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LED professional Review

LpR

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July/Aug 2013 | Issue 38

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LED Die Manufacturing

The optimization of the manufacturing process for LED dies plays an important role in accelerating Return-On-Investment (ROI) in the lighting business. The industry focuses on payback to especially drive demand in the general lighting market.

Efficiency (lumens/W) drivers are mainly die design optimization, new materials and processes, increasing performance needs and increasing device complexity, whereby on the cost side (lumens/$) drivers such as higher production volumes, larger wafer size, decreasing die prices and improving bin yields are the major influencing factors.

In 2015 more than 2/3 of all wafer sizes will be equal to or larger than 4 inches and more than 50% of all die sizes will be beyond 0.25 mm^2. This trend of larger wafer and die sizes will result in higher defect impacts on the yield. For instance 1016 um x 1016 um dies may show yields below 40% while 240 um x 600 um dies may reach a yield of nearly 50%. And finally, the LED technology used, such as GaN-on-Silicon etc., is inherently responsible for the number of defects (e.g. micro-cracks, Epi hex bumps or Epi micropits).

Defects result in poor yield and lower reliability of the final product. Yield losses from various manufacturing steps (Substrate, Epi, Wafer Fab and Die Fab) have a cumulative effect.

It is obvious that high-quality end products can only be achieved with SPC controlled production lines. In a discussion with KLA-Tencor we have also learned that the inspection of LED dies is, to some extent, unique in regards to in-line inspection. Some crystal defects can only be found with so called “contrast channels” in-line but such a product would lead to lumen degradation and/or wavelength shifts in the field.

In general, the manufacturing process is getting more and more critical due to technologies and cost-optimization developments. The process control, from the substrate to packaging, is a very important factor for ensuring the quality of LEDs and LED lighting systems. It maximizes the production efficiency, reduces material at risk and field failures and accelerates time-to-market.

Yours Sincerely,

Siegfried Luger

Publisher, LED professional
Event Director, LpS 2013

Content

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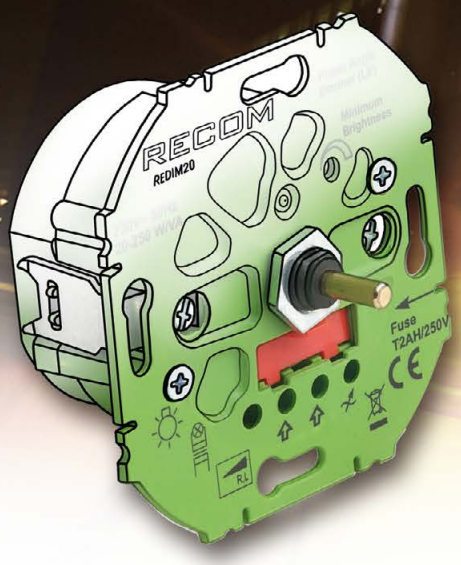

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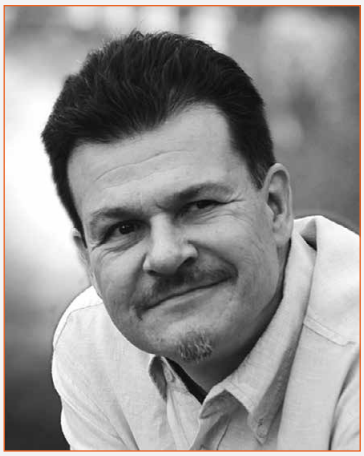

Arno Grabher-Meyer

Arno Grabher-Meyer originally studied biology at the University of Innsbruck, where he was involved in several scientific documentation projects for the Alpenzoo (Alpine Zoo) and a documentary film for the BBC with David Attenborough.
He earned his engineering degree through continued education and in 2005 went to work for Luger Research e.U. Here Arno worked on several LED lighting research projects in conjunction with the Austrian Competence Center Light.
His job as Chief Editor started in 2006 when Luger Research started up LED professional.
Part of this multi-faceted job is being responsible for the editorial content of the magazine and online news.

LATEST LED LIGHTING HEADLINES – "THE GOOD, THE BAD AND THE UGLY"

"Researchers Discover LED Lights Damaging French Impressionist Paintings" "Can't Sleep? Blame Your LED Backlit Screen", "LED Lights Can Cause Irreparable Damage to Retina"…

More and more headlines like the ones above are flooding our daily news. These types of captions can easily lead the public to the conclusion that LEDs are harmful to the environment, artworks and even our health. The result of the global press presenting this type of information to the public are demands for preventive measures, new regulations and standards, or even banning LEDs altogether.

All three of the above issues cannot be ignored. The research results seem to be crying out for fast and sufficient action so that harm to our health and cultural assets can be avoided. In order to be able to determine what the appropriate action might be, though, it is necessary to take a closer look at the original paper's results. Quite often we are surprised by the fact that the researcher's conclusions and the headlines of news articles are very different.

In the end, it seems that the only way to shed light on the truth is to find out how much the headlines published by the press or a PR agency coincide with what was researched and published in the scientific paper. Before that we just cannot have a fair discussion about the issues mentioned above or the consequences thereof.

When we checked the headline concerning the damage to French Impressionist paintings against the original paper, we found the headline to be misleading. The researchers did not use an LED light source for any of the tests. The systematic research does not allow for a conclusion that would confirm what the headline claims. It seems like a very creative public relations person made it up and the newspapers and websites enthusiastically re-published it without doing their own research. This is the power of copy-paste.

There is a grain of truth in the second headline. Blue light has a clear influence on melatonin suppression, which may cause irregularities in our biological clocks and in turn lead to some health issues like not being able to sleep. However, the minimum intensity of blue light needed to cause this effect wasn't clearly identified. The statements in the paper are conflicting. Generalizations like "…we are readily replacing…with new energy-efficient blue light technology like LEDs" are also a critical factor in the article. This leads the reader to believe that all LED based lights cause this effect. It is true that computer monitors are usually lit by white light of a high CCT. On the other hand, most replacement lamps have lower incandescent-like CCT, and in high quality products, the amount of blue light is very similar to that of an incandescent lamp.

The third, and most recent, headline is the most alarming one. The author claims that everyone that has an LED display or TV is in danger of damaging their retinas if they don't wear sunglasses. However, other experts in the field have indicated their concerns about this study. They believe that it "fails to stimulate realistic conditions for the retinal cells."

In addition, it seems that the author is involved in research on age related macular degeneration and is also the founder of a company that deals with the prevention of macular degradation. It is very possible that he is sensitized (or biased?) when it comes to these types of issues. Of course we don't know what else the author said during the interview. The journalist may have edited some comments or key words. Since we can't find the original publication we can't compare and we still don't know the truth.

Inaccurate quotations by journalists and unexplained statements by authors and interview partners cause the end user to be unsure and technologies to be discredited. On the other hand, unproven reactions and recriminations discredit researchers and journalists. Both are unacceptable. A more thorough and responsible type of communication would be welcome in future. ■

A.G-M.

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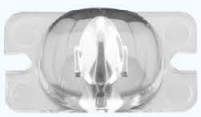

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Cree CXA Platform Set Bar for Light Quality and Efficacy

Cree, Inc. expands its industry-leading CXA family with new 95 CRI options and two new LEDs providing lighting manufacturers high-performance, design versatility and low cost in one robust platform. Delivering up to twice the efficacy of equivalent CRI LED light sources, the new CXA CRI options deliver halogen-like color and push the boundaries of lighting-class performance by combining high quality light with unmatched light output and efficacy. Cree's extended family of CXA LED Arrays include the XLamp® CXA1304 and CXA1816, providing manufacturers the broadest opportunity to optimize and expand their LED lighting product portfolio.

Cree's XLamp CXA1816 LED Array is intended to replace up to 70 watt ceramic metal halide lamps

The new XLamp CXA1304 LED Array is the most compact member of the family, delivering up to 1034 lumens in a 6mm optical source size, and enabling lighting manufacturers to rapidly address small form factor lighting applications. The new XLamp CXA1816 LED Array can enable LED replacements for up to 70 watt ceramic metal halide in spot lighting or for 2000 lumen downlights with a 12mm optical source size.

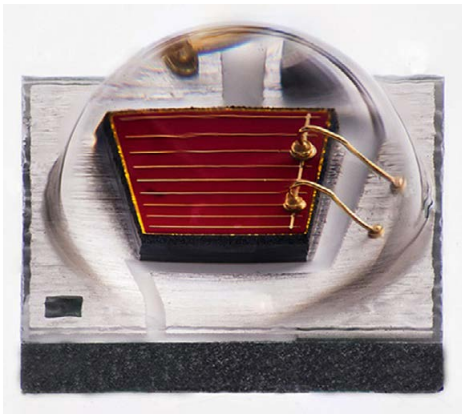
"The family of CXA LED Arrays appeals to us because of the wide range of lumen options available, all at very high efficacy levels," said Michael Lin, CEO of Buckingham Industrial Group. "Regardless of the lighting application that we want to address, there is a CXA LED Array offered that is optimized for it."

"Customers are looking for LED-based halogen replacements that do not have the current trade-off between light quality and output with energy efficiency," said Paul Thieken, Cree director of marketing, LED components. "With Cree's high CRI CXA LED Arrays, lighting manufacturers finally have a LED solution that can deliver high quality of light combined with high performance."

All the LEDs in the CXA family offer 6,000 hours of LM-80 data published and are designed to support TM-21 reported L90 lifetime of over four years, even at 105°C. Available in 5000K through 2700 K CCTs, the high CRI CXA LED Arrays deliver a typical CRI of 95 with a typical R9 value of 85 at 3000 K. All CXA LED Arrays are available in EasyWhite® color temperatures, providing the LED industry's best color consistency for designs that use only one LED. The new family of CXA LED Arrays now delivers from 300 to over 10,000 lumens. ■

Cree Introduces Highest Efficacy Color LEDs

Cree, Inc. announces commercial availability of XLamp® XP-E2 color LEDs. The new XP-E2 color LEDs deliver up to 88 percent higher maximum light output compared to alternative high-power color LEDs, enabling lighting manufacturers to more cost-effectively address a wide spectrum of applications such as architectural, vehicle and display lighting.



Cree's new XP-E2 color LEDs deliver up to 88 percent higher maximum light output compared to its predecessors

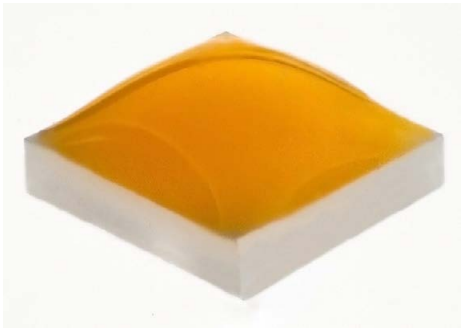
Built on Cree's revolutionary SC^3 Technology™ next-generation LED platform, the new XP-E2 color LEDs deliver higher lumens-per-watt and lumens-per-dollar compared to the original XP-E color LEDs to lower system costs for existing XP-E color designs. The new XP-E2 color LEDs leverage the same XP footprint (3.45mm x 3.45mm) and are optically compatible with the original XP-E LED – providing drop-in-ready performance enhancements to shorten design cycle and improve customer time to market.

"We are excited that Cree is offering higher performance color LEDs in the XP footprint," said Greg Campbell, executive vice president and chief technology officer, Lumenpulse. "The brighter XP-E2 color LEDs enable Lumenpulse to continue to provide innovative, high-performance LED lighting systems."

XLamp XP-E2 color LEDs deliver up to 1409 mW for royal blue, 109 lumens for blue, 253 lumens for green, 203 lumens for amber, 193 lumens for red-orange and 155 lumens for red, all at maximum drive currents in the 3.45 mm x 3.45 mm footprint. ■

Cree Offers Ceramic Mid-Power LEDs

Cree, Inc. is redefining the mid-power LED market with the new XLamp® XH Series LEDs – the first family of mid-power ceramic LEDs that offer no-compromise performance and reliability. Unlike today's common mid-power plastic packages, XLamp XH-G and XH-B LEDs enable lighting manufacturers to create a new generation of more energy-efficient, longer life LED lighting solutions without sacrificing cost or performance. XH LEDs are optimized for fluorescent replacement lighting applications such as troffers and panel lights, where high efficacy, lifetime and smooth appearance are critical.



Based on an unique ceramic base, Cree's new XH series mid power LEDs deliver breakthrough reliability and performance in its class

The XH-G LED delivers leading efficacy levels of up to 170 lm/W at 65 mA, 5000 K, 80 CRI and 25°C. In addition, the ceramic-based XH LEDs are designed to deliver the long L70

lifetimes at high temperature and high current operation of Cree's other high-power LEDs, such as XP and XT LEDs. In comparison, plastic LEDs are known for very short L70 lifetimes at high temperature and high current operation. The XH LEDs allow lighting manufacturers to offer products that meet the reliability expectations of LED technology.

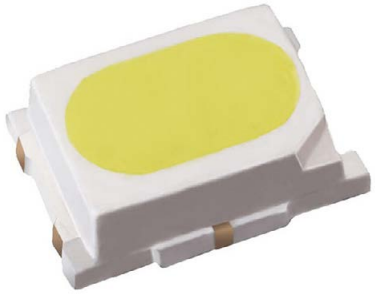
"We're excited that Cree is offering high-quality, ceramic-based mid-power LEDs designed for real world lighting applications," said Roger Suen, supply chain management director, Light Engine. "The XH LED family gives us confidence in providing products that deliver stable lumen maintenance and good color consistency that cannot be duplicated by plastic packages."

"The use of plastic packages for lighting solutions places a high degree of risk for end-customers and the industry in general," said Paul Thieken, Cree director of marketing, LED components. "The XH LEDs provide peace-of-mind to lighting manufacturers while enabling them to better differentiate their products in the marketplace."

Both XH-G and XH-B LEDs share a common 3.0 mm x 3.0 mm footprint package with a 13% wider beam angle than most plastic mid-power LEDs. Cree® XLamp XH LEDs are offered in 2700 K to 7000 K CCT with high CRI options available. Samples are available now and production quantities are available with standard lead times. ■

Everlight Offers Low-Power LED with Overdrive Capabilities

Everlight, a leading player in the global LED industry with three decades of experience in optoelectronics, expands its broad product range of low-power LEDs with a 0.2 W top-view white LED featuring a lead frame technology with heat slug for good heat dissipation. The new 45-21S series is especially suitable for LED light tubes in general lighting.



Everlight's low-power 45-21S package makes LED light tubes brighter

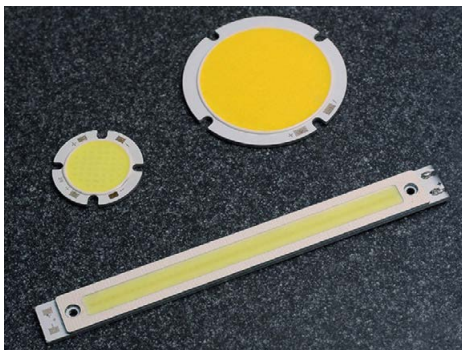
Everlight's 45-21S series is an upgrade from standard 3020 packages. With efficient thermal dissipation, this compact (3.0x2.0x0.8mm LxWxH) white LED can be overdriven up to 30mA or 60mA while maintaining high efficiency (115lm/W for the cool white and >104lm/W for the warm white versions), and cost effectiveness. These superior product characteristics turn the 45-21S LED into a real cost and energy saver and is a top solution for most general lighting applications, but especially for light bars or panel lights that need more brightness or require fewer LEDs.

Traditionally, light bar applications have been utilizing small 20 mA PLCC packages that enable high lumen density and uniformity to emulate the appearance of fluorescent tubes. As the required specifications for fixtures in that market improve, light tube manufacturers are looking for ways to increase the brightness of their fixture without changing the board layout or any part of the mechanical design. The best way to do this is to use an LED that can be overdriven. Another reason for higher brightness PLCC packages are the efforts of some manufacturers to maintain minimum system brightness while decreasing the number of LEDs used. Thus, LEDs that can be overdriven make the entire tube more cost effective.

The Everlight 45-21S series has a CRI of >80Ra and is offered with ANSI CCTs ratings from 2700K to 6500K. This low-power LED provides a typical light output of 20 lm (ww) and 22 lm (cw) at 60 mA and achieves a very high luminous output of 26-41 lm @ 75 mA.

New Lumex Flip Chip LEDs

Lumex announces the global launch of its TitanBrite Wireless Bonded LED featuring "flip chips" that are up to 15% brighter than any others in the market. In addition to the standard 3 W and 6 W LEDs, Lumex's TitanBrite Wireless Bonded LED is also available in 9 W.



Lumex's TitanBrite Wireless Bonded LED offers several key performance benefits over traditional LEDs including enhanced durability, superior light performance and enhanced heat dissipation

Wireless bonded LED technology, often referred to as "flip chip", offers several key performance benefits over traditional SMT (Surface Mount Technology) LEDs including enhanced durability, enhanced heat dissipation and superior light performance.

Applications for the TitanBrite Wireless Bonded LED include:

- Automotive – daylight, running light, dome light, foot well and floorboard runner lighting
- Appliance – cabinet lighting, accent lighting, backlighting
- Industrial control – donut lighting, warning indicators, inspection lighting
- Medical – surgical lights, examination lights, oral surgery lighting
- Signage – channel lighting, backlighting, warning and hazard lights
- Construction – warning lights, light towers, traffic lights
- Military – heavy equipment, construction and transportation lights

Enhanced Durability:
The enhanced shock and vibration resistance of wireless bonded LEDs compared to traditional LEDs stems from its more durable design. Due to the absence of a wire bond and a hard epoxy layer, the wireless bonded LEDs are five times stronger and more robustly designed than standard, high power LEDs.

Enhanced Heat Dissipation:
Wireless bonded LEDs offer superior heat dissipation and are more adverse to shock and vibration than traditional high power LEDs. They can withstand higher temperatures without compromising performance and have a greater surface area for heat dissipation, making them more efficient at removing heat. Due to the placement of junction pads on the bottom of the flip chip, heat can be transported faster than with a regular high power LED, keeping this technology 25% cooler than traditional high power wire bond technologies.

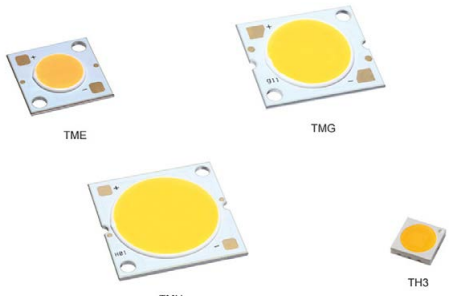
Superior Light Performance:
Wireless bonded LEDs provide superior light performance when compared with traditional LED technology. Higher light output is achieved in a more compact space and the light performance is not disrupted by shadows or other obstacles to consistent performance. With wireless bonded technology the chip can directly emit light from the top and the side with no wire bond casting shadows or creating uneven light distribution, providing 15% more light output.

Design options:
Lumex's TitanBrite Wireless Bonded LEDs are the only flip chip LEDs on the market available in both standard and custom colors and shapes. Standard shapes are circular and rectangular. Lumex can also design custom shapes such as octagons and triangles in order to fit any application. Standard colors include warm white and cool white and blue is available for custom products.

The RoHS compliant TitanBrite Wireless Bonded LEDs are available in 3 W wireless bond light bar modules (cool white and warm white) and 6W wireless bond round modules (cool white and warm white) in addition to custom colors (including blue) and sizes for 3 W, 6 W and 9 W. Pricing ranges from $6-$10 per unit. Lead times range from 8 to 10 weeks.

TSMC Releases TH3 and TMx Series LEDs

TSMC Solid State Lighting (TSMC SSL) announced the release of the TH3 and TMx series products and showcased their applications in 2013 Guangzhou International Lighting Exhibition. Based on the company's flip chip technology, superior reliability of the two products enable customers develop high-end lighting product.



TSMC Solid State Lighting's new products are the TH3 in a common 3030 package and the TMx series which are leading COB products

TH3 is a common 3030 package with power of up to 3 W capability. The unique feature of no wire bonding is free from loose electrical contact during the high current operation. Also, since the chip is bonded directly on the lead frame, the TH3 has very low thermal resistance (4.5 K/W) and performs efficient heat dissipation and lowest light decay as hot / cold factor (95% efficiency at 85°C), and low droop efficiency 90%. With its superior high lumen performance and excellent reliability, the TH3can be perfectly applied to wide lighting products such as general indoor lights, retrofit lamps as well as backlighting.
It answers the majority of customers' needs of high lm/$ value.

TMx series products are the leading COB product using flip-chip structure developed by TSMC SSL. It owns features of low thermal resistance (0.2 K/W), high 90% hot/cold factor, Zhaga compliance footprint and 3-step McAdam color binning. With unbreakable aluminum COB substrate, the TMx offers benefits including easy assembly, efficient thermal conduction, scattering –free beam and quantified lumen package. These benefits enable lighting makers to maximize the creative product categories in track and spot lights, downlights, high/low bays, flood lights and PAR lamps.

"We are proud of showing the TH3 and TMx series products to the lighting world customers. By applying TCMS SSL state-of-the-art technology and manufacturing capability of integrating Epi to the package, we demonstrate the solutions definitely competitive to products from other world-class companies." said Dr. Jacob Tarn, the president of TSMC Solid State Lighting Ltd. "High reliability and low thermal resistance are our technology strengths. They prove our capabilities and determination for innovation in this industry. "

To offer better service to customers in the China region, TSMC SSL is now preparing a business and technical supporting office located in Shenzhen, Guangdong province of China. With this new setup, TSMC SSL then would be able to meet customers' needs of quick responses and direct technical services in a vast and fast-growing LED lighting market.

TH3 and TM series products are now commercially available and ramping to volume production upon the orders through the TSMC SSL direct sales team. Meanwhile, TSMC Solid State Lighting Ltd. also appointed three official agents: Shenzhen Baolian Suppy Chain Service Limited, Gredmann Technology (Shenzhen) Co., Ltd, and Powertronics Co., Ltd. to provide extensive sales services and to cover activities of regions.

Lextar Debuted Plug-In COB "CORE"

Lextar Electronics Corp. announces its latest plug-in COB "CORE" Series, which brings its plug-and-play concept to realization. With the mechanically incorporated COB, Core allows series connection that effectively reduces assembly costs. Lextar formally unveiled the new product at the 18th Guangzhou International Lighting Exhibition in June.

Lextar demonstrated its new Plug-and-Play COB "Core" at the 2013 Guangzhou International Lighting Exhibition

Having foreseen the integration trend in LED lighting components, Lextar presents the CORE Series that is optical mechanical integrated and delivers high lumen output. Its plug-and-play connector brings additional savings to customers from reduced costs of luminaires, since the conventional soldering process was replaced with a mechanically designed connector that allows CORE to be connected in series. The CORE series is also applicable to omni-directional bulbs when equipped with a designated lens for a wider beam angle. In addition, thanks to the special substrate, reflectance improves to 97% and thus brings excellent lumen output. As many as 1,500 lumens can be delivered within less than 1cm diameter, giving an unrivaled lumen per area of over 60% advancement. High efficiency of 125 lm/W enhances its competitiveness for commercial lighting, such as downlights and spotlights. Additionally, this plug-in COB "CORE" is especially popular in Europe and Japan, where precision mechanic and luminaire design is highly emphasized. Lextar expects Core series to be mass-produced in the second quarter of this year.

Lextar is also showcasing its whole series of COB products at the exhibition– the "Nimbus" series, covering widely from 4 watt to 75 watt, applicable to bulbs, street lamps and high bays. COB is widely adopted recently thanks to its quality light, no multi shadow, low thermal resistance and good uniformity. It brings benefits to manufacturers for its simplifying luminaire design and reducing assembly costs.

As for surface mount package, apart from the LM-80 accredited 3014 and 5630, Lextar releases high power products of 3030 and 5050. While a single 5050 can reach as high as 5 watts, it is deemed most competitive in the high power market, especially suitable for flashlights, candle lamps and MR16's. On the other hand, 3030 is applicable to PARs, ceiling lights, and direct-lit panel lights, delivering cost advantages to customers.

The Guangzhou International Lighting Exhibition has been valued significantly as a great opportunity to demonstrate Lextar's lighting component products and technologies, said Allen Huang, President of Lextar. This year's display reveals three core competences including quality, cost and integration. Firstly, light quality comprises requirements upon light shapes, color rendering and uniformity. Such quality should be achieved under an effective cost reduction scheme involving chip efficacy from upstream through packaging design, and material optimization. In order to simplify luminaire design for customers, after all, integrated design is necessary with optical optimization, mechanical refinement, electrical scheme and thermo management. Lextar offers competitive technologies and products by utilizing its advantages of vertical integration.

Tridonic's New TALEXXengine STARK LLE 24

Creative luminaire design for linear and panel luminaires is now easier and more flexible because Tridonic is now offering a double-length version of the TALEXXengine STARK LLE 24 LED solution measuring 560 mm.

Tridonic's TALEXXengine STARK LLE is now available with twice the length of the existing version

In addition to the existing version with a length of 280 mm, the TALEXXengine STARK LLE 24 is now available with a length of 560 mm and with the same height of only 6 mm. Up to six modules can be connected to a dimmable or non-dimmable converter. Long and short modules can be combined with no problem at all. This opens up even more opportunities for creative luminaire design. At the same time, the new dimensions help reduce the time and cost of installation during luminaire manufacture.

Like their short counterparts, the long modules have an impressively high color rendering index of >80 and are available in color temperatures of 3000 and 4000 K. Module efficiency is as much as 118 lm/W. Conventional T5 or T8 fluorescent lamps can easily be replaced by these efficient LED solutions.

Martini HD Retina LED Light for an Unmatched Color Quality

All truly great inventions, the ones that really have affected the course of history and people's lives, have changed the context of a world that was not ready to welcome them. Small and large objects have introduced new solutions and unprecedented perspectives that previously only existed in the minds of their creators. They are innovative, surprising, revolutionary products: in a word unexpected.

Martini's HD Retina LED technology demonstrated its outstanding color rendering capabilities for the first time at Euroluce 2013

Indeed, unexpected is the adjective that best expresses the concept of HD Retina, as the payoff itself reads "Unexpected light for your mind". HD Retina is not simply a new LED, rather it is a product that incarnates a different way of considering light and its function and upturns the perspective we usually take in approaching the concept of lighting.

HD Retina is a high definition LED that saturates both warm and cold colors at the same time, in a balanced manner, making them pleasing to the human eye. This is why this type of LED is well-suited to multiple areas of application and in particular in general lighting situations in which different color objects need to be illuminated all together.

The HD Retina project develops the intuition of Giorgio Martini, Deputy Chairman of the company, according to whom it is important not so much to understand how to best illuminate the color of an object, but rather to study how the human eye reconstructs colors.

What is ideal visual comfort? We normally say that it is sunlight but, in actual fact, this is not the case because this too tends to distort color: thus a natural light has been identified that is considered ideal on the eyes, corresponding "to dawn and dusk" or, more precisely, to a color temperature of between 3,500 K and 3,700 K.

The further innovation proposed to the market is a different but real perspective with which to consider "color". Color, in fact, is not a physical characteristic of objects, but rather the result of the visual perception of the light that illuminates them. When we look at an object, our eye knows how to recognize the different shades of color; yet when we recall it in our memory, that object will always be associated with a single, unique color, which we recognize as familiar and perceive as the "real" color, "ideal", which is in actual fact that associated with the objects in an ideal context of the natural light of dawn and dusk, when the source par excellence – the sun – illuminates indirectly.

This is, therefore, very briefly, the heart of HD Retina LED: technology able to make colors true to those the memory associates with familiar objects, with excellent color saturation, making an unprecedented result possible with any artificial light source. ■

WAC Lighting Unveils InvisiLED® Pro 2

Integrating high performance and innovative technology, WAC Lighting introduces the InvisiLED® Pro 2, a 24-volt professional grade low profile lighting solution. This upgraded tape light offers high output, energy efficient, LED illumination of fine wood cabinetry, granite countertops and cove lighting in luxury residences, upscale retailers, hotels and other commercial spaces.

InvisiLED Pro 2 is backed by WAC's five-year warranty

Available in four color temperatures, InvisiLED Pro 2 includes 12 evenly spaced LEDs per foot, for consistent, balanced illumination. The sealed silicone cased tape is constructed with a 3M™ adhesive backing for easy installation and long-lasting durability. InvisiLED Pro 2 is practically invisible at less than 1/8th of an inch tall, and a 3/8th inch wide.

Consuming only four watts, this next generation LED tape has a light output of 320 lumens per foot, a typical CRI of 85 and a 50,000-hour life. This versatile system has a minimum run length of one foot with a maximum of 24 feet, can be field cut every six inches at the end of the run, and can be dimmed using an electronic low voltage (ELV) dimmer.

InvisiLED Pro 2 is available in 6", 1' and 5' sections and has 5 LED "L" connectors to create right angle turns without the loss of light. Three mounting options, cables and accessories are available for a highly customized lighting layout. Class 2 plug-in and remote power suppliers are available in 60 W and 96 W capacities. ■

Ultra Narrow Color Mixing Optics from Khatod

The newest Color Mixing Optics from Khatod are able to perform very narrow beams, while providing an excellent RGBW color mixing of the light coming from the LED sources.

Khatod's latest color mixing optics is available with an ultra-narrow 8° beam angle

General Characteristics:

- Lens material: Optical Grade PMMA
- Operating temperature range: -40°C / +90°C
- Storage temperature range: -40°C / +90°C

Features:

- RGBW Color Mixing Lenses, available in Ø 35 mm and Ø 45 mm
- From extraordinary 8° ultra-narrow beam up to 40° wide beam.
- Available with Moving Lenslet Array (MLA), enabling zoom from 12° to 50° beam angle
- Innovative design
- High optical efficiency over 90%
- Perfect uniform flux
- Shadows or glare totally eliminated
- Easy fixing onto the PCB

COB Lens& Reflector

LedLink
Linking LEDs to The Real World

By offering optical solutions, connectors, with suitable design in terms of :

- Optical performance: Suitable CBCP and various beams depending on different COB LED
- Easier Assembly
- Shorten product development time to market

Ledlink is pleased to release the following cost effective solutions for the innovative lighitng manufacturers.

Holder
LL01A00SUKB2
WxH(mm)
Φ37.6 x 6

LL01SP-ASOxxR49

DxH(mm) 90 x 50
FWHM 15° 24° 38°
LED For
CREE CXA25xx
CITIZEN CLL030
SHARP Mega Zenigata (15~50W)
NICHIA NSBW121A

LL01ED-ASAxxL06-P

DxH(mm) 90.6x 22
FWHM 12° 24° 38°
LED For
CREE CXA15xx/25xx
CITIZEN CLL030/CLL040
NICHIA 110

Holder
LL01A00SUKB2
WxH(mm)
Φ37.6 x 6

LL01SP-ATHxxR49

DxH(mm) 75 x 40
FWHM 15° 24° 38°
LED For
CREE CXA25xx
CITIZEN CLL030
SHARP Mega Zenigata (15~50W)

LL01CT-APGxxL06

DxH(mm) 84.6x 18
FWHM 24° 38°
LED For
CREE CXA2530
CITIZEN CLL030
NICHIA 110
SHARP GW5BMR10~12W
GW5DLA15W
GW5DLC25W

Connector
LL01CRRY15H2
DxWxH(mm)
40.45x47x4.45

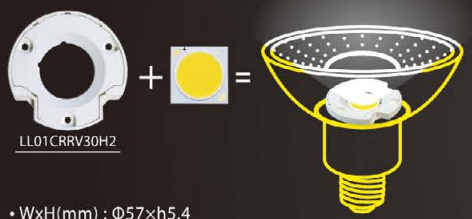
LL01CR-AYMxxR14-P

DxH(mm) 90 x 50
FWHM 15° 24° 38°
LED For
CREE CXA25xx
CITIZEN CLL030

LL01CT-AOFxxL06

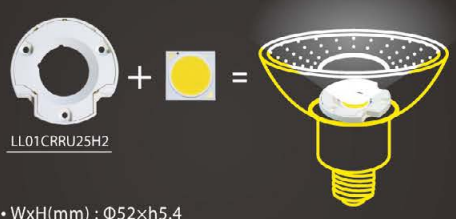
DxH(mm) 74.4 x 13
FWHM 24° 38°
LED For
CREE CXA1512
CITIZEN CLL020
NICHIA 110
SHARP GW5BMR10~12W
GW5DLA15W
GW5DLC25W

Connector



LL01CRRV30H2

- WxH(mm) : Φ57xh5.4
- Temperature : 110˚C
- Material : PBT white (V-0 •Within glass•Light-reflection)
- Voltage resistance with insulation sheet: 6KV
- To take pay Bldg su : M3 × 3 Up
- Suitable for wire :
  · Non-consolidated line Φ0.8, Φ1.0
  · For solder-dipped stranded 0.5㎟ · AWG20



LL01CRRU25H2

- WxH(mm) : Φ52xh5.4
- Temperature : 110˚C
- Material : PBT white (V-0 •Within glass•Light-reflection)
- Voltage resistance with insulation sheet: 6KV
- To take pay Bldg su : M3 × 3 Up
- Suitable for wire :
  · Non-consolidated line Φ0.8, Φ1.0
  · For solder-dipped stranded 0.5㎟ · AWG20

LL01CRRT15H2

- WxDxH(mm) : 36x30.4x5.4
- Temperature : 110˚C
- Material : PBT white (V-0 •Within glass•Light-reflection)
- Voltage resistance with insulation sheet: 5KV
- To take pay Bldg su : M3 × 2 Up
- Suitable for wire :
  · Non-consolidated line Φ0.8, Φ1.0
  · For solder-dipped stranded0.5㎟ · AWG20

Further technical information is available, please contact us for more details.

service@ledlink-optics.com www.ledlink-optics.com

Typical Applications:

- Architectural Lighting
- Stage Lighting
- Entertainment & decorative
- Shop windows, halls & entrances
- Downlights
- Flashlights
- Border/contour
- Lamps, etc.

These latest solutions for color mixing are the result of our experienced optical and mechanical engineering as well as the employment of High-Tech software and equipment for R&D, Production and Quality Control. Our proven capability in molds fabrication and the use of superior quality polymers, specific for optical mechanical and technical properties, are further fundamental aspects for our success in delivering the best solution to lighting designers using the color-mixing-LED technology of the latest generation in their fixtures.

Khatod's RGBW Color Mixing Lenses – available in Ø 35 and 45 mm - allow performance in a full range of beam angles, from an extraordinary 8° ultra-narrow beam up to 40° wide beam.

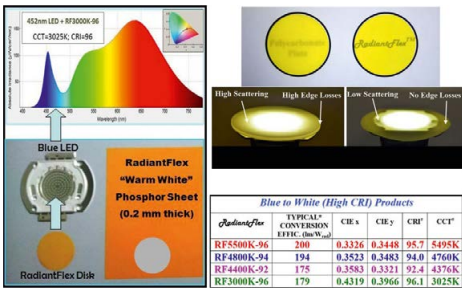
Also, they can be equipped with a special optical accessory, a Moving Lenslet Array (MLA), to be mounted on top of the lens. The use of the lens with the MLA allows zoom and autofocus applications. By sliding the MLA on top of the lens, you can vary the beam angles in a range from 12° to 50° by preserving a perfect color mixing and a high optical efficiency over 90% in the full range of the beam angles.

The MLA and the lens fit perfectly as they have the same diameter. The beam angles vary from the narrow configuration when the device is nearly in contact with the lens, to the wider configurations when the MLA is sliding over the lens.

What makes these lenses superior is the great color mixing performance, which exceeds any expectations. The red, green, blue and white beams produced by the high brightness chips are perfectly mixed and concentrated in a unique light beam of high intensity while delivering an incomparable uniformity level. Shadows or glare are totally eliminated and the highest in light color mixing is guaranteed. Fit for any applications, they are perfect in architectural lighting: entertainment & decorative, border/contour, shop windows, halls & entrances, lamps. ■

PhosphorTech Introduces High CRI RadiantFlex Products

PhosphorTech has just released its latest RadiantFlex phosphor sheet product series for ultra high color rendering (CRI) LED applications. The new products are available from "warm white" (CCT~3000 K) to "cool white" (CCT~5500 K) versions with CRI as high as 96 using blue LEDs between 450-455 nm. These products offer un-matched luminous efficacies when compared to competing technologies having similar CRI. Such high performance is achieved by the unique ability of the RadiantFlex manufacturing process to accurately layer different phosphors and achieve unique spectral shapes while minimizing self-absorption and scattering losses.



PhosphorTech adds high CRI versions to its RadiantFlex product series

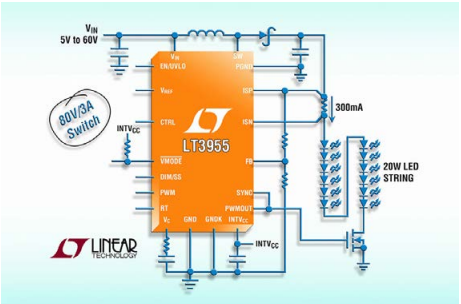
The most common usage of phosphors in solid-state lighting (SSL) involves pre-mixing micron-size particles with a polymer and directly depositing the phosphor slurry on the LED die. Unfortunately, such a traditional approach results in lower wall plug efficiency (WPE) due to optical scattering losses and light trapping within the phosphor/polymer matrix. Furthermore, as LED power increases, this method becomes more limited because of the significant thermal and optical loads on the phosphor, which lead to further drop in efficiency and performance at higher temperatures and power densities. Therefore, the remote phosphor approach becomes more attractive. PhosphorTech Corporation has been developing and supplying remote phosphor technologies and products since its inception in 1998 and has one of the earliest known patents in this area involving an LED and a phosphor compound.

The RadiantFlex technology and corresponding patent-pending manufacturing process are a direct result of over a decade of research in various remote phosphor application methods, phosphors, and substrate materials.

Unlike conventional remote phosphor plates, the RadiantFlex technology enables package-level application of phosphor layers to blue (and UV) LEDs. This removes the need for expensive mixing chambers and external reflectors and provides higher performance at lower costs. The RadiantFlex approach also eliminates the need for LED producers to handle phosphor powders and invest in expensive phosphor mixing and dispensing equipment. This will result in considerable R&D savings for LED and lamp manufacturers who typically must spend significant time and resources developing a custom phosphor mixture for each application. As is well-known in the SSL industry, achieving high CRI with high luminous efficacy in white LEDs is a complex process plagued with repeatability and uniformity problems since it involves a carefully controlled mixture of several different phosphor compounds. The RadiantFlex enables detailed analysis and quality verification of the phosphor layers prior to integration with the LED. This results in significant savings in terms of materials and resources. ■

80 VOUT LED Driver with Internal PWM Generator

The LT3955, a DC/DC converter designed to operate as a constant-current source and constant-voltage regulator with an internal 3.5 A switch, is now available from Linear Technology. The device's internal PWM dimming generator makes it ideal for driving high current LEDs, and it also has features suitable for charging batteries and super capacitors. The LT3955's 4.5 V to 60 V input voltage range suits a wide variety of applications, including automotive, industrial and architectural lighting.



Linear Technologies LT3955 is a versatile DC/DC converter that delivers an efficiency of up to 94% in boost topology applications

Summary of Features: LT3955:

- 3000:1 True Color PWM™ Dimming for LEDs
- Wide VIN Range: 4.5 V to 60 V
- Rail-to-Rail Current Sense Range: 0V to 80V
- Internal 80 V/3.5 A Switch
- Programmable PWM Dimming Signal Generator
- Constant Current (±3%) and Constant-Voltage (±2%) Regulation
- Accurate Analog Dimming
- Drives LEDs in Boost, SEPIC, CUK, Buck Mode, Buck-Boost Mode, or Flyback

Configuration:

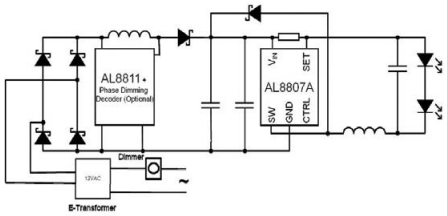
- Output Short-Circuit Protected Boost
- Open LED Protection and Reporting
- Adjustable Switching Frequency: 00 kHz to 1 MHz
- Programmable VIN UVLO with Hysteresis
- C/10 Indication for Battery Chargers
- Low Shutdown Current: <1 µA
- Thermally Enhanced 5 mm × 6 mm QFN-36 Package

The LT3955 uses an internal 3.5 A, 80 V N-channel MOSFET and can drive up to twelve 300 mA white LEDs from a nominal 12 V input, delivering in excess of 20 watts. It incorporates a high-side current sense, enabling use in boost mode, buck mode, buck-boost mode or SEPIC topologies. The LT3955 can deliver efficiencies of over 94% in the boost topology, eliminating the need for external heat sinking. A frequency adjust pin permits the user to program the frequency between 100 kHz and 1 MHz, optimizing efficiency while minimizing external component size and cost. Combined with a 5 mm x 6 mm QFN package, the LT3955 offers a highly compact high power LED driver solution.

The LT3955 has an internal PWM generator that delivers dimming ratios as high as 25:1 or it can utilize an external PWM signal, delivering dimming ratios of up to 3,000:1. For less demanding dimming requirements, the CTRL pin can be used to provide a 10:1 analog dimming range. Its fixed frequency, current-mode architecture offers stable operation over a wide range of supply and output voltages. Output short-circuit protection and open LED protection enhance system reliability. The LT3955's ground-referenced voltage FB pin serves as the input for several LED protection features and makes it possible for the converter to operate as a constant-voltage source. ■

Diodes Releases New DC-DC Converter

Diodes Incorporated, a leading global manufacturer and supplier of high-quality application specific standard products within the broad discrete, logic and analog semiconductor markets, announced a miniature DC-DC converter supporting boost, buck and voltage-inverting circuit topologies for LED lighting and general-purpose power management applications. The AL8811 is available in an 3.0x4.9 x1.1 mm MSOP-8L package, requiring minimal external components and enabling significant reductions in both circuit footprint and BOM cost.



Simplified schematic for an electronic transformer compatible MR16 lamp using the new AL8811 DC-DC converter IC

Applications:

- Low Voltage LED Lighting such as MR-16
- General Purpose DC-DC Converter

Features:

- Operation from 3.0V to 20V Input
- Low Standby Current
- Current Limiting
- Output Switch Current to 1.6A
- Output Voltage Adjustable
- Frequency Operation to 100 kHz
- Precision 2% Reference
- Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)
- Halogen and Antimony Free. "Green" Device (Note 3)

Notes:

1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant
2. See http://www.diodes.com/quality/lead_free.html for more information
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900 ppm bromine, <900 ppm chlorine (<1500 ppm total Br + Cl) and <1000 ppm antimony compounds

While the AL8811 is advantageous for many low-voltage LED lighting applications, dimmable MR16 lamps will particularly benefit from the new device. For example, using the AL8811 in boost mode in conjunction with an AL8807A buck LED driver creates a high-power factor, dimmable MR16 solution that is both compact in size and low in component cost. Additionally, this two-stage design ensures good compatibility with a variety of electronic transformers and low LED current ripple.

With a wide 3V to 20V input voltage operating range and an output voltage up to 36V, the AL8811 is suitable for an array of different 12V AC lighting applications. The device's shut-down current is also very low at 0.01µA (typical), while its maximum output switch current is 1.6A.

Comprising an internal temperature-compensated reference, a controlled duty cycle oscillator with an active current-limit circuit, driver and high-current output switch, the AL8811 from Diodes Incorporated provides designers with a particularly versatile solution for DC-DC conversion circuits. ■

NXP Brings Dimmable LED Controller for 12 V MR16 Lamps

NXP Semiconductors N.V. unveiled the SSL3401 – a dimmable single-stage controller IC for retrofit MR16 LED lamps using 12V AC mains. The SSL3401 offers compatibility with an exceptionally wide range of dimmers and transformers – working with over 80% of the most common combinations – in a compact form factor that fits in all commonly used MR16 GU5.3 and AR111 housings and sockets. Supporting an ambient temperature range up to 105ºC, the SSL3401 also provides temperature rollback protection.

NXP showcased the SSL3401 at Guangzhou International Lighting Exhibition

Features and benefits:

- Easy migration to existing lighting control infrastructure
- Support most available dimmers and low voltage transformation solutions
- Excellent stability of LED current
- Double PI controllers to enhance the line regulation of the LED current
- Optimized dimming curve for low voltage transformer compatibility
- Automatic supply frequency detection for seamless operation with 50 Hz, 60 Hz or DC sources
- Dimmer conduction angle detection
- Coil current limitation
- Temperature roll-back protection
- OverVoltage Protection (OVP)
- Power-On-Reset (POR)
- Shorted LED protection
- Open LED detection
- UnderVoltage LockOut (UVLO)

Applications:

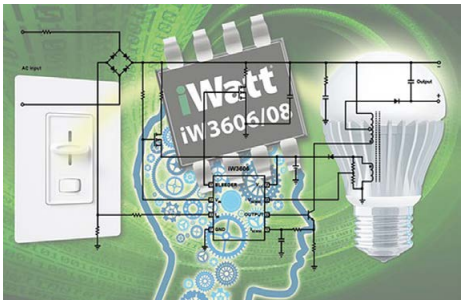
- General LED lighting with various power requirements
- Dimmable 12 V MR16 and AR111 applications

Based on NXP GreenChip™ technology, the SSL3401 generates a stable and accurate current while dimming down to below 5% of maximum light output in most common practical situations. While maximum lamp power depends on the thermal design of the lamp, a typical 7W MR16 LED lamp using the SSL3401 achieves THD below 15%, power factor above 0.9, efficiency up to 78% and LED ripple current below ±10%.

"Energy-conscious consumers and businesses worldwide are keen to replace halogen lamps with LEDs – but making the switch to dimmable MR16 LEDs is not always as straightforward as one would expect. With the SSL3401, we've designed a compact single-stage controller IC specifically for dimmable MR16 LED lamps, and tested it extensively for compatibility with a wide range of dimmers and transformers," said Ryan Zahn, general manager, lighting solutions product line, NXP Semiconductors. "By helping retrofit lamp manufacturers to reduce costs, we also hope to ease the transition from halogen to LED on a broader scale, particularly as 12V MR16 lamps emerge as a popular choice in both commercial and residential lighting." ■

iWatt Introduces New Single-Stage LED Drivers

iWatt Inc., a leading provider of digital-centric power management integrated circuits (ICs), launched its latest single-stage, solid state lighting (SSL) LED drivers to address cost, performance and lifetime issues in dimmable bulb applications. Following the introduction of its single-stage LED driver for non-dimmable incandescent bulb replacement applications earlier this year, iWatt is debuting the iW3606 (8 W output power) and iW3608 (15 W output power), giving LED bulb manufacturers an alternative approach to significantly lower cost and tackle the lifetime and performance issues in dimmable applications. Both new LED drivers allow SSL designers to reduce their bill of materials (BOM) cost by 20% to 40% compared to competitive solutions. The iW3606 and iW3608 incorporate iWatt's patented, configurable over-temperature protection (OTP) and derating functionality to provide predictability and reliability of bulb operating life and offer what the company believes is the industry's lowest pop-on current, < 5% of light output.



iWatt's new driver ICs both promise high dimming performance while lower BOM costs, as is demonstrated in the simplified application circuit

iW3606, iW3608 Key Features:

- Output power: 8 W and 15 W
- Single-stage design with 20% to 40% BOM cost savings(1)
- Configurable LED over-temperature protection and automatic derating of LED current
- High PF > 0.92, low THD < 20%
- Wide dimmer compatibility, automatic detection of dimmer type
- Wide dimming range: 1% to 100%
- Lowest pop-on current < 5% of light output
- Configurable dimming curve compliant to NEMA SSL 6(2) dimming standard
- Meets global standards, including EU IEC61000-3-2 requirements

Designed for all retrofit bulbs, including candle and GU10 lamp replacements used in existing phase-cut dimmer installations, the iW3606 and iW3608 manage the key issues that could impact consumer adoption of SSL lighting, including poor dimming performance (pop-on, popcorning, dead travel, drop-out, flicker), short bulb lifetime or failure, and high cost. Both drivers meet or exceed global regulations for power quality and efficiency with a high power factor (PF) of > 0.92, low total harmonic distortion (THD) of < 20%, and high efficiency 82%. The iW3606 and iW3608 have already been designed in to the next-generation of dimmable SSL bulb products from key iWatt customers.

The on-chip over-temperature protection (OTP) and derating feature of the iW3606 and iW3608 addresses the thermal issues caused by the high and unpredictable operating temperatures in dimmable SSL applications. The lifetime of many of the components in the LED driver circuit, especially electrolytic capacitors, degrades as temperatures increase, potentially reducing overall bulb lifetime to less than 2,000 hours, well under the 30,000 to 50,000 hours expected for SSL bulbs. iWatt's OTP derating monitors the temperature inside the sealed SSL bulb and when thermal conditions reach a point set by the system designer, the LED drivers automatically reduce the current drive to the LEDs, lowering the power dissipation and resulting in cooler overall operation. This helps prevent exceeding the temperature rating of the electrolytic capacitors in the system, helping to ensure a predictable and safer bulb operating life.

"The challenge with dimmable SSL bulbs is in delivering a similar lighting experience to that of incandescent dimmable bulbs at low cost with long lifetime," said Mr. Zhang Wenlong, general manager at Xiamen Tenia Lighting & Electrical Co. Ltd. "We selected the iW3608 because of its excellent compatibility with dimmers and the configurable OTP derating allows us to deliver the bulb lifetime and safety consumers expect, all with a low BOM cost and reduced potential for warranty issues."

The iW3606 and iW3608 feature a wide, flicker-free dimming range from 100% all the way down to 1% of measured light, to closely match the dimming performance of incandescent bulbs. This enables the smooth, "natural" dimming consumers expect, with no light drop-out at the low end of the dimming range and virtually no dead travel where the light turns off before the dimmer control reaches the bottom of its travel. The very low internal power consumption of the iW3606 and iW3608 allows them to start at a very low dimming level of < 5% of light output. This virtually eliminates pop-on, a phenomenon where the light does not turn on at low dimmer levels and as the dimmer level is raised, the light suddenly turns on. This also helps eliminate popcorning effects, in which various bulbs in multiple-light installations on the same dimmer circuit can turn on at different dimmer setting thresholds.

The configurable dimming curves of both parts are compliant with the NEMA SSL 6 ming standard. Both devices also use iWatt's patented digital dimming technology with its embedded intelligence that detects dimmer characteristics to provide wide dimmer compatibility, including leading edge (TRIAC), trailing edge and non-traditional R, R-C and R-L types, with automatic dimmer detection.

The iW3606 and iW3608 enable approximately 40% and 20% lower BOM costs (respectively) compared to competitive single-stage solutions, which can require as many as nine additional external components. The lower BOM costs are achieved via high levels of integration, including on-board OTP and derating, along with replacing field effect transistors (FETs) with lower-cost bipolar junction transistors (BJTs). A combination of BJTs and valley mode switching lowers electromagnetic interference (EMI) and reduces the need for external EMI filtering components. Also, iWatt's patented PrimAccurate™ primary-side control eliminates the need for a secondary-side regulator and optical feedback isolator. Additional savings come from the standard, low-cost 8-lead SOIC package, which can be used in single-layer PC boards for additional cost savings and a smaller design footprint.

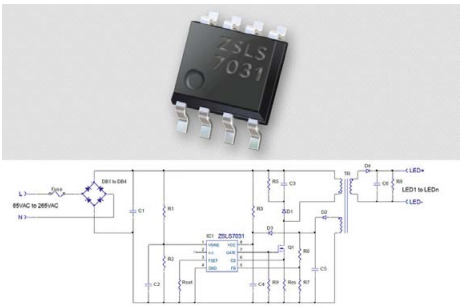
"SSL bulb manufacturers are under severe pressure to reduce cost," observed Hubie Notohamiprodjo, iWatt's director of marketing for SSL products. "The outstanding dimming, high integration and low BOM cost of the iW3606 and iW3608 preclude the temptation to accept mediocre SSL LED driver performance in order to keep the cost low, and they have been designed to help OEMs deliver the bulb lifetime expected by consumers." ■

ZMDI Releases the ZSLS7031 Primary-Side Peak-Current Mode LED Driver IC

ZMD AG, a Dresden-based semiconductor company that specializes in enabling energy-efficient solutions, announces the release of the newest member of its LED driver family, the ZSLS7031, a primary-side peak-current mode LED driver for high-brightness LED lighting. As a global supplier of analog and mixed-signal solutions for automotive, industrial, medical, information technology and consumer applications, ZMDI specializes in products that enable energy efficient solutions such as the ZSLS7031.

Key Features:

- Power factor correction to > 0.95
- Wide input voltage range: 85 V to 265 VAC
- Isolated and non-isolated applications
- Internal over-temperature, over-voltage and primary side open connection protection
- Operating temperature:-45°C to +105°C



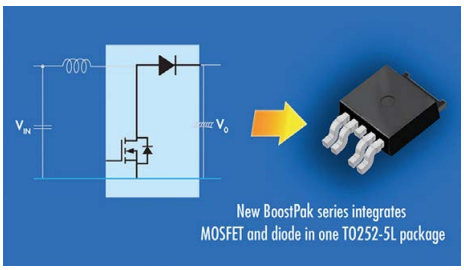
ZMDI's new ZSL7031 LED driver IC and its typical schematic for an isolated application

The new product is well suited for many consumer, commercial and industrial lighting applications, particularly where electrical isolation is required. LED drivers from ZMDI can significantly improve the quality and energy efficiency of end-product LED applications.

"The ZSLS7031, our second line-power LED driver, complements the advantages of our ZLED7001 by adding isolated and exciting new non-isolated applications. The device works at a constant frequency in discontinuous conduction mode to provide constant power to the output. The ZSLS7031 eliminates the need for an opto-coupler or any other type of secondary-side feedback and operates from a wide input voltage range of 85 VAC to 265 VAC," said Erhard Muesch, System Architect at ZMDI. ■

Fairchild 100 V BoostPak Solution

Fairchild Semiconductor, a leading global supplier of high performance power and mobile semiconductor solutions, optimizes the MOSFET and diode selection process by introducing a family of 100 V BoostPak devices that combines a MOSFET and diode in one package to replace discrete solutions currently used in LED TV / monitor backlight, LED lighting and DC-DC converter applications.



Fairchild's BoostPak integrated solution features MOSFET and diode in one package to simplifying board assembly and saving space

FDD1600N10ALZD Features:

- RDS(ON) = 124 mΩ (Typ.) @ VGS = 10 V, ID = 3.4 A
- RDS(ON) = 175 mΩ (Typ.) @ VGS = 5 V, ID = 2.1 A
- Low Gate Charge = 2.78 nC (Typ.)
- Low Crss = 2.04 pF (Typ.)

FDD850N10LD Features:

- RDS(ON) = 61 mΩ (Typ.) @ VGS = 10 V, ID = 12 A
- RDS(ON) = 64 mΩ (Typ.) @ VGS = 5.0 V, ID = 12 A
- Low Gate Charge = 22.2 nC (Typ.)
- Low Crss = 42 pF (Typ.)

Both:

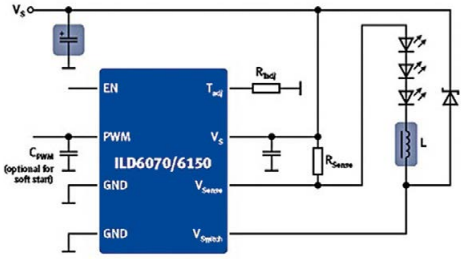
- Fast switching
- 100% avalanche tested
- Improved dv/dt capability
- RoHS compliant

By integrating the MOSFET and diode into a single package, the FDD1600N10ALZD and FDD850N10LD devices save board space, simplify assembly, lower bill of material (BOM) costs and improve reliability of the application.

The devices feature an N-channel MOSFET produced using Fairchild's PowerTrench® process that has been tailored to minimize the on-state resistance while maintaining superior switching performance. The NP diode is a hyper fast rectifier with low forward voltage drop and excellent switching performance. It has much lower leakage current than a Shottky diode, which improves system reliability in high temperature applications. ■

Infineon 60V DC/DC LED Drivers to Improve Efficiency

The products ILD6070 and ILD6150 have a maximum current capability of up to 0.7 A and 1.5 A respectively. The ICs offer excellent power conversion efficiency up to 98%, benchmark current accuracy of +-3% across the load from 4.5 – 60 V that helps assure constant light output, and first-in-the-industry adjustable over-temperature protection that protects LEDs from damage through overheating. The products are defined as general purpose LED driver ICs, mostly to be used in professional lighting systems, luminaires and electronic control gears.



Simplified schematics of a LED driver using ILD 6070 orILD6150 driver ICs

Benchmark features of the new devices include the following:

- Typical DC/DC conversion efficiency up to 98 percent, which improves overall efficiency of a luminaire and reduces thermal load.
- Current accuracy of 3 percent across the full 4.5V to 60V input range, which contributes to exceptional stability of light output.
- The adjustable over temperature protection feature, which reduces light output when a threshold temperature is reached instead of turning off the light. With this feature, an LED light will always operate in a non-critical thermal range, which leads to significantly longer lifetime.

"As the lighting industry's transition to LED-based luminaires accelerates, with growth rates forecast at 30 percent across the next several years, manufacturers need to simultaneously innovate in engineering design while doing everything possible to gain competitive advantage in performance and cost," said Dr. Christian Burrer, Head of Product Segment AC/DC and Lighting ICs at Infineon Technologies. "At Infineon, our goal is to provide a single point of supply for optimized and highly efficient power conversion and control elements of lighting system designs."

The new drivers extend Infineon's portfolio of switched-mode, buck (step-down) topology LED drivers for low voltage driven lighting applications, including indoor and outdoor systems in residential, commercial and industrial environments. They operate at up to 1 MHz switching frequency, which reduces manufactured cost and PCB space by reducing the size of external components needed in a design. Reduced size is also supported by the high efficiency and corresponding improved thermal performance of the drivers.

Samples of the ILD6070/ILD6150 drivers will be available in March, at a cost of USD 1.50 and USD 1.80, respectively. High volume pricing, above 10k quantity, of the DSO-8 packaged devices is approximately USD 0.80.

Designers working with Infineon LED driver ICs can access the "Infineon Light Desk" (www.infineon.com/lightdesk) design tool. The tool allows quick design and simulation of LED Driver circuitries for all types of LED applications, with optional redesign, and download of the design summary with specification, schematics and bill of material. ■

TALEXXconverter ECO - Tridonic's New High End Platform

Tridonic presents the ECO series of TALEXX converters, a new addition to its LED converter platform. It combines high quality with a wide range of applications. These high-end products can be infinitely dimmed from 100 percent to 1 percent and offer impressive properties, including luminous flux compensation for the connected LED module and long life. The LED control gear can be adapted to different module parameters with a high degree of flexibility.

Tridonic's new TALEXXconverter ECO series is available as in-built surface mount versions and deliver 10 to 55 W

A special feature of the TALEXXconverter ECO series is its high-quality dimming in accordance with all the usual dimming standards. Of particularly high quality is the combination of amplitude and pulse width modulation that enables dimming to be infinitely varied from 100 percent down to 1 percent. Various interfaces and functions are provided for control purposes: DALI DEVICE Type 6, DSI, switchDIM and corridorFUNCTION. The LED control gear is available as in-built and surface mount versions, each with different outputs. This makes the converters suitable for a wide variety of LED modules.

Excellent dimming and flexibility:
The in-built units are available in 10 W, 20 W, 35 W and 55 W versions. They are designed for different LED operating currents, depending on the wattage:

- 10 W version for 150 – 400 mA and 350 – 900 mA,
- 20 W version for 350 – 900 mA,
- 35 W version for 350 – 900 mA and for 900 – 1750 mA,
- 55 W version for 900 – 1750 mA.

Surface mount versions are available with outputs of 20 W, 35 W and 55 W:

- 20 W version for 350 – 900 mA,
- 35 W version for 350 – 900 mA and for 900 – 1750 mA,
- 55 W version for 900 – 1750 mA.

Adjustable operating currents for high flexibility:
On all the units it is possible to select different output current ranges. The output current can be set by means of a resistor or via the DALI interface. The output current tolerance is only ± 3 percent.

The numerous versions cover a wide range of applications and offer users enormous flexibility in designing their lighting solutions. The main applications include spotlighting and downlighting in retail outlets, offices and hotels. The low standby losses of less than 0.2 W and the possibility of emergency lighting mode via a central battery are especially noteworthy. Long life of a maximum of 50,000 hours ensures maintenance-free operation for many years. The devices are future-proof thanks to CE/ENEC and RCM certification. CQC certification is already at the preparatory stage.

Compared with conventional products, the new platform offers higher efficiency, a smaller harmonic distortion and lower ripple factor (THD < 10 %) on the output current across all the product versions.

A complete and transparent platform:
The new LED converter platform from Tridonic will be complete as early as September. The manufacturer will then be offering a complete portfolio for all applications and requirements comprising just three clearly defined series (ECO, TEC and TOP). The TOP series will be launched by the autumn as flexible LED control gear for fixed-output applications (compact design). The TEC series was introduced back in the autumn of 2012 as simple and reliable LED control gear also for non-dimmable applications. A linear design is currently being added to this series. ■

New liniLED® Controllers complement the liniLED® System

Two controllers have been added to triolight's range and replace the old controllers as currently listed in the catalogue on pages 53 and 54. Both controllers are easy to connect to the liniLED® Wall Panel via an RJ45 cable. After connecting, the controllers can immediately be used (Plug & Play).

triolight's new controllers replace and supplement the current liniLED® product range

liniLED® Basic Controller:
With the liniLED® Basic Controller (product code 11100) you have a small but powerful controller with an output of 3 x 40 Watt. The liniLED® Basic Controller is therefore suitable for controlling up to 20 meters liniLED® RGB*. Besides liniLED® RGB, you can dim three groups of monochrome liniLED® products independently. The liniLED® Basic Controller works together with the liniLED® Wall Panel. It is possible to order them as a set (product code 11101), whereby you will benefit from an additional discount.

liniLED® RGB/Dim Controller:
A more powerful controller is the liniLED® RGB/Dim Controller (product code 11120). With this controller, you have an output of 3 x 80 Watt. Besides connecting three groups monochrome liniLED® products, which dim separately, 40 metres liniLED® RGB* can be controlled. The liniLED® RGB/Dim Controller can be connected to the liniLED® Wall Panel via an RJ45 cable. If there is more power needed to control your liniLED® products, the liniLED® RGB/Dim Controller has the ability to couple the signal to a second liniLED® RGB/Dim Controller (or liniLED® Basic Controller). This way, you can scale the required power to the wattage that is desired. Soon the liniLED® RGB/Dim Controller will also be available in versions for DMX, 0-10 V and 1-10 V. ■

Xenerqi's 75W LED Drivers with External Current Control

Xenerqi introduces its popular 75 W Ambient Lighting driver (XEL-A075A Series) by adding compatibility with general step dimmers and by allowing for external adjustment of the output current on all members in this family, providing installers and fixture makers the widest flexibility possible since they can do field adjustments as needed.

The XEL-A075A is a Skinny (26mm in height) Series driver with universal input (108-305VAC)

The XEL-A075A offers a wide operating temperature range, 0-10 V (2-Wire) Dimming, is UL Dry/Damp and 8750 rated, CE and FCC compliant.

The XEL-A075A Series has been designed to meet the strictest requirements of the Ambient lighting space and has been put into an industry standard T5 style metal case familiar to installers and which allows for easier retrofit implementations. At the same time, the family is optimized to work at peak efficiency for LED loads with nominal power requirements of 60~75 W, which allows a single platform to work on the newest highest efficiency LED's becoming available today as well as providing a path into the future.

This family's wide input voltage range, high efficiency and 5 year Warranty make it an ideal candidate for applications requiring Energy Star or DLC Certification. The XEL-A075A family has both Constant Current (CC) and Constant Voltage (CV) variants, which can drive output currents in the 1.25 A ~ 3.25 A range and output voltage ranges from 15 ~ 54 V. This driver family is also empowered by Xenerqi's "Custom Made Simple" program and customized variants with specific output currents or voltages can be created within a week.

This Xenerqi 60 W ~ 75 W series has undergone extensive compliance and certification testing. The products in this family are cUL 8750, CE, UL Dry/Damp Rated, FCC Part15/18 Class B compliant, meet Class A noise rating, meet Energy Star guidelines, abide by ROHS, and have a 5 year standard warranty. ■

Xenerqi Launches LED Drivers that Provide TRIAC and 0-10V Dimming

As an industry first, Xenerqi Limited has launched its line of LED Drivers with embedded DUO DIM® Technology. These revolutionary drivers allow installers to use a single driver for installations with mixed TRIAC and 0-10 V dimming technologies.

Xenerqi's DUO DIM® Technology provides dimming in both TRIAC and 0-10 V modes

Xenerqi's revolutionary DUO DIM® Technology provides consistent dimming in both TRIAC and 0-10 V modes which enables unprecedented light consistency and simplicity in this kind of application.

The DUO DIM® product families span power ranges from 20 to 40 W and come in an industry standard metal case ideally suited to be placed inside a junction box. The product's Dry/Damp UL Rating allows maximum versatility on the locations where it can be used.

This driver family is also empowered by Xenerqi's "Custom Made Simple" program and customized variants with specific output currents or voltages can be created within a week.

These Xenerqi DUO DIM® Drivers have undergone extensive compliance and certification testing. The products in these families are cUL 8750 and CE compliant, FCC Part15/18 Class B compliant, meet Class A noise rating, comply to UL Dry/Damp rating, meet Energy Star guidelines, abide by ROHS, and have a 5 year standard warranty. ■

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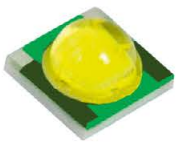

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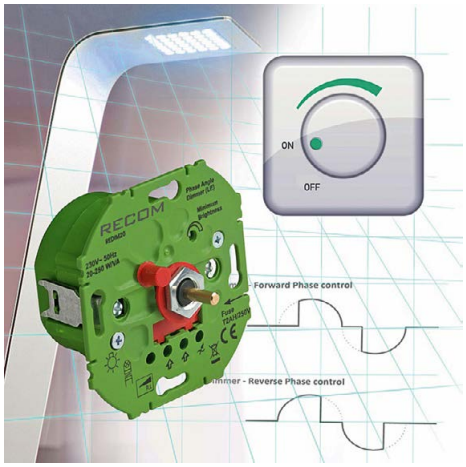
Recom Releases Dedicated Triac Dimmer for LED Lighting

Modern lighting solutions offer considerably more than just a means to switch luminaires on and off. Continuously adjustable brightness creates atmosphere. Due to the rise of LED lighting, the consumed energy has also decreased. These things continue to pose new challenges to dimmers. While the base load of an incandescent bulb is about 50 W or more, dimmers now must also operate with the significantly lower input power of an LED system.



Recom's dedicated TRIAC solution offers reliable operation from 7 W compared to a minimum load of 50 W for standard dimmers

The solution is a dimmer that reliably operate from 7 W, such as those of the RECOM REDIM series. These dimmers and the RECOM RACT20 LED driver series are ideally matched and provide a smooth dimming curve and deep dimming down to zero. The dimmers are designed for installation in mounting boxes that meet DIN 49073. The connection is made safely and easily with screw terminals that ensure a secure hold for flexible or rigid conductors (2x2.5 mm^2). The basic light level can be adjusted individually and easily for a customized lighting solution. To be compatible with all common switches, an adapter is included as a standard.

The devices can be used for LED-luminaires as well as for energy-saving-lamps, low-voltage-halogen lamps and even incandescent bulbs. ■

New GlacialPower GP-LD Series DC Input LED Drivers

GlacialPower, a division of the Taiwanese technology manufacturer, GlacialTech Inc., is pleased to announce two new GlacialPower LED drivers for variable voltage LED lights – GP-LD10-30C and GP-LD15-24C.

The GP-LD10-30C and GP-LD15-24C DC-DC LED drivers complete the existing GP- DC-DC driver series

Features:

- Universal DC input 11-15 V DC and 22-30 V DC
- Built-in constant current design
- Operation temperature from -20°C ~40°C at full load
- High power conversion efficiency >84% at 12/24 V DC
- IP65 Approved

Protections:

- Short-Circuit Protection (SCP)
- Over Voltage Protection (OVP)
- Undervoltage-Lockout (UVLO)
- Reverse Voltage Protection

The GP-LD10-30C and GP-LD15-24C are multi-use scenario LED drivers fit for a wide range of implementations. They can be used on vessels or vehicles and with power sources with fluctuating voltage. They have been designed to work well with solar panels for LED luminance. Included are many power and environmental ruggedness features to ensure maximum safety.

Both drivers have built-in constant current design with buck-boost topology, and a variety of safety cut off features to withstand the harshest ripple in the supplied power. An integral component is the low voltage protector. If the input voltage is lower than the UVLO protection point, below the operational value, the device will shut down automatically thus saving the connected lights. Standard Short-Circuit Protection and Over Voltage Protection are also included.

The two drivers have auto input voltage detectors. This ensures driver safety as it can detect 12 or 24V input. In order to prevent connecting the power lines in reverse accidentally damaging the driver, Reverse Protection with an automated disconnection from the current, is included. The highly secure and rugged IP65 design exterior insures no ingress of dust and water as well as complete protection against contact. It also ruggedly operates at a wide variation in temperature, from -20 to 40°C. ■

Mean Well Introduces Multiple Stage Output Current LED Power Supply Series

In response to the demands of intelligent LED lighting control and to provide a flexible power solution for project style lighting design, Mean Well introduced 40 W / 60 W multiple-stage output current LED power supply series.

Built in PFC, 1-10 V dimming and PWM signal function are some of the features of the new flexible LED driver series

With "constant current output" design, the output current level can be flexibly selected by the built-in DIP switch. The basic models, LCM-40 and LCM-60, are designed with "2-in-1" dimming function (0~10 Vdc and PWM signal), while the digital control models, LCM-40DA and LCM-60DA, are built-in DALI interface and push dimming function. These launched units can fulfill the increasing demands of intelligent digital dimming applications. Featuring with 180~295 VAC and built-in two stage PFC function, these new series comply with harmonic current limitation per EN61000-3-2 Class C (>35% load) and also fulfill PF>0.9 if loading over 35%. In addition, they possess 2 KV surge immunity ability (EN61000-4-5, heavy industry level) between Line and Neutral, which complies with the related lighting requirements.

Features:

- Output current level selectable by DIP switch
- 180~295 VAC input range
- Built-in active PFC function
- Protections: short circuit, over voltage, over temperature
- Cooling by free air convection
- Fully insulated plastic case, IP 20 design
- Class II power unit, no FG
- Built-in 0~10 VDC and PWM signal dimming function (LCM-40/60)
- Built-in DALI interface and push dimming function (LCM-40DA/60DA)
- Built-in NTC temperature compensation function
- Built-in 12 V / 50 mA auxiliary fan output
- No load power consumption < 1 W for LCM-40/60; <1.2 W for LCM-40DA/60DA
- Power supply synchronization function up to 10 units
- Dimensions (LxWxH): 123.5x 81.5x 23 mm
- 3 years warranty

With up-to date high performance circuit topology, LCM-40(DA)/60(DA) possess up to 91.5% of high efficiency, so they can be cooled by free air convection from -30°C to +60°C ambient temperature. Built-in temperature compensation function, by connecting an external temperature sensor (NTC resistor) between the NTC+/- terminals, the output current could be correspondingly changed with the detected temperature to ensure the long lifetime of LEDs. In addition, they equip with synchronization dimming function that can operate 10 drivers (max.) synchronously in response to the dimming control signal of LED lighting systems with multiple lighting fixtures.

LCM-40(DA)/60(DA) are rectangular and low profile (23 mm) plastic enclosed power supplies. Different from the general design with input in front and output in rear, the I/O connection of these new models are changed to the same side, which allows system designers a more convenient wiring installation. Other standard functions include Class II design (no F.G.), built-in 12 V / 50 mA auxiliary output (for driving fan), protections for short circuit, over voltage, and over temperature. All of them comply with certificates per UL8750, ENEC EN61347-2-13, and EN62384 of lighting regulations. LCM-40DA and LCM-60DA also comply with IEC62386-101, 102, 207 norms per DALI lighting control systems. Suitable applications include LED commercial lighting, office lighting, indoor LED decorative lighting. ■

MechaTronix's New Active Cooling Platform for High Bay Designs

MechaTronix launches a first 200 W active LED cooler for high bay and industrial light designs - the "IceLED Ultra"; the name the new active LED cooler. In a diameter of just 99 millimeters and with a weight of less than 500 grams this revelation in LED cooling keeps luminaires up to 20,000 lumen on their expected temperature. This makes the IceLED Ultra ideal for high bays and industrial light designs

MechaTronix's ultra-compact "IceLED Ultra" active cooling solution for COB LEDs and modules with up to 200 W and 20,000 lm

Main Features:

- Ultra high cooling performanc
- from 5,000 to 20,000 lumen
- holes for most LED modules
- Fan rated voltage 12Vdc (3W - 250mA)
- Warranty 5 years

Technical Data:

- Dimension (mm): ø 99 x h 75
- Fan Voltage (Vdc): 12
- Fan Speed (RPM: 3000
- Noise @ 1m (dBA): <39
- Weight (gr): 400.39 g
- Thermal Resistance (°C/W): 30.25
- Power Pd (W): 200
- Heat Sink Material: AL6063-T5

More and more LED manufacturers have recently launched high lumen LED packages in COB format or as a LED module. Citizen just came out with their new CITILED CLL052 COB producing 10.850 lumen in just a 38 x 38 millimeter chip-on-board package; Vossloh Schwabe introduced the Luga Industrial LED module for 10.000 hot lumens high bay designs.

Keeping these new developments on the required temperature is a nice challenge for industrial lighting designers. A passive LED heat sink would easily reach up to 3 kilograms for these kind of power platforms and is not always an option with regards to design and aesthetics

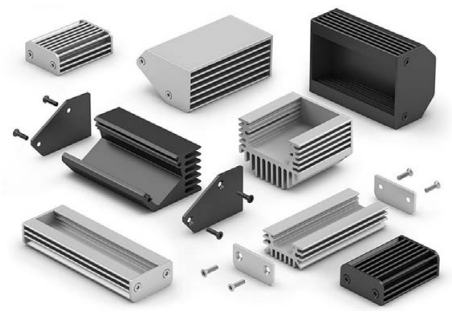
And that's where the IceLED Ultra fits in. With a thermal resistance as low as 0.25°C/W and a life time of over 60Khrs this active LED cooler just does what it is made for: offering a proven reliable cooling solution in the smallest package currently on the market and all that at a price level that hasn't been seen before on the LED market

The IceLED Ultra is again designed on a same modularity platform like the IceLED and the ModuLED LED coolers. This means that all Zhaga book 3 LED modules as well as the Bridgelux RS, Vossloh Schwabe Lugashop and Industrial, Citizen and Xicato XSM LED modules can be standard mounted on the cooler by use of simple self-tapping M3 screws.

A flipchart has been created for the IceLED Ultra, both in soft and hard copy versions, which gives a perfect overview of the compatible LED modules, as well as easy to use overlay which indicates the mounting holes needed for each LED module. ■

Fisher Elektronik Provides Housings for Linear LED Modules

Fischer Elektronik has expanded its product range of heat discharge housings by adding an additional housing series, the G LED range. In order to avoid overheating of LEDs, these special housings offer efficient heat management, which help to optimize the heat discharge.



Fischer Elektronik's G LED housing series is available as standard in three different versions and three lengths

Thanks to their wide range of applications, modern LED lighting systems have gained general acceptance in many areas, such as industrial design, architecture, the internal furnishings sector and advertising as well as many others. Despite an improved level of efficiency, a large part of the electrical power with LEDs is still converted into heat. As a result, efficient heat management is still important.

The new U-shaped housing profiles, which are open on one side, have integrated guide grooves to take LED line modules and slot-in cover plates or plexi-glass discs, which can vary in their material thickness. The plexi-glass discs and LED line modules are fixed by means of the lid plates at the front, which are screwed onto the housing profile. The housing profiles also have external cooling ribs, which ensure that the heat is fully discharged to the environment.

The G LED housing series is available as standard in three different versions and three lengths (50, 80, 100 mm), as well as in two surface versions (natural-colored and black anodized). Other lengths, surfaces and types of mechanical processing and printing can be manufactured to the customer's request. ■

Verbatim Launches First Commercially Available VxRGB LED Product

Verbatim announces the commercial release of Vivid Vision™, a directional LED lamp using VxRGB® technology developed by Verbatim's parent company, Mitsubishi Chemical Corp.

Vivid Vision ensures that colors and fine details of objects are rendered accurately through a unique combination of red, green and blue phosphors applied to a violet, rather than blue, LED die. This type of LED lighting is particularly effective in spaces where small differences in color hues, tints and textures can have a significant impact.

Vivid Vision is an MR16 VxRGB LED lamp designed to meet specific requirements in professional applications such as prestigious hospitality venues, sophisticated retail outlets and museums where high contrast lighting enhances the unique features of artworks.

Verbatim's VxRGB technology generates vibrant saturated and natural colors (left), which is relevant for restaurant lights as well as many other applications

"Based on the technology and knowledge of our parent company Mitsubishi Chemical Corporation, Vivid Vision LED lamps use a unique phosphor mix to ensure that the colors in certain lighting applications appear as they should," comments Paul Johnson, Vice President, Verbatim Asia Pacific.

"The CRI is not the measurement that is relevant for this type of specialist product. It is all down to customer needs in utilizing the unique characteristics of the light in making objects appear more vivid with high perception fidelity," said Mr. Johnson.

The MR16 LED lamp is a retrofit replacement for typically 20 W low voltage halogen reflector lamps. Rated at 6.5 W (equivalent to 20 W incandescent lamps), it produces 180 lumens output over a 35° beam angle, with a color temperature of 2900 K and a CRI of 85.

"We plan to expand our product portfolio based on VxRGB technology in the future. This technology offers us greater freedom in creating products with a dedicated light output that fits according to special applications and customer needs," explains Paul Johnson. ■

GL Optic Announces World's First Smart Spectrometer

The Android-based GL Spectis 1.0 touch spectrometer from GL Optic is an innovative spectral instrument featuring intuitive operation for mobile light measurement in the visible spectrum. In addition to the many performance features of previous models, the GL Spectis 1.0 touch also measures luminous flux (lumen) from LEDs and other light sources.

The GL SPECTIS 1.0 touch is the ultimate handheld tool for measuring and analyzing light parameters

With its extended functionality, the instrument is a valuable tool for light designers and lighting product manufacturers. The light output of LEDs is typically listed as luminous flux (lumen). The GL Spectis 1.0 touch in combination with the GL Opti Sphere 48 mini integrating sphere can be used for luminous flux measurement of individual LEDs and with the standard diffusor can also used for distance-dependent illuminance measurement of LED lamps. The spectrometer is a highly useful instrument for the entire lighting product manufacturing process.

The GL Spectis 1.0 touch is the ultimate tool for measuring, analyzing and storing key parametric data using the integrated touch display (240x320 pixels). Data needed for LED qualification includes the color rendering index (CRI) in accordance with the CIE standards, correlated color temperature (CCT) in accordance with the CIE standards, color coordinates in accordance with CIE 1931 and CIE 1964 as well as the radiant power value (mW) and luminous flux. The handy instrument has a spectral range of 340 - 750 nm. The physical resolution is ~ 1.7 nm with a wavelength reproducibility of 0.5 nm. The convenient, user-friendly instrument includes everything needed for high-precision calculation of colorimetric data. High sensitivity and innovative noise suppression are key features that make it possible to obtain reliable measurements at low signal strengths. Innovative technology limits the measurement uncertainty of the color coordinates (x/y) to 0.0015, putting the spectrometer on a par with complex, expensive lab instruments.

GL Optic performs spectral calibration on all of its spectrometers prior to shipment. The standard diffusor is cosine-corrected and calibrated for measuring the illuminance and irradiance of light sources.

The instrument is also calibrated in combination with the GL Opti Sphere 48 integrating sphere for luminous flux measurement. With the aid of an intelligent coding system, it detects the optical probe and automatically selects the appropriate calibration, virtually eliminating the risk of measurement errors.

The instrument features Android operating system architecture and state-of-the-art connectivity including WiFi and Bluetooth. An SD card slot and USB 2.0 port enable the spectrometer to interact with PCs and notebooks. The handy, mobile instrument features a compact design (74 mm x 146 mm x 24 mm) and weighs only 315 g. Many accessories including optical probes and integrating spheres are available in a range of sizes.

The optional GL Spectro Soft software provides all of the functionality needed for lab use or production. It can be used to control the spectrometer, the portfolio of peripherals and external integrating spheres. It also offers various data acquisition functions, multiple numeric and graphic display options for visualization of the measurement results and a number of export options. Users can perform spectral analyses and save the measurement results on a PC via the built-in USB port. ■

Radiant Zemax Launches New High-Resolution Imaging Colorimeter

Radiant Zemax, a leading provider of light and color test and measurement systems and optical and illumination design software, introduced ProMetric® I, the latest in the company's industry-leading line of imaging colorimeters. ProMetric I is engineered to meet the strict testing requirements of high-volume production lines for flat panel displays (FPDs), illuminated keyboards, and LED lighting products.

ProMetric I includes industry-first Smart Technology™ innovations that greatly simplify measurement setup and enable fast, accurate measurements matching human perception of brightness and color. The advancements in ProMetric I provide a new dimension of testing capability, particularly for high-volume manufacturing customers. The addition of a high-resolution, high-speed CCD sensor in ProMetric I enhances spatial measurement accuracy and reduces test time by 5-10x per pixel. This enables customers to conduct more thorough testing with a reduced cycle time.

Radiant Zemax's new highly accurate ProMetric I colorimeters are available with 8 and 16 megapixel sensors

With innovations in speed, resolution, and precision, ProMetric I delivers performance improvements that address key pain points for our high-volume manufacturing customers, said Paul Caragher, President and CEO at Radiant Zemax. The improved speed is a game changing feature. ProMetric I allows for significantly more complete test coverage without impacting overall throughput, so our customers can improve product quality and reduce costs by capturing and quantifying defects before they make it to market in finished products.

ProMetric I Delivers Speed and Flexibility for High-Volume Production Environments

ProMetric I imaging colorimeters deliver highly accurate color and luminance measurements in the demanding constraints of an automated manufacturing environment. ProMetric I is engineered around a high-speed, high-resolution CCD sensor that enables pixel-level measurements on FPDs, intra-character luminance measurements on illuminated keyboards, and highly accurate measurements of LED luminance and color in luminaires with large LED arrays. ProMetric I also supports high-speed USB and Ethernet communications, providing highly reliable operation over long distances, even in the most difficult manufacturing environments. ProMetric I works seamlessly with the Radiant Zemax TrueTest automated visual inspection system. TrueTest provides a complete, turnkey solution for high-volume manufacturing of FPDs, illuminated keyboards, and lighting products. ■

MIT Demonstrates New Method for Fine-Tuning Emissions from Quantum Dots

Tiny particles of matter called quantum dots, which emit light with exceptionally pure and bright colors, have found a prominent role as biological markers. In addition, they are realizing their potential in computer and television screens, and have promise in solid-state lighting. New research at MIT could now make these quantum dots even more efficient at delivering precisely tuned colors of light.

This new technique determines whether the width of the spectrum in a given batch is caused by different NCs in the batch having slightly different colors, or if each particle's emissions has a wider spectrum (Credits: Image courtesy of Lauren Aleza Kaye)

Advantage of the new fine-tuning process:
Vials containing colloidal semiconductor quantum dot nanocrystals (NCs) emit colors that are determined by the exact size of the particles. In the image, curves in front of each vial show the measurements made by the MIT team: The outer, wider curve shows the spectrum of colors from all the NCs in that vial, while the narrower curve shows the average single-particle spectrum within that vial. Until this new technique was developed, there was no way to tell whether the width of the spectrum in a given batch was caused by different NCs in the batch having slightly different colors, or whether each particle's emissions had a wider spectrum.

These materials, called colloidal semiconductor quantum dot nanocrystals, can emit any color of light, depending on their exact size or composition. But there is some variability in the spread of colors that different batches of nanocrystals produce, and until now there has been no way to tell whether that variability came from within individual particles or from variations among the nanocrystals in a batch.

That's the puzzle an MIT team has now solved, using a new observational method. The results appear in the journal Nature Chemistry in a paper by chemistry professor Moungi Bawendi, graduate student Jian Cui, and six others.

For many applications — such as flat-panel displays — it's important to make particles that emit a specific, pure color of light. So, it's important to know whether a given process produces nanocrystals with an intrinsically narrow or broad spectrum of color emission.

"You need to understand how the spectrum of a single particle relates to the spectrum of the whole ensemble," Cui says. But existing observational methods that detect an entire ensemble produce data that "is blurring the information," and methods that attempt to extract data from single particles have limitations.

Observing billions at once:
The new method, developed in Bawendi's lab, is a radical departure from conventional means of observing light emissions from single emitters. Normally, this is done by isolating individual emitters, stabilizing them on a substrate, and observing them one at a time.

But this approach has two drawbacks, Bawendi explains: "You only get small numbers, because you're looking at one at a time, and there's a selection bias, because you usually look at the bright ones."

The new method — called photon-correlation Fourier spectroscopy in solution - makes it possible to extract single-particle spectral properties from a large group of particles. While it doesn't tell you the spectral peak width of a specific particle, it does give you the average single-particle spectral width from billions of particles, revealing whether the individual particles produce pure colors or not.

In addition, Bawendi explains, the particles "are not isolated on a surface, but [are] in their natural environment, in a solution." With the traditional methods, "There's always a question: How much does the surface affect the results?"

The method works by comparing pairs of photons emitted by individual particles. That doesn't tell you the absolute color of any particular particle, but it does give a representative statistical measure of the whole collection of particles. It does this by illuminating the sample solution with a laser beam and detecting the emitted light at extremely short time scales. So while different particles are not differentiated in space, they can be differentiated in time, as they drift in and out of the narrow laser beam and are turned on by the beam.

"We get the average single-particle line width in the solution, without any selection bias," Cui says. By applying this method to the production of quantum dot nanocrystals, the MIT team can determine how well different methods of synthesizing the particles work.

Fine-tuning the process:
"It was an open question whether the single-dot line widths were variable or not," Cui says. Now, he and his colleagues can determine this for each variation in the fabrication process, and start to fine-tune the process to produce the most useful output for different applications.

In addition to computer displays, such particles have applications in biomedical research, where they are used as staining agents for different biochemicals. The more precise the colors of the particles are, the greater the number of different colored particles that can be used at once in a sample, each targeted to a different kind of biomolecule.

Using this method, the researchers were able to show that a widely used material for quantum dots, cadmium selenide, does indeed produce very pure colors. But, they found that other materials that could replace cadmium selenide or produce different colors, such as indium phosphide can also have intrinsically very pure colors. Previously, this was an open question.

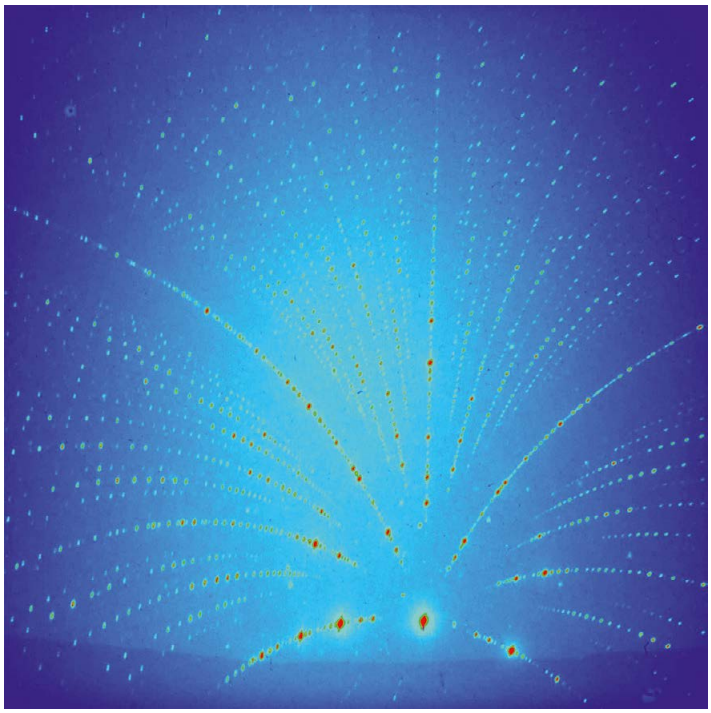
Todd Krauss, a professor of chemistry at the University of Rochester who was not involved in this research, says the MIT team's "approach is very clever and builds on what this group has done previously." Measuring the line widths of individual particles is important, he says, in optimizing applications such as television displays and biological markers. He adds, "We should be able to make much better strides now that this technique is published, because of the ability to get single-particle line widths on many particles at once." ■

New Family of Tiny Crystals Glow Bright in LED Lights

Light-emitting diodes, better known as LEDs, offer substantial energy savings over incandescent and fluorescent lights and are easily produced in single colors such as red or green commonly used in traffic lights or children's toys. Developing an LED that emits a broad spectrum of warm white light on par with sunlight has proven tricky, however. LEDs, which produce light by passing electrons through a semiconductor material, often are coupled with materials called phosphors that glow when excited by radiation from the LED. Minuscule crystals that glow different colors may be the missing ingredient for white LED lighting that illuminates homes and offices as effectively as natural sunlight.

"But it's hard to get one phosphor that makes the broad range of colors needed to replicate the sun," said John Budai, a scientist in ORNL's Materials Science and Technology division. "One approach to generating warm-white light is to hit a mixture of phosphors with ultraviolet radiation from an LED to stimulate many colors needed for white light."

Budai is working with a team of scientists from the University of Georgia and Oak Ridge and Argonne national laboratories to understand a new group of crystals that might yield the right blend of colors for white LEDs as well as other uses. Zhengwei Pan's group at UGA grew the nanocrystals using europium oxide and aluminum oxide powders as the source materials because the rare-earth element europium is known to be a dopant, or additive, with good phosphorescent properties.



Oak Ridge National Laboratory scientists are using x-ray diffraction analysis to better understand tiny crystals that could be used in warm-white LEDs

"What's amazing about these compounds is that they glow in lots of different colors—some are orange, purple, green or yellow," Budai said. "The next question became: why are they different colors? It turns out that the atomic structures are very different."

Budai has been studying the atomic structure of the materials using x-rays from Argonne's Advanced Photon Source. Two of the three types of crystal structures in the group of phosphors had never been seen before, which can probably be attributed to the crystals' small size, Budai said.

"Only the green ones were a known crystal structure," Budai said. "The other two, the yellow and blue, don't grow in big crystals; they only grow with these atomic arrangements in these tiny nanocrystals. That's why they have different photoluminescent properties."

X-ray diffraction analysis is helping Budai and his collaborators work out how the atoms are arranged in each of the different crystal types. The different-colored phosphors exhibit distinct diffraction patterns when they are hit with x-rays, enabling researchers to analyze the crystal structure.

"What that means in terms of how the electrons around the atoms interact to make light is much harder," Budai said. "We haven't completely solved that yet. That's the continuing research. We have a lot of clues, but we don't know everything."

The knowledge gained through their atomic-scale analysis is helping the research team improve the phosphorescent crystals. Different factors in the growth process - temperature, powder composition, and types of gas used - can change the final product. A fundamental understanding of all the parameters could help the team to perfect the recipe and improve the crystals' ability to convert energy into light.

Advancing the material's luminescence efficiency is key to making it useful for commercial LED products and other applications; the new nanocrystals may turn out to have other practical photonic uses beyond phosphors for LEDs. Their ability to act as miniature "light pipes" when the crystal quality is high enough could lend them to applications in fiber-optic technologies, Budai said.

"You can keep growing the crystals and measuring them, or you can understand why it's doing what it's doing, and figure out how to make it better. That's what we're doing - basic research. We have to figure out nature first."

The team's most recent study is published as the inside front cover article in the April 25 issue of Advanced Functional Materials as "New Ternary Europium Aluminate Luminescent Nanoribbons for Advanced Photonics."

Budai and use of the Advanced Photon Source at Argonne were supported by DOE's Office of Science. Zhengwai Pan was funded by the National Science Foundation.

The Advanced Photon Source at Argonne National Laboratory is one of five national synchrotron radiation light sources supported by the U.S. Department of Energy's Office of Science to carry out applied and basic research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels, provide the foundations for new energy technologies, and support DOE missions in energy, environment, and national security.

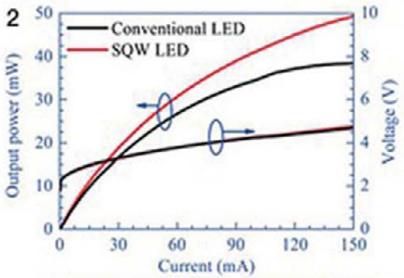
To learn more about the Office of Science X-ray user facilities, visit http://science.energy.gov/user-facilities/basic-energy-sciences/.

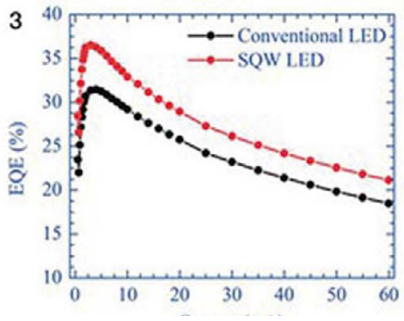
DOE's Office of Science is the single largest supporter of basic research in the physical sciences in the United States, and is working to address some of the most pressing challenges of our time.

For more information, please visit science.energy.gov. ■

1

Contact	p-GaN	200nm
Electron blocking	p-AlGaN	20nm
Active	MQW	
Contact	n-GaN	2μm
Buffer	Undoped GaN	2μm
Nucleation	Low-temperature GaN	30nm
Substrate	Sapphire (0001) c-plane	





Schematic of epitaxial material for conventional and shallow quantum well (SQW) LEDs (Figure 1). Light output power–current–voltage (L–I–V) characteristics of conventional LED and SQW LED (Figure 2). EQE versus current characteristics of conventional LED and SQW LED (Figure 3)

Chinese Scientists Find that Strain Engineering Improves Light Output from Green LEDs

The Chinese Academy of Science reports that researchers in China have used strain engineering to improve the light output power of 530 nm green light-emitting diodes (LEDs) by 28.9% at 150 mA current injection [Hongjian Li et al, Appl. Phys. Express, vol6, p052102, 2013]. The research was carried out by Chinese Academy of Sciences' Institute of Semiconductors, Beijing, and University of Hong Kong.

Green-emitting nitride semiconductor LED structures tend to suffer from low light output due to the difficulty in producing the high-indium-content indium gallium nitride (InGaN) needed for longer-wavelength light

emission. Apart from the material quality challenge, strain induced by the lattice mismatch with pure GaN leads to large piezoelectric effects, giving electric fields that tend to pull electrons and holes apart, reducing rates of recombination into photons (i.e. the quantum-confined Stark effect, or QCSE).

The Chinese team tackled the problem by inserting a layer of lower-indium-content InGaN before the high-In-content light-emitting layer. Simulations were carried out first, suggesting that such a layer could reduce the strain-dependent electric fields in the active light-emitting multiple quantum well (MQW) structure.

Epitaxial material with a low-In-content InGaN shallow quantum well (SQW) step was realized using metal-organic chemical vapor deposition (MOCVD) on c-plane (0001) sapphire (Figure 1). Conventional device structures were also produced. The conventional multi-quantum well (MQW) active region consisted of 12 periods of 3nm In0.3Ga0.7N wells between 12 nm GaN barriers. The SQW structure consisted of 12 periods of a 2 nm In0.1Ga0.9N shallow well and a 3nm In0.3Ga0.7N deeper well between 12 nm GaN barriers. These materials were then fabricated into 256μm x 300 μm mesa-structure LED chips.

A 325nm helium-cadmium laser was used to excite the photoluminescence spectra of the materials at low temperature (85 K) and room temperature (298 K). One effect of the SQW was to reduce the width of the spectral peak full-width at half maximum (FWHM) at 85K from 16.7 nm for the conventional LED material to 13.1 nm for the SQW material. The 298 K measurement reduced the conventional FWHM of 20.1 nm to 15.7 nm.

The peak intensity was also higher with the SQW structure. These results are taken as indicating improved crystal quality for the SQW material. In particular, the narrow FWHM suggests, “more uniform indium distribution and less carrier localization within the active region” due to lower stress in the active region.

The peak height for the SQW material at 298 K was 55.1% at 85 K. The corresponding ratio for the conventional structure was 24.1%. The higher ratio for the SQW material indicates a higher rate of radiative recombination and higher internal quantum efficiency (IQE) due to a smaller QCSE.

The electroluminescence was measured in an integrating sphere, giving light output power–current–voltage (L–I–V) results (Figure 2). The voltage performance is similar in the SQW and conventional devices. However, the light output at 150mA is 28.9% greater in the SQW LED (49.3 mW) over the conventional device (38.4 mW).

The researchers attribute the enhanced results for the SQW LED to improved overlap of the electron and hole wave functions in the device, leading to improved recombination into photons. The performance is not enhanced to the same extent as for photoluminescence because the biasing in electroluminescence increases the polarization fields.

The external quantum efficiency (EQE) is increased 10.2–13.3% over the conventional LED performance (Figure 3). ■

LED professional Symposium +Expo (LpS) – Experts Present Their Most Recent Results in the Areas of LED and OLED Technologies

From September 24th to 26th, 2013, researchers and designers will discuss their newest insights and future trends in the areas of general, architectural and industrial lighting in Bregenz, Austria. 45 informative lectures, 5 detailed workshops and networking opportunities combined with a diversified exhibition make this a "must go" event for experts in the areas of LED and OLED technology.

Preview: LED and OLED Technology Trends

Innovation and Design: "LED and OLED technologies are evolving dynamically. This means that lighting systems have to be improved and adapted continually. For this reason it is imperative to be able to recognize technical trends for future innovations in this area. This year the LpS program encompasses design, technology and implementation which creates a deeper understanding for the requirements of future lighting systems," said Siegfried Luger, the event director and publisher of LED professional. In the course of the symposium, topics like "Technology for the Next Generation of Flexible OLEDs for Lighting" by Dr. Christian May from Fraunhofer or "Trends of Chip-on-Board Technologies" by Siegmund Kobilke from Excelitas Technologies ELCOS GmbH will be presented. In addition to the expert talks, a complete lighting solution in the form of a modern lighting installation by Zumtobel will be displayed in the newly opened Vorarlberg Museum on the first evening.

System performance and reliability: "The reliability of the LED-system is the most important issue of the current LED-luminaire technology and has a substantial impact on the determination of the maintenance factor which has to be defined and determined by the luminaire manufacturers before the LED-luminare installation can start in real LED-lighting projects" emphasized Prof. Tran Quoc Khanh from the Technical University in Darmstadt.

Stimulating lectures inspire detailed discussions throughout the exhibition

For this reason, the symposium will feature a number of lectures and a workshop that focus on this subject. One of the talks is by Matteo Meneghini from the University of Padua titled "Degradation Mechanisms and Methods for Lifetime Extrapolation of LEDs". Another interesting lecture will be "Long-Term Electrical, Optical and Thermal Behavior of LED Light Bulbs" by Laurent Massol from LED Engineering Development. In addition to that there will be the "LED Luminaire Design" workshop, presented by Cree.

Smart Lighting and Digitalization: In an interview with Siegfried Luger in May, 2013, Franco Musiari, technical director of the Assodel organization said that he thought the new main trend is going in the direction of "Differentiation through Smart Lighting". Ed van den Kieboom, the Conference director at Smart Lighting in Frankfurt mentioned, that the introduction of Solid-State-Lighting in the lighting industry will end up being digital. He also said that, through this, light management would become more efficient but at the same time would have to be adapted more and more to the needs of the buyer and user. With the correct light, optimal work and living conditions can be created that, in the long run, can even influence our health. Digital approaches are also given a lot of attention at the symposium. One of the talks on this subject will be given by Stefan Zudrell-Koch from Dialog Semiconductors titled "Digital Signal Processing Techniques in Retrofit Lamp Driver ICs".

Program Overview

The keynote speeches by Dietmar Zembrot, President of Lighting Europe, Menno Treffers of the Zhaga Consortium and Alfred Felder from Tridonic will be followed by two parallel lecture tracks with a total of 45 expert talks on the subjects of LEDs, OLEDs, LED Future, LED Systems, Drivers and Steering Elements, Optics, Thermal Management and Implementation. Concurrent to the lectures, there will be two workshop tracks with a total of five distinctive workshops. These workshops will offer symposium attendees detailed information about UL standardizations and certifications, 3-D module designs, printed optic technologies, LED system design tools and LED test procedures. In addition to all that, there will be two interactive tech-panels where attendees can discuss topics of the future in the area of LEDs and OLEDs. More information can be found at: www.LpS2013.com/program.

In addition to the symposium program, visitors can get first-hand information from internationally renowned companies who will be showing their newest developments and products at the ground-breaking exhibition. The Light Art project and dinner on a cruise ship on Lake Constance make the evening events something that shouldn't be missed. Guests will be able to make contacts, discuss ideas and wind down to the sound of live music in a relaxed atmosphere.

Registration

Those wanting to attend can register at: www.LpS2013.com/Registration.
The event organizer will be happy to give information to anyone interested in exhibition space and the various options available.

LpS 2013

LED professional | SYMPOSIUM +EXPO

3rd INTERNATIONAL LED professional Symposium +Expo

LED Lighting Technologies

International Winning Approaches

EVENT OVERVIEW

LED professional Symposium +Expo (LpS) is Europe's foremost LED lighting technology event for experts in industry and research focussing on general, industrial and architectural lighting applications. LpS covers LED and OLED lighting technologies for components, modules, lamps and luminaries.

Over **1000** visitors from all LED lighting technology fields anticipated.

Top class contributors will present **45** lectures covering highly relevant technologies.

More than **80** exhibitors expected from all over the world.

KEYNOTE SPEAKERS

Dietmar Zembrot
President of LightingEurope and CEO of TRILUX, Germany

"Challenges and Opportunities of the European Lighting Industry"
Effects of Solid-State Lighting on products manufactured by European companies and the strategies of the new LightingEurope organization.

Menno Treffers
General Secretary of the Zhaga Consortium, The Netherlands

"Zhaga - Lowering the Risk and Cost of Getting LED Technology Innovation to Market"
An in-depth discussion of the impact of the Zhaga interface specifications on the competitive light market.

Dr. Alfred Felder
CEO of Tridonic, Austria

"Lighting Module and Component Industry - Market and Technology Opportunities"
Correlations between market and technology activities in Solid-State Lighting; risks and opportunities for module and component manufacturers in a rapidly changing environment.

EVENT PROGRAM

- **3 Keynotes** | From Opportunities to Strategies
- **45 Lectures** | From Light Sources to Applications
- **5 Workshops** | From Design to Standardization
- **2 Tech Panels** | From Ideas to Solutions
- **2000 m² Exhibition** | From Technologies to Projects
- **Light Art Project** | From Imagination to Inspiration
- **Get Together Event** | From Visitors to Networkers

24-26 SEPTEMBER 2013 | BREGENZ | AUSTRIA

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LED Lighting Taiwan Review – Focus on Taiwan's Key Players in the SSL Market

Arno Grabher-Meyer from LED professional attended LED Lighting Taiwan 2013 where he got the chance to talk with the key personalities from Taiwan's most innovative SSL companies. He was given views of the volatile LED lighting market, current and future technology trends, roadmaps and exciting innovations.

Figure 1: **Opening ceremony of the Photonics Festival Taiwan 2013**

LED Lighting Taiwan, part of PIDA's Photonic Festival that covers several exhibitions including Display Taiwan, Opto Taiwan and Solar Taiwan, once more attracted visitors and exhibitors from around the globe. For the first time this year, Hai Hong, Chinas biggest OEM/ODM contractor for electronics products joined Display Taiwan and drew a lot of attention. However, a good portion of the 33,187 visitors belonged to the audience of LED Lighting Taiwan. The biggest visitor group consisted of locals, followed by LED specialists from China, Japan, the USA, South Korea and Germany.

Compared to last year, the number of visitors showed an increase of 9.1%.

Many of Taiwan's big names from the industry were present, covering all technologies and components for LED lighting systems. A clear focus on the high-tech industry for chip manufacturing, packaging and the corresponding manufacturing and testing tools providers was seen. The technological power demonstrated by their own industry was enhanced by some of the world's most innovative foreign companies.

A Strong Scientific Focus

This year's LED Lighting Taiwan once again covered the Taiwan Academic Research Expo. All relevant Universities, Colleges and Universities of Applied Science were demonstrating capabilities and projects. Many had to do with photovoltaic; others with optics and some were also of great interest to the LED lighting business. It is to mention here that the results of one of these research projects from the National Central University Taiwan, about the effect of light emission patterns on the external efficiency of white phosphor-packed LEDs will be demonstrated in a lecture at LpS 2013 in Bregenz, Austria. Another technically interesting project, not exclusively, but also for LED manufacturing, was part of the scientific seminar program. The Chung-Shan Institute of Science & Technology explained their approach for SiC production. This base material for many different electronics semiconductors is very expensive. "One main reason is that two companies hold the IP for production which restricts availability," explained Ping-Ya Ko, general director of the institute. The new processes developed at our institute could help lower these costs," he added, "but a number of strong competitive companies that start using this technology are needed to change this situation. In Taiwan there are enough of these companies that could start." While the LED lighting industry would have some advantages, there are many other areas in electronics that it would be even more advantageous too.

LEDs, LED Chip Manufacturers and Packaging

LED and LED chip manufacturers were not just one of the major exhibitor categories; they also drew the most attention from visitors and the press. The majority of exhibitors in that category are from Taiwan who traditionally introduce novelties and new product lines. This year was no exception.

Everlight displayed all recently announced products, like the 45-21S series that is an upgrade of standard 3020 packages. With efficient thermal dissipation, this compact white LED can be overdriven up to 30 mA or 60 mA while maintaining its high efficiency. Also the second new release, the versatile XI3535 1 W LED package was shown. But the technical highlight at Everlight's booth was the new Color Choice Series. This specialty is a color changing COB LED for the indoor retail and residential lighting industry. It consists of two color temperatures of 2700 K and 5700 K that can be thoroughly mixed to achieve all ANSI color temperatures up to 5700 K CCT. All mixture points achieve at least 97 lm/W and a Ra of 80. This COB is ideal for setting the proper lighting environment. Everlight's sales director for Taiwan, Allan Lee commented on the developments of LED lighting in general: "We recognize a change of the prioritization from efficiency issues to cost saving to reliability and ending up in complex, intelligent solutions. In our opinion, CCT controlled LED lighting could become a standard product in 2 years."

In general, Epistar followed the same track that they pursued at the LEDs Conference in 2009 in San Diego, California with the introduction of their blue-phosphor and red system. Meanwhile, many improvements were introduced and efficiency has almost doubled. Myway Hsu, associate vice president of the GaN R&D group at Epistar, clearly identified the key parameters that Epistar works on for further improvements. He explained: "One of our primary challenges and goals is to simplify structure while preventing or increasing efficiency, but we are on the road to success. Our original roadmap planned for warm white LEDs with an efficiency of 141 lm/W in 2012, 202 lm/W in 2015 and 253 lm/W – virtually the same as for cool white LEDs – in 2020. In parallel, a cost reduction from 18 $/klm when introduced to the market to 1 $/klm in 2020 is on our track. However, today we have reached the 247.5 lm/W in our lab." Mr. Hsu also disclosed, "We are also working on many other issues to improve LED technology and to lower costs even further. We improved sapphire substrate patterning methods with our nano-scale patterned sapphire substrate (NPSS). We are researching options to lower droop. Our R&D has made a lot of progress in GaN-on-Si technology with crack free epitaxy layers on 6" wafers, and we are currently developing chips for special functions." With the new Venus G2, Epistar managed to simplify structures while maintaining high performance and reducing costs. The visible highlight at the booth was the Epistar approach to providing a filament-like look for LED replacement bulbs.

Figure 2: Everlight's new Color Choice Series allows CCT tuning from 2700 to 5700 with at least 97 lm/W efficiency

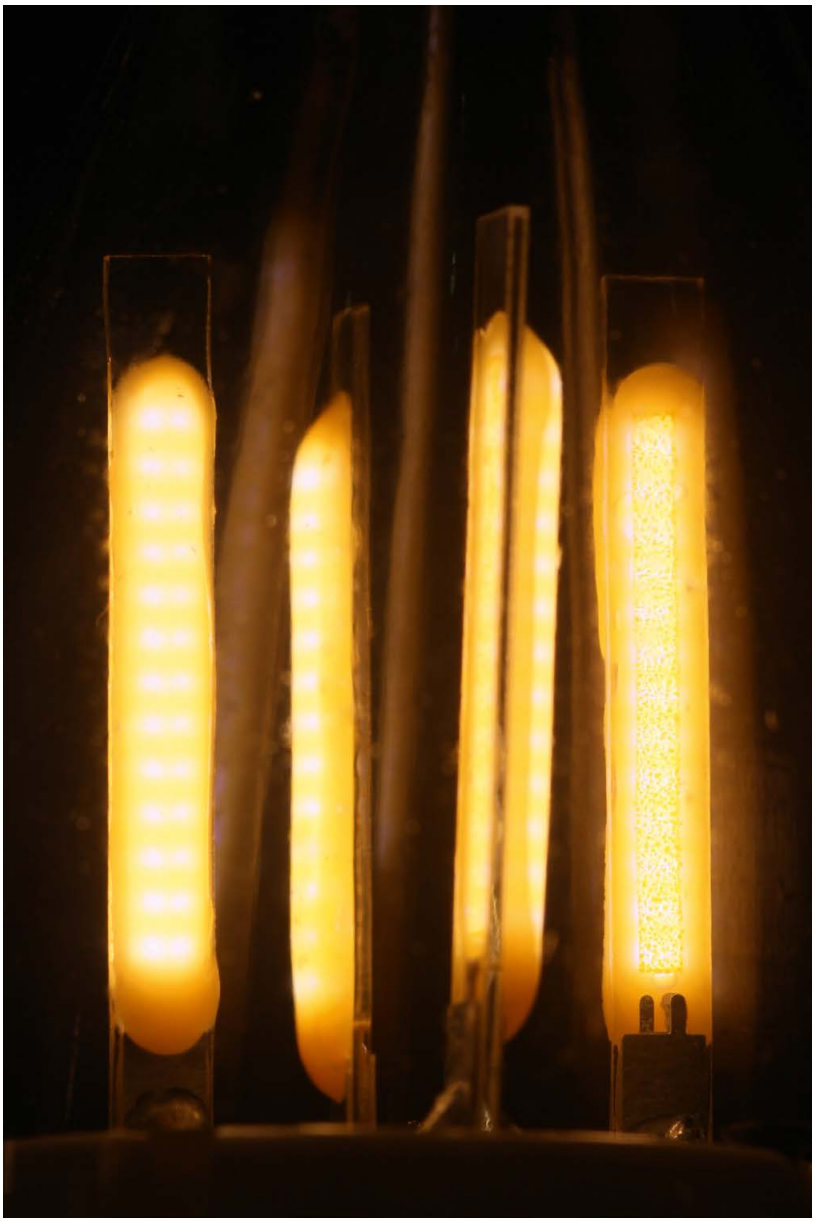
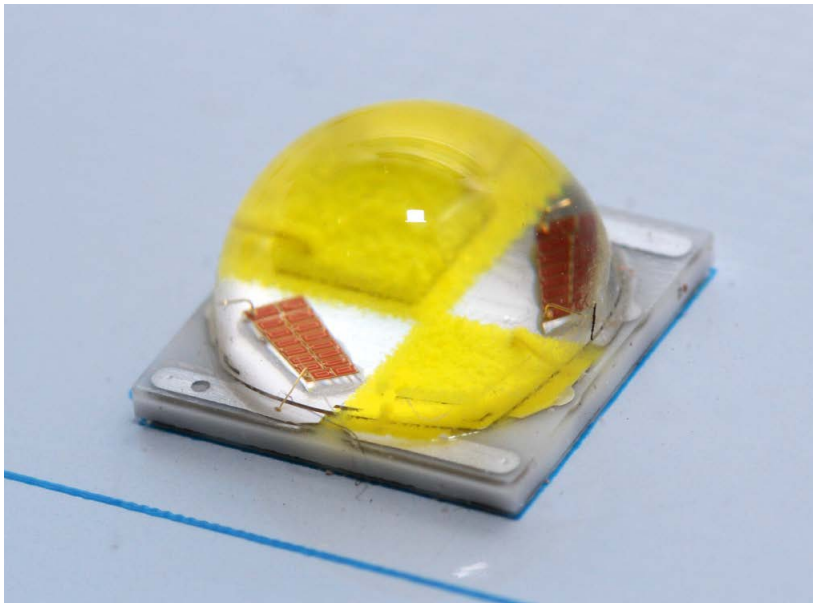
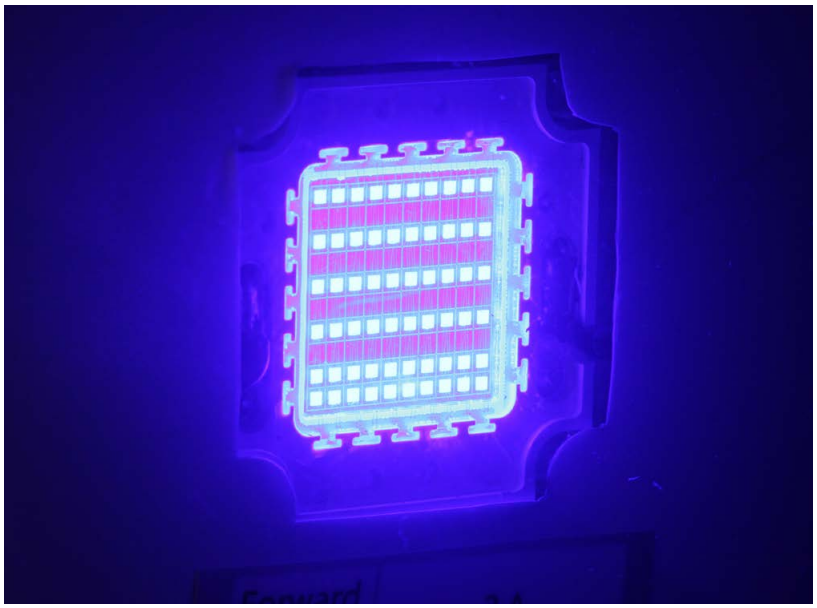
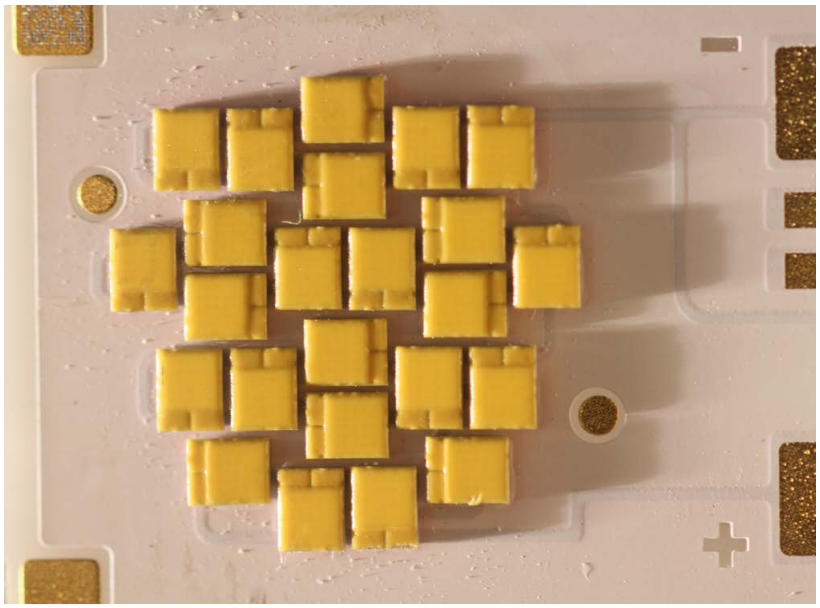


Figure 3: A visual delicacy at the Epistar booth was their filament mimicking design for replacement bulbs







Figures 4: Different package designs and concepts for different applications (Top: LiteOn multi-chip globe top package; Center: COB package from BRT; Bottom: Philips LUXEON S)

LiteOn, a company with a long tradition in LED manufacturing has had a strong focus on LEDs for BLU for long time. They entered the LED general lighting business relatively late but since 2010 LiteOn has been strengthening its activities in the general lighting market. Marvin Lee, director of product development explains, “Next to Philips, our current main market is Japan. They are adopting LED lighting technology very quickly with our products, with NEC being one of our main clients. Europe and the US are clearly slower. The main reason is the price structure given through their distribution chain.” LiteOn is well prepared for the different requirements of the general lighting market. With several license agreements, like for phosphors with Nichia, Toyoda Gosei and Osram, they provide an interesting portfolio of products, especially in the low- and mid-power range. As OEM manufacturer for well-known brands they are used to manufacturing customized solutions with high quality and a high technical level.

Bright LED Electronics Corp. (BRT), originally started with packaging, and now provides the whole system integration line from chip to luminaire. These capabilities were demonstrated at their booths. While SMD LEDs make up the largest part of their LED manufacturing, they also showcased their high power COB LEDs and Zhaga modules. Their white LED portfolio is built upon their phosphor licenses, but in other technology areas they have a strong IP. Asked for BRT’s technology roadmap and highlights, Ken Yu, the associate VP of the technical project division said: “We have a proprietary system for an LED bulb in our pipeline for which a pending patent is expected to be granted this Fall. The IP is on series connected LEDs where the string will not fail if an LED within this string is damaged.” BRT’s biggest market for LEDs is still China and the rest of Asia but 30% are exported to the US, Germany and Turkey.

The highlight at the Formosa Epitaxy booth was their package free chip (PFC) technology which was introduced with a first product in September, 2012. According to “ForEpi” this design can lower production costs while increasing brightness and efficiency. The company states that white LEDs based on that technology have an efficiency of 180lm/W, but Formosa Epitaxy has developed package free chips (PFC) with increased efficiency of up to 230 lm/W. The latest PFC products were on display. The eye-catchers at their booth were the 3.5 W LED candle lamps with the incandescent-mimicking look and a beam angle of 330° and a color temperature of 2,700K.

Optotech completes the picture of Taiwan’s exhibiting LED chip manufacturers. While being a specialist in manufacturing colored LEDs, Optotech completely concentrated on their display products with their exhibition appearance. Therefore the company is also especially known for their high quality large in- and outdoor LED matrix installations.

From outside Taiwan, Nichia, Philips Lumileds and Refond were present. Taiwan’s branch of Nichia showcased their latest COB products and featured the 2200 K LEDs by

demonstrating product samples of their clients and by pointing towards the light quality of these products. Philips Lumileds as another big player also demonstrated their products “at work” in different luminaires. A special highlight here was certainly their recently introduced LUXEON S with a never-before-possible Center Beam Candle Power (CBCP) of over 50,000 cd. Refond from China, joined the show with their broad product range, highlighting their latest COB products and 3535 type LEDs.

Manufacturing, Testing and Packaging Materials

While being the second biggest product category, most exhibitors were local distributors or sales branches of the well-known manufacturers. A complete presentation of all companies would clearly go beyond the scope of an event report. However, two companies out of Taiwan’s innovative industry need to be highlighted.

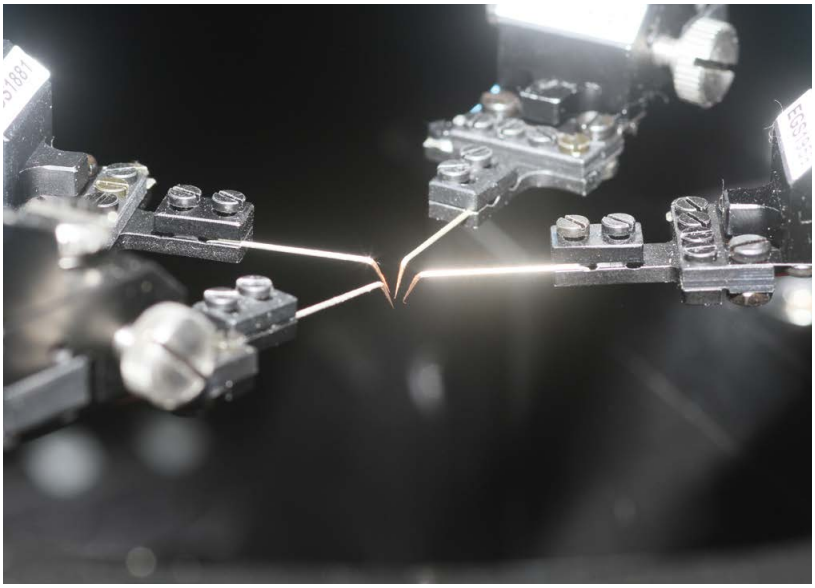
MPI/Chain Logic, Taiwan’s only probe card & test equipment provider for LED & Semiconductor testing applications, demonstrated the highlights of their product range. Rudolf Ku, MPI’s international sales manager explains, “With MPI’s latest technology advances, we provide the highest quality solution for any type of LED testing. From the wafer and tape probing to die and package test, our products can be configured for any electrical contact and light collection system with the highest of optical measurement accuracy. Top emitting, bottom emitting, or even side emitting LEDs/lasers are all solution sets where we have been able provide an answer to our customer’s most challenging measurement requirements.” Apart from these products, MPI also specializes in sorting and AOI inspection all the way though to Tape & Reel. Highlighted at the event was MPI’s latest sorter system. Not only for highest throughput and most accurate binning, but it also has unique capabilities for the careful handling (pick-and-place) required to deliver reliable and defect-free LED binning. Special coatings are used in specific mechanical locations to enhance the handling of very sensitive packaged LEDs where optics must not be damaged during the process.

Sentec E&E, where Director Jason Huang himself was present to explain the products and technical features and demonstrate their portfolio of different substrates for LED packaging from standard to their high end Aurora Award winning 300 W/mK glass-ceramic substrate. The main strength of this company is their research power. While some of the products with outstanding qualities and performance are too expensive for mass application or are still in a pre-production phase, they are promising and are first choice for some specific applications where performance issues are coming before the costs.

Some other Taiwanese and foreign companies - sometimes represented by their distributors - also showed manufacturing machines, testing products or materials. Plansee Taiwan, a branch of Austria’s high end metal and raw material provider with its outstanding products demonstrated the latest “bird’s cage” for sapphire growth, built of highest quality wolfram providing an exceptional product lifetime. Also from Austria, the EV Group, specialists for lithography, bonding and process technologies with the highest quality standards, was present. Furthermore, just to name a few, Bergquist, BASF, Dow Corning, and Monocrystal as raw material providers, Hamatsu Photonics, BK Precision, Isuzu Optics, Instrument Systems, Optimum Electronics, Wei Min Industrial presented testing equipment like spectrometers, goniometers, integrating spheres or equipment for measuring electrical parameters.

Components - Drivers and Optics

Compared to the huge number of exhibitors in the two groups mentioned above, component manufacturers were in the minority. Taiwan’s most important representatives on stage in this field are the optics manufacturer LedLink and the power supply specialist Mean Well.



Figures 5:
Probe testers like the one from MPI (left) were also demonstrated, as well as stationary and hand-held light measurement tools, for instance from GL optics, Isuzu Optics or Optimum Electronics (right)

Figures 5:
A selection of LedLinks' latest optics, TIR optics, refractive optics and reflectors. In the center we have the best of two worlds: reduced weight and dimensions without sacrificing quality

Taiwan's optics manufacturer, LedLink was on stage with an impressive product portfolio at their booth. While often known as a manufacturer with a broad standard product portfolio, LedLink manufactures an increasing number of custom products. While the share in 2012 was approximately 50%, it is currently at about 70%. Demonstrating the technical roadmap, James Tsai, LedLink's general manager explained: "We are working hard on the optimization of our products. By improving positioning accuracy a 2-4% higher optical efficiency is possible." He added, "Other important research topics are color mixing, methods and designs for weight reduction and – of course - cost reduction." LedLink is also following the latest trend of COB with special optics solutions, and also solutions for automotive products. One of the latest developments are their reflectors for COB products.

Gin Lian, a Taiwanese provider of plastics products for different applications also showed a broad range of optics as well as products for isolation and mechanical connections.

Mean Well strategically focused on their core competency, which was impressively demonstrated with straightforward designed products shown at their booth. "We are building on discrete driver topologies and are just adding the basic interfaces like 1-10 V, PWM and resistors to control the output," said Ted Cheng, manager of Mean Well's marketing department. He went on to say, "The only exception is a driver with DALI interface." With this strategy, Mean Well allows its clients to easily combine drivers with different controls. They have been looking for new form factors to allow better integration into LED luminaires. The first step was to create drivers for high bay luminaires that seamlessly fit on different standard sized heat sinks. "We are continuously observing the market. We recognized that this product was missing. If we identify the need for other sizes and dimensions, for instance for flush-mount installations, we will also provide an appropriate solution," commented Mr. Cheng. With the different driver lines, Mean Well serves simple, economic standard applications as well as highly efficient high-end solutions.

Power Integrations from the US was also present with its latest driver ICs. – One day before LED Lighting Taiwan opened its doors, PI launched its LYTSwitch-0, a unique combination of simplicity, reliability and efficiency for cost-sensitive, non-isolated, non-dimmable replacement solutions up to 10 W, like GU10 bulbs.

Figure 7: Mean Well's high bay driver fits on standard heat sinks seamlessly

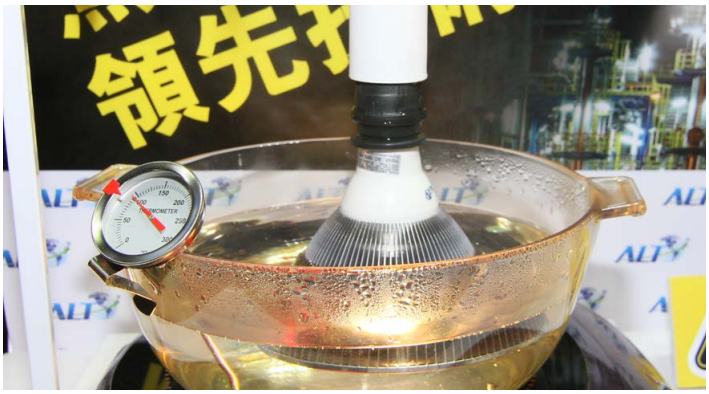


Figure 8: ALT's "Ultimate Challenge of LED" demonstration

Figure 9: Rich Wall Technology's replacement bulb has the exact same dimensions as an Edison bulb

Consumer Products

Several innovative and creative manufacturers of luminaires and replacement products were also displaying their products at the show. Some attracted visitors with an astounding and unique presentation strategy to create a sensation.

ALT LED's demonstrations focused on the quality of their products, not just by showing an LED Lamp in boiling water, but also the CNS certified ALTLED™ E01 in -40°C dry ice while maintaining normal operation without luminous decay or flickering. – The company called it "The Ultimate Challenge of LED." Because all manufacturing steps are done at Aeon Lighting Technology's facilities, they can guarantee the highest quality standards. Harry Wei, director of business development explained, "As one of the key partners of Cree, we receive engineering samples very early and can develop our products thoroughly and designed in detail." After demonstrating different products he added, "We also provide replacement lamps with the highest CRI up to 98, and our broad portfolio contains low CCT versions with 2200 K, candle mimicking lamps as well as explosion-proof luminaires." Asked for a statement about the tube replacement market he commented: "This is a complex topic. We think this market will develop but probably not very fast. We'll observe this market like all other niches very carefully." ALT expects the replacement market to boom for another 10 years, much longer than the Philips analysis. Addressing this fact, he smiled and said, "This is what we believe right now but we are prepared for changes."

Rich Wall Technology shared a booth with AD Electronics Corp., a representative of Dow Corning's products, and presented an LED replacement bulb with the exact same dimensions as an Edison bulb. David Liu's impressive replacement lamp shows very similar properties like frosted incandescent lamps. It has a beam angle of 33° while providing 95 lm/W in 3000 K warm white and 110 lm/W for the 5000 K versions preferred in some Asian countries. The lamp is available with 6 W and 12 W respectively and in both 110 V and 230 V versions. Mr. Liu pointed out that, "Although we have a reduced driver design without electrolytic capacitors to extend lifetime and without a transformer, our product provides an excellent power factor of above 85. It has integrated temperature control and is dimmable with virtually any existing dimming control switch." Rich Wall's CooBulb is specified for 30,000 hours lifetime.

Summary of the Impressions and Conclusion

This year's LED Lighting Taiwan demonstrated the technological power of the industry in Taiwan as well as coming back to the roots of PIDA, the strong photonics industry of chip manufacturers and packaging companies with all service providers. These two groups were the backbone of the event. Both groups also demonstrated innovative power with their exhibits. Extraordinary products presented by very interesting companies rounded off the show, making it an event that no one can't afford to miss. ■

SOME OTHER BIG NAMES COMPLETING TAIWAN'S LED LIGHTING LANDSCAPE

Prolight Opto :

Prolight Opto is specialized in LEDs for lighting with a clear focus on the packaging of LEDs and modules. They are not planning to extend in vertical integration. Michael Hsing, Prolight's President, said, "Our main advantage is our own proprietary material that we use for packaging, for instance in our Phenix LED series. It is cheaper without compromising reliability." Another unique product is the COB series that resists environmental influences like sulphurs due to non-silver plating. Mr. Hsing is especially proud of the 200, 400 and soon 800W high power packages. He pointed out, "They are also available in multi-color - RGB, RGBW, RGBA, and an 8-color combination. They are in great demand for studio and TV lights." Prolight's latest product, the "DOB" is a low cost high power module with a 4-channel driver that is available in power ratings from 6W to 25W. The philosophy of Prolight Opto is that light quality is not only defined by CRI but also additional criteria.

Edison Opto:

Edison Opto was always a forerunner in high power LEDs and high power array LED applications. They were the first to challenge conventional high-bay lamps and their declared main goal is to replace HID in all power ratings. "For many HID lamps and luminaires this seems to be possible within the next half year" stated Ken Chen, R&D Division Director at Edison Opto. He went on to say, "A clear focus of our company is to further improve PLCC, COB and ceramic emitters. We are aware that our performance data is approximately 10% below Cree but we are 30% cheaper. At the same time our products perform 10-20% better than most of the counterparts of other competitors." Right now Edison has no official product roadmap to present; instead, they act based on strategic decisions. Ken Chen recognizes the balance of the system to be the most important issue for a successful high quality product.

Semileds:

"Within the last one to two years, Semileds' focus has changed from pure chip manufacturing to packaging and also OEM integrator" says Ilkan Cokgor, Semileds' Executive VP Sales and Marketing. "One proprietary and special product is our 'white chip', which is a phosphor plated chip that is sold to clients for further processing." Due to the vertical chip technology, Semileds strongly focuses on directional lighting products and the commercial market and not that much on the home and residential market that is mainly characterized by replacement lamps for omnidirectional illumination. With their UV-LEDs, Semileds is also one of the leading companies for non-lighting LED products.

Aether Systems:

As opposed to most other optics manufacturers, Aether Systems concentrates on optics for Omni-directional light distribution. At LLT 2011 they presented their unique optics for the first time. Now they are using a basically identical design in different sizes for various applications from candle lights to automotive lamps. Jonathan Liu, Chairman and Co-Founder of the company said, "Our IP protected design allows us to vary, scale and adapt to any requirement and therefore offers further potential. We expect our latest adaptation for automotive applications to have a bright future. The advantages of this product over conventional bulbs are obvious. LED bulbs are less prone to vibration-caused damage." Aether's optics solution can be configured for any socket size. A design highlight based on Aether's technology, are also the candle lamps of several manufacturers that perfectly emulate the outdated incandescent originals.

Macroblock:

Macroblock originally comes from the display driver area and has expanded its business into general lighting during the last few years. With the aim for cost effective solutions they currently provide non-dimming solutions with the exception of their 4-step dimming controller. This product is not just available as an IC, but also as a module in two versions to power LED T8 replacement tubes. Steven Ho, Technical Marketing Dpt. Project Deputy Manager at Macroblock said, "Our next step will be a power line solution. We identified this technology to be the more cost-efficient and viable solution for most applications in the near future than any current wireless technology." This product has to be seen as the replacement of triac dimmers for low cost systems and residential use.

Chroma ATE:

Chroma ATE is well known for their high quality AC/AC and AC/DC programmable power supplies and testing solutions for different applications. Their experience with PV testing certainly was of great advantage for the development of their unique LED lighting test solution. Jeff Lee, Chroma's Director for Integrated System Solution BU explained: "Our system allows automated in-line measurement of linear systems and our method is capable of measuring almost all of the key performance parameters like total luminous flux, CRI, CCT, flicker, and even the spatial distribution." Chroma sees the importance of in-product-line-testing, especially for linear systems. Most lamp manufacturers did not recognize this for a long time and other test equipment manufacturers cannot satisfy the demand with their technology. Chroma ATE also provides a load mimicking driver test system that allows the identification of relevant quality issues like flicker. Asked for his impression of the LED lighting market, Mr. Lee stated, "The strategic position of LED technology within lighting products still seems to be unclear. However, that is not uncommon in a relatively early stage of technology adoption. The industry seems to play around with technology, producing gadgets like 'light-fi' that may not be useful in the long run. But who knows?" ■

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In-Line Process Control and Yield Management in LED Manufacturing

LED manufacturing is undergoing a tremendous transformation. The evolution to high brightness LEDs, larger wafer size and new complex architectures make LED manufacturing more challenging than ever before. Even though these trends greatly benefit the advancement of the LED industry in terms of LED efficiency and performance, they can also potentially negatively impact yield. In order for LED manufacturers to stay competitive in this dynamic environment, they need to have a comprehensive in-line process control strategy to improve the yield to make the solution cost effective. LED professional talks with Frank Burkeen, V.P. and General Manager, Candela Division, Growth and Emerging Market (GEM) Group of KLA-Tencor Corporation about In-Line process control. Some answers were given by Steven Chen, KLA-Tencor.

LED professional: How does the In-Line Process Control work in general? Which analysis has to be made beforehand to adapt the manufacturing process?

Frank Burkeen: One of the sensitive things in the LED field is the current situation with intellectual property, so the manufacturing process and yield figures are not known in a first step. The methodologies we use are less for the manufacturing process and more for inspection at a certain manufacturing process step. So we do not need to know the absolute yield numbers, but we need to be able to take the output data.

We need to obtain accurate bin sort data, a list of wafers, yield information and defect types from the inspection tools. Then, we use the yield management software tool to do the analysis. In this step, we need to ensure that the defect map aligns with the bin sort map accurately. It is crucial to have an accurate wafer alignment because it is the basis of the kill ratio analysis. Using this kill ratio information, we can derive the yield-impacting defects of interest (DOI) definition. Once we have obtained the DOI definition, we can apply it to all wafers. Upon finishing the kill ratio analysis, we perform data analysis to identify yield-impacting defects by correlating the defect counts to the final bin yield. Lastly, we will obtain trend charts and be able to set upper control limits and SPC controls. The analysis is repeated until the yield-impacting DOI definition is satisfied.

Defect information inspected from substrate, epitaxy, front-end of line (FEOL) and back-end of line (BEOL) can feed into an automated defect analysis tool. In this particular case, we are interested in learning whether the epitaxial defect correlates to yield.

LED professional: Could you explain the kill ratio in more detail please?

Frank Burkeen: Kill ratio represents a proportion of defects estimated to cause die failure. It is also derived from past data. It is used to find the amount of defects on a current inspection that will cause die failure at the end of the process. It can help to determine the disposition of

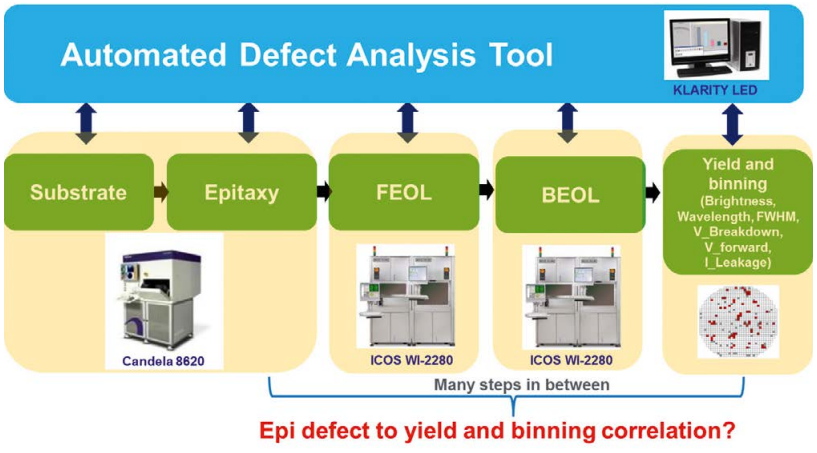

Figure 1:
In-line monitoring solution

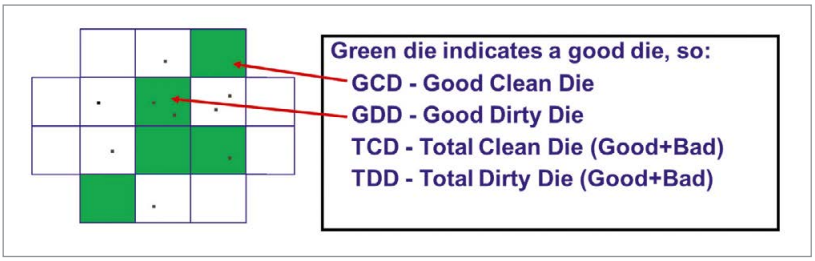

Figure 2: Bin data and defect data illustration

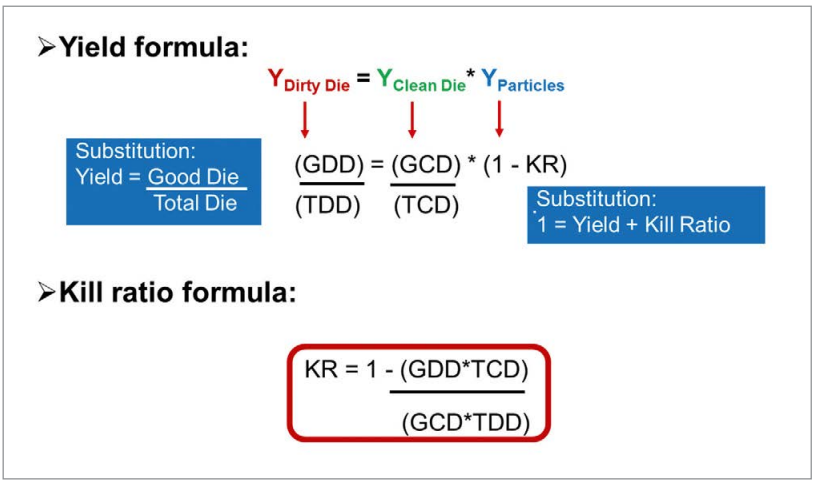

Figure 3: Yield and kill ratio formula

problem wafers or lots. In order to understand how kill ratios work, we need to understand the kill ratio model terminology. First, bin data represents good or bad die from bin code. The bin data is typically provided by the LED manufacturer. In addition, the defect data separates clean or dirty dies from adder defect location. A clean die contains no detected adder defects while a dirty die contains detected adder defects (Figure 2 illustrates this concept). The square boxes represent dies. The dots represent defects. Green boxes indicate good dies while white boxes indicate bad dies. Therefore, good clean dies means good dies without defects. Good dirty dies mean good dies that have defects. Furthermore, we also have total clean dies and total dirty dies which are self-explanatory from the names. (Figure 3 depicts yield and kill ratio formulas)

LED professional: What kind of defects are found?

Frank Burkeen: With the first tools we're able to find defects in the range of 3-5 microns. But a couple of defects are on the Epi-layer such as micro-pits with sizes of about 0.5 microns and also micro-cracks now can be found with our new equipment.

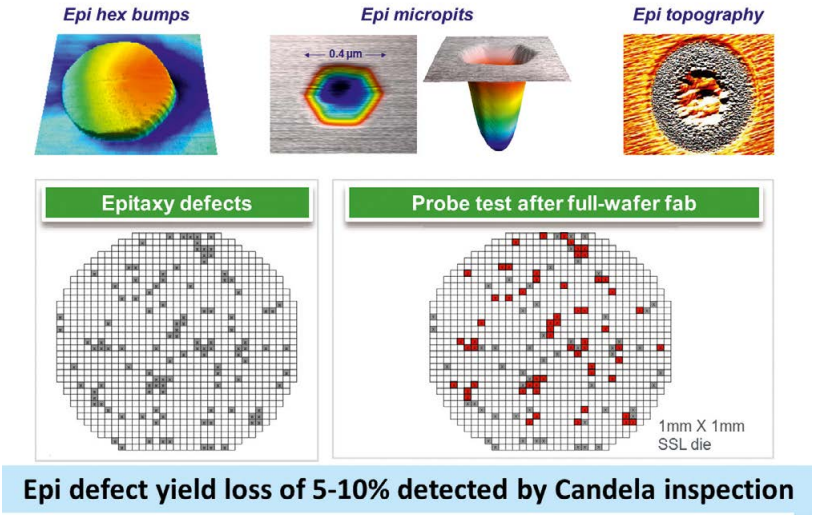

Figure 4: Epi hex bumps, Epi micropits, Epi topography

LEDs might work with micro-cracks but during operation they might degrade in lumen output or change the wavelengths of the produced light.

LED professional: Could you give us some indication of the potential of improvements when implementing in-line inspection?

Frank Burkeen: We did a collaboration with Philips Lumileds, here in Silicon Valley. They essentially had the problem of not being able to distinguish between 6-inch sapphire wafers from different vendors. With their new inspection tool we could give them the possibility to see very, very small defects, which were scratches and micro-cracks on the sapphire surface due to the polishing process. So, they got the eyes to see the differences and they could go back to the vendors to increase the quality. Subsequently, this process enabled Philips Lumileds to make the transition from 4 to 6 – inch wafers in their production line.

LED professional: How do you see the differences in material types related to yield data?

Frank Burkeen: The real challenge in using different material types and different substrate types is to produce a relatively defect-free substrate. The lattice-mismatch between the substrate and the GaN crystal structure is the primary problem here. So, if you grow GaN on a GaN substrate, which some companies do, it will lead to the lowest mismatch. Si-C has a very close crystal lattice constant, so it's actually the second best. Sapphire is a more challenging substrate but the Silicon substrate is the worst. Here the lattice-mismatch is so high, that you get a lot of stress in the crystal and you get cracking, bowing and many other issues. In terms of cost it's just the opposite of the mismatch view.

LED professional: Is this in-line process control only used in die production or can it also be applied for packaging?

Frank Burkeen

Frank Burkeen is responsible for a range of product lines targeting KLA-Tencor's LED, Compound Semiconductor, HDD and Solar market requirements. As GM of Candela, Frank provides both the tactical and strategic leadership for the development of new, innovative inspection and metrology systems targeting KLA-Tencor's Growth and Emerging Market opportunities. Prior to KLA-Tencor, Frank held senior-level marketing positions within Brooks Automation, Asyst Technologies, and Applied Materials. Frank was also an entrepreneur in the software business, with experience in starting a company and raising venture financing. Prior to moving to the Silicon Valley, Frank was a nuclear engineering officer in the U.S. Navy. He holds a B.S. degree in chemical engineering from Cal Poly Pomona and an MBA/MS in engineering management from Cal Poly San Luis Obispo.

Frank Burkeen: There are also component inspection machines available. This is a very important area in the semiconductor business. Today, in LED packaging the processes are more manual. Right now KLA supports the in-line inspection up to the point of packaging the LED die, and not further.

LED professional: What are the major differences between LED production and any other semiconductor manufacturing process?

Frank Burkeen: There is uniqueness in the LED production that you don't see in any other semiconductor industry. We do need the inspection with so-called contrast modes showing defects, which do not occur on the surface. These defects could be seen, for instance, in the light distribution but could not be seen with inspections of the surface only.

LED professional: Do people know the value of automatic in-line process control?

Frank Burkeen: If a company is not familiar with process control, people have to be convinced that with automatic process control, they will get higher-quality products.

In-line monitoring is critical to the LED manufacturing process. Separation of yield-impacting defects from nuisance defects is demonstrated with this monitoring methodology. The LED manufacturers can implement SPC control to avoid expensive excursion and to realize the return on investment.

LED professional: Thank you very much for this discussion.

Frank Burkeen: Thank you. ■

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OLED Technology in Lighting Applications – Current Status and Outlook

Prototypes and niche applications with OLEDs for lighting have been demonstrated over the past few years. Now there are indications that OLED technology is ready for mass production or at least will be ready very soon. Franco Musiari, Technology Specialist at ASSODEL analyzed the current status and future perspectives of OLED technology.

OLEDs are often presented as the light source of the future which makes them a direct competitor of LEDs. The name suggests that they are just a special variety of LEDs. An OLED (Organic Light Emitting Diode) is a solid-state light generator in which emission occurs when current passes through the layers of organic materials of which it is made up, similar to LEDs.

Both OLEDs and LEDs transform electrical energy into light by means of a semi-conductive material, but that is where the similarity ends. OLEDs come in the form of extremely thin panels - 0.8 to 2 mm - in various sizes starting from 50×50 mm². In an LED, the light source is concentrated in just a few square millimeters – of course, we're talking about single chips – and hence almost punctiform, while the brightness of an OLED is distributed over the entire surface of the panel.

This is the basic difference that makes the OLED appealing: diffused light that DoEs not glare or project hard shadows but rather, generates uniform lighting. This characteristic is not easy to achieve with LEDs, nonetheless, LEDs have their advantages for all other lighting requirements. That means that instead of being in competition with one another, LED and OLED products complement each other.

Figure 1: **While at Light+Building 2008 only a few OLED based products were on display, in 2010 the numbers almost exploded, and in 2012 virtually all lighting companies displayed OLED luminaires**

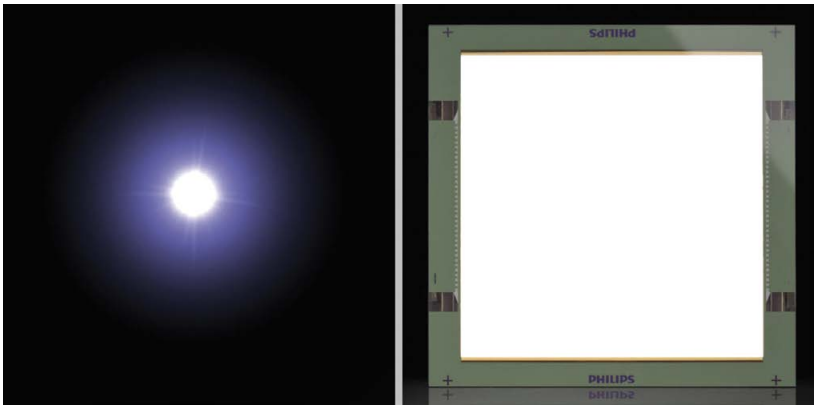

Figure 2:
In the OLED, light is emitted from the entire surface; in the LED, the light source is almost punctiform

Technical Differences between OLEDs and LEDs in Detail

There are several aspects in which OLEDs differ from LEDs. For instance, how they dissipate generated heat. In LEDs, the energy not transformed into light is turned into heat that is concentrated in the small crystal of which it is made up. In OLEDs, the same phenomenon occurs, but the heat, like the light, is evenly distributed over the entire surface of the panel.

Hence, while in LEDs it is mandatory to have a system capable of removing the heat from the LED to prevent it from overheating and thus reducing its life, in OLEDs this problem is not posed. The heat in OLEDs is naturally dispersed across the entire surface of the panel and DoEs not require any particular heat removing measure.

In LEDs, the wavelength generated is closely tied to the physical characteristics of the crystal which is the heart of emission. For this reason, an LED not aided by phosphors always and only generates a certain wavelength, or rather a precise color. Typically, "white" is obtained with LEDs that generate in blue and then doing a conversion to lower wavelengths using the phosphors that cover them.

In OLEDs, the generation mechanism is tied to each single emission molecule and DoEs not require a crystalline structure. The various organic materials that generate the light can be appropriately mixed in the emission layer to obtain the desired color.

Efficiency of OLEDs

One of the marketing arguments often cited by manufacturers of OLEDs for lighting is that they save energy. This, of course, has to do with the expressed luminous efficiency. Some predict that OLEDs will reach efficiencies of 90-100 lm/W by 2015. Fortunately, the evidence of the last few years is that the efficiency of OLEDs is on an upward curve, but has not yet reached levels that can confirm the marketing targets.

In order to maximize the energy efficiency of an OLED, you need to find the right compromise with other characteristics, such as lifetime, color quality, size and cost. For example, in 2012 Panasonic presented a panel with an efficiency of 142 lm/W. However, the panel surface area was only 4 mm^2 and the technology adopted did not allow application on larger surfaces.

Referring to products already on the market, we can talk about efficiencies of:

- 23 lm/W at 1,000 cd/m^2 with CCT of 2,800 K for the Osram Orbeos CDW-031, one of the first panels that appeared on the market in 2010;
- 40/45 lm/W at 6,500 / 4,000 cd/m^2 with CCT of 3,200 K for the Lumiblade GL350 (data updated to April 2013 for product availability in the second half of 2013);
- 40 lm/W at 3,000 cd/m^2 with CCT of 2,800 K for the Lumiotec P05 series;
- 45 lm/W at 3,000 cd/m^2 with CCT of 4,000 K for the LG Chem N4SA40;
- 60 lm/W at 3,000 cd/m^2 with CCT of 4,000 K for the LG Chem N6SA40;

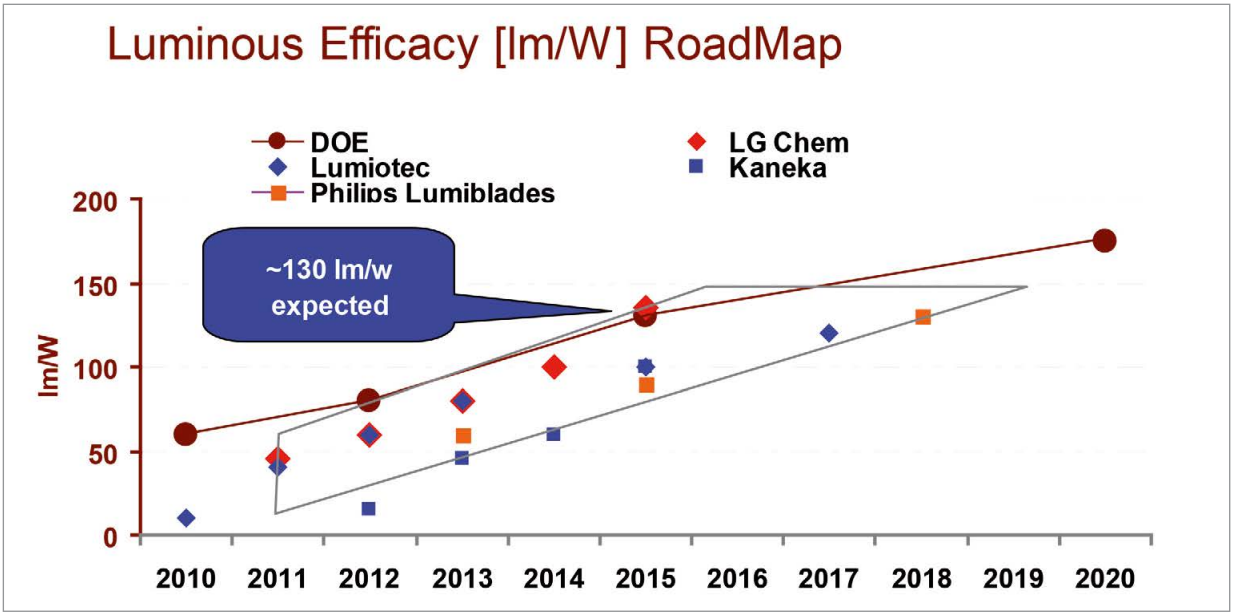

Figure 3:
Roadmap of some OLED manufacturers with reference to luminous efficiency

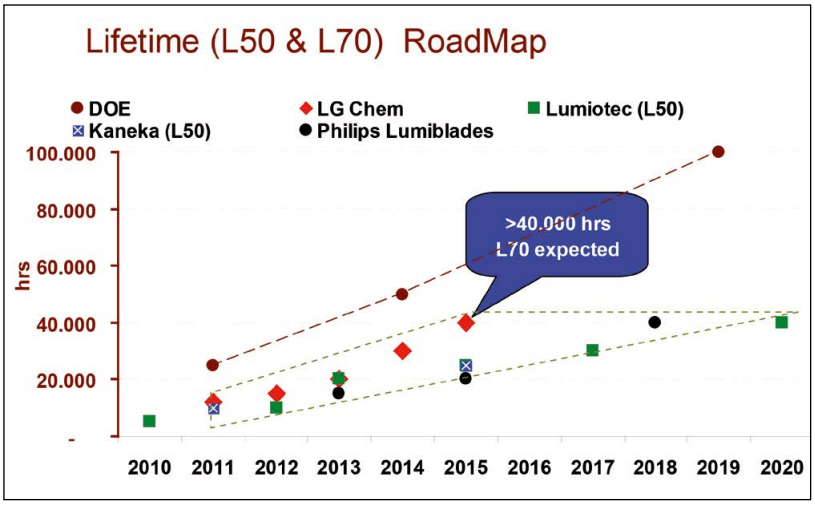

Figure 4: Roadmap of some OLED manufacturers with reference to lifetime

However, the graph in figure 3 which joins the roadmaps of some big names in the sector shows further improvements are expected in 2013.

Kaneka expects to reach 60 lm/W this year with LG Chem predicting 80 lm/W. If we look ahead to 2015 we see Philips Lumiblade predicts that they will reach 90 lm/W while LG Chem's goal is 135 lm/W. These levels justify using OLED lighting for energy saving.

Lifetime Comparison to LEDs

This is the other critical parameter that still causes confusion in the lighting communities. This is especially so if the comparison is made with LEDs that now easily reach 30,000-50,000 hours (L70).

Today's vague claims like "The lifetime should reach 40,000 hours in a few years' time" indicate that we are still a long way from ceasing comparing OLEDs with LEDs. Looking at the same panels analyzed above, we find that:

- The Osram CDW-031 declares three L50 values (i.e. 50% of the initial brightness):
  - 5,000 hours @ 1,000 cd/m^2
  - 10,000 hours @ 500 cd/m^2 and
  - 15,000 hours @ 250 cd/m^2.
- The Philips GLT350 declares an L70 of 10,000 hours @ 4,000 cd/m^2 and 6,000 hours @ 6,500 cd/m^2.
- The Lumiotec P05 series shows an L70 of 25,000 hours @ 1,000 cd/m^2 and 5,000 hours at 3,000 cd/m^2.
- The LG Chem N4SA40 indicates an L70 of 10,000 hours @ 3,000 cd/m^2.
- The LG Chem N6SA40 indicates an L70 of 15,000 hours @ 3,000 cd/m^2. The latter is the most recent (but not that recent) model and already shows an improvement of 50% on the expected lifetime.

The graph in figure 4 shows some roadmaps looking just a little ahead and the outlook for 2015 is an L70 of 40,000 hours which would put OLEDs closely in the wake of LEDs.

This is the target declared by LG Chem. But it is also an incentive for many others to follow.

Costs – the Major Issue

According to the DoE, "OLED production costs will drop 25% a year from 2012 to 2020". Costs are the most crucial issue of this product panorama. They are still seemingly exorbitant and the manufacturers are not making any forecasts.

Many of the products on the market have been manufactured on lines which may be defined as R&D, in other words, almost handmade products.

For example, a 10 x 10 cm^2 panel by Lumiotec costs $130 and produces 55 lm resulting in a cost of ~$2,700/klm.

A kit by Philips containing three GL350s costs $520 and produces 360 lm which translates into $1,500/klm.

Lines specifically dedicated to volume production are being started up today, for example, by LG Chemical, and the R&D lines of Osram and Philips have been boosted to make commercial production possible. The prices should sink significantly once these lines reach their maximum production capacity.

In the meantime, the projections of the DoE (American Department of Energy) are deemed valid since their roundtable discussion with major manufacturers. The discussions helped them understand the manufacturers' outlook for the future.

The ensuing forecasts are shown in figure 5. Both the production cost expressed in dollars per square meter (graph on the left) and the cost evolution expressed as dollars per kilo-lumen are shown.

According to the first graph, the production cost should go from $1800/m^2 in 2012 to $250 in 2015 to then drop to $90/m^2 in 2020: an 86% reduction in the first period and another 64% in the second, that is, an average annual reduction of more than 25%.

What will draw the most attention is the $/klm data, which immediately leads to comparing it with the same parameter we are used to seeing for LED price projections, which today, again according to the DoE, would be around 18$/klm.

However, this approach is partially misleading as it DoEs not take into account that when designing a lighting system using OLEDs, two particularly important problems are eliminated:

- The heat problem
- The need for optics

To solve the heat problem in an LED application, a heat dispersion structure is required, which carries significant weight. According to the DoE, thermal management carries a weight of almost 30% of the total lighting system.

The need for optics arises from the almost punctiform nature of LED sources. Therefore, light beam distribution requires optics that absorb part of the luminous flux (3-5%) but add costs to the system.

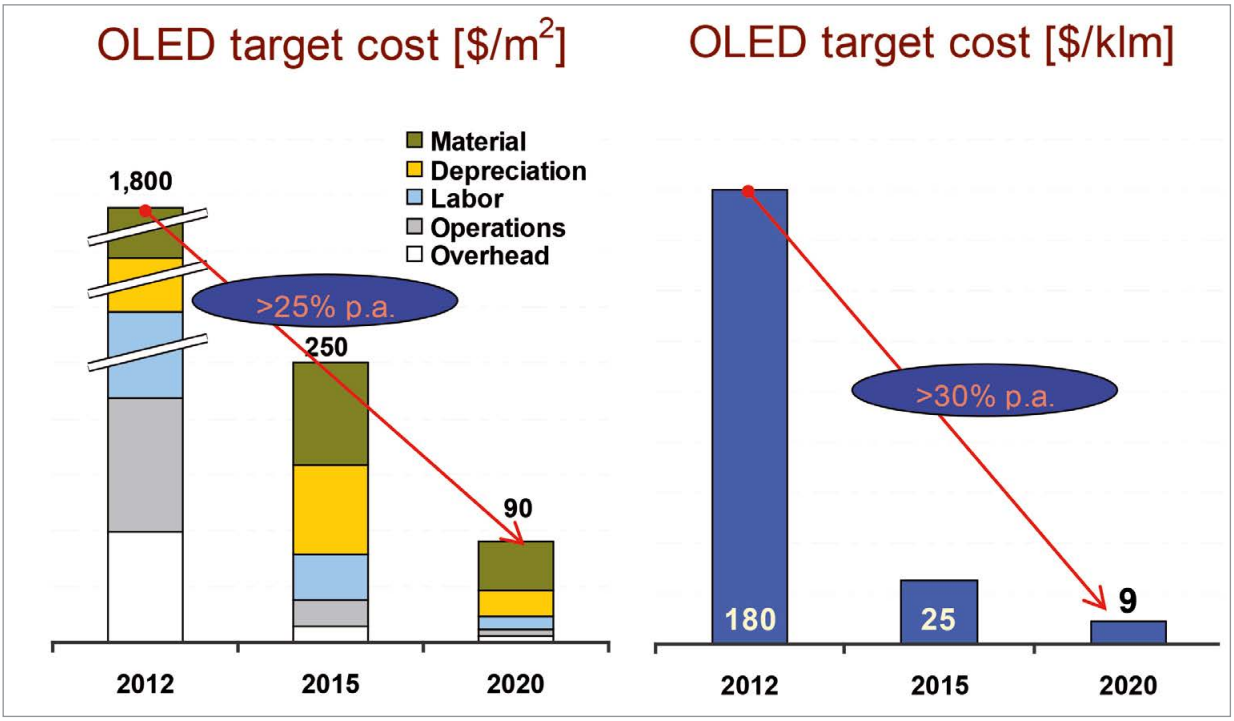

Figure 5: **Medium/long-term projections from the last OLED roundtable held by the American Department of Energy**

Color Consistency and CRI

CRI, or color rendering index, expresses the capability of a light source to make the colors of an illuminated object recognizable.

Often indicated with the symbol "Ra", it is determined by quantifying and averaging the visual difference between the test colors (R1 - R15) when illuminated by a reference source or by the source being assessed. The closer the index is to 100 the greater the capability to reproduce the colors of the source under test.

All the products described have a CRI above 80 while the Philips GL350 offers a CRI above 85, and the projections show values largely above 90. The Lumiotec P06 series arrives at a Ra of 93.

Physical Properties

Dimensions

Taking the square shape as a reference and considering the emission surface area, today the GL350 comes in the size 104 × 104 mm^2, the LG Chem panel is 90 × 90 mm^2 (but they'll be bringing out a 130 × 130 mm^2 panel within the year), while the Orbeos is round in shape with an active area of 80 mm in diameter.

At any rate, all the manufacturers are working towards making bigger sizes and, for example, LG Chem should bring out a 300 × 300 mm^2 (outside dimensions) panel between 2014 and 2015.

Flexibility

Because, right now, there is at least one glass wall, it means that the available panels are rigid. However, on this front, everyone is working towards a flexible version.

LG Chem has promised a flexible version of a 200 × 50 mm^2 panel by the end of the year.

Philips too has declared its commitment in this direction. Flexibility, even if limited, would offer designers a new dimension to adapt their projects to the environment.

Production and Manufacturing Capacities of OLEDs

Having looked at all the more or less critical aspects of the technology, the question that remains is: "Will it have the power to conquer the market and will sufficient manufacturing capacities be provided?"

Figure 6 compares the forecasts of two expert analysts in the sector: Digitimes Research and Nanomarkets. The two forecasts are quite contradictory: the most optimistic, that of Nanomarkets, talks about an OLED lighting market of 21 billion dollars in 2020 while Digitimes stops at 8 billion, almost a third.

It is interesting to read the introduction to the data presented by Nanomarkets of which we give the salient points below.

"In the proposed scenario, the technical progress, the cost reduction and the investments made were deemed positive. The main manufacturers of OLEDs for lighting have made significant headway in their development efforts, especially on the performance front. But, going from here to the proposed scenario will still take a lot of work on the technical development and marketing front in the next five years.

Several challenges still remain, including improvement of performance, reduction of costs, standardization and expansion of the production capacity. If the industry overcomes these challenges, then OLED lighting can become the next 'big thing' in lighting.

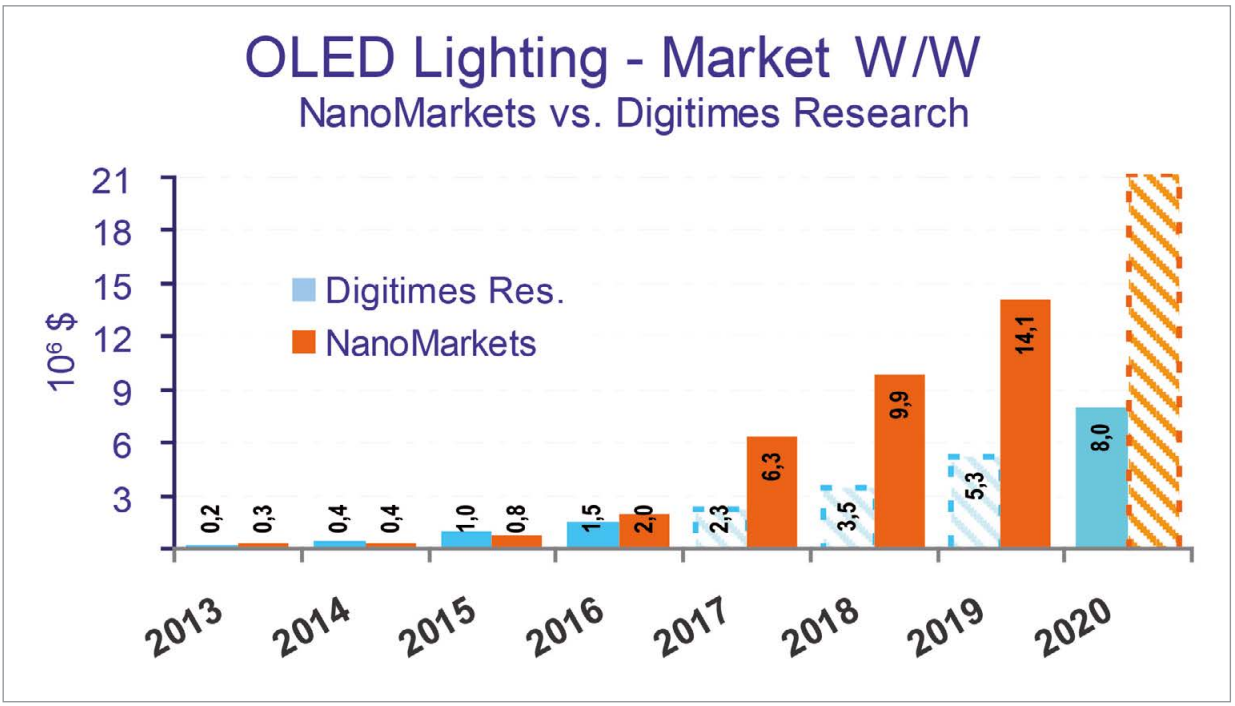

Figure 6:
OLED Lighting W/W Market forecasts - Nanomarkets vs. Digitimes Research

Nanomarkets believes that the proposed scenario cannot be realized unless a champion of the industry emerges and invests in the sector despite the risks. A company that not only has broad shoulders, but is also well consolidated in the lighting world so as to be able to capitalize on an existing supply chain in order to bring OLEDs to the mass market".

Final Considerations

To date, potential saviors are a select group of companies, including: GE, Osram, Panasonic (together with Mitsubishi), LG Chemical, Philips and Samsung. Although GE has thrown in the towel, it can always make a comeback.

There is also a firm possibility that this OLED champion will emerge from Korea where both LG and Samsung are creatures of the country's industrial policy. Rumor has it that pursuant to Korea's industrial policy, Samsung has been chosen as the champion of OLED displays while LG is the champion of OLED lighting.

The other two companies nominated to emerge as champions of OLED lighting are Philips and Osram, in the sense that they were the first to realize pilot lines and develop products. They also participate in various projects financed by the European Community. ■

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New MOCVD Platform for Cost-Effective Production of GaN-based HB LEDs

GaN-based blue and ultraviolet light emitting diodes (LEDs) are steadily becoming more widely used in solid-state lighting (SSL) applications [1-3]. Enabling dramatic energy savings when compared to contemporary incandescent bulbs and fluorescent lamps, these high-brightness LEDs (HB-LEDs) have a market potential in the billions of dollars. Yole Development estimates that by 2017, the market for LEDs will be approximately $75 billion [4, 5]. Shiping Guo, the Senior Technology Director of Advanced Micro-Fabrication Equipment Inc. presents a new approach to support this goal with a cost effective MOCVD solution for HB-GaN LED manufacturing.

The greatest barrier to accelerating the widespread adoption of HB-LEDs is cost-per-watt parity. Although decreasing LED bulb prices, coupled with concerns about reducing energy consumption, are helping to position LEDs as the de-facto alternative to traditional incandescent and fluorescent (FL) lamps, their commoditization poses a challenge for manufacturers. According to a Yole Developement report [4], the price of today's LED bulbs is approximately ten times higher than that of incandescent bulbs and approximately three times higher than that of FL lamps.

While MOCVD has shown to be the superior technique for growing III-nitride materials for optoelectronic and electronic devices, and producing the highest quality/best-performing devices, it is an expensive process. Almost a quarter (21 percent) of total LED manufacturing costs derive from the epitaxial growth process alone, with MOCVD reactor depreciation accounting for the lion's share of those process costs. Clearly, the key to accelerating HB-LED adoption lies in effectively reducing manufacturing costs to ensure the competitive pricing and acceptable margins needed for LED manufacturers to succeed.

To address these economic imperatives, it will be essential for future-generation MOCVD tools to improve process efficiencies. This means demonstrating superior process performance and high-quality manufacturing capability. Excellent tool uptime is a must, as well as high throughput, good reproducibility and high yield.

Tests with a new MOCVD reactor show promising results to provide these performance characteristics and capabilities. Quality data from single layers, as well as LED wafers grown on the new platform, brightness results and data from a min-marathon test that demonstrates excellent growth reproducibility and tool function stability prove the performance of this now MOCVD platform – the so called Prismo™ D-Blue.

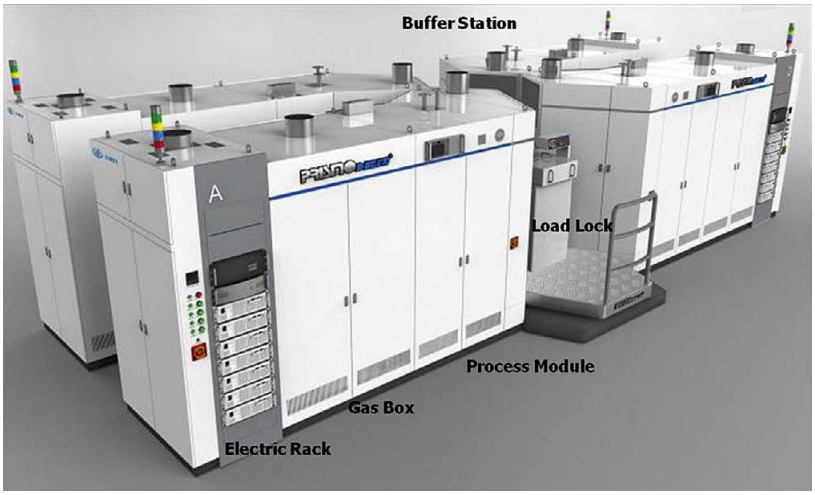

Figure 1: **The four reactors of the new MOCVD platform**

Design and Experimental Details

The new patented MOCVD platform architecture can accommodate up to four reactors, as shown in figure 1. Each reactor consists of a process module, gas box and electric rack. The load lock and buffer station are shared by all reactors. Each reactor can be controlled independently, enabling the

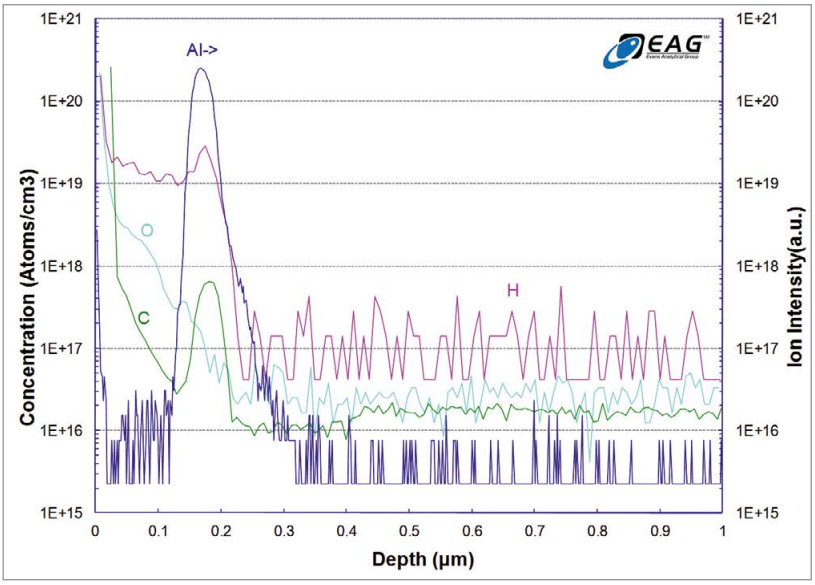

Figure 2:
The SIMS spectra of GaN based LED structures

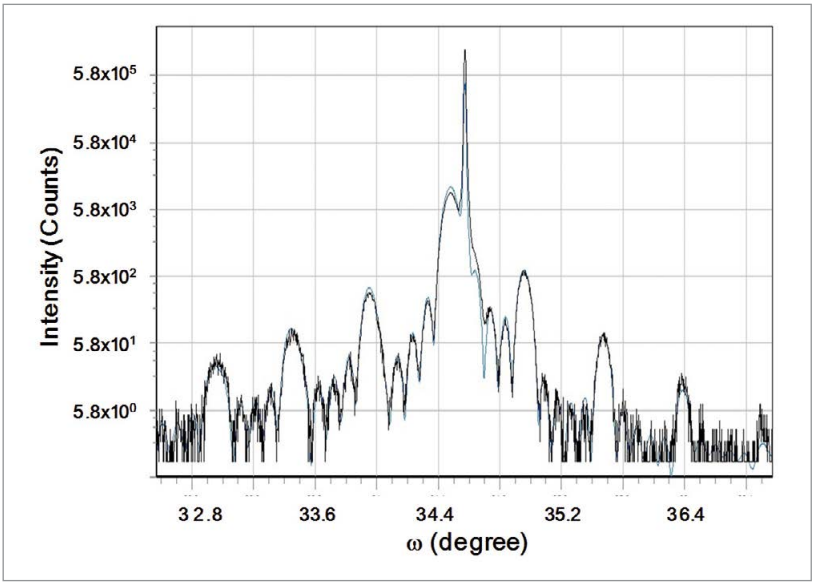

Figure 3:
Typical XRD satellite peaks with clear interference fringes from the InGaN/GaN MQW sample

use of various (49/54 x 2", 14 X 100 mm, 5/6 x150 mm or 3 x 200 mm) susceptor patterns—a design that enables exceptional manufacturing flexibility. The platform architecture controls critical gas precursor dynamics through a unique combination of uniform gas laminar flow and high-speed susceptor rotation to ensure the formation of a uniform boundary layer. This enables high-volume manufacturing of the GaN, InGaN and AlGaN thin layers required for high-brightness LED structures. The platform is fully automated, with precise parameter control and an ultra-compact design.

All GaN-based epilayers and LED structures were grown on either flat sapphire substrates or patterned sapphire substrates (PSS).

Trimethylgallium (TMGa), triethylgallium (TEGa), trimethylaluminum (TMAl) and trimethylindium (TMIn) were used for group III precursors and ammonia (NH3) was used for group V nitrogen. Silane and bis(cyclopentadienyl) magnesium (Cp_2Mg) were used for n-type and p-type dopants. The GaN LED structures consisted of a low temperature GaN nucleation layer, an unintentionally doped GaN buffer layer (including a 3-D roughing layer and a 2-D recovering layer), a Si doped n-type GaN layer, InGaN/GaN strain engineering layers, InGaN/GaN MQWs, an Mg-doped p-AlGaN electron blocking layer, an Mg-doped p-GaN layer and a p+-GaN layer.

A variety of tools were used to establish experimental results. A Bruker D8 XRD system determined crystalline quality and aluminum content, while a Lehighton Eddy current system measured sheet resistance (Rsh). An HL5500 system was used to perform the Hall test, and a Bruker Dimension Edge atomic force microscopy (AFM) system was used to measure surface morphology. An Accent RPM2000 system measured total layer thickness and room temperature (RT) photoluminescence (PL) emission wavelength.

Results and Discussion

Control of background doping levels is critical for MOCVD performance and epitaxial growth process development. Figure 2 shows SIMS spectra of a GaN-based LED structure grown on a 2" sapphire substrate. Very low background doping levels were observed for O, C and H in the n-GaN layer. Optimizing the growth conditions for the 3-D roughing layer and 2-D recovering layer enabled high crystalline quality GaN epilayer growth on both 2" and 4" sapphire substrates with a typical XRD FWHM of <250 arcsec for (002) reflection and of <300 arcsec for (102) reflection. Many XRD satellite peaks with clear interference fringes can be observed from InGaN/GaN MQW samples (as shown in Figure 3), indicating the high crystalline quality and sharp InGaN/GaN interfaces. The Hall test shows that the electron concentration in the various Si-doped n-type GaN layers is almost linearly dependent on the silane flow. A high electron carrier concentration of up to $1x10^{19}cm^{-3}$ was achieved with an activation efficiency of >99 percent. Lehighton measurements of n-GaN wafers from different rings showed excellent ring-to-ring uniformity. Sheet resistance uniformity for all wafers from different rings was <1 percent. SIMS measurements demonstrated a maximum Mg doping concentration of approximately $2x10^{20}$ cm^{-3} in the p-GaN layer with a hole carrier concentration as high as $5x10^{17}cm^{-3}$. These results were equivalent to or better than those from GaN layers grown in reactors from comparable tools available on the market [6, 7].

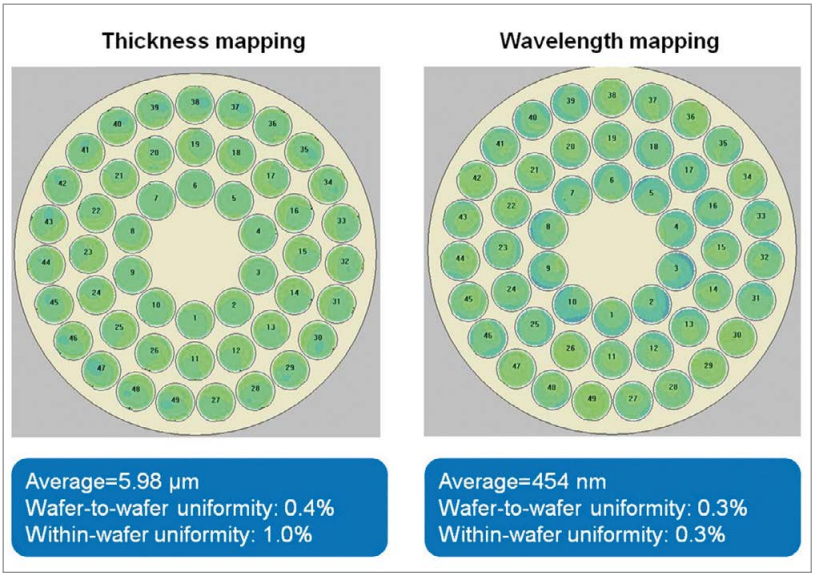

Figure 4: **Total layer thickness and RT PL emission wavelength mapping**

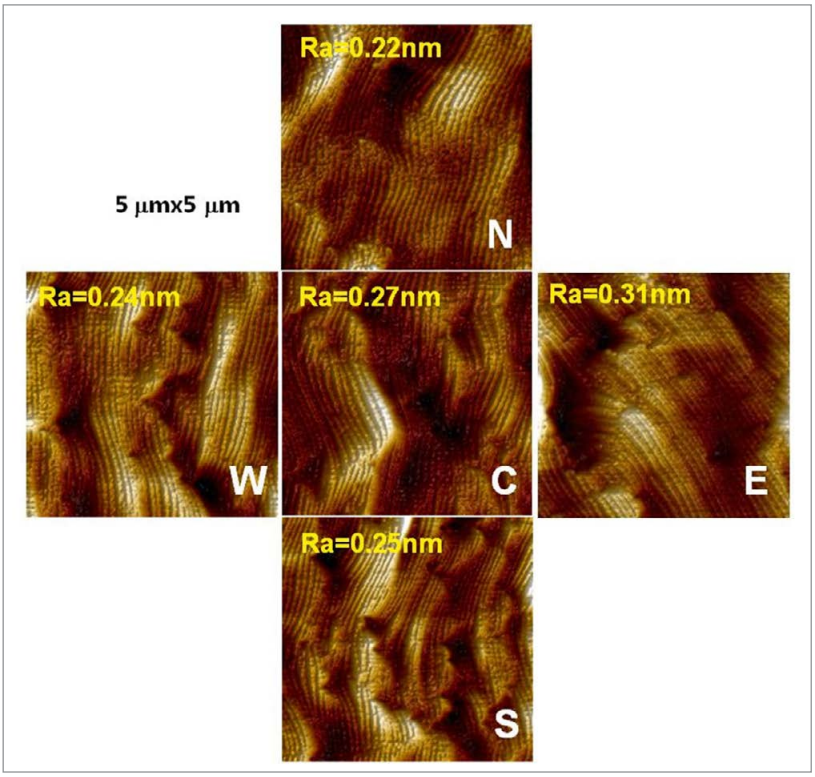

Figure 5: **AFM images measured from a typical GaN LED wafer**

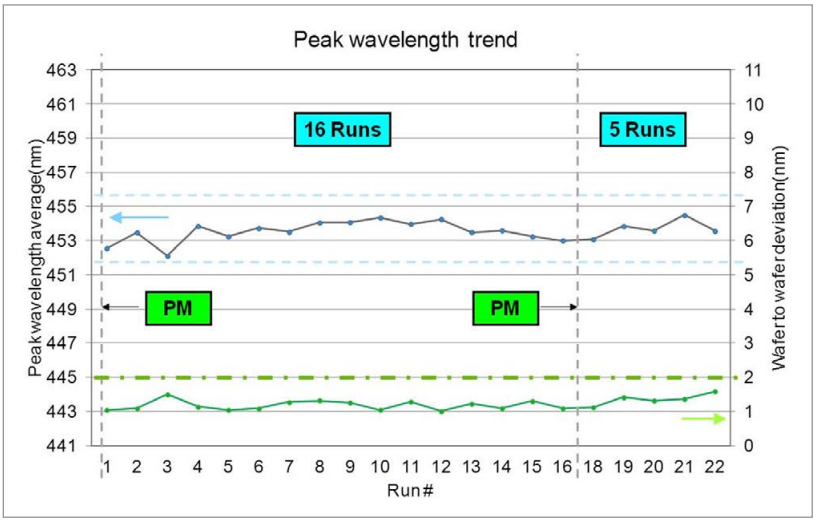

Figure 6: **Peak PL wavelength trend of 21 mini-marathon runs with the same recipe**

Figure 4 shows total layer thickness and RT PL emission wavelength mapping of full susceptor (49x2") loaded InGaN/GaN MQWs grown on a 2in sapphire substrate. The average thickness is approximately 6 µm with an average within-wafer uniformity of 1.0 percent and wafer-to-wafer uniformity of 0.4 percent. The average PL emission wavelength is 454 nm with excellent within-wafer uniformity of 0.3 percent and wafer-to-wafer uniformity of 0.3 percent (<1.3 nm). Figure 5 shows 5 µm x 5 µm AFM images measured from a typical GaN LED wafer. Atomic step surface morphology is an average RMS of 0.26 nm for 5 points across 2" LED wafers. In addition, the surface morphology obtained from different wafer areas is almost identical, indicating uniform growth conditions across the whole wafer.

Data from a mini-marathon test with identical recipes for temperature and gas flow conditions demonstrated excellent growth reproducibility and tool function stability. Figure 6 shows the peak PL wavelength trend of 21 mini-marathon runs with the same recipe. In marathon runs, the tool demonstrated breakthrough repeatability and excellent within-wafer and wafer-to-wafer uniformity. The wavelength variation range is within +/- 2 nm for all 21 runs. These results were achieved with no recipe adjustments throughout the entire epitaxial process. For a process with extreme sensitivity to chamber surface conditions, chemical environments, temperature shifts, and other variables, the new platform's repeatability performance establishes a new performance standard.

There were no process interruptions during the marathon test. The high level of reliability is enabled by in-situ real-time monitoring of growth process parameters, as well as sophisticated software, advanced transfer modules, and process automation and control technologies.

Table 1:
Key parameters for 0815 LED chips from an AMEC LED wafer compared to that from LED manufacturing company wafers

	Vf1 (V)	VZ1 (V)	IR1 (mA)	LOP (mW) (COW)	WLD1 (nm)	HW1 (nm)
AMEC's wafer	3.07	32.6	0.04	23.3	452.3	19.8
LED company wafers	3.0-3.1	>35	<0.05	20-25	450-460	20-22

Early work on GaN-based epilayers grown on 4" sapphire substrates showed good thickness and PL wavelength uniformity. Further growth process optimization is currently underway. Initial results are promising. To evaluate the new MOCVD reactor performance, LED wafers grown on the Prismo D-Blue MOCVD reactor were processed at a LED manufacturing company through their LED production line. Table 1 shows key parameters for 0815 LED chips from an AMEC LED wafer compared to LED production wafers grown at the LED manufacturing company. It can be seen that LED wafers grown on the Prismo D-Blue reactor shows equivalent chip performance to production LED wafers grown at the LED manufacturing company with comparative MOCVD reactors.

The average LOP (COW) of 23.3 mW has been achieved and it is at the up side of the LOP range from their production LED wafers, validating excellent reactor performance of the new MOCVD platform.

Given that MOCVD reactor depreciation accounts for the main expense of epitaxial growth, it is essential that next-generation MOCVD reactors can deliver economic efficiencies while offering a level of manufacturing performance comparable or better than those currently available. The performance results from the mini-marathon discussed above demonstrated excellent tool reliability and performance – critical factors for overall CoO reduction.

Conclusion

The LED market is poised for considerable growth, as concerns about climate change spur the transition from higher-energy incandescent and fluorescent lighting to HB-LEDs. The greatest obstacle to quicker and more widespread adoption is the high cost of HB-LEDs, which can be up to ten times more expensive than conventional light bulbs. The key to accelerating adoption is to reduce the expenses involved in HB-LED manufacturing, especially those associated with MOCVD processes, which account for nearly a quarter of HB-LED production costs. As detailed in this article, the new MOCVD platform offers a new architecture that delivers the necessary quality production performance, throughput and yields which help lower overall tool CO2 and enable LED manufacturers to close the gap in cost-per-watt-parity with conventional light sources. ■

Acknowledgments:
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High-Index Nanocrystals – Key to Next Generation Advancements in Lighting

Solid-State Lighting is destined to be a next generation lighting option. LEDs have already entered main stream applications and OLED technology has advanced greatly in the past few years in terms of efficacy and performance. Both technologies need to continue to improve performance to achieve high market acceptance. Dr. Gregory Cooper, Chief Technology Officer and Founder of Pixelligent Technologies LLC, illustrates how LED and OLED technology can advance to the next level by incorporating nanomaterials into existing packaging.

While the market acceptance of LED and OLED technology has been accelerating, both are facing continued pressure to improve light efficacy and to reduce cost. One of simplest ways to achieve this goal is to improve light extraction efficiency by more effectively coupling the trapped light out of the device.

The Need for Improved Light Extraction

Light trapped inside a solid state lighting device leads to a number of undesirable results. The first of these is related to the wasted energy that occurs when the light is trapped, which significantly lowers the efficacy of the device. Second, the trapped light becomes heat, which must be removed to prevent premature device aging, requiring bulkier and more expensive thermal management. Third, the device may have to be run at a higher current mode, which is less efficient as the device consumes more energy but produces the same amount of light output. Improved light extraction gives HB LED makers and luminaire designers the freedom to make lighting systems that are brighter, more efficient, longer lived, more compact, and cheaper.

Although LED's have entered mainstream market and applications continue to expand at an accelerating rate, there is still plenty of room to further improve the light extraction efficacy. The active region of an LED has a refractive index of 2.6 while the silicone encapsulant has a refractive index - 1.5.
The mismatch in indices is one of the main sources of photon loss in the LED structure, which creates extra reflection at the chip-silicone interface and limits the acceptance angle due to total internal reflection. Another area where index mismatch causes a problem is in phosphor-containing layers. Phosphors are typically larger (>1 micron) particles that have a significantly higher refractive index as compared with the silicone encapsulants in which they are dispersed. Because of this refractive index mismatch, light cannot be effectively coupled into and out of the phosphors and the phosphors will cause significant scattering. An improved light extraction scheme can further boost the efficacy and lower the cost, taking the LED lighting to the next level of performance and wider market acceptance.

OLED lighting is still at least several years away from mainstream adoption. The active layer of an OLED has a refractive index of - 1.9 and the mismatch in indices with the surrounding layers creates several competing modes of photon loss, which results in nearly 70% of the light being lost. OLED light extraction can be dramatically improved by various light extraction schemes that include a high refractive index internal light extraction layer. A cost effective light extraction solution can help enable an efficient OLED solution for many applications that are otherwise not practical, and accelerate the market adoption of OLED as a lighting option.

Light Extraction Requirements

Almost all light extraction solutions, both for LED and OLED, involve a high refractive index layer. The light extraction materials need to simultaneously possess very high refractive index and high optical transparency. In addition to the superior optical properties required, the advanced light extraction materials need to maintain transparency and excellent light stability under elevated operation

temperature and photon flux. They also have to have a long shelf life and be easy to incorporate into existing manufacturing processes. The ability to provide a cost-effective, drop-in solution to the existing manufacturing process cannot be over emphasized. Otherwise they become an irrelevant option to lighting manufacturers because the added risk, cost, or process complexity can easily surpass the benefits they promise.

Typically the light extracting layers are made with polymeric materials, in large, because they can be readily incorporated into the manufacturing process. Finding this combination of attributes necessary for high efficiency light extraction in a pure polymer system has proven difficult. Common polymer materials that meet the processability and stability requirements do not provide refractive index higher than 1.5, which is significantly lower than the ideal requirements for many index matching applications.

Many inorganic materials possess very high refractive index and light optical transparency, for example, bulk zirconia has a refractive index of 2.2 and is completely transparent in the entire visible range. The inorganic materials, however, require a high temperature process to form thin films and these films are usually brittle and rigid. As a result it is difficult to integrate them into an LED or OLED structure.

The solution lies in combining the advantages of polymer systems and inorganic materials. The past attempts to combine micron sized or nanometer sized inorganic fillers with polymer materials resulted in poorly dispersed composites with an opaque or cloudy appearance, eliminating any potential gains achieved with index matching. Only when the inorganic additives are well dispersed can manufacturers mix them with various polymer systems, and ultimately achieve highly transparent index matching extraction layers.

The Current Shortcomings of Nanomaterials

When looking for ways to enhance light extraction, LED and OLED manufacturers have often been disappointed with nanomaterial solutions. As described in the previous section, in the past, inorganic nanocrystals were often poorly dispersed and highly agglomerated; resulting in a cloudy appearance, which then translates into poor optical performance when incorporated into a polymer. Additionally, many nanoadditives have shelf lives measured in days versus months. These materials also have very high viscosities at high loadings that inhibit processibility, making them unusable in standard manufacturing processes. In addition, the stability of these nanocrystals under elevated temperature and high photon flux, typical in the actual working conditions in LED and OLED devices, can be even worse. The stringent requirements for LED and OLED packaging have made it difficult to find materials that can be easily incorporated into end-products.

Historically, few nanocomposite materials have shown they can achieve a high enough index to extract significantly more light or reduce the amount of heat produced and energy wasted. Again, the difficulty lies in the poor dispersion quality that makes it impossible to incorporate sufficient nanocrystal loading in a polymer material to achieve the desired refractive index without either losing the transparency or significantly increasing the viscosity of the material.

As a result of these challenges, to date the role of nanomaterials in LED and OLED technology and applications has been limited. Currently, the most commonly used nanomaterial in the industry is silica nanocrystals, which are used to make devices more durable and scratch resistant. However, in these applications, transparency is much easier to achieve because silica nanocrystals have a refractive index that is close to the polymer system, so agglomeration is less noticeable than with a high refractive index nanocrystal.

Advancements in Nanotechnology Create Solutions for LEDs and OLEDs

The nanomaterials market is rapidly gaining momentum in almost every major industry across the globe. The emergence and implications of nanotechnology for improvements in computer technology, telecommunications, energy, the environment, and human health is being dubbed a “second industrial revolution” by the National Research Center.

Currently, many nanotech companies are working vigorously to turn innovative breakthroughs into successful commercial products. Given the challenges faced by the LED and OLED industry, some nanotech companies are focusing on the issues at hand and are developing solutions that will address the current challenges and help take solid state lighting to the next level.

Today, there are nanomaterials available, such as PixClear™, that are created with unique synthesis and surface modification technologies, rendering them dispersible in a wide variety of solvents, monomers, and polymers. The sub-10 nm particle size, narrow size distribution, and superior dispersibility make the light scattering negligible. This enables formulations with nanocrystal loading in excess of 90 wt% with no loss of transparency, which can achieve a refractive index as high as 1.85, and which has a minimal impact on viscosity/processability. The high available index range translates into greater flexibility to index match dissimilar materials, and compatibility with modern high-speed polymer film forming techniques.

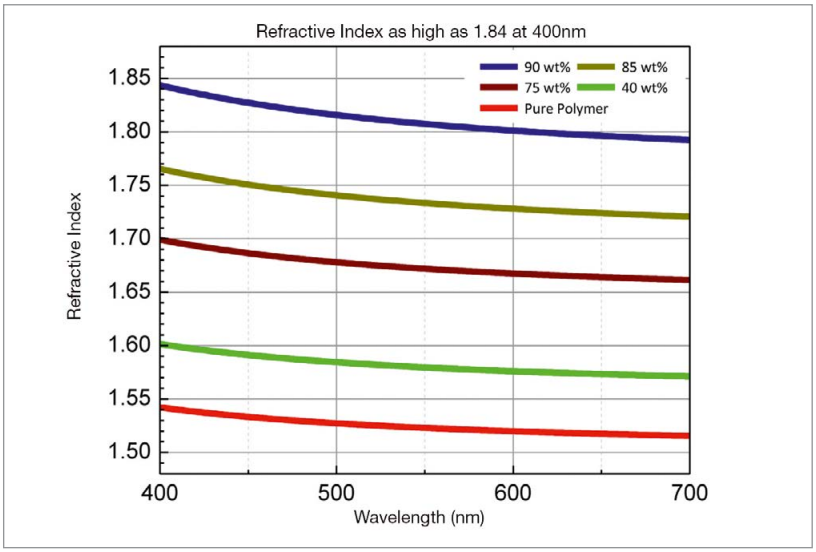

Figure 1: **Refractive index increases with nanocrystal loading while the transparency remains high and light scattering remains low. For all films the k values were <10^{-3} and haze was <0.5**

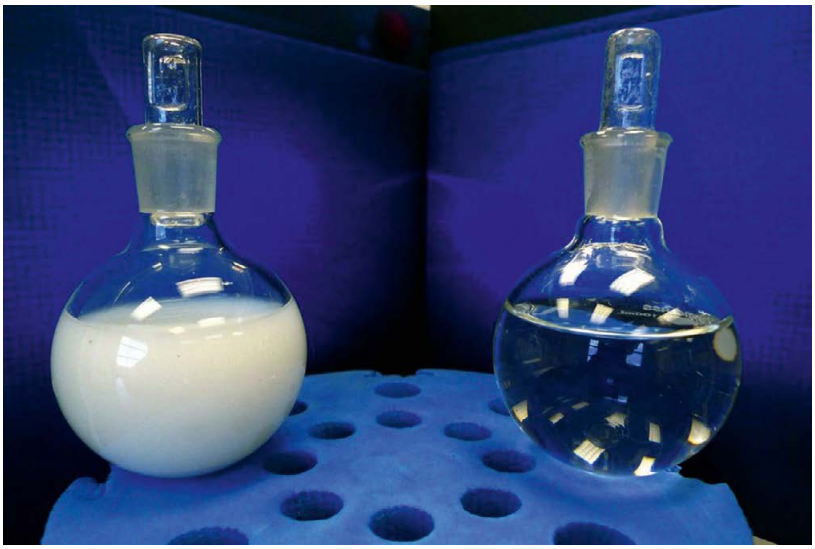

Figure 2: **Standard dispersed vs. PixClear™ dispersed nanocrystals**

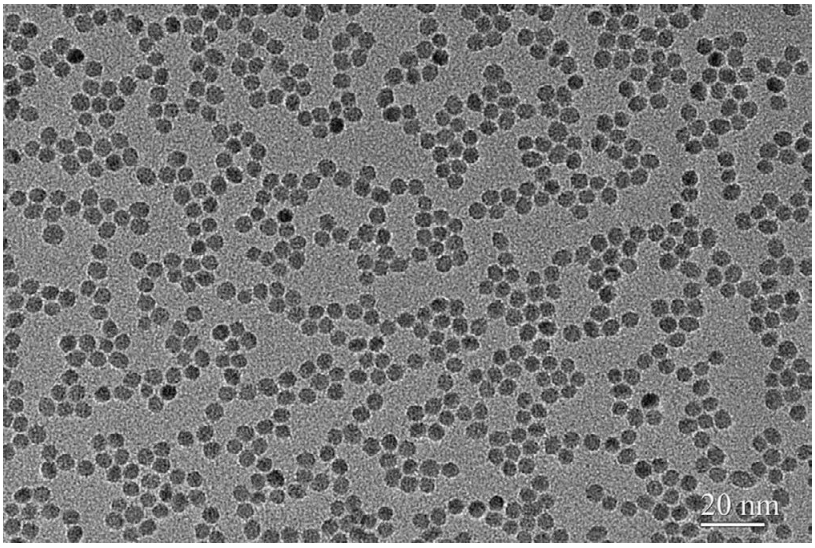

Figure 3: **A typical TEM image of PixClear™ shows spherical nanocrystals with 5 nm size and narrow size distribution**

To best demonstrate the quality of the PixClear™, figure 1 shows the refractive index of nanocrystal loaded into acrylic polymer films. Figure 2 compares the traditional clouded nanocrystals dispersion in a solvent and a PixClear™ dispersion with the same loading. The TEM images in figure 3 illustrate the small size and tight size distribution of the nanocrystals.

The superior dispersibility of these nanomaterials also enables them to be mixed directly into a monomer without a solvent. A solvent free formulation is often desirable in a number of manufacturing processes, by offering process simplicity as well as health and environmental benefits. As an example, Figure 4 illustrates the change of viscosity with capped nanocrystal loading in a solvent-free acrylic monomer system. Even with up to 80 wt% loading, the material has a viscosity of ~ 200 cPs at room temperature, well within the range required for most high volume manufacturing processes.

The new product family is also highly stable, with a shelf life of more than 3 months and the surface chemistry can be specifically tailored to achieve refractive index tuning of commonly used polymer systems including acrylates, siloxanes, and silicones.

Unlike many other nanocrystals and nanocomposites that only exist in lab scale quantities, PixClear™ product family is available in commercial quantities. Breakthrough nanomaterials are making the promise of nano-enabled applications a reality.

Finding the Best Nanomaterial Supplier

Finding the right technology is a major component to improving solid state lighting. When choosing a nanomaterial supplier, one of the most important factors to consider is the quality of the dispersion technology. It is possible to achieve high-quality dispersion through a nanocrystal synthesis, where the size and shape of the nanocrystal can be tightly controlled, and the surface of the nanocrystals can be modified with proprietary capping techniques. When dispersions are optically clear, which indicates the nanocrystals are small and agglomeration free, precise control can be delivered over the target applications' optical, chemical, and mechanical properties, and ultimately deliver unparalleled light extraction, transparency, and scratch resistance.

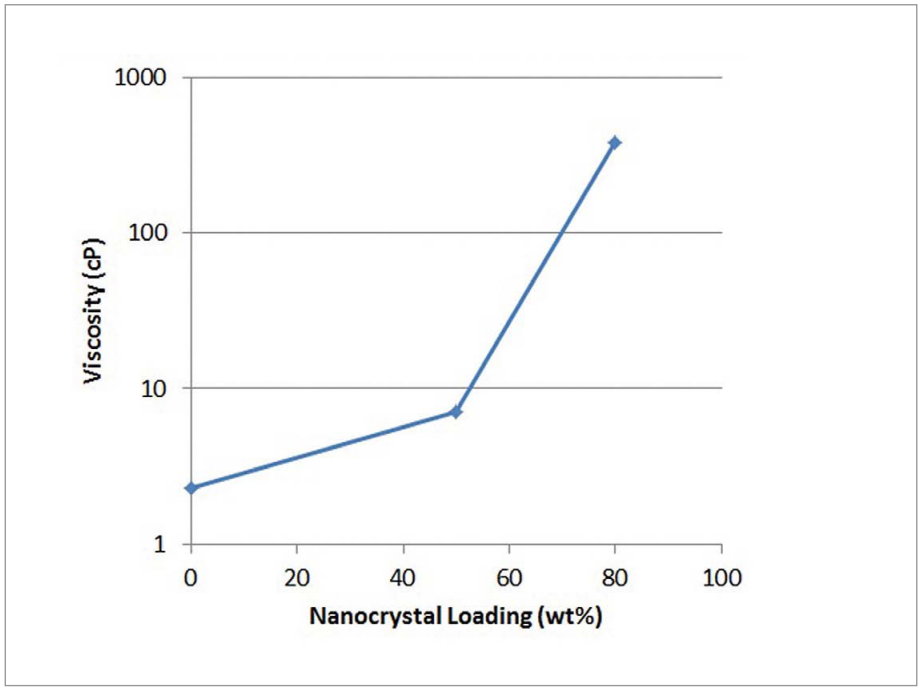

Figure 4: **Viscosity increases with nanocrystal loading in an acrylic monomer**

In addition, a capping technology that allows the control of the surface chemistry of the nanocrystal is also the key to the wide adoption. The ability to chemically bond materials to the nanocrystal surface that are compatible with the target polymer system affects the loading, dispersion, manufacturability, and versatility of the nanocomposites.

Fortunately, the surface engineering of nanomaterials has advanced significantly in recent years. Most of the challenges mentioned above have been addressed. Today, high quality nanoadditives that are easy to work with that solve the common challenges of incorporating materials into LED and OLED applications are becoming more readily available. The implications of nanotechnology for improvements in solid state lighting are game-changing.

A more pressing challenge for the nanotechnology industry is in scaling-up production quantities. Some nanomaterials sacrifice quality during the high volume manufacturing process, resulting in materials that are “nano” in name only and do not offer the ability to make designer materials with controllable properties. In addition, many nanocrystal manufacturing technologies, although they can produce exceptional quality in the lab scale, cannot be scaled up to commercial quantities, due to prohibitive costs or daunting technology challenges. With this in mind, it is crucial to select a nanomaterial manufacturer that has demonstrated success in moving from the research and development phase into the commercialization phase. The process must be inherently scalable and the company must be able to produce commercial quantities of nanocrystal additives and nanocomposites at a reasonable price and consistent quality. Lighting manufacturers must assess whether the quality is maintained as the quantity of materials produced is scaled up to commercial levels.

The Future is Bright

There are materials available today in commercial quantities that can address some of the challenges described above. These materials simultaneously possess high-refractive index, high optical transparency, and high dispersibility into a large variety of polymer systems. Additionally, they can be easily integrated into existing manufacturing processes and have longer shelf lives. Clearly, the future is bright for those LED and OLED manufacturers who can successfully integrate this new breed of nanomaterial into their products and drive the continuous innovation that is being demanded by the lighting industry. ■

Handheld Photometry Supports LED Lighting Design

With SSL new dimensions were introduced to light measurement, especially concerning handheld light measurement tools. Norbert Harkam, General Manager at SalesLink GmbH, a Representative of UPRtek, explains what criteria have to be considered and what the requirements of a handheld photometer are.

Lighting design is often seen as the "fourth dimension" of architecture and interior design. Appropriate lighting determines the appearance of color and form and it impacts how people feel and act in public and residential environments. Meaningful measurement data, derived on location with a handheld instrument, such as the MK-350 from UPRtek, are the basis for ergonomically and energetically optimized LED luminaires and large-scale illumination systems.

Lighting Design - an Interdisciplinary Task

Lighting design is a broad-based interdisciplinary activity based on various scientific and technological pursuits - from photometry and physiology to perceptional psychology. Lighting design enhances the architectural appearance of public spaces - from airport terminals and shopping malls, museums and event locations, parks and piazzas, administrative buildings and offices, to high-caliber residential environments.

The objective in all these cases, which are often guided by stringent architectural concepts, is creating optimum illumination solutions as well as satisfying aesthetic and perceptional values. A third consideration is energy efficiency and long-term viability.

An everyday experience in this regard is a look at the fresh-meat counter (Figure 1) of a well-stocked supermarket. These goods look particularly delicious when illuminated by a yellowish, warm-white light source of the proper correlated color temperature. Yet CCT alone doesn't suffice. Equally important is the light source's color rendering index (CRI). It must be high enough to deliver a favorable color impression compared to natural sunlight (CRI = 100).

In Figure 1A (CCT: 3,000 K), CRI is 52 – which is rather low. In Figure 1B the CRI is 82, so the depicted objects look much more attractive. The same is true for Figure 1C, where the displayed goods, at a somewhat cooler 6,500 K and a CRI of 82, are quite appealing to the eye.

CCT and CRI are core photometric categories. Next to the measured illuminance level they have a strong impact on lighting design. In this regard, LED lighting, supported by appropriate measurement methods and tools, has led to novel solutions in lighting design.

LED Lighting – Revolution to Mainstream

The traditional incandescent light bulb is on its way out. Its temporary replacement, a fluorescent tube often called energy-saving lamp, is not a real ecological alternative. It contains, like many gas-discharge lamps, the highly toxic mercury. At the end of its life, it must be disposed as hazardous waste. Thus, advances in LED technology now drive the greatest change in illumination systems.

A significant difference to incandescent lamps is the emission spectrum of LED lighting systems. It is limited to the visible wavelength realm of 360 to 760 nanometers. There is no emission of infrared. In other words, LED lighting doesn't radiate heat at wavelengths above 780 nm. Thus, the objects in Figure 1 cannot be spoiled by heat.

Figure 1: **Appropriate lighting helps sell the goods**

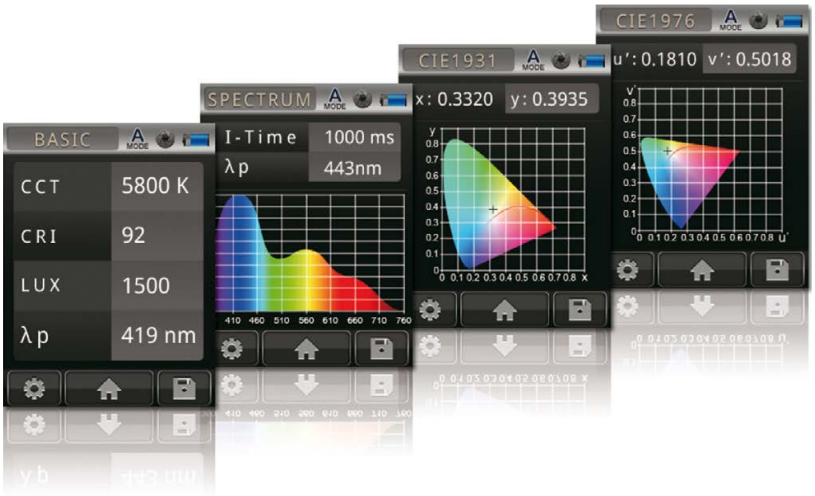

Figure 2:
Four operational modes for a wide range of applications offered by the spectroradiometer MK-350

Figure 3:
The measured spectrum characterizes the type and qualification of a light source

The situation is similar at the other end of the visible spectrum: LED lighting systems don't emit ultraviolet energy (below 380 nm). This prevents damage to paper, textiles and light-sensitive pigments and it makes LED lighting well suited for art galleries and museums. A possible drawback is the subdued effect of whiteners added to pigments for enhancing contrast and color brilliance by reflecting UV radiation.

Another important reason for using LED lighting is energy efficiency. A high-power LED (5 W) delivers the same luminous flux of 415 lumens as a 13 W fluorescent energy-saving lamp, or a 40 W incandescent bulb. But the LED consumes just an eighth of their energy.

LED technology is continuously evolving in terms of brightness, efficacy and chroma-ticity. Spectroradiometers laid out for these measurement tasks, such as the one referenced in this article, are useful tools to evaluate LED lighting systems under real-life conditions outside the lab.

Portable Photometry

Up to now portable devices for measuring vital optical parameters of lighting installa-tions at customers' premises consisted of several separate components: sensor, spectrometer and PC (or notebook) to gather and analyze the data. To make things easier on lighting designers and maintenance crews, and to give them unprecedented mobility in the field, it is advantageous to combine the entire functionality in one com-pact device. A measurement requires just three steps:

- aiming the device at the light source,
- initiating the measurement by pushing a button, and
- reading and storing the measured quantities after three seconds

The handheld instrument referenced here combines a light sensor with cosine correc-tion close to the ideal curve, a high-resolution spectrometer with advanced architec-ture, whose half-power width of 12 nm enables a wavelength increment of 1nm, plus a CMOS line-scan-sensor including integrated readout circuitry in a robust and compact housing.

A portable meter typically has a 3.5-inch color screen with quarter-VGA resolution, ideally laid out as a touch screen. The light sensor must have a sufficiently small di-ameter to securely capture the emissions of spot-beam sources such as individual LEDs. Four measuring modes, BASIC, SPECTRUM, CIE1931, and CIE1976, deliver the significant optical parameters (Figure 2):

- Illuminance
- Spectral energy distribution
- Color Space Coordinates
- Peak Wavelength
- Correlated Color Temperature
- Color Rendering Index

The illuminance measurement range should extend from a dim 70 lux to a glaring 70,000 lux. Spectral distribution is measured between 360 and 750 nm. Ultraviolet and infrared contributions outside the visible realm are safely suppressed by the wavelength limits of the device. Thus, this measurement method is not particularly well suited for measuring light sources other than LEDs, such as halogen lamps or flu-orescent tubes, due to possibly reduced measurement accuracy.

Another condition is to operate the light sensor inside its optimum sensitivity range for highest measurement accuracy with the integration time adjusted automatically between 8 and 1,000 msec, and to have it manually settable when comparing light sources of different radiation characteristics. Peak wavelength is derived from the spectral distribution. It should be switchable to display the spectrum to indicate pos-sible secondary maxima for evaluation.

A typical spectrum measurement routine is shown in Figure 3. The task is to determine what kind of light source is deployed. The depiction on the left is typical for daylight with a peak wavelength at 466 nm (color: blue). In the center is an incandescent lamp with a maximum in the infrared realm – which is not captured. The highest indicated value therefore is towards the long

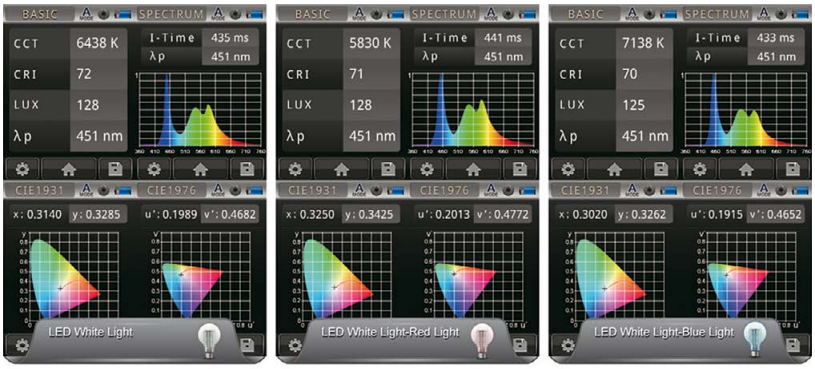

Figure 4: **Chromaticity calculation according to CIE ensures continuous quality of lighting products**

wavelength area at 760 nm (dark red). The right image characterizes an LED with a radiation maximum at 451 nm along with its secondary maxima transformed by fluorescence.

Portable light meters usually provide measurement modes for a light source's CIE (Commission Internationale de'Eclairage) chromaticity coordinates. They are located as x,y-coordinates according to CIE1931, or as easier to be determined u',v'-coordinates to CIE1976.

Derived from the measurement of the color space coordinates is the calculation of correlated color temperature in Kelvin. CCT characterizes the color of the measured light source by locating it as close as possible to an ideal blackbody radiator. A CCT measurement range of 2,500 to 10,000 K reliably covers the usual colors such as yellow (3,000 to 4,000 K) or white (5,000 to 6,000 K).

The data obtained from the spectral analysis are also used to determine the color-rendering index. CRI is calculated as the arithmetic mean value Ra of the first eight test colors (out of a total of 14) with standardized remission according to DIN-6169 when comparing their appearance under artificial light to that in natural sunlight. Ra is indicat-ed in a range between 0 and 100 (the ideal value for direct sunlight). A CRI above 90 is excellent. Values between 80 and 90 are in most cases sufficient for good color rendering. Values below 60 indicate poor color rendering.

Product Characterization

The growing demand for LEDs in lighting systems confronts their producers with a sorting and binning task to fulfill the specifications of their customers. A manufacturer of halogen luminaires ordering 100 lamps can be sure that all 100 of these will emit the exact same white light. Manufacturing LEDs for lighting applications, however, is significantly more complex and leads to certain deviations in their specs in terms of brightness and chromaticity. Integrating multiple LEDs in luminaires must avoid that some of them exhibit unacceptable color shifts. Thus, LEDs must be selected in a standardized binning and sorting procedure. A spectroradiometer is suited for such a procedure if it carries out these two steps:

- Measurement of illuminance and determination of color coordinates, either in the CIE1931 x,y- or CIE1976 u',v'-space. This ensures uniform chromaticity of the LEDs used.
- Measurement of color rendering index and comparison of the measured spectra. This ensures the LEDs' spectral identity.

Figure 4 shows measurement results from three LEDs marked "white". The LED on the left behaves as required. In the center is a slightly red-shifted version. On the right is a blue-shifted specimen. These data points quantify the deviations for improved product characterization.

A typical application that calls for binning is the design and manufacture of high-end LED lighting systems. For instance, the Nimbus-Group has specialized in architectur-ally advanced LED luminaires and illumination systems, and has gained a global leadership position in this market.

Basic idea, and recurring aesthetic feature, of this manufacturer's lighting design is the grid-like planar embedding of multiple low-power LEDs (0.3 W) in a clear acrylic sheet about 1 centimeter thick. This leads to a strictly minimalist design of floor and table-top luminaires, and also of large-scale wall and ceiling illumination systems that fit modernist, stylistically reduced interiors. One advantage of these extremely flat wall and ceiling systems is that they require a very low installation depth.

Guaranteed Lighting Mood

"Architectural lighting systems," says Frank Schlosser, director of project development at Nimbus, "must be predictable under all operational conditions and fulfill agreed-on specifications in terms of color rendering and brightness. Residential quarters, for instance, tend to a relaxing, warmer color temperature, whereas work places require a cooler light to stimulate alertness and creativity."

Being semiconductor components LEDs can be controlled and regulated in wide margins by complex driver circuitry, which is usually mounted, along with the LEDs, on printed circuit boards like in other electronic devices such as cell phones and PCs. Automatic daylight controllers and presence detectors are standard in this applicative realm.

Portable photometric instruments are typically used when developing lighting projects or testing installed systems at customers' premises (Figure 5). "This saves us from taking along heavy lab-type equipment including laptops," Frank Schlosser says. "A portable light meter is advantageous when evaluating lighting systems mounted at various heights or close to the ceiling, especially if it can be operated with one hand."

A plus of portable meters is that the data gathered can be stored and documented on a regular SD Card, or USB-transferred to a computer for further processing. "With a

Figure 5: **Application of the portable light meter at a customer's premises**

measurement head attached one can also point the meter at every single LED and check its correct specification and operation."

This feature set of a portable meter makes it easier to replace single LEDs, or to expand existing systems by ordering LEDs with appropriate bin numbers, Schlosser says. "The customer can be sure to get the best possible color value to fit his lighting and room design." Especially with a relatively new medium as LED lighting, Schlosser points out; the sensitivity for slight deviations in color and brightness is still high. ■

Credits:
Figures 1 to 4: URPtek
Figure 5: Nimbus-Group

Trends in LED Lighting Design and Function

Over the past few years, many business press and newspaper articles have discussed the future of LEDs, lighting networks, and other elements of the new lighting infrastructure. Mick Wilcox, Head of R&D and VP of Products & Operations at Bridgelux and Aaron Merrill, Director of Marketing at Bridgelux give us their views on the technical future of solid state lighting.

Table 1: Summary of the Lighting Market Characteristics in 2010 for US (lamps/sockets, operating hours, wattages and electricity consumption)

	Lamps	Average Daily Operating Hours	Wattage per Lamp	Annual Electricity Use (TWh)
Residential	5,811,769,000	1.8	46	175
Commercial	2,069,306,000	11.2	42	349
Industrial	144,251,000	13.0	75	58
Outdoor	178,374,000	11.7	151	118
Total	**8,203,700,000**	**4.7**	**48**	**700**

LED technology is revolutionizing the lighting market. Improving performance, better light quality, steady price declines, innovative financing models and new applications have spurred the adoption of LEDs. This is particularly true for retailers, large property owners, and government agencies where the benefits of LED lighting are most apparent.

Early Adopters

Businesses are often the early adopters as they have the most to gain from newer technology. Today US businesses spend as much as 25% of their electricity budget on lighting alone. Solid state lighting offers an attractive value proposition to businesses looking to reduce energy costs and bolster their short and long term profitability. The average return on investment period for companies who convert over to LED lighting is less than two years. This ROI period will be reduced even further with dimming and remote control technology via network connection.

Solid state lighting helps reduce energy consumption from heating and air conditioning. It can take 2.5 kilowatts of power to eliminate 1 kilowatt of wasted heat in an office building. It can take 4 kilowatts to eliminate 1 kilowatt of wasted heat in a manufacturing environment or clean room due to higher levels of required air filtration. Solid state lighting solutions pose a particularly strong value proposition for large data centers where energy consumption comprises nearly 30% of their operating expenses. Here are some statistics from the U.S. Department of Energy regarding national energy consumption that give a sense of the scale of the opportunity.

- Lighting consumes 19% of the electricity in the U.S.
- Commercial, industrial and outdoor lighting account for 525 terawatt hours of power a year in the U.S. Those spaces are lit by 2.4 billion bulbs.
- There are 81 billion square feet of commercial real estate in the US spread over 5.5 million buildings. The average square footage is 14,447.
- In the commercial sector, 80% of the lamps are linear fluorescents
- Compared to the 2001 base case, average operating hours estimated for the commercial and industrial sectors in 2010 are 13 percent higher and 4 percent lower, respectively. Outdoor operating hour estimates have increased 11 percent since 2001.
- Only 18% of lights in commercial buildings are connected to energy management systems.

Governments and utilities are using both carrot and stick approaches to accelerate commercial adoption. Australia, the U.S., Canada, the European Union and many other jurisdictions have passed regulations that effectively favor the adoption of solid state lighting in new construction and retrofits. California, New York and Ohio have crafted incentive policies that reduce the upfront investment required for solid state lighting solutions.

There will also be an increase in "lighting as a service" business plans that pay for new fixtures through savings. Similar to solar leases, these "as a service" deals will become more popular as more data becomes available that demonstrate proof of concept. Municipalities are the initial adopters, using these contracts to retrofit streetlights. The federally funded National Optical Astronomy Observatory (NOAO) reports that poorly-aimed, unshielded outdoor lights waste $2 billion (17 kilowatt-hours) of energy in the U.S. each year.

It is easy to imagine large property owners using these contracts to enhance tenant-occupied spaces. According to studies from the

Figure 1:
LED lighting has improved the quality of commercial lighting. Appropriate light color can be chosen to display products like the watches shown here

University of California San Diego, energy efficient floor space rents at a premium price relative to typical floor space.

Residential applications will follow. The recent introduction of the new $10 LED light bulb by Cree is a good example of how this market will evolve. CFLs began to sell once they hit a $5 price point. LEDs dropped from $90 in 2008 to $20 in just a few years. $10 fixtures are now within the ambit of acceptability, particularly with the advantages LEDs offer.

And don't forget fixtures like the Philips Hue and Google Android bulb. Those products help demonstrate the "other" benefits—automation, messaging, color schemes—that exist beyond efficiency and savings.

Seeing the World in a New Light

Light has become an important design attribute. 'Quality' light enhances the perception of a business and the utility of a space. The palette of colors from LED light sources allows retail and hospitality areas to be illuminated in ways that create an inviting ambience that attracts users and customers.

Realistic color rendering and high lumen light sources enhance product displays. Visual aesthetic is vital to these businesses, and high quality light provides these merchants with an advantage.

For example, car dealerships are switching out traditional lighting for LEDs in an attempt to reduce energy consumption whilst improving the presentation of their inventory. Jewelry stores utilize high quality lighting to bring out the sparkle and shine of their high end pieces. Grocery stores and bakeries utilize particular color coordinates to ensure their produce, meat, and baked goods look their best. Incidentally, LEDs also help minimize inventory spoilage by eliminating heat and UV emitted from traditional lighting. Not only do LEDs create a perception of quality, they contribute to it as well.

With the proliferation of high definition television, professional sports teams are honing stadium and arena lighting with specific LEDs to ensure that the game is viewed with high quality colors. This focus on lighting enhances the experience of viewing a game from the comfort of your own home.

Over the next several decades, emerging regions will experience monumental changes thanks to the spread of the grid technologies. An additional 1.3 billion people will jump onto the grid by 2030 and one of the primary necessities for many of them will be lighting.

Demand for lighting is anticipated to grow by 80 percent by 2030, bringing the benefits of lights to billions of people while reducing the health risks, pollution and safety hazards caused by oil-burning lamps.

Design Improvements

The performance and technology of solid state light engines continues to improve with each generation. Ten years ago the primary focus was lumens per watt, then lumens per dollar, then lumen packages (lumens per area). While these are still important metrics being pushed to their limit with each new generation, ease of use and design flexibility have emerged as important features to help accelerate the adoption of solid state lighting and take solid state lighting to the next level in terms of functional integration.

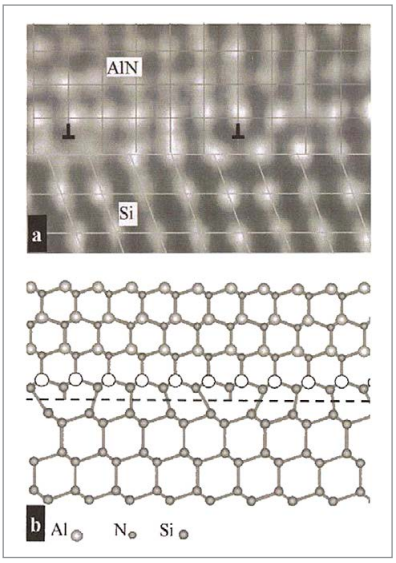

Figure 2:
One of the main hurdles to overcome for GaN-on-Si technology was the lattice mismatch between GaN and silicon. With transition layers between the GaN and silicon strain can be reduced. This opens the way for cost effective production of LEDs

Early LED designs used individual LED devices mounted on a PCB. Efficacy (lumens per Watt) was low (70 lm/W for 3000 K) and color quality imprecise by today's standards. By the nature of their design, it was difficult to manufacture products with consistent performance. The advent of LED arrays or Chip on Board (CoB) devices introduced consistency and predictability to the LED industry. CoB devices provide a solution with fully engineered and predictable thermal, electrical and photometric properties. They have been widely adopted as a preferred lighting solution.

However, as the use of CoB increased, ease of use and manufacturability became important industry criteria. Extensive feedback from luminaire OEMs and lighting designers has influenced designs of next generation LED arrays.

Luminaire manufacturers want devices that can be operated reliably at higher currents, giving luminaire manufacturers greater design flexibility with fewer part numbers. The option of driving a CoB device at up to 2x its nominal current allows a designer to optimize a luminaire around total lumen output with a smaller form factor and a lower unit cost. Alternatively, if efficacy is what is needed for a specific application, the CoB can be driven at lower currents. Ideally, a CoB device is designed to operate with widely available drivers using industry standard driver currents, which helps optimize luminaire design flexibility and minimize cost and inventory complexity.

The packaging, or LED layout, in a modern CoB design is optimized with smaller Light Emitting Surfaces (LES) to provide greater lumen density. This enables greater beam control and precision. Light quality has increased significantly with 3 SDCM color control as a de facto standard for clean, consistent uniform lighting. Many CoBs are available with high CRI options to provide high quality light for stunning visual appearance and very realistic color rendering.

Quality of light will continue to advance. ANSI color bins have been replaced by MacAdam ellipses for very precise color control. Improved phosphor formulations and processing technology allow suppliers to offer 3 or 2-step MacAdam color control. Improvements in the thermal stability of the phosphor support improved lumen maintenance at higher operating temperatures.

LEDs

At the heart of every LED lighting product is the LED chip itself. Although researchers continue to refine the basic architecture of LEDs to increase performance, there is a continuing drive toward the twin goals of increasing efficacy (lumens per Watt) and reducing cost. Ongoing cost reductions and increased supply demands require high volume and low cost manufacturing capability. This goal can be achieved by growing high power LEDs on larger diameter substrates in less expensive manufacturing facilities.

Today, Gallium Nitride (GaN) LEDs are grown on a sapphire (Aluminum Oxide, $A_{l2}O_3$) substrate which is expensive. Processing techniques and equipment availability needed for high volume Al_2O_3 substrate production is cost prohibitive and limiting for achieving economies of scale.

Gallium-nitride-on-silicon (GaN-on-Si) is regarded as a critical technology for cost effective, high volume manufacturing of power LEDs. It involves growing GaN LEDs on 8 inch diameter silicon (Si) substrates in existing, fully depreciated and highly automated CMOS semiconductor fabrication plants (fabs). CMOS processing is a mature, highly automated and high yield technology. Si substrates are cheaper than Al_2O_3. Due to the wide availability of 8-inch silicon fabs, manufacturing GaN-on Silicon requires little or no capital investment in production facilities.

Estimates from industry analysts predict LED chip costs could be clearly reduced for GaN-on-Si wafers in very high volume production relative to current manufacturing costs of 4-inch wafers grown on Al_2O_3. As well as keeping raw material and production costs to a minimum, increasing wafer size from 4 to 8 inches yields 4x the number of LEDs for the similar production time and costs.

One of the most critical problems is overcoming the mismatch between the crystalline structures of GaN-on-Si and managing stress and strains during thermal expansion. Without addressing these problems, cracks and defects lead to unacceptably low yields. However, there are technical solutions available and a number of companies, including Toshiba, Lattice Power and Plessey are active in developing and scaling this technology. Laboratory scale capability has been demonstrated and industry leaders are focused on scaling production capability to high volume.

Design, Manufacturability and Simplicity

As LED products gain wider use, manufacturers are paying more attention to the cost and challenges of high volume assembly. LED arrays have been built on MCPCB (metal core printed circuit board) substrates which are typically connected to the driver power supply by soldering – a notoriously difficult and unreliable manufacturing process for hand assembly. There has been a strong demand for an alternative approach.

Materials science has provided a solution. The latest designs incorporate the MCPCB into a composite device. A high temperature engineered plastic holder surrounding an LED array.

Figure 3:
New designs of array LEDs like the Bridgelux Vero LED Arrays, which are built on a composite body, enhance interconnectivity, and establish a platform for SMART control/ sensor integration

Borrowing from the consumer electronics industry, an onboard solderless connector port utilizes a miniature connector for ease of connectivity and simplicity. This solder free connectivity feature simplifies the manufacturing process for luminaire OEMs, improves their time to market, reduces inventory carrying costs, and enables field upgradability.

The hybrid substrate approach facilitates other user friendly features like optics location and mounting holes. Part numbers and bar codes can be marked on top of the device – where they can be read after installation - to facilitate inventory management. These simple, ease-of-use design changes add up to a great deal of value to luminaire manufacturers, reducing total system costs and installation problems.

Composite design sets the stage for future developments, providing a platform to support future SMART function integration.

SMART – Integrated Functionality

Today, LED luminaire designs are discrete component solutions. Designers must select several functional devices to design a new product. This is reminiscent of the early days of personal computers when the user required additional components to add functionality. Over time external floppy disk drives, graphics and audio cards gave way to internal hard disks and microprocessors with build-in cache memory, communications, and graphics. The same trend will unfold in lighting.

We already see indications of the future. A number of companies have developed systems to control and manage lights and building lighting. The low cost and ubiquity of electronic sensors.

A CoB with a composite substrate body design provides an ideal SMART node to support a variety of value add applications (i.e. motion/occupancy sensors, daylight harvesting) via ubiquitous networking protocols. Commercial buildings are beginning to transform into SMART properties with multifunctional solid state luminaires playing an increasingly important role in that emerging ecosystem.

The next level of integration takes these system devices down to the platform. What could be possible?

Traditional building controls are added to the existing wiring scheme in a building. Adding this functionality to a building is complex and expensive to install and maintain. Some control schemes use a ‘central controller’ to manage a network of luminaires hard wired into a network.

Adding this level of functionality to a light fixture creates a new level of flexibility and ease of installation. A smart light fixture can be aware of its environment: sensing movement and occupation, measuring ambient light from neighboring luminaires or natural light from windows. The device can ‘learn’ how the space is used and what levels of light are chosen by users.

LED fixtures can also be incorporated into building security applications. Smoke detectors and alarm systems will be wirelessly connected lighting fixtures. With the lighting fixtures sensing temperature changes, smoke, CO2, the system becomes immediately aware of a fire and its exact location. In response to abnormal conditions, the lights can flash to warn occupants of danger, all lights can illuminate at maximum brightness to ease exit from a building or highlight the presence of an intruder.

Informal surveys show that users like the idea of ‘remote control’ of dimming functions. The concept of adjusting your workspace environment with a smart phone is very attractive. However, there are additional benefits. Smart light fixtures can provide rich data on a building’s environment: the status of lighting, heating, cooling and utilization leading to additional improvements in energy efficiency.

Although the efficiency of the LED light source results in significant energy savings, sensor and control technology can ‘harvest daylight by allowing a fixture to adjust its light output according to the ambient natural daylight levels measured at its location. Building owners can combine measurements of light levels, temperature and occupancy to manage the total building HVAC and lighting loads.

Conclusions

As lighting technology evolves, the light fixture will become more of a complete system. A further level of integration could leverage the GaN-on-Silicon production process to integrate system functionality with LEDs on the same silicon package. This could be the lighting equivalent of the microprocessor.

The convergence of SMART functionality, innovative design flexibility, ease of use, and manufacturability will lead LED lighting to the forefront of technological innovation globally. ■

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Next LpR: Thermal Management & Reliability

Issue 39 - Sept/Oct 2013 - Short Overview

Technology: Reliability-Oriented Design of LED-Based Light Sources
The transition from traditional light sources to SSL systems requires a different design philosophy to achieve the advantages offered by LED light sources. The key approach is based on the parallel design of thermal, electrical, optical and spectral properties of the light source. In addition, the importance of the electrical management of LEDs, comparing modulation techniques is discussed, differentiating between versatility and efficiency compared to constant current.

Thermal Management: Natural Design for Heat Sinks
The luminous flux of LEDs decreases with the rise of the operating temperature. Therefore the dissipation of the heat is, aside from the efficiency of the LED chip itself, an essential part in the development of efficient LED systems. The analysis of natural inspired shapes will show an approach to heat sinks that combine high thermal performance with a high aesthetic value. The basic mathematical and computational fluid dynamics models as well as simulation results will be shown.

Standardization: An Update on Safety Regulations in LED Lighting
It is important to remember the most fundamental safety related considerations when designing any new product that derives its power from an electrical source. General health and safety issues related to the current main classes of regulations affecting LED lighting as well as the highest risk product safety factors and some fundamental strategies and methods for designing safer LED lighting products will be discussed.

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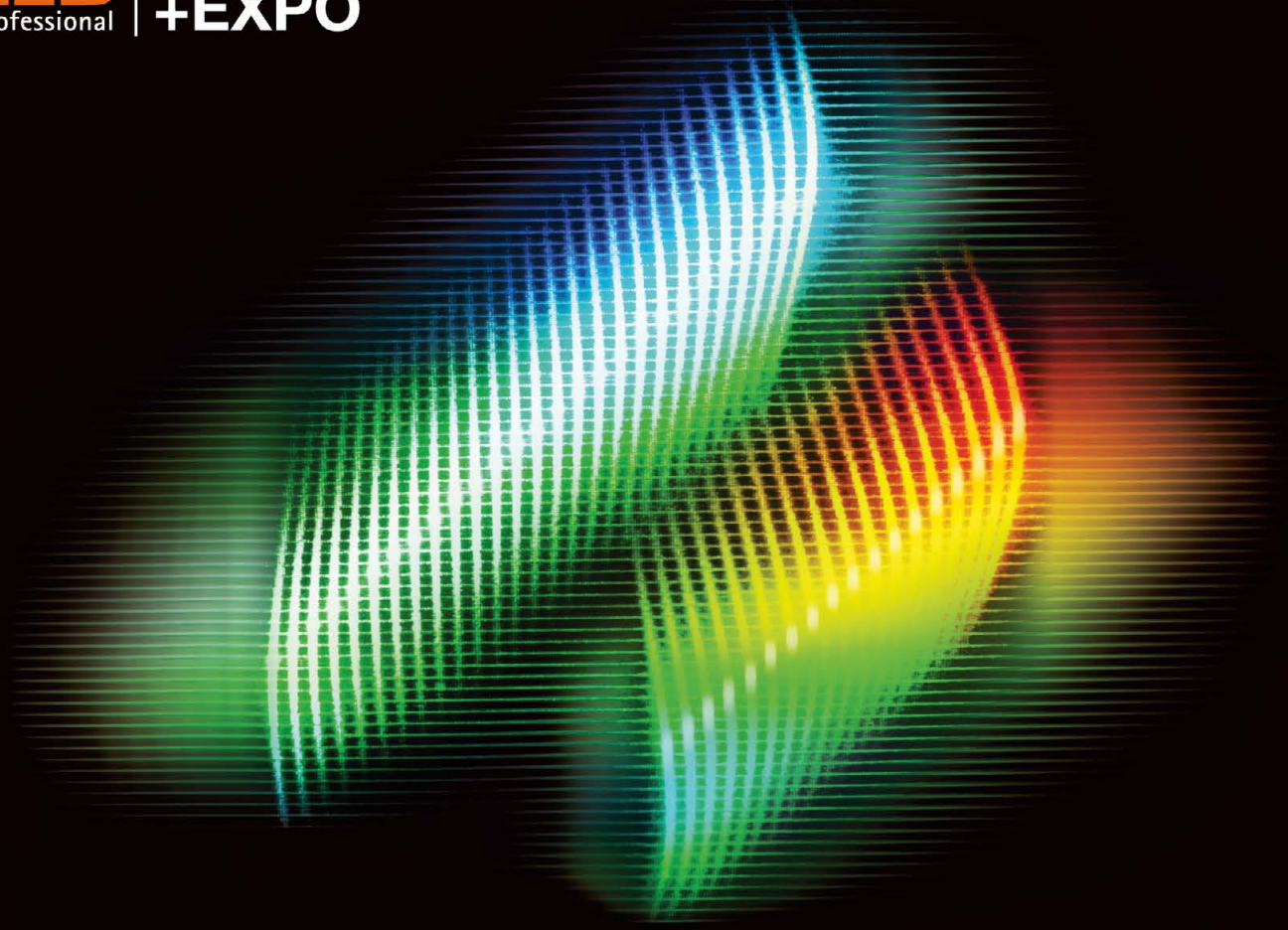

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