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LpR

The leading worldwide authority for LED lighting technology information

Sept/Oct 2011 | Issue 27

Enhanced LED Driving Concepts

Patterned Sapphire Substrates

HB-LEDs on FR4 PCBs

Lighting Event Report

Preview – LpS 2011

CREE XLAMP® LIGHTING-CLASS LEDs

XLAMP ML-B & ML-E LEDs

OPTIMIZED FOR SMOOTH LOOK LIGHTING

Longer lifetime than backlighting LEDs (and the LM-80 data to prove it)

Best color consistency with industry's smallest color bins

XLAMP XP-E HEW LEDs

OPTIMIZED FOR NON-DIRECTIONAL LIGHTING

Lowers the cost of high-efficiency LED systems

Light optimized for your application - many CCT & CRI options available

XLAMP CXA2011 LEDs

OPTIMIZED FOR NON-DIRECTIONAL LIGHTING

Simple assembly – no soldering or connectors required

Wide lumen output range - up to 3500 lumens at 45W, 85°C

CREE XLAMP LEDs ARE APPLICATION OPTIMIZED FOR LOWER SYSTEM COST

REVOLUTIONARY!

Cree XLamp® Lighting-Class LEDs are purposefully designed to deliver the industry's best performance and optimized specifically for distinct applications.

Our revolutionary product portfolio enables you to design brighter, more efficient luminaires with fewer LEDs or simply use less LEDs and save space. So whether you're designing the next generation of indoor downlights or lights that emulate the look of fluorescent tubes, you can lower your system cost.

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

Get Cree reference designs for non-directional applications at cree.com/ref

CREE®

LED Lighting Technologies – LpS 2011

In general, there is no doubt that LEDs will be the light source of the future. This is true even if it takes a few more years to cut down costs before entering increasingly more application areas. It is an evolutionary law that technical systems evolve according to S-curves and at the beginning one of the most important drivers is the development of the technology which makes the system work in an efficient, robust and cost effective manner.

This ongoing, fast technology development can also be seen in the LED domain. We just have to look back at recent new approaches in the fields of LED arrays, high-voltage LEDs, remote phosphor platforms, off-line drivers, driver-less systems, RGBX control, spectral tuning, free-form optics, and cooling concepts to name a few. Understanding winning technologies is key, but understanding them in the context of the environment, regarding requirements, standardization and realization capabilities is crucial.

This is exactly what the *LED professional Symposium +Expo 2011*, (LpS *2011*) offers you. Get insights into LED lighting technologies and explore winning approaches in combination with an exhibition where you can meet international leaders from the field of LED lighting.

A workshop about disruptive innovation technology and LED market research will open the event. Seven sessions, including 27 technical papers and 9 poster presentations, will cover the areas LED technologies, optical components, electronic components, measurement, testing, manufacturing, lighting systems, standardization and reliability. Exhibitors from Europe, North America and Asia are presenting their technologies, products and services in 60 booths with a total booth area of about 550m^2 in the Bregenzer Festspielhaus. This convention center recently won an award for the best European congress-center 2011.

We are very excited about hosting this event and meeting all the experts at the symposium. This is a great chance for new business prospects and making key contacts.

I would like to take this opportunity to personally invite you to this event!
Use this chance to learn about the Winning Approaches of LED Technologies.

I'm really looking forward to meeting you in the heart of Europe!

Yours Sincerely,

Siegfried Luger
Publisher

PS: Registration – www.lps2011.com
September 27-29, 2011 in Bregenz / Austria

Content

Advertising Index

LED professional | SYMPOSIUM +EXPO

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LED Lighting Technologies

International Winning Approaches

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e:lumix LED Technologie GmbH
TRIDONIC enlightening your ideas

Eduardo Pereira
The principal engineer of the LED driver technology team at Tridonic (Zumtobel) Switzerland, currently researches high frequency power converter topologies applied to LED drivers together with color control and stabilization algorithms. He received his B.S. and M.Sc. degrees in electrical engineering from the Federal University of Santa Catarina, Florianópolis, Brazil, in 2000 and 2002, respectively.

WHAT ABOUT THE DRIVER?

Back in the eighties, LEDs were only seen when your record player was on. By the nineties small LEDs were employed on the keyboards and displays of mobile phones. Nowadays, they are being used to backlight TV panels and soon they will be replacing incandescent and compact fluorescent bulbs in most households.

Today, in LED technology, there are plenty of reasons to think that the technical limits of the amount of useful light that can be created by a single LED chip is nearly reached. Back in 2009 the IEEE Spectrum magazine presented an instructive article on the LED “droop”. This limitation can only be resolved in advanced research labs. In the meantime, this hurdle is overtaken by getting larger amounts of LED chips in the design of a luminary. While most research efforts are trying to increase the luminous efficacy (lm/W) of the LED chip, little or almost no attention has been given to the electronic driver. When the driver electrical efficiency is not taken into account, even the biggest achievement in terms of luminous efficacy can be hidden by the wrong selection.

The ones dealing with the LED chip rarely create a specification for the electronic driver; this is a job for the luminary manufacturer. Until some years ago, only small steps were made in the development of electronic drivers for LED luminaries.. The LED array itself is created by electronic engineers and the electronic driver is often developed alongside the LED, which in all honesty, is an easy job for these engineers. However, this fact caused a delay in the development of universal or perfectly matched LED arrays and power supplies. Happily, this is changing.

A state of the art isolated LED driver has a typical efficiency of about 83%. On the other hand, more complex topologies can boost the efficiency up to 97%. This difference in performance can be directly measured in the input power to the LED system. Therefore, by choosing the right the total system, efficacy can be improved by more than 10%. I am not saying that the actual efforts to increase luminous efficacy of LED chips are useless, they are just the tip of the iceberg. The energy balance of the total system shall be taken into account. This balance will define the size of the solar panel required in a remote application, the amount of battery power necessary in an emergency system or the energy bill to be paid by the end user. Another aspect to be taken into account is safety and protection mechanisms. An LED driver should not only protect itself but also signal failures and circumvent destruction of the LEDs, which are the most expensive part of the total system. Special attention should be given to temperature management.

Lifetime and light output of LEDs are affected negatively with increased temperature. Consequently, the electronic driver must show the ability of not only detecting the LED’s temperature but also to manage the limits properly. Some sort of “Intelligent Temperature Guard” is required. The driver shouldn’t shut the LEDs down at the first over temperature event; keep in mind that the main goal of an LED system is to generate light! An electronic driver which, for example, is able to detect an over temperature event and keep a track of the tendency of the LED temperature would be a solution.

In summary, the right electronic driver can be selected based on an improved understanding of the LED technology and the interactions with the electronic driver. Another issue when specifying an LED system (LED + driver) is to understand how manufacturers are communicating the performance of their devices. This can be extremely hard given the way each manufacturer reports its performance.

There are two big challenges when selecting the right driver: choosing the relevant features given the particulars of each project and distinguishing the truth from fiction in published data.

E.P.

Lumenpulse Illuminates Banner MD Anderson Cancer Center

Next to US 60 – the main highway that travels through the Southeast Valley town of Gilbert, Arizona - the new Banner MD Anderson Cancer Center is a state-of-the-art facility built on the campus of the Banner Gateway Medical Center.

Above the doors to the future main entrance of the facility is a four-story, 69 ft. tall, latticed tower. This metal structure is roughly 30 X 30 square feet in dimension, and designed to resemble the leaves and branches of the palo verde tree – known to be synonymous with nursing for its healing properties.

In the daytime patients and visitors can relax on balconies from the 2nd and 3rd floors looking into the tower where they are bathed in a natural light show created by the day's sunlight dancing against panels of translucent white fabric that line the interior of the tower.

By night the client wanted to create an even more inspiring patient experience through the tower's presence by lighting the structure in a way that represents an eternal flame – a universal and well-loved symbol of endurance and hope.

The Challenge: Transforming a tower into a beacon of light at night

The goal set for the lighting designer was to transform the metal-based feature into an inspiring beacon of light that would represent healing and hope for the center's patients and staff after the sun goes down.

The "Lantern of Hope" is lit with cutting edge LED technology*

The cancer center building project itself was already conceptualized before the client decided to illuminate the symbolic tower structure but as the design progressed, it became apparent that the structure resembled a lantern, the "Lantern of Hope".

With the end goals clearly in mind, the lighting project presented a number of design challenges created by the unique structure in place and the physical environment it resided in.

The heat and dryness of the desert was a key factor, requiring that any fixtures used be robust enough to withstand substantial shifts in temperature and provide protection from intrusive sand particles.

The unique nature of the structure made mounting the fixtures a design and technological obstacle. The luminaires had to be in just the right locations and at the correct angles to accomplish the desired result of creating consistent color effect across each cloth panel while remaining hidden.

Consideration also had to be given to getting people up the four stories of the tower for maintenance so it was crucial to have a low maintenance solution and fixtures that could be easily attended to when necessary.

Finally Arizona's dark night sky was a consideration, with the lighting design requiring a solution to perform within acceptable brightness and contrast limitations to avoid skyglow effects.

The Lumenpulse Solution: Lighting the "Lantern of Hope" with LED technology

LED technology was ultimately chosen because of low maintenance requirements, longevity, and the ability to utilize color changing effects but it took some education from the design firm:

"We had to convince the client that LED technology could accomplish the task," said Sara Schonour, lighting designer at Cannon Design. "We did several rounds of calculations that compared 3 different manufacturer's

Lumenpulse transforms a tower into a beacon of light at night*

Narrow beam optics with light diffusing film were used, and half of the fixtures were precisely focused to direct light onto the vertical fabric planes*

* Photo Credit: Mark Skalny, Bill Timmerman

fixtures to prove that we could get the color they wanted, that we could control it, and that the light would reach to the top of the structure. We also made a small scale mock-up to demonstrate color changing effects, color saturation control, and source intensity."

Lumenpulse Lumenfacade RGB fixtures were chosen to light the structure. These IP66 rated fixtures were robust enough to withstand the harsh desert environment, and offered dual chamber technology that minimizes maintenance by increasing lifetime and enabling simple component vs. fixture replacement.

Using custom mounting brackets developed in concert with Lumenpulse, luminaires were placed at the bottom of the Lantern's panels to graze the interior fabric. For the full height panels, two rows of luminaires were installed at the bottom of the lantern, and a single row of fixtures dimmed to a lower intensity were placed at the base of the shorter, upper panels. This ensured that all four sides of the Lantern had the same visual appearance and a uniform glow from bottom to top of each panel.

Narrow beam optics with light diffusing film were used, and half of the fixtures were precisely focused to direct light onto the vertical fabric planes, and not straight up, as part of the solution to reduce sky-glow.

A glass roof was also added to the structure, and although the driving force for this element was rain and bird related, it enabled the lighting designers to utilize the ceiling to redirect some of the up-light back down into the lantern's body to further respect the dark night sky, and achieve a more uniform illumination across the surfaces of the lantern.

"The Lumenpulse products out-performed its competitors in every aspect with the total package of performance, reach, cost, accessibility, adjustability, maintenance, and fixture look and design winning it for Lumenpulse," said Schonour. "The ease of control through the Lumentouch system, giving the staff the ability to adjust the lighting to suit their facility's needs, was another key element."

With this innovative Lumenpulse solution the goal has been achieved where natural light comes through the aluminum panels in daytime to provide a dappling effect and at night the lantern can be seen clearly from the passing highway and from miles around, as the structure glows with the light of hope. ■

Illumitex Announces Production of Artavi™ Precision LEDs

Illumitex Inc., developer of high-brightness LEDs and emerging LED technology, released today the lighting industry's first and only precision beam LED for use in general, architectural and entertainment lighting applications, ranging from high mast street lights to stage and spot lights. Utilizing patented Illumitex technology, the Artavi™ produces a narrow 10 degree beam directly from optics integrated at the emitter level. With more than 90% of the light exiting the lens in the beam, the Artavi™ promises to significantly reduce energy consumption as well as minimize overall system costs when compared to other LEDs that require secondary optics (lenses, reflectors and mechanical shields) in order to achieve a similar directional beam effect.

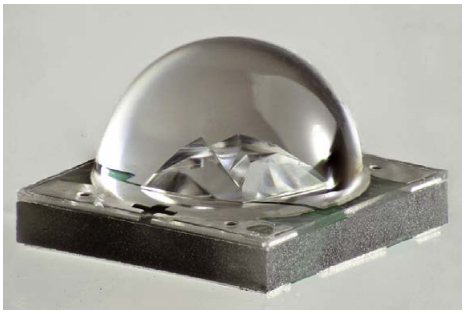
Illumitex' s new Artavi™ produces a narrow 10 degree beam directly from optics integrated at the emitter level

"No one else in the world can do what Illumitex has achieved with the Artavi™", says Matt Thomas, CEO of Illumitex. "As our next big step in the 're-invention' of LED technology, we're pushing the envelope to drive better and more energy-efficient lighting wherever LEDs are used. But the industry is also demanding a better quality of light itself, and we're delivering on that front as well."

While leading the industry's mission to create energy efficient lighting that will speed widespread adoption of LED use, Illumitex technology also improves the quality and functionality of light itself. The Artavi™ utilizes patented Illumitex technology to deliver edge-to-edge uniformity of light—both in terms of color and illuminance—directly to the intended surface while the beam's sharp cut-offs allow light to be positioned exactly where needed. The Artavi™ has an IP66 rating to protect against humidity and water. ■

Cree Launches New High-Performance XLamp® XT-E Royal Blue LED

Cree, Inc., a market leader in LED lighting, announces commercial availability of a new XLamp® XT-E Royal Blue LED optimized for use in remote-phosphor lighting and other applications with similar requirements. The new XLamp XT-E LED delivers the industry's tightest wavelength bins combined with category-leading brightness to simplify remote-phosphor designs and lower system costs.



Cree's new XLamp XT-E Royal Blue is optimized for use in remote-phosphor lighting

In addition, Cree announces a remote-phosphor-component patent licensing program that provides access to Cree's pioneering remote-phosphor patents. The program is designed to drive the LED lighting revolution by enabling lighting-fixture companies to develop and introduce their own high-quality LED system products using LEDs such as the XLamp XT-E Royal Blue. With a license under the new program, lighting OEMs can gain access to a number of fundamental Cree patents required to manufacture and use the combination of a remote-phosphor optical element with blue LEDs in LED lighting applications.

"Customers using remote-phosphor designs for their lighting products need both high output and consistent color," said Mike Watson, Cree senior director of marketing, LED components. "The new Cree XLamp XT-E Royal Blue LED outperforms the competition in both elements enabling our customers to design high-performance and low-cost systems."

Built using Cree's proven Direct Attach™ LED technology that delivers higher flux, lower forward voltage and lower thermal resistance

Samsung LED Lighting

Light.

Reinvented.

The world's icons of technological advancement exist today as the result of great change and evolution. Now, it's the light bulb's turn. Introducing Samsung LED – developers of the energy-efficient, longer lasting light source of tomorrow. And at the core of LED lighting, you'll find the world's leader in semi-conductor and LED TV technology, who from LED chips to light engines & lamps, provides the complete solution for all lighting applications.

Samsung LED Lighting Solutions For more about Samsung LED lighting solutions, visit **www.samsungLED.com**


HV-AC


HV-AC


Ceramic


Light Engines


PAR, MR Lamps


Tubes


A19 Lamps

SAMSUNG SAMSUNG LED

Main Parameters:

Color	DWL (nm)	Max Current (mA)	Viewing Angle (°)	Standard Min. Flux @ 350 mA, 85°C	Product Status
Royal Blue	450-465	1000	140	500 mW 475 mW	Active

than other technologies, the XLamp XT-E Royal Blue LED delivers up to 525 mW at 350 mA and 85°C. The new XT-E Royal Blue LED is also available in 2.5-nm wavelength bins to allow customers to achieve desired color consistency. ■

LUXEON Rebel Color Portfolio: New Deep Red 650-670 nm LED

Demand for colored LEDs is on the rise and the LUXEON Rebel color portfolio performance is increasing and new colors are being added to the family. 'Deep Red', the most recent color added to the portfolio, delivers light in the 650-670 nanometer range. This wavelength range is essential for horticultural applications and is required by some governments around the world for applications like road and railway signaling.

650-670	Deep Red	720 mW
620-645	Red	53 lm
610-620	Red-Orange	72 lm
584.5-597	Amber	61 lm
588-592	PC Amber	91 lm
520-550	Green	102 lm
490-520	Cyan	83 lm
460-490	Blue	41 lm
440-460	Royal Blue	1120 mW

Rebel Color Portfolio: All colors at 350 mA except royal blue and deep red at 700 mA (see DS68 for complete details and specifications)

"We are committed to the continuous improvement of our color portfolio and have delivered substantial light output increases," said Steve Barlow, Sr. VP of Sales and Marketing. "For more than a decade, LUXEON LEDs have been the first choice for enlivening city centers and architectural wonders, bringing drama to concerts and performances, and ensuring people can move safely on our public transit systems."

The LUXEON portfolio provides designers with a more sustainable lighting component and new creative license to show the world what LED light can do. ■

Seoul Semiconductor Sets a New Benchmark for Top View Level LEDs

Seoul Semiconductor, one of the world's leading providers and innovators in LED technology, is now providing an additional parameter for the performance assessment of its 5630 Top View LED: SSC will not only feature the power and the luminous efficacy of the LED not only in lumens per watt (lm/W) from now on, but also in the description price per lumen. Thereby the LED manufacturer aims to create greater transparency and investment security for its customers and end users.

SSC provides additional parameters for its 5630 Top View Level LEDs

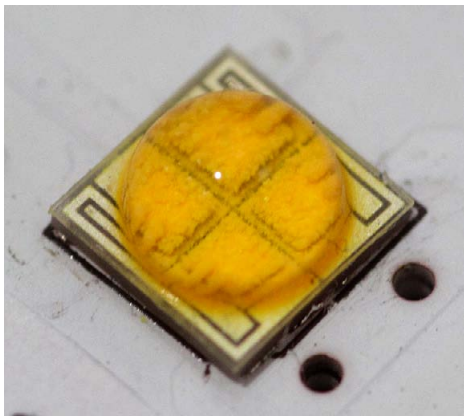
"With the additional indication of price per lumen, we see ourselves as a revolutionary in the LED industry," said Manuel Zarauza, Managing Director of Seoul Semiconductor. "The main reason for the change is we reduce potential entry barriers by the competitive price and provide a simple payback period for the customer. At a glance the customer oversees how much the investment is using LEDs by SSC in the same or higher lumen output. "

Until recently, only the performance of LEDs in lumens per watt was specified. Due to the more and more powerful LEDs, the significance in the indication of the LEDs in lm/W is qualified as the only reference, because LED solutions already achieve the benefits of conventional light and can even take over. Since the LED 5630 by SSC can be used in 80% of all lighting applications, allowing much more energy-efficient solutions than ordinary bulbs, the price per lumen specification is the crucial reference value in the LED lighting market.

This is not the first time that SSC is setting new standards in the LED market: SSC was the market pioneer for lights with a color rendering index (CRI) of 80 and above. Another leading product is the Acriche, the first AC LED without a converter. ■

Super Small 4-chip LEDs – Federal FM Series is Now Available

The newly launched super small 4-10W 4-chip LED Series is now available in the full spectrum of white and RGBA, RGBW, RGGB multi colors. It offers great performance in a single ultra small component of only 5mm x 5mm. The super mini size allows designers to develop much simpler optics and consequently help to reduce the overall system cost.



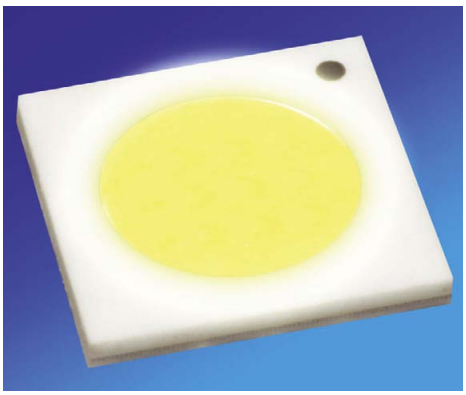
Edison Federal FM is a new, smaller and brighter multi-chip LED which provides multicolor packaging flexibility

The white FM LEDs deliver up to 750 lumens in cool white and 550 lumens in warm white at 700 mA. Their bright and high-performance characteristics make it especially suitable for high lumen applications such as indoor lighting, commercial lighting, industrial lighting or LED replacement lamps. In addition, a family of 3in1, 4in1, 7in1, 9in1 and 12in1 modules and related lenses are also available.

Part Number	Color	CCT (K)/ λd(nm)	Flux (lm) (Typ.)	VF (V) (Typ.)	IF (mA)	Radiation Patterns	CRI
EFE4W-1CE7		5000~10000K	440 750	3.3 3.7	350 700	140	70
EFE4H- 1CE7		3800~5000K	370 630	3.3 3.7	350 700	140	75
EFEX- 1CE7		2670~3800K	320 550	3.3 3.7	350 700	140	80
EFERTBW-1CE1 EFERTTB-1CE1 EFERTBA-1CE1		620~630nm	50 100	2.1 2.3	350 700	140	
		520~535nm	80 125	3.4 3.8	350 700	140	
		455~470nm	20 35	3.3 3.7	350 700	140	
		585~595nm	50 100	2.1 2.3	350 700	140	
		5000~10000K	105 180	3.3 3.7	350 700	140	

The multi-color Federal FM Series is the smallest 4-chip LED in the industry at the moment. The addition of white provides softer lighting effects while the amber expands the color gamut. The multi color LEDs deliver a brilliance of color mixing and lighting quality to many applications ranging from architectural, decorative, entertainment to stage lighting. The multi-color FM components can also be applied to a related square module and related lenses which have been designed by Edison Opto.

Lumex's updated TitanBrite Series is a cost effective, highly reliable and efficient solution for a wide range of applications



New High Power LED Provides Market-Leading Brightness and Thermal Resistance

Lumex announces the global launch of a new TitanBrite 10-Watt High Power LED. Available in cool, neutral and warm white colors, the SMD high-power LED technology provides market-leading brightness and thermal resistance. The technology also provides opportunities for significant cost and real estate savings for applications switching from two 5 W or ten 1 W technologies to a single 10 W LED.

The new TitanBrite 10 W White LED provides market-leading brightness (23% brighter than alternative 10 W LEDs) of 600 lm for cool white, 550 lm for neutral white and 530 lm for warm white technologies.

Thanks to its unique thermal enhanced design with the LEDs mounted onto a ceramic substrate (rather than onto a PCB), heat dissipation performance is improved up to 61% compared to the use of two 5 W LEDs.

PN	Emitted Color	Chip Material	Color Temp (K)	Lens Type	Vf (V)	If (mA)	Total Flux (lm)	View Angle
SML-LX4747MWC-TR10	Warm White	InGaN	3000	Yellow	10.4	1000	530	120
SML-LX4747NWC-TR10	Neutral White	InGaN	4000	Yellow	10.4	1000	550	120
SML-LX4747UWC-TR10	Cool White	InGaN	6000	Yellow	10.4	1000	600	120

Compatible with standard LED drivers, the new TitanBrite 5 W White LED is ideal for use in a wide range of applications that require bright, intense light with low power consumption. - This is for instance small space lighting (including cavity, under cabinet, task and decorative lighting and channel light backlighting)

At the same time, the new technology provides cost and real estate saving opportunities and enhanced visual performance. The TitanBrite 10 W LED offers up to 10% cost savings compared to alternative 10 W LEDs, up to 40% cost savings compared to the use of ten individual 1 W LEDs and up to 25% cost savings compared to the use of two 5W

LEDs. Its compact 12mm² package size allows the TitanBrite 10 W to provide up to 47% real estate savings compared to the use of two 5 W LEDs and 20% space savings compared to the use of ten 1 W LEDs. The ability to replace ten 1 W or two 5 W LEDs with a single 10 W TitanBrite LED enhances color consistency by eliminating the need for binning while simplifying assembly efficiency.

Lumex´s new TitanBrite 10 W White LEDs feature a 120° viewing angle and an extended operating temperature range from -40°C to 90°C. Pricing dependent on quantity ordered and is roughly $15.00 in production quantities, with a lead time of eight to ten weeks.

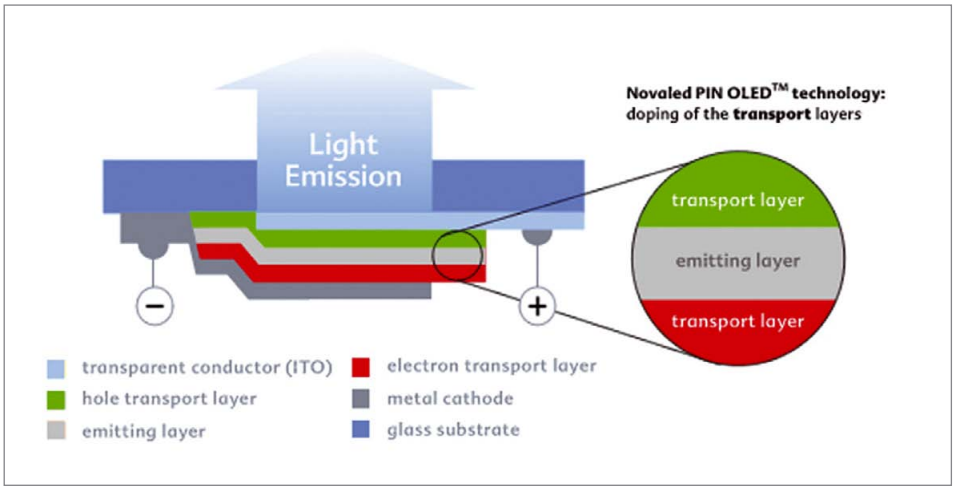
Lumex Technical Design Specialists can integrate TitanBrite LEDs with metal core boards, optics, enclosures, switches, connectors and other key components to create solutions that maximize performance and efficiency in each individual application. Finish product solutions can be UL/CE approved when necessary.

With this extension of its TitanBrite line, Lumex now provides over 10 different high-power LED technologies including 1 W, 2 W, 3 W, 5 W and 10 W sizes. ■

Novaled Develops Improved Highly Power-Efficient White PIN OLEDs

Novaled, a leading technology and materials provider specializing in high-efficiency, long-lifetime organic light-emitting diodes (OLEDs) for display and lighting applications, today announced it has developed a highly power-efficient white OLED structure achieving 60 lm/W at a brightness of 1,000 cd/m2 capable of reaching a very long lifetime of 100,000 hours at an initial brightness of 1,000 cd/m2 while using commercially available fluorescent blue emitting material.

The high efficiency device also demonstrates a high color rendering index (CRI) of 87. A very broad light emission spectrum and good CIE color coordinates (0.470/0.429) were achieved, which is close to illuminant A and inside the US Department of Energy (DOE) quadrangles meeting the DOE energy star color specifications.



The principle architecture of a bottom emission OLED incorporating the intrinsic emission layers into the Novaled PIN OLED® technology by using doped transport layers: holes are injected from the anode and transported by p-hole transport layer (p-HTL) to the emitting layer (EML). Electrons are injected from the cathode and transported by the n-electron transport layer (n-ETL). Recombination of the charge carriers takes place in the EML and light is emitted

For this OLED stack Novaled intentionally used a classical and commercially available fluorescent blue emitter material. The OLED power efficiency with such materials is usually much less than with phosphorescent emitters, but due to the advantages of the Novaled PIN OLED® technology and proprietary materials a remarkably high value could be reached.

The use of the fluorescent blue emitter material has several advantages. Beside the fact that it is commercially available, it allows very good device stability and guarantees a higher lifetime of OLED devices. Also, it enables a broad coverage of the complete visible colour range, resulting in the very high colour rendering index value.

The OLED sample incorporates Novaled light extraction technology and dedicated material NET 61 thereby enhancing the efficiency and improving the angular dependence of emitted light. By meeting the standards for commercial lighting applications, Novaled's new power-efficient white PIN OLEDs are already ideal for OLED lamps and luminaires for general and design lighting.

"Associating commercially available and robust fluorescent blue emitters with Novaled technology and materials leads to high OLED performances which meet major lighting market needs immediately", says Gildas Sorin, CEO of Novaled AG. "Once phosphorescent blue emitter materials become real commercial products our technology will allow for a further boost in OLED device efficiencies."

Novaled's manufacturing uses standard processes to produce the white PIN OLED device structures. Standard glass substrates with ITO, ordinary evaporation processes and simple outcoupling methods allow for an easy adoption to existing manufacturing lines and for a cost efficient volume production of such devices. ■

Philips Introduces Fortimo to Outdoor Lighting Applications

Philips today announced a new addition to its Fortimo LED family - the Fortimo LED High Brightness Module (HBM). Fortimo LED HBM is an easy to design-in, compact, high lumen LED module for white light applications. The product delivers all the benefits of LEDs without the complexity and recurring R&D costs of lens optics-based LED solutions.

The brand new Philips Fortimo LED HBM LED delivers 4000 respectively 6000lm at CCT 4000, 4100 and 5700

LedLink

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- Wide range of standard optics for different LEDs.
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CREE CITIZEN Micro Humantech EDISON PHILIPS LUMILEDS

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F:+886-2-8227-6127
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The HBM is an “LED lamp” – a compact rectangular light engine which allows for creation of different light distributions using a metal reflector. This LED solution can be used by luminaire manufacturers to develop LED-based luminaires. The design-in is further simplified with one form-factor offering multiple lumen packages, so a single design can be translated into a full portfolio of products.

The Philips Fortimo LED High Brightness Module is a future-proof solution – its light emitting area, optical and electrical characteristics, and mechanical interface will remain constant, incorporating future LED efficacy upgrades.

The high light output (4000 or 6000 lumen) and choice of two color temperatures make this High Brightness Module an excellent solution for both Outdoor and High bay applications. ■

PHILIPS Further Expands Retail Lighting Opportunities with the LEXEL LED SLM System

Philips announces the launch of its Lexel LED SLM tuneable white and RGB modules, enabling the creation of various atmospheres in retail environments with changing tones of white light and different colors from a single light source.

With the LEXEL LED SLM, Philips adds a tunable white solution to its Fortimo SLM module series

As a result of the increasingly competitive landscape, retailers are looking for opportunities to distinguish themselves from the crowd to win customers. Lighting is one of the ways to deliver a differentiating shopping experience. Wouter Boxhoorn, Marketing Manager for Philips OEM Lighting Solutions for Retail, explains: “We added this LED lighting technology to our retail portfolio in order to provide a solution which enables retailers to differentiate with impact and to distinguish their brand to the maximum”.

The Philips Lexel LED SLM tuneable white guarantees precision tuning across thousands of white colour temperatures (2,700K to 4,200K) due to its dedicated intelligent feedback system. The Philips Lexel LED SLM RGB offers a unit gamut colour temperature. Both modules allow color rendering (Ra) of 80 or higher and color consistency between engines across its lifetime of ≤ 5 SDCM.

For retailers, this brings new adaptability to displays, delivering an array of ambiences throughout the store, enabling varied scene setting with accent lighting luminaires. Combining an LED module and dedicated LED driver, along with an optional cable for use in new luminaires, the Philips Lexel LED SLM systems use a fixed form factor, making it fully future-proof. ■

ALT Chandelier Lights for High-End Hotel and Boutique Market

Aeon Lighting Technology Inc. (ALT) is proud to announce its superior Metis LED Chandelier Light has been successfully entered in a famous 5 star hotel and boutique stores in the South Asian territory. ALT not only obtained a firm project deal with chain-hotel operation head-quarters in Singapore, but also has upcoming orders from other branches in Malaysia, Indonesia, and the Philippines which will be confirmed next year. This deal will definitely boost the amount of LED light bulbs being used in the hospitality market.

High Power Chandelier Light—Perfect Solution for Hospitality Industry
Metis Chandelier Light series was launched at the end of last year and went into mass production phase in March. Metis series are only using CREE XP-G and XP-E LED chips for their light source. The light quality and lumen output is superior compared to low power LED candle light. In addition, with ALT’s unique heat sink and power management

Now with ALT's Metis series, chandelier lights are ready to successfully enter the lighting market to furnish luxury 5 star hotels and boutiques

design, the product is guaranteed to have a long lifespan and high power efficiency. Moreover, ALT has adopted a special light pole structure to extend its beam angles to widen its usage. As the result, the Metis series has attracted a lot of attention from interior designer and hotel managers around the world. At the end of June ALT sold the Metis Chandelier Light to a chain of boutiques in Hong Kong and Macau. In the middle of July, the Metis series passed the quality test of a five-star hotel chain in Singapore, and the hotel management is planning to replace all existing incandescent candle lights with LED light bulbs in the coming year. The total saving cost from switching will reach over hundred thousand US dollars.

According to ALT’s general manager, Baly Lo, LED candle light has been widely used in the commercial field, especially for chandelier light fixture in hospitality. Due to the special operation hours of the hospitality business, the lights are left on all day long. This is an incredible expense for hotel owners. Therefore, most high-end hotel owners have already stated their intention to switch from traditional incandescent bulbs to LED lighting to save on operation costs. However, most LED candle lights currently on the market are low power, which means low brightness and quality. Their lifespan is also uncertain. The maintenance and replacement fee would be another cost for hotel owners when they use low power LED bulbs. On the other hand, the Metis series only uses high power LED chips for its light source. The brightness can reach up to 93 lm/W. The light quality and lifespan are much higher than low power LED bulbs. Besides, ALT’s unique heat sink and power management can guarantee energy-saving efficiency. Hotel owners can use this product longer and save more money and energy in the long term. ■

LEISO Introduces "Stereoscopic COB" Replacement Bulb

Leiso Lighting Tech. Ltd. recently launched a light bulb with using an SCOB light source successfully and is now developing the MR16 & GU10 using the reflector and stereoscopic COB light source to increase the lumen output and beam angle while keeping the traditional size & shape of the light.

Leiso's proprietary SCOB technology allows a wide light distribution angle of 300 degrees in LED replacement bulbs

Features of LS-BA606-6W:

- Voltage available: 85-265 VAC 50-60 Hz
- CE certification and RoHS compliance
- Color temperature: 2700 K~5000 K
- Color rendingindex: 76
- Luminous flux: WW: 360 lm/ W: 420 lm
- Power consumption: 6 W
- Beam angle: 30°
- Base: E27/E26
- Material:6063 aluminum
- Average lifetime: ≥35000 hours

New ILD 4001 step-down LED controller – perfect fit for various lamps and general lighting systems

This brand new product offers you maximum design flexibility.

- Scalable output stage with external MOSFET up to 5A
- Choice of dimming concepts – PWM or analog voltage
- Supply voltage for 12V, 24V and 40V applications
- Overcurrent, overvoltage and thermal protection

To learn more about the LED driver portfolio for General Lighting, please visit [www.infineon.com/lowcostleddrivers]

While COB is a wide spread technology, SCOB is a new approach introduced by Leiso. This new patented light source was designed and developed by Leiso's R&D team to achieve over 300 degrees of viewing angle to overcome the hurdle of the inadequate narrow beam angle of 120 degrees used in most replacement LED bulbs on the market that causes insufficient light distribution.

New FZLED's PAR38-03 Series LED Spotlights with Cree LEDs

FZLED, maker of high-performance LED lighting products, reveaed a stunning new range of 22-Watt LED Spotlights featuring cutting edge long-lifetime high power Cree LEDs. The PAR38-03 series is a simple money-saving plug-and-play replacement for inefficient traditional lights in E27/E26 sockets. Options include both switch dimmable and non-dimmable versions, with a clear or frosted lens.

IMG: FZLED's new 22 W PAR38 Series LED replacement lamps uses Cree LEDs to provide 1300 to 1500 lumens

Applications:
- Indoor lighting
- Architectural lighting
- Mood lighting
- Flood lighting
- Easy E26/E27 socket replacement

Features:
- Energy saving
- Dimming or non-dimming
- No heat, no UV, or IR light radiation
- Ra > 75 for white light
- E26/E27 socket compatible
- High power driver efficiency > 80%
- CE, FCC and ETL approved

The PAR38-03 series is the clear lighting choice for all interior locations with a choice of both a warm white (FZL-PAR38-03-WW-22) and a cool white (FZL-PAR38-03-CW-22) version. The WW-22's warm 3000 K illumination provides 1300 lm with a Color Rendering Index (CRI) of more than 80, while the CW-22 achieves 1500 lm with its bright 6000 K beam.

FZLED puts lighting power back into the hands of the customer. Users of switch dimmable models can quickly choose their desired brightness by pressing the power on/off switch to step through the four options: 12%, 25%, 50%, or 100% of full light intensity.

In all models, easily selectable beam angles of 120°, 60°, 40° and 25° make the PAR38-03 series the most versatile choice for all indoor, architectural, mood and flood lighting applications. These spotlights can accept a wide range of input voltages, from 100 to 240 volts.

Thanks to their ultra low-maintenance Cree LEDS and durable, stylish aluminum and plastic housings, FZLED's latest LED spotlights are clearly built to outlast the competition even as they save energy for users.

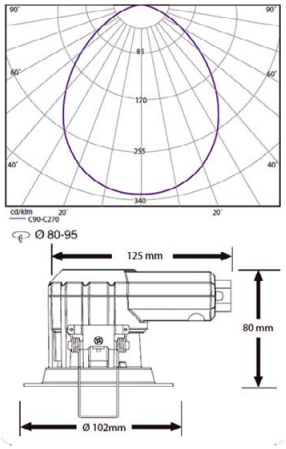
Cree Revolutionizes International Lighting Market with 100mm LED Downlight

Cree, Inc. announces the industry's first system-level LED downlight for the international 80 to 100 mm MR16 market. A direct replacement for the 50 W MR16-based fixture, the Cree CR100™ downlight surpasses its antiquated counterpart in brightness and efficacy. Commonly used in residential and retail lighting applications, Cree estimates there are nearly 1.5 billion MR16 lamps in Asia, Australia, and New Zealand, representing a tremendous opportunity to save money on energy and maintenance, using the high-quality LED light only available with Cree TrueWhite® Technology.

"Customers that demand high-quality light have been disappointed with the current LED products in the market," said Raymond Lau, Tachibana Engineering (HK), Ltd. "The Cree CR100 fixture changes that by enabling customers to replace high-lumen MR16 tungsten lamps with an energy efficient LED fixture that delivers beautiful light."

The CR100 fixture has an output of 650 lumens while consuming just 11.5 watts delivering minimum efficacy of 52 lumens per watt, which combined with a CRI of at least 90 and featuring integrated dimming, sets a new industry benchmark for beautiful, highly efficient LED light. Available in shallow and deep recess models, the CR100 product is designed to handle heat dissipation in an enclosed environment, a key factor in LED fixture lifetime ratings. Featuring a five-year warranty, the CR100 downlight is designed to last at least 50,000 hours compared to a traditional 50 watt MR16 fixture, which has a lifetime of about 2,000 hours.

"Cree is once again driving LED lighting adoption with the launch of the CR100 fixture," said Francis Cheng, sales director for Asia-Pacific, Cree. "Customers looking to implement LED lighting no longer have to trade off beautiful light for increased efficiency."



CREE's new CR100™ series downlights, here the CR100-SR650L, offer several features like a built-in color management system to maintain color temperature over the entire working life or the tool-free installation

Future-proof, high quality and progressive LED technology for offices.

Designed to give you the highest energy efficiency and comfortable white light, now and in the future. Many leading manufacturers already use Fortimo as the trusted light source in their luminaires. See why at philips.com/fortimo

PHILIPS
sense and simplicity

FuturoLighting Introduces Smart LED Luminaire Based on Cree XLamp® ML-E LED Solution

FuturoLighting, a new company focused on LED lighting solutions, introduces Aurora a fully autonomous, motion detecting, lighting application which uses Cree's latest XLamp® ML-E LED. Due to its immediate light output and no lifetime limitation due to switching, Aurora offers advantages over traditional incandescent and fluorescent light sources as well as improved reliability due to its solid-state construction.

FuturoLighting's Aurora luminaire is fully autonomous, motion detecting with easy max/ min ambient light threshold setting

Aurora has a simple setup using its microcontroller with integrated high resolution control over light output levels, ambient light threshold, dimming functionality, and gamma correction which improves visual comfort. Once the desired settings are set the Aurora doesn't need to be adjusted again. It can be installed in any location that is dry and has a standard wall outlet. Suggested applications are under cabinet lighting (kitchens, shelves, desks, etc.), smart illumination for galleries, museums, cupboards, stair illumination, architectural lighting and many others.

"We're thrilled by the innovative products our customers are developing," says Yuri Dorozhkin, Regional Sales Director Eastern Europe at Cree. "From our perspective, solutions such as Aurora prove that offering specific LEDs for a variety of applications is the right strategy to further promote the LED lighting revolution."

FuturoLighting plans to extend the range of Aurora lighting solution to various models and configurations, including indirect range, all according to customer needs and expectations. ■

Digital Lumens Expands Intelligent Lighting System Product Line

Digital Lumens, the leader in intelligent lighting systems, today expanded its product line with new 15,000-lumen Intelligent Light Engines (ILEs) for highbay and midbay applications. Designed for industrial facilities with higher ceilings, high foot-candle requirements and/or wider spacing of fixtures, the new systems increase delivered light by more than 50%. Available now, the new fixtures feature Digital Lumens' system-wide intelligence, which is proven to maximize energy efficiency and deliver lighting energy reductions of up to 90 percent.

Also unveiled today is the latest version of LightRules, the company's lighting management software, which provides commercial and industrial staff with the flexibility to effectively manage lighting resources. The latest version of LightRules adds new capabilities specifically designed to support large-facility deployments:

- A calendar view for easily scheduling and managing lighting programs and profiles;
- The ability to wirelessly move lights from one network to another to support changes in facility use;
- Data report exports in a number of file types, including csv spreadsheet files, simplifying the measurement and verification phase of utility rebate programs, and supporting ongoing facility management and improvement initiatives;
- Advanced diagnostic tools for monitoring system performance.

"Our global customers have a broad range of environments and evolving lighting requirements, which we are committed to addressing across our Intelligent Lighting Systems," said Michael Feinstein, Digital Lumens' Vice President of Sales and Marketing. "For customers who are building taller facilities, have higher light-level requirements, and those who have extra-large facilities, these latest additions make Digital Lumens the only logical choice for maximizing light while minimizing power use."

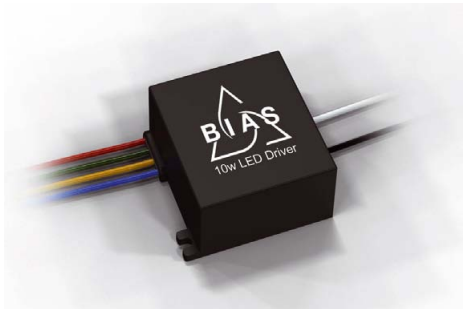
Digital Lumens expanded its product line with 15,000-lumen Intelligent Light Engines (ILEs) for highbay and midbay applications

Designed specifically for rugged industrial environments, the Digital Lumens Intelligent Lighting System typically replaces 400 W HID, HPS or HIF highbay lighting fixtures and reduces lighting energy use by up to 90%. Installed as 1:1 retrofits of legacy fixtures and in new construction, the Digital Lumens System is a smart LED lighting solution that delivers unmatched savings and lowest total cost of ownership (TCO) to customers in numerous industries - cold storage, manufacturing, warehousing and others. ■

Dimmable 10 Watt, AC-DC LED Drivers Meet Harsh Requirements

Bias Power's new 10 watt BPOXLD10 LED drivers offer 350 mA constant current operation with 1% regulation over the entire input voltage range of 100-308 VAC, 50/60 Hz. LED string voltages up to 30 VDC at 350 mA or 14 VDC at 700 mA are supported. The drivers are dimmable and adjust output current based on either 0-10 VDC reference or ELV/Triac tracking. A constant-voltage version handles LED string voltages up to 12 VDC. Either is compatible with digital control circuitry.

Unlike conventional LED drivers, the BPOXLD10 has unique cold-starting circuitry, tested to -55°C; proven to kick-start LEDs in extreme cold. The modules meet NEMA 6P / IP67 moisture and submersion and easily satisfy the strict requirements for outdoor architectural, building and low-bay garage LED lighting. Rated for 3,000VAC isolation, they feature inherent over-current; short circuit (shorted string), overload and open circuit (string break) protection.



Bias Power's new BPOXLD10 LED drivers complement the recenty introduced BPWXL Series 10 Watt constant current LED driver

These capabilities combine to make a superb solution for high-reliability indoor and outdoor LED lighting fixtures.

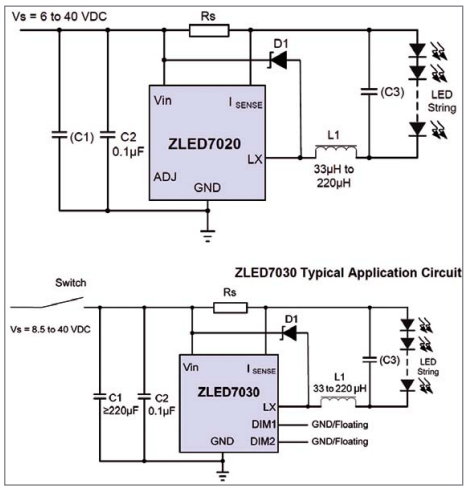
All modules are specified for full-rated power over the temperature range of -40 to +85°C. The nominal 82% efficiency results in some of the highest lumens/watt, end-to-end efficacy ratings for LED solutions in the market today. Performance is based on Bias' patented* circuit design, incorporating its own custom ASIC controller.

The ultra-compact square design gives lighting designers options not possible with longer, rectangular packages. The BPOXLD10 measures 2.1 x 2.3 inches, with a height of 1.25 inch. Standard connections are by 11- inch, 18AWG color-coded "flying leads," with dual-mounting slots to simplify installation.

Bias Power LED Driver modules comply with UL/CSA and EN Product Safety Requirements (UL8750 Class 2) and meet conducted EMI emissions EN 55022, Class B and FCC Part 15, Class B. The modules have an MTBF rating of >500K operating hours.

ZMDI Introduces 98% Energy Efficient LED Driver IC for Retrofit LED Lamps

ZMD AG, a global supplier of energy-efficient analog and mixed-signal solutions, has announced availability of the ZLED7320, a new member of its high current ZLED7x20 family of 40 V LED-Driver-ICs. The ZLED7320, which operates at up to 98% efficiency and is available in a small-footprint DFN-5 package, is designed to help manufacturer's cost-effectively address the growing high-brightness (HB) LED lighting market.



ZLED7X20 block diagram with basic application circuit with output current determined only by Rs

"The ZLED7320 bridges the gap between our existing 0.75 A and 1.2 A high-efficiency drivers while the small-footprint package provides easier assembly" stated Dr. Hendrik Ahlendorf, Product Manager at ZMDI. "The ZLED7320 provides an ideal solution for many cost- and size- sensitive applications, including Retrofit LED lamps, signage, street and traffic lights, spotlights, appliance lighting and all types of general home and office illumination".

The LED driver features on-chip switching transistor, 1200:1 dimming via PWM signal or fixed voltage, up to 1 amps of output current at +/- 3% accuracy and high-side current sensing. Built-in protection includes thermal shutdown, open-circuit and short-circuit protection. Due to its output current capabilities, the ZLED7320 supports the new high brightness and high current LEDs from major LED manufacturers without requiring an additional MOSFET to the application circuit. Only the addition of 4 passive components is required for a complete LED driver solution. The device operates at a temperature range of -40°C to 105°C.

The DFN-5 package simplifies board assembly and offers improved packing density for area- or volume- constrained systems. Thanks to its compact size, manufacturers can develop innovative new products and applications where efficient high-brightness LED solutions are a market advantage.

ZMDI has also introduced the ZLED7330, a high-current 40V LED driver with user selectable switch dimming suitable for high brightness LED lighting applications and the ZLED7002, a dual channel LED Driver with supply voltage switchable channel toggling suitable for extended-life battery operated portable LED lighting applications. Both the ZLED7330 and the ZLED7002 are in full production and complete evaluation kits are available. ■

MEAN WELL Extends Metal Case LED Power Supply Series to Higher Power with its 320W Models

After launching the new generation of high efficiency metal case LED power supplies at lower wattage range, MEAN WELL continuously introduced the 320W models~HLG-320H series, to fulfill the demands of high wattage LED lighting applications.

Featuring 90~305 VAC wide AC input range, HLG-320H series not only fit for general 115 VAC or 230 VAC main input, but also can be operated under 277 VAC input in North America. HLG-320H has five options (A/B/C/D/blank type) in different mechanisms and functions for your selection. For A/C type

Multiple Models:

Model	IP	Input/ Output	Vo/Io Adjustment
HLG-320H-xA(Standard)	IP65	Cable	Vo/Io can be adjusted by internal potential meter
HLG-320H-xB(Standard)	IP67	Cable	Io can be adjusted by 1~10 VDC, PWM or resistance
HLG-320H-xC(Standard)	Non	Terminal	Vo/Io can be adjusted by internal potential meter
HLG-320H-xD(Optional)	IP67	Cable	Io can be set as multiple stage timer dimming by customer's request
HLG-320H-x (Standard)	IP67	Cable	Not adjustable

MEAN WELL HLG-320H series high efficiency metal case LED power supply

designs, users can adjust DC output voltage range from 90% to 110% and current range from 50% to 100% by removing the rubber stopper on the cover; B type equips with three-in-one dimming function (1~10 VDC, PWM, resistance) and D type (optional) equips with "multiple stage timer dimming" function that can be customized by request; while Blank type has basic features without voltage and current adjustment function. In addition, in order to fit in with the outdoor harsh environment, aluminum case and stainless screws are designed in these new 320 W LED power supplies.

Features:

- Wide range input 90~305 VAC
- Aluminum case and potted by glue, comply with IP65/67
- Output voltage and current adjustable
- Meet 4 KV surge immunity level (EN61000-4-5)
- Built-in active PFC function, comply with EN61000-3-2 harmonic Class C (>50% load)
- 95% extremely high efficiency
- 3 in 1 dimming function: 1~10 VDC / PWM signal / resistance (B type)
- Cooling by free air convection
- Protections: Short circuit/Overload /Over voltage/Over temperature

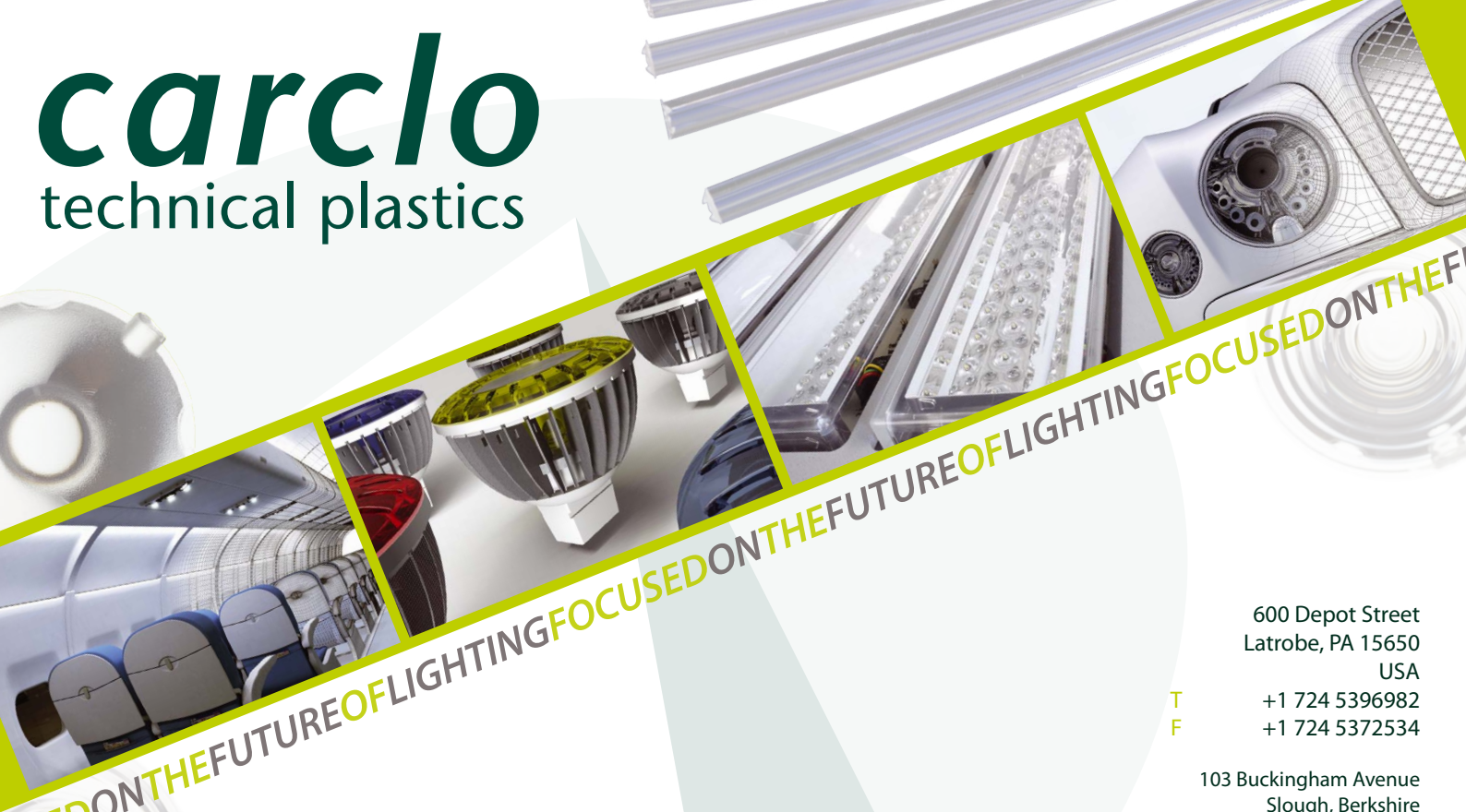
With up-to date LLC topology and synchronous rectifier technology, HLG-320H possesses up to 95% of extremely high efficiency, so it can be cooled by free air convection from -40°C to +70°C ambient temperature that meets the requirements of outdoor installation. Standard functions include protection for short circuit, over voltage, overload, and over temperature. These power units have five options (A/B/C/D/blank type) in different mechanisms and input/output designs that I/O connection can be cable type or terminal block, which allows users a flexible installation in various systems. These high efficiency power supplies are suitable for LED street lighting, LED high-bay lighting, outdoor electronic display, LED decorative lighting, indoor/outdoor LED lighting…etc. They are also good solutions for general applications at outdoor environment with high dust and moisture. ■

LUXdrive™ Announces its Smallest High Current Boost Driver

LUXdrive is pleased to announce a further addition to its line of high power, constant current drivers with the full release of the A011 FlexBlock™ LED driver.

The device, configurable in either boost only or buck-boost modes, is ideal for driving the new high-brightness, high-power LEDs and LED arrays. It is available in 350mA and 700mA versions and, with the same small footprint and extremely low profile (2.0" x 1.2" x 0.38") as the previously announced A009 BuckBlock™, the A011 is the smallest high current boost driver available.

LUXdrive™ claims the A011 to be the smallest high current boost driver available



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The FlexBlock™ module operates from an input voltage of 10 to 32 VDC and provides a maximum output voltage of 48 VDC.

In many applications, it can be operated with no additional heat sinking. An attachment point for a thermocouple or other temperature sensor is indicated for ease in determining the need, if any, for additional heat sinking. Fully protected against reverse polarity, output short circuit, and ouput open circuit, the A011 is also fully dimmable and is compatible with many commercially available 0 to 10 VDC low voltage dimming controls.

The A011 can be used in a wide variety of LED lighting applications that include architectural, solar, accent, track, automotive, marine, desk and reading, point of purchase, signal and marker, cabin and display, and more.

Updated LINEARdrive Gives Increased Design Freedom and Future Proofing

eldoLED's LINEARdrive 720D - the number one choice for full-colour LED applications in architectural, façade, entertainment and stage lighting - has been upgraded to support 5 V, 12 V, 24 V and 48V LED strips. The LED strips can even operate concurrently, giving designers increased freedom and future proofing for the installation. The LINEARdrive, which dims down to as low as 0.1%, can be used with all leading protocols (DALI, DMX, DMX/RDM, 0-10 V). A wealth of configuration settings is set over the user-friendly user interface.

eldoLED's LINEARdrive 720D is intended to serve "full-color" LED applications

LINEARdrive 720D (LIN720D2) Features:

- runs 5 V, 12 V, 24 V ánd 48 V LED strips, even concurrently
- offers RDM support (explore & address, ANSI E1.20)
- delivers great dimming and color fade smoothness in every situation
- supports choice of dimming curve to suit your control device
- can be completely configured via 3-button user interface
- upload of your show sequences for use in standalone mode through ShowMaster

Thanks to the driver's Remote Device Management support, you can easily track down and address your luminaires from an RDM capable DMX controller. No need to open luminaires to re-address the driver during installation or re-commissioning.

When using the LINEARdrive in a DMX network, you can easily configure it to get the light output response that fits the dynamic effects of your application, even if you have to work with a DMX controller whose signal quality is not the world's greatest. No matter which type of application you have, be it 'video snappy' or 'lava lamp smooth', the LINEARdrive will deliver the effect you want.

Pharos Launches New Touch Panel Controller

Pharos Architectural Controls has announced the new Pharos Touch Panel Controller. The TPC is an advanced, standalone, solid state lighting controller with an integrated 4.3" customizable touch screen, 512 channels of eDMX output and vast interfacing potential all over a single PoE network connection.

Main Features:

- Realtime control of playback selection and lighting levels - gracefully transition between scenes, sequences, effects and pixel-mapped media
- Customizable touch screen user interface - create multiple pages of controls and configure their appearance and visual feedback
- Triggering and show control via touch screen, learning IR sensor, temperature sensor, ambient light sensor, proximity sensor, Ethernet, realtime and astronomical clocks
- Conveniently and intuitively programmed and simulated in Designer on a PC or Mac. Graphical user interface created in Interface Editor and all uploaded over Ethernet
- One universe of eDMX output directly to KiNet, sACN, ArtNet and Pathport fixtures. Optional remote devices for DMX, DALI, linear timecode, audio, MIDI, serial ports, digital/analog inputs and relay ouptuts
- Remote management and control via built-in web server. Monitor, trigger and reprogram units remotely and securely over the Internet using a web browser or Pharos Installation Manager
- LPCs & TPCs seamlessly network together for synchronized control on larger systems with multiple controllers
- Elegant wall mounting, solid state, instant-on, lighting control solution
- 5 year warranty

Programmed in Pharos Designer, the TPC has the same advanced playback and show control engine as the popular and award winning Pharos Lighting Playback Controllers. Over an Ethernet network it can interface with other Pharos controllers, button panels and remote devices. The companion Interface Editor application allows you to build themed user interface pages, creating and organizing multiple pages of buttons, sliders and colour pickers to suit the installation and customer needs.

The Pharos TPC has the same advanced playback and show control engine as the Pharos Lighting Playback Controllers

The wall-mounting design features a magnetic overlay within the plated bezel to produce a modern, streamlined design; a variety of finishes and overlays will be available. The TPC is a Power over Ethernet (PoE) device and therefore requires just one cable to install. It controls networked eDMX fixtures, integrates with building management systems, serves web apps to mobile devices and allows remote management over the Internet. Built-in environmental sensors can be used to influence screen behaviour and as triggers for lighting events.

Pharos product manager Liz Cecil says, "The TPC is an exciting addition to our range of controllers at a very competitive price. With the TPC we are delivering an elegant, fully-featured lighting controller, with an integrated, capacitive touch screen - it will be a perfect solution both for smaller installations and as a touch screen interface for larger Pharos control systems." ■

Essemtec Doubles Speed and Accuracy: Scorpion Automatic Dispensing System

Essemtec introduces the new Scorpion automatic dispensing system in August 2011. The machine is built on the Paraquda machine base, which enables highly accurate dispensing and performance of up to 100,000 dots per hour. The machine can be equipped with up to four different dispensing valves and is designed for flexible and productive dispensing in electronics manufacturing, LED assembly and other industries.

New machine base increases speed and accuracy:
The Scorpion can dispense up to 100,000 dots per hour with an accuracy of ±25 µm (3σ). The exceptional performance is achieved due to the new dispenser base, the Paraquda machine platform. Its XY-portal is built on a robust mineral cast chassis that provides excellent damping and smooth motion at high speed. The H-Drive features precision linear measuring devices to guarantee highest accuracy for demanding tasks.

The XY-drive is so powerful that it can move up to four independent dispensing valves simultaneously. This minimizes changeover time between different applications and allows multiple media to be dispensed in one run.

Twin dispensing:
The Scorpion implements a Twin Dispensing mode for the production of high volumes. Two valves can dispense simultaneously on two different locations, the distance between the valves is adjustable. Typical Twin Dispensing applications include LED manufacturing and electronics assembly with multiple printed panels. When the distance between two panels is constant, two jet valves can apply glue dots simultaneously. Twin Dispensing can double throughput for such applications.

Freedom of motion:
The working range of the Scorpion is bigger than most other dispensing systems. The dispensable area is specified at 650 x 500 mm (25.6 x 19.7") for a standalone machine and 510x470 mm (20x18.5") for inline machines. However, the working area can be used flexibly and can be equipped with

Essemtec's new Scorpion automatic dispensing system for LED assembly, electronics manufacturing and other industries

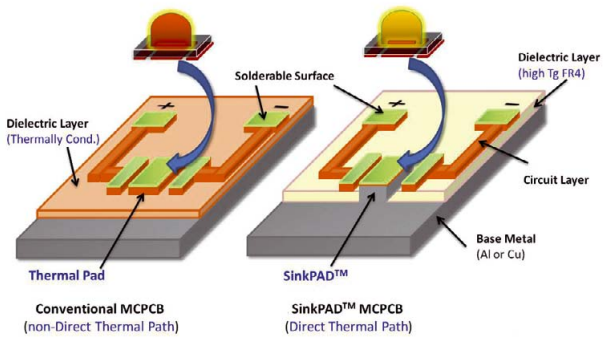
customer-specific substrate holders. Each of the dispensing valves (maximum of four) is equipped with an independent, highly accurate C-drive with a 85 mm stroke (3.34"). As such, the Scorpion can dispense on multiple levels, and it can dive into cavities or vault over components.

Any metering valve:
Almost any kind of dispensing valve can be used with the Scorpion. Standard valves include Time-Pressure, Archimedean Screw and Piezo-Flow-Valve for solder pastes. The ideal valve for an application is determined by the user or by process specialists. The maximum performance of the Scorpion is achievable with Jet valves that allow drops to be shot over several millimeters and, therefore, does not need vertical motion.

Needle distance control with laser sensor:
When dispensing with a needle the distance between the needle and the substrate is one of the most important process parameters. If the substrate is warped, a constant distance must be guaranteed. For this, Scorpion includes an accurate, fast regulation system. A high precision laser sensor scans the substrate prior to dispensing with an accuracy of 1 µm. During dispensing, the position of the dispensing head is automatically corrected and follows the surface.

Simple for operators,flexible for specialists:
The graphical user interface of the Scorpion makes setup and production easy tasks for the operator. The process specialist, however, can still influence all dispensing parameters and can fine tune the dispensing process as desired. Programming is possible by teach-in, by importing coordinates or using pick-and-place data. The latter are automatically converted into dispensing programs with the use of the integrated template library.

Proven system with potential for the future:
The Paraquda pick-and-place, which has proven its reliability in many electronics production facilities worldwide, is the base of the Scorpion Dispenser. The Scorpion not only is a fast, accurate dispensing machine, it also is a safe investment. Essemtec's engineers have used the most modern, accurate systems that drive and steering technology can offer today. Future developments will be based on the platform. Therefore, the Scorpion not only meets today's dispensing application requirements but also those of the future. ■



SinkPAD's PCB design makes a great difference to thermal management efficiency

SinkPAD Corporation Introduced New Aluminum PCB Applications at the LEDshow in Las Vegas

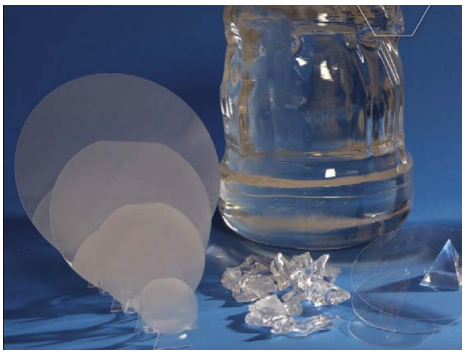
SinkPAD corporation's new thermal technology printed circuit boards, which were introduced at the LEDshow in Las Vegas, are a complete and effective solution to the challenges faced by the solid state lighting industry, specifically those with aluminum LED PCB applications.

Available now, the new SinkPAD™ technology significantly improves LED thermal management in all LED systems. It is most effective in high-power high-bright surface mount LED systems; those systems that cannot efficiently dissipate heat thus making them unviable for commercial systems.

SinkPAD™ conducts heat out of the LED system (LED cooling) by enabling a direct thermal path between the LED and surrounding atmosphere, which eliminates thermal resistance introduced by the dielectric material in a traditional IMS PCB or MCPCB. The SinkPAD™ design completely removes the substance with the lowest thermal conductivity/highest thermal resistance from the structure. SinkPAD™ still uses a dielectric, but this dielectric isolates the metal base electrically and leaves it thermally connected. The thermal path should be electrically neutral within the LED package, i.e. Cree XLamp, Luxeon Rebel from Philips Lumiled, PhlatLight from Luminus, in order to solder the LED directly to the SinkPAD™. ■

Rubicon Technology Supports Large Diameter Sapphire Demand for LED Industry

Rubicon Technology, Inc., a leading provider of sapphire substrates and products to the LED, RFIC, Semiconductor, and Optical industries, today announced that the company has completed a company-wide installation of enhancements to its proprietary crystal growth furnaces bringing all furnaces up to Rubicon Furnace Version ES2-XLG3.0. This is the latest version of the company's proprietary furnace design for the production of high quality, large diameter sapphire material and provides even greater automation and yield consistency.



Rubicon now offers a complete range of high quality sapphire substrates

Over time, the company's Design for High Volume Manufacturing (DHVM) approach has led to numerous furnace design improvements that have created an industry-leading equipment platform for high volume sapphire crystal growth. Rubicon Furnace Version ES2-XLG3.0 provides even greater automation resulting in additional yield improvements. The ES2-XLG3.0 encompasses numerous innovations and now operates in Rubicon's United States high-efficiency crystal growth facilities in Batavia and Bensenville, Illinois.

"Compared to the production of other substrate materials, sapphire crystal growth is extremely complex," explains Raja Parvez, Rubicon President and CEO. "Variables such as stable power, growth profiles, cooling profiles and feedback controlmechanisms must be optimally managed to maximize the yield of quality sapphire crystal. This is even more vital when producing sapphire for the expanding large diameter wafer market. With hundreds of years of combined experience and innovations such as those embedded in the Rubicon Furnace Version ES2-XLG3.0, Rubicon's design and equipment engineers and material scientists have achieved industry leading yields and performance."

The Rubicon furnace design is just one component of the company's efficient equipment platform that has differentiated the company in the large diameter sapphire wafer market. This effort, combined with Rubicon's robust process platforms and the company's ability to scale to high volume, creates superior performance factors for the LED industry. With the Batavia crystal growth facility qualified with more than a dozen customers and the Malaysia polishing facility now also qualified, Rubicon has successfully shipped more than 100,000 six inch sapphire wafers.

The transition to larger diameter wafers in LED production has started. Several key LED chip manufacturers have announced plans to migrate to and/or test large diameter wafers in 2011/2012. ■

Translucent Announces Availability of vGaN™ Wafer Templates

Translucent, Inc., announced the commercial availability of its vGaN™ family of silicon-based wafer templates. The vGaN products provide a low-cost, high-quality epitaxial surface for the growth of gallium nitride (GaN) devices such as light-emitting diodes (LEDs) or field-effect transistors (FETs).

The vGaN product line is the world's first commercial REO-based family of 'III-N semiconductors' with scalable GaN-on-Si wafers. Translucent's use of crystalline REO layers provides stress relief and wafer flatness through customized lattice engineering, leading to a high quality growth surface.

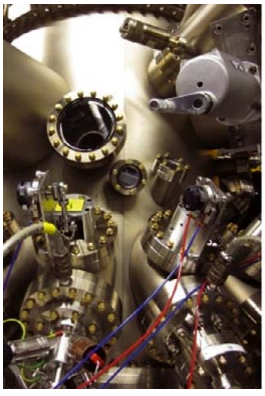
vGaN stands for "virtual gallium nitride." It provides a semiconductor growth surface that has the physical properties of GaN, but utilises a silicon substrate upon which is grown an epilayer of REO material that accommodates a top epilayer of Group III nitrides such as GaN. The vGaN substrate enables for the first time, industry-standard MOCVD growth processes with the low cost structures and economies of scale currently enjoyed by the silicon industry.

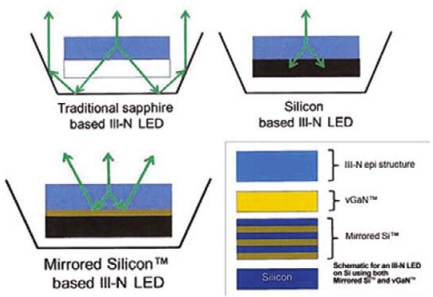
Michael Lebby, Translucent's general manager, noted, "We are bringing a decade of Translucent REO epitaxial experience to bear on the challenge of enabling GaN growth to scale cost-effectively well beyond current limitations. Our vGaN platform is an 'on-silicon' technology, allowing us to harness mature silicon-substrate technologies and their low costs, and we expect this to have an extremely beneficial impact in driving down costs for GaN-based LEDs and FETs."

GaN is typically grown on sapphire substrates, which are significantly more expensive at large diameters, especially 200 mm and larger. Additionally, a major challenge facing device manufacturers today is the handling of the large, heavy, and expensive sapphire wafers. Conversely, the widely-used infrastructure of fabrication plants that are ready to run silicon wafers up to 200 mm already exists. This makes large-diameter silicon an ideal choice to bring economies of scale into the lighting (LED) and power electronics (FET) industries.

Translucent's vGaN wafers are now available in 100 mm diameters.. 150 and 200 mm will be available next year.. ■

Translucent's GaN-on-Si wafers, called vGaN (stands for "virtual gallium nitride."), provide a semiconductor growth surface that has the physical properties of GaN



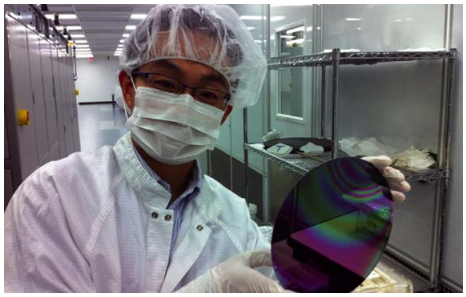


BRIDGELUX: New Efficiency Record for GaN-on-Silicon LEDs

Bridgelux Inc., has shattered its previous industry record for highest Lumen per Watt values for Gallium Nitride on Silicon (GaN-on-Si). Using its proprietary buffer layer technology, the company has demonstrated growth of crack-free GaN layers on 8-inch silicon wafers, without bowing at room temperature, extending the company's lead in driving the performance and manufacturability of GaN LEDs on silicon substrate.

Bridgelux is demonstrating LED performance levels comparable to today's state-of-the-art sapphire-based LEDs. Cool white LEDs showed efficiencies as high as 160 lm/W at a CCT of 4350 K. Warm white LEDs constructed from the GaN on Si chips delivered 125 lm/W at a color temperature of 2940 K and CRI of 80.

Conventional LEDs are made using sapphire or silicon carbide substrates as the starting material. Both are more expensive than silicon. As a result, production costs have inhibited the widespread adoption of LED lighting in homes and commercial buildings. But growing GaN on larger, low-cost silicon wafers that are compatible with modern semiconductor manufacturing can deliver a 75% improvement in cost over current approaches. Bridgelux's technology process has the potential to significantly drive down the cost of manufacturing LEDs and make them competitive to conventional white lighting technology.

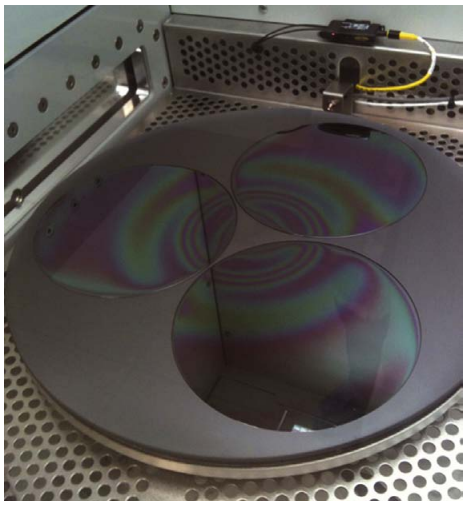


Growing LEDs on low-cost large diameter silicon substrates needs special knowledge

"The performance levels that we announced today are the highest Lm/W values yet published for GaN-on-Si and rival the best commercial LEDs grown on sapphire or silicon carbide (SiC)," stated Dr. Steve Lester, Bridgelux chief technology officer. "We are very pleased with the pace of our progress in this area, and we will continue to aggressively develop our GaN-on-Si processes."

The thermal expansion coefficient of GaN is considerably larger than that of silicon. This mismatch can cause the epitaxial films to crack, or the wafers to bow, either during epitaxial growth or at room temperature. Bridgelux's proprietary buffer layer process produces crack-free wafers that are virtually flat at room temperature.

Encapsulated 1.5 mm blue LEDs emit 591 mW with wall plug efficiencies as high as 59% at 350 mA, exceeding any published values. The LEDs have very low forward voltages, 2.85 V at 350 mA, making them ideal for use at high current densities. At a drive current of 1 amp the LEDs emitted 1.52 Watts of blue power at a forward voltage of 3.21 V, resulting in a wall plug efficiency of 47%. Wavelength uniformity of sigma 6.8 nm has been demonstrated for 8-inch LED wafers with median wavelength of 455 nm.



An optimized epitaxy process on 8-inch Si wafers will make LED manufacturing compatible with existing automated semiconductor lines

"This key innovation is a game-changer for the industry, delivering dramatic reductions in the up-front capital investment required for solid state lighting and thereby significantly increasing the rate of market adoption." said Bill Watkins, Bridgelux CEO. "Bridgelux, which maintains an asset-light operating model, is uniquely well-positioned to benefit from the transition to silicon substrates. Leveraging our R&D and Intellectual Property position in LED epitaxy will allow the Company to pursue partnerships with existing semiconductor manufacturers. That has the potential to favorably impact production costs, margins and returns on invested capital."

LpS 2011 - Focusing on the Light Source of the Future

From September 27th to 29th, 2011 the LED Lighting Technologies Symposium in Bregenz, Austria will offer developers, buyers, users as well as researchers, suppliers of LED and system solutions, distributors, and others an information and communication platform focused on the implementation of LEDs in lighting applications.

LpS 2011 is the first symposium that focuses exclusively on LED lighting technologies

There is finally a trade show and symposium focusing exclusively on the subject of LED lighting. The LED professional Symposium + Expo 2011 – also known as LpS 2011- will be host to the LED community on September 27th -29th in Bregenz, Austria – directly on the shores of Lake Constance.

“LED technology for lighting applications needed its own international platform, and now there is the LpS 2011,” explained the person responsible for the focus of the event – the symposium director, Siegfried Luger. “Just like the “Embedded World” event in Nuremburg has become the event for the embedded community, the LED professional Symposium has the potential to become the leading trade fair and the most important European event focused on LED technology for lighting applications.”

Worldwide, LpS 2011 is the first symposium that focuses exclusively on the subject of Solid State Lighting in the nature of active, passive, mechanical and optical components. A considerable number of experts in the areas of specific tools as well as the complex subject of Measuring/Testing/Manufacturing will be attending. Four of the world’s biggest LED manufacturers are amongst the over 60 exhibitors at the fair. Fifteen media partners from Germany, France, Great Britain, Austria, Switzerland and the U.S.A. are all supporting the event.

Wide Range of Lectures
The range of lectures at the symposium, under the motto of “LED Lighting Technologies – Winning Approaches” covers the entire range of topics that Solid State Lighting encompasses: Starting from electroluminescent diodes in the areas of research and practice, to optics and driver IC’s, on to heat sinks, substrates and complete steering modules. Other topics that will be discussed are commercial aspects, the corresponding design and configuration tools, testing and measuring instruments as well as production technology aspects.

Three Keynote-Speeches
On the first day, a three part workshop sets the stage for the official opening and three keynote speeches. These will touch on the topics of possibilities and challenges that LEDs bring for luminaire manufacturers as well as the “Challenges of LED Lighting Systems”. The third keynote speech will be given by Prof. DDr. Sergei Ikovenko from the Massachusetts Institute of Technology (MIT) in Boston. He will be talking about the technological evolution in the area of LED lighting.

Technology, Components, Testing and Systems
The second day of the symposium starts off with LED technologies. The afternoon will focus on electronic and optical components whereby the subjects of customized and free form optics and the effects of material variations in synthetic lenses and cost optimized optics will be presented. In the area of electronic components the subjects will be drivers, spectral tuning, design perspectives for controlling and special printed circuit board technologies.

At the end of the second day the Gala Dinner not only offers the participants a festive evening, but also presents the chance for an additional communication platform.

Three sessions on the subjects of Testing/ Measuring/Manufacturing, LED Lighting Systems and Standardization/Reliability round the symposium up on the third day. The last of the presentations will be about standardization, norms and the selection of LEDs in order to guarantee quality and reliability.

Further information and Registration:
LED professional Symposium + Expo 2011
27. bis 29. September 2011
Bregenz/Österreich
www.lps2011.com

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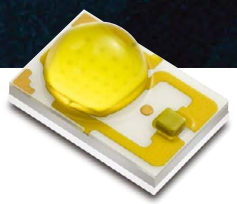

Transforming Light

LUXEON LEDs are changing the way we light the spaces we live, shop and play in. With unparalleled efficiency, quality, and reliability, LUXEON LEDs are a simple way to transform lighting and improve the well being of our environment.

Whether you're lighting a restaurant, roadway or architectural masterpiece, you can count on LUXEON to deliver long life, high-quality white light while reducing energy consumption.

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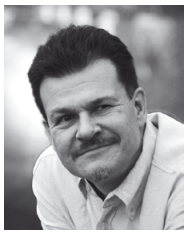
LpS 2011 Advisory Board Q & A

Siegfried Luger, CEO of LED professional asked the Advisory Board questions about what they expect from the symposium and the technological trends and challenges in LED lighting.



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Chief Editor,
LED professional

Dr. Paul Hartmann
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Joanneum
Research

Nisa Khan, Ph.D.
President,
LED Lighting
Technologies

Dr. Günther Sejkora
Managing Director,
Kompetenzzentrum
Licht

What does LED technology mean to luminaire manufacturers and the lighting industry as a whole?

Dr. Günther Sejkora
Through the implementation of LED technology, completely new applications, like RGB color changing lighting can be developed. A large number of innovations for known applications like shop lighting, office or street lighting are also made possible by LED technology.

At the same time, the framework of suppliers and distributors also starts to change. Suddenly electronic and semiconductor manufacturers enter the market and start competing with the luminaire manufacturers.

In this way LED technology creates a number of new chances as well as challenges.

Dr. Paul Hartmann
Besides the ongoing hunt for the ever higher, absolute efficiency and/or an ever better lumen/Euro ratio, the quality of white light, especially in the warm white area, is an important topic. The restriction of production tolerances and innovate binning concepts play an important role for the user and a decisive role for commercial success. In the area of LED retrofits, achieving the stipulated 806 lm for a nominal 60W light bulb replacement at the best possible price as well as a replacement for a 100W light bulb (preferably without active cooling) set by the EU, has priority.

Ing. Arno Grabher-Meyer
There is certainly not only one single challenge; on the contrary, there are a considerable number of challenges. The industry itself set high standards when introducing the LED into the lighting market. Now that the biggest challenge is no longer mastering the technology, the main challenge lies in proving that LEDs not only generate light but can also light an application properly - and not only in niches or high-end areas where costs often play an insignificant role.

There is always a certain amount of compromise in lighting, whether it is between efficiency and the color rendering index (CRI) or correlated color temperature (CCT), or between light distribution and design, or the geometric dimensions of a luminary, cooling system, efficiency and life span. The combinations are manifold. The requirements of the various applications and users, likewise.

What technology trends do you see in the field of LED lighting?

Dr. Paul Hartmann
On the one hand, the trends are fixed in the area of standardization: While the LED retrofit market can draw on a very large installed base of luminaires and calls on technical solutions in the classic light bulb class or a spotlight with the standard interfaces of established lamps, the activities in the professional lighting field are already oriented on the future Zhaga Standards, which are being developed especially for LED technology in the area of spotlights and street lamps and which don't contain as many compromises.

On a technical level, LED solutions are seen as implementing the ever brighter high-power spots as a light source, on the other hand also using those that work with a large number of small, low-power LEDs in order to cushion the thermal and binning problems.

Ing. Arno Grabher-Meyer
The trend to modular systems has been recognized since 2010. This modularity can be seen in various levels and to different extents. First, Zhaga, as a consortium for the most significant LED and luminaire manufacturers, should be mentioned. It was founded in 2010 to define the various application standards for the various interfaces of an LED module, from the mechanical to the optical and thermal interfaces and on to the electric interface.

On the LED component level, more and more attention is being given to having as small a number of different shapes as possible on offer. These few shapes are delivered with various electric, optical and light engineering parameters in order to meet the standards for the most diverse applications. In this way, a relatively cheap and simple light platform can be produced for various requirements which differ in price, light quality and light efficiency.

In addition, the trend of reducing binning and tolerances in the light color is continuing. McAdams 2-3 is, for the most part, already the standard.

Above all that, practically all LED manufacturers are looking into the possibility of producing LEDs on Si-substrates in order to be able to eliminate the very expensive MOCVD process on sapphire substrates. Using wet etching for the surface treatment of LED chips is also supposed to be a way to be able to cut costs drastically without reducing light extraction efficiency.

Producers of driver modules are generally moving in the direction of solutions with a reduced number of

individual components. Various concepts are also targeting the idea of eliminating electronic components that can have negative effects on the life span of the end product.

How do you see CO2 emission savings if LED lighting is used for all new installations during the next five years?

Nisa Khan, Ph.D.
Currently, lighting accounts for approximately 20% of total global energy consumption. In many cases, LED replacement lights can already save up to 75 to 80% on energy usage. The industry is still developing LED lighting technologies to achieve such energy savings for many lighting applications in the future. But, for arguments sake, if we could replace all lighting with such new energy-efficient products, we would reduce global coal production by about 600 megatons per year. This leads to an aggregate reduction of over 3 gigatons of coal production in five years!

What do you think LpS will mean to the lighting industry? Where do you see the special possibilities?

Dr. Günther Sejkora
The target audience of LpS is technicians from the lighting industry. Up until now, the focus of LED conventions was either on scientific advances or they were oriented on strategies or commercial aspects. The LpS can fill a niche between these different directions and with that, bring new impulses to the lighting industry.

How can luminaire manufacturers profit from LpS?

Dr. Günther Sejkora
The requirements of the typical product developer in the area of LED technology have changed a great deal. While luminaire designers, for the most part, used to be specialists in one area, LED technology requires a high amount of interdisciplinary knowhow. LpS offers presentations and poster presentations from the most diverse areas of LED technology and the surrounding areas. At LpS, technicians and developers can get information about the trends in the different areas of LED technology at one event.

What is the importance of LpS for the Central European Market?

Nisa Khan, Ph.D.
Central Europe is one of the regions in the world that is historically a major contributor in science, technology, environmental aesthetics, and ecological sustainability. A symposium focused on LED lighting technologies in such a region that already has had a strong presence in premier lighting is indeed important as well as exciting.

Why do you think a symposium and exhibition for LED lighting may have been overdue in Central Europe?

Nisa Khan, Ph.D.
The Central European region is at the forefront of semiconductor technologies that is now playing a primary role in LED lighting, which serves various markets including high-end uses such as automotive headlights and high-quality ambient lights. Central Europe plays a dual role in such markets as they are both manufacturers and end-users of such applications. LED lighting also holds a promising future for many other lighting and display markets around the world. As Central Europe is and will continue to play a very substantial role as LED lighting manufacturers and consumers, a professional gathering such as LpS is surely overdue.

Dr. Paul Hartmann
Endeavouring to bring a wide circle of experts - from scientists to marketing managers and on to the user itself- together in an international, high quality conference means that there is a chance to demonstrate and communicate the meaning of LED technology for Central Europe to the many players of this highly competitive market away from the sales dominated mega-shows.

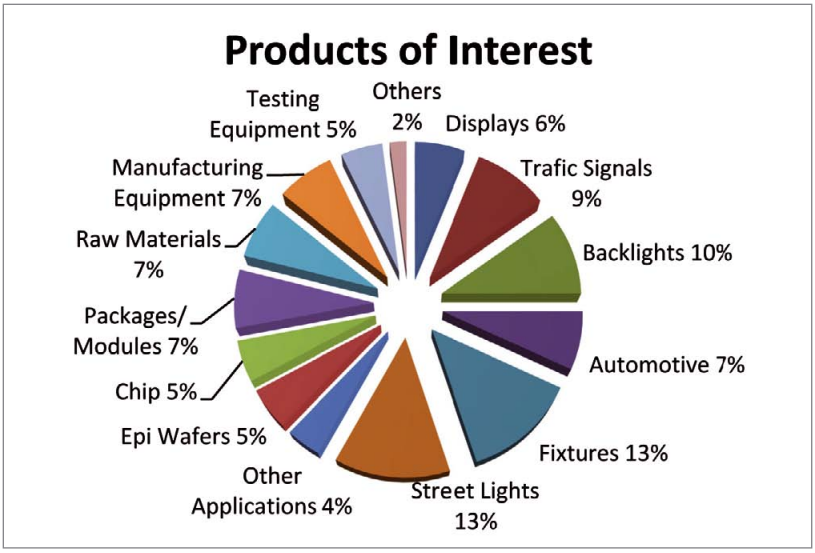
What are your expectations for the LpS event?

Nisa Khan, Ph.D.
I expect LpS will be application-oriented with high technical excellence. It will have a high-degree of emphasis on lighting systems, measurements, and standards for the latest LED breakthrough technologies. ■

LED Lighting Taiwan 2011 – Photonics is LEDs

Arno Grabher-Meyer, from LED professional met the big players in the Taiwanese LED business at LED Lighting Taiwan 2011 in Taipei. He reports here about the most recent products and trends as well as market expectations.

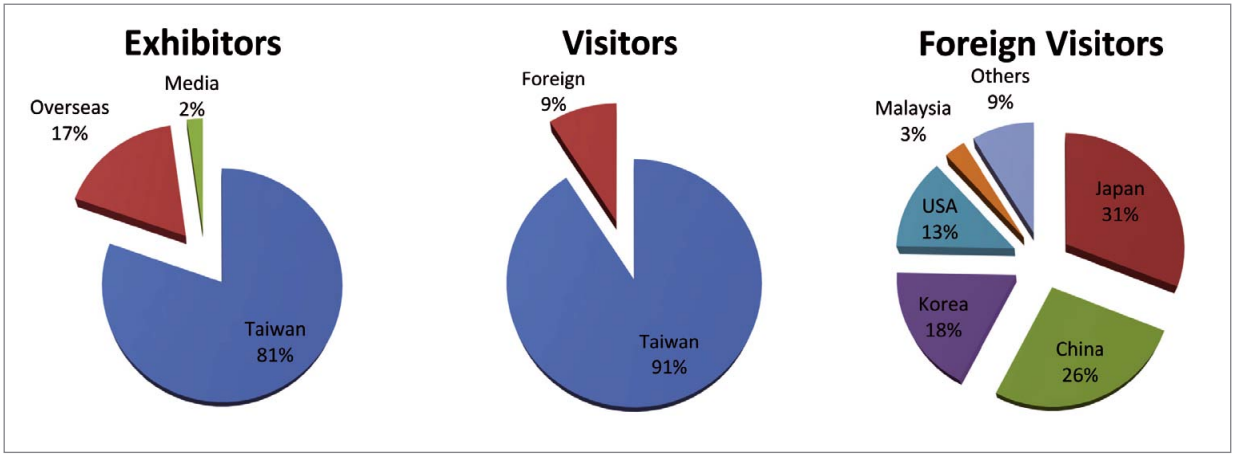
Figure 1:
Visitor's interests statistics



Taiwan's largest LED light Show, Photonics Festival 2011, opened its doors on June 13th. At the opening ceremony, Taiwan's President Ma Ying Jeou pointed out the importance of the application of clean energy and the improvement of energy efficiency for our ecosystem brought about by photonics technology.

The exhibition, which was a great success, closed again on June 16th. The event organization, PIDA, announced that the number of both exhibitors and visitors exceeded previous years. In 2011 the exhibition attracted 215 exhibitors from Taiwan and overseas which equates to a growth rate of 28%. At the same time the number of booths increased by 50% to 681. 81% of the exhibitors were Taiwanese companies. That shows just how strong the Taiwanese photonics industry is. An 11% increase in visitors meant that the 40,000 mark was exceeded for the first time. 9% of the visitors (or 4,078) were from overseas – mainly from Japan (31%), China (26%), Korea (18%) and the USA (13%). The main interests of the visitors were fixtures (13%), street lights (13%), backlights (10%), traffic signals (9%), automotive (7%), and displays (6%). About a third of the visitors were interested in the production relevant issues like packaging and modules (7%), raw materials (7%), manufacturing equipment (7%), followed by testing equipment, epi-wafers and chips (5% each). Most visitors were from the R&D departments followed by management and the sales and marketing departments. The visitors came from different industries like consumer electronics (25%), components (20%), suppliers of raw materials (17%), system integrators (17%), equipment manufacturers (10%) and distributors (3%).

Figure 2:
From left to right, origin of exhibitors, visitors and in more detail, foreign visitors



Highlights at LED Lighting Taiwan 2011

215 companies showcased state-of-the-art products starting with raw materials, moving on to manufacturing tools then to the LEDs, the electronics and finally the luminaires and replacement bulbs. In every product category numerous new products, concepts or designs were presented.

Testing and manufacturing

Many well-known testing and manufacturing equipment suppliers were on site as well as numerous representatives of celebrated companies like Suss Microtec, Ocean Optics, Instrument Systems, or StellarNet, to name just a few.

One of the most interesting suppliers of testing equipment at the fair was Chroma ATE, known around the world for their high quality computer controllable AC or DC power sources and different load simulation equipment. Chroma showed a huge amount of equipment for LED driver development and LED measurement. Most of the products that were introduced were relatively new. One highlight at the booth was the LED simulating load that is used to test drivers under clearly defined conditions. Chroma argues “this is the only solution where a driver can be tested without the risk of external factors and product variations having an influence on the results.” Another new product was the LED Luminaire In-Line Test System that can be used for LED bulb and LED tube testing and which is claimed to deliver more accurate measurement results for tubes than integrating spheres do.

Raw materials and substrates

Raw materials and system component suppliers were mainly represented by phosphor material manufacturers, substrate and PCB manufacturers and some thermal management specialists. Some prominent companies in this product group that should be mentioned are Monocrystal, Heraeus, Bergquist, Kyocera, Nusil, DuPont, and Intematix.

In addition, a few electronic components suppliers like Power Integrations or Taiwan’s TM Technology Inc. were present. Instead of having their own booths at the fair, some of the companies were represented by local distributors or representatives. Most companies in the electronic components category are based in Taiwan and for the most part, they provide packaging solutions with different materials and technologies. A lot of these companies sprang from other businesses like thin film or thick film resistor or circuit protector manufacturing.

Figure 3: Chroma’s LED Luminaire In-Line Test System uses PV cells to measure light distribution and intensity

TA-I Technologies is one of these companies. They use the knowledge they have from those branches for design and manufacturing services for the SSL industry. TA-I launched their LED ceramic thermal dissipation substrate and lighting module substrate business in 2010. They provide several types of metalized ceramic substrates for LEDs, backlighting and lighting products like LED replacement bulbs. The most recent product line is for COB boards, MR16 and E27 products.

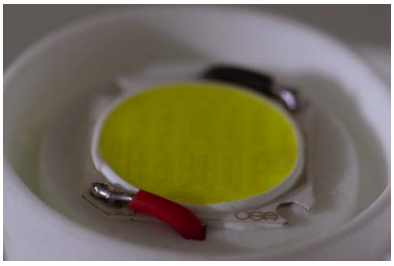


Figure 4: TA-I's ceramic substrate for replacement bulbs with E27 socket

ICP, founded in 2009, with its team members having over 10 years of thin film components developing experience, provides different services and products for the LED industry including LED substrates, ceramic heat sinks, and electro-deposition/ electro-less-deposition processing. The most recent generation of ceramic substrates for LEDs offers a new design of LED devices with built-in protective components.

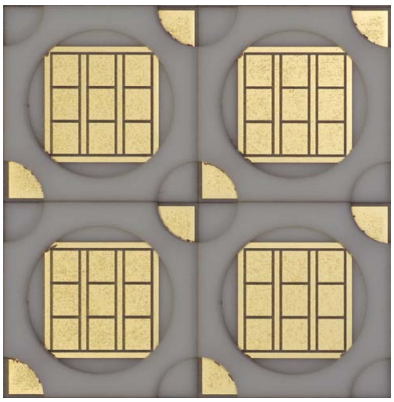


Figure 5: ICP multi-chip ceramic substrate

In addition to Fitilite who presented ceramic packaging substrates and bulb sockets to keep the LED's cool, Viking Tech Corporation, a professional manufacturer of chip resistors, inductors and capacitors extended its product range a while ago to heat dissipating ceramic substrates for LEDs.

Optics and optics materials – the key to successful applications

Germany based Evonik Degussa has been supplying the industry with PMMA for many years now. PMMA is used in many standard applications including LED lighting products. Since several competitors provide a similar substance the key to success on the market is the capability to process this material perfectly. Evonik can provide high accuracy, micro-structured panels of up to 30x30 cm. There is also SAVOSIL™, a relatively newly developed material for high quality, highly reliable products that allows for special applications because of its unique properties. Production of LED lenses using Evonik's patented SiVARA™ Sol-Gel technology, allows glass lenses of consistent quality to be manufactured in any desired shape which means that this process can be used to produce primary or secondary lenses. With its huge spectral transmission range from 200 to 3,000nm, the lenses made of SAVOSIL™ can be used in LED lighting products for UV as well as for visible light and infrared applications. Glass produced by the SiVARA™ Sol-Gel technology is an ideal LED optics solution and is highly reliable. It also offers the phosphorous in the lenses outstanding protection against humidity and heat during operation and is thus ideal for outdoor lighting or automotive products. To serve the brand concept of SAVOSIL - "customized solution" - in 2010, Evonik Industries established a partnership with Taiwan-based Cristal Material Corporation. "Many very important clients and potential clients have their facilities in Taiwan or the adjoining countries, hence it was a logical consequence to establish this partnership and to concentrate forces in research, development and production in Taiwan" stated Gerard Berote, President of Evonik Degussa Taiwan. The aim of both partners is to help the LED market that will see many new areas of applications open up, to develop new technologies faster.

New optical concepts, especially a tendency to change the optical models for replacement bulbs was visible at various booths from optics manufacturers to the bulb manufacturers at the fair.

LedLink, renowned as a manufacturer of high quality, standard solution LED optics for the MR series, PAR Series, and Bulb Series modular products, also provides customized secondary optical lenses of virtually any shape and size and every LED brand and type. Apart from that, LedLink also provides all-dimensional R&D design from optical to mechanical and thermal design for its clients. LedLink can provide the complete solution ready for

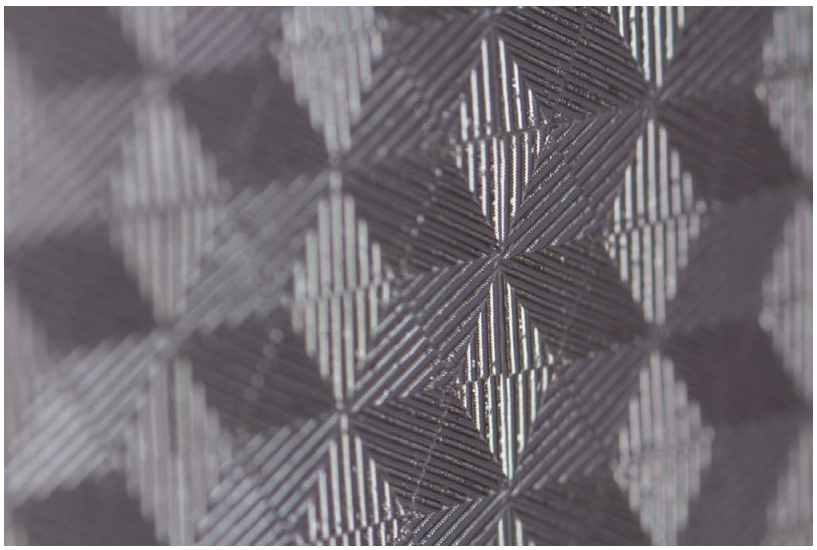


Figure 6: PMMA is Evonik's established product for several (lighting) applications, while SAVOSIL™ is the new high-end material predestined for LED and PV applications. Currently under development is a technology of SAVOSIL to create a microstructure on panels. The microstructure was printed onto a PMMA sheet.

EDISON
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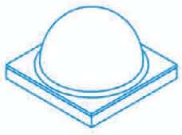
EdiPower® II Series & Reflectors

EdiPower® II series provides different operating powers and is offered in various colors. They serve as optical engines and can be utilized in general lighting and special lighting applications. Furthermore, the high CRI options allow the customers to optimize the effect in various fields.

	Edipower II ★ EPCx-xxxx	Edipower II HV EPSx-HFBx	EPSx-Vx44	EPSx-VF0B
CRI	80/80/80	70/80	70/75/80	70/75/80
Power	6W-10W	9W/13W	10W-15W	100W-120W
I_F(mA)	700/1000/250mA	250/350mA	1200mA	3600mA
V_F(V) (Typ.)	9.6V/9.8V/26.5V	38.5V	13.0V	33.0V
Flux(lm) (Typ.)	● 435lm ● 675lm ● 575lm	○ 970lm ○ 1380lm ● 900lm ● 1250lm	○ 1400lm ● 1190lm ● 980lm	○ 9500lm ● 8600lm ● 7300lm
Reflectors Angle(Beam)	25°/35°/50°/60°/100°	25°/35°/50°/60°/100°	25°/35°/50°/60°/100°	

1. LED is a dynamic, creative and evolving technology. Please refer to the datasheets for final specifications.
2. Other colors is available upon request.

Federal FM Series



The New High Brightness Multi-chip LED

Series	Picture	Part Number	Color	Type	λd(nm) / CCT (K)	V_F (V)	I_F (mA)	Flux(lm) (Typ.)
NEW Federal FM Series		EFE4W-1CE7	○●●	4W/10W	W:5000~10000K	3.3/ 3.7	350/ 700	440/ 750
NEW Federal FM RGB Series		EFERTBW-1CE1	●●●○	1W/3W	R: 620~630	2.1/ 2.3	350/ 700	50/ 100
					T: 520~535	3.3/ 3.7		80/ 125
		EFERTBA-1CE1	●●●●		B: 455~470	3.3/ 3.7		20/ 35
		EFERTTB-1CE1	●●●●		A: 585~595	2.1/ 2.3		50/100
					W: 5000~10000K	3.3/ 3.7		105/ 180

Federal 5050 Series is a smaller and brighter multi-chip LED which provides multi-color packaging flexibility. Federal is a surface mount, compact, high brightness LED that is suitable for various illumination needs such as general illumination, ashlights, streetlights, spot lights as well as industrial and commercial lightings. The multi-color LEDs (RGBW/ RGBA) are especially suitable for stage lights, and with its smallest dimensions in the world, enables a higher flexibility for optical design.

4F, No.800, Chung-Cheng Rd., Chung-Ho Dist., New Taipei City, Taiwan 23586
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Figure 7:
One of LEDLink's most recent developments is a highly efficient solution for omnidirectional light distribution in LED candle lamps

Figure 8:
The LEDLink team gave LED professional a warm welcome at their booth

assembly or already assembled. Products that show the whole range of capabilities were displayed at the fair. One of the most interesting lens developments is aimed to provide omnidirectional light distribution for an E14 candle bulb.

Another very innovative company at the fair was Aether Systems, provider of optical solutions for LED lighting. Combining world class optical design and mathematical capability, ASI designed and produced the world's first digital lens for LED. This lens, Aether Digital Lens, ADL™, is a cost effective, high performance lens for LEDs and produces excellent light shape. In addition to ADL, ASI has also designed and produced many innovative and high performance geometric lenses for indoors and outdoors lighting applications. The patent pending OmniStar™ lens is a unique and cost effective plug and play secondary optics that makes it possible to deliver energy star compliant A19 light bulbs quickly and reliably.

Figure 9:
Aether Systems optical solution for LED replacement bulbs delivers a really omnidirectional light distribution with high uniformity

LEDs, modules and LED systems

Lextar, as the largest supplier of LED backlight modules in Taiwan, manufactures products featuring high luminosity and a long lifespan. In 2008 Lextar was founded as a subsidiary of AU Optronics to provide LEDs for the LCD and backlighting business. David Su, Lextar Chairman and President explained to LED professional: "Based on the backlighting business, the SSL business was set up, extending the vertical integration from the existing epi-chip production to LED packages and lighting modules and finally the end-user application, which was a new challenge." Besides the newly released products, a 6 watt candle lamp and the chip array COB, that were introduced to the Chinese market in Gangzhou and at LED Lighting Taiwan at the same time, Mr. Su presented some new ideas to LED professional. "Based on the strategy to strengthen the market position by the vertical integration, not just the efficiency of LED lighting is a key issue," he explained "but also the huge number of new opportunities. Especially the adaption of color temperature on demand that can be done with relatively low effort and low additional costs is an excellent argument to switch over to LED lighting. – The additional benefit that LED luminaires can offer is the true selling point, but to realize these benefits the resellers need to be educated." Then Mr. Su showed the most recent development

Figure 10:
Lextar also displayed a newly designed replacement lamp with 300° homogeneous light distribution

Figure 11:
ALT's newly introduced A55 replacement lamp

Figure 12:
At the Everlight booth different applications and illumination sceneries could be compared, from outdoor lighting to office lighting, shop lighting or residential lighting

from Lextar with strategic partners; the implementation of Bluetooth in an LED lighting system that offers easy control options with the lowest energy consumption at low costs. The system should serve the residential market as well as the commercial market – especially offices. "This system offers identical features to WiFi based systems or hard-wired systems, but it is much more price competitive" David Su added.

Aeon Lighting Technology Inc. (ALT) set up an exclusive "Taiwan Aboriginal Plant Zone" with its Grow Light product in respect of the Living Green theme at the exhibition. It also shows the beautiful convergence of nature and technology. ALT's grow lighting products were especially successful when entering the Japanese market. ALT introduced the new AR111 and A55 replacement lamps, which were the highlight at their booth. Designed according to traditional light fixtures, users can easily install these light bulbs without modifying existing light fixtures.

Everlight had two booths at the fair; one presenting the end-user products and one the LEDs. This is the logical consequence of the company policy to clearly distinguish between these two divisions. Everlight SSL introduced a variety of LED lighting fixtures for different lighting applications including outdoor, street, commercial place, office, storage, parking lot and home lighting. For outdoor street usage, Everlight presents the second generation of Dolphin street lights with dimming function to save even more energy than with its original LED street lights. Everlight Electronics Co., Ltd. presented the new Chip-on-Board (COB) LED series to offer a solution that addresses important issues in general lighting replacement applications. Competing with previously dominating standard discrete low power, mid power, and high power LED components, Everlight expects Chip-on-Board LEDs to take on a third of all LED A-lamp applications in 2011.

Figure 13:
Everlight's downlight impressed with its pleasant design and pleasing light quality

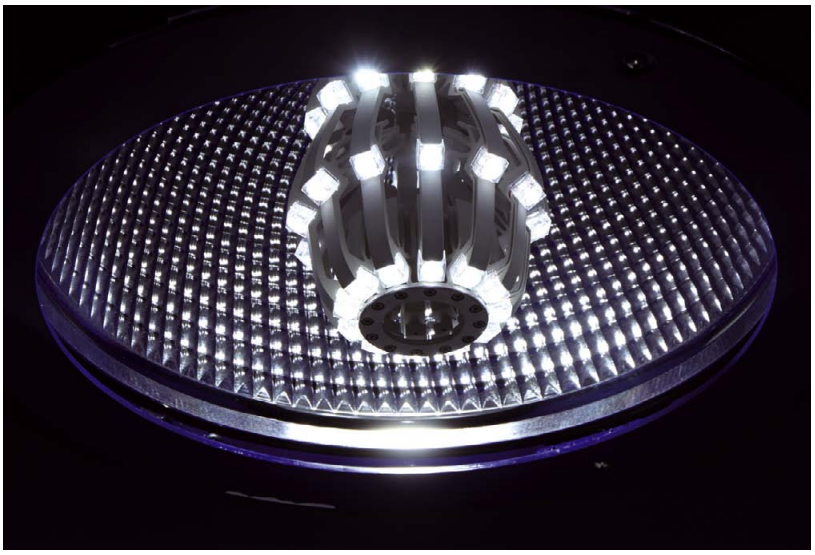


Figure 14:
Almost too good looking for a high bay light; PDD's LED high bay bulb using Cree's XP-G LEDs

Figure 15:
The U-Light is reminiscent of the CFL-bulb, which might not be successful, but it embraces a different design approach

Figure 16:
LiteOn's candle lamp is an optical reduction, a step towards an independent design off the conventional design of LED candle lamps (right)

This year, Cree showed up with the whole well known and established LED product portfolio, also presenting the vertical integration capabilities with its modules and luminaires examples. They also demonstrated the newly released products, the XLamp® MT-G EasyWhite™ and the XLamp® CXA2011 LED Array. In addition, they featured some of their partner's and customer's products. With the KingStar series LED module from Wu-Feng Photoelectric Co. Ltd, based on 16 XLamp XM-L LEDs, Cree and its partner impressively demonstrated the low thermal resistance of a properly designed and manufactured product. "With the XM-L LED and our patent pending heat-sink technology, this new LED module can deliver up to 10,000 lumens without sacrificing efficiency and longevity" explained Gui-Fang Chen Head of Wu-Feng Photoelectric."

PDD's extraordinarily designed High Bay / Low Bay solution that looks almost too exclusive to be used only for this application also drew a lot of attention. The LED High Bay bulb uses Cree XP-G LEDs and a unique thermal technology. It can be installed directly to replace mercury vapor or HPS lamps.

LiteOn has been manufacturing LEDs for backlighting and other optoelectronics for many years now, although they are better known for several other electronic products. For this reason their general lighting

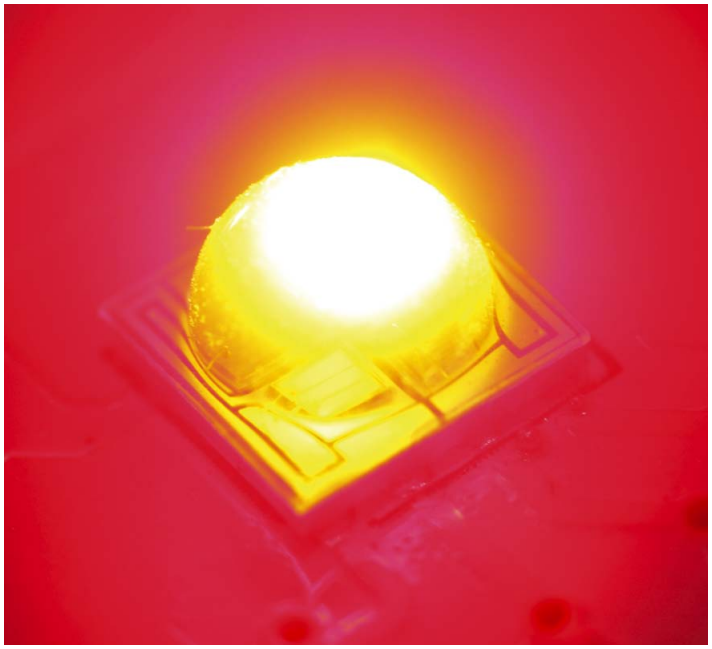


Figure 17: The RGBW and RGBA Federal FM series LEDs deliver a brilliance of color mixing and lighting quality to many applications

products were not really noticed at the Light + Building fair in Frankfurt last year. At LED Lighting Taiwan 2011 LiteOn presented their new lighting products and sparked off a real firework. Some of these products were very surprising with extraordinary optical solutions and designs like the 6 watt "U-Light" that aims to replace 8 W CFL lamps or 40 W incandescent lamps and which offers a 300° light distribution. The LED candle lamp reduces the bulb design to a heat sink and a massive optics that almost mimics the flame of a candle.

Edison came to the show with examples of the whole vertical integration, from LEDs to modules to the application. "While many other companies produce and sell luminaires under their own brand name, Edison aims to support its clients by integrating our products in the applications with thermal and optical simulations in an optimal way. On the other hand, we can also provide the final product for our customer. That is what we are demonstrating here with the end-user products," Eddy Kao explained.

On the module level, Edison presented its new EdiPower Module, based on its EdiPower II 15W-24W high brightness LEDs, and the Street Lighting Module. On the component level, the new EdiPower® II Series products with 6-10 W, 25-40 W and 50-120 W extend the portfolio of array LEDs. The Federal LED Series was updated with the Federal FM series. Edison Opto now offers the world's smallest white and multicolor 4-10 W 4-chip LED package which can be driven with 700mA and deliver up to 750 lm for cool white and 550 lm for warm white. The multicolor versions allow exceptional full color capabilities.

In addition to their well-known product range, Philips Lumileds featured their high voltage Luxeon H for the mainstream replacement bulb market that only needs a bridge rectifier and resistor to work. Like some other companies they seem to see the future of the replacement market mainly characterized by costs and a reduction of system components.

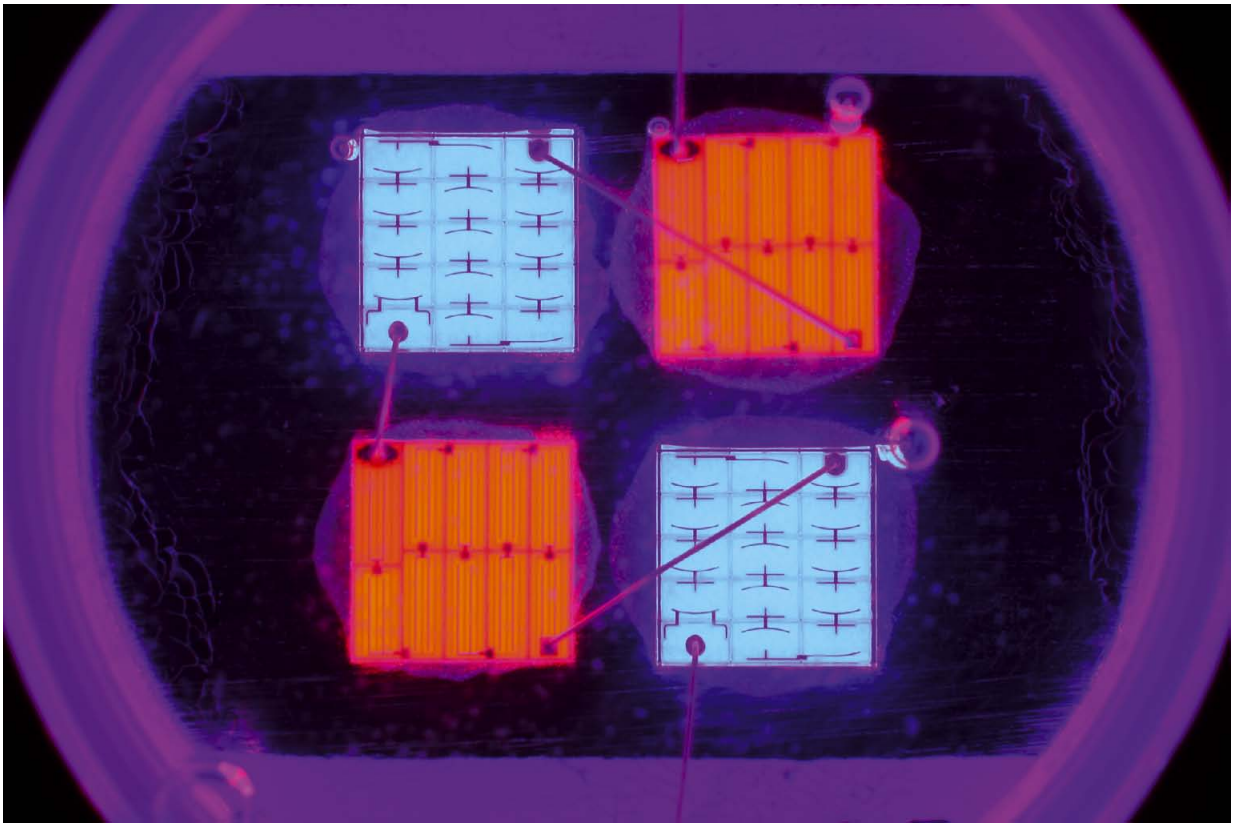


Figure 18:
Epistar's HV concept for efficient white light generation (here without phosphors) consists of a series connection of matched red and blue LEDs

Nichia presented their most recent products for lighting applications as well as backlighting or signage and automotive. "Nichia's strategy differs from the strategy of most competitors. Nichia stays at its roots and shows no ambitions for a vertical integration" Masaki Mukaiyama from Nichia Taiwan explained. "We see our strength in supporting the clients in implementing Nichia products in the application in the best possible way." Nichia proves this with the extension of different product lines. For uncompromising quality, Nichia recently released the NVSx219A line with conformal phosphor coating to provide the best possible color consistency over the distribution angle. According to the company's statement, this line of high intensity point source LEDs offers unprecedented luminous efficacy, source brightness, a compact footprint of a mere 3.5 mm x 3.5 mm, and superior color quality. In addition, Nichia added and upgraded the more budget priced NS Power LED Series white the 183A and the more compact 153AM type LEDs to serve cost sensitive main stream applications in general lighting.

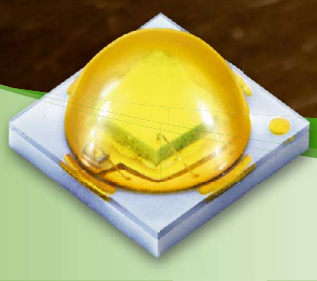
Unlike most other companies Epistar's main interest is in selling the LED chips and supporting their clients with Epistar's know-how in the product development, whether they produce packaged LEDs, COB LEDs and LED modules, replacement lamps or complete luminaires and lighting systems. Epistar featured its HV blue-red LED system for high CRI and highly efficient white light generation. When two red LED chips and two blue LED chips are connected in series, the maximum luminance efficiency is 120 lm/W at 140 V and 20 mA, having a CRI of approximately 90 for a 2700 K warm white LED system, according to the company spokesperson. This design with a close voltage match to the mains voltages (110 V or 230 V) allows driver solutions with better costs and performance than low voltage systems. Epistar planned to start sample shipments in July 2011 and volume shipments in September 2011.

Final Thoughts

Compared to previous years, where we mostly saw products for commercial use, most exhibitors also brought products for residential lighting applications with them. We think this means that the LED luminaire and replacement bulb manufacturers feel that the time is ripe for moving into the consumer market. Publicized announcements of companies prove DoE's prognosis regarding the price development of LED products while the efficiency and lumen/package have exceeded the DoE prognosis for a while. It really seems that $/klm are coming down to the level where the residential market can be exploited successfully. ■

LED Z5

For bright moments



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New Technology Concepts in the LED Lighting Industry

Thomas Zabel, CTO of e:lumix in Germany, explains his technology concepts in an interview with Siegfried Luger, publisher of LED professional. The main topics are silazane technologies in phosphor and the enhanced PWM technology which causes LEDs to "oscillate". These technologies should substantially increase the efficiency of LEDs for lighting applications.

LED professional: The research you have been carrying out in the field of LEDs over the years has brought new technology concepts to light. If we talk about phosphors first, can you tell us what the current status of that research is?

Thomas Zabel: We already have a few grams of model silazane technology, a silicon organic complex that has been synthesized. This technology makes it possible to have a higher CRI – over 90 – even in the area of warm light.

LED professional: What are the efficiency values that this technology can achieve?

Thomas Zabel: The conversion level of phosphor lies between 40% and 75%. Nichia has even achieved levels of over 80%. Their patent is based on YAG technology and only marginally differs from our chemistry for silazane technology. However, on a molecular level they are different.

LED professional: Are there other advantages for silazane technology?

Thomas Zabel: Apart from the improved level of efficiency, it is easier to conciliate the phosphor with the LED chip. Basically, there are three technologies that can be used to link the phosphor with the chip. First of all you can use the so-called surface phosphor where plates are coated with phosphor – Remote Phosphor. Secondly, the chip can be coated directly with phosphor and thirdly, the technology where we can mix the phosphor with the silicone; quasi the volume approach. We made many comparisons. Personally, I am a fan of the volume method because this technology results in the best homogeneity and application efficiency. This is dependent on an ideal mixture of silicone and phosphor particles on a molecular level with the help of trichlorosilane.

LED professional: To what extent does the volume method effect the quality or the life expectancy of an LED since we are talking about close contact here in contrast to, for example, remote phosphor technology?

Thomas Zabel: If you create a pod globing that doesn't tolerate the LED die or the bond to the die, it can lead to unwanted interactions. Possible loss or change of the LED color is one likely effect. I still claim that most LED failures whose origin is not over-current, are lift-offs where the cause is to be found in the metallurgy of the bonding and the interaction with the globe.

LED professional: Are there other critical areas that are crucial for the life expectancy of the LED?

Thomas Zabel: Basically, you must always perceive the LED itself as a very complex physical system. It begins with the lead frame which in the simplest case is made out of copper or a substrate such as ceramic. A layer of nickel is galvanized onto the substrate and bonded to the LED chip using die bond glue. The die itself is connected with a very complex bond using a die bond wire and connecting again to the lead frame. In the end, we have the pod globe.

Of course, this type of setup has very critical thermodynamic influences which lead to shearing or traction within the LED.

LED professional: Let's come back to the phosphor. Do you use silazane phosphor for your own products only or do you offer it on the free market?

Thomas Zabel: There are strategic aspects that have to be taken into consideration here. Right now we are still in the research phase. We can produce about 10 to 15 grams a week. Obviously, this amount is not enough for the mass market.

LED professional: How much phosphor is needed per LED?

Thomas Zabel: That depends mainly on the individual structure of the LED. In addition – it is a secret that no LED producer will want to give you details about. You may assume that about 10-12 grams are needed daily for an average line production. This type of manufacturing produces about 10,000 pieces an hour excluding defects.

LED professional: Let's change the subject from phosphor technology to control technology. You have developed a new procedure that makes LED efficiency possible using a special type of control. Can you describe this procedure for us in a little more detail?

Thomas Zabel: Let's assume we have quartz that we can trigger to start it vibrating. Through a special multi-layer coat sequence – divided into zones – in combination with an additional material in the growing process, it is possible to start the LED die vibrating. In this technology we vibrate the molecules in order to be able to bring the photons out of the grid structure more easily. You can track the effects quite easily metrologically by measuring the die with and without the impressed vibrations.

LED professional: How does this change the light yield? How much of an efficiency increase can be reached?

Thomas Zabel: Our measurements show an increase of 40% – 45%. An existing product in the area of retrofit lamps shows an increase of about 30%. Our data is obtained from the output, namely, the amount of light emitted. The losses of the LED depend on two factors: The resistance in the junction and the conversion losses. These are the things that our technology can reduce and consequently less heat is produced in the LED die.

LED professional: The special construction alone is probably one side of the picture. What do you need to create the vibrations in the first place?

Thomas Zabel: You can't have one without the other. We need the appropriate die structure that allows itself to vibrate and we need the intelligent controlling that prompts the vibrations. We call this the Key-Lock principle of enhanced PWM (EPWM) technology. An additional signal is modulated on the PWM signal. I call this the inoculation vibrations.

LED professional: Is digital control always the requirement?

Thomas Zabel: You can use linear controlling as well. We have also experimented with an analogue OP-control and sourced the LED with the overlapped signals using a ramp. This works in the same way.

LED professional: What is the frequency range for these so-called inoculation vibrations?

Thomas Zabel: You're not the first person to ask that. I can't give you any information about that at this point in time.

LED professional: So what you're saying is that if you want to use EPWM technology, you also need a special LED chip and an additional EPWM driver. Is that right?

Thomas Zabel: That is correct. We offer the EPWM driver as a module and the LEDs can be operated with that. Of course our LEDs can be operated without the EPWM but in this case they no longer have the advantage of increased efficiency.

LED professional: Would the EPWM driver function if used with other LEDs?

Thomas Zabel: There is an LED manufacturer whose LEDs have structures which would be suitable but that are not optimized for EPWM.

The current measurement that shows a comparison of an LED from a well known producer shows a system efficiency of 42.2 lm/W to 114.5 lm/W with EPWM.

Thomas Zabel

CTO of e:lumix LED Technology GmbH in Germany

LED professional: Will you be changing your entire portfolio to EPWM?

Thomas Zabel: Our goal is to equip all systems with EPWM technology. In China, for example, we are selling our LEDs at a lower cost if the EPWM technology is being used in order to make market entry easier. The electronics are quite inexpensive.

LED professional: What does your production technology for LEDs look like?

Thomas Zabel: We work more in the wet chemical area in our production. We process our wafers in baths at certain temperatures for a certain amount of time. In comparison with evaporation equipment, the investment for wet chemical production is quite a bit cheaper. The learning process cost us a lot but it is now stabile. We have about 9%-12% defects whereby 70% of the chips are in the main binning groups.

LED professional: How do you see OLED technology in comparison to LED technology?

Thomas Zabel: For me, OLED is a very big research area and has its place in the display sector. I don't see OLED technology in general lighting. e:lumix is working solely on LED technology.

LED professional: What is the future of LED technology?

Thomas Zabel: It's going to be very close at over 200 lm/W. On the other hand, the theoretical limit is 355 lm/W, calculated by the charge carrier. I think that in reality, 250 – 260 lm/W will be a line that will be very hard to cross. I am also not a fan of high power LEDs that have a droop effect. String / Array / Cluster assemblies seem to me to have a more promising future. In connection with that, more and more systems are coming out for higher voltages that can, for example, be plugged directly to the mains – without a driver.

LED professional: Thank you for the interview and good luck with your technologies.

Thomas Zabel: Thank you very much.

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Sapphire Wafer Wet Etching versus Dry Etching

Light Extraction Efficiency (LEE) from the LED chip is one of the major topics to improve overall efficiency. Several approaches are proposed to improve LEE. A very common approach is to use dry etched Patterned Sapphire Substrates (PSS). Carolyn Gruske and Derek Mendes from Imtec Acculine Inc. explain the new and more cost effective approach of wet etching.

According to a market research report published by Strategies Unlimited (SU), the high-brightness (HB) LED market experienced a 93 percent growth rate between 2009 and 2010. In 2009, the global market for packaged HB LEDs was $5.6 billion. In 2010, it grew to $10.8 billion. SU is predicting that by 2015 the global market will be worth $18.9 billion, representing a compound annual growth rate (CAGR) of 11.8 percent.

Despite the positive forecast, there is one element that has the potential to stifle the growth of the LED market: high (and growing) production costs.

The U.S. Department of Energy is expected to release a report stating that in order to compete effectively with the fluorescent lighting market, solid-state lighting manufacturers need to cut the cost per lumen (currently at $18/klm) by 8x to $2.20/klm by 2015

Gaining efficiencies during the manufacturing process is a key method to drive down costs. Larger-diameter sapphire wafers hold the promise of making the manufacturing process significantly more efficient, but they also present challenges to fabricators.

Transitioning from the utilization of a standard 2-inch wafer to a wafer measuring 4-inches in diameter essentially quadruples the available surface area of the wafer. A doubling of the surface area occurs when moving from a 4-inch to a 6-inch wafer, and with every subsequent jump in size comes further substantial increases in surface area.

Unfortunately, theoretical efficiencies gained through the use of larger wafers are drastically undercut if existing manufacturing equipment is unable to cheaply or easily scale up to accommodate the larger form-factors.

Patterned Sapphire Substrates (PSS) serve a dual-purpose role in the LED industry. On the wafer supplier side, they are money-makers. PSS wafers represent higher gross margins than traditionally polished sapphire wafers. On the product development side, PSS-based LEDs are more efficient, more effective light sources.

“The PSS reduces the dislocation density in the GaN (Gallium Nitride) layer and enhances the light extraction efficiency (LEE) from the LED chip (Figures 1, 2) by scattering the light confined in GaN layer attributed to the critical angle between GaN (n=2.4) and sapphire substrate (n=1.7) (or air (n=1.0)).”[1]

The results, shown in Figure 2, indicate that the electrical performance of LED chips fabricated on the n-pss and standard sapphire wafers is very similar. From the L–I curve (measured by an integral sphere apparatus), it was revealed that the LED chips on the n-pss wafer have a higher light output power than those on the standard sapphire wafer. At an input current of 350 mA, the average light output power of the LED chips on the n-pss wafer is 37% larger than that of the LED chips on the standard sapphire wafer

Dry etching is currently the most common method for producing PSS wafers. At this point, the techniques and technology for dry etching, including the inductively coupled plasma (ICP) variant of dry etching are commonplace: lithography exposes a pattern onto the sapphire substrate’s photoresist, which is subsequently anisotropically etched into the crystalline structure via exposure to fluoride-base plasma gas and microwave energy. The resulting, highly uniform and densely packed dome-shaped pattern encourages lateral film growth, resulting in fewer defects and increased light refraction. The LEDs formed using dry-etched PSS wafers produce highly efficient, very bright light.

Dry etching is a very slow process with a low throughput rate. Depending on the type of film used and the depth of the pattern being etched, a standard 2-inch wafer can take between 30 and 60 minutes to etch. Although it is nearly impossible to talk about average rates, given all the possible variables in the process, it is estimated that dry etching rates range between 50 nm to 200 nm per minute, or 20 minutes per micron.

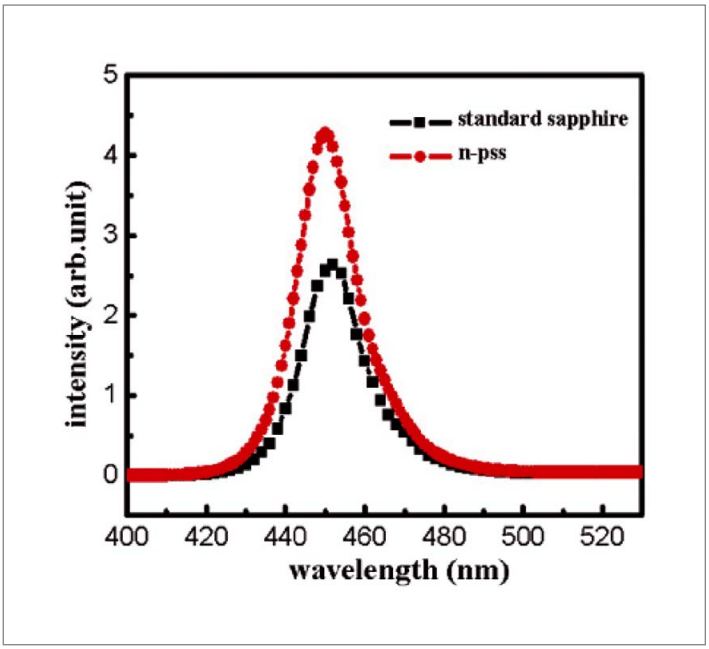

Figure 1: **The PL measurement of the GaN epilayer on the n-pss wafer indicates a higher intensity and narrower full width at half maximum (FWHM) than those of the GaN epilayer grown on the standard sapphire wafer. This is indicative of the higher axial quality of the GaN epilayer grown on the n-pss wafer (i.e., lower defect level) than that of the GaN epilayer grown on the standard c-plane sapphire wafer**

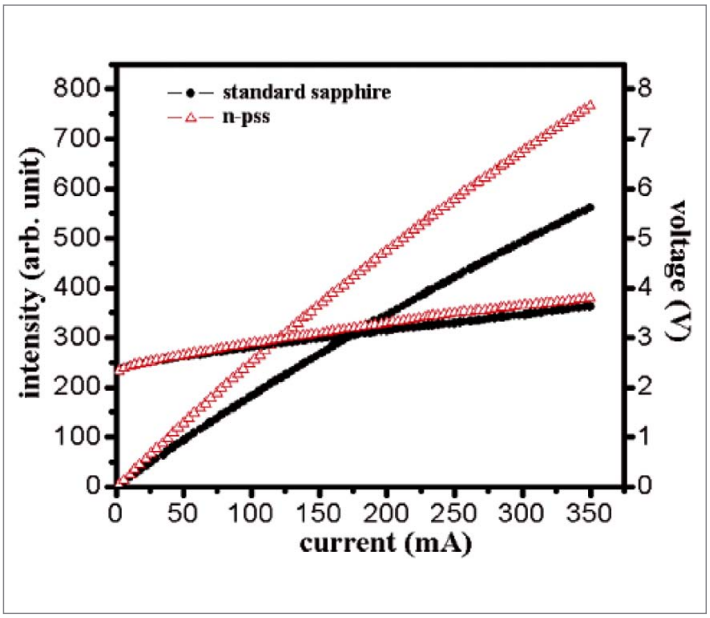

Figure 2: **When the input current is 350 mA, the turn-on voltages of both LED chips are similar (about 3.6 V). The leakage currents for the LED chips on the standard sapphire wafer and n-pss sapphire wafer are -1.7×10^{-7} and -9.5×10^{-7} at -5 V, respectively**

The dry etch process also does not scale effectively. As wafer size increases, throughput of a dry etcher decreases as fewer wafers fit inside the vacuum chamber. This means more expensive plasma etching tools are required to obtain the same throughput as was achieved on smaller wafers. More tools also come with increased operational costs, such as facilities, maintenance, utilities, and consumables.

Figure 3:
The liquid in the Accubath Xe tank comes in contact with nothing but high purity quartz. No teflon connections, sensors, or any other parts are used in the process area. Even the built in condensing coils and automated lid are quartz.

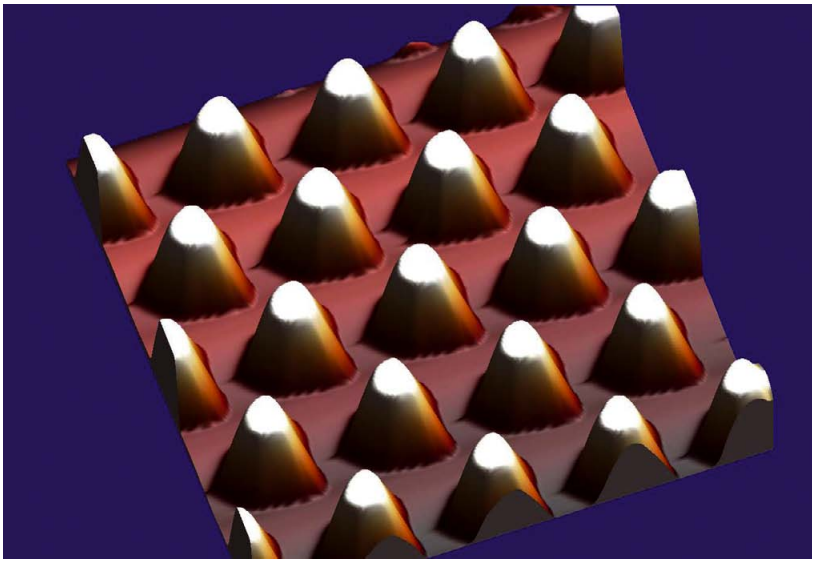

Figure 4:
Unfortunately, the flat top surface of the cone poses two significant challenges to those used to working with the dry etching process. The flat topped surfaces act to discourage the lateral growth of film and encourage vertical film growth, resulting in an increased number of defects. Additionally the shape of the structures inhibits efficient light refraction

In comparison, the high-temperature wet etching process provides the dual advantages of being extremely fast and comparatively much cheaper than dry etching.

During high temperature wet etching, Gallium Nitride (GaN) or Indium Gallium Nitride (InGaN) coated wafers are placed in a tank containing a mixture of etching and buffering agents - normally sulphuric and phosphoric acids typically in a 1:1 or 3:1 ratio. Prior to submersion, a silicon dioxide mask is spun onto the sapphire substrate via a plasma enhanced chemical vapour (PECVD) process and lithography is employed to expose the desired pattern. Temperatures ranging between 260°C and 300°C are applied to the mixture. These temperatures greatly surpass those used in traditional semiconductor fabricating (which typically range between 150°C to 180°C).

Rather than etching rates increasing along a linear scale as the temperature rises, they increase exponentially; Hence a 300°C temperature may have an etch rate that is twice as fast as the etch rate experienced at 260°C. Conversely, researchers have demonstrated that “the etching rate increased linearly when the H_2SO volume ratio increased from 0 to 75%.” [2]

According to Sinmat’s Singh, high temperature wet etching rates can be measured in microns per minute, with a rate of more than 1 µm per minute certainly being achievable under the correct conditions. He says it is reasonable to expect a standard 2-inch wafer to be fully etched in five minutes.

Natsuko Aota, an Engineer at Namiki Precision Jewel Co. Ltd. is a proponent of the wet etching process and believes in its role as a key cost reducer in LED mass production.

The high temperature wet etching process holds the advantage over dry etching in terms of speed, cost, and scalability. A process tank for a batch of 6-inch wafers, for example, is only slightly more in cost than a tank designed for a batch of 2-inch wafers and can hold the same number of wafers.

Of course, the use of extremely hot chemicals can pose a challenge for manufacturers. Chemicals hot enough and powerful enough to rapidly etch sapphire surfaces must be contained and handled safely. At the core of any system is the tank. It must be designed not to react with any of the chemicals, so tanks are constructed of high purity, virgin annealed quartz (Figure 3). They contain no plastics that come in contact with the mixture. Built-in temperature sensors feed precise readings back to the systems management equipment. As added safety features, the XE-Series includes a cool down module to house the hot chemistry while it cools and an overflow tank that can hold 120 per cent of the volume of the main tank, in case an accident should occur.

The PSS that results from the high-temperature wet etching process is a significant improvement upon a non-patterned wafer in terms of light extraction and efficiency. The process results in the creation of truncated cone shapes – conical structures with flat tops (Figure 4).

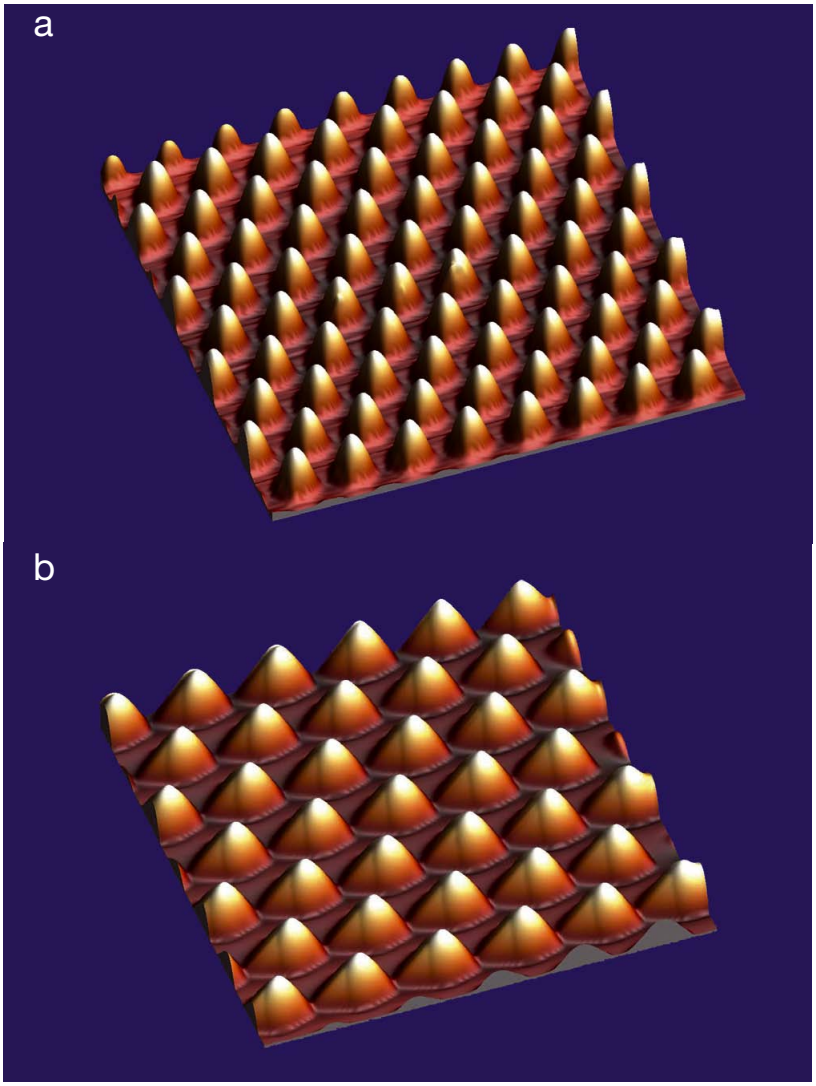

Figure 5:
Formerly flat, truncated shapes polished and rounded (a) now more closely resemble dry-etched PSS patterns (b)

Since this is still a relatively new process, research is being conducted into improving the quality of wet etched sapphire wafers. One company undertaking such research is Sinmat Inc., which has developed a method to polish the flat structures thereby producing rounder, more efficient domes – domes that more closely resemble the shape of those produced by the dry etching process (Figure 5a, b).

Others are investigating the creation of patterns other than cone shapes. At the National Chung Hsing University in Taiwan, researchers created "truncated-triangle-striped patterned-sapphire substrate and a rhombus-like air-void structure at the GaN/sapphire interface to increase the light extraction efficiency. The truncated-triangle-striped patterned-sapphire substrate was fabricated through a wet etching process in hot sulfuric and phosphoric acid solutions. A rhombus-like air-void structure at the GaN/sapphire interface was formed though a wet etching process along a V-shaped air-void structure on the patterned sapphire substrate." After testing, the researchers concluded that "the [rhombus-like air-void structure LED] RA-LED has a 65% light–output power enhancement, a smaller divergent angle, and a periodic higher light intensity profile compared to a [flat sapphire substrate standard LED] STLED that provides a high external quantum efficiency in Nitride-based LED applications." [3]

Currently, LED manufacturers have the choice of two very different manufacturing processes. Dry etching creates bright efficient LEDs but does so slowly and with limited throughput. Wet etching is fast and very scalable, but produces LEDs that aren't quite as effective or efficient. Wet etching, however presents a considerable cost savings over dry etching, even if polishing touch-up work is performed on the wafers to increase light extraction efficiencies. It also scales much more efficiently making the cost savings multiply dramatically as throughput and wafer size increase.

Looking at the financial side, Rajiv K. Singh, founder and CTO of Sinmat breaks the numbers down like this: "Say you look at a flat substrate, and then you make a patterned substrate, the cost of making a patterned substrate increases the cost by 20% or maybe 25%. The wet etch would decrease that added cost by half."

Given the combination of per unit cost savings with significantly higher etch-rates, LED manufacturers and sapphire wafer suppliers need to give high temperature wet etching serious consideration. ■

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An Advanced and Complete LED Driving Solution

The presence of artificial, electrical lighting is a constant in our daily lives. Luigi Pistoni and Massimiliano Merisio from STMicroelectronics analyze the advantages of LEDs and give an overview of the numerous lighting applications involved. As a result they propose a dedicated driver solution capable of exploiting the best of an LED's peculiarities.

Introduction

For several years, traditional incandescent bulbs, fluorescent and halogen lamps have been our main light sources. The massive diffusion of LEDs as replacements for these light sources has significantly changed the concept of lighting, easing design and meeting new demands. The ever growing use of LEDs in various lighting segments justifies the importance of tailored driving solutions.

LED Diffusion in the Lighting World

These days, the presence of artificial light in daily life is taken for granted. Both in private and in public contexts, indoors and outdoors, lighting plays a fundamental role in human activities as a basic need, for safety reasons, for decoration, or recreational activities.

The traditional sources dominating the lighting world in the last few decades (incandescent bulbs, fluorescent lamps, halogen lamps, etc.) are giving way to LEDs, and the fact of their wide diffusion today.

The use of LEDs in indoor and outdoor lighting is prevalent as ambient lighting, emergency lighting, street lighting, decorative lights, as well as lighting in museums, stations and airports are all examples of applications where LEDs are widely employed (Figure 1).

There are several reasons why LEDs are revolutionizing this market segment:

- Ecological solutions, since LEDs do not contain hazardous materials
- Long lifetime (up to 50,000 hours and over), which simplifies maintenance and improves reliability
- Low driving voltages, significantly impacting the safety of the applications
- High brightness efficiency compared to most of the traditional light sources
- Wide availability of colors, particularly appreciated in architectural lighting solutions

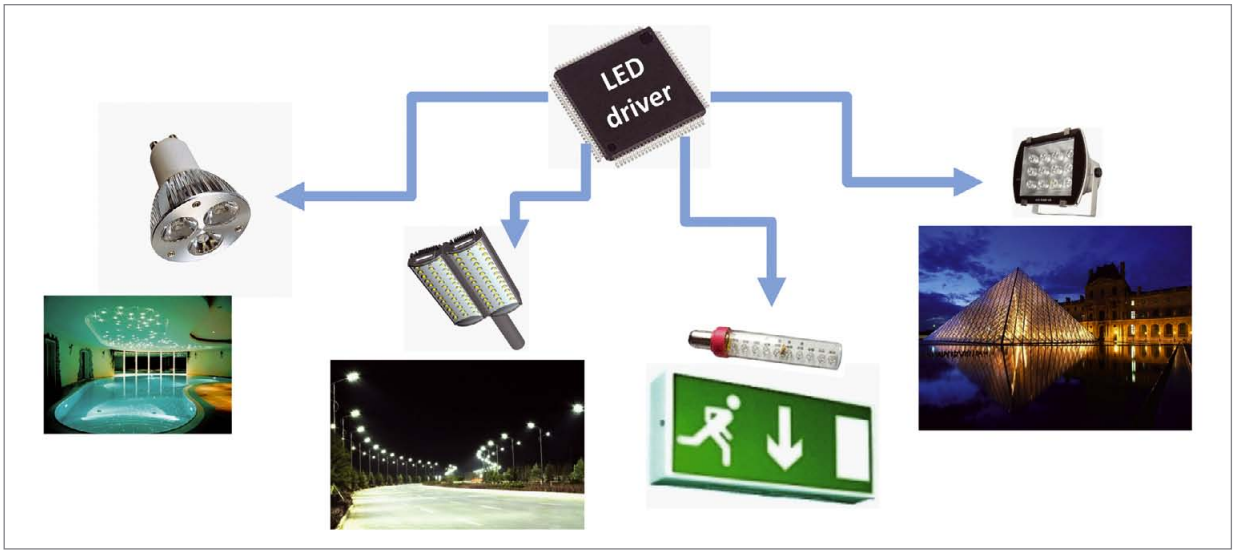

Figure 1: Examples of LED lighting applications

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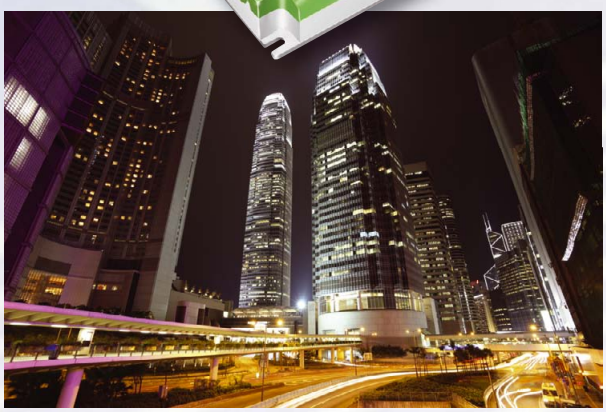

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It is worth mentioning that in the past a disadvantage of LEDs was the cost. However, the cost of LEDs has recently become increasingly competitive, making this choice even more attractive.

LED Lighting Requirements

In the wide world of lighting, different requirements can arise according to the variety of applications involved.

A common and basic demand of any lighting solution is the capability to regulate the brightness.

As the brightness of the light emitted is proportional to the current flowing through the LEDs, the driving principle implies the control of the current.

However, an accurate control of the brightness cannot be achieved by simply adjusting the current. The variation of the current in a LED also results in a change in the light's color, unacceptable in most applications.

Therefore, in order to guarantee good chromatic performance, more effective dimming techniques have to be implemented.

From this perspective, the adoption of PWM dimming is a common way to succeed in brightness adjustment, preserving the color of the emitted light at the same time (Figure 2).

This PWM dimming (Figure 2b) consists of controlling the average current (proportional to the programmed duty cycle), which regulates the brightness whereas the instantaneous value fixes the color of the light.

The analog dimming described in Figure 2a means simply varying the instantaneous current, instead. But this does not allow color preservation.

In accordance with the final application, the range of the current (and therefore the power of the selected LED) can vary a lot. Moreover, the number of LEDs to drive and their arrangement (series or parallel) can change significantly as well.

In home lighting, for example, a different number of LEDs and different powers can be requested depending on the ambient where the light is placed. Even though the LEDs might be the same in terms of power and number, particular design needs could request different LED arrangements.

An additional differentiating parameter is doubtless the voltage rail. Typical available voltages range from 6 V (e.g. emergency lighting) to 12 VDC and 12 VAC (e.g. MR16 replacement in home lighting), also to 24 V or 48 V (e.g. street lighting).

A single LED driving solution flexible enough to fit these different demands would surely be appreciated if it also eased the lighting design and saved costs.

Since saving money is a key concept, the choice of efficient systems becomes fundamental.

It is worth re-acknowledging that LEDs are known to be environmentally friendly not only because they are free of hazardous materials but also because of their high efficiency. This valuable feature should be emphasized by the use of smart ICs capable of reducing power consumption.

Furthermore, lighting solutions must comply with the more and more strict regulations in terms of efficiency and energy saving, which is now of primary importance.

A Dedicated LED Driving Solution

The LED driving solution described in this section uses the LED7707.

This IC combines a switching step-up conversion, which provides the LED voltage rail, and six current generators.

The boost converter is not the only solution to regulate the proper voltage to supply LEDs. A buck conversion could only fit some applications; however as the number of LEDs (in series) increases, this solution is no longer acceptable.

Certainly, a buck-boost conversion has the highest flexibility, but the complexity and the typical poor efficiency of this architecture are worth considering.

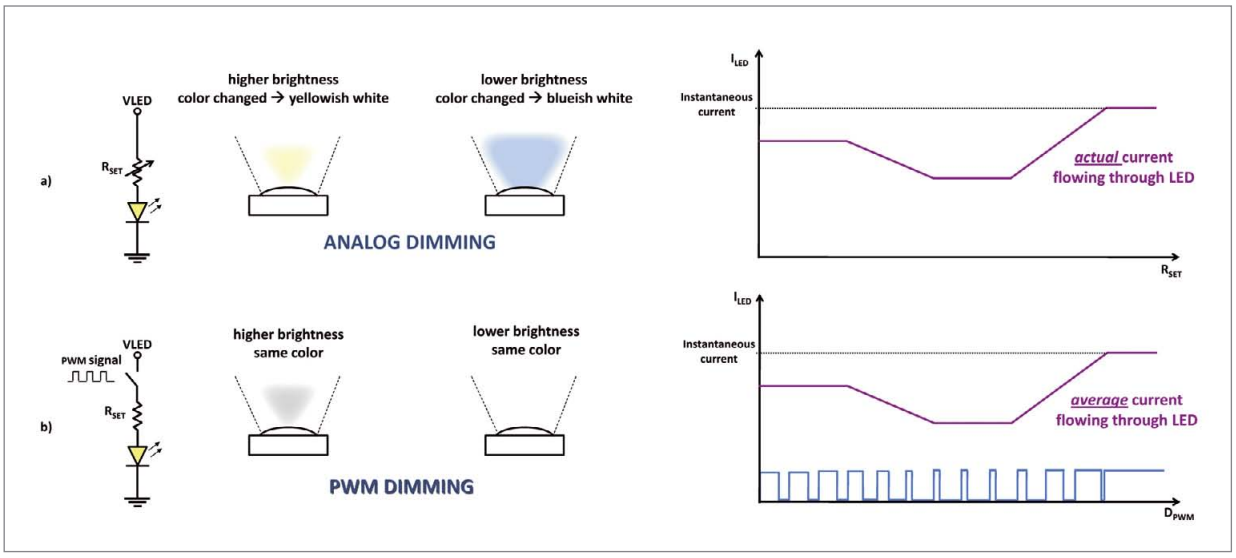

Figure 2: Comparison between analog dimming (a) and PWM dimming (b)

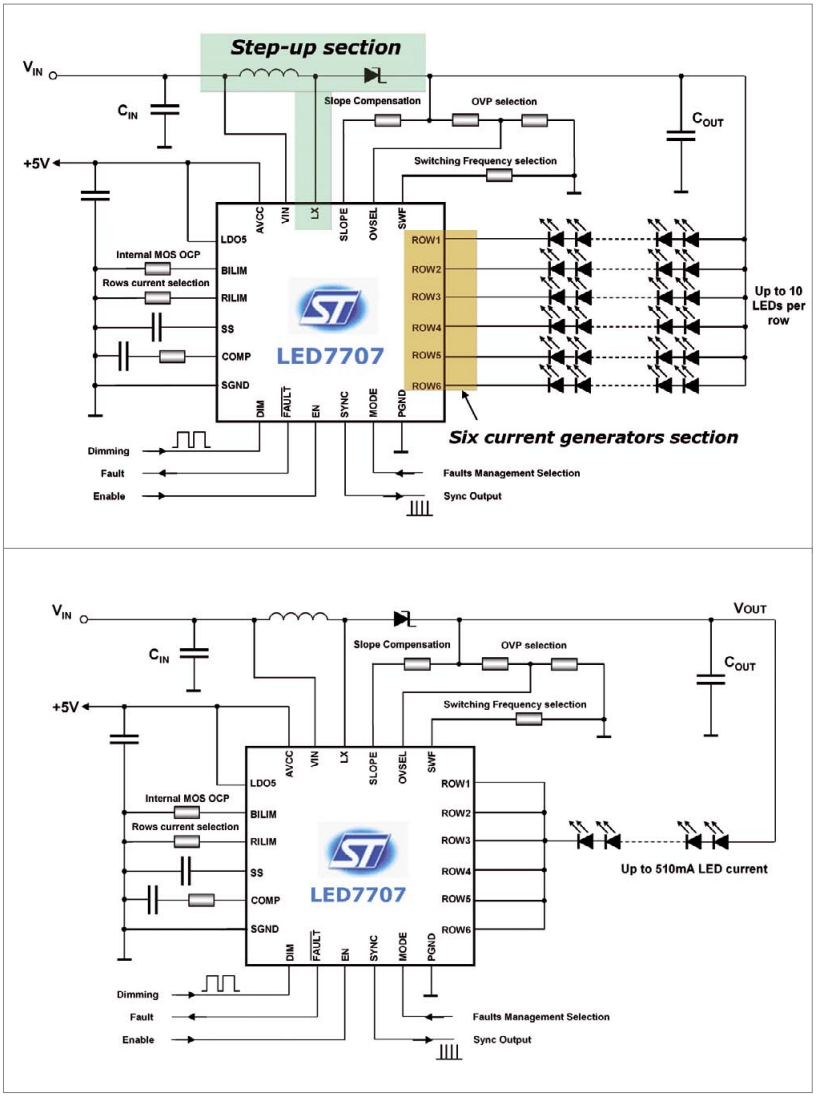

Figure 3:
Two different LED driving solutions for lighting using LED7707: six separate channels (top) or single string (bottom)

The boost conversion, together with the 40 V silicon technology employed to design the LED7707, allows up to ten white LEDs per channel to be driven (ten LEDs in series to each current generator).

The LED current is programmed by an external resistor for all channels and can be set up to 85 mA per channel.

According to the application requirements, the LEDs can be arranged in series and parallel (more LEDs in series over several rows), using channels separately (for lower current request) or connecting two or more generators together (achieving a maximum current of 510 mA for high brightness LED driving). Different LED arrangements are shown in Figure 3: More LEDs in series in a single string ensure uniform brightness. On the other hand, the number of LEDs in series is limited by safety constraints in terms of maximum voltage and by the external components cost. LEDs distributed on several rows reduce the voltage to manage, but intrinsic differences in current regulated in each channel can cause a slight unevenness in brightness.

In this way, the good current accuracy (maximum ±2%) between rows offered by the LED7707 becomes an essential feature.

Beyond satisfying different current requests, the flexibility of the LED7707 is also enhanced by managing wide voltage ranges.

In fact, the switching section can boost the input voltage from 4.5 V up to 36 V implementing a smart adaptive voltage regulation.

As is known, an LED's forward voltage (V_F) is characterized by a spread. Although the giant steps in LED technology have reduced the V_F variation, and LED suppliers also provide selections based on the V_F range, the voltage rail for a string of LEDs must be carefully chosen. This voltage should be high enough to guarantee the correct driving of all LEDs in the same string. On the other hand, a voltage excess should be prevented for power dissipation concerns.

Moreover, the intrinsic variation of V_F with the temperature (V_F decreases as temperature increases) complicates the LED voltage choice further.

The adaptive voltage regulation (Figure 4) implemented by the LED7707 automatically regulates the boost voltage.

In the "not adapted" approach (Figure 4b), the boost voltage is fixed according to the expected maximum voltage string, which is usually much higher than the actual one. The voltage excess causes further useless power dissipation.

In contrast, the adaptive regulation allows the device to determine in real time (see Figure 4a and Figure 4c) the string with the highest voltage, and consequently, to set the boost voltage.

Hence, the automatic regulation of the boost voltage implies the correct driving of all LEDs, and at the same time, the limitation of the voltage drop across current generators.

This not only represents a strong contribution to power saving but also becomes particularly useful in battery powered applications, like emergency lighting.

As extensively noted in this paper, the idea of accurate regulation of the brightness is fundamental in lighting.

The excellent time response of the current generators integrated in the LED7707 is a key factor to obtain high performance PWM dimming: an

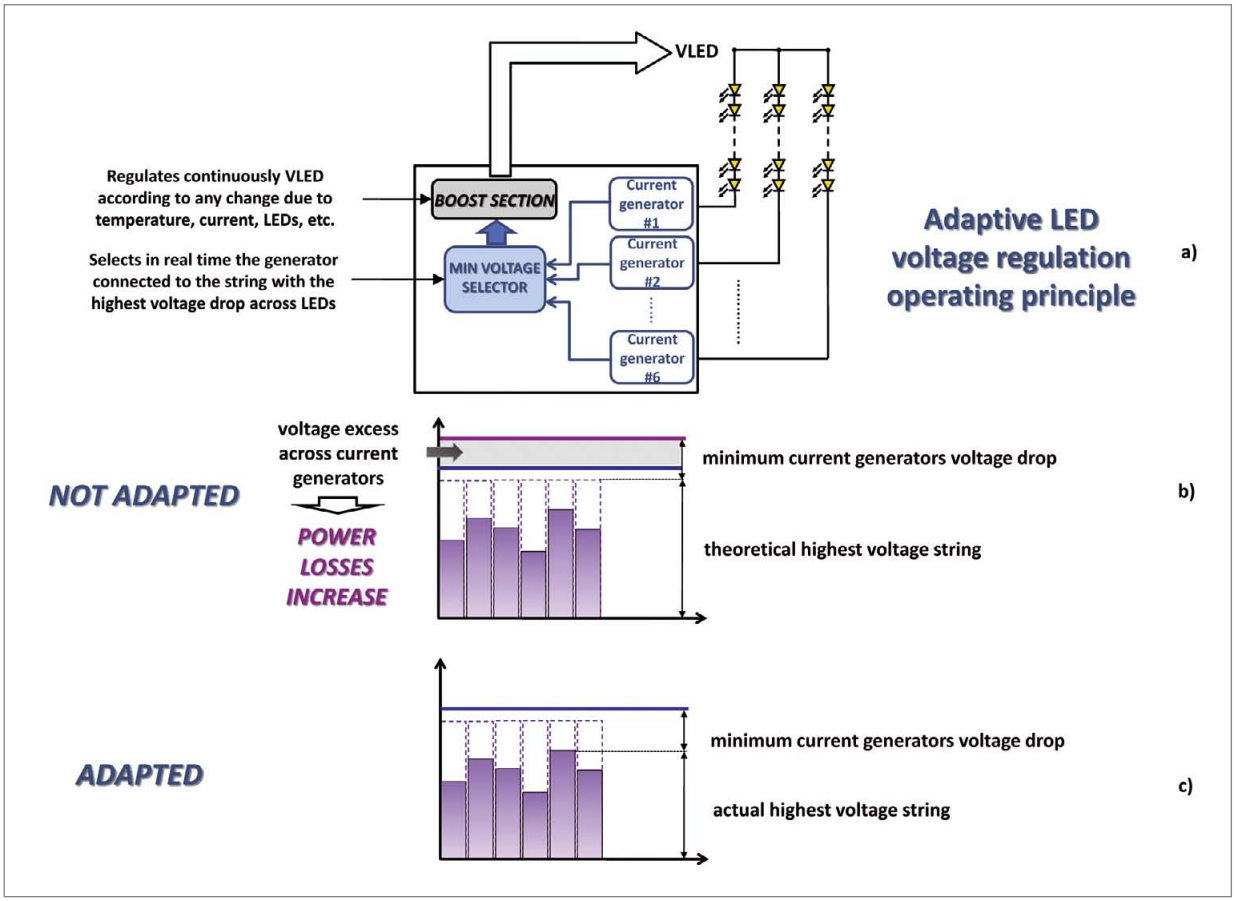

Figure 4:
Description of adaptive LED voltage regulation

enhanced brightness control can be accomplished because of the capability to manage 1% dimming steps at a 1 kHz dimming frequency.

However, the quality of a lighting system should not be evaluated in terms of performance only, but also, for example, in terms of reliability.

From this point of view, the real time faulty LEDs' detection implemented by the LED7707 enhances the robustness of the solution and eases the maintenance of the system.

Shorted LEDs or open channels (due to LED failure or to any other cause) are identified and the anomalous condition is indicated by a signal present at a dedicated open drain pin. A remote control can easily identify the issue.

Meanwhile, the device can manage the abnormal condition in different ways in accordance with the selection of a dedicated pin (MODE): the system can stop working or continue supplying only those rows not affected by the LED failure.

Conclusions

The well-known advantages of LEDs combined with dedicated drivers ease the design of LED lighting solutions employed in various applications.

The use of tailored drivers satisfying the demands of this market segment further facilitates the diffusion of LEDs as the prevailing light source in the near future.

The LED7707, characterized by good performance in terms of efficiency, brightness control, flexibility in voltage and current ranges, represents a positive solution to meet the different, and often strict, requirements of the lighting world. ■

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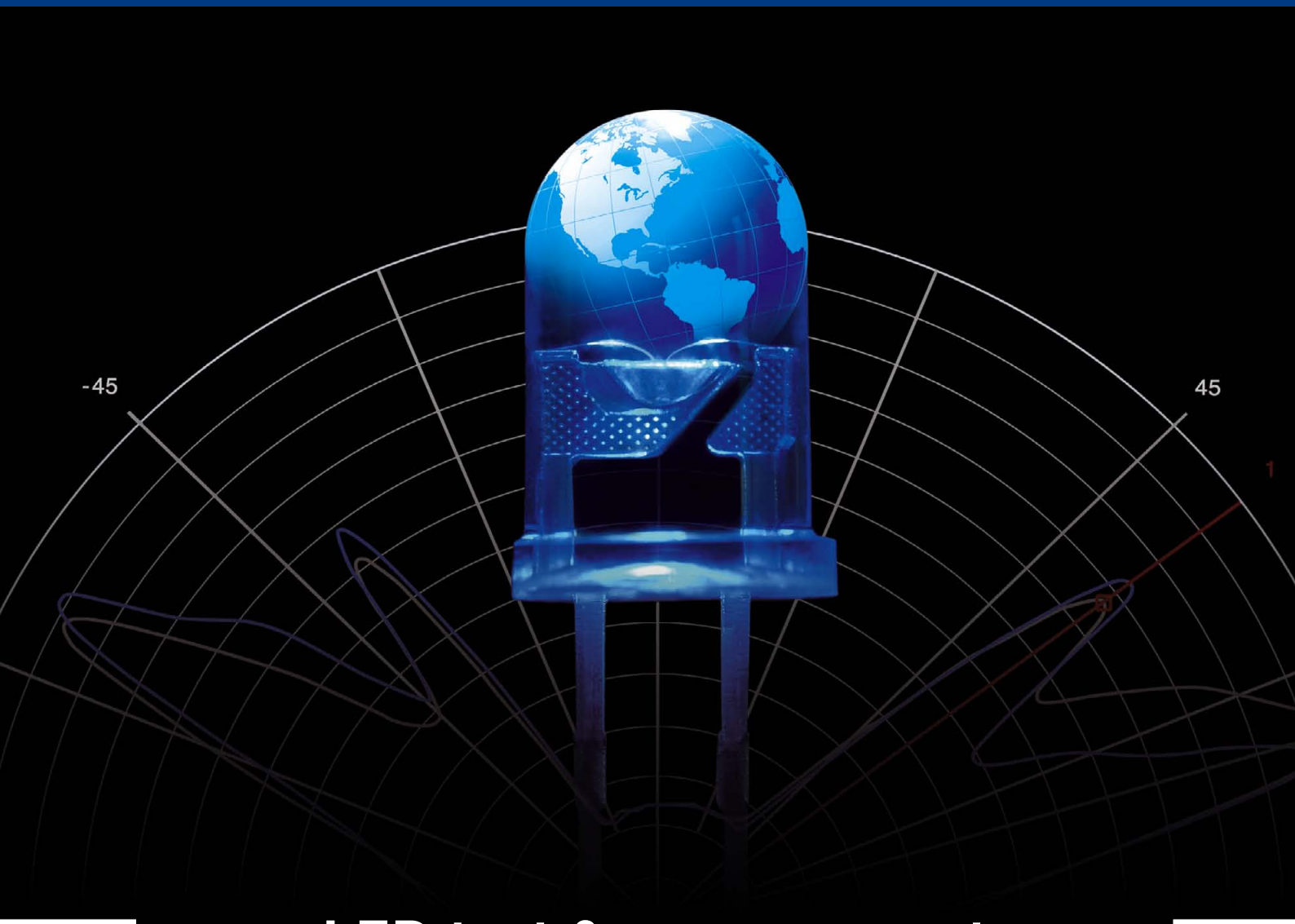

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High-Efficient, High-Power Multi-Channel LED Driver

For high performance LED-Drivers in high quality lighting applications multi-channel output is one of the most desired features. This is a big market for semiconductors, of course, but there are often alternatives which are smaller, more efficient or less expensive. Winfried Beyer, Senior Design Engineer and Stephan Gruber, MD from exscitron GmbH introduce a new approach to increase efficiency and performance of isolated multi-channel off-line LED-drivers.

The Problem

In most street lights, multiple strings of high-power-LEDs are fitted to reach the desired light output. Each string is made of several (e. g. 12) in series connected LEDs to keep the overall string-voltage below the SELV-limit (Safety Extra Low Voltage) in order to keep heatsink insulation and mounting as simple as possible. If these strings are connected in parallel, the current flowing in one string will not be the same as in the other due to tolerances of forward voltage and temperature differences between the LED chips. Figure 1 shows how a current mismatch between two strings would arise when connected in parallel and driven with constant voltage (CV).

Due to the low dynamic resistance of LEDs a small difference in voltage drop causes a significant different current in the paralleled strings. As a consequence the string with the higher current and hence higher power loss becomes warmer resulting in an even lower forward voltage and a more uneven current distribution. This finally results in a visible brightness difference and overloading of one string reducing its lifetime.

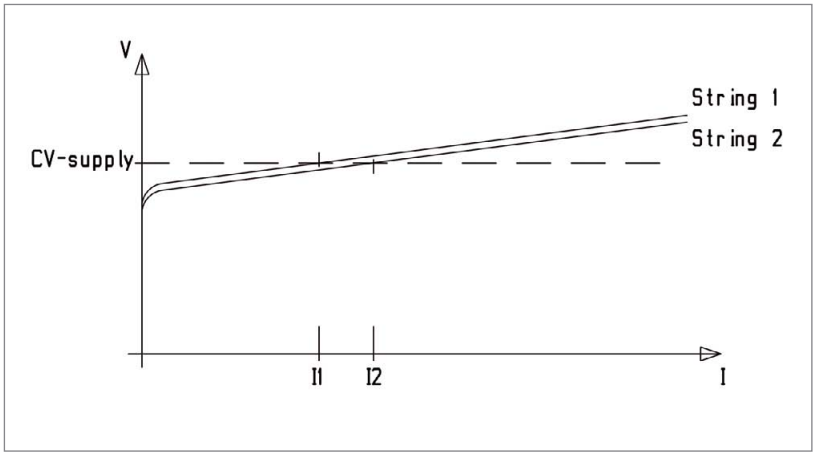

Figure 1: Different currents flowing in paralleled LED-strings

Standard Solution

Therefore each string has to be supplied from an individual current source which is achieved by adding a buck-regulator circuit between the constant voltage source and each string. Figure 2 shows this configuration.

The buck regulators could also receive an individual control signal and thus a color mixing scheme could be installed if each string consists of LEDs of a different color.

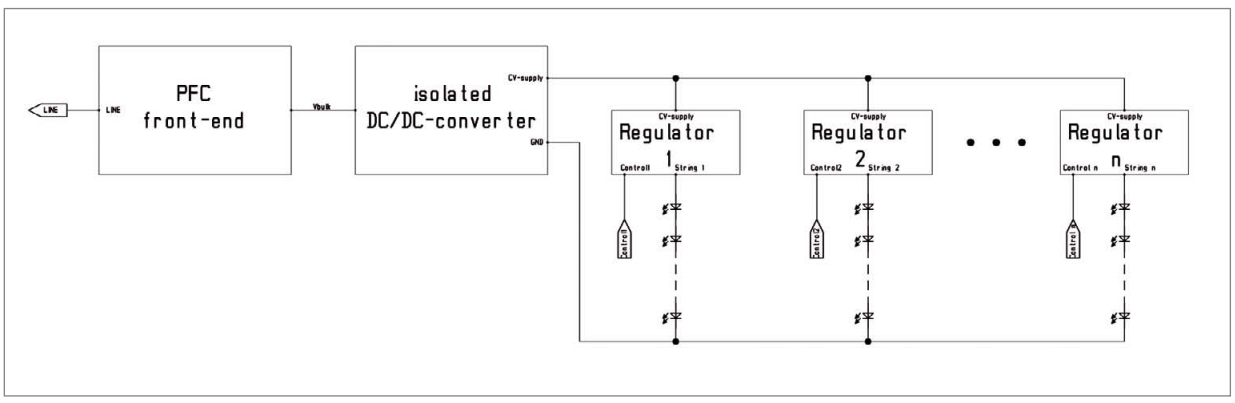

Figure 2: 3-stage concept with individual current regulator stages for each LED-string

The shortcoming of this 3-stage concept, however, is the poor overall efficiency of the whole current supply unit. The overall efficiency is the product of the efficiencies of the single stages.

$$\sum \eta = \eta_{PFC} * \eta_{DC/DC} * \eta_{Buck}$$

If an overall efficiency better than 90% is desired each single stage of the system needs to have an efficiency of at least 96.55%. This is only possible if fancy topologies and benchmark parts are employed making the whole unit quite expensive and complicated.

With cheap standard parts and concepts the following efficiency figures are reality:

PFC-stage:	94%
DC/DC-stage:	93%
Buck-stage:	92%
Overall:	80%

This efficiency figures are based on a narrow range 120 W output power 4-channel unit with string voltages of 48 V. If a lower string voltage or wide range input are used the efficiency figures drop further. With the example above the power loss of the driver alone is 30 W! To give a better feeling for this number a normal soldering iron used in electronics has this power consumption.

Doing it Better

To improve the efficiency the PFC- and DC/DC-stage could be combined into a single stage concept. A flyback converter is a common choice in this case because of its easy control scheme and low parts count. However, the efficiency of this stage won't be above 90% best more common are 85%, the buck-regulators for multiple channels at the output are still needed and with power levels >100 W this concept hits its limitations.

A high efficiency power stage would be a LLC-converter. To achieve off-line a good power factor with this concept an additional controller is necessary. This controller monitors the line-voltage and varies the setpoint for the LLC-converter in such a way that the input current meets the desired power factor and the applicable standard [1] for the harmonic current content. The regulator on the primary side ensures a constant output current rather than a constant voltage. As there is now already a constant O/P-current passive current splitter stages could easily be driven avoiding the buck-stages in this way. Figure 3 shows this concept with cascaded splitter stages to form a 4-channel solution.

Looking to the efficiency figures at foresaid conditions reveals the following for this concept:

Single stage LLC-converter:	93%
Current splitting stages combined:	99%
Overall efficiency	92%

To achieve this efficiency only off the shelf standard parts had been used and the dissipated power is only 10.4 W so the power losses at the driver are reduced by almost 70% compared to the 3-stage concept. Spinning it further and use benchmark parts would achieve an overall efficiency of up to 95% with a reduction of power losses by then more than 81%. The measured values of this 4-channel unit in a street light at full load are shown in table 1.

Vin(V)= 230			Pin(W)= 132.8		PF= 0.966	
0/P	Vdc (V)	Vac (V)	Idc (mA)	Iac (mA)	Irms (mA)	P (W)
CH 1	43.63	0.52	698	48	699.6	30.53
CH 2	44.38	0.51	696	46	697.5	30.96
CH 3	43.62	0.51	697	48	698.7	30.48
CH4	43.46	0.51	699	49	700.7	30.45
					Pout(W):	122.41
η(%)= 92.2						

Table 1: Full load test results

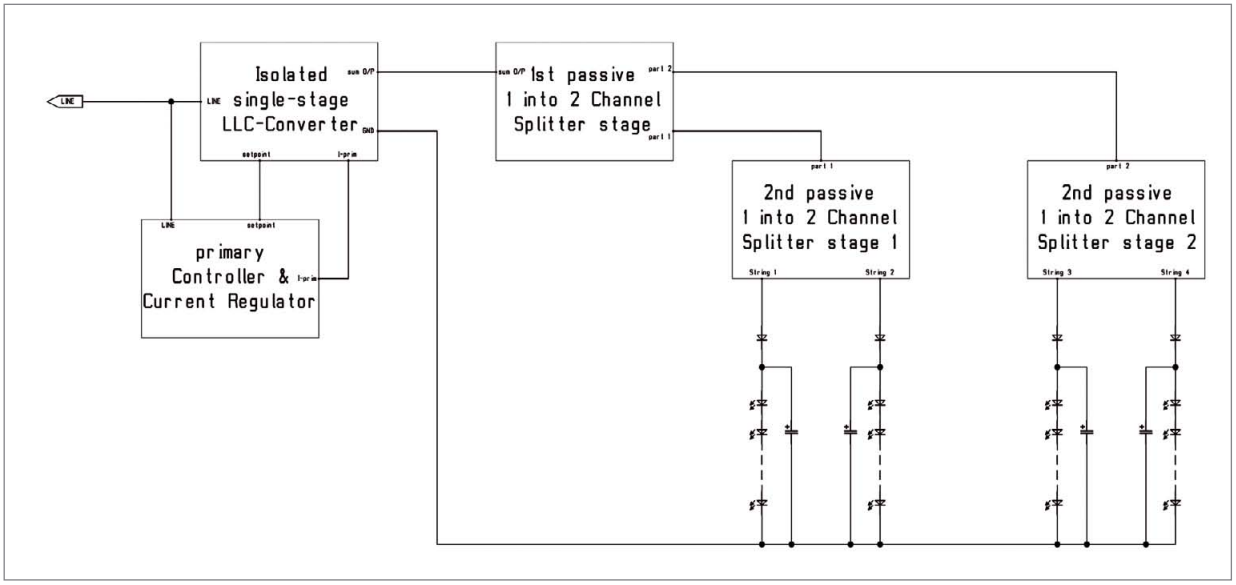

Figure 3: Primary single stage concept with secondary passive current splitting

Furthermore remarkable for this concept is the fact that for an isolated off-line 4-channel LED-driver only 2 power switches at the LLC-converter are employed making it very economical!

Instead of the primary high-voltage bulk capacitor low voltage capacitors are used on the output for line ripple attenuation. This low voltage electrolytic capacitors have much higher life-time figures than those for high voltage. All this factors together also increase the life-time figure for the ballast unit to match those for LEDs. That there is virtually no input capacitor eases the circuit in so far as no measures have to be taken to limit and avoid excessive inrush currents and so the line fuse doesn't have to be oversized.

The regulator circuit on the primary side keeps the overall (sum) output current provided by the ballast unit constant. As every individual channel is a current source itself the voltages across each channel can vary from zero (short circuit) to the maximum voltage allowed by the design of the ballast unit. This maximum voltage could be 12, 24, 48 V or any other value depending from the actual transformer turns ratio and system set-up used. This allows for example to use strings with different number of LEDs or different color. The efficiency of the ballast unit drops only slightly when driving a RGBW light engine mount with 12 LEDs per string but different color. The results are shown in Table 2.

	Vin(V)= 230		Pin(W)= 110.6		PF= 0.97	
0/p	Vdc (V)	Vac (V)	Idc (mA)	Iac (mA)	Irms (mA)	P(W)
R(Ch 1)	26.38	0.5	704	72	707.7	18.67
G(Ch2)	40.36	0.5	699	51	700.9	28.29
B(Ch3)	37.83	0.5	702	67	705.2	26.68
W (Ch4)	38.79	0.5	703	60	705.6	27.37
					Pout(W):	101
			η(%)= 91.3			

Table 2: Full load results with RGBW-load

Controllability

The fact that each output channel is actually a current source makes switching off and thus dimming of an individual channel easy, too. The output just has to be shorted. A shorted switching current source allows only the same current as in normal operation but the primary fed power is reduced by the shorted fraction. In order not to discharge the output capacitor every time when such a short circuit switch is closed they are connected before the rectifier on the RF-side of the output. In Figure 4 this switches are added.

With this configuration PWM-dimming of each individual output and therefore color mixing could easily be achieved. The only difference to the control signal for buck stages is the inverted duty-cycle here. The PWM-signal is low frequency, at least high enough not to encounter visible flicker, thus keeping the switching losses at a minimum. For example those switches for a 120W 4-channel ballast unit are mounted in a 6-pin SOT-23 case each.

As the maximum possible current IMAX flowing in each string of LEDs is given by the configuration and setpoint value of the primary power stage the resulting individual string current ISTRING calculates simply from the applied ON-duty-cycle D of the control signal driving the associated short circuit switch:

$$I_{STRING} = (1 - D) * I_{MAX}$$

Or the other way around with a desired string current given the necessary control signal duty cycle is as follows:

$$D = 1 - I_{STRING} / I_{MAX}$$

Principle of Operation

Principally the splitter stages act as auto-transformers if one string voltage is different to the other. The fact that a LLC-converter with a push-pull signal drives the primary side has the advantage to reset/reverse the magnetizing current of the splitter stages each half-wave after another when one output string is shorted or

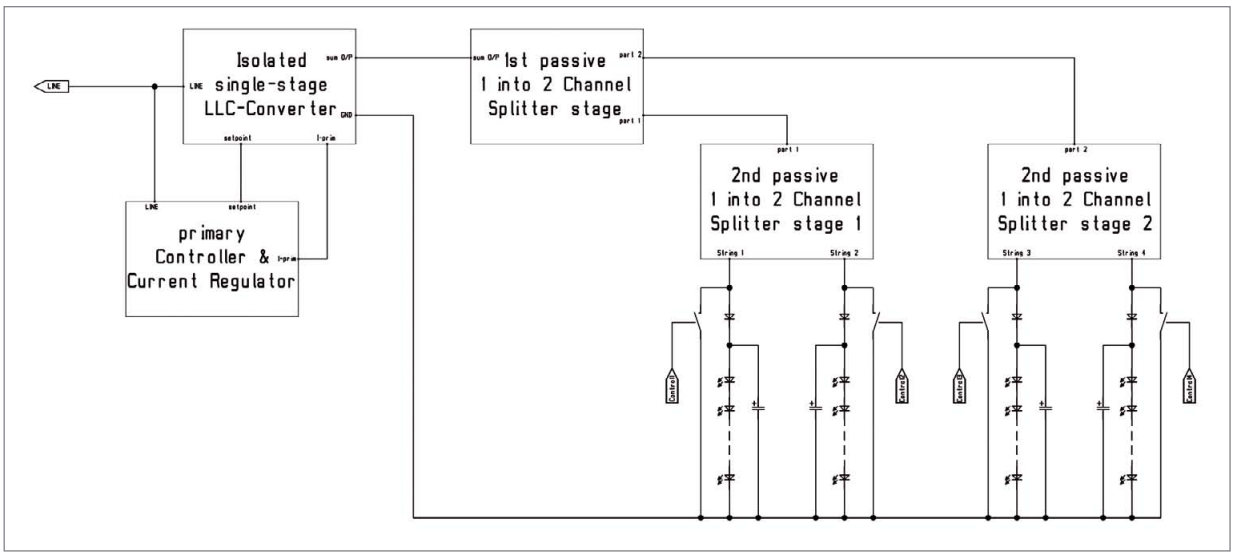

Figure 4: Added switches to short each output

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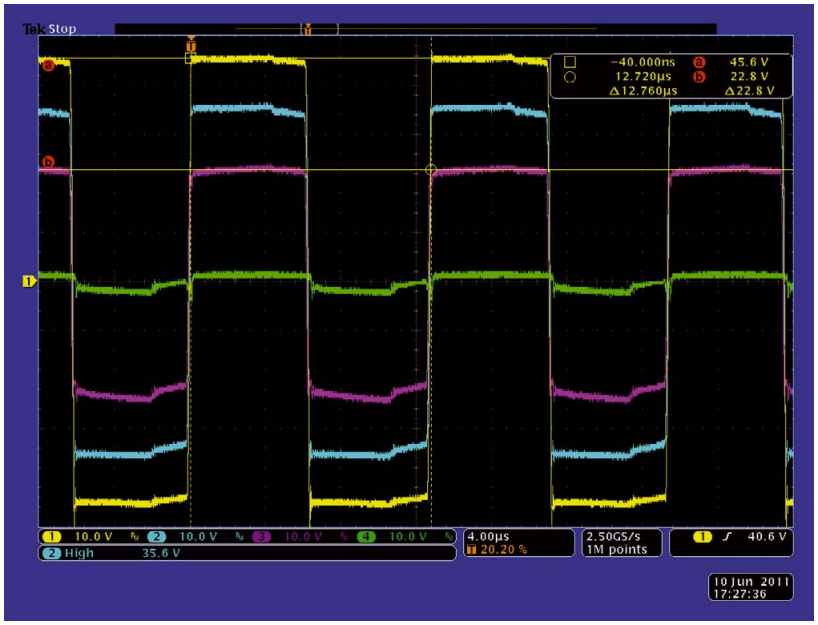

Figure 5: Waveforms with one O/P shorted
Channel 1: Voltage at the non-shorted outputs.
Channel 2: Voltage fed into the first splitter stage (signal 'sum O/P' shown in Figure 4).
Channel 3: Voltage fed into the last splitter stage (signal 'part 2' shown in Figure 4).
Channel 4: Voltage at the shorted O/P String 4.

	Vin(V)= 230		Pin(W)= 103.3		PF= 0.971	
0/P	Vdc (V)	Vac (V)	Idc (mA)	Iac (mA)	Irms (mA)	P (W)
Ch 1	43.75	0.5	702	47	703.6	30.78
Ch 2	44.5	0.5	698	45	699.4	31.13
Ch 3		0.5	701	47	702.6	30.76
Ch 4	0	0	766	588	965.7	0
					Pout(W):	92.67
			η(%)= 89.7			

Table 3: Results with channel 4 shorted

has a different forward voltage as the other. The latter for example would be the case when LEDs of different strings have other colors as used in color mixing applications. The key waveforms of a 120 W 4-channel unit with one output completely shorted are shown in Figure 5. The load of this unit are 4 strings of 12 white LEDs driven with 700 mA (DC) each.

Table 3 shows the measuring results and efficiency with this configuration. Even with a fully shorted output the measured efficiency still is almost 90%. The drop is mainly caused by magnetizing losses of the splitter stages and the bigger weight of the housekeeping functions because of reduced overall power.

It can be seen that with one O/P of a 4-channel unit shorted the fed voltage into the splitter stages is only ¾ of the voltage level at full load. As the current is kept constant the drawn power in this case is only ¾, too. For better understanding Figure 6 shows the splitter stages and the voltage levels in the system are visualized graphically.

Now with our 4-channel ballast unit a RGBW light engine had been driven with each channel set to a different dim level. Figure 7 shows the waveforms and Table 4 the recorded measurements. W (Ch4) was set to 100%, R (Ch1) to 75%, G (Ch2) to 50% and B (Ch3) to 18%.

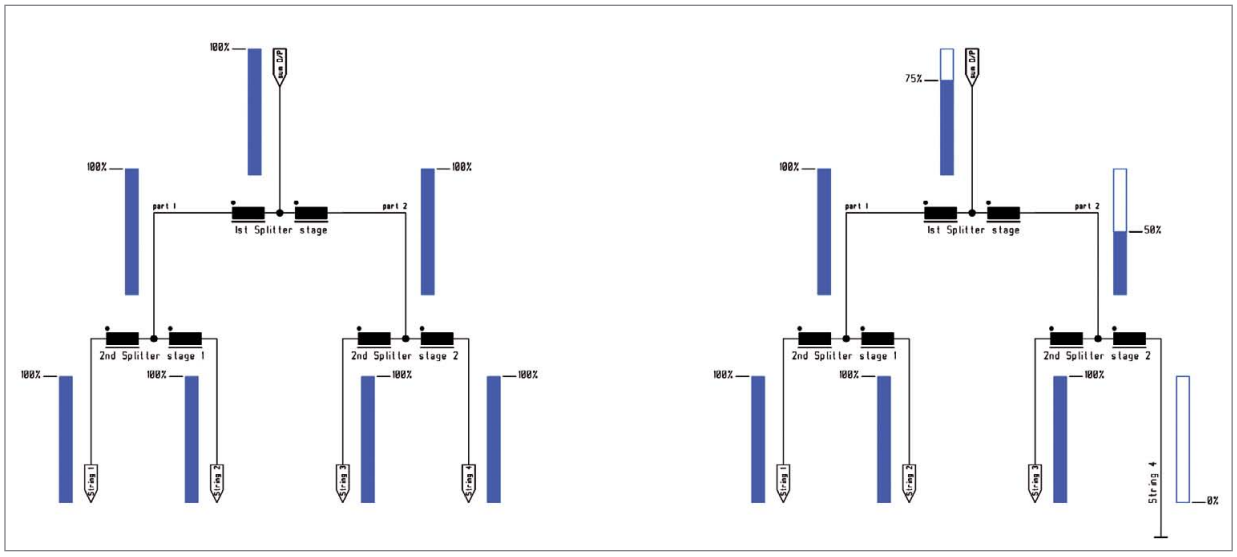

Figure 6: All 4 channels at full load (left), Channel (String) 4 shorted (right)

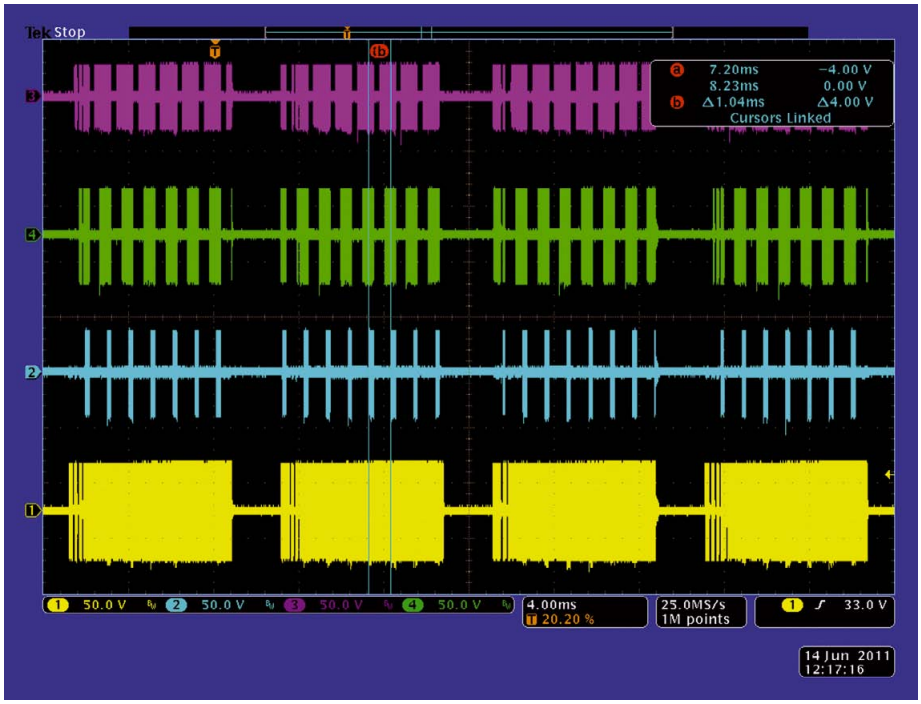

Figure 7: **RGBW with different dim-level each channel**
Channel 3: Voltage fed into R-channel (signal 'String 1' shown in Figure 4).
Channel 4: Voltage fed into G-channel (signal 'String 2' shown in Figure 4).
Channel 2: Voltage fed into B-channel (signal 'String 3' shown in Figure 4).
Channel 1: Voltage fed into W-channel (signal 'String 4' shown in Figure 4).

	Vin(V)= 230		Pin(W)= 67.3		PF= 0.904	
0/P	Vdc (V)	Vac (V)	Idc (mA)	Iac (mA)	Irms (mA)	P(W)
R(Ch 1)	25.68	0.37	522	50	524.4	13.47
G(Ch2)	37.79	0.25	349	19	349.5	13.21
B(Ch3)	33.18	0.1	124	7	124.2	4.12
W (Ch4)	39.7	0.49	696	57	698.3	27.72
					Pout(W):	58.52
			η(%)= 87.0			

Table 4: **Measurement results with dimmed RGBW**

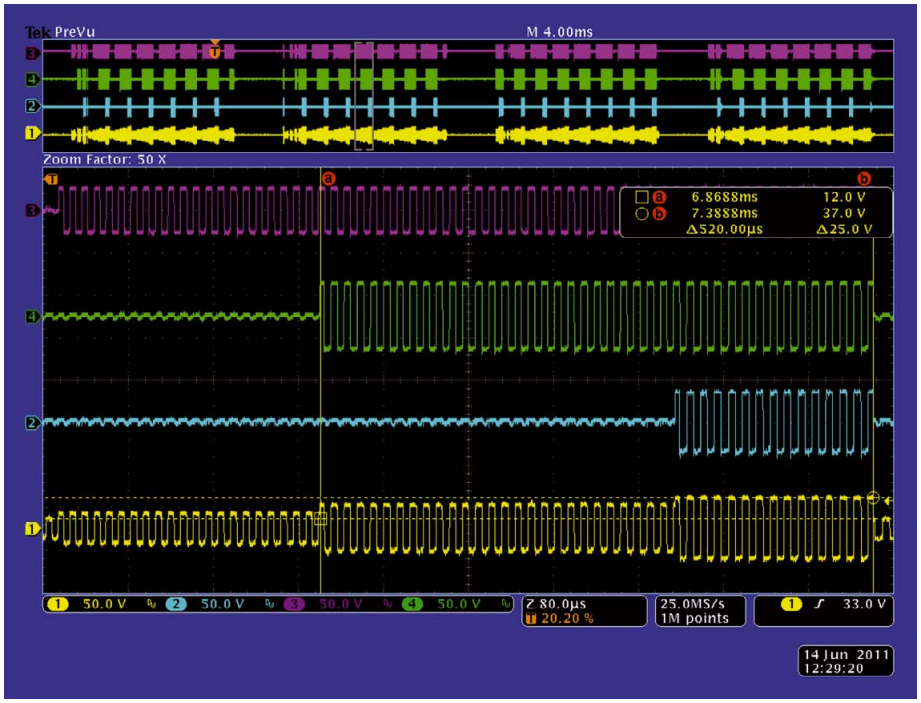

Figure 8: **RGBW with different dim-level and sum-signal**

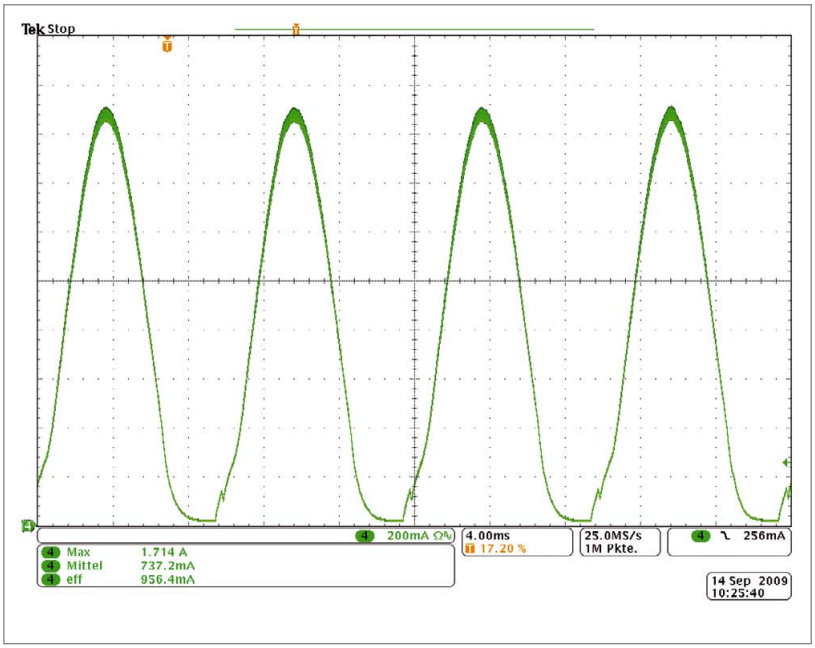

Figure 9: Short circuit switch current at ON state

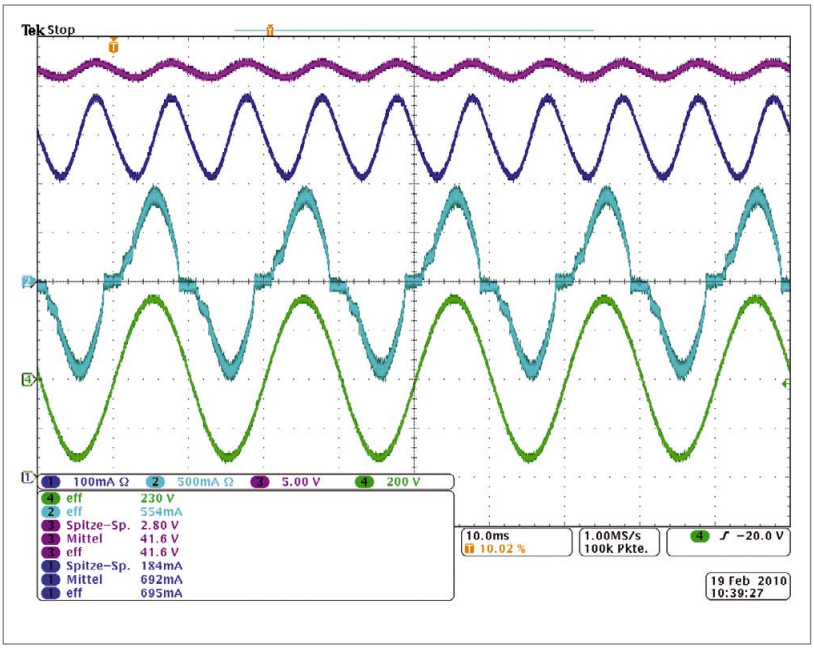

Figure 10: Full load I/P and O/P waveforms of the 120W 4-channel LED-driver
Channel 3: Voltage at the outputs.
Channel 1: Output current of a single string.
Channel 2: Input current drawn from the main supply.
Channel 4: Mains voltage.

The chosen dimming frequency was set to 1 kHz to keep the light output absolutely flicker free. Figure 8 was recorded with the same set-up as at Figure 7 but the difference that channel 1 now shows the voltage fed into the first splitter stage (signal 'sum O/P' shown in Figure 4).

It can be seen that the feeding ballast unit is a true current source as the sum voltage shown by channel 1 changes instantaneous with shorting a channel or release a short circuit.

Dimensioning

Dimensioning the short circuit switches is rather easy. Because the voltage on the secondary side is SELV small low voltage switches could do the job for this purpose. Figure 9 shows explicit the current waveform flowing in a short circuit switch when ON at full load.

As the nominal string current is 700mA it can be seen from this picture that the peak current handling capability has to be 2.5 times and more important the RMS current handling capability of those switches must be roughly 1.4 times the nominal DC string current because a significant AC-component is also present.

Figure 10 shows the I/P and O/P waveforms of the 120W 4-channel LED-driver under normal conditions at full load powering a street light.

The measured power factor here is >0.96 and the applicable EMI-standard [2] is met as well as the standard for the harmonic current content [1].

Conclusions

All this is making the single stage concept with passive splitting a good choice for temperature critical applications. Heat not generated doesn't have to be dissipated, even better when this comes through with added functionality, simple and for a competitive price either. ■

References:

[1] EN61000-3-2 class C
[2] EN55022 class B

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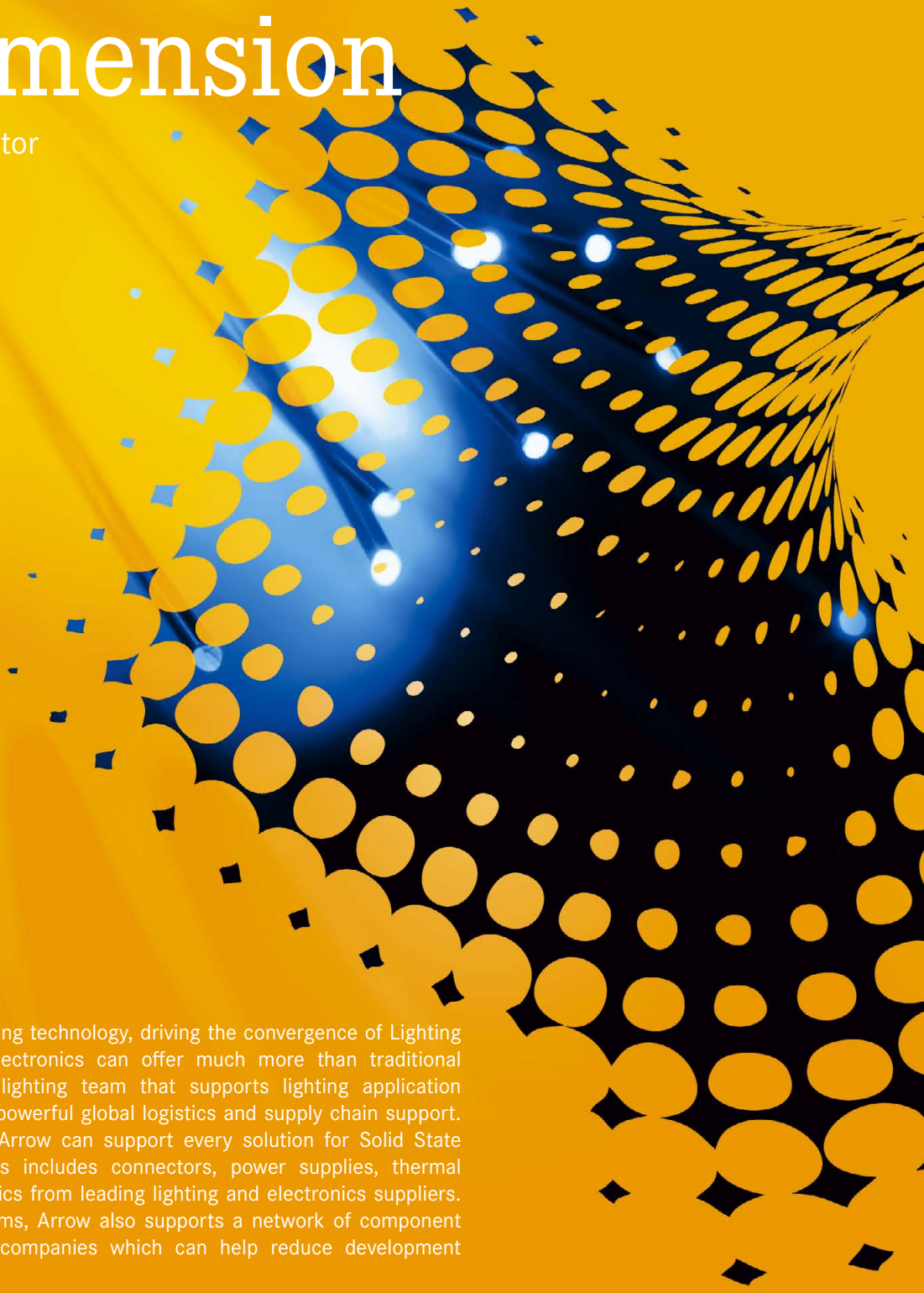

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High Brightness LEDs on FR4 Laminates

Gerhard Neumann is convinced that there is no need for Insulated Metal Substrates for LED applications. The Melecs Head of R&D and his engineering team have proven that common FR4 laminates will sufficiently withstand the heat of HB LEDs.

Introduction

The need to dissipate heat from electronic modules and assemblies is gaining importance quickly – not only as a consequence of the inevitable "smaller, faster" trend for microelectronics to operate at higher frequencies and higher performance levels. In the field of automotive engineering, thermal management becomes a critical consideration. Despite the widespread experience with heating issues of DC power supplies, inverters, power controllers and motor drivers, the design of applications with high-brightness LEDs (HB LEDs) is still challenging and in consequence the use of expensive Insulated Metal Substrates within printed circuit boards is the first choice. However, a tricky thermal management construction now allows for the use of FR4 laminates in headlamps using HB LEDs.

Generally, the thermal management of an electronic system encompasses all of the thermal processes and technologies that must be employed to remove and transfer heat from individual components to the systems' thermal sink in a controlled manner. Engineers developing a system have to ensure that the temperature of all components is maintained within functional and absolute maximum limits. For this, the functional temperature limit is the range within which the electrical circuits can be expected to meet their specified performance or cause logic errors. Temperatures exceeding the limits can cause physical destruction or may result in early failure of electronic components in the system.

Considering the Cost Challenges

How to disperse the heat? Conduction, convection, and radiation are the three means of heat transfer. Probably the most efficient mode of heat transfer is conduction through the substrate. Many power-electronics and under-bonnet automotive devices are built using direct bonded copper (DBC) substrates on ceramics with good thermal conductivity, although at a significantly higher cost. Another alternative are Metal Core Printed Circuit boards (MCPCB) which combine an aluminium core with an epoxy isolation and copper conductor pattern.

The disadvantage of these thermal management solutions is that normally it's not possible to mount LEDs and the required driver electronics on a single printed circuit board at a reasonable price. The additional space needed comes with a huge cost penalty.

In order to maintain a low junction temperature to keep good performance of an LED, every method of conveying heat away from LEDs should be considered. An LED is

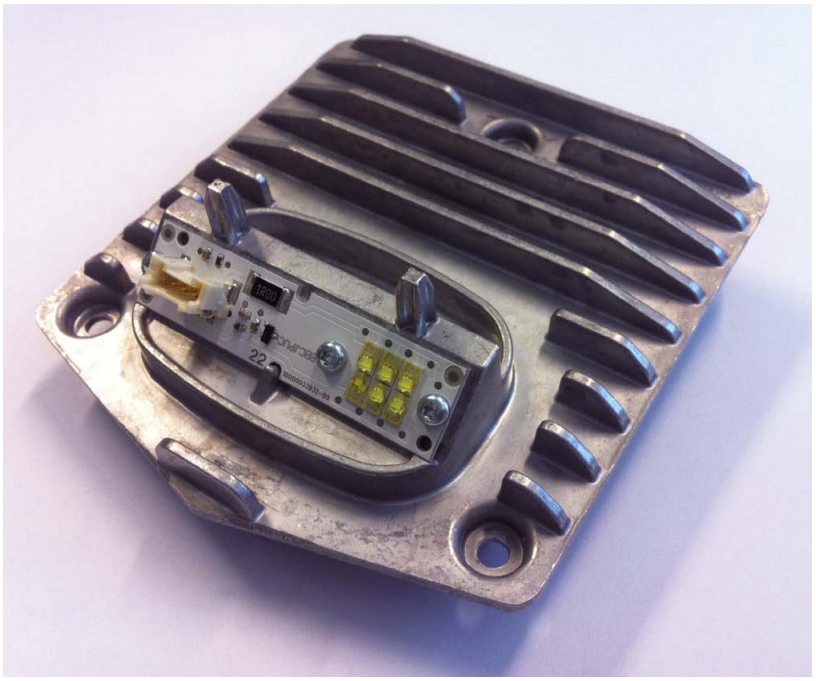

Figure 1:
Test setup of a British luxury car headlamp: Six Luxeon Rebel LEDs assembled on a FR4 substrate are integrated in the headlamp housing

essentially a p-n junction semiconductor diode that emits light by electroluminescence when an electric current is applied. Light intensity is a function of the forward current across the junction, and higher currents cause the junction temperature to increase. Good thermal management is required to achieve bright light without overheating the junction. The life expectancy of an LED is closely related to the operating temperature of the junction: A 10°C reduction in junction temperature will approximately double the life expectancy of the LED. Clearly, the key to energy efficiency and longevity is proper thermal management. Just a bit too much heat can cause a complete colour change, the light intensity will decrease and spectral parameters like colour temperature, colour coordinates or dominant wavelengths will suffer accordingly.

A New Way of Thermal Management

However, for the very cost sensitive automotive business, these solutions are quite expensive. Ease of production and ease of use were the main challenges in order to realize an affordable headlamp. Looking for increased production efficiencies and lower cost FR4 laminates seemed to be a way; especially high-Tg laminates with a nominal glass transition temperature of 170 to 180 °C (DSC). This kind of epoxy system offers very good resistance to heat and chemical attack. Additionally, they cope with the increasing thermal stress associated with lead-free interconnection technology to an extremely high degree.

Although common printed circuit materials have good electrical insulation properties, they generally provide acceptable thermal insulation as well. The idea was to find a way using high-Tg FR4 for the HB LEDs like Luxeon Rebel from Philips Lumileds. These LEDs with their InGaN/GaN flip-chip design create brilliant white light. Moreover, they combine a compact package design with a simplified secondary optic design and integration. This way, they reduce the need for sophisticated thermal management engineering and ease assembly and integration which leads to reduced manufacturing costs. However, two steps are necessary in order to obtain good heat dissipation:

- The thermal path needs to be as short as possible
- The thermal path needs to be as wide as possible

To achieve this, thin printed circuit boards are required with a thickness of at least 0.7 mm or 0.8 mm. Boards with a thickness below 0.7 mm may be difficult to handle in the assembly process due to the need for additional supports or removable substrates. On the other hand, the thermal resistance of boards with more than 0.8 mm thickness will increase significantly.

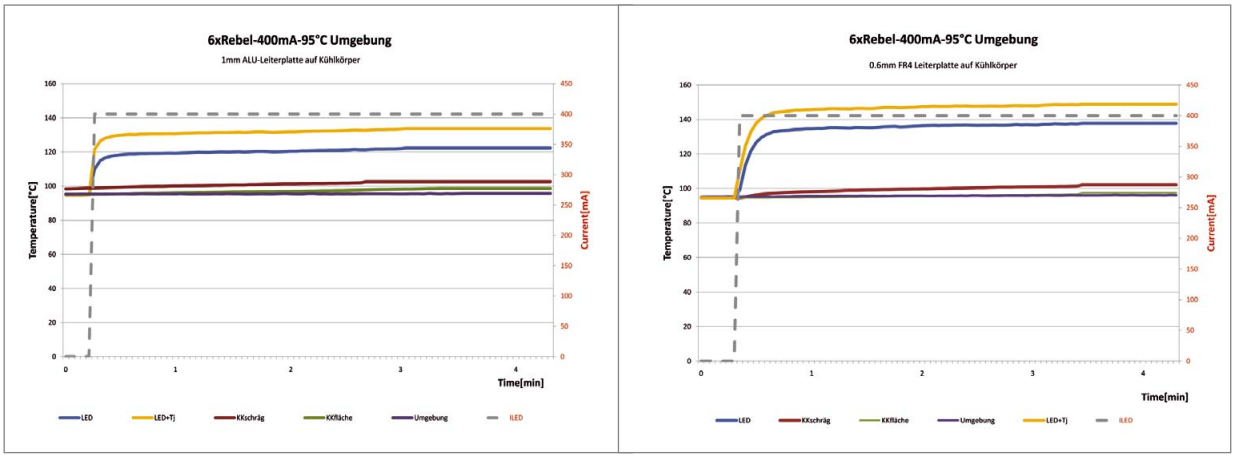

Figure 2: **Measurement results of a 1mm Al-PCB (a) and an FR4-PCB (b) under extreme temperature conditions of 95°C clearly showed a temperature difference of about 14 K at 7 W total power**

Several tests have shown that a double sided, plated-through printed circuit board with an external copper layer between 70 µm and 105 µm on the bottom side are ideally meeting the requirements to dissipate the point-shaped heat from the LED on a horizontal area of about 15mm x 15mm. The heat is then conducted through the board through vias with a pitch of 0.8 to 1mm. Good results have been achieved with a final hole diameter of 0.35mm. A low thermal contact resistance paves the way for the heat to the heat sink. Additionally, due to the good thermal spreading in the bottom-side copper layer, no full-area thermocouple contacts are needed. Hence, efficient thermal management with common insulated metal substrates doesn't have to be the first choice any longer. While omitting the interface material reduces the active heat transfer area, the direct contact without the interface's conduction losses easily makes up for that.

The measurement results clearly showed a temperature difference of about 14 K at 7 W total power. That means that the contact resistance by using FR4 substrates increases by only 2 K/W while cost reductions in manufacturing the printed circuit boards amount to approximately two thirds.

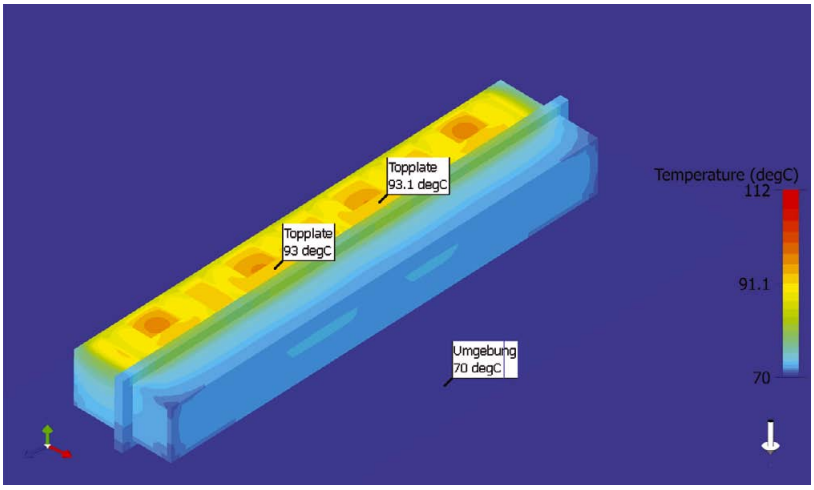

Figure 3:
No thermal stress has shown up at an ambient temperature of 70 °C by using standard PC ABS moulds

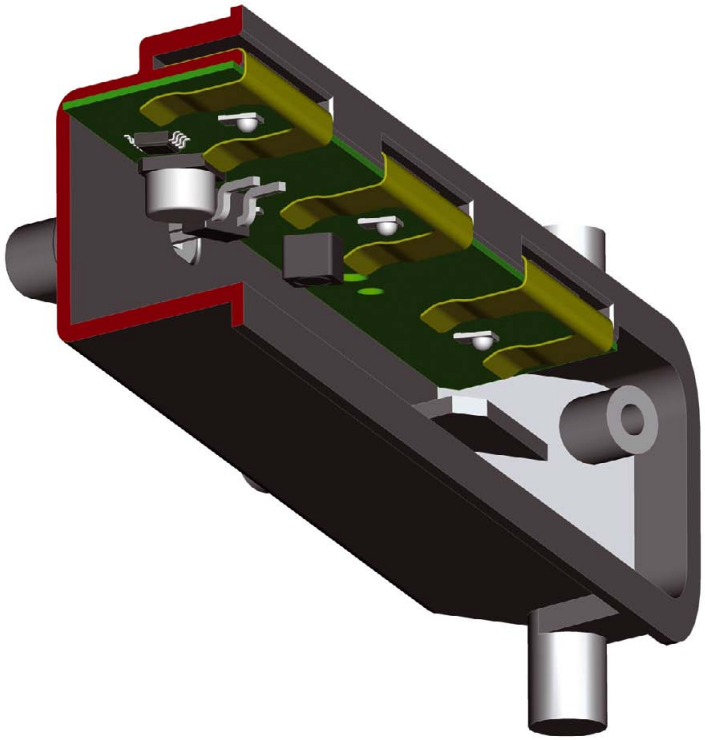

Figure 4:
Ease of production and use: The printed circuit board is connected to the lamp housing by proprietarily developed steel clamps which allow a solid thermal management

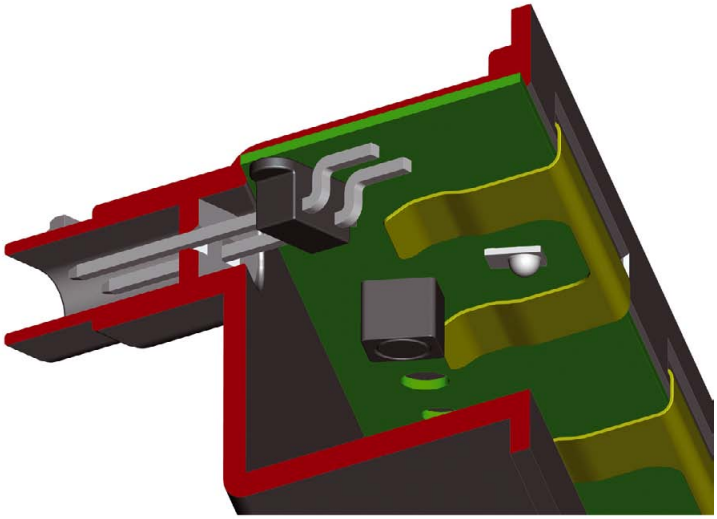

Figure 5:
If, however, connector and LED are orthogonal, using a single board is more difficult. A customized SMD part could do the trick

Success with Cramps

Using a standard printed circuit board with conductor path width and spacing of 200 µm not only lowers the costs. Tests proved that in the case of daytime headlights with four Luxeon Rebels LEDs aluminium heat sinks can be avoided even when the ambient temperature reaches 70 °C. However, the latter case requires a reliable thermal contact between the printed circuit board copper and the heat-resistant thermoplastic moulding (e.g. PC ABS; Polycarbonate Acrylonitrile Butadiene Styrene) of the lamp over the whole life expectancy of the LED.

This special contact is provided by proprietarily developed steel clamps which connect the printed circuit board to the lamp housing. Therefore, the housing material doesn't necessarily need an improved thermal conductivity. The only requirement is standard PC ABS material. Due to this, friction-welding of casing and face-plate is easy to do. The elastic force of the steel clamps compensates for shrink, flow, contraction or twisting.

Several simulations indicated that at an ambient temperature of 70 °C, the housing temperature acceptable for standard PC ABS reaches 93 °C. These results were confirmed through measurements of A-class samples.

From Car to PCB

Additional cost savings are possible by connecting the vehicle-side contacts directly on the printed circuit board. As SMD parts they may be assembled on the pick-and-place line. By mounting the connector pins, as required by the OEM, directly on the printed circuit boad, the number of cables can be reduced significantly as well as both parts of the PCB connector. Alternatively, Pressfit contact pins may be used.

In both cases, the connector pins are led outside through openings in the housing during the final assembly. The connector flange then is part of the injection-moulded housing. For mounting the pins on the printed circuit board, Pressfit, SMD or THT technology may be used. While

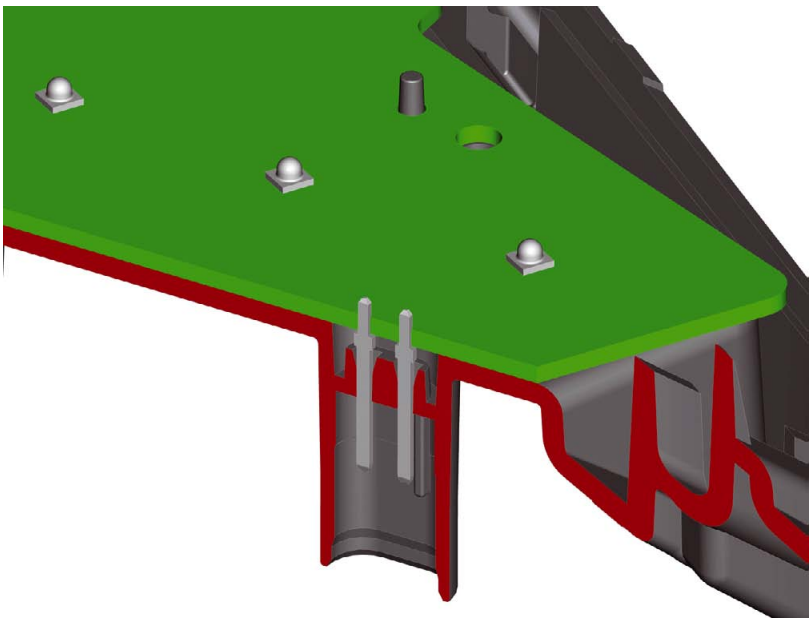

Figure 6:
Additional cost savings are possible by connecting the vehicle-side contacts directly on the printed circuit board

Pressfit technology is the preferred way, it requires more coordination effort with the lamp designer as it is imperative being able to mount the printed circuit board in a right angle to the connector. Ideally, the directions of LED light emission and the connection are parallel. In that case, LEDs, drivers and OEM connectors may be assembled on a single PCB. If however connector and LED are orthogonal, using a single board is more difficult. A customized SMD part could do the trick.

However, Pressfit is well known within the printed circuit boards industry. As a connection, solid press-fit technology offers a favourable alternative to soldering. In order to generate a reliable press-fit connection, the pin of the press-fit component must have a slightly greater surface area than the actual contact area with the PCB's plated-through hole. Consequently, solid press-fit technology is most notably suitable for high-current applications and for the use under adverse environmental conditions. One of the main reasons is the excellent electric characteristics, especially for high-current applications. There it is important to minimise voltage drop and heat generation. These values are directly proportional to the resistance, so the resistance also needs to be kept to a minimum. This resistance is minimised as the press-fit connection has a lower resistance value than the pin itself. For verifying the connection's quality, it is important to know how current flows through the system of press-fit component, pin, barrel, and conductor track of the printed circuit board. Due to the conduction behaviour within a press-fit zone, it is logical to assume that the electrical conductivity of a press-fit zone is not affected by deformation and residual thickness of copper, as long as the connection of tracks to the plated-through hole barrel remains intact.

This well-established technology has been transformed by Melecs to reduce production cost as much as possible. Using both described methods, unsophisticated ancillary lamps like daytime running lights, indicators, fog lamps, etc can be manufactured at very low prices, maybe even below 10 €.

Assembling LEDs Accurately

Still challenging, is the assembling of LEDs: Manufacturing LED products requires highly flexible and accurate machinery and specific process know-how. Cost-efficient production is a high priority, especially in the automotive sector. As HB LEDs are getting more efficient and brilliant, their handling during the SMT assembly process is quite tricky. As they become tinier with each generation, the surface of the optical lens becomes extremely delicate.

Special attention is needed in the Pick-and-Place section: Nowadays, Pick-and-Place takes over more functions. With changes in software, nozzles, drive systems, feeders and other elements, pick-and-place systems can place bare die or LEDs, perform high-speed IC shooter functions, handle large connectors and other oddforms, etc.. However, nozzles and the right intake pressure are crucial to accurately and consistently place LEDs preventing any damage. The right choice of the nozzle avoids placing mechanical stress on the LED lens by not touching the optical surface during component picking or placement processes. This reduces the possibility of degraded LED performance after the circuit board is assembled.

Conclusion

Especially in the cost-sensitive and safety-centered automotive business, a cheaper and equally reliable alternative to high-end PCB technologies could pave the road to success. FR4 has been around for decades and test results indicate that it shows a good performance with high brightness LEDs. An additional copper layer allows for at least acceptable thermal properties at and unbeatable cost. Thus, FR4 with a copper bottom has the potential to replace insulated metal substrates at least in not life-critical systems. ■

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