver is designed for an extremely wide range of output power (1 W-300 W) and ambient temperature (-50°C to 150°C). The technology is protected by a broad “frontier” pending patent executed by an experienced inventor, Beniamin Acatrinei, who originally conceived of the novel constant voltage constant current (CVCC) driver topology during the 1995 – 1997 time period when he obtained his first US patent.

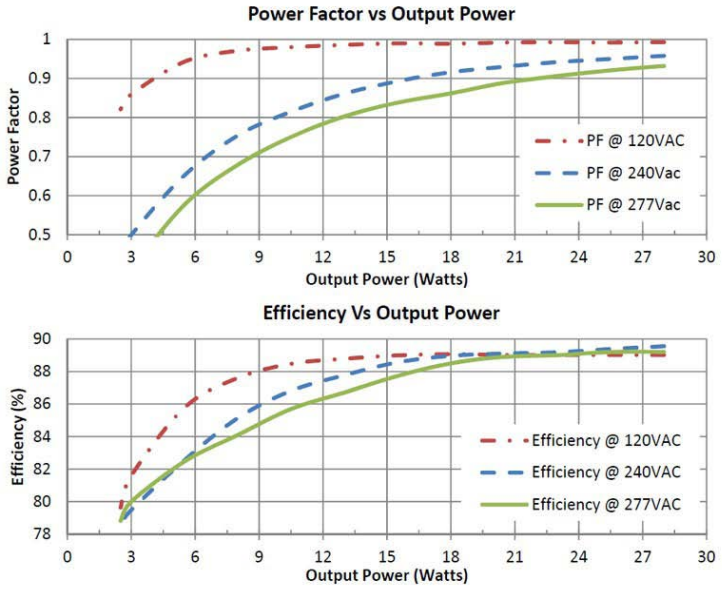
## Ultra-fast-startup LED Driver for Linear Lighting Fixtures

Microsemi Corporation, a leading provider of semiconductor solutions, unveiled a new dimmable LED driver module optimized for worldwide residential, commercial and industrial light fixtures. The 30 watt LXMG221W-0700030-D0™ LED driver enables start up times of 150 ms or faster, closely emulating the "lights-on" performance of a typical incandescent lamp.

Additional features include:

- High-voltage AC input (90-305 VAC) for worldwide installations
- Constant current single 700 mA string applications using 5-12 LEDs without flickering (up to 30 W output)
- High power factor (PF > 0.9) and low total harmonic distortion (THD < 15%) across the entire input voltage range at full load to meet or exceed standard requirements
- Dimmable to 10 percent via 0-10 VDC (compliant to IEC 60929), PWM controls or potentiometers for additional energy savings
- FCC Title 47, part 15 Class B compliant

Microsemi's new LED driver is compatible with 50 Hz and 60 Hz AC power sources worldwide with standard voltages ranging from 120 VAC +/ -10 percent to 277 VAC +/-10 percent. The output is a 700 milliamps (mA) dimmable constant current source. It complies with UL, CUL, CE and EMC industry standards.




**Microsemi's new LED driver offers high efficiency and power factor, especially at 120V line voltage**

# High Tech Lights Introduces its New and Advanced MR-16 COB LEDs

High Tech Lights introduces its new and advanced MR-16 Chips on Board (COB) LEDs to the market. High Tech Lights are in constant research and development for new and innovative LED products .

**HTL MR16 spotlights can easily be customized for beam angles of 15, 30, 45, and 60 degrees**

High Tech Lights' MR16 COB LEDs bring flexibility with quality, calling it the "Multifaceted Reflector Lens with LED Technology". These interchangeable lenses can be easily removed and replaced with another lens with a different beam angle. Used in such locations as spotlights for display, open recessed fixtures, hallways, lobbies, galleries, and retail locations.

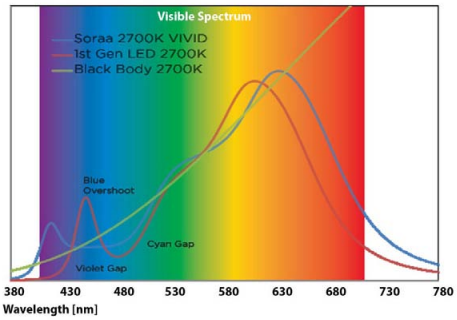
High Tech Lights' MR16 COB reflector design LED lights provide dimmable, energy efficient, attractive light while they dramatically reduce the heat from the light bulbs with their custom designed heat sink and lower energy consumption, saving up to 90% of lighting energy and delivering a touchable level of operating temperatures.

For example, 20 to 35 watt MR16 halogen lamps can be replaced with High Tech Lights 3,4,5, 6 or 9 watt LED MR16 bulbs producing halogen equivalent lumens and lasting 50,000 hours with a 5-year warranty based on 24/7 operation. Since the LED bulbs last at least five years, labor costs drop as well.

In addition, color temperature options Kelvin for High Tech Light's LED MR16 series are cool white, natural white, and warm white along with beam angles of 15, 30, 45, and 60 degrees for customization. ■

# Soraa's Full Spectrum LED MR16 Lamp Challenges Halogen Color Performance

Soraa, the world's leading developer of GaN on GaN solid-state lighting technology, announced the launch of its VIVID LED MR16 lamp. The new product is the first full spectrum LED MR16 lamp with color quality and rendering superior to both traditional halogen and competitor LED lamps. With a CRI of 95 and R9 > 90, the VIVID LED MR16 is the highest output LED MR16 lamp with the best color performance available on the market today.




**The new released MR16 lamp clearly improves the spectral match to the black body curve compared to the 1st gen LED**

With rich saturated color rendering, and excellent color stability, Soraa's VIVID LED MR16 lamp is the lamp of choice for demanding display applications. Soraa's VIVID MR16 lamp offers superior light quality, while being 75% more energy efficient than comparable halogen lamps. It is designed to replace standard 40 to 50 W MR16 halogen lamps and is available in 2700 K and 3000 K correlated color temperatures.

Soraa's proprietary GaN on GaN technology allows for LED products that match the black body curve as is produced by halogen and incandescent lamps, widely considered the optimal light color spectrum. Unlike competitor LED lamps, Soraa's VIVID LED MR16 offers full coverage over the entire spectral range and has no pronounced blue peak or violet and cyan dips common in all other LED lamps. Having overcome the blue overshoot commonly associated with poor color quality in competitor LEDs, Soraa's VIVID LED MR16 lamp is unparalleled in color quality and color rendering. ■

# GE's 100-watt Incandescent Replacement LED Bulb Uses SynJet

GE Lighting illuminated a light-emitting diode replacement for the 100-watt incandescent light bulb that packages 27-watts of input power in a standard "A-19" bulb shape. The GE Energy Smart® 27-watt LED bulb incorporates proprietary synthetic jet technology that was enabled by GE's collaboration with Nuventix, creator of LED cooling technologies for energy-efficient lighting.

**Nuventix's SynJet technology allows GE to design a 100W equivalent LED replacement bulb with A-19 dimensions**

GE's innovation team has tackled a previously insurmountable technical challenge: cooling a 100-watt A-19 shaped replacement LED bulb without making it physically bigger. Each subsystem such as optics, electronics and thermals needed to be designed for miniaturization and cooperative performance.

New LED bulb performance metrics:
GE testing confirms 100-watt incandescent replacement metrics: 1,600+ lumens, uniform omnidirectional light distribution, 3000 K color temperature, 25,000 hour life rating, dimmable, no mercury, instant full brightness and 60+ lumens per watt—all fitting neatly in the standard A-19 bulb shape.

Incandescent replacements need to perform as expected:
Every GE Energy Smart® LED incandescent replacement bulb offers smooth, incandescent-like dimming, minus the stepped dimming, flicker, shimmer, pop-on, drop-off or even inaction that plague other LED bulbs touting a dimming capability. GE's LED bulbs also feature an aesthetically pleasing incandescent size and shape, and a design that allows for a soft-white appearance when turned off. ■

# WAC Lighting Showcases Future of Solid State Lighting with Two New Organic LED Luminaires

Creating a symbiosis of eco-friendly nanotechnology and modern aesthetics that simply inspires, WAC Lighting continues to push boundaries with two new Organic LED luminaires that transform the future of lighting into a unique platform for today. WAC, a global manufacturing leader of decorative and architectural lighting, introduces the Vela Organic LED chandelier with a matching OLED wall sconce.

**WAC Lighting's Vela OLED Chandelier is defined by a dramatic contemporary profile laser-crafted of aluminum**

The Vela OLED Chandelier is defined by a dramatic contemporary profile laser-crafted of aluminum, with 12 OLED panels that illuminate surfaces below, and 12 additional OLEDs that shine upward to render a soft ambiance that evokes a lighter sense of space and visual comfort. The chandelier delivers a high light output of 2040 lumens while offering a CRI (color rendering index) of 80 and an efficacy of 35.2 lumens per watt. The luminaire features a total of 24 OLEDs with a CCT (correlated color temperature) of 4000 K while using just 58 watts of power. Aircraft cables suspend the chandelier from the ceiling, with a height adjustment up to 36 inches.

The Vela OLED wall sconce is designed in a unique decorative aluminum profile with six sophisticated OLED panels on its perimeter. Four square panels are connected in the center, by cross-shaped arms that are attached to two OLED panels on the ends. Housed within this exceptionally thin luminaire, the panels provide a wide, even illumination without glare. Perfect for use in hallways or as a decorative focal point, the brushed aluminum finished sconce uses 16.4 watts with OLED panels offering a 4000 K CCT, a CRI of 80, and an efficacy of 31.1 lumens per watt while delivering 510 lumens. With a depth of merely 2.25 inches, the sconce is 24 5/8 inches long and 13 inches wide.

Inherently sustainable and precision engineered, the luminaires are individually crafted with the world's most revolutionary light source in WAC's wholly owned, zero landfill manufacturing campus. With instant on/off and dimming capabilities, the Vela family delivers mercury free, consistent beams of light without glare and a 10,000 hour rated life. The OLEDs are uniformly luminous and evenly spaced on the luminaires with utility, proportion and style. ■

# World's First Zhaga Certified LED Recessed Luminaire

Cooper Lighting, an industry leader committed to delivering innovative products and driving transformational technology in the lighting industry, has announced that its IRiS™ Lighting Systems P3LED directional series is the first in the world to be a Zhaga certified luminaire.

**Cooper Lighting's IRiS(TM) Lighting Systems P3LED Directional Series features energy efficient LED technology and is the first in the world to be a Zhaga certified luminaire.**

Comprised of more than 190 companies from the lighting industry, Zhaga aims to develop mechanical, photometric, thermal and electronic specifications for interchangeability of LED light sources. Its goal is to achieve interchangeability of LED light sources to reduce cost and risk when developing products while not sacrificing design freedom and creativity. With Zhaga's efforts and certification, new LED light sources will be simpler to integrate and upgrade into existing environments and provide added confidence to end users.

Developed for demanding commercial and residential applications, the P3LED 3-inch aperture LED recessed series combines the flexibility of interchangeable optics with energy savings, long life and the sustainability of LED. The P3LED's unique design allows the light distribution to be modified during construction or years later by changing out the optical elements (trims), which are available in downlight, accent, wall wash and lens solutions. The series is currently available in 3000 K CCT, 85 CRI typical (80 CRI minimum) and is designed to last 50,000 hours.

The P3LED features a digital addressable lighting interface (DALI) option to work with Cooper Controls' Fifth Light advanced lighting management control system. The Fifth Light Technology Control and Management System conserves energy, reduces operating costs and improves light quality to maximize a building's performance. The system enables facility management to measure and control energy consumption across individual fixtures as well as provide for the integration and control of other building management systems across multiple applications.

The IRiS P3LED has recently been honored and recommended for specification in the fourth annual Next Generation Luminaires™ (NGL) Solid-State Lighting Design Competition. The prestigious NGL competition recognizes and promotes excellence in the design of energy-efficient LED commercial lighting luminaires. ■

# New Energy Efficient Marl LED Lighting Provides 1-2 Year Payback

Marl International has just released its most efficient ever range of high performance white LED lights, providing energy savings of 20% to 60% against conventional lighting technologies in applications like industrial, office and warehouse internal lighting, security and event floodlighting, street lighting and other applications.

**Marl's Bay Range of efficient industrial and office lights uses latest LED technology and provides 1-2 year payback**

The key feature of the new Marl Bay Range is its efficiency of 83-94 lumens/watt from a 110V-277V AC mains supply. For example, the 770 series light generates up to 8,800 lumens from a 94 W supply, making it amongst the most efficient light sources available. Bay Range LED lighting is very directional, so that all of the light created illuminates the target area and there are no UV emissions, further enhancing efficiency. Bay range lights are offered with a choice of narrow (23°) or wide (50°) beam angles.

Commenting on the release of the Bay Range, Marl Managing Director, Adrian Rawlinson, said, “LED technology has moved forward rapidly even in the last few months, and more efficient light engines allow the creation of much brighter luminaires without excessive heat generation. Marl’s designers have exploited these characteristics to the full, creating a range that makes energy efficient LED lighting a viable option for the most intense illumination applications such as street lighting, flood lighting and even photographic studio lighting as well as more standard interior or exterior industrial and office lighting applications.”

He continued, “The new Bay Range is amongst the most energy efficient lighting available for industrial and office premises, and provides an instant, convenient and highly controllable source of light.

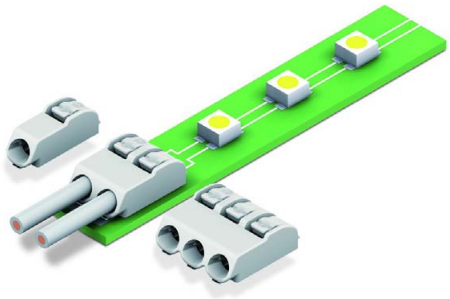
The first products in the Bay Range to be released are the 770, 771 and 778 series. The 770 series are square units with 2 or 3 LED modules offered in Cool White, Neutral White or Warm White form. For high bay applications, Marl is offering the 778 series, featuring six LED modules as well as the 771 series for long bay applications. All three offer the same exceptional efficiency and operate direct from a standard European or US mains electrical supply. The Marl Bay Range has been built using the latest high efficiency, high brightness Cree and LumiLEDS LED light engines.

Colour renditioning for all lights is very good, and each product is offered in a choice of cool or natural white colour temperatures. The lights can be readily integrated with dusk to dawn and motion sensors, and are offered with optional 1 to 10 volt dimming control lines. Most are sealed to IP67 standards, rendering them suitable for most indoor and outdoor applications.

Following the launch of the new range, Marl is offering customers the opportunity of a free lighting survey of their premises by a professional lighting engineer, who would produce a report detailing the energy savings available by adopting Marl’s class leading technology. Its team is nationwide, and can provide local support on upgrading customer’s lighting installations. ■

# WAGO's 2060 Series PCB Terminal Block for LED Lighting

When the focus is on ease of use and compact design: WAGO is going forward with the transition of lighting technology to LED systems with its 2060 Series PCB terminal block.



**2060 LED lighting terminal block from WAGO**

Screw base, glass bulb, filament – and an efficiency level of less than 10%. The classic light bulb has, at least from an energy perspective, long since become obsolete. Alternative technologies are making rapid advances, halogen, and energy-saving lights are steadily replacing the technology that established itself at the onset of the 20th century. These alternative technologies are now also faced with a competitor that profits from ongoing technological advances and that is becoming more and more popular both in private households and in industry: the LED.

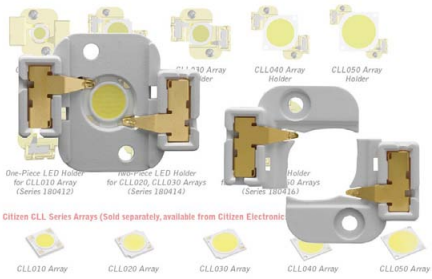
As a partner to the lighting industry over many years, WAGO has also developed the fitting product for this current lighting trend. The physical dimensions of the resulting product are extremely small - which makes its impact all the greater: the 2060 Series push-button-equipped PCB terminal block. This product has set the new standard on the market when it comes to quick and reliable connection and installation of LED modules and industrial SMD electronics components.

No bigger than a small fingernail, the 2060 still has all the standard connection features for which WAGO is so famous around the world: CAGE CLAMP® S connection, for example, enables direct, easy push-in of solid conductors, which saves a great deal of time during installation. Integrated push-buttons simplify connection of fine-stranded conductors and disconnection of all types of conductors – even for cross sections of 0.2 $mm^2$ to 0.75 $mm^2$. Lateral conductor entry combined with push-button action from the top means easy, convenient handling for manual wiring tasks. This series is also suitable for use in future, automatic lighting fixture wiring tasks.

With a height of just 4.5 mm and its light color housing, this module minimizes on-board LED shadowing. WAGO offers the 2060 Series in tape-and-reel packaging, meaning it can be fully integrated into automatic production processes. Any number of poles can be obtained by combining 1-, 2- and 3-pole terminal blocks, as they can be positioned adjacent to one another without loss of any poles. This provides full flexibility with fewer versions for lighting fixture and LED module manufacturers, ordering parties and industrial end customers. ■

# Molex Introduces New Connectors and a 50mm Diameter SSL Source

Molex Incorporated continues to support lighting designers and manufacturers with a broad portfolio of interconnect solutions for the solid state lighting market. Over the years, Molex has utilized its extensive resources and expertise to develop products that help advance LED technology by providing vital electrical connections for multiple applications.




**The solderless LED holders for the Citizen COB LEDs are just one example of Molex's broad product range supporting SSL**

Solderless LED Holders:
Molex Solderless Array Holders are designed to allow light fixture manufacturers to easily create an electrical connection between an LED array and a power source. The unique dual wire trap compression contact powers the arrays while eliminating the need for hand soldering or expensive surface mount technology equipment. This product simplifies the installation process and provides field serviceable benefits when designing and maintaining LED lighting applications.

Molex currently offers LED array holders for the Citizen CLL-330 and CLL340 LED array products, which provide unique compression contacts to power the arrays while eliminating the need for hand soldering or expensive Surface Mount Technology (SMT) equipment. Ideal for light fixture original equipment manufacturers (OEMs), the holders reduce installation time and increase connectivity options while lowering costs. its new LED array holder will support Citizen Electronics' recently introduced Chip on Board (COB) series of arrays: CLL010, CLL020, CLL030, CLL040 and CLL050. The solderless screw-down connection allows for a standardized manufacturing process, adding to the design flexibility of the Citizen COB series of LEDs.

Light Disk:
Molex is developing a new generation solid-state lighting product that will integrate the light source, electronics, optics and thermal management into a 50 mm diameter, 10mm high disk using state-of-the-art Molded Interconnect Device (MID) technology. This universal light source will be capable of being "dropped" into a PAR bulb, A19 bulb, downlight or a variety of other light sources currently under development. It will be powered directly from line voltage and be the equivalent to a 75 watt light bulb.

Molex showcased some of its fine pitch micro miniature connectors ideal for the lighting market:

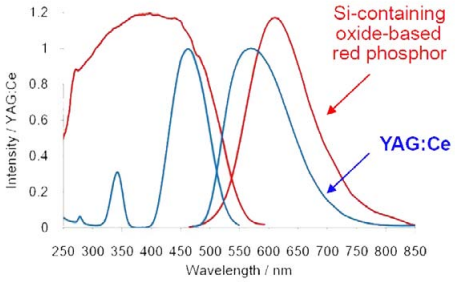
- Pico-EZmate™ wire-to-board connectors
- PicoBlade™ wire-to-board connectors
- CLIK-Mate™ wire-to-board connectors
- SlimStack™ board-to board connectors

"One of the most critical aspects of solid-state lighting is developing electrical components that can efficiently, reliably and safely power the LEDs without incurring large cost increases," said Greg Kuchuris, product manager, Molex. "By tapping into our long-standing electrical, connector, thermal and optical expertise we've developed world-class solutions that provide lighting manufacturers and designers with the highest quality, safest and most cost-effective lighting interconnect products on the market today." ■

# New Oxide-based Red Phosphor

Sumitomo Metal Mining Co., Ltd., working in collaboration with a research team from Tohoku University's Institute of Multidisciplinary Research for Advanced Materials (IMRAM) headed by Professor Masato Kakihana, has succeeded in developing a new silicon-containing oxide-based red phosphor for use in white LEDs. The new phosphor can be manufactured less expensively than earlier red phosphors and is expected to contribute to higher performance in white LEDs as sources of illumination.




**Si-containing oxide-based red phosphor excitation and emission**

Today, most white LEDs in usage combine a blue LED and a yellow phosphor (YAG:Ce), but the obtainable white light offers insufficient color rendering for use as a source of illumination. Achieving fine natural hues has posed a challenge, and a solution has been sought through simultaneous usage of yellow and red phosphors. To date, the only commercially viable red phosphors available have been nitride-based, and these have been costly owing to the need for a special manufacturing process involving firing at high temperature and pressure levels.

The collaborative R&D program succeeded in developing the first oxide-based phosphor containing silicon (Si) capable of emitting light across the orange-to-red spectrum (600-625 nm). The phosphor's host crystal is a composite oxide of alkaline-earth and Si, with europium added as a light-emitting element; it emits red light by blue LED irradiation. The new phosphor can be manufactured at lower cost since production can be carried out at lower temperatures than nitride-based phosphors and at normal pressure levels, eliminating the need for expensive equipment. Going forward they are expected to come into use in white LEDs answering the call for sources of illumination offering greater color rendering. ■

Another epoch making aspect of this R&D is the use of a proprietary aqueous solution method whereby a water-soluble silicon compound – propylene glycol-modified silane (PGMS) – is applied to achieve synthesis of a Si-containing oxide-based compound. Going forward, further usages of PGMS can be expected to accelerate the development of high-luminance and other new phosphors.

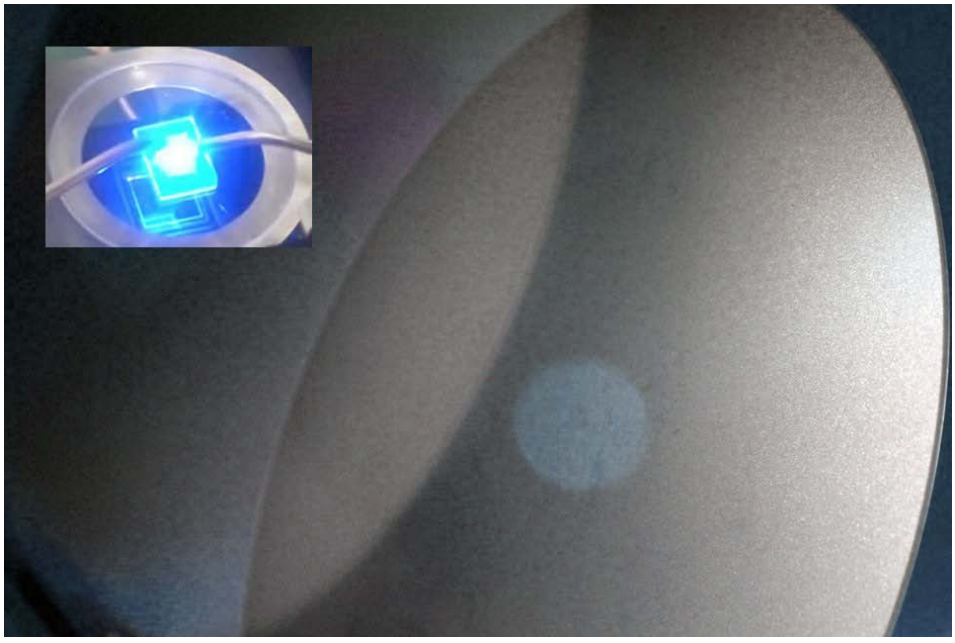
To date SMM has undertaken the development of technology for manufacturing high-luminance Si-containing oxide-based phosphors and technology for coating phosphor surfaces with a thin film in order to further enhance their moisture resistance and optical properties. These technologies have been applied in the newly developed oxide-based red phosphor, and plans will now focus on providing film-coated oxide-based red phosphors to the market.

# NGK Developed GaN Wafer for Ultra High Brightness LEDs

NGK Insulators has announced it has developed gallium nitride (GaN) wafers that double luminous efficiency of a LED light source compared to conventional materials. Created with original liquid phase epitaxial growth technology, NGK's GaN wafer has low defect density and colorless transparency over the whole wafer surface.

With the assistance of a research institute outside the company, a light emitting test was performed on a LED element using NGK's GaN wafer. The test showed a world top class internal quantum efficiency of 90% at an injection current of 200 mA. The GaN wafer achieves a luminous efficiency of 200 lm/W, which is twice as efficient as those on the market today. Under the same brightness, this reduces power consumption by 50%. Since the wafer reduces heat generation within LEDs, it lengthens lifetime of LEDs and enables downsizing of lighting equipment.

NGK established a new department named "Wafer Project" this month, aiming at prompt commercializing of wafer products. Within 2012 the Company will launch the shipment of sample products of 4-inch-diameter GaN wafer, which is the world's first 4-inch-diameter GaN wafer produced with the liquid phase epitaxial growth technology. NGK is accelerating the development of GaN wafers with lower defect density and of larger diameter (6 inches), aiming at the market for wafers to be used for power devices for hybrid cars, electric vehicles and power amplifiers for cellular base stations. The GaN wafer is optimum for such applications, taking advantage of its features including high breakdown voltage, high frequency operation. ■



**NGK's GaN wafers promise improved internal quantum efficiency - small image shows LED element under light emitting test (Substrate size: 1cm square, Element size: 0.3 mm square, Injection current: approx. 200 mA, Center wavelength: 450 nm)**

# Your LEDs should only dim when you want them to.

The most trusted name in lighting is now powering the most innovative lighting solutions in the industry. Introducing the **GE Lightech™ LED Driver.** Effective, reliable and intelligent, the **GE Lightech LED Driver** enables you to create next-generation LED lighting systems that push the boundaries of performance and redefine efficiency.

Visit GELighting.com/Lightech to learn more.

imagination at work

# LFI 2012, LED-Lighting and Architecture Progress

The LIGHTFAIR® International (LFI) Exhibition is an annual Trade Show that serves the architecture and commercial lighting industries as the world's largest annual architectural and commercial lighting trade show and conference. Alan Mills visited the show for LED professional and reports about the most innovative awarded products and technology highlights.

As may be anticipated, the Light Fair International benefits greatly from light emitting diode (LED) design and application technologies that are increasingly used each year in architectural lighting. LIGHTFAIR® 2012, celebrates its 23rd annual event, which was held in Las Vegas. Based on its popularity, the increasing use of LEDs and perhaps aided by its location, the event broke many of its own records. These included 505 exhibitors, 200,000-plus square feet of exhibition space, and an all-time record of over 24,000 registered attendees from 73 countries, all being eager to see or display what were claimed to be the most innovative lighting products of 2012. LFI also provided 72 educational courses whose topics included LEDs, OLEDs, retrofitting, daylighting, lighting design, controls, and energy efficiency. Exhibitors often use LFI to introduce new products and many actively partake in the Innovation Awards program. This meeting is also sponsored by IALD, the International Association of Lighting Designers and IES, the Illuminating Engineers Society.

## Defense and Security LED Perimeter Lighting

The "Most Innovative Product of the Year" at LightFair 2012, was awarded to CAST Lighting Inc., for the Company's 'Defense and Security LED Perimeter Light'. CAST Lighting, based in Hawthorne, New Jersey, is a manufacturer of low voltage outdoor lighting, mostly LED-based and claims to have "the lighting industry's most durable and robust outdoor lighting for defense, security, landscape, and architectural applications." This award represents the conference's highest honor, recognizing the "best of the best" in the lighting industry selected from 228 entries.

The winning product is CAST Lighting's LED Perimeter Light, a compact, energy efficient security light adapted from landscape lighting and designed to mount on chain link fence posts. Powered by a small 24-volt, 200 watt transformer, the lights are positioned every 20 to 30 feet along the chain link fence and can provide highly controlled illumination along extremely long fence lines. It is an order of magnitude improvement over existing long-perimeter and other security lighting products. The award panel judges, all top lighting professionals, were impressed by the innovative design and thinking behind the luminaire and their comment was "Never has so little light done so much work. We found this (luminaire) to be a simple, clean, efficient, energy-effective solution which could be used on nearly every property. It leverages the best benefits of the LED; low voltage operation, optical efficiency, small size and long life for a very robust security lighting solution." As an example, the CPL-1 lamps are dark sky compliant and a 500 foot installation costs about $1700 US to install. It uses cast bronze cases and stainless steel internal components that are corrosion resistant even in coastal regions. With

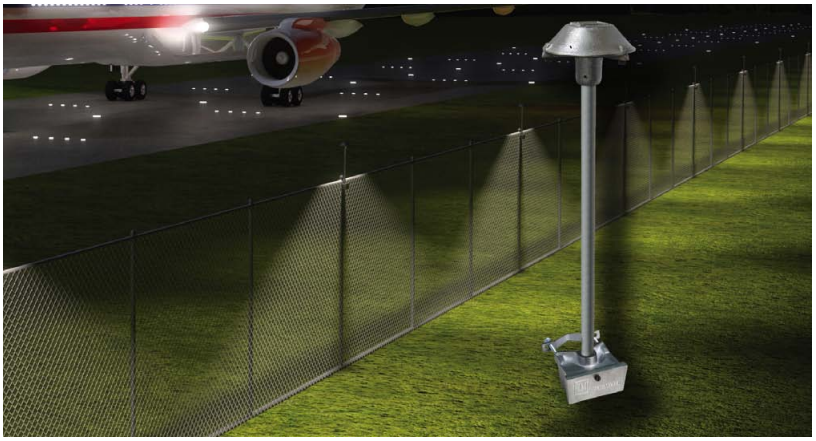


**Figure 1: Typical application of the CAST Lighting Defense and Security LED Perimeter Light (CPL1)**

the Cree LEDs using only about 20 W per 100 feet, annual costs are quite low and a 13 to 20 year useful life is expected, depending on their daily use. Rapid deployment versions for military or disaster use are now available.

The task of illuminating long perimeter fences has always been problematic with a typical solution being to install tall, pole-mounted luminaires such as metal halide lamps that flood fence regions with light. This approach wastes considerable amounts of energy since most of the illumination falls outside the perimeter region. Installation of these pole-mounted lights is also very expensive in both material and labor. Typical metal halide pole-mounted lamps would require nearly 4,000 watts to light that same length of fence. The new CAST Lighting LED Perimeter Light uses just 7 watts per luminaire and can illuminate 500 feet of fence with less than 150 watts of power (Figure 1). It represents a 96% savings in energy cost, with the LEDs providing much longer lamp lifetimes and greatly reduced maintenance costs. CAST's focus for their entire line of outdoor products has been the unique challenge of putting sophisticated electronics into a light fixture that could withstand extreme environmental conditions. "We protect the LED circuit from moisture, heat, voltage variations, and electromagnetic interference." The result is an extremely robust LED security light that will survive many years without problems." For these reasons, the CAST Perimeter LED Lights are becoming are becoming a must have product for Homeland Security and other government surveillance needs.


**Figure 2:**
**Lumenetix's compact color tunable module was another innovative award winning product at LFI 2012**


**Figure 3:**
**Juno Lighting presented the 3rd generation of its award-winning WarmDim™ light engines that changes CCT when dimmed towards zero**

## Color Tuning of Light and Illumination

An interesting and forward looking Innovation Award was presented to Lumenetix Inc. of Scotts Valley California for the Araya Color Tuning Module (CTM) and their Light Commissioning Tool (LCT). They have adapted the superior properties of LED based light engines to provide the high level of color tuning that is essential for the reproduction of natural shades or variations in the white lights of daylight that change with the sun's elevation during the day. The different colors of daylight available from the Araya CTM replicates natural shades of white light that range from the warmer light of sunrise and sunset to the cooler light of the afternoon sun. It could become an integral part of many future lighting systems. The color tuning modules feature 12, 19 and 32 mm sources powered by 10 or 14 LEDs, which offer the 'warm white' light of about 2500-2700 K to the cool white light of over 6000 K Correlated Color Temperature (CCT). The Araya Light Commissioning Tool (LCT) wirelessly dims and tunes the CTM along the Planckian curve at very high CRIs (color rendition indices) and within the Kelvin warm to cool natural source temperature range. Illustrative of the high quality, natural white light produced by Araya, the CTM 019 features delta UV of ±0.001, Ra values of 91-95 and R9 values of 92 - 98 throughout the tunable range. This LFI Innovation Award was given to Lumenetix for the 'LED/OLED Chips, modules, light engines, plasma and OEM subassembly category,' in which other well known finalists (Cree Inc., Nichia Corporation, Philips Electric, and Ushio America Inc.) were also competing.

## LEDs to Mimic Incandescent Lighting

The Technical Innovation Award was given to the Juno Lighting Group, a Division of Schneider Electric, for their WarmDim™ LED Downlights. Such downlights and their recessed cans are usually mundane articles of commerce, but Juno Lighting has been able to mimic incandescent lighting with respect to one of its 'most

desirable properties' for the developed World user, namely a red shift when being dimmed. Incandescent bulbs typically produce a 'warm' ambience due to their low °Kelvin source temperatures (usually in the 2700 to 3000 K range) and as they are dimmed they exhibit a red shift and produce even 'warmer' or redder illumination. The Award winning Juno Lighting 3rd Generation WarmDim™ light engines have achieved this LED red shift technology by the use of micro-processors for controlled dimming using dedicated 120 V drivers. At the same time, the 3000 K WarmDim™ downlights produce 600 lumens from only 14 watts and their 'effective thermal management' should guarantee a 50,000 hour service life to 70% output. Juno's WarmDim™ LED Downlights can be used either with magnetic or electronic low-voltage dimmers and they are compatible with a wide selection of existing housings.

**Figure 4:**
**FIN™ luminaires use Lumina™ panels**

**Figure 5:**
**DEFINITY™ PAR 30 lamps combine Wi-Fi, advanced lighting intelligence and control by integrating both motion and ambient light sensing**

## Decorative Lighting Panels

The Design Excellence Award was presented to Sensitile Systems, LLC® of Ypsilanti, Michigan for the manufacture of decorative luminaire lighting panels now sold under the FIN™ product name. The company supplies a wide range of materials and lighting products to the architectural and design communities. It has modified their Lumina™ decorative LED panels into interior wall and ceiling mountable FIN™ series LED luminaires. These are now offered as the FIN™ series of energy efficient and award winning Light Fixtures.

Sensitile describes their Lumina™ panel as a revolutionary material that transforms a single energy efficient LED light source into an entire surface within which thousands of points of light appear to seemingly float. Lumina™ panels not only allow the creation of ever changing "walls" of light, whose color can be effortlessly renewed, they also extend the usability of intense LED point sources by effortlessly radiating their brightness and allowing (an owner or designer) to build with light itself. 'Our materials are designed to creatively interact with all facets of light and illumination and are distinguished by their dynamic qualities."

The FIN™ luminaires are made as one-inch-thick panels with anodized aluminium trim and are available in two foot to eight foot lengths for either wall or ceiling mounting. When illuminated, the entire panel surface "appears to contain thousands of floating points of light producing a dramatic and decorative" lighting effect. The use of LEDs and the Lumina™ panels allows the FIN™ luminaires to be offered in either packaged illumination solutions or customizable designs that create 'color changing lighting effects to activate any indoor space.' Incidentally, Sensitile Systems also won the Best Booth Award (see Figure).

## Motion Activated PAR 30 LED Lamps

The final winner in the key technology group of companies is the Lighting Science Group from Satellite Beach Florida, which received the Judges' Citation Award for its DEFINITY™ motion activated PAR 30 LED lamps. This was a special-recognition innovation award given at the judges' discretion.

As the use of LED luminaires continues to grow worldwide and their applications base continues to expand, additional requirements are being made for more features to be included in new product groups. This was the case for in the past when video and motion sensors such as passive infrared use (not reliable over wide temperature variations) were required external to the lamps for a complete system operation. Lighting Science's new DEFINITY™ PAR 30 lamps combine Wi-Fi, advanced lighting intelligence and control by integrating both motion and ambient light sensing into the lamp thus eliminating the need for external automation controls. The user-selectable options built into the DEFINITY™ lamps include dimming range, time delay, and motion and distance sensitivity. At the same time this 'winning' LED PAR 30 is 80% more efficient than the halogen lamp that it can replace. These new Wi-Fi intelligent lighting systems allow lower system installation costs and can boast of much lower lifetime maintenance and manufacturing costs.

This LFI exhibition was a technical eye opener into future LED luminaire advances being made possible for domestic and commercial lighting and even virtual film making technology, as could be heard in Professor Paul Debevec's keynote speech to his 21st Century curriculum covering a concrete and virtual world of entertainment, whose LED based Light Stage Systems facial scanning technology was used by Sony Pictures Image Works to create photo-real digital actors in the Academy Award winning visual effects in Spider-Man 2 and for Avatar.

Should this report's technology have piqued your interest, next year's LightFair International 2013 will be held April 23rd to 25th in Philadelphia, PA, USA. ■

# LpS 2012 Preview – Latest Technologies, Presentations, Discussions and Networking

The 2nd LED professional Symposium +Expo will take place on September 25th to September 27th. Gerlinde Graf, the LpS Promotion Manager at LED professional gives us a glimpse of the highlights, explains what is new and what we can expect from LpS2012.

There are still a vast amount of challenges related to the development and manufacturing of LEDs. Some of them are not directly related to the manufacturing technology for LED-based luminaires. Nonetheless, they are important factors in the general commercialization of LED products. There is, for example, the need for education in LED-based luminaire design and the understanding and manufacturing of luminaire reliability. Other tasks include integration at the components level as an important consideration for lowering costs and improving product quality. Among other things, hybrid integration schemes could have a significant impact on the final luminaire costs.

The LED professional Symposium & Exhibition targets groups and individuals who are involved in some or all of the above and are looking to gain and exchange information on LED lighting technologies and its applications in light modules and lighting elements. The symposium is technology oriented and therefore an ideal meeting place for specialists from research and industry.

## A Big Leap Beyond Last Year's Event

Quality growth is just one feature at the LpS 2012. While in 2011 over 700 experts from all LED lighting technology fields attended the LED professional Symposium +Expo, this September more than 900 industry specialists and more than 70 exhibitors are expected in September in Bregenz. Visitors come from a wide range of luminary and lighting industries. In 2011 20% were involved in luminary & lighting system manufacturing, 12% came from research & education, 9% from distribution, 7% from LED manufacturing, 6% were involved in engineering & design services, 5% were driver & supply manufacturers, 12% were electronic component manufacturers, lamp manufacturers and consultants. Specialists from all these fields are expected in Bregenz again this year to glean information from the new Tech Panels, the highly significant sessions and a cutting edge workshop. Additional product information and the latest industry developments will be available from the exhibitors directly. A specially organized networking event will provide still more opportunities to discuss a vast variety of subjects, establish new contacts and intesify existing ones.

**Dr. Eng. Stelian Matei, Manager Semiconductor Lighting Centre, Electromagnetica SA. commented on the LpS 2011:**
"I was not only impressed with the conference content, but with the venue and set-up as well. I had the opportunity to attend a similar event afterwards which unfortunately did not impress me as much as LpS did. I hope the LpS event will become a permanent European event. Thank you again and hope to meet with you at the next LED professional Symposium."

## LpS 2012 Introduces Tech-Panels

The newly established Tech-Panels will give attendees the opportunity to discuss highly current topics with a group of specialists. OLED, Thermal-Management and LED Lamp Tech-Panel discussions will be set-up with the experts to deepen the attendee's knowledge in these specific domains.

OLEDs are the next challenge that luminaire manufacturers will be facing. In some aspects they can be treated similarly to LEDs but not in others. Luminaire and module manufacturers have certainly learned from the inorganic relatives of the OLEDs and OLED suppliers are working hard to optimize the technical and quality parameters. However, some questions may still be unanswered or unclear. The expert panel will discuss

and clarify technical issues such as OLED types, color consistency and luminous homogeneity, reliability, temperature dependencies as well as how to drive OLEDs.

Thermal management will deal with the efficacy of LEDs that have improved a great deal over the years. However, in an LED lighting system 60-80% of electrical energy is still transformed into heat and has to be dissipated. Discussions are ongoing concerning which thermal management method should be applied. There are the questions of whether active or passive cooling is sufficient or necessary and if it leads to a relevant increase of system efficiency or not. Does it sacrifice or improve system reliability? Does it increase costs disproportionally? Can it improve light quality?
The expert panel will talk about and shed light on these and other technical issues.

LED replacement lamps have made a great deal of progress. The first 100W equivalent bulbs were announced recently and will be available on the market soon. Designing reliable replacement bulbs is still one of the most challenging tasks. Engineers have to deal with inappropriate form-factors, sockets, dimming devices or other electronics. One may ask if there are alternative solutions and what they might look like. On the other hand, we have to find solutions that will serve the billions of existing sockets and apply technologies that lead to reliable products immediately. The plenum will be discussing the different approaches and technical key issues for lamp designs.

**Figure 1:** **Enthusiastic and informative speeches can be expected again this year like the one given by Andrew Dennignton, Optical Design Manager at Polymer Optics in 2011**

**Figure 2:** **Attendees are captivated by the lectures**

## Sessions Jam-Packed with Highly Relevant Topics

This year's event will feature three keynote speakers, one workshop and 26 lectures in eight sessions. LED-professional is proud to announce that Dr. Sergei Ikovenko has agreed to lead the workshop in 2012. Over 50 satisfied participants attended the workshop in 2011 and "Operating Beyond Competition" in 2012 will deal with competitive patent circumvention strategies using Function Analysis and TRIZ. The workshop will precede the symposium and will be followed by the keynote speeches and the opening of the exhibition.

The participation of Mr. Michael Ziegler (Ph.D.), member of the Photonics Unit at the European Commission's General Directorate as keynote speaker underlines the importance of the LpS for the LED community. He will report about the status of the Green Paper "Lighting the Future" initiative. He will also report on the results of the open consultation and provide an overview of EU initiatives relevant for the faster deployment of SSL in Europe.

The second keynote speaker, Dr. Hans Nikol, the VP of LED Technology Strategy at Philips Lighting will give insights into future perspectives with intelligent light sources, embedded lighting and new form factors not possible before. In addition, exciting features for luminaire manufacturers, specifiers, light designers and other key players in the lighting industry will be discussed.

The closing session will be presented by Prof. Andreas Schulz, Professor HAWK Hildesheim and CEO LichtKunstLicht AG, and Member of the IALD Board of

Directors, who will demonstrate state-of-the-art technology for LED lighting designs using the example of a museum project. He will also discuss strategies, design approaches and explain the characteristics implemented in lighting technologies.

The eight sessions are scheduled for days two and three. The first session will disclose disruptive LED technologies to the audience. GaN-on-Si, while being a challenging technology is already around the corner with mass production announced for 2013. Two speakers, Pars Mushik (Yole) and Tom van den Busche (Bridgelux), will concentrate on this topic. Another hot topic, driverless AC LEDs, will be covered by Bob Kottritsch (Link Labs) and Thomas Zabel (e.lumix). In addition, Mr. Zabel will show in-chip protection using a grid load regulator in-chip layers to prevent hot-spots and improve thermal stability of the LEDs.

The morning will continue with talks on LED light conversion technologies. The three speakers Lena Pilz, Johannes Nicolic and Dominic Sacher will speak about mechanisms of white light generation with phosphors, from efficiency to physical limits, thermal issues of phosphor converted LEDs like temperature distribution in an LED package and thermally induced color deviations and new and remote phosphor technologies for future solid-state lighting designs with improved CRI of more than 95 and phosphors with higher temperature stability.

After the lunch break Alexander Leis, Hans Laschefski and Angelika Hofmann will introduce the audience to the latest developments in LED optics design, speaking in detail about optical design challenges when using multi-chip or single-bin LEDs, such as spatial color and distribution problems, intelligent reflector technology for glare reduced LED luminaires with high optical efficiency and tolerancing tailored freeform optics for illumination systems to compensate shape and assembly deviations by automated tolerancing.

The concluding session of the day will cover important aspects of LED electronic systems design. Subjects such as LED driver designs to overcome the costs vs. performance dilemma, understanding the challenges and complexity of LED dimming technology explaining pros and cons of current vs. PWM dimming, application of color-managed ambient light sensor for advanced LED lighting systems to optimized daylight harvesting, and optimization of absolute accuracy for true color sensors in a closed control loop to provide constant luminous color over life-time will be presented by Peter Green, Steve Roberts, Sajol Ghoshal and Fredrik Hailer.

On the third day most current issues of LED Production Technologies & Materials, LED System Standardization & Measurement, LED System Reliability and LEDs in Outdoor Lighting Applications will be covered in four sessions.


**Figure 3:**
**Exhibition floor space has been increased by almost 50% giving exhibitors more opportunities**

In the first session of the day Harald Reisigl will introduce the audience to “Glass - A Viable Alternative Optical Material for LED Applications”. He will be followed by Huub Claassen speaking about compression and transfer molding solutions for HB LED optics for a significant cost reduction. The final speaker of this session is Andreas Steffen Klein with his important subject of stamped circuit board technology as an alternative solution for SSL thermal management.

Before the lunch break Dawson Liu will speak about Zhaga compatible light engines. Requirements, design and compliance will be explained for the "Book 3" spotlight engine. Dirk Hansen will cover LED measurement issues to obtain polychromatic raydata using a near-field goniometer and their value for simulations, and Peter Laepple will address the subject of measurement of LED light sources and interpreting data in respect to photobiological safety standards.

The afternoon will start with three presentations on LED system reliability. The speech about fundamentals of LED system design to avoid mistakes by Shawn P. Keeney comes first and will be followed by Reinhard Pusch's contribution about failure analysis and actions to improve lifetime and reliability. The session will be concluded with the topic of reliability issues of LEDs and LED based luminaries for outdoor applications in respect to humidity and sulphur contamination by Janick Ihringer.

The final session of the symposium will feature Andreas Ueberschaer, Bob Derringer and Daria Casciani with their highly relevant talks on the influence of the light spectrum on visual perception in street lighting applications showing results under normal and poor light intensity, design process and optics selection for roadway lighting applications, and discussing why the optics selection should take place in an early stage. There will be an analysis of three projects to optimize the design process of street lights with the goal to define a design strategy toward efficient, sustainable and performing lighting fixtures.

LED professional | SYMPOSIUM +EXPO

LpS 2012


# LED Lighting Technologies

## International Winning Approaches

### 2nd International LED professional Symposium +Expo

LpS (LED professional Symposium) is Europe's foremost LED lighting technology event for lighting experts in industry and research. The symposium covers LED lighting technologies for luminaries, lamps and modules focusing on new system approaches, new components and the most up to date design methodologies.

### Keynote Speakers / Workshop

**Michael Ziegler**
Member of the Photonics Unit at the European Commission's General Directorate for Information Society and Media

**"The Future of Solid State Lighting in Europe"**
*An overview of EU initiatives launched under the Digital Agenda for Europe in the area of Solid State Lighting.*

**Dr. Hans Nikol**
VP LED Technology Strategy, Philips Lighting, Netherlands

**"LED Technology Overview & Trends"**
*Summary of recent LED technology trends and strategies for future lighting system developments.*

**Prof. DI Andreas Schulz**
Professor HAWK Hildesheim and CEO LichtKunst Licht AG, Germany. Member of the IALD Board of Directors

**"Challenges and Opportunities of LED Technology in Lighting Projects"**
*Demonstrating state-of-the-art technology for LED lighting designs using the example of a museum project.*

**Prof. DDr. Sergei Ikovenko**
Director and Chief Specialist, Innovation Leadership Programs, Massachusetts Institutes of Technology (MIT), USA

**"Operating Beyond Competition" - Workshop**
*Competitive patent circumvention techniques using TRIZ with examples from LED lighting and other industries.*

### EVENT OVERVIEW

Over **900** experts from all LED lighting technology fields anticipated.

Top class contributors will present **30** lectures covering highly relevant technologies.

More than **70** exhibitors expected from all over the world.

### SYMPOSIUM SESSIONS

- Disruptive LED Technologies
- LED Light Conversion Technologies
- LED Optics Design
- LED Electronic Systems Design
- LED Production Technologies & Materials
- LED System Standardization & Measurement
- LED System Reliability
- LEDs in Outdoor Lighting Applications

## 25-27 SEPTEMBER 2012 | BREGENZ | AUSTRIA

**CONTACT:** LUGER RESEARCH | Moosmahdstrasse 30 | 6850 Dornbirn | T +43 5572 39 44 89 | F +43 5572 39 44 89 90
info@lps2012.com | www.lps2012.com

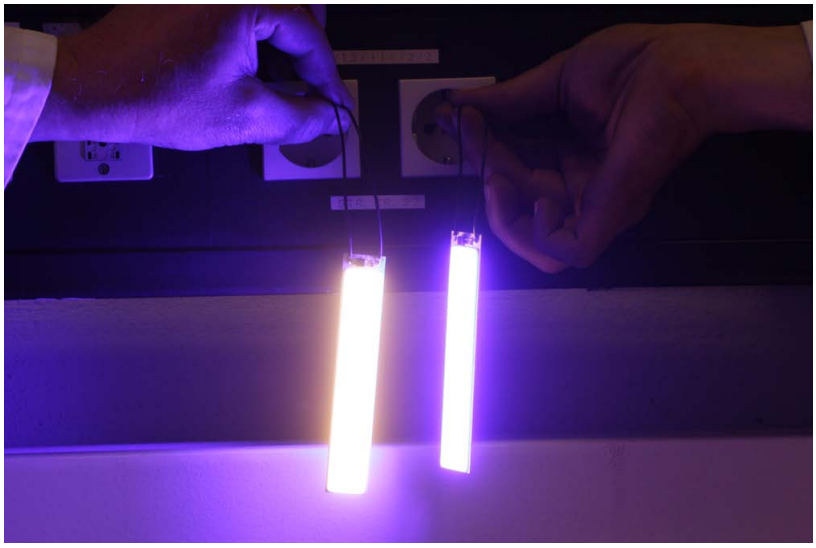


**Figure 4:**
**The driverless AC LED modules from e:lumix is just one example of the new developments which will be displayed by a number of exhibitors**

All speakers will be available for questions and further discussions after their talks, during the breaks and at the Get Together networking event.

## Meet the Sponsors

Some of the biggest names in the LED industry have already joined the LED professional Symposium +Expo 2012. Sponsoring maximizes marketing opportunities in the run up to the September event online at www.lps2012.com, LED professional event newsletter, the symposium program and PR.

As the exclusive Platinum Sponsor, e:lumix can take advantage of a high amount of exposure before, during and after the event. e:lumix Technologie AG is a leading and innovative manufacturer of LED-Chips and solid state lighting solutions. As a producer of LED semiconductors as well as a vendor of replacement light items and innovative lamp bodies for general lighting technology, the company is in control of the complete process chain beginning with chip production all the way to the final product. Based on the long experience of the team in the field of architecture lighting and production of semiconductors, as well as the vertical range of manufacture (own production of LED semiconductors (Chip-FAB), metal and plastic processing, own production of boards and electronic components), e:lumix is able to act demand-oriented as well as flexible on market needs and special requests from costumers.

e:lumix will be presenting standard products as well as prototypes that Thomas Zabel talks about in his presentation on 54 m$^2$ of exhibition space. The booth will also enhance their exposure and maximize customer contacts.

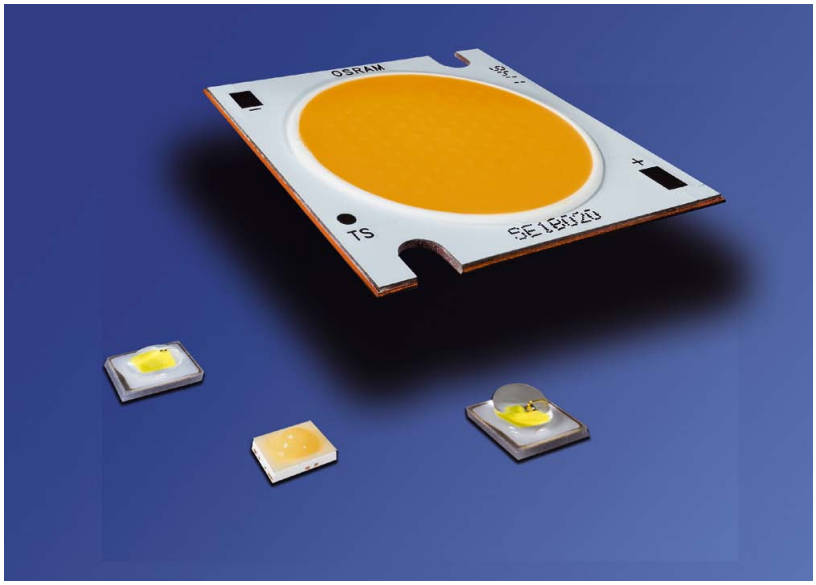



**Figure 5:**
**The SOLERIQ® E (top), the OSLON® Square (left), the DURIS® P 5 and the next generation OSLON® SSL are Osram OS's most recent innovative products that will be shown at LpS 2012**

Our Gold Sponsor, Osram Opto Semiconductors, one of the leading manufacturers of opto-electronic semiconductors will be present in their 27 m$^2$ booth. The world-wide network, LED Light for you, offers a platform where certified partners can put their know-how forward to help realize LED projects. It doesn't matter if they are standard or individual solutions. The specialists come from the areas of optics, thermal, electronics and system integration. The latter accompanies a project through all of its phases, from development to the finished product.

Osram Opto Semiconductors will be presenting its most innovative products in the area of Solid State Lighting, SSL, at the LED professional Symposium. Just to name a few, the 3 mm x 3 mm outstanding, efficient, high performance LED OSLON® Square that offers maximum flexibility for indoor and outdoor lighting. Furthermore, the highly efficient mid power class LED, DURIS® P 5, impresses with its long life even at high currents and temperatures as well as high luminance efficacy, a high maximum current of 200 mA and its elevated corrosion resistance. The SOLERIQ® E array LED will also be there. It comes in two sizes and is easily applied using a metal core board. It is especially made for downlight solutions from 1500 lm to 4500 lm and diverse color temperatures from 2700 K to 6500 K. The Chip-on-board LED with its color consistency within 4 Step MacAdams, impresses with high light yield and a color rendering of CRI > 80. Of course the next generation of the compact OSLON® SSL, the first high performance LED with optimized radiation angles (80°/150°) is on display too. It is an excellent choice for use with secondary lenses or reflectors. A range of CRI variations in color temperatures from 2700 K to 6500 K fulfil the most diverse application requirements.

Tridonic is the second LpS 2012 Gold Sponsor. Their R&D department has been engaged in the quest for perfect light for over 50 years. They focus on making a contribution towards better lighting results by providing constantly upgraded modern components, continuously improving the reliability and security of lighting systems and doing their bit towards climate protection. Tridonic's latest highlights are the OLED products that came out at Light+Building this spring.

## More Networking Opportunities

In addition to the networking opportunities during the session breaks and also at the exhibition throughout the three days of the Symposium, a relaxing Get Together Event has been organized for Wednesday, September 26th from 07:30 pm to 11:00 pm. Whereby last year the Get Together Event was exclusively for the attendees, this year, visitors, attendees, exhibitors, press and sponsors can join the cruise around Lake Constance with dinner and live entertainment. This will provide additional opportunities to continue technical exchanges started earlier in the day, mingle, develop contacts and meet new people. The objective of the evening is to relax and enjoy.

**Figures 6 & 7: The Gala Dinner networking event in 2011 was highly appraised. This year a Get Together Event will be on board the MS Vorarlberg on Lake Constance**

## A Central Location

Bregenz is located on the shores of Lake Constance. it is one of Austria's leading cultural and leisure areas, the capital city of the state of Vorarlberg and the seat of the provincial government with a population of 28,000. The area is known as a high tech region in the heart of Europe and is only a 2-3 hour drive from other technology hubs in northern Italy, France and Germany. Last year's participants were not only impressed with the quality of the presentations, but also the perfect location – "Bregenz and the location on the lake-side of the Lake Constance provided a beautiful backdrop for the important developments in lighting" said Bodo Arlt, Publisher of Bodo's Power Magazine. – This unique package will also provide an efficient and at the same time, attractive environment for the dialogue requirements between the players in the SSL market this year from Sptember 25th to 27th, 2012. ■

# Metal Alloy Substrate Technology – An Alternative to Sapphire

Dr. Chuong Anh Tran, President, Chief Operating Officer and a director at SemiLEDs Corp. talks about the metal alloy substrate LED technology in an interview with LED professional, and highlights the advantages of the thermal management design. SemiLEDs is a Taiwan based company that entered the lighting business recently and is also known as a manufacturer of UV-LEDs.

**LED professional:** What is the basic principle of metal alloy technology?

**Dr. Tran:** Our LED chips are vertically structured chips on a metal alloy substrate. Thermal and optical issues are the most important topics in chip design right now. We were looking to find solutions for these problems on a die-level to make application easier for LED packagers and luminary designers. When using a metal alloy we "connect" the P-GaN part of the semiconductor directly to the metal alloy, only having a reflective layer and some intermediate layers in between. Since these layers are extremely thin, we have a very good connection to the substrate. In the end, this means you can run the die at higher currents and it is more reliable due to lower junction-temperatures.

**LED professional:** Can you give us the major advantages in figures?

**Dr. Tran:** The thermal conductivity of this structure can be improved a lot. Since the main element of the substrate is copper, the thermal conductivity is around 400 W/mK. In comparison, silicon has 150, SiC has 100 and sapphire only has 35 W/mK. This means that the thermal conductivity of copper is 10-times greater than sapphire. This kind of structure also increases optical efficiency. Conventional sapphire-based chips do have more light distribution on the sides, which makes the optical design more complex. During the manufacturing process we are able to recycle sapphire and reduce costs as well as lower the carbon footprint.

**LED professional:** What about the passivation layer on the sides of the chip?

**Dr. Tran:** The main reason for that is to protect the GaN layer. You can also put the dies close together in multi-chip designs. When using vertical structured LEDs, nearly all of the light emissions come from the top of the LED surface. You can see our technology as a bi-dimensional chip, where all the light is coming out of the surface. This enables the direct placement of phosphor on the top, ending up with very good color uniformity and single bin behavior.

**LED professional:** Could we go into a little more detail in connection to the recycling process and the cost advantages?

**Dr. Tran:** About 200 kWh of primary energy is needed to produce a 2 inch sapphire wafer. Therefore, we replace and recycle the sapphire and grow copper on top of the GaN layer instead. We use a low-temperature process for this growing process. The cost structure is very important for lighting applications. I can guess that the GaN-on-Si technology is very attractive in terms of costs; however, there are lot of challenges in dealing with the mismatch between silicon and GaN. GaN-on-GaN is elegant because

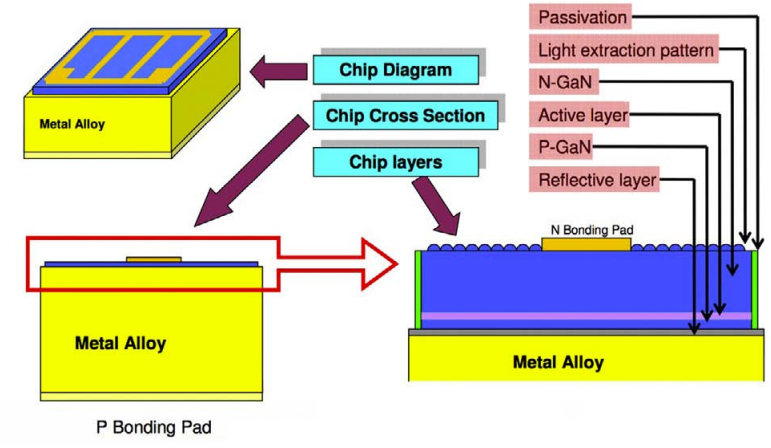



**Figure 1:** **The SemiLEDs metal-alloy based chio structure**

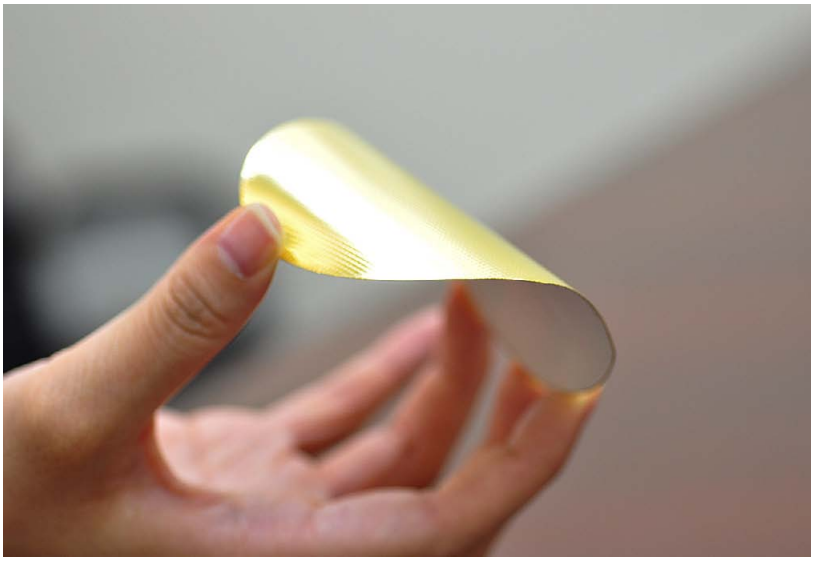


**Figure 2:** **The SemiLEDs metal-alloy wafer is flexible and robust**

you have a homogeneous epitaxy and you get rid of the droop-effect. On the other hand, this is a very, very expensive design. We do not see an alternative, right now, to using sapphire as a growing material and will be using it in the foreseeable future. Together with the cheaper copper material we can offer a cost-effective solution.

We know how to detach the GaN layer from the sapphire which is key to our manufacturing process. This means not cracking the GaN layer and keeping the sapphire to be able to use it again and again.

LED professional: Which wafer sizes are you using today and how often can you reuse the sapphire?

Dr. Tran: For the most part, we produce 4-inch wafers but we do experiments with 6-inch and even bigger wafers. Sapphire is a very hard material (second to diamond) which can be destroyed at temperatures of about 1600-1800°C. When we use the MOCVD process to grow an LED structure we use a temperature of about 1100°C which is much lower than the critical temperatures for sapphire. We can therefore use the recycled material many times without having problems with the quality. The only issues you may get are small cracks at the edges due to mechanical stress during the growing process. This can lead to the total destruction of the wafer.

LED professional: What about the mismatching of the two different materials GaN and a metal alloy?

Dr. Tran: Basically the interface between the GaN layer and the copper alloy layer is not uncomplicated. We actually have an additional sub layer which absorbs the stress and mismatch between these two materials. We call this a transition layer or multiple transition layers. They act as a compliant layer which can overcome the mismatch. These layers need to have good thermal and electrical conductivity. So far we're the only company that offers a growing process for a metal alloy on a GaN layer. There are other manufacturers who attach the copper-based substrate to the GaN layer with a kind of a gluing process - but that makes a big difference.

LED professional: How about the scalability of this technology, meaning application for low-, mid-, and high-power devices?

Dr. Tran: The vertical structure die chips have very similar efficiencies depending on the chip size. So from 0.4 mm up to 2 mm the efficiencies differ by only a small percentage, whereas conventional LEDs on sapphire show a reduction up to 30% with bigger chip dimensions. Chip sizes of 1.5 mm are available commercially, right now.

LED professional: What about the base-wavelength that is produced? Are there any differences to conventional LEDs and are you also producing phosphors for your LEDs?

Dr. Tran: We are offering wavelengths from 360-530nm in all of our chip-sizes. Depending on the type of phosphors most clients focus on the 450-460 nm wavelength when working with blue light and do the yellow phosphor conversion. It's not popular to use UV for white light generation but some companies are doing it. It's similar to FL lamps and RGB type phosphors. The nice thing about using UV for white light is that the CRI is a little bit higher than with a blue light source and yellow phosphors. SemiLEDs does not produce its own phosphors; we produce the LED chips, LEDs and modules.

LED professional: What about reliability?

Dr. Tran: Reliability depends on the current you are using for a specific device. This technology enables you to drive the LEDs at high currents with very good efficiencies because the copper-alloy can dissipate the heat faster into the heat-sink. It keeps the junction-temperature lower than a chip mounted on sapphire. So in terms of reliability I can say that this technology is very good, especially when the chip is driven in very high-current modes.

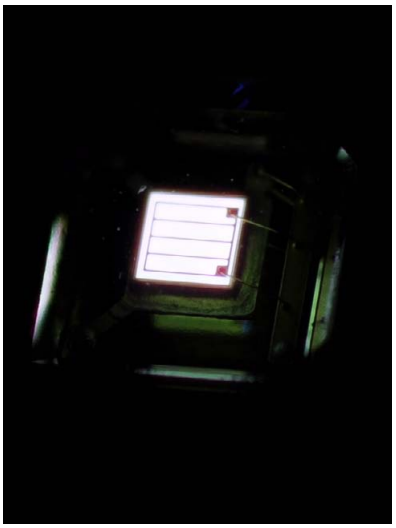


**Figure 3:** **A bonded SemiLEDs chip**

## Anh Chuong Tran

Dr. Anh Chuong Tran has served as President, Chief Operating Officer and a director of SemiLEDs since January 2005. Dr. Tran served as the Vice President of Highlink Technology Corporation from November 2000 to November 2004 and the senior staff scientist of Emcore Corporation from 1995 to February 2000. He holds a Bachelor of Science degree in physics from the Czech Technical University, and a doctor of philosophy in physics from the University of Montreal.

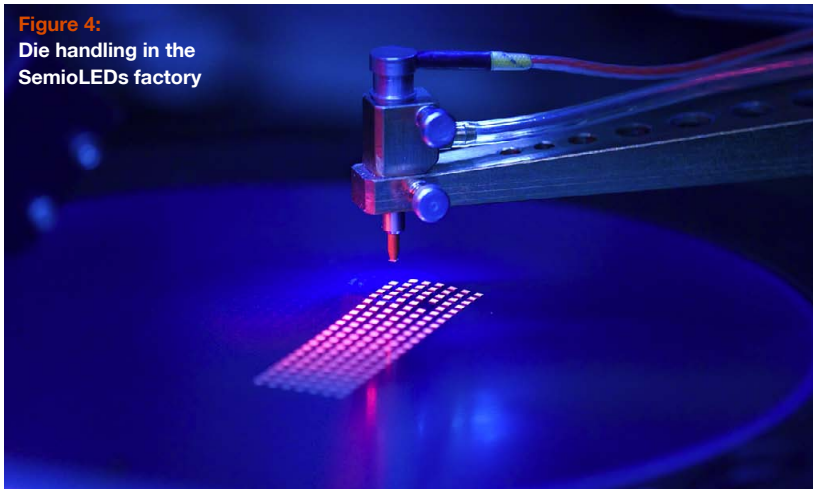


**Figure 4:**
**Die handling in the SemioLEDs factory**

LED professional: Your technology seems to be very unique with a lot of advantages. What are the challenges you are dealing with? Will you be able to mass produce it?

Dr. Tran: As you know, innovation never stops. We are ready and in mass-production with many products, but we are still trying to improve on how to extract more light or how to improve the yield. The truth is, we're just at the beginning of this technology and there is always room for improvement. Therefore, we have quite an aggressive roadmap showing the steps we will be taking.

LED professional: What are your business targets in the LED area?

Dr. Tran: It is our goal to be the best in the market. We are very ambitious. We have to scale out production and business as much as we can. We can move forward fast but it depends on our partners and the market conditions.

LED professional: Thank you very much for you time.

Dr. Tran: I really appreciated talking to you. ■

## The International Marketplace for Next Generation Lighting

LIGHTING WORLD is the only trade show in Vietnam
where all kinds of lighting devices,
lighting fixture, bulb, components, parts & materials gather.

LW 2012
LIGHTING WORLD IN VIETNAM

# Nov 29 – Dec 1, 2012

**TBECC**(Tan Binh Exhibition & Convention Centre),
**HO CHI MINH CITY, VIETNAM**

- The Only Lighting Trade Show in Vietnam
- Well-filtered visitors and good quality of attendees
- High satisfaction with One-on-One Business Meetings arranged by organizer
- Vietnam Lighting Projects Presentation and Marketing Conferences

| Organizer | STAVIS KOREA

Tel 82.2.780.1040 | Fax 82.2.785.1042 | E-mail info@lighting-world.com

For more details, please visit
www.lighting-world.com

CIOE

YOUR ACCESS TO CHINA'S
# OPTOELECTRONICS MARKET !

# 14TH CHINA INTERNATIONAL OPTOELECTRONIC EXPO

## SEPTEMBER 6-9, 2012

SHENZHEN CONVENTION & EXHIBITION CENTER • CHINA

# LED EXPO

**ON-SITE ACTIVITIES**

- ★ CIOE 2012 Face to Face Sourcing Meeting
- ★ Market Access and Supply & Demand Meetings
- ★ More International Purchasing Delegations
- ★ New Products and Technologies Presentation
- ★ China Optoelectronic Investment Conference 2012

**CONCURRENT EVENTS**

- OPTICAL COMMUNICATIONS EXPO
- LASERS & INFRARED APPLICATIONS EXPO
- PRECISION OPTICS EXPO
- global sources Electronics Global Sourcing Fair

**ONLINE PRE-REGISTRATION IS AVAILABLE RIGHT NOW!**

CIOE CHINA INTERNATIONAL OPTOELECTRONIC EXPOSITION OFFICE

**Add**: Room 607, East Block, Coastal Building, Haide 3rd Road,
Nanshan District, Shenzhen, Guangdong, 518059, China
**Tel**: +86 755 8629 0891 **Fax**: +86 755 8629 0951
**E-mail**: international@cioe.cn

ufi Approved Event

FOR MORE INFORMATION, PLEASE VISIT
WWW.CIOE.CN

# Glass Optics for LED Applications

Historically seen, glass is a very old material and evolved with many different mixtures into a broad variety of applications, from objects of daily use to art objects and high end technical tools like optics. Dr. Thomas Hessling, Optical Engineer at Auer Lighting's R&D/Lighting Technology department explains why glass is also the first choice for secondary lenses in LED systems.

Glass has become such an integral component of a vast amount of everyday objects that it would be impossible to imagine today's world without it. Its use by humankind dates back several millennia and has evolved since then from a mere cutting tool to a wide range of applications, such as windows, vessels and the dominant optics material, to name just a few. The appearance of glass lenses in the middle ages led to great discoveries in the field of optics and astronomy that changed our view of the world and the universe forever.

In the field of illumination optics glass became invaluable with the invention of the electric light bulb. An evacuated glass housing was necessary to prevent the filament from oxidizing and glass was the material of choice. With the advance of artificial light sources to higher and higher powers glass remained the number one material due to its high temperature and mechanical stability. It easily withstands the operating temperatures of incandescent as well as even more powerful light sources and so it was also chosen as material for the primary optics such as reflectors, lenses or diffusers.

## Light Emitting Diodes

In the middle of the 20th century a new light source appeared: the light emitting diode. At first it was only a side-product of the semiconductor revolution and found its niche applications in signaling or simple display systems in electronic devices. Their monochromatic light and low power was insufficient for any illumination purposes.

### First LED optics

In these simple applications not much thought was spent on the secondary optics for these LEDs. The light distribution didn't matter much. So it was only natural to choose an already heavily utilized material in all electronic devices: plastics. The manufacturing tools for other parts were already present and the type of plastic easily exchanged to a transparent one like PMMA or polycarbonate. The mass production of these optical parts kept the prices low despite the usually high tooling costs of plastic manufacturing. This dominant role of plastic optics in LED applications survived to the present day. Although they nowadays are precision products with good surface accuracy the material still has its limitations.

### Evolution towards illumination

As LEDs evolved from low-power signaling devices to high-power illumination light sources that they are today, the disadvantages of their plastic optics will become a limiting factor soon. The relatively low melting point of common plastics makes it susceptible to the strong heat produced by the increasingly powerful modules that can lead to deformations or worse. While this is somewhat manageable to a certain degree there are more, severe aspects to consider. Signaling lights and their optics are often placed in sealed environments and it's not really important if their optical properties degrade after some time as long as there's still some light. This is not true for illumination optics: long lifetimes and constant properties are required. Additionally harsher operating conditions are common, such as outdoor operation (street lighting, architectural lighting). In these environments the optics are exposed to UV light, chemicals and mechanical stress. All these pose challenges for plastics. Ultraviolet light makes plastics brittle and turn yellowish, simple cleaning often scratches the surface and it is easily affected by common chemicals. In summary plastic optics often have a low life expectancy in real-world applications.

### Glass optics

Glass, on the other hand, is long known and valued for its resilience to tough environmental conditions. Operating temperatures of several hundred degrees Celsius, a high hardness and tolerance to most acids, bases and other chemicals ensure constant optical properties and brilliance over a long period of time. This makes it the perfect companion for long-lasting LEDs.

Despite high-grade optical glasses such as BK-7 other types of glass, like SUPRAX 8488, are available at a much lower price. The optical properties are similar to that of PC or PMMA in terms of index of refraction and bulk absorption. While the density of glass is almost twice as high compared to plastics it exhibits a low thermal expansion coefficient and high chemical resistance. Operation temperatures of up to 400°C allow its use even with the highest power LED modules. Its higher thermal conductivity than common plastics supports the cooling devices in transporting the heat away from the LEDs.

While imaging optics require highest precision that can only be achieved by repressing in illumination optics direct hot-forming is the standard manufacturing method. It delivers a high-quality surface and shape accuracy that commonly needs no additional processing steps, except milling or sawing. Generally lower tooling costs than in plastic manufacturing give an additional economic benefit.

Coatings, if necessary, can be applied by various methods that are suitable for mass production. The composition of the coating in combination with the low thermal expansion of the glass makes the coating efficient and durable.

## Optical Design

The design process for LED optics is no different than for any other optical system. It starts with a detailed description of desired illumination properties, light source (ray-file) and geometrical and other constraints, e.g. color deviations. In a robust and fully non-sequential ray-tracing software the optical setup is implemented and the proper method for the particular problem selected. No ray-tracing software is an all-in-one solution for any optical element to be designed, especially not when it comes to free-form surfaces which are often found in LED optics. They only provide a solid foundation onto which the actual design software is tailored. For all the different kinds of optical elements, such as facetted reflectors or TIR (Total Internal Reflection) lenses, additional software must be developed and combined with the ray-tracer. If no analytical solution of a problem exists (e.g. for Fresnel lenses) the ray-tracer's optimization capabilities are of great value.

The final stage is the transformation of a constructed optical surface into a full 3D CAD model of the component. Verification of this model by importing it into the ray-tracing software is a crucial step and should always be done.

The range of LED optics made of glass spans from Fresnel lenses over TIR optics to reflectors, to name just a few. In the following a selection of such optics are presented.

### Reflectors

A customer requested the development of LED reflectors for a down-light, designed as a direct replacement for common incandescent MR16 solutions. The requirements were very demanding: a set of four reflectors for different beam angles from 10° to 40° was to be designed with identical outer dimensions. It makes them easily exchangeable in the final system.

The resulting reflectors are shown in Figure 1. All of them have a free-form surface, specifically optimized for the intended optical properties. The facets ensure a good homogeneous light distribution and outstanding color mixing. A high-quality diachronic coating provides the necessary reflectivity (typically: 95 %) for a high system efficacy. The mounting is enabled by the directly pressed wings on both sides for a snap-in system. Tight tolerances ensure a proper alignment of the reflector with respect to the LED.

**Figure 1:**
**A set of four reflectors for different beam angles but identical outer dimensions and mounting clips**

### TIR Reflectors

TIR reflectors are a kind of hybrid optical element that are basically designed like the reflectors described before but don't use any coating. Instead the outer surface is beset with multiple prisms that light entering the interior surface of the reflectors fulfills the total internal reflection condition. They are very suitable for larger LED modules, such as the Zhaga book 3 (D = 25 mm) type modules. The multiple internal reflections have a positive effect on the color mixing and create a smooth light distribution. Although it is a bulk optical component absorption losses are only marginal and comparable to the coating losses of regular reflectors.

In addition to the benefits described above a particular advantage for lighting design is the small amount of upward light these optics exhibit. Most reflectors on the market are fully housed and direct all of the light downward leaving a completely dark ceiling. TIR reflectors, as they are aesthetically pleasing to look at, are regularly mounted without any housing and ensure a slight illumination of the ceiling.

**Figure 2:**
**A TIR reflector specifically designed for Zhaga Book 3 LED modules**

One such reflector that is designed specifically for Zhaga LEDs is depicted in Figure 2. It has a flexible design to adjust the beam angle by moving the module into the reflector.

## Refractive Optics

Refractive optics are the most common type found today for LED applications. While their use is somewhat limited to smaller, low-lumen LED packages larger fixtures are often constructed of a multitude of smaller light points. The individual placement provides an additional degree of freedom to design the desired illumination profile but special care has to be taken to avoid glare by the small light points with a very high brightness.

Some typical examples of TIR optics are shown in Figure 3. These are single collimators for a specific LED, combined TIR lenses for a retro-fit application and Fresnel lenses. All of these are manufactured out of glass.

**Figure 3:**
**A small selection of TIR collimators and Fresnel lenses commonly used for LED lighting**

## Summary

Today the majority of LED optics is made of plastics like PMMA or PC and date back to the origins of light emitting diodes with small power packages. Technological progress in LED manufacturing lead to a drastic increase not only in power rating but also in the efficacy of more than 3 orders of magnitude. Off-the-shelf products reach values of more than 100 lm/W and wattages of almost up to 100 W. This remarkable evolution is still in its early stages and the optical systems need to evolve alongside the LEDs themselves. Plastic has its limitations in dealing with the large amount of heat produced by today's modules. New application fields for illumination purposes, including harsh outdoor environments, pose additional hazards to the plastic optics, reducing its life-time considerably.

Optical components of glass have been the standard for almost all other illumination systems. Not only is it highly tolerant towards harsh environments but has a brilliant appearance and high perceived value. Contrary to plastics, which are manufactured from limited fossil resources, glass is made from natural non-toxic and abundant substances and is recyclable. All these advantages make it the optimal companion for today's (and future) high-power LED modules: long-lasting, efficient light sources with a highly efficient, aesthetic optic. ■

MEX
MEDIA EXPOSITION
PRESENTS

# India No.1
INTERNATIONAL EXHIBITION
ON **LED LIGHTING**
PRODUCTS & TECHNOLOGY

www.theledexpo.com

**Over 400 Booths & 200 Brands at the Exhibition**

**OVER 20,000 VISITORS, EXHIBITORS FROM 11 COUNTRIES**
**97% SATISFIED EXHIBITORS**

# LED® EXPO 2012

## EXHIBIT SEGMENTS:

- LEDS
- LED APPLICATIONS & LIGHTING
- LED LIGHTING PRODUCTS
- LED PRODUCTS
- LED SIGNAGE & DISPLAYS
- LED COMPONENTS/ ACCESSORIES & RAW MATERIALS
- LED DRIVERS & POWER SUPPLY
- LED MANUFACTURING EQUIPMENT MACHINERY & ALLIED PRODUCTS

**INDIA'S PREMIER INTERNATIONAL CONFERENCE ON LED LIGHTING PRODUCTS & TECHNOLOGY**

# LED SUMMIT/2012

**14 15 DECEMBER, 2012**
**PRAGATI MAIDAN, NEW DELHI, INDIA**

**14 15 16**
**DECEMBER, 2012**
**PRAGATI MAIDAN, NEW DELHI, INDIA**


MEX | **Media Exposition & Events**
**Head Office :** 9 LGF, Sant Nagar, East of Kailash, New Delhi-110065, India
Tel:+ 91-11-46464848 Fax:+ 91-11-41071644
Mobile : +91-9810301644, +91-9312285142
E-mail: info@themediaexpo.com, gaurav@themediaexpo.com
**Website: www.theledexpo.com, www.mediaexhibits.com**


**Supported by :**

ELCINA | SESI SOLAR ENERGY SOCIETY OF INDIA | IBC INDIAN BUSINESS CONGRESS

# Methods of Determining LED Operating Junction Temperature Experimental and Theoretical

Today, LEDs are the first choice for many lighting applications, but the LEDs have to be operated within relatively narrow specifications to provide the optimal performance and lifetime. One key parameter to know is the junction temperature. James R. Pryde, Design Engineer at Integrated System Technologies & University of Wolverhampton will compare different methods to measure $T_J$ and discuss their advantages and limitations.

The light emitting diode (LED) is fast becoming the first choice for many commercial and domestic lighting applications. Its long lifetime, high reliability and versatility make it an attractive option for a wide range of applications. However, these benefits can only be fully realized if the LED operates within its optimum parameters. Of particular concern is the components junction temperature, the active area from where light is emitted. Knowing the junction temperature allows us to make predictions about the LED performance and thus the luminaire system. The difficulty arises when trying to measure this junction temperature. While there are undoubtedly numerous commercial cases where these are applied, there is very little information to describe these methods and evaluate the advantages and limitations of each in a thorough, reasoned and pragmatic manner. There is even less side by side comparison of these methods and discussion of how to integrate this knowledge into the development and testing of products to optimize performance.

Here we set out to compare some of these methods. The aim is to demonstrate how they can be applied in a practical manner. That is they provide accurate, reliable, confident results rapidly enough to meet the commercial demands for progress. Its purpose is not to criticize other practices. Nor is it intended as a comprehensive evaluation of every possibility. It is a basic introduction to the merits and limitations that should be considered with some of the more prominent methods.

## A Typical Application

Limiting discussion of these methods to theory would be almost useless. The value of knowledge is in applying it and understanding the practicalities of doing so. A suitable test subject provides the opportunity to assess how these truly compare (Figure 1) [1]. It was selected from the potential candidates for a number of reasons. It is a fairly typical example of an LED downlighter. Surface mount LED's on an aluminum core printed circuit board (PCB) are fixed to a die cast aluminum heatsink. An intermediate thermal

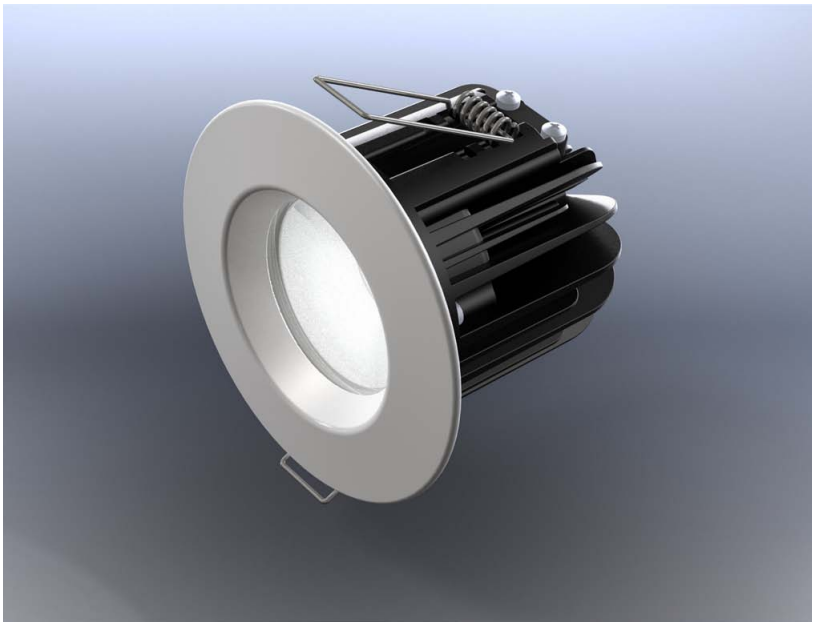


**Figure 1:** **LED downlighter used to demonstrate these test methods**

interface material minimizes contact resistance between components. A bezel, diffuser and reflector have negligible effects on the thermal behavior so are excluded. The form of the heatsink is fairly typical. A finned structure provides maximum heat dissipating surface area for minimum material volume. It takes a fairly symmetrical shape so the thermal performance is nearly uniform all directions. It is produced in high volume so multiple, consistent samples are available. It is relatively low cost, readily available and compact so easy to handle. It is currently in the market place so has proven performance with a wealth of test reports, approval documentation and product data to support the investigation.

## The Options

### Thermocouple data

The thermocouple exploits the thermoelectric effect. Application of temperature produces an electrical potential proportional to its temperature. Measuring this voltage provides a measure of the thermocouple's temperature. Before assessing the component it is worth considering the thermocouple type and attachment to the device.

In this investigation K-type thermocouples are employed. These are considered the 'general purpose' thermocouple. The combination of sensitivity, low cost, wide sensor range and different probe options make them an attractive choice. This does not mean they are ideal for this analysis. The sensitivity of the thermocouples used here is a claimed ±2.5°C. More precise sensor classes are available but with increased cost. There are also different sensor material combinations with different thermal characteristics. These alternatives may be better suited to the analysis. For instance, T-type thermocouples claim sensitivity to ±0.1°C over a narrower temperature range more appropriate to this investigation. However, they are less common and often expensive. Here the objective is to measure LED junction temperature to allow us to make our predictions about performance. K-type thermocouples provide sufficient accuracy for this therefore investing in more accurate analysis equipment is unnecessary. Alternatively if we had very little tolerance for error, such as determining safe maximum conditions, more accurate measurement would be required. The equipment used therefore needs to be specified with reference to the requirements.

Three attachment methods are compared simultaneously (Figure 2). Bulb type probes are used. Again these are not necessarily ideal for the investigation. Alternative probe forms are available that could measure temperature more reliably and accurately. However, we will restrict ourselves to the common thermocouple type as they are the most likely to be used. The analysis was performed in a windowless room with no air vents to minimize environmental variables such as ventilation and solar radiation. Test samples were separated by 500mm to minimize any interaction effects. Performing the test in parallel helped ensure any remaining variables were consistent across the test subjects. In this analysis the sensor is approximately 52mm from the heat source, attached to the heatsink back face. The first sensor was attached with electrical tape. It is quick, simple and easily removed. The second method coiled the sensor wire to create some elastic spring which was exploited to maintain pressure against the test surface. This creates better surface contact. The final method was to drill a small Ø1mm, 1mm deep indent in the heatsink surface which was filled with thermally conductive paste. The thermocouple is inserted and the wire spring maintains some pressure against the test surface.

The objective here was to demonstrate that the attachment method has a significant impact on the results produced. This was clearly demonstrated by the results (Figure 3). There was just under 10°C difference between the three samples which should have been identical. The thermal paste and recessed sensor was the most effective and consistent showing minimal fluctuation. The thermal tape attachment showed temperature dropped off significantly towards the end. Shortly afterwards this probe came away from the device becoming completely ineffective. Clipping the sensor and using the tension to maintain contact was somewhere between the two and with the addition of thermal paste to improve contact we would expect this fluctuation to be minimized as it ensures good thermal contact less susceptible to vibration or airflow in the room.

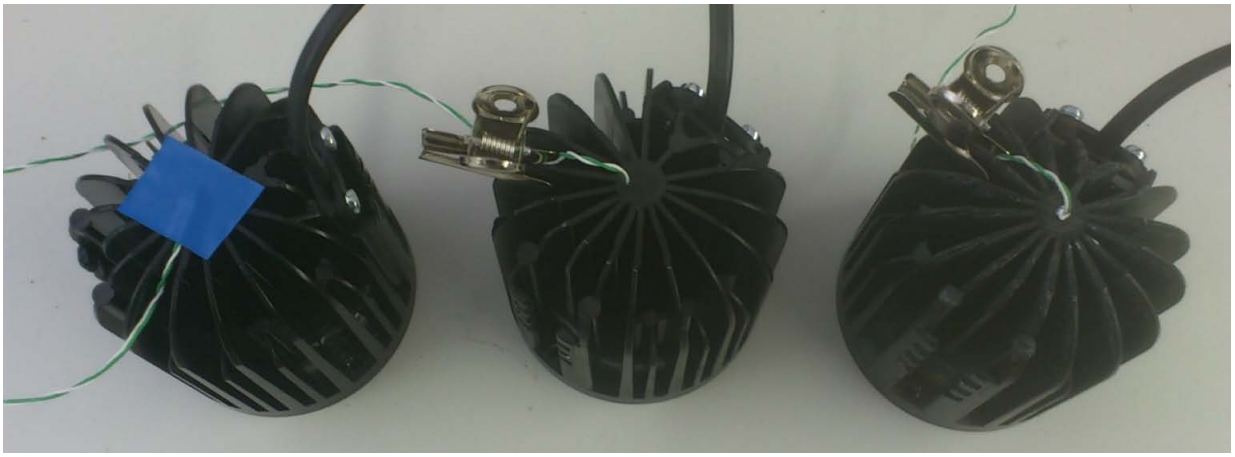
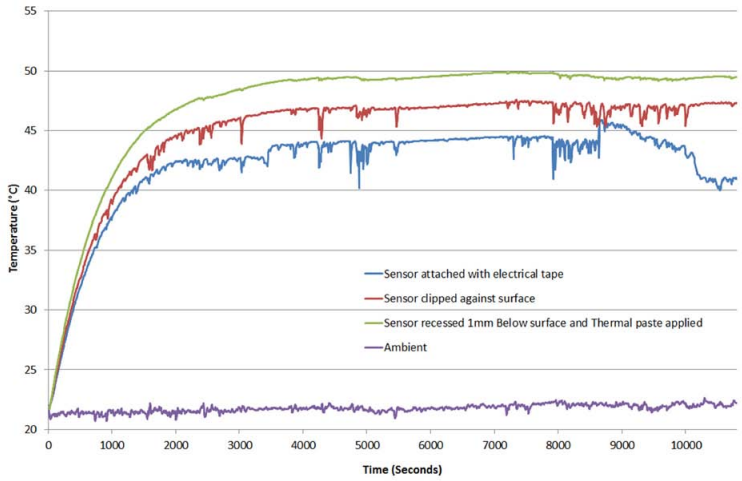


**Figure 2:** **Comparison of thermocouple contact methods**

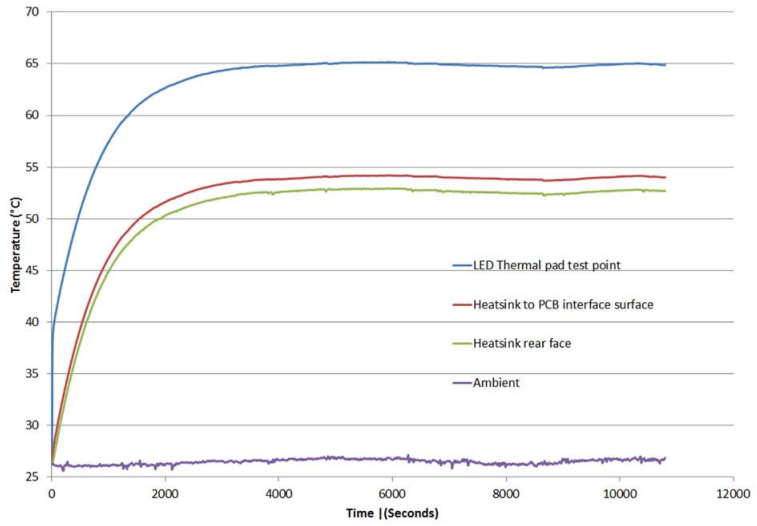
**Figure 3:**
**Comparison of thermocouple attachment methods**




It should be clear that using tape to attach the device does not provide reliable contact between the sensor and the test subject. Also, it will alter the properties of the device acting as an insulating layer and modifying radiative properties. This is clearly not a suitable method except where speed and convenience are a priority. Using the wires elastic deformation to maintain pressure against the surface improved the consistency of the results. Recessing the thermocouple and adding thermal paste showed additional improvement. Any readings should always be treated with caution and wherever possible calibrated against an alternative method or known temperature. From this we can draw some conclusions. The attachment method significantly influences the results. The contact needs to be reliable and consistent. The addition of thermal paste and recessing the probe produces much more reliable data that closer represents the subject temperature. From this we can infer that recessing the sensor and adding thermal paste reduced contact resistance and minimized environmentally induced fluctuations. Based on this we can see that to achieve the most useful results we need to ensure effective thermal transfer between device and sensor. This is achieved by maintaining close surface contact and minimizing contact resistance. We should also minimize any external influences on the sensor and avoid significantly altering the properties of the test subject.

Our aim is to identify the junction temperature of the component. Because the LED package encapsulates the junction it is not possible to directly apply a sensor. It may be feasible to modify the device to get access to the junction but to do so would alter the thermal properties rendering results useless. Instead chip manufacturers usually specify a test point and provide information from which the junction temperature can be calculated. The heatsink, the heatsink - circuit board interface and ambient temperatures were also monitored (Figure 4).

**Figure 4:**
**Measurement of thermal energy in a luminaire product**




The results indicate the temperature at the LED test point was 64.92°C (average value calculated from final 50 samples recorded at 5 second intervals). The LED used in this sample is a Philips luxeon rebel [2] with a claimed thermal resistance from junction to test point of 10°C/W. The measured forward voltage of this LED was 2.93 V, driven at 680 mA. Therefore the LED was running at 1.99 W. The efficiency of the LED means there is a significant amount of this energy converted to light but this has not been measured. It would be possible to measure the energy of the light output and thus the energy remaining in the component as heat. Unfortunately this ventures into very involved and complex analysis that is often too unwieldy for simple testing. Instead we will assume all power supplied is converted to heat. This is flawed but is at least conservative. It is consistent with the theoretical calculation later but not present in the other methods demonstrated. The thermal resistance specifies that the junction temperature must have been 20.51°C higher than the test point temperature. Therefore we arrive at a junction temperature of 84.84°C. This still relies on calculating the junction temperature from information provided by the manufacturer which has not been verified.

## Thermal imaging

An alternative analysis method for verifying surface temperature is to use thermal imaging equipment. This is calibrated to calculate temperature based on infra-red radiation from a surface. This allows the user to quickly verify the component temperature. It also provides a very detailed and powerful analysis tool to evaluate thermal distribution across a surface.

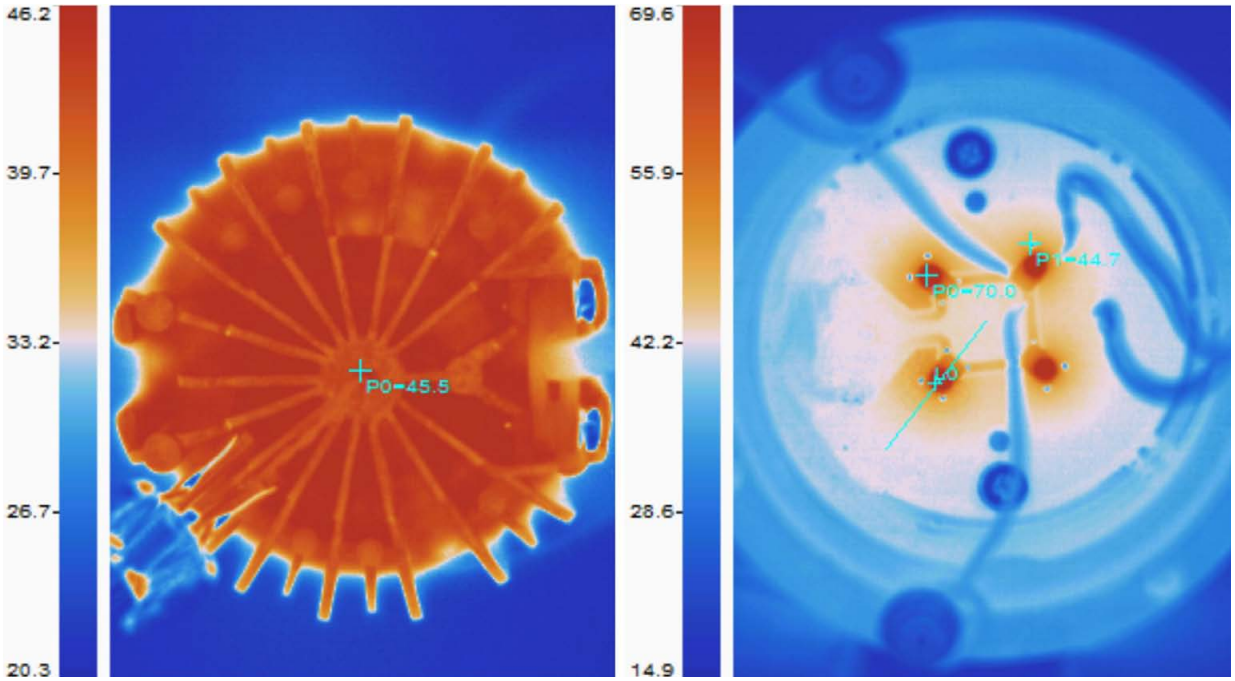



**Figure 5:**
**Heatsink thermal images**

Figure 5 shows some images recorded using a thermal camera [3] with a supplementary piece of software [4]. The image is used to calculate the temperature at the marked locations. On the rear where the thermocouple is applied the surface reads 45.5°C. The front image demonstrates how the heat is distributed through the PCB traces. The high thermal conductivity copper increases conduction of thermal energy increasing local surface temperatures. The image shows the thermal pad temperatures of the LED are much cooler than the thermocouple measurements. This is flawed because the camera is not calibrated to measure from these reflective surfaces. There is also a question about the validity of the LED junction temperature. The emitter uses a phosphorescent material to produce something approximating white light. The optical properties of this material are not understood in enough detail to draw any reliable conclusions about its temperature or the temperature of the LED junction below. What we can take from this is a better understanding of the thermal distribution. The results are in the same range as the thermocouple data although show significant variation. The pad temperature measurement is of no value. The LED junction temperature accuracy is questionable but the heatsink rear should be reliable. Even so it still reports a much lower temperature than the thermocouple sensor. It is also interesting to see just how significantly the copper trace alters the thermal distribution in the PCB, though in the heatsink this variation is negligible.

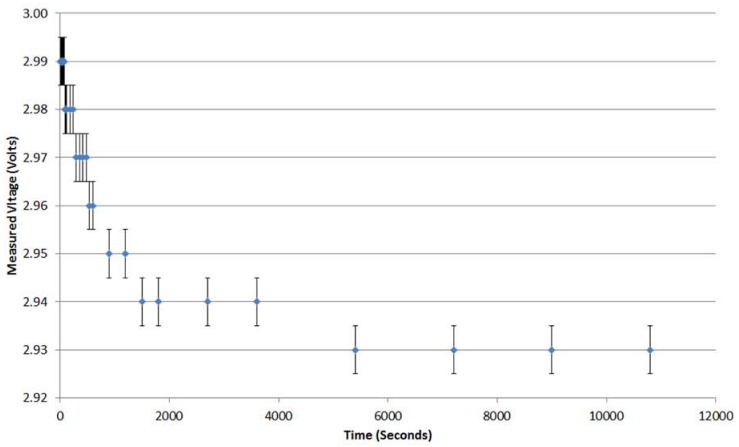



**Figure 6:**
**Evolution of $V_f$ with time**

## Derivation from change in forward voltage

A novel method that shows promise is to measure the LED junction temperature from the change in forward voltage across the component. Electrical resistance changes proportionally to temperature. In Ohmic materials resistance, current and voltage are related by Voltage (V) = Current (A) x Resistance (Ω). Therefore at a constant current voltage will be proportional to temperature. The LED manufacturer reports a coefficient of forward voltage vs. temperature with the component literature. Therefore from measuring the change in voltage it is theoretically possible to calculate the change in temperature. To apply this we need a reference point of known junction temperature and forward voltage. The simplest way to achieve this is to allow it to reach thermal equilibrium with the environment (26.3°C). The voltage across the component when operating at this temperature is then required. This is trickier to establish as once the power is applied the junction temperature quickly rises. Instead the voltage across the component as it heats up and reaches thermal equilibrium is recorded and from this the initial forward voltage can be extrapolated (Figure 6).

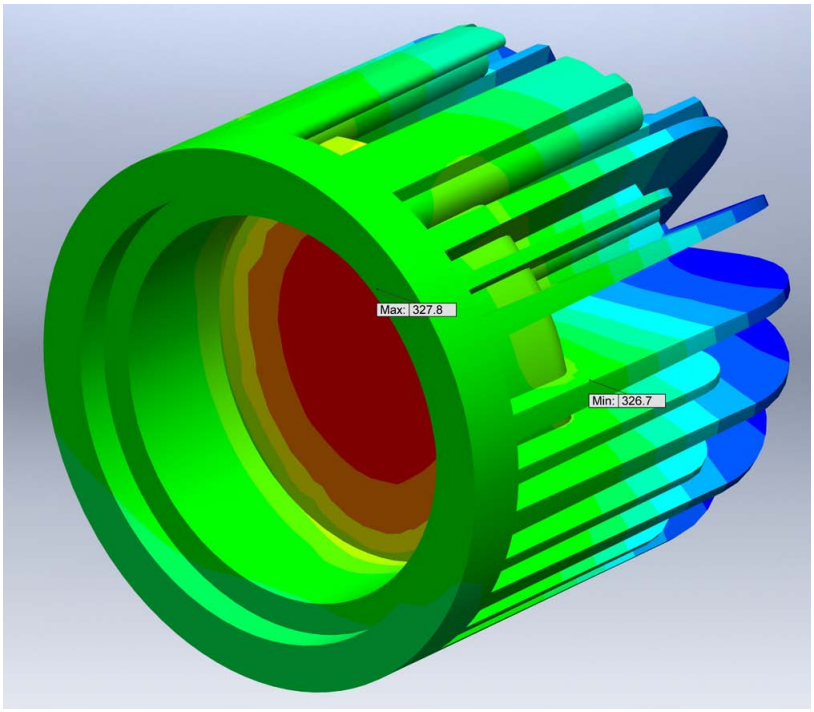



**Figure 7:** **Results of thermal analysis**

Due to the resolution of the voltmeter it is difficult to precisely identify the exact voltage. We can reasonably determine it is between 2.99 and 3.00 V. It is advisable to lean towards the most conservative value so the initial 3.00 V @ 26.3°C is used. The total change in voltage when the product had reached a steady state was 0.07 V. The datasheet specifies this components temperature coefficient of forward voltage is between -2 and -4 mV/°C. This indicates that the junction temperature increased between 140 and 280°C. This is in addition to the initial 26.3°C. Therefore this method would indicate the component is operating at between 166.3 and 306.3°C.

This result is vague, apparently inaccurate and demands further investigation. The datasheet claims the component junction has a maximum rating of 150°C which would suggest that the product should already have failed. There is nothing theoretically wrong with this method. The effect of change in voltage with change in temperature is present in the results. The question is how to more accurately determine the temperature coefficient of forward voltage. It is necessary to explore the physics of this method and determine the validity of the assumptions made before this is a viable method. For instance, it is assumed the LED die acts as an ohmic material demonstrating a linear relationship between voltage and resistance. This is unlikely to be true but exactly how it behaves is unknown. There is also room for improvement in the method. At present the measured voltage has an accuracy equivalent to +- 9°C at best. It is worth mentioning that it is possible to measure the voltage change across multiple components, multiplying the effect and averaging out any variation. However, this doesn't increase measurement resolution and introduces additional resistance effects to account for.

## Theoretic calculation

Obviously direct measurement is only possible when we have a product to test. There are some errors and improvements to be made over the investigation performed here but generally speaking these should give a more definitive result. However, we often do not have the product to measure. Instead we need to make a prediction, especially during product development. There are numerous studies comparing different load conditions and derivation of temperatures. The challenge is taking these simple cases and applying it to more complex geometry. This is where computer aided simulation excels.

The important feature of this process is to make the model as simple as possible but still accurately represent the products behavior. Obviously the simpler the model the less processing power it takes to solve but it also helps us improve the quality of the results. The more comprehensive the model is then the more information required in the definition. The more information required then the more assumptions have to be made, more variables to control or measure and more uncertainty that creeps in. The rest of the system (LED, circuit board and interface material) usually specify thermal resistance data from the manufacturer. All we need to calculate is the thermal resistance between where the power is applied and the environment. We can then derive the junction temperature from standard calculation methods. The boundary conditions applied are representative of the physical model tested. Power is applied to the entire surface assuming even spreading through the PCB. Convection and radiation transfer rates are specified on the finned side. Figure 7 displays the results performed with a standard parametric modeling package [5]. Post processing offers the user the opportunity to interrogate designs in far more detailed ways than a prototype can. The real strength of such a method is allowing us to quickly assess the product, make important decisions and work towards creating an optimized, effective, efficient design. This process can help us eliminate a significant amount of prototyping and evaluation but should never be considered a substitute.

Based on an applied power of 7.97 W and standard thermal calculations we arrive at a thermal resistance of 3.52°C/W from the heatsink to the environment. The rest of the components in the system claim a combined thermal resistance of 3.03°C/W. In total the thermal resistance from LED junction to ambient should be approximately 6.55°C/W. Working backwards from this, with a known power and known ambient temperature we can calculate the peak temperature, the LED junction temperature. By this method we reach a theoretical junction temperature of 78.7°C.

## Evaluation of Methods

What we have here are 4 different methods of determining the LED junction temperature none of which show agreement. Obviously there are always going to be some errors creep in due to rounding, measurement accuracy, systematic errors and random errors from variables in the analysis. All of these we can determine and manage. However, we still need to understand factors that are inherent to the methods and what effect they have on the results. Firstly let us eliminate measurement of LED forward voltage from the discussion. There is more work needed before this will offer us any usable results. The other results are in the same range and so we can be confident that these are roughly reliable. Thermal imaging is better suited to analyzing thermal distribution across a part. It is ideal for identifying component hotspots and thermal bottlenecks in a design which can then direct subsequent measurement but is not ideal for directly recording results. There are too many uncertainties with the information it provides, whether it is calibrated properly to measure infra-red radiation from the emitting surface being the first. With time and resources it would certainly be possible to refine this approach to accurately measure temperature but this is not where its strength lies. This leaves us with simulation and thermocouple data which still show a mismatch. We can attribute this to both poor measurement of component temperature with the thermocouple and inaccurate simulation setup. We have already looked at how best to apply the sensors but this could be taken further. Bonding the sensor to the test point with soldering or a thermally conductive adhesive would minimize any contact resistance resulting in the most accurate measurement. Using more refined sensors designed specifically to operate in a narrow range could improve the accuracy further. It is often overlooked that the thermocouple is a non-linear sensor. The voltage generated will vary at different temperature ranges. The magnitude of this non-linearity should be known to determine its significance. If it is an issue it can be compensated for or thermocouples with the most linear relationship across the test range can be specified. In practice the methods applied here would probably be sufficient to determine the approximate LED junction temperature. Provided it is understood that there is still room for error they should be sufficiently reliable to make judgments about performance.

If we take the thermocouple results as our reference the theoretical calculation underestimates the temperature. The main reason for this comes down to the information used to calculate the results. Firstly the definition of the analysis depends heavily on the knowledge and experience of the engineer. Understanding how the boundary conditions should be applied is no simple task and if incorrect has a significant influence on the results. This was borne out in the calculations which showed that the theoretical heatsink-ambient thermal resistance was 3.52°C/W compared to a measured 3.44°C/W. Obviously investing in more complex and detailed analysis tools such as computational fluid dynamics helps to manage this to some extent but not entirely. Until any element of judgment is removed the process is fallible. Secondly there is the data actually used in the calculation. Often this information will come from manufacturers who report the best case, most attractive figures. The reality is that the design may not meet these conditions. In the results the actual thermal resistance from LED junction-heatsink was 3.87°C/W compared to the theoretical 3.03°C/W. The material literature may not be an accurate representation of what is achieved. Variation in how the system is assembled, different surface conditions, manufacturing variation and flaws can all lead to errors that need to be considered.

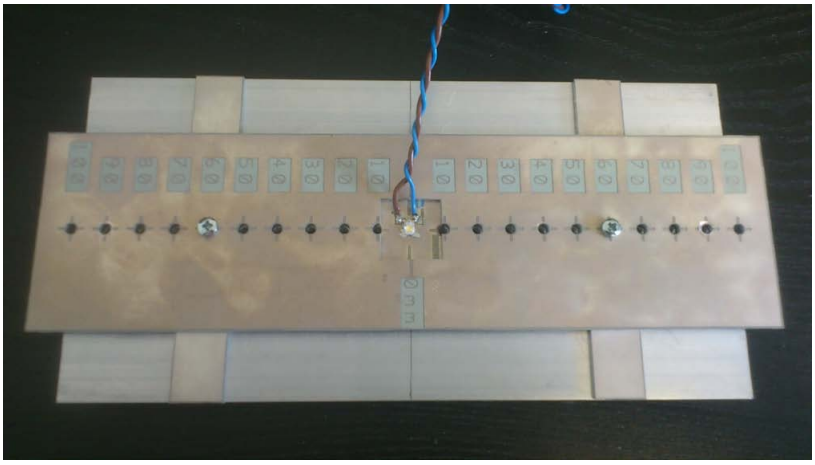


**Figure 8:**
**Test rig to measure thermal resistance for different assembly configurations**

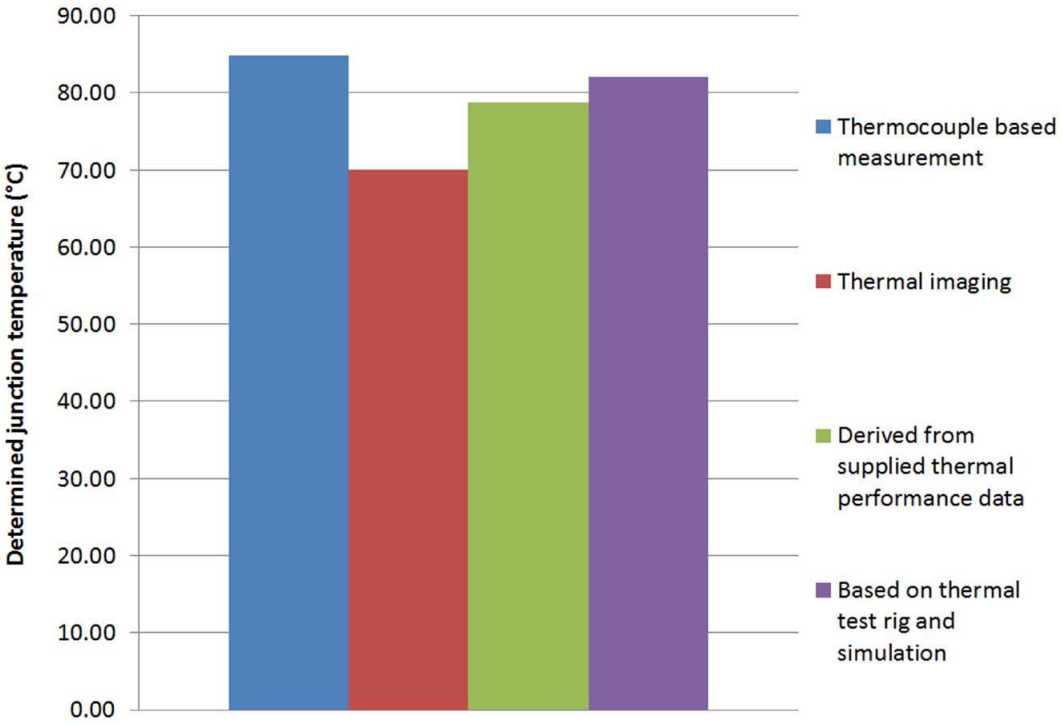
### Improving the theoretical prediction

If the simulation results are so closely related to the component properties it is unreasonable to assume, and clearly demonstrated to be false, that the information supplied is accurate for the application. What is needed is some verification of the data. To this end a test rig was developed. This was designed to allow measurement of the combined thermal resistance from the LED heat source to heatsink. This allowed a simple verification of the thermal interface material, the interface area, the interface pressure and assembly configuration properties (Figure 8).

The circuit board was designed by the author and produced by Spirit circuits 'go naked' prototyping service in their aluminum core material [6]. It has a claimed thermal conductivity of 2°C/W through board (approximately equivalent to the circuit board material used in the product). With this apparatus it was possible to measure the combined thermal resistance from LED pad to the heatsink. This measured 3.46°C/W, closer to the actual performance. There is still work to be performed here to match the experimental values to the actual

**Figure 9:**
**Comparison of calculated LED junction temperature**




performance. Assessing different interface materials and contact pressures as well as effects such as spreading resistance is planned. It also still relies on external unverified data for the LED component thermal resistance which needs to be investigated. However this testing is clearly a movement in the right direction.

When we compare the results it is clear that with this verification of the thermal resistance integrated with the thermal simulation the calculated junction temperature is closer to the thermocouple determined result (Figure 9). Currently this is less than 5%. Well within advised levels of confidence for simulation techniques.

There will always be opportunities to refine these methods but if properly considered they can provide reliable enough results from which we can make predictions about performance and lifetime. The challenge is in ensuring that information is gathered on a reasoned and considered basis. Thermal imaging is ideal for visualizing thermal distribution through a component but the accuracy of measurements is uncertain without complex calibration. Measuring forward voltage can potentially be used but is the subject of on-going research. It is of no value to simply apply a thermocouple sensor to the LED and assume it is accurate because the data logger reads temperature to 2 decimal places. The sensor application needs to be understood to ensure it is reporting an accurate temperature, not just reporting temperature to within a suitable degree of accuracy. The information is significantly affected by the means of attaching the probe and needs to be thoroughly explored to ensure results are of value. The properties of the thermocouple are also significant and should be properly specified to ensure it meets the needs of the analysis. Simulation will only be as good as the information supplied. It can be a useful tool when this is verified and benchmarked. Testing and measurement is invaluable for understanding the thermal performance of an application and it should not be assumed that the information supplied is the performance achieved by the system. When we can understand where the limitations of these methods lie we can understand the consequences on the conclusions we draw from them.

## References:

[1] Integrated System Technologies Ltd. Serenity Astraea, 4LED, 3000K, 700mA, 70°, www.istl.com
[2] Philips, Luxeon Rebel, LXM8-PW30
[3] Eluox EIRC5p infrared camera
[4] IR See report, thermal imager software. EL-RP-1.9.1
[5] Solidworks, Simulation 2011, x64 SPO.0:2010/277
[6] Spirit Circuits, Go Naked prototyping service. www.spiritcircuits.com

# The decisive component in your electronic design


www.EL-info.de

Elektronik Informationen erscheint in der AT-Fachverlag GmbH, Saarlandstr. 28, 70734 Fellbach

## Complete below and fax back to +49 (0)711 952 951-99

☐ YES I would like to take out a free subscription to Elektronik Informationen. Please send the magazine to the adress beside.

☐ YES Additional and free of cost too send the weekly EL-info newsletter to my email adress.

**AT-Fachverlag GmbH**
Reader service
Saarlandstraße 28
70734 Fellbach

Name / Prename

Company

Street / Box ZIP/Postcode City

Phone Fax

Email

# Novel Approaches to Thermal Management for Power LED Packaging

Thermal management is crucial for the efficiency and reliability of LED products which have become very popular during the past few years. For the past few decades carbon has been known for its good thermal conductivity and as a result, different carbon carbon based materials are available on the market. One of these materials with very special properties is CarbAl™. Nan Jiang, James P. Novak, and Zvi Yaniv from Applied Nanotech Inc. will demonstrate novel approaches using this unique material.

High power LEDs are continually replacing traditional incandescent lighting due to reduced energy consumption, high luminosity and the ability to create form factors not possible with existing structures. However, a primary obstacle to widespread implementation of LED lighting systems in established lighting networks is thermal management. Proper temperature control of the p-n junction can enable increased operational efficiency while simultaneously extending the LED lifetime. Herein, we describe novel approaches to thermal management that incorporate various materials and architectures aimed at reducing the total thermal resistance between the LED junction and the ambient environment.

High-performance graphitic carbon-based thermal management materials now appearing in the market have an optimal combination of thermal and mechanical properties. These materials have high thermal diffusivity, high thermal conductivity, low density and a low coefficient of thermal expansion (CTE). One such group of materials, CarbAl™ can be derived using unique surface engineering techniques. These functionalized layers include high-thermal conductivity dielectric materials and additive print processes to deposit circuit conductors. The combination of high-performance graphitic carbon-based materials and functionalized layers provide considerable reduction in total thermal interfaces in a power LED package.

## Introduction

High-intensity discharge (HID) lamps represent a lighting application with enormous potential for energy and cost saving. High-intensity discharge light sources are primarily installed in large public areas where high levels of illumination are required. These areas include indoor overhead lighting—such as arenas, warehouses, and parking structures—and outdoor overhead lighting, such as stadium and street lights. Compared to mercury vapor or high-pressure sodium lamps, LEDs can exhibit two to four times greater system efficiency as measured in lumens of output per watt of input power. With over 40 million HID fixtures installed in the United States alone [1], and 1.5 million new installations each year, just the energy savings from moving to LED-based systems could save billions of dollars per year. Additionally, LEDs can have more than double the installation lifetime before replacement, considerably reducing replacement intervals and cost.

The primary obstacle to readily implementing energy-saving LED lighting systems in established commercial and municipal lighting networks lies in dealing with the waste heat that is generated by high power LEDs [2]. To produce the light output that is needed for commercial luminaries, high power LEDs are needed. Even at the efficiency levels of today's state-of-the-art LEDs, they consume in excess of 10 Watts each, with the majority of that power converted to heat at the semiconductor junction of the device. Unlike a light bulb that radiates its heat, the heat is generated internally to the structure of the LED package and needs to be conducted away from the LED junction as efficiently as possible to maintain proper operation. Rises in junction temperature in the LED result in color shift, reduced light output, and ultimately, reduced life of the LED.

One way of reducing the amount of heat that is generated in an LED luminary is to increase the number of LEDs in the array. For a given light

output level, a larger number of LEDs allows them to be operated at a lower current level and subsequent power consumption. This moves the operation of the LED to a more efficient point on the Current vs. Light Output efficiency curve, so the Lumens per Watt efficiency increases and the amount of heat for a given level of light output is reduced. The high cost of these leading-edge LEDs makes increasing the LED count the less desirable option in most cases. Beating the heat and keeping the cost down for a given design is the task of every LED lighting engineer.

Approaches to thermal management incorporate various materials and architectures aimed at reducing the thermal resistance between the LED junction and the ambient environment [3]. Currently, there are several key areas to address LED junction temperature. These include:

1) reducing the number of thermally-resistant layers between the LED junction and the environment,
2) reducing the thermal resistance of said layers, and
3) using high thermal conductivity materials as heat dissipation substrates. If properly engineered, new concepts in thermal management can address each of these key areas to maximize performance of mechanical heat conduction.

In this article, a group of high-performance graphitic carbon-aluminum based thermal management materials known collectively as CarbAl™ will be reviewed, and the corresponding surface functionalization techniques developed for the purpose of meeting the tough thermal management requirements of high-output LEDs will be explained. This combination of high-performance graphitic carbon-based materials combined with novel functionalized materials and techniques are able to provide new methods for thermal management package designs that define a route for improving overall power LED performance.

## Properties of Graphitic Thermal Management Substrate Materials

It is possible to design and manufacture special graphitic carbon-aluminum composite thermal management substrates with a unique combination of low density, excellent thermal diffusivity, high thermal conductivity, and a low coefficient of thermal expansion that far exceed the capabilities of conventional passive thermal management materials. Table 1 shows the comparison of materials properties of two types of carbon aluminum composites to other commonly-used thermal management materials and typical graphite foams. Today, aluminum, copper, and their alloys are the most widely used thermal management materials. CarbAl™ materials have a thermal conductivity of 350-425 W/mK vs. 200 W/mK for Al and 390 W/mK for Cu. On the other hand, comparing with the commercial thermal management graphite foams, CarbAl™ presents a much higher thermal conductivity and mechanical strength and much lower cost. In terms of thermal diffusivity, they have a thermal diffusivity of 2.55–2.9 $cm^2$/sec vs. 0.84 $cm^2$/sec for aluminum and 1.1 $cm^2$/sec for copper.

In general, a substance's thermal diffusivity is the key factor contributing to fast heat transfer and rapid temperature equilibrium. Thermal diffusivity can be represented as follows:

$$\alpha = k / ( C_p * \rho) \quad (1)$$

whereby: α is the thermal diffusivity ($cm^2$/s); k is the thermal conductivity (W/mK); Cp is the specific heat capacity (J/gK); and ρ is the material density (g/cm3).

The heat equation is the function of thermal diffusivity:

$$\frac{\partial T}{\partial t} = \alpha \nabla^2 T \quad (2)$$

where t is time.

The 1-dimensional Green's function for heat equation is defined as follows:

$$G(x,t) = \frac{1}{\sqrt{4\pi\alpha t}} e^{-\frac{x^2}{4\alpha t}} \quad (3)$$

that is the temperature field evolutionary response for a δ-function initial temperature at x = 0.

A normalized temperature–time curve plotted according to equation (3) shows that a high thermal diffusivity will allow rapid diffusion of heat from the point of creation to a dissipative heat sink (Figure 1). In other words, a material with high thermal diffusivity can rapidly adjust the temperature to that of its surroundings, preventing overheating.

This point is especially important for high-power, high-speed electronic devices like power LEDs, where high

Performance comparison of CarbAl™ to other heat exchanger materials

| Constant | units | Graphite Foam | Aluminum | Copper | CarbAl™-N | CarbAl™-G |
|---|---|---|---|---|---|---|
| Thermal diffusivity | cm2/sec | - | 0.84 | 1.12 | 2.45 | 2.9 |
| Thermal conductivity | W/mK | 220 - 245 | 203 | 390 | 425 | 351 |
| CTE | ppm/K | 0.69 – 1.02 | 24*10-6 | 17*10-6 | < 7*10-6 | 2.0*10-6 |
| Specific Heat | J/gK | - | 0.9 | 0.385 | 0.75 | 0.69 |
| Specific Gravity | g/cm3 | 0.48 – 0.90 | 2.7 | 8.9 | 2.3 | 1.75 |
| Bending strength | MPa | 2.1 – 2.7 | 80 | 350 | 40 | 24.5 |
| Porosity | % | 60 - 70 | - | - | - | 20 -25 |
| Cost (in volume) | $ | >> X | <<X | X | X | <X |

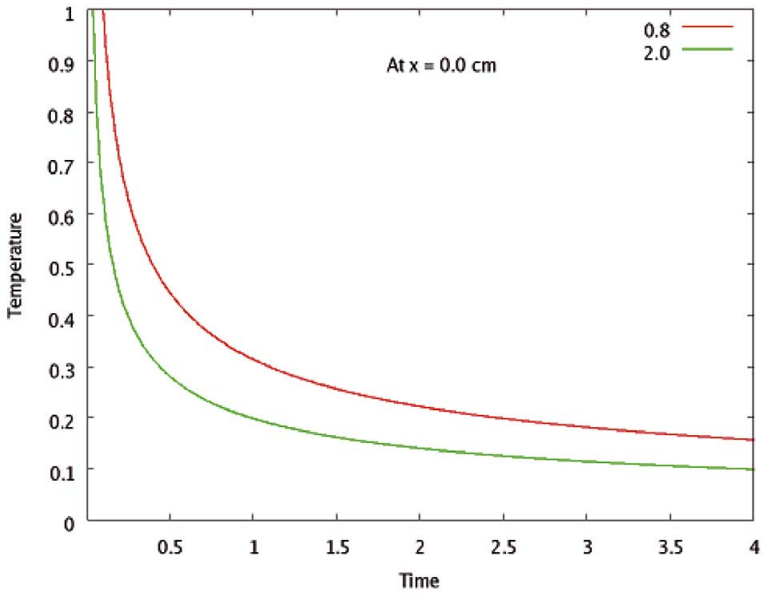



**Figure 1:** **Normalized temperature-time curve at a hot-spot site**

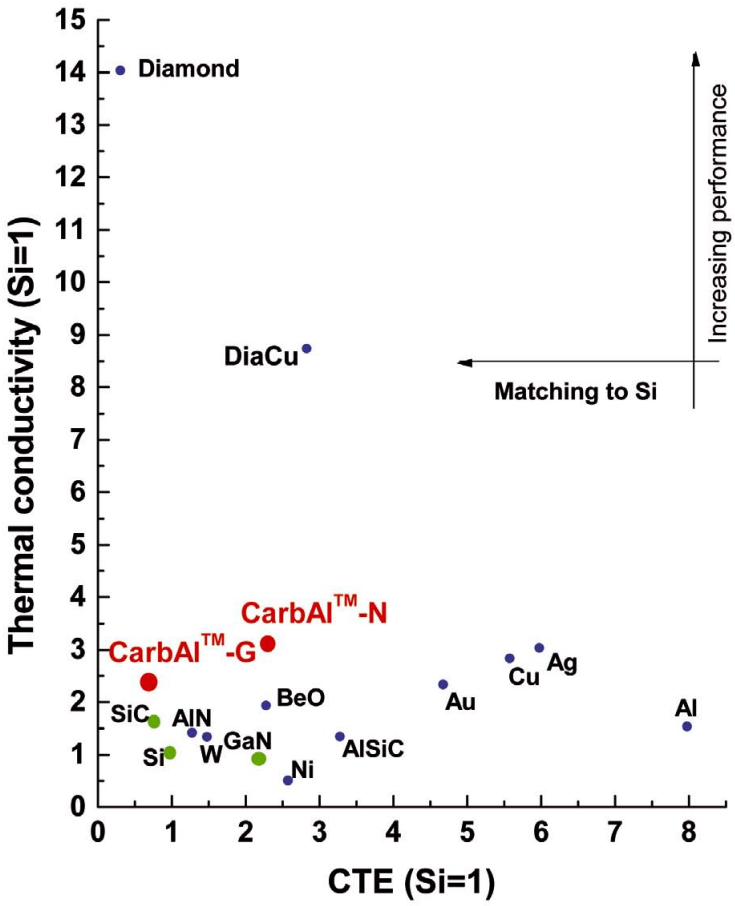



**Figure 2:** **Plot of CTEs for various thermal management materials**

thermal diffusivity materials are strongly required to modulate temperature and eliminate “hot spots” since temperature dramatically impacts device lifetime. For high-performance carbon-based materials, the speed to remove heat from a heat source or "hot spot" is two to three times higher than Cu and Al.

Figure 2 is a chart comparing CTE and thermal conductivity of thermal management materials including silicon. CTE and thermal conductivity values for each material have been normalized to Si, which was assigned a value of 1. Figure 2 shows that commonly-used semiconductor materials such as Si, GaN and GaAs have a thermal mismatch when interfaced with materials currently used for the heat sink and heat spreader (i.e. Cu, Al). The thermal mismatch creates stress by differences in thermal expansion rates of materials. This has a deleterious effect on the lifetime and reliability of electronics. It can be seen in Figure 2 that CarbAl™ materials have a much closer match in CTE to commonly-used semiconductor materials, whereas Cu and Al, have CTEs that are far from matching semiconducting materials. Besides eliminating thermally-induced delamination and cracks, a lower CTE allows direct attachment of bare chips on the composite material to minimize the number of material interfaces and maximize heat dissipation, benefitting a wide variety of thermal management applications like power LED packaging.

## Surface Engineered Thermal Management Circuit Boards

Like other metallic thermal conductors, these materials are electrically conductive. In order to make electronics circuit boards, a dielectric isolation is required to prevent electrical shorts. One of the most common approaches for construction of PCBs is lamination of a dielectric layer on the top of a thermally conductive substrate followed by laminating the Cu circuit traces on the dielectrics. A good example of this construction method for power electronic substrates is direct bond copper (DBC). A different method for manufacturing that is easier to manufacture, potentially reduces cost and shows increased performance is described below.

In the following example, modern additive manufacturing processes is demonstrated to generate high-performance thermally-conductive substrates. The process begins with the substrate material. Taking advantage of its low CTE and excellent thermal transfer characteristics, a CTE-matching polymeric, thermally-conductive dielectric is applied by a screen printing method. This method eliminates the high-temperature,

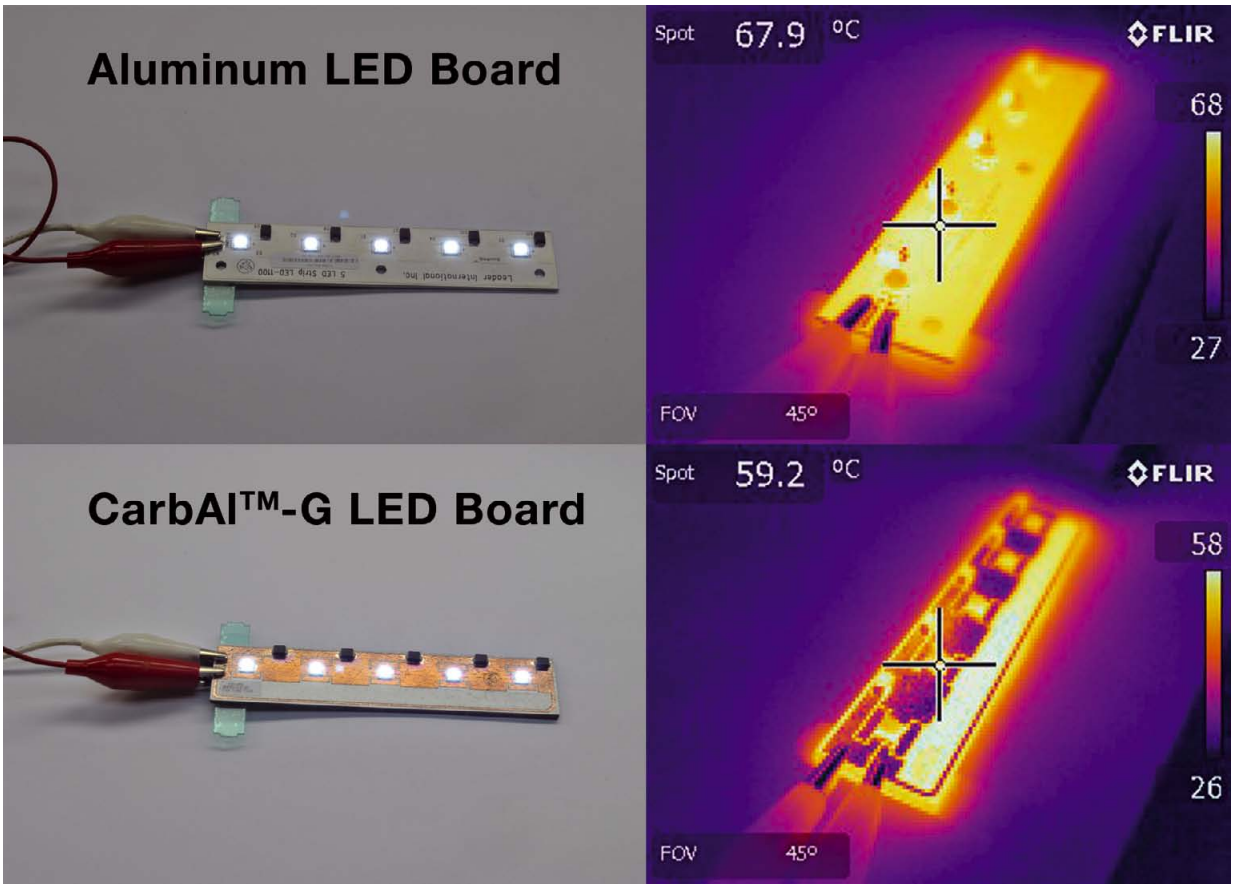



**Figure 3:**
**Power LED circuit boards using Al and CarbAl™-G substrate, respectively**

pressure-bonding required to bond ceramics to metals. The print method also allows for superior control over material thickness. Thickness of the dielectric layer can be reduced, thus reducing the overall thermal resistance. The final step is application of the final circuit traces. This can be accomplished through direct trace lamination or direct additive printing.

By printing the necessary circuitry directly onto a material that possesses the highest thermal conductivity available, two characteristics may be maximized: thermal distribution across the available surface area and conduction of the heat as rapidly as possible through the thickness of the material to the next level of thermal management. These functions are critical to get the heat away from the semiconductor junction in the LED as quickly and efficiently as possible.

Figure 3 shows two power LED circuit boards manufactured using a lamination process onto both Al and graphitic thermal management material substrates, respectively. The boards were populated with identical circuit traces and components. With identical power input (7.7 W) to each LED circuit board, the temperature on the CarbAl™-based LED circuit board was much lower than that on the Al-based circuit board. In fact, the actual temperature difference is 8.7°C lower. Of course, one can use Cu as a substrate to achieve similar results, but a similar Cu LED circuit board will be five (5) times heavier, than and more than twice as expensive as CarbAl™-G. In an application with multiple boards for a hanging overhead application, weight and prices differentials are significant.

## Assembly of Engineered Thermal Management Circuit Boards

As mentioned previously, reducing the number of thermally-resistant layers between the LED junction and the ambient environment must be addressed for widespread use of power LEDs. To fulfill this purpose and exploit a much more advanced LED circuit board, specially designed and developed unique ceramic dielectric inks and nano-Cu inks can enable direct printing of a dielectric layer - or example, Cu traces on CarbAl™ substrate to build fewer layered circuit boards, since such a direct printing approach can successfully eliminate the highly thermally-resistant organic adhesive layers that would be needed when using lamination method. The ceramic dielectric ink, in this example, consists of ceramic filler particles and a little amount of ceramic binder material, having a thermal conductivity of 4 W/mK that is more thermally conductive than normal epoxy based dielectric films. Moreover, the dielectric layer formed by this ceramic ink has excellent adhesion with CarbAl™ substrate and can sustain a working temperature up to 500°C. On the other hand, proprietary Cu nano-inks and pastes can be fully cured and transferred into highly-conductive (resistivity < 3 μΩ cm) Cu traces at around 400°C. The high temperature stability nature of the ceramic dielectric layer is particularly important for curing Cu traces, and in contrast, most polymer dielectric materials are not compatible with Cu ink curing processes due to their poor thermal stability.

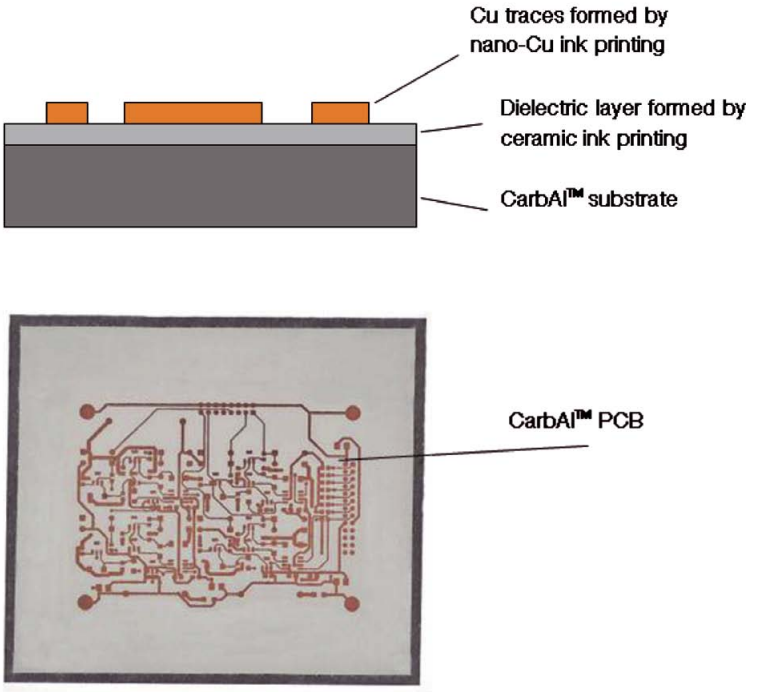



**Figure 4:**
**Directly printed CarbAl™ PCB using ceramic dielectric and nano-Cu inks**

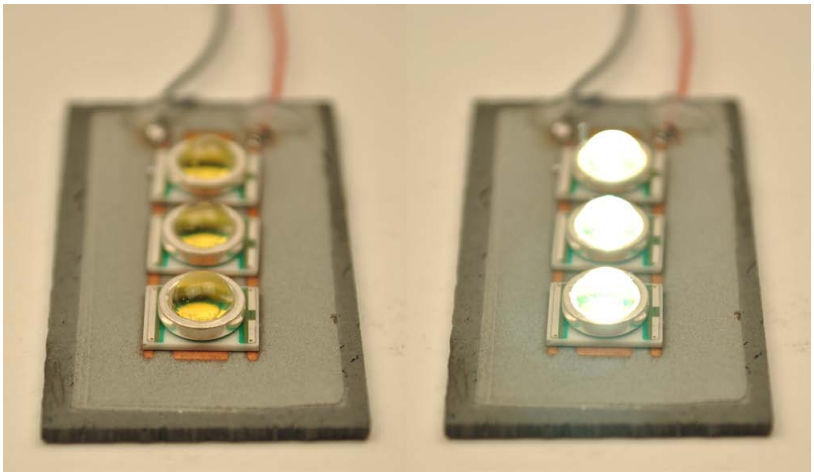


**Figure 5:**
**Proof of concept of directly printed CarbAl™ LED circuit board using ceramic dielectric and nano-Cu inks**

PCBs have been developed with an optimal combination of high-performance graphitic carbon-based materials, ceramic inks, and nano-Cu inks (Figure 4). Comparing the PCBs with laminated circuit traces on top of thermal insulators, these directly-printed circuit boards are believed to be very promising candidates for power electronics applications due to the reduced interface layers between the highly-thermally conductive dielectric substrate and heatsink, as well as its low CTE nature. By a similar approach, the proof-of-concept directly printed CarbAl™ LED circuit boards have been fabricated as well (Figure 5), and fully-integrated high-power LED lamps utilizing directly-printed circuit boards are being developed.

## Conclusions

Advanced low CTE thermal management materials have been successfully developed, which have a CTE smaller than 7 ppm/K, thermal conductivity over 350-400 W/mK, and thermal diffusivity 2.5–3 times higher than that of Cu. The combination of high performance graphitic carbon-based materials and functionalized layers described above can provide considerable reduction in total thermal interfaces in a power LED package while controlling potential issues of delaminating due to CTE mismatch. This type of package can drive widespread implementation of high-power LED lighting. ■

**References:**
[1] http://www.hubbell-unenco.com/media/products_img/high_bay/highbayBROCHURE.pdf
[2] James Stratford, LEDs Magazine, December 2005, P1.
[3] http://www.newark.com/pdfs/techarticles/ledengin/15W_thermgmt-note.pdf



TOP

Acg MadeInAsia 亞洲制造

Asia TOP Lighting Brand Only

HENSEL MEEK SignComplex BCX 宝诚鑫 LOEOD 乐尔 FSL COMYAN

TOP LED MANUFACTURERS IN WWW.MADEINASIA.COM

---

# Excellent chance
# for your business in Korea !!

LIGHTING KOREA 2012

KOREA INT'L LED/OLED LIGHTING FAIR2012

**Exhibits**

Lighting Fixture, Materials, System Lighting
LEDs, OLEDs, Manufacturing & Testing equipment

**Contact US**

Tel. 82-2-6000-6676 | Fax. 82-2-2051-3326
E-mail. lighting@lightingfair.co.kr

2012 10 OCT. Wed 17 Thu 18 Fri 19 coex

**CONNECT with US!**

www.lightingfair
www.facebook.com/lightingfair
www.linkedin.com/in/lightingkorea

# Optimizing Remote Phosphor for LED Lamp Applications

To generate white light in luminaires, different oportunities exist. One is remote phosphor technology. This technology allows luminaire manufacturers to differenciate and tune different light parameters depending on the requirements. However, in many cases this means a lot of effort. Guenther Hasna, Chief Technology Officer at Optis GmbH presents a software based approach to optimize and adapt remote phosphor for lighting applications.

**Light-emitting diodes, originally used as indicator lamps in many electronic devices, can now be found in almost any lighting system. Phosphor-based LED technology achieves white light sources by adding a coating with phosphors of different colors around the chip. A fraction of the original light undergoes the Stokes shift being transformed from shorter wavelengths to longer. If several phosphor layers of distinct colors are applied, the emitted spectrum is broadened, effectively raising the color rendering index (CRI) value of a given LED.**

The key point in phosphor LED development is to raise the efficiency by adapting better package design and using a more suitable type of phosphor, requiring state-of-the-art optics, mechanics, electronics and analysis software. Although commercialized CAD and optical design software are widely available, most of them work independently. It is technically challenging and time consuming to find an optimal solution for the final design using separate software.

OptisWorks provides a unique solution by integrating the optical and mechanical design into the same software platform. Powered by OPTIS SPEOS technology, the software assists optical design, optimization and system integration by simulating light propagation through complex 3-D optical components as well as opto-mechanical assemblies. The complete integration in SolidWorks allows optical engineers and mechanical engineers to design different modules using the same software platform. Overall system performance can be evaluated at any checkpoint in the design process, significantly shortening the design cycle and reducing cost.

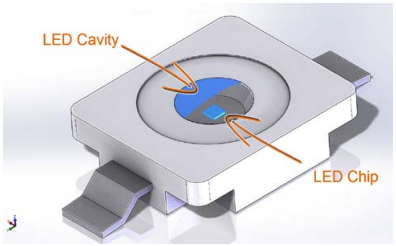



**Figure 1:**
**Phosphor LED mock-up**

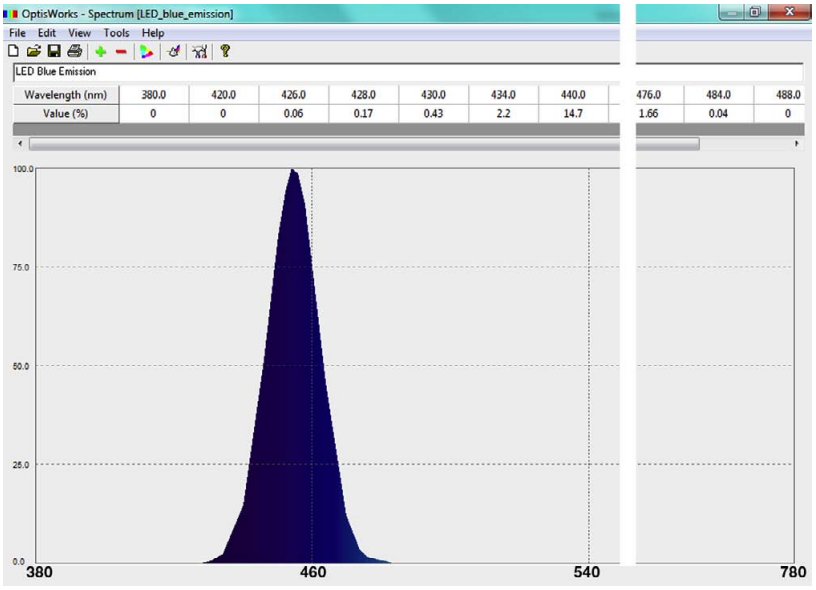



**Figure 2:**
**LED chip emission spectrum**

## Overview

LED chip light source (Figure 1 shows the phosphor cavity mock-up from the LED chip emission to the phosphor dyes) emits photons that could be scattered or absorbed by the cavity phosphor dye. Each phosphor particle can then reemit according to the quantum efficiency, with a longer wavelength.

Optical sources are modeled and created, based on specifications such as luminous flux, emittance uniformity, radiation pattern and continuous spectrum (Figure2 shows the emission spectrum of the LED chip source).

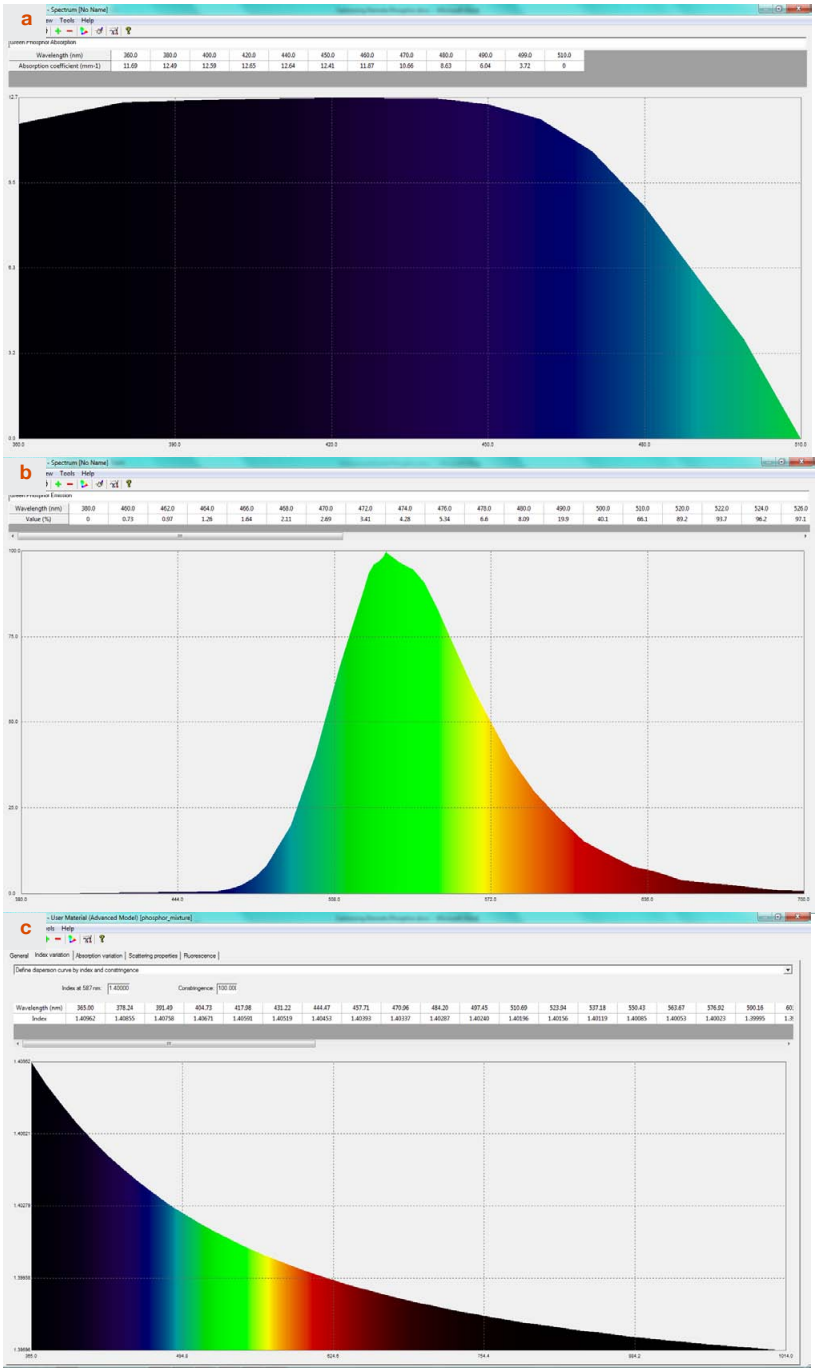



**Figure 3a/b/c:**
**Phosphor dye absorption and emission spectrums. The user materiel editor**

## Phosphorescent Material Modeling

The simulation tool can model the optical properties of a fluorescent sample, including the fluorescent dye and the media in which the dye particles are immersed. These properties include quantum efficiency, absorption spectrum, emission spectrum and dye concentration. The absorption spectrum and emission spectrum can be import from the dye manufacturer data sheet.

We used two different dyes absorbing broadly blue wavelengths from 360 to 510 nm. Their main difference consists in the emission spectrum, the first dye emitting photons around 530 nm and the second one around 610 nm. Figure 3a/b shows the imported absorption and emission as part of the properties to model the fluorescent dye.

The LED phosphor encapsulant has been defined with the input of the refractive index (n=1.4 at 587nm) and Abbe number (100). Figure 3c shows the volume optical material editor.

## Simulation Results and Optimization

Immediate effects of phosphor cavity on light propagation are observed. Figure 5 shows the interactive ray tracing, each ray taking the color corresponding to the reemitted wavelength.

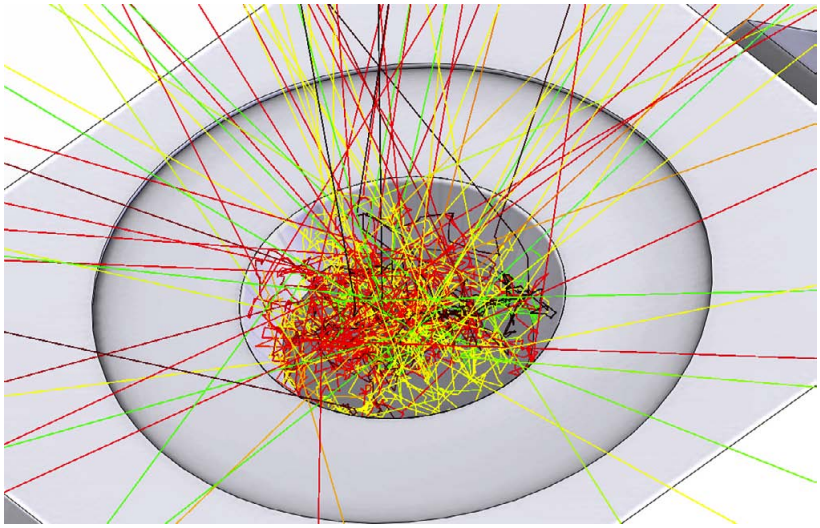


**Figure 4:**
**Interactive ray tracing**

Once the optical effect of the phosphor has been verified through ray tracing, optical detectors are set up to measure the output of the LED. Depending on the desired output, for example luminance, illuminance or intensity measurements, different detectors can be defined.

Preliminary simulation results are obtained, giving the output of the LED in candela along with the color coordinates. Figure 6 illustrates intensity and color measurements.

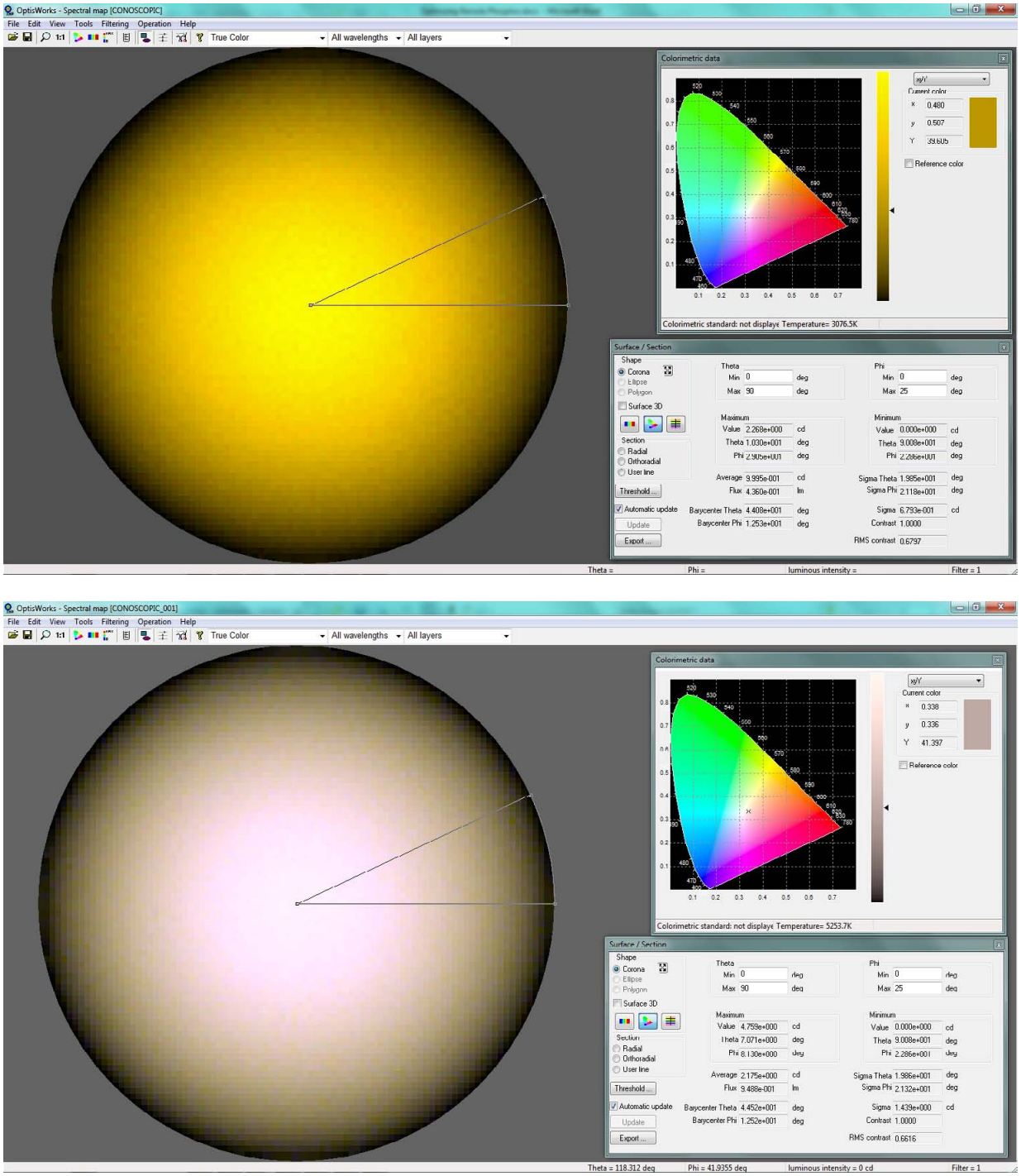



**Figure 5:** **Intensity and color measurements (top) and optimized phosphor concentrations (bottom)**

The user is now able to change concentration of each defined phosphor to affect the final spectral output of the LED. The software allows this operation to be done manually or through an optimization loop to converge LED output to color coordinates of interest.

## Summary

The work process how to design, analyze and optimize a phosphor LED using a software tool was demonstrated. With the seamless integration of OptisWorks and SolidWorks, it is possible to model optical components and opto-mechanical assembly in the same software environment, thus, eliminating the potential risk of data conflict and data loss during import and export designs between different software. The integration also enables the optimization and evaluation of the entire system simultaneously, which is often difficult to achieve using separate software for different engineering tasks. ■

**International Expo & Conference gathering 500* exhibitors from around the world**

Held inside **LIGHTING JAPAN 2013**

# 5th LED/OLED Lighting Technology Expo

## Light-Tech

*Lighting Devices*

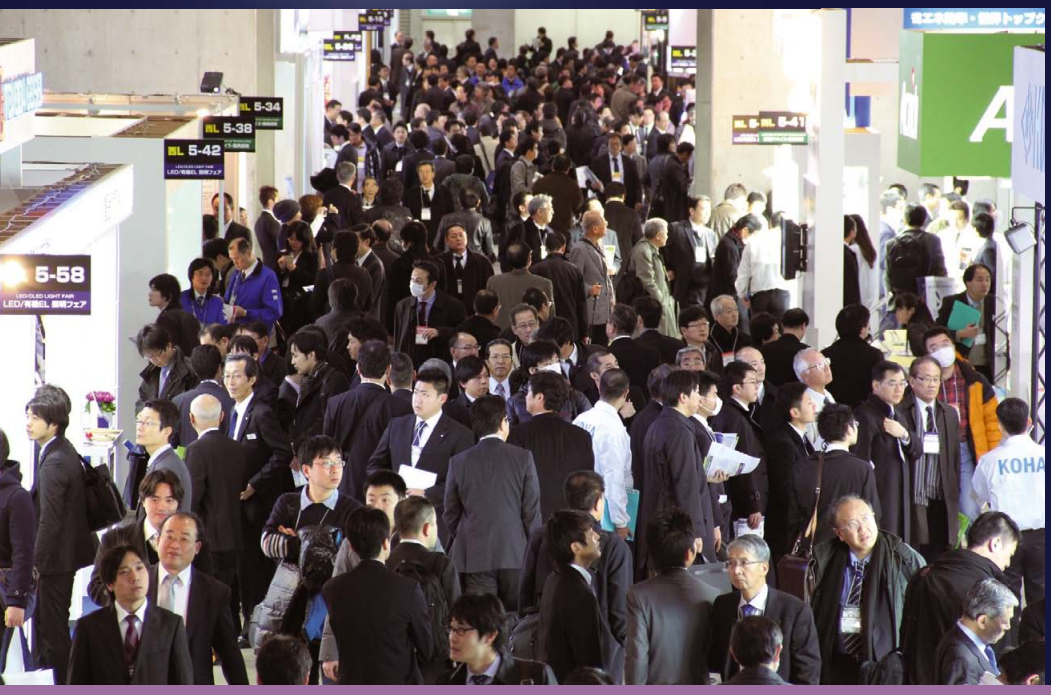
*Components*

*Equipment*

*Materials*

**Exhibit here and conduct business with 32,000* quality visitors.**

( *expected, figure of LIGHTING JAPAN)




***For exhibiting information >>> www.lightingjapan.jp/en/***

**Concurrent Shows inside LIGHTING JAPAN**

3rd LED/OLED Light Expo — Light-Expo

DESIGN LIGHTING TOKYO 2013 — 1st Tokyo Design Lighting Expo & Conference

**January 16 [Wed] – 18 [Fri], 2013**

**Tokyo Big Sight, Japan**

Organised by: **Reed Exhibitions Japan Ltd.**

Organised by

Reed Exhibitions

# Imprint

*LED professional Review (LpR),* ISSN 1993-890X


## Publisher

Luger Research e.U.
Institute for Innovation & Technology
LED professional Dept.
Moosmahdstrasse 30
A 6850 Dornbirn, Austria / Europe

phone +43 5572 394 489
fax +43 5572 394 489-90
email editors@led-professional.com
web www.led-professional.com

## Publisher

Siegfried Luger

phone +43 5572 394 489
email s.luger@led-professional.com

## Editor-in-Chief

Arno Grabher-Meyer

phone +43 5572 394 489-18
email a.g-m@led-professional.com

## Int. Account Manager

Theresa Koenig

phone +43 5572 394 489-20
email theresa.koenig@led-professional.com

## Promotion & Sales Mgr.

Gerlinde Graf

phone +43 5572 394 489-43
email gerlinde.graf@led-professional.com


**Cover-page**
Image: Arno Grabher-Meyer, LED professional; POSCO LED AC-LED retrofit bulb
Artwork: Thomas Klobassa, ©LED professional 2012




## LED professional Review (LpR) - Annual Subscriptions

**LpR Digital Magazine**

- 6 issues
- pdf download
- high resolution pictures and graphs
- printable
- commercial use
- access to all previous issues
- Euro 78.80

http://www.led-professional.com/subscription

**LpR Printed Magazine**

- 6 issues
- Euro 158.40

Next LpR Issue - Sept/Oct 2012
System Integration & Technology Trends
LpS 2012 - Bonus Distribution







# Accelerate Your Time To Market

Expedite your next project with Future Lighting Solutions. From LUXEON® LEDs, optics, drivers or heatsinks to fully integrated or custom solutions, we have the products, tools and knowledge to help you make the right decisions in specifying your LED lighting system solutions.

**LUXEON LEDs & System Components**

**Integrated Light Engines**

**Modular System Solutions**

**Remote Phosphor Solutions**

**Contact Us**

**NORTH AMERICA**
1-888-LUXEON2
Americas@FutureLightingSolutions.com

**EUROPE, MIDDLE-EAST, AFRICA**
00-800-44FUTURE
Europe@FutureLightingSolutions.com

**ASIA PACIFIC**
+86-755-8304-1300
Asia@FutureLightingSolutions.com

**JAPAN**
+81-0120-667-013
Japan@FutureLightingSolutions.com

**www.FutureLightingSolutions.com**

FUTURE Lighting Solutions
*Making LED Lighting Solutions Simple™*

# WE ARE LIGHT

## EBV ELEKTRONIK AND OSRAM OPTO SEMICONDUCTORS

OSRAM Opto Semiconductors appointed Avnet EM as 'Preferred Global Partner'.
EBV Elektronik is representing this 'Preferred Global Partnership' in EMEA.

To get the best from LED technology, you need the right partners with the appropriate expertise and the ideal product range. This is where our customers benefit from the partnership of the EBV LightSpeed team and OSRAM Opto Semiconductors. With more than 30% market share according to DMASS, EBV is the leading specialist for optoelectronics technology in EMEA semiconductor distribution.

Together with OSRAM Opto Semiconductors innovative, trend-setting technologies for illumination, visualisation and sensing we will offer you full support in turning your lighting ideas into reality.

With the EBV LightLab, EBV is the first company in EMEA semiconductor distribution, to offer customers all over EMEA to perform photometric measurements and analyse their lighting projects. The complete spectrum of products from individual LEDs right up to the complete luminaires are covered in the EBV LightLab. More info under **ebv.com/lightlab**.

For all services around LED technology from OSRAM contact your local partner of the EBV LightSpeed team.

**Distribution is today.**
**Tomorrow is EBV!**
www.ebv.com

LED Light for you powered by OSRAM CERTIFIED PARTNER | EBV LightSpeed | OSRAM Opto Semiconductors | EBV Elektronik An Avnet Company