LED professional Review

www.led-professional.com
ISSN 1993-890X
LpR

The technology of tomorrow for general lighting applications.

Mar/Apr 2008 | Issue 06

EVERLIGHT

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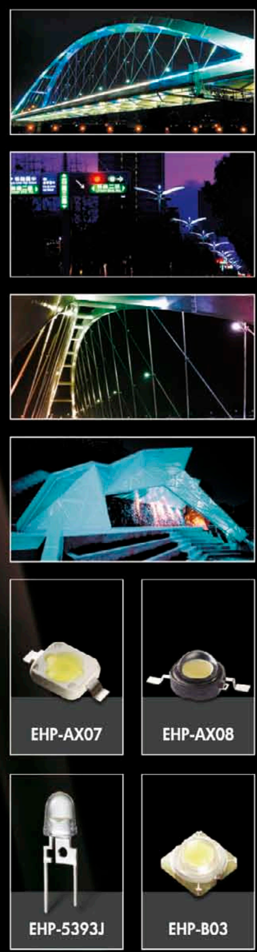

Ultra Bright - High Power LEDs

Leading the way in innovation and specialty, EVERLIGHT continues to develop a broad portfolio of high-power LEDs providing high luminance and high efficiency, while satisfying the demands of today's interior and exterior lighting applications.

As a pioneer in the optoelectronic industry, our everlasting mission is to develop leading edge LEDs that brighten our world whilst being environmentally safe and contributing to a better life for all mankind.

More information about the company's diverse products and solid-state lighting solutions can be found at www.everlight.com

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(LED)Light and Building

LED technology is not an evolution from existing lighting technologies. It is a disruptive revolution based on an emerging light emitting technology that will find its way in nearly all lighting applications within a couple of decades. LEDs will dominate all lighting applications because of their superior value proposition offered to the consumer, the economic infrastructure and the environment.

LEDs will lead to energy and environmental savings, but it will change the way we think about lighting too. LED devices are vibration and shock resistant, and exceptionally long-lived. They will allow for a wide variety of lighting, including artificial lighting similar to natural daylight. Moreover, with appropriate circuitry, the color and intensity of the lighting can be controlled. LED devices also offer interesting design possibilities; they can be manufactured as flat packages of any shape that can be placed on floors, walls, ceilings, or even furniture.

As the LED manufacturing process improves and the quantity produced increases, the price should rapidly drop. As the latter is reduced, it will encourage new applications and the cycle will accelerate. As per Haitz's law, LED output (in lumens) doubles every 18-24 months, resulting in cheaper and more efficient devices. This will be of great import to the industry as cost is the main deterrent to consumers. Bringing down the price of semiconductor material by improving the quality and rate at which epitaxial reactors produce semiconductor wafers is crucial to reducing the overall cost of LED lamps. Other keys to cost reduction include designing low-cost packages with high reliability and low thermal impedance, and increasing the area of substrates while reducing their cost.

LED component volumes have been driven mainly by mobile phone sales recently, showing an incredible annual compound growth rate of more than +45% per year. Due to the strong pressure on component prices, revenue growth has been moderate: only +8% over the last 2 years. "It is now clear that LED market needs to expand into new and profitable sectors with higher margins. We believe that this growth will come from 3 additional application areas: automotive lighting, architectural lighting and general illumination, in addition to the LCD backlighting market." says Philippe Roussel senior analyst at Yole Développement.

Light & Building in Frankfurt is a great chance to explore latest LED product developments, and discuss new market opportunities within the lighting community. We wish you a pleasant stay in Frankfurt and successful business relationships.

Please send us your feedback about the LpR content. We would like to get your opinion on how to continuously improve our services to you. Furthermore take the opportunity for your own editorial contribution as well.

Yours Sincerely,

Siegfried Luger

Publisher

Imprint

LED professional Review (LpR)

ISSN 1993-890X

Publisher

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Front-page picture

National Institute of Standards and Technology

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Project News

Mall of America Changes to Eco-Friendly Parking Ramp Lighting

Mall of America™, which opened in 1992, is the nation's largest retail and entertainment complex. The 4.2 million square foot facility is home to more than 520 shops and is located in the Minneapolis suburb of Bloomington.

As a facility committed to being eco-friendly, management is always looking for products and programs to help reduce the Mall's carbon footprint. One such area is the Mall's two nearly identical seven story parking ramps. Recently, Mall of America examined the lights in a section of these ramps and teamed up with Beta LED™ to conduct a test project using light emitting diodes (LEDs) luminaires.

Mall of America™ entrance

These new lights use fewer than 100 watts, which is less than half the energy of the ramps' traditional sodium lights. Since the two ramps have approximately 4,000 lights installed, the Mall of America anticipates savings between $300,000 and $500,000 in electricity costs if all of the lights were changed.

Anna Lewicki Long, Mall of America spokesperson, is pleased with the project's initial results. "What we are finding is these lights are extremely bright and illuminate very well. The Mall's energy costs are being cut in half."

The project's luminaires are rated at 105,000 hours, approximately 20 years without needing to be replaced. This is compared with traditional high-pressure sodium lights that are rated to last approximately three years.

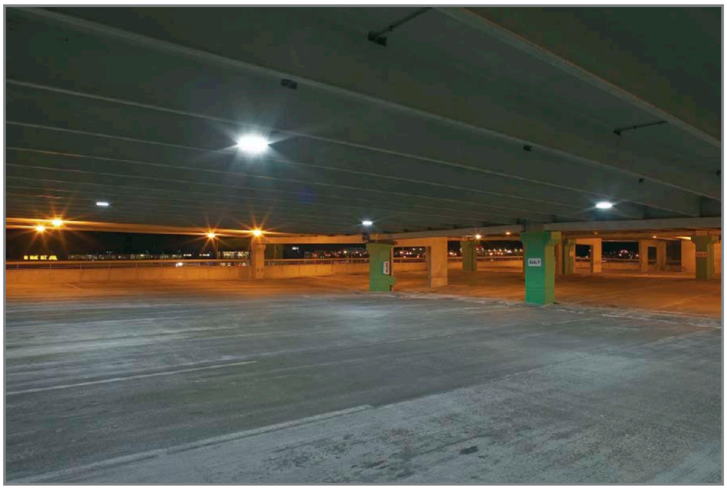
The Mall of America will observe the lights throughout the winter to make sure they respond well during Minnesota's coldest weather. They also want to make sure the lights provide adequate illumination, as safety is always a concern in a parking ramp.

Environmental benefits are huge, according to Long. "The Mall is designed to be eco-friendly; for example, there isn't even a heating system in the Mall, which is incredible if you think about it. The body heat of 40 million visitors each year is one of three heating sources. Sunshine from the skylights, which are seven and a half acres of glass and miles of artificial lights help too. The mall is typically 72 degrees Farenheit in the winter."

These are the types of green initiatives that made the Mall think about the lighting for the parking ramps.

Exterior lighting has three primary functions – safety, security and ambiance. Some examples where lighting form and function do not always meet are parking garages, walkways, canopies and parking lots. However, with LEDs as the light source, these applications can retain the aesthetic and performance integrity of the property, while offering savings on energy and maintenance.

"Beta LED is pleased to be a part of this test project with the Mall of America because parking garages provide an excellent platform for LEDs, given the high cost of electricity and the demand for energy-efficient lighting, particularly in applications that operate 24/7," said Kevin Orth, Beta LED director of sales.



Parking ramp with Beta LED luminaires

The opportunities to save energy and improve the bottom line through energy efficient initiatives, construction design and products such as LED general exterior lighting are as numerous as there are parking facilities. ■

Product News

Philips/Color Kinetics Announces Series of New Products

Philips/Color Kinetics introduces 4 new prodocts of EssentialWhite Lighting Systems. eW Flex SLX flexible point lighting system and eW Cove Powercore linear fixture are still available. eW Profile Powercore linear under- cabinet lighting fixture and eW Downlight SM Powercore will be available soon.

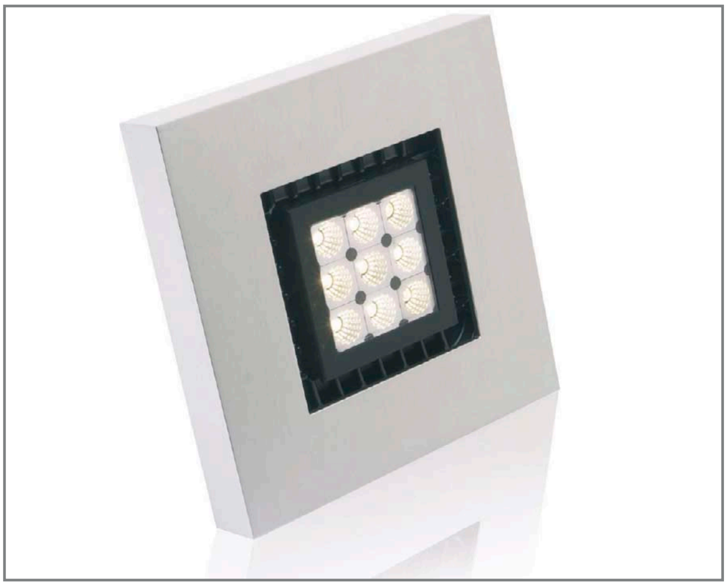
eW® Flex SLX is a versatile strand of 50 white LED nodes that apply Chromasic®-based intelligence for individual control. The durable, flexible form factor allows for dynamic points of white light to be installed across nearly any interior or exterior surface – walls, ceilings, floors, and three-dimensional sculptures and set pieces. It is also well suited for lighting tight alcove spaces and signage.

- 2700K or 4200K color temperature
- 50 individually controllable nodes
- Standard node spacing is 4" (10.1 cm) or 12" (30.5 cm)
- Custom on-center spacing is available up to 12" (30.5 cm)
- Available as an independent system or as a component for custom fixtures
- Indoor/outdoor rated

eW® Cove Powercore is a best-of-breed LED fixture that delivers high-quality white light, has a simple line-power installation, and lasts for years. This high-performance linear fixture is designed for interior alcoves in lobbies, atriums, schools, museums, malls, stores, and other public spaces. It also works well in applications such as shelving, product lighting, and display cases. The eW Cove Powercore fixture uses high-efficacy, high-brightness LEDs, enabling lighting installations to meet California's Title 24 requirements.

eW® Profile Powercore is a low-profile, linear fixture for common under-cabinet lighting, task lighting and display case lighting. Powered by line voltage, it can support a run of up to 50 feet on a single circuit. At 7/8" thick and 1.5" wide, the fixture is easily and discretely installed to illuminate work surfaces and displays in both commercial and residential settings.

- Available in two color temperatures: 2700K and 4000K
- 11", 21" and 41" nominal lengths available
- Extremely low profile (7/8")
- Line voltage operation via Powercore® technology
- Controllable via commercially available dimmers
- UL/cUL listing as permanent (UL1598) and portable fixture (UL153)
- Low power consumption, up to 50 feet on a single circuit



EssentialWhite lighting system: eW® Downlight SM Powercore

eW® Downlight SM Powercore is a sleek, competitively priced downlight for general illumination. Unlike typically larger, surface mount downlights using conventional sources, its low-profile housing allows for easy and unobtrusive installation in wide-ranging interior environments. Powered by line voltage and using standard mounting hardware, eW Downlight SM Powercore offers an attractive solution to the challenges associated with installing fixtures into shallow recess depths.

- Available in color temperatures options: 2700K & 4000K
- Extremely low profile (2")
- Multiple trim colors
- Multiple mounting options
- Multiple beam angles
- Line voltage operation via Powercore® technology
- Controllable via commercially available dimmers

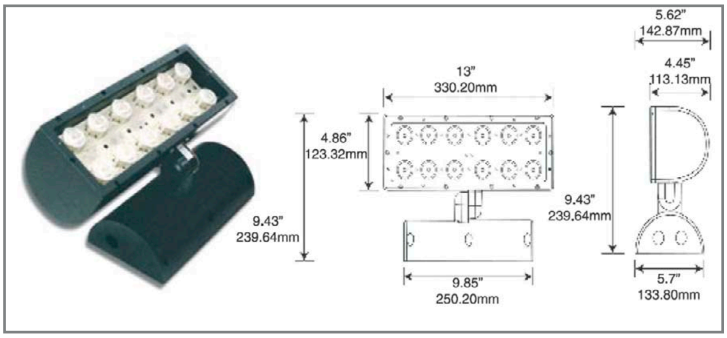
Hall: FOR.0 Walkway: A Booth: 01 ■

Line Voltage LED Floodlight for General Illumination

Nexxus Lighting, Inc.has announced that its SV Lighting business unit has introduced the industry's first LED floodlight for general illumination that operates on direct line voltage without the need for an internal or external power supply.

This breakthrough has produced the new Savi SHO White Floodlight. Utilizing Seoul Semiconductor's new Acriche LEDs, the Savi SHO White Floodlight is a new white light LED floodlight for interior and exterior applications that can operate on a standard 120VAC supply. With patents pending on the technology, SV Lighting plans to launch additional direct 120 volt products for the commercial lighting market in 2008.

Although light emitting diodes have been lauded for their long life; 30,000 to 100,000 hours depending on color, they have required internal or external power supplies to convert line voltage down to low voltage to operate the LEDs. These power supplies add cost, can have a shorter life than the LEDs and can potentially be a weak link in the system, says Nexxus.



Savi SHO White Floodlight, equiped with Acriche LEDs

The new Savi SHO White Floodlight solves this problem by eliminating the need for any power supply. Simply connect the 120-volt supply wires to the color-coded leads in the wiring compartment base, and the unit is ready to go.

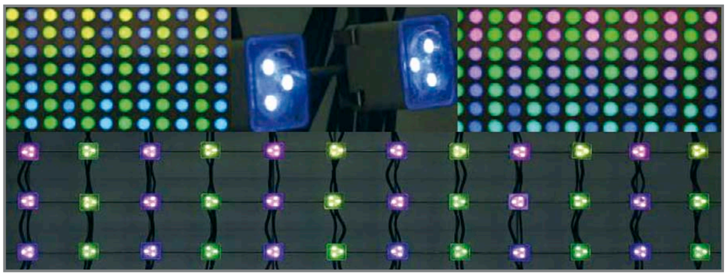
4.1 Walkway: H Booth: 21 ■

Ledon Lends Impetus to Light+Building 2008

Ledon will exhibit LED.Light.Emotion.Dynamics at the Light+Building, international trade fair in Frankfurt am Main. As an innovation driver in the LED sector, the Zumtobel Group brand's futuristic stand, which occupies approximately 160 square metres, offers an exciting glimpse into the future of innovative light sources and inspiring LED application solutions for a wide variety of applications, with a focus on media-capable applications in the entertainment field, ultra-modern LED solutions for showcases and the latest generation of XED digital light sources.

LEDs turn light into a communication medium

Ledon will be demonstrating examples of how technology and applications can be linked in the form of video-capable wide-area LED lighting for ceilings and walls as well as linear LED solutions with interval-controlled colour gradients and light sequences.

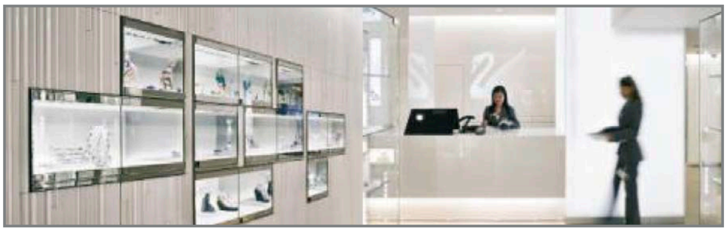


Applications of Pixelnet, a flexible LED network, effective at long-distance

Pixelnet, Ledon's latest development, will be on show for the very first time: LED chains, each comprising three RGB LEDs in one pixel, are positioned on special-steel profiles to form a flexible LED network. Thanks to almost freely selectable pixel spacing, this gives a randomly configurable LED solution, which because of its statically stabilised substructure, can be adapted to suit any surface. Controlled by a video protocol, Pixelnet can be adapted to operate with widely used protocols in studio and media environments and can therefore be smoothly integrated. Clips can be produced from all commonly used formats. With a lighting output of 1 W / pixel, Pixelnet can produce impressive lighting scenarios effective at long-distance and is ideally positioned as the future solution of choice for media-capable exterior design of buildings and properties. Colour and light are refreshed in real-time, which lends the LED network a remarkably lifelike effect.

LEDs set the stage for lighting in furniture

Ledon offers a variety of LED solutions for optimum functionality with furniture, thus addressing a new application area. Because of their shallow recessed height combined with extremely low heat emission and no emission of UV/infrared radiation, LEDs are perfect for integration in showcases and display cabinets. The Ledon stand features a mixture of integrated and flexible systems in the form of a LED wide-area, including line and spot illumination developed in the course of completed projects such as the Swarowski boutiques in London and Hong Kong. A flexible track system with an aluminium section and diminutive LED spots shows just how playfully luminaire design can meet the exacting requirements of glass furniture while simultaneously showing objects off in the right light. The linear lighting excels thanks to different lighting scene settings and dimming levels for special accent lighting. Wide-area LED modules for ceilings and walls provide spaces with a designer look. All showcase systems are fitted with high-quality white light LEDs, which deliver a colour temperature of 4200K.



LED display cabinet moduls, developed by Ledon for new Swarowski boutiques

XED portfolio for the highest quality white light

nanoXED and powerXED high efficiency light sources are new additions to the Ledon product portfolio. The XED range offers highly competitive light sources with outstanding features: XED is the smallest power emitter on the market measuring only 2,5mm x 2,5mm x 0,6m, with a 120 lambert beam pattern and a unique Zero Colour Binning guarantee ensuring that with the use of several XEDs no visible difference in colour temperature and colour rendition occurs. Colour Rendering Index (Ra 8) of up to 90 for powerXED in the warm white range, the characteristics of both nanoXED and powerXED bring a new highlight to white light quality.

Hall: 2.0 Walkway: A Booth: 50 ■

TRIO Light Introduces New LED Fixture Series

Advanced, compact and multi-functional: the Bandit®LED-Module has it all. This module has especially been designed in order to build different fixtures very easily. The Bandit®LED-Module gives the designer total freedom in the use of colour, lens and fixture.

The Bandit®LED-module is fitted with a patented lens changing device, enabling you to change the diffusion of light to your personal preferences. The LED-Module is available with two reflector lenses and four different Fraen lenses, namely narrow beam (9 degrees), medium beam (22 degrees), wide beam (38 degrees) and elliptical beam (10x20 degrees). These lenses have been designed especially for Luxeon K2 LEDs and deliver a perfect radiation.

The Bandit®LED-Module uses Luxeon K2-LEDs.The performance of the Luxeon K2-LEDs is better than ever and they yield light more effectively. For the technical specifications of the LEDs, we refer you to the Luxeon datasheet or visit: www.luxeon.com or www.lumileds.com.

Design example LED-Wallwasher, based on the Bandit®LED-module

Properties

- changeable lens
- Luxeon K2 LED
- Thermal protection
- Excellent warmth control
- LED-Module dimmable
- Size: L40xW40xH27.5mm
- An average yield of light of 180 Lumen
- Power 3 - 5 W
- Different colours possible: amber, red, green, blue, white, natural white and warm white.

Thanks to its square, compact shape, the Bandit®LED-Module fits very easily in different fixtures. Tri-O-Lights offers a pioneering series of fixtures consisting of groundlights, wall lights, downlights, shuttle lights, wall washers and beamers. Its high reliability and light yield make the Bandit®LED-Module especially suitable for a demanding environment. These fixtures make it possible for the Bandit®LED-Module to be used for the lighting of buildings, but also as lighting in public places. The dimfunction in the module also enables you to create specific work lighting during the day and pleasant atmosphere lighting at night.

Hall: 4.1 Walkway: E Booth: 61

TARMLED 4x4 Awarded at Light 2008 in Warsaw

TARMLED 4x4 was presented with this year's award for the most innovative product at the "LIGHT 2008," Warsaw. Thomas Lottig, one of the duo who developed the system, accepted the award, stating that, "These are the brightest things we have ever seen."

TARMLED 4x4 is the world's only modular LED system employing high-power RGB (3 Watt, 3-in-1 SMD) LEDs capable of displaying full-color, full-motion video. The system qualifies for Protection Class IP65 due to its passive cooling, and every 418 mm x 418 mm tile is equipped with its own, integral electronics.

Warsaw Light Fair award 2008

tarm LED GmbH & Co. KG will be exhibiting at light+building from 06. – 11.04.2008 in Frankfurt.

Hall 4.2 Walkway: K Booth 60

Enfis Launches QUATTRO Mini

Enfis Ltd, a global leader in the development and manufacture of smart, multi-watt plug-and-play light engines and arrays, launches the QUATTRO Mini: the latest in it's range of high-power, smart, compact LED Light Engines and Arrays.

Based on Enfis' existing QUATTRO product, the QUATTRO Mini provides a very high-power, cost-effective spot source, packing up to 160W of power into a 2x2cm array. Packing a huge amount of power into such a small area, reliably and efficiently, enables Enfis to offer lighting companies an extremely bright, high quality, yet flexible spot source. Enfis' proprietary packaging and smart array technology ensure that colours are mixed evenly and effectively, giving a unique, homogenous spot of light rather than a cluster of different colours offered with conventional high-power LED solutions. As with it's UNO Plus range, the three multi-channel variants are optimized to meet the differing requirements in the market:

- RGBA offers an extra-large colour gamut versus conventional RGB colour-mixing technology
- RGBW provides RGB colour-mixing, with the addition of a white channel to provide a higher maximum lumen capability
- Hi-CRI Vari-CCT enables one device to provide a very high quality light source (Ra>90) at a range of CCTs from 3000K to 6500K.

With optical and thermal solutions designed in parallel, and in-built optical feedback at the array level to ensure consistent performance through-life and product-to-product performance, the QUATTRO Mini is a very powerful enabler for smart, efficient, high-quality lighting solutions in the architectural, retail, commercial and entertainment lighting sectors, such as high-power PAR Lamp replacement, floodlights, spot lights, and stage/theatre spotlights.

Hall 4.2 Walkway: J Booth: 60 ■

LEDworx Debuts with LED-Streetlight

LEDworx GmbH (LEDworx), a European innovator of LED lighting systems and technologies, enters its 6th year of developing on applications for High-Power-LED illuminants, focusing on streetlights.

Based upon its experienced knowledge over the last years, LEDworx finalized the development of a mass producible LED-Streetlight named FALCON.

"We focused on developing a mass series product, applicable to all purpose - from sidewalks to highways." said Franz Witthalm, CEO, LEDworx.

LEDworx expects a revolutionary change in general street lighting. Well known, that there have been similar applications of different companies all over the world, the FALCON-product line is expected to be the first mass produced all-purpose LED-Streetlight.

"There has been enormous interest from all over the world, since the rumours about our new project were afloat. Especially European, in particular Austrian and German companies and governmental communities, as well as US-companies and governmental organisations joined the wait list for the first deliveries." said Andreas ROMAN, Sales Manager, LEDworx.

The construction of LEDworx' newest development is based on a modular concept. The LED-Power-output from 40 to 200 Watt is user-defined expandable. Both the electronic design and the LEDworx thermal management system are designed for applying the latest High-Power-LEDs coming into the market, from LedEngin to Cree.

After LEDworx' test installations of LED-Streetlights named Hawk-Eye in Dubai in 2006, it was just a matter of time, when the next development step to a mass-producible LED-Streetlight would be presented to public. The presentation of the latest generation of LEDworx' technically improved "FALCON" - will take place at the Light&Building trade fair.

Hall: 5.01 Walkway: B Booth: 86 ■

10 Watt, 900 Lumen Z-Power P7 Series

The 10W P7 single LED package produces luminous flux of 900 lumens, much higher than the 60-watt general residential incandescent lamps, which only produce 660 lumens. The Z-Power P7 Series has an efficacy of 90 lumens per watt from a single package, which is eight times higher than incandescent lamps.

The Z-power P7 Series overwhelms incandescent lamps in terms of energy efficiency, a significant development that signals LED's penetration into the general lighting market is just around the corner. Compared to general 60-watt incandescent lamps, which provide an efficacy of approximately 11 lumens per watt, Z-Power P7 Series emits light at 900 lumens and has efficacy of 90 lumens per watt. This breakthrough is happening at a time when rising oil prices and environmental concerns have fueled the interest for energy- efficient systems all around the world.

In addition, the Z-Power P7 Series shows remarkable performance compared to compact fluorescent lamps, which are widely available at most retailers. In a comparison between Z-Power P7 and a compact fluorescent lamp consuming electricity of 15 watts and emitting light at 924 lumens, the compact fluorescent lamp shows an efficacy of 61 lumens per watt, while the Z-Power P7 Series' efficacy is nearly one-and-a-half times higher at 90 lumens per watt.

Another advantage is low light loss rate. General light sources, such as fluorescent lamps and incandescent lamps, emit in all directions and the light loss rate is high. This means that only 60% to 70% of light produced from general light sources is applied to illuminate an object. In contrast, Seoul Semiconductor's Z-Power P7 series is able to focus light in a specific direction based on the users' need. As a result, there is little loss of light generated from the source. Efficacy of the Z-Power P7 Series is almost one-and-a-half times higher than general light bulbs, but when the light loss is considered also, the actual luminous efficacy of the Z-Power P7 Series is nearly two-and-a-half times higher than that of a general light bulb of approximately the same luminous flux.

Seoul Semiconductor's Z-Power P7 Series can be applied in many fields such as general residential lighting, streetlights, a variety of task lights, high-end flashlights for military, police or rugged use, and landscape lighting requiring extremely bright light.

"Development of the 900 lumens, 90 lumens per watt P7 Series is a milestone achievement that reinforces Seoul Semiconductor's leadership position in the global LED industry," said Mr. Kwon, a director of the company's power LED business department. "We will develop new ultra high power products emitting over 1,000 lumens during the third quarter of this year to consolidate and continue advancing our technology."

Hall: 4.1 Walkway: J Booth: 21
Hall: 4.1 Walkway: J Booth: 39 ■

3, 5, 10 and 15-Watt Warm White High Power LEDs

LedEngin, Inc. announced the addition of Warm White products to its high power product portfolio. Production availability includes 3, 5, 10 and 15-Watt emitters. Typical performance levels of 500+ lumens are achievable, setting new records for warm white products and enabling high flux density for spot, accent, track and down lighting applications.

The nominal color temperature of these products is 3200K with a range spanning 2870 to 3700K. The color binning structure developed for these warm white products aligns with the new ANSI standard enabling customers to meet the Energy Star lighting criteria for luminaire development. The typical color rendering index (CRI) of LedEngin's warm white products is greater than 80 with options available that provide a typical CRI of 90. The combined quality and quantity of light emitted can enable the first true 35-Watt+ halogen replacement from a single 7x7mm LED package.

The combination of proprietary LedEngin packaging technology with advanced material developments enables a high quality light source with industry leading flux density. LedEngin LEDs are engineered to optimize light extraction, minimize stress, and maximize thermal performance resulting in monumental reliability, color point stability and lumen maintenance. Target markets for these products include museum, retail, hospitality and other general lighting applications.

"We are very excited about these new additions to our product portfolio" said David Tahmassebi, President and CEO of LedEngin. "Our Warm White products offer a unique alternative to conventional light sources for interior lighting applications. The combination of high flux density and high light quality will enable the development of new lighting fixtures which capitalize on the miniaturization benefits of LEDs. We look forward to supporting our customers in their design in activities."

Hall 4.2 Walkway: H Booth: H11

New MultiLINQ DC Power Splitter from ROAL

ROAL Electronics launched the first in a series of revolutionary new products for the LED signage industry at the Strategies in Light conference in Santa Clara, California.

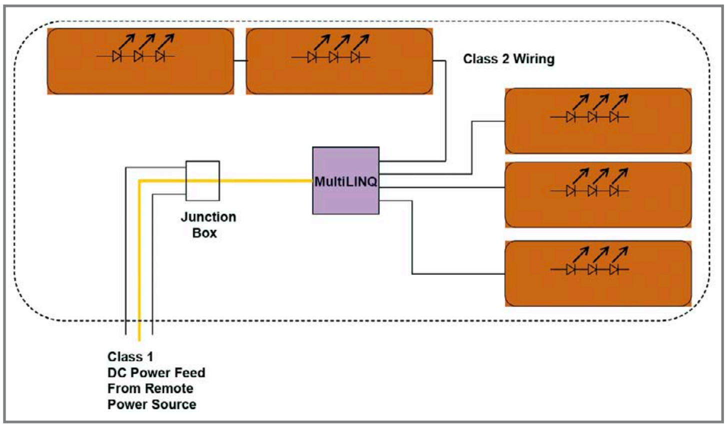
MultiLINQ was designed to address several long standing industry concerns, the most important of which is the service life of the LED lighting system. MultiLINQ eliminates the need for multiple Class 2 power supplies within the sign, and relocates the power to an easily accessible location.

The MultiLINQ is a non-dissipative device with no wear-out mechanism that can be mounted in or near the sign and splits the main power source into four (4) intrinsically safe class 2 power outputs capable of powering up to 400 watts of LED lights. It is encased in a NEMA 6/ IP67 weather-tight package suitable for wet locations.

MultiLINQ works with a remote supply that can be located in an easily accessible place. Current power supplies must be located in or very near to the sign, difficult to maintain and service.

The main power feed for the MultiLINQ may come from a large power supply such as ROAL's RHPS190. The output of the PS190 is low voltage, but not suitable for certain LED light fixtures that require a limited power input. To meet regulatory requirements, the power must be limited by an electronic device. The type of electronic device required does not exist yet, so the industry currently uses many small power supplies to satisfy these regulations. The MultiLINQ module changes this dramatically by permitting the use of a larger power supply, like the RHPS190, in theses applications.

The combination of one RHPS190 plus 2-3 MultiLINQ modules could effectively replace 4 to 20 small power supplies. This could save the money for the equipment, lower the cost of installations, improve system performance and increase reliability dramatically.



Typical configuration of a MultiLINQ system

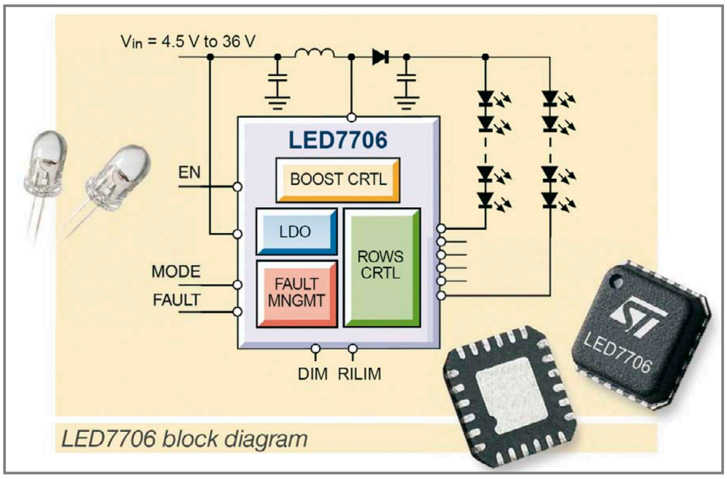
Sign companies will enjoy reduced total cost of ownership with fewer power supplies and no maintenance at the sign. MultiLINQ works with a remote supply that can be located in an easily accessible place. Current power supplies must be located in or very near to the sign, difficult to maintain and service. Other uses include Architectural, Facade and Commercial lighting applications.

MultiLINQ technology is patent pending, and will be available in production quantities starting in April 2008. Volume pricing is expected to be around $60 per module. MultiLINQ will carry UL approval and it will be listed in ULs Sign Components Manual (SAM).

Hall 4.1 Walkway: D Booth: 31

Monolithic Step-Up Converter Drives up to 60 LEDS

The LED7706 consists of a high efficiency monolithic boost converter and six controlled current generators (ROWs) specifically designed to supply LED arrays. An output voltage of up to 36 V, means the device can manage up to 10 white-LEDs per ROW.



LED7706 block diagram

The boost section is based on a constant switching frequency with a peak current-mode architecture. The device regulates the lowest ROW's voltage at the internal reference voltage (400 mV typ.), and adapts the boost output voltage in order to reduce the power losses.

The switching frequency of the boost converter is fixed at 630 kHz for a good compromise in terms of efficiency, size and cost of the power elements; in addition, it can be set in the 200 kHz to 1 MHz range, by connecting a simple resistor to SGND, if more flexibility is required.

The device, thanks to its input voltage range, which is from 4.5 V up to the output voltage, is able to cover the most common voltage buses (5 V, 12 V and 24 V). LED7706 has an internal LDO that supplies the internal circuitry of the device and is capable of delivering up to 40 mA.

LED7706 Main Features:

- 4.5 V to 36 V input voltage range
- Internal power MOSFET
- Internal +5 V LDO for device supply
- Up to 36 V output voltage
- Constant frequency peak current-mode control
- 200 kHz to 1 MHz adjustable switching frequency with sync capability
- Pulse-skip power saving mode at light load
- Stable with ceramic output capacitors
- Six ROWs with 30 mA maximum current capability
- ROWs disable option
- Less than 500 ns minimum dimming time
- ±1.5 % current matching between ROWs
- LED failure (open and short circuit) detection
- Small QFN24L 4x4 package

Hall 4.1 Walkway: D Booth: 31

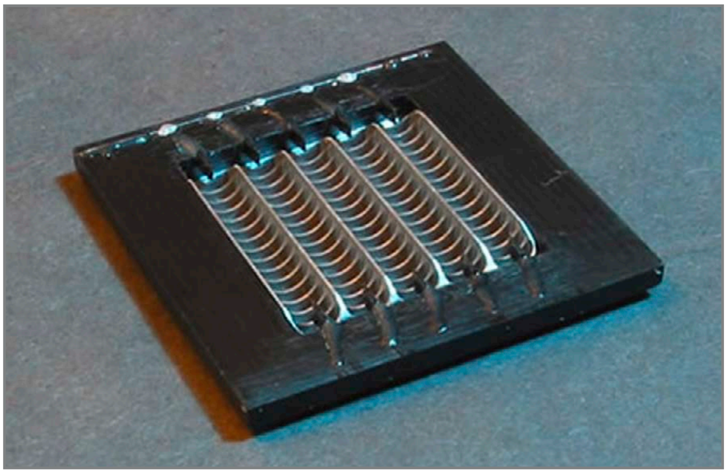
Research News

Extending the Limits of Air-Cooling for Electronic Devices

Thorrn Micro Technologies has developed an ultra-thin, silent and light-weight cooling system for mobile electronics. The critical innovation in the cooling system is a miniature solid-state fan that blows air like a typical rotary fan but without any moving parts. The solid-state fan uses a proprietry technology which is based on the principle of electro-aerodynamic pumping.

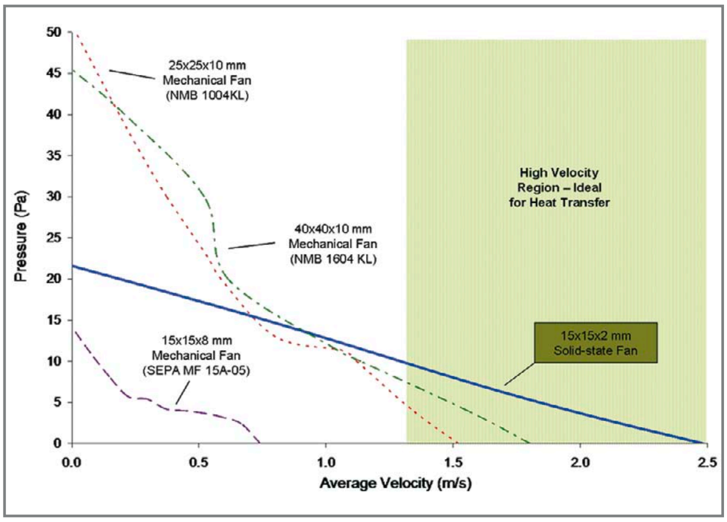
About the Technology

Solid-state fan uses a proprietry technology which is based on the principle of electro-aerodynamic pumping. Electro-aerodynamic pumping is based on corona discharge which is the underlying technology in many consumer and industrial products, from silent household air purifiers and photocopiers to electrostatic precipitators and some lasers. It involves application of a voltage difference between two electrodes; a geometrically sharp electrode and a blunt electrode. This creates an intense electric field in the region near the sharp electrode and breaks down the air locally. Ions produced in this discharge are attracted to the distant blunt electrode. As they traverse the gap between the electrodes, the ions collide with neutral air molecules creating a body force and a pressure head in the air. This pressure head causes the desired air flow.


The active area of the fan is 15 mm x 15 mm

Performance Comparison of Solid-State Fan and Mechanical Fans

The solid-state fan is 15 mm x 15 mm x 2 mm. The 3 mechanical fans are all larger in size than the solid-state fan. The volume of the largest fan is 35 times as much as that of the solid-state fan. The solid-state fan produces higher flow pressure head and higher flow rate than all 3 fans in the high velocity region. Electronics cooling systems are designed to operate in this region.



Performance comparison diagram

Additional Advantages over Mechanical Fans

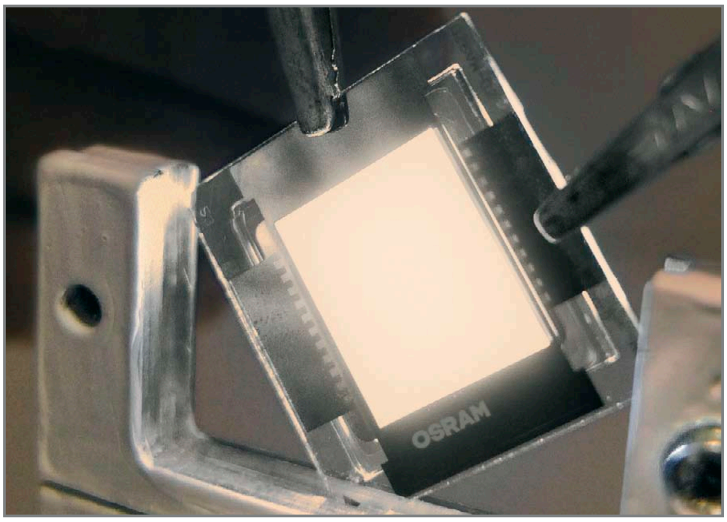
- Low cost
- Silent operation
- Thin profile
- Low power consumption
- Small foot-print
- Light-weight
- High reliability
- Versatile form factor

Solid-state fan is the thinnest, smallest and lightest forced convective cooling system. It is the ideal cooling system for laptops, LEDs and other applications where small fan have typically been used. ■

OLEDs Achieve High Levels of Efficiency and Lifetime

After only two years of development, OSRAM has achieved record values in the laboratory for organic light emitting diodes in warm white. With an efficiency of 46 lm/W the organic light emitting diodes for lighting applications (OLED Lighting) have a brightness of 1000 cd/m² and last more than 5000 hours. For the first time it has been possible to improve two crucial OLED characteristics simultaneously as up to now these have generally changed in inverse proportion to one another. Higher efficiency used to mean shorter life, and vice versa.

Dr. Karsten Heuser, Director of OLED Lighting Technology at OSRAM Opto Semiconductors is pleased with the excellent intermediate results. "Our development team has reached a real milestone for warm white OLEDs with an efficiency of 46 lm/W (CIE of 0.46/0.42 measured in the integrating sphere) and a life of more than 5000 hours. With this significant increase in efficiency and life, OLED flat light sources are approaching the values of conventional lighting solutions and are therefore becoming attractive for a wide variety of applications."



OSRAM OPAL Project (OLED)

The color rendering index (CRI) of the almost 100 cm² large prototype is 80. By March 2009, development should be so far advanced that a demonstrator for an energy-saving OLED flat light module comprising several tiles will be able to deliver an overall luminous flux of 500 lm from a power consumption of less than 10 W.

New warm white OLED with an efficiency of 46 lm/W (CIE of 0.46/0.42 measured in the integrating sphere), CRI of 80 and a life of more than 5000 hours.

OLEDs Will Enhance the Premium Segment with Atmospheric Light

OLED light sources will be particularly welcome where their special properties as flat light sources offering high quality of light make a real impression, for example in illuminated wall coverings, atmospheric canopies of light and light partitions. With their pleasant diffused light, the color of which can be individually controlled, OLEDs will enhance the premium design segment, for example as light tiles that can be attached to any surface. For widespread applications it will be necessary to produce efficient OLEDs in large numbers at reasonably low cost – an essential objective of the research project.

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Hall: 4.1 Walkway: D Booth: 31
Hall: 4.2 Walkway: J Booth: 10 ■

Correction

Thermal Management

For the article "**Direct cooper bonded ceramic substrates for use with power LEDs"** Electrovac curamik accidentally submitted an incorrect list of authors which was published in LED professional Review (LpR), Issue 5 – Nov/Dec 2007 on p3 and p32. The authors of this article are **Dr. Jürgen Schulz-Harder, Ingo Baumeister and Alexander Roth.** ■

Application

LED-Systems in Shoplighting

> Andreas Siegmund, Marketing Communication Manager, OSRAM GmbH

Modern architecture needs new materials – the combination of these with the latest achievements in lighting design is nearly a must as it is in the Italian city Riccione close to Rimini. Different design labels and trendy shops in the big pedestrian zone pull numerous clients in. The glamouros city lives from its visitors. Also during the modification of the BOP Shop which specialised on sporty trendy casual wear the modern and dynamic surrounding was integrated in the concept and is reflected with the selection of the interior and exterior materials utilised.

BOP Shop sport shoe department

A new way of illumination was realized by the designers with the sport shoe department in the basement. The illumination of the shelves is exclusively taken place through most advanced LED technology: Overall 340 OSRAM LINEARlight-DRAGON LED modules controlled with 60 electronic control gears OPTOTRONIC OT75 illuminate the exposed shoes and accessories.

The modern technology offers many advantages compared to conventional illuminants. LED do not emit any thermal and ultra violet radiation, therefore also sensitive goods can be illuminated without any problems. Furthermore conventional illuminants can also damage the goods – e.g. colors can bleach and goods could not be sold anymore. Among these advantages also the high LED efficiency is important which is reflected in less energy consumption as well as the long lifetime and the related low maintenance costs.

If singular LED lighting points as shown in this case are visible side by side, also the color homogeneity within LED modules themselves and within the overall 340 inserted modules is very important. While with existing LED applications the color nuances within one module and between the LED modules differentiate, OSRAM has created a new generation of white LED modules. The new FineWHITE LED module „W3F" from OSRAM achieve highest requirements of the trendsetting lighting technology. With "Finebinning" similar LED groups are sorted out and are mounted on a board so that a consistent color reproduction emerges.

Color homgeneity at the shelf is ensured by the use of the new FineWHITE LED-products

The result: best color homogeneity within one module and therefore first class quality; thus homogeneous illumination scenarios result from illumination areas and goods.

The advantages of the FineWHITE products also affect other sensible cases: backlights with low installation depth and diffuse coping. The W3F FineWHITE products provide furthermore from 50 up to 100% more luminous efficiency than the last generation „W2" – and with the same consumption device. With the W3F FineWHITE products OSRAM provides a LED light quality that refers to the known standards for fluorescent lamps regarding their homogeneity.

Interview with Jason Bruges – Jason Bruges Studio

> Siegfried Luger, LED professional

What is the core business of Jason Bruges Studio?
One of the exciting aspects of the studio is that our core business overlaps three disciplines architecture, art and interaction design.

How is Jason Bruges Studio organized to run this business?
The studio has 13 full time members of staff. Comprising of architects, industrial designers, product designers, architectural lighting designers, interaction designers, with expertise in technological innovation and set design.

What are the most beneficial new features for your customers when using LED lighting?
There are quite a lot, but most important are longevity, ruggedness, compactness and minimal heat build up.

Are the installations purely LED based or mixed with different light sources?
We use generally one type of source within each installation although we may utilize a variety of LEDs within one project.

What are the bottlenecks when planning and realizing LED projects? Which LED system elements should be further improved?
Bottlenecks occur when we use technology that is particularly innovative and we have to test reliability if manufacturer data isn't available. Also there are time implications because we use a lot of customized technology in order to realize precisely what we envisage during inception. Generally powers supplies let down the flexibility of these types of system.

Are you satisfied with the quality of existing LEDs? Which improvements should be done?
The optics technology and mixing and light quality always requires particular attention.

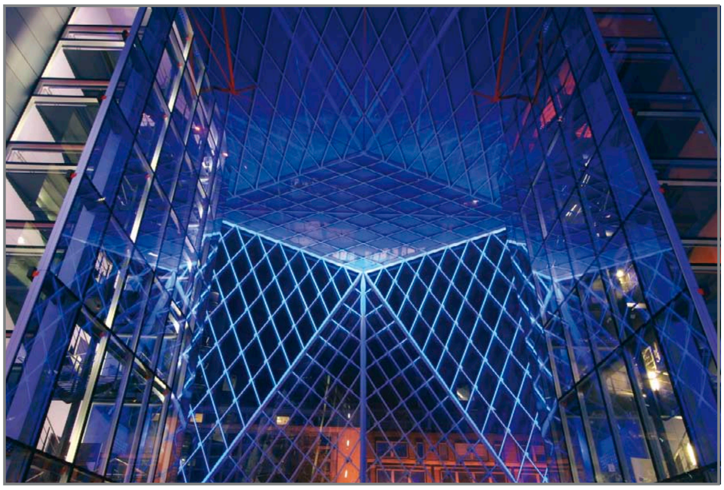
Which has been your most exciting project?
Working with a large LED matrix stage for George Michael's 25Live tour with onedotzero industries and Willie Williams enabled us to test and experiment with interaction on a truly architectural scale and at an amazing resolution.

What about the next steps in LED installations? What about your plans for the future?
The next steps in LED installation are streetscape installation on a large scale that enable multifunctional space both utilitarian and fantasy. The studio stays innovative; we are involved in projects that investigate interaction with crowds. In addition we are working on a large stadium scale and desert landscape which are dynamic and self-powered. ■

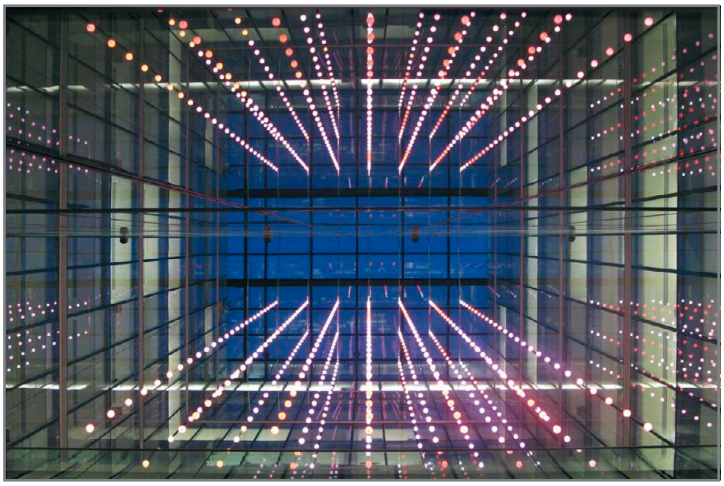
About Jason Bruges:

Jason Bruges founded Jason Bruges Studio in 2001 to create bespoke interactive installations for a diverse range of clients. Jason trained as an architect at Oxford Brookes University (Degree) and University College London (Diploma) before working at Foster and Partners and as an interaction designer at Imagination.

Jason Bruges, Founder and Creative Director of Jason Bruges Studio



A large scale integrated public artwork for the 55 Baker Street building redevelopment by make architects



An eight storey tall 3D matrix of light globes suspended in the North Atrium of the new Allen & Overy building

Interview with Klaus Vamberszky – Zumtobel Lighting

> Siegfried Luger, LED professional

Klaus Vamberszky is Director Central R&D at Zumtobel

What are the most beneficial aspects when LEDs come into day for a luminary?
The main aspects are long life, high lumen output and good Lumen per Watt-ratios. LEDs open new design possibilities also and it's a real point source.

What are the major obstacles today which hinder the LED technology coming into general illumination applications?
The obstacles are high cost, lack of reliable data and short market lifetime of the LED itself. Short-term "semiconductor" thinking of the LED suppliers does not suit the long-term thinking of lighting companies.

LEDs open totally new functions such as variable CCT and/or colored light. Is the market ready for these new functions?
Definitely yes, especially for colored light. A lot of architects and lighting designers already work with "fully colored" light (RGB), whereas it is more difficult to convince people that there is a real benefit in a tunable CCT in white only.

Can you obtain regional market differences for LED lighting?
No! As usual in the lighting business, it is a trickle-down in the market pyramid, starting with prestigious projects with famous lighting designers and architects who work on a global basis coming down to local project business. So far we do not experience different market behavior with regard to LED lighting.

Will LEDs displace halogen lamps or even fluorescent lamps in a long term view?
In the beginning LEDs will be an additional light source, competing with the existing ones. In certain niche areas - like emergency lighting / exit signs with the small 8 W T5 lamp - the LED's are currently replacing the old fluorescent solutions. Over time they will displace mainly incandescent and halogen lamps. The time to do so depends on the behavior of the national bodies. If they ban certain light sources, the replacement will be much quicker.

Will the market see totally new designed luminaries in the future thanks to LED technology?
Yes. In certain product categories - like spots with LED's - the dominant design still has to be found. Nowadays we see either "bulky" products with huge heat sinks or smaller ones even with a built-in fan. But the products will get nicer over time.

How does LED technology change the way of developing and producing a luminary?
In the development stage we need a much more holistic approach: We do not only design a luminary, but also a lamp, a gear and some controls. The circle: selection of the appropriate LED, define the PCB-board, search for a driver, design the heat sink, and further steps have to be gone through several times to achieve a good product. In the production, the assembly process is very much the same, but the processes are different: We need batch management, and e.g. have to take care of software versions.

LED binning is an undesirable aspect of the technology today. How important is it really for your products?
It is important but it has to be solved between the LED supplier and the luminary producer; we must not carry the problem to the end-user.

How is Zumtobel organized to support LED based luminaries the best way?
All our divisions (TRIDONIC.ATCO, THORN, ZUMTOBEL) have a big interest in this subject. In addition to that, the ZUMTOBEL group founded smaller companies dedicated to LED's like LEDON for LED luminaries and LEXEDIS for packaged chips. They support their sister companies with LED-specific know-how whereas the "old" companies have market access in their dedicated areas.

Which new product lines based on LED technology will Zumtobel release and show at the Light & Building in Frankfurt?
Come to our booth and have a look: You will see a whole variety of new LED products! ■

Discontent Led to Lumiramic Phosphor Technology

> Steve Landau, Director of Marketing Communications, Philips Lumileds

When first demonstrated by inventors starting in the early 1800s, the light bulb produced little usable light and lasted at best a few minutes. Developing commercially viable and useful light bulbs for general lighting required the ongoing efforts of inventors including Sir Humphrey Davy, Frederick de Moleyns, Joseph Swan, Thomas Edison and many others that followed. Today we are more likely to know the names of companies than of individual inventors but the same types of efforts that led to the continued development of the incandescent bulb continues today for light emitting diodes (LEDs).

Among the many problems faced by developers of incandescent technology were short lifetimes, fragile materials, discoloration of the glass bulbs, cost, manufacturability and so forth. For those that have followed the development of LEDs from a small source of light suitable for indication purposes to the heir-apparent for the general light source of the future, these types of problems will be familiar.

Forty years of invention and development of LEDs has resulted in the availability of white solid-state light sources that can generate significant light output, efficiently enough, to warrant the development of new luminaires in certain markets. But as Thomas Edison aptly stated "discontent is the first necessity of progress," and the general lighting market is not yet satisfied with the quality and consistency of white light output from LEDs and is seeking ever better light output and efficiency. The industry is waiting anxiously for a continuous supply of homogeneous white LEDs that can be used in applications without regard for visible variation between light sources. Fortunately, the drive to invent and advance technology is as powerful as it ever was and the scientists are readying a new phosphor technology—called Lumiramic Phosphor Technology that will deliver consistency and uniformity levels that are not possible through the conventional powdered phosphor and semiconductor manufacturing processes.

Although the manufacturing process for LEDs is a high technology process, it has inherent limitations; today, the semiconductor manufacturing process is such that a manufacturer has only limited ability to control the outcome of the process—there is embedded variability in the outcome. This is as true for LEDs as it is for the computer chips and microprocessor ICs. For this reason, when manufacturing is complete, emitters are sorted in to bins. In the case of white LEDs, these bins reside on or parallel to the black body locus and typically range from a CCT of about 2600K to about 10000K (Figure 1). It is only after final product testing and binning that the distribution of final product is known. Lumiramic Phosphor Technology will address the lighting industry's need for a dependable, high volume supply of white LEDs on or near the black body curve and of specific CCTs by introducing a highly controllable manufacturing process.

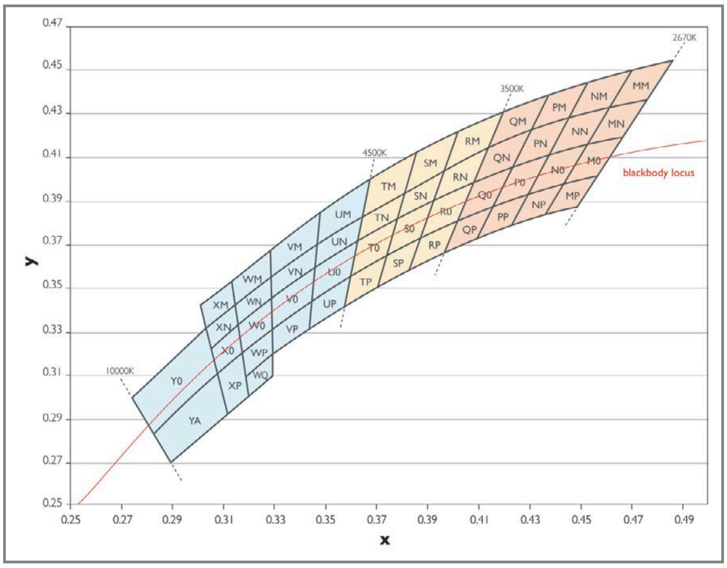


Figure 1: Typical White LED binning

Making white LEDs

White light can be created by mixing different colors such as red, green and blue, or by using phosphors to convert a UV or more commonly a blue LED. The first "phosphor converted" white LEDs were made by essentially applying YAG:Ce3+ phosphor over the LED chip in the package (Figure 2). This resulted in white LEDs that are off the black body curve and which had poor uniformity of color in the beam because the thickness of the phosphor varied across the emitting area of the chip. In 2002 the introduction of the patented conformal coating process allowed an uniform layer of phosphor coating of the LED chip, thereby creating a beam of light that was more consistent in color. Neither of these methods however solved the variability problem in the manufacturing process.

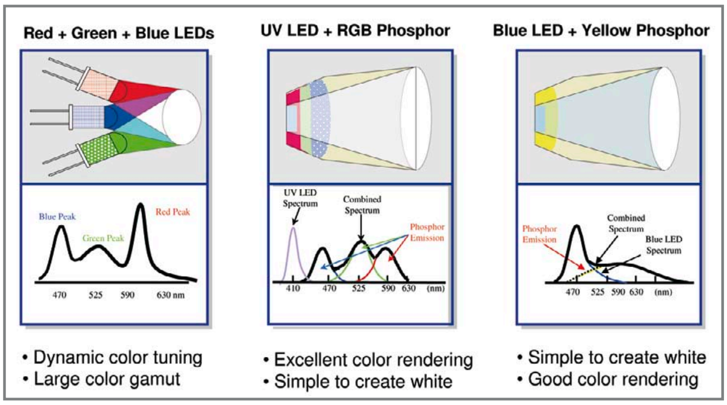


Figure 2: Comparison of different technologies for white light generation

Further, as the efficiency and light output of the blue LEDs has increased, phosphor choices have become more limited. In high power LEDs, compared to low power LEDs, the criteria are more stringent. The most obvious factor is higher working temperature and phosphor solutions must not react negatively so as to impact performance of the final LED package. It was clear to all that advances in phosphor technology needed to move forward in pace with the improvements in chip performance.

The Lumiramic Phosphor Technology concept is straightforward: manufacture a phosphor platelet, which one can characterize fully in its optical and luminescence properties, and match it to the 'right' blue chip, pre-characterized as well. The realization required years of coordinated work and changes to chip design as well.

The effort to develop a new solution required advancements in both phosphors and LED chip design. As is often the case, more than one objective must be achieved, hence the Lumiramic Phosphor Technology program had to be part of a program that would also significantly boost light output, efficiency and create a platform for future LED development. So in 2006 a project to that today has become Lumiramic Phosphor Technology was initiated. The phosphor expertise led on an invention path to determine how to combine phosphors and manufacture a solid-state solution. In conjunction thin film flip chip technology was developed which provides the required interface for the new phosphor plate approach and achieve the higher light output and efficiency the general lighting market would require.

Applying the phosphor plate to the LED chip requires a flat, unobstructed plane. TFFC die (introduced in 2007) have the anode and cathode located on the underside of the chip thereby providing the clear plane at which the two technologies can be joined (Figure 3).

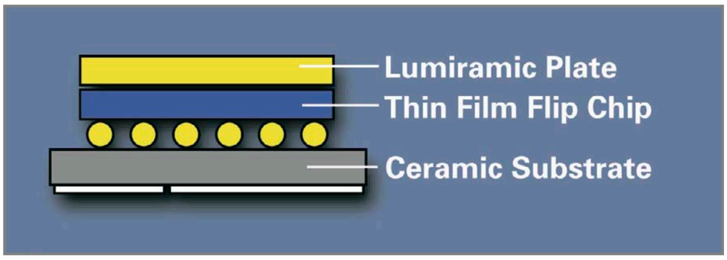


Figure 3: Simplified TFFC die configuration

The ability to characterize the light output of the blue LEDs was already in place. Once the teams achieved the ability to manufacture and characterize platelets, it became possible to target production of the white LEDs to a very specific CCT. Each wavelength of blue LED theoretically has a corresponding thickness of platelet that the photons must pass through to realize a specific CCT on or close to the black body curve.

Looking ahead, with the combination of Lumiramic Phosphor Technology and TFFC, the basic variance of CCT and tint of white LEDs can be managed through a controlled manufacturing process and it will be possible to proceed with high-volume manufacturing of white LEDs to a specific, targeted CCT and on or proximate to the black body curve.

ANSI and Energy Star guidelines in the U.S. for solid-state lighting luminaires call for white LED bins to be no larger than a 7 step MacAdam ellipse today with plans to shrink that space to a 4 step MacAdam ellipse in the next several years. Within a 3-4 step MacAdam ellipse, the human eye can begin to discern differences of CCT and tint. By comparison, incandescent and halogen lamps are manufactured within a 4 step MacAdam ellipse space and that the variance between lamps from a single manufacturer is often only one or two steps MacAdam ellipses and so we are not visually aware of any differences in color.

It's anticipated that as the manufacturing process for power LEDs using Lumiramic Phosphor Technology phosphor matures over the next 12 -18 months, the targeting of specific CCTs on the black body locus will improve to the point at which 90% or more of the white LEDs produced will be within a 4 MacAdam ellipse along the black body locus. This will, for the first time, result in a continuous supportable supply of white LEDs of a particular CCT that can be used by the millions in general lighting applications with minimal concern for the variation of white light encountered today. It will also dramatically alter the appearance of the white binning charts so prevalent today.

That being said, there remains significant variability in the manufacture of LEDs including flux and forward voltage variation. We can be certain that there will be sufficient discontent to warrant continued technology development and progress well into the coming decades.

Philips Lumileds will be showing products using Lumiramic Phosphor Technology at the bi-annual Light + Building show in April in Frankfurt Germany.

Improvements in Solid State Lighting III-V Semiconductor Production

> Dr. Rainer Beccard, Director of Marketing, AIXTRON AG

The rapid adoption of LEDs in various fields of applications is stimulated by the continuous improvement of LED performance and reduction of cost per lumen. New application areas, such as backlight units for LCD displays or solid state lighting, require significant progress with respect to the performance properties of LEDs. These improvements must be achieved throughout the entire LED production chain. A key part of the LED manufacturing process is the MOCVD deposition process. As a consequence, there is a continuous effort to improve the MOCVD process regarding performance and production cost. In the following article, we will describe how critical MOCVD is to the LED performance, and what potential exists in this process to improve performance and cost.

Nearly all LEDs today are based on compound semiconductors (also referred to as III-V semiconductors), and are usually composed of multiple thin layers of these semiconductors. The name alludes to the fact that these compounds consist of elements from the third and fifth columns of the periodic table, like GaAs, InP, GaN, and multinary compounds thereof, e.g. InGaN, that emit in the blue-green to near UV range of wavelengths. Their properties, like the colour of light emission, are controlled by the thickness and composition of each individual layer in a multilayer stack. The method of choice for making LEDs is Metal Organic Vapour Phase Deposition (MOCVD), a deposition technique using gaseous metalorganic and hydride species. The precursors are supplied to the MOCVD reaction chamber with a flow of carrier gas at a process pressure below atmospheric pressure, and the monocrystalline solid thin film is formed on heated substrates at temperatures from 600°C to 1400°C, depending on material and application.

The accurate control of each layer's composition and thickness, which can be as low as a few nanometers, with uniformity requirements on multiple substrates of less then +/- 1% deviation from the mean value, poses a formidable challenge to reaction chamber and process design.

Figure 1: MOCVD system based on the Integrated Concept (IC) standard

Two major types of reactors dominate the compound semiconductor industry: The Close Coupled Showerhead® (CCS) Reactor and the Planetary Reactor®. The CCS type is available with wafer capacities ranging from 3x2" to 31x2" (alternatively up to 7x4" or single 300 mm). It is available for the growth of GaAs, InP and GaN based materials, with the majority being installed for GaN LED (i.e. blue, green and white) applications.

The Planetary Reactor® is available from 11x2" to 42x2" (alternatively up to 11x4" or 6x6") for GaN and up to 60x2", 15x4" and 7x6" for As/P based materials. Major applications are GaN (blue, green and white) and AlGaInP based (red, orange and yellow) LEDs, but also electronics, lasers, solar cells and other devices. Several types of the Planetary Reactor® can be equipped with automatic wafer handling to increase throughput.

The CCS reactors are based on a unique showerhead concept that allows an extremely uniform gas injection using up to 15,000 tubes injecting separately group III and group V gases close to the substrate surface. The substrates are placed on a heated susceptor which rotates at an appropriate speed to ensure maximum temperature uniformity during the deposition process. The design of the reactor also allows maximum process stability and efficient precursor usage. Good uniformities are achieved in a wide range of parameters without major tuning of the process being required.

In the Planetary Reactor®, group III and group V gases are injected separately into the center of the reactor. The gases flow radially through the reactor while the substrates undergo a dual rotation in the flow field. This principle allows a unique combination of highest precursor efficiency and excellent uniformity independent of parameters like growth pressure or total gas flow. In its latest manifestation, the Planetary Reactor® makes use of a novel triple gas injector that allows even better control, stability, uniformity and efficiency of the processes.

The CCS and Planetary Reactors® are designed to be operated at the highest throughput level and lowest Cost of Ownership (CoO). This is achieved by minimized maintenance requirements, high load capacity, high growth rates and very efficient usage of costly metalorganic precursors. Additionally, in situ monitoring is used to increase yield and throughput. Such in situ devices can monitor and control wafer surface temperature, wafer bow or growth rate and contribute to efficiently optimize the CoO. Both reactor types today are manufactured in a modular manner, making use of a common platform (IC platform, Figure 1). Within this modular platform concept, however, a wide variety of MOCVD tool configurations is offered to the LED manufacturers, making sure that the MOCVD system design fits exactly with the customers' requirements.

To date, more than 1,100 MOCVD systems have been manufactured and delivered by AIXTRON since its foundation in 1983. Besides others, today, LEDs are the dominant application. This includes both red, orange and yellow (ROY) LEDs based on AlGaInP and blue, green and white ones based on (Al, In)GaN. Although the main end application for LEDs over the last few years has been mobile phones, today, the industry is starting to focus on LED based backlight units (BLUs) for displays as the next big application.

The driving force behind MOCVD reactor development activities are the next generation requirements that arise from new emerging novel applications. Such requirements demand better device performance, higher wafer and chip yield and higher throughput. This is particularly true for LED manufacturing, however, the main target remains the continuous reduction of MOCVD related cost per chip. To achieve this, the reactor hardware is continuously being improved and these efforts are internally supported by sophisticated numeric software modeling of the MOCVD reactors and processes. AIXTRON has been using CFD software for nearly ten years to provide design guidance during the conceptualization, hardware development and process tuning processes. Modelling and simulation play a key role in reducing the technological risk and the time-to-market for product innovations. The impressive increase in reactor wafer load capacity over the past few years speaks highly for the industry's ability to innovate.

Figure 2: Planetary Reactor® AIX 2800G4 HT in 42x2" configuration for blue, green or white LEDs

A reduction of cost per epiwafer is generally achieved by developing higher throughput reactors, as was done through the introduction of the high capacity GaN reactors AIX 2800G4 HT (42x2", Figure 2) or CCS CRIUS® (30x2", Figure 3). Just recently, also a novel high throughput AlGaInP platform was launched - the AIX 2800 G4-R, which has a wafer capacity of 60x2" (alternatively up to 15x4", 8x6" or 5x8") plus an automatic wafer handler option. The wafer handler enables wafer loading and unloading at high reactor temperatures, thus shortening the system cycle time and reducing CoO significantly. Furthermore it increases the process reproducibility as it eliminates any human influence on the process.

Figure 3: CRIUS® CCS reactor in 30x2" configuration for blue, green or white LEDs

The use of larger substrates can also significantly reduce CoO. AIXTRON reactors today provide customers with 4" and 6" capabilities and by using such large wafers, the reactors are used more efficiently resulting in better chip yields, improved uniformities and reduced edge effects. Future processes may even use much larger silicon substrates as this again offers further potential for cost reduction. To meet this particular requirement, CRIUS® CCS reactor is available in a 300 mm configuration. This reactor can be integrated into cluster environments, allowing the efficient combination of different processes.

The yield and thus the cost per LED chip are also critically affected by the uniformity and reproducibility of the MOCVD process. Consequently, a lot of effort is spent to improve these characteristics of the MOCVD tools. A good example for such development work is the improvement of the gas injector in the Planetary Reactor®.

The gas inlet of an MOCVD reactor chamber is one of the key components and essentially determines process performance and versatility. A well controlled injection of gases into the MOCVD reactor provides a uniform gas distribution in the chamber, eliminates undesired parasitic reactions and maintains stable growth conditions from run to run. Primarily using a rigorous CFD based multiphysics modelling approach, a novel gas injector (Figure 4) was developed for the latest generation Planetary Reactor® with 42x2" wafers, which is currently one of the world's

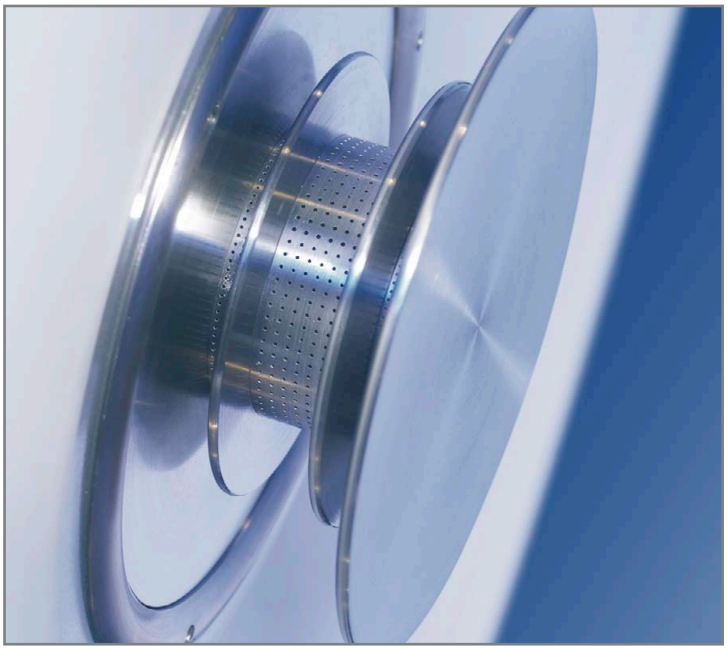


Figure 4: Novel gas injector used in the Planetary Reactor®

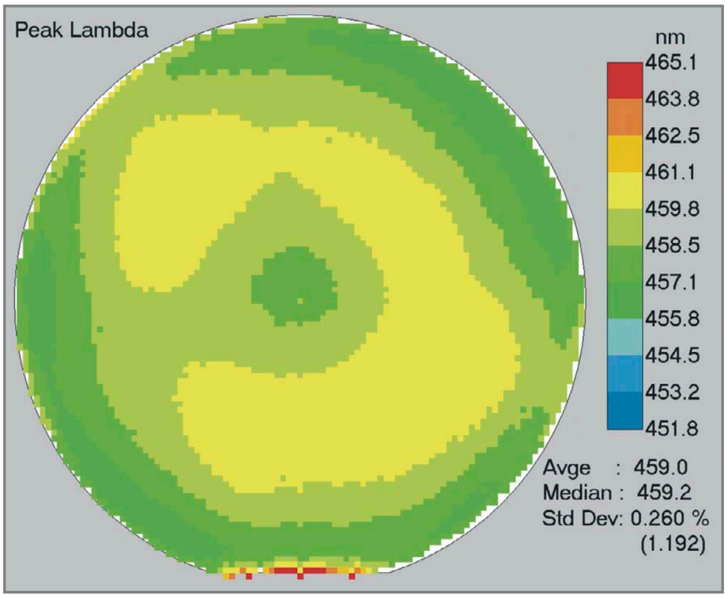


Figure 5: Room temperature photoluminescence (PL) plot of a GaN LED structure grown on a 4" substrate (11x4" configuration)

largest production scale reactors for processing GaN based LEDs. The gas injector features multiple gas inlets for advanced deposition uniformity control, a symmetric and uniform gas flow to guarantee wafer-to-wafer reproducibility and thermal control of the injector, to prevent premature gas phase reactions. As an example for the improved performance resulting from this new design, Figure 5 shows a photoluminescence (PL) map of an LED structure that was grown on a 4" substrate (11x4" configuration). Revealing a uniformity of approximately 1 nm only, it is impressive proof of the very high yield obtained with this reactor and gas inlet design.

All these technological improvements contribute to higher throughput and reduced MOCVD-related cost per wafer. The cost per single LED chip is also significantly reduced. At the same time, such developments allow the achievement of a higher performance level of the LED. These improvements are part of a continuous effort to improve the MOCVD technology, and consequently there is now a realistic pathway for further performance/cost improvements. This will allow the LED industry to continue to grow and, most importantly, to open exciting new application areas.


PLCC


Edixeon® K

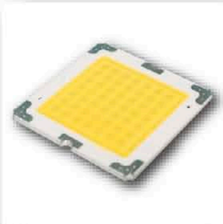

Edixeon® RC


Multi Color


Edixeon®


EdiPower®


EdiLine


EdiStar


MC PCB

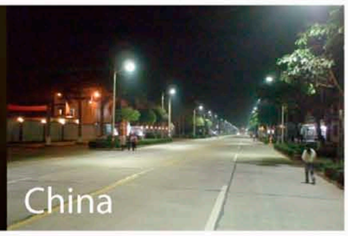

10W PAR30 Module

Plant Growth

Dental Curing

Jewelry Display

Street Light

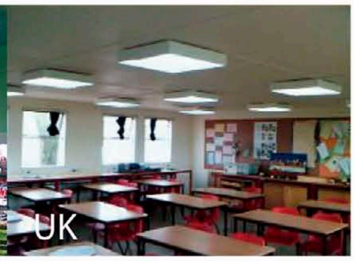


Theater

Pub

Supermarket

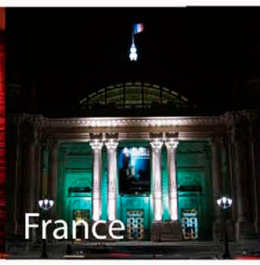
School



Airport

Restaurant

Museum



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Optics design for Colour Mixing LEDs

> Dr. Andreas Timinger, COO, OEC AG

Mixing the colourful light of LEDs raises new challenges for optical designers of illumination systems. Concepts need to take into account that light is not only redistributed in an appropriate manner, but also that the colour appearance of the target surface is uniform. Where colour fringes can occur, they add to the complexity of colour appearance analysis. Using state of the art optical design software, we show different typical approaches for successful colour mixing using a spotlight, a wall washer and a light guide as examples.

Small size and the colourful light are two key characteristics of LEDs. Distinctive luminaries can be developed combining different coloured LED chips into one light engine with controllable light colour. This principle has been successfully demonstrated in products which give unique possibilities to lighting designers. By this way the LED could, despite its high price per lumen, enter the high end general illumination market.

Optics design for colour mixing

Optical designers are challenged to develop highly efficient systems which yield a good quality of colour mixing. The light-forming function of the optics can often be described by one of three cases, collimation, specified illuminance pattern or uniform luminance across a large exit area. In a spotlight the light has to be condensed to a narrow bundle. For a typical technical luminaire, a given target area has to be illuminated with high uniformity or a well defined illuminance distribution. For transparent light guides, as used in signs and decorative lighting, the light has to be distributed across a large area inside the light guide and then extracted with uniform luminance. In all cases, colour uniformity must be maintained and multi-colour shadows, often referred to as colour fringes must be avoided efficiently. Colour fringes are usually the result of separated colours at the exit of the luminaire. Many colour controlled spotlights on the market are composed of LEDs with individual collimating optics which are arranged next to each other. The light of the individual LEDs can be superimposed on the target surface to yield good uniformity. Yet an object will cast an individual shadow for each individual LED. Because the LEDs are arranged next to each other, the shadows will not overlap completely, but form thin stripes of imperfect overlapping at the edge of the shadow. Since the LEDs have different colours, these stripes are also coloured and yet form the colour fringes.

A good way to avoid colour fringes is to mix the light of the different LEDs before feeding it into the light shaping part of the optical system. Standard means to this are mixing rods. These form little kaleidoscopes out of transparent material or mirrors. They must be attached as close as possible to the light source to avoid losses. Diffuse transparent surfaces or satinated mirrors are also often employed very successfully. Other, more expensive elements for colour mixing optics are lens arrays or dichroitic filters.

Simulation software today is a reliable tool for illumination optics development. It speeds up the development process with accurate predictions of the performance of the system before they are built. By using the right software, the optics designer can model LEDs, available materials and all occurring physical effects accurately. The analysis in virtual experiments will usually include illuminance, intensity and luminance. For all three, the colour analysis, using CIE coordinates real colour display or rendering for visualization, will be important.

We distinguish three phases in optics design with the software playing a different role in each of them. In the concept phase, illumination simulation can work as a virtual workbench for the quick test of ideas. A basic system can be defined quickly for a rough check. For example, whether a mixing rod of a certain length can yield good colour uniformity at its output end for a given set of LEDs can be found out within a few minutes. In the design phase, a well defined model of the LEDs and the optics will be composed of parts imported from CAD and parts defined within the software. Often the optics will be parameterised and then optimised for best performance. The result is a virtual prototype along with a prediction of its performance. In the tolerancing phase, the software helps to assess the sensitivity of the system's performance to manufacturing errors. A series of slightly deformed copies of the system is analysed to define the manufacturing tolerances to be kept. In the end, the system is exported to CAD for manufacturing and the analysis results can be translated, e.g. into Eulumdat or IES for light planning tools.

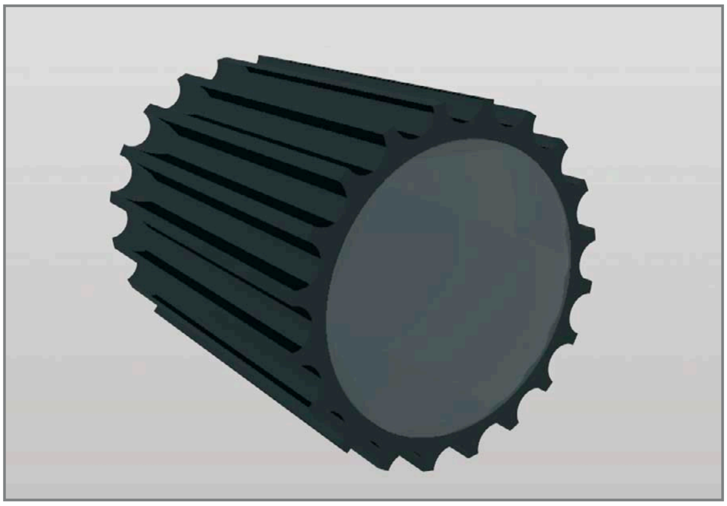

Figure 1: Colour mixing spotlight in a circular housing. The lens diameter is 40 mm

Spotlight for general lighting

This system uses a cluster of four single Power LEDs with a small footprint, e.g. the Rebel LEDs from Lumileds.

The optical elements are a hollow mirror in combination with a lens. This approach can yield a good efficiency which is mainly controlled by the quality of the mirror coating. Because the light is already mixed inside the mirror, colour fringes will not occur. The mirror shape is mainly defined by the space of construction being 40 mm in diameter and 50 mm in length for the optics. The lens shape has been optimised in LightTools for best collimation. The colour mixing requires a well chosen quantity of scattering on the lens surfaces. One way to achieve this is using the standardised MoldTech structures which can be applied to the insets of a moulding tool. Changing the grade of scattering by applying different standardised scattering structures affects the quality of the colour mixing. Figure 2 shows the angular colour distribution in two cases with sufficient and insufficient colour mixing. The full width half maximum intensity angle of the good system is 22° as measured from an intensity analysis in the software. The efficiency of the system is 91% assuming 98% reflectivity for the mirror, which can be achieved using the best metal or plastic mirrors available.

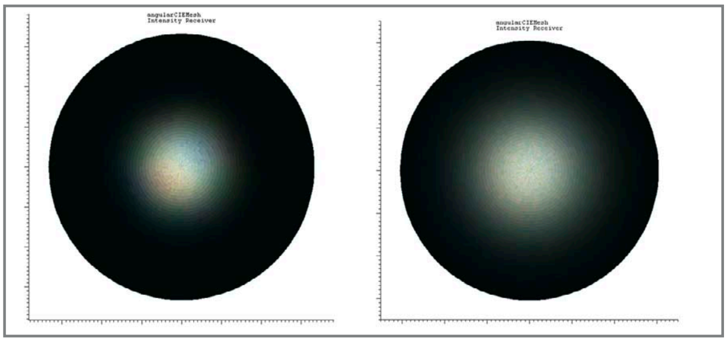

Figure 2: RGB-far field distribution with weak scattering at the lens exit surface (left) and with stronger scattering at the lens exit surface (right). The good colour mixing is achieved at the cost of a larger angle of the spotlight (22° full width half maximum intensity on the right side)

Light guide for signs or decorative accent lighting

The light of 18 multi-chip LEDs is coupled into a flat plate of PMMA in this system. We use small SMD type LEDs like they are commonly used for backlighting displays and are available as LED lines on boards. The transparent plate is mechanically held by a metal support which also holds the LEDs. The light is distributed within the light guide by total internal reflection. On the back side of the light guide, structures extract the light out through the front side. These structures can be either moulded together with the plate or can be embossed into the flat material. The pattern of the extraction structures is optimised in LightTools with a utility dedicated for backlight design to yield very good uniformity. Colour uniformity is reached by many interactions of the light with the light guide before the light is extracted.

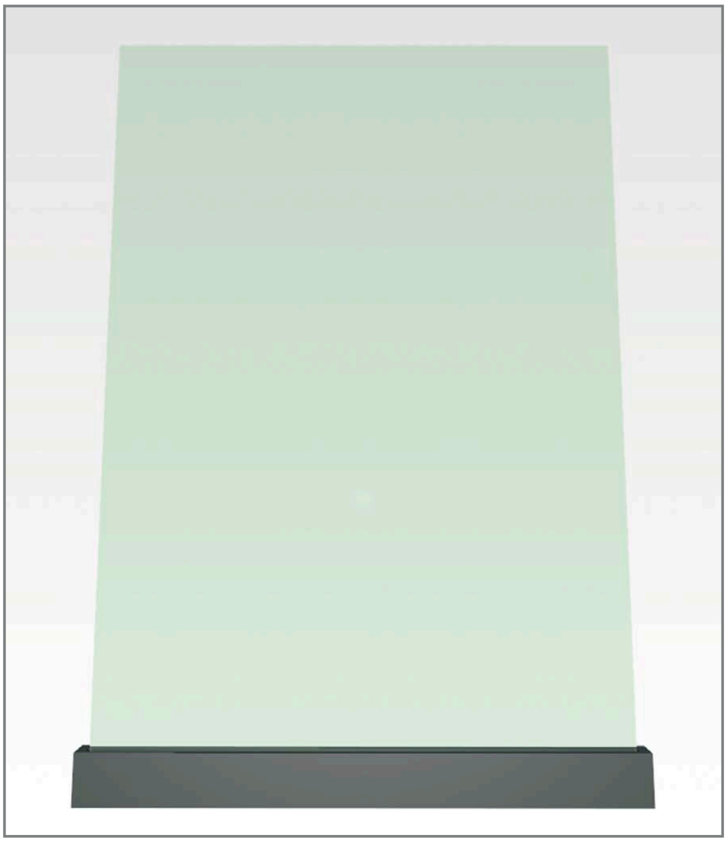

Figure 3: Light guide of 30cm x 20cm in minimalistic design. It is illuminated from the lower side by RGB LEDs

The analysis of the optimised system shows an efficiency of 80%, with light being extracted through the front and back surface in equal parts. Therefore the system can be used free-standing or would provide indirect lighting when mounted on a wall. The brightness uniformity of the system can be analysed with an illuminance analysis. Illuminance levels are shown in false colour representation in Figure 4.

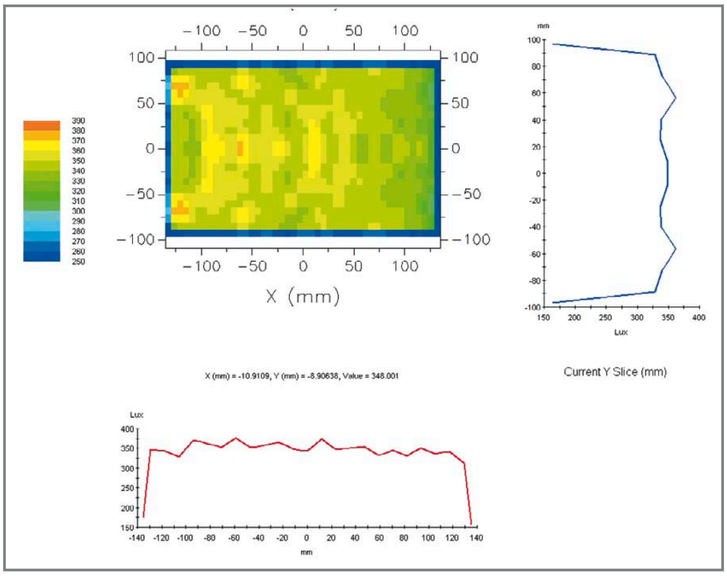

Figure 4: False colour rendition of the illuminance distribution of the light guide in operation. The backlight pattern optimisation achieves very good uniformity with variations below 10% in the active area

We analyse the colour uniformity using a colour coordinate plot. The colour location of each pixel of the receiver is shown within the CIE 1931 colour diagram. All pixels fall within a very small region of the colour triangle in Figure 5.

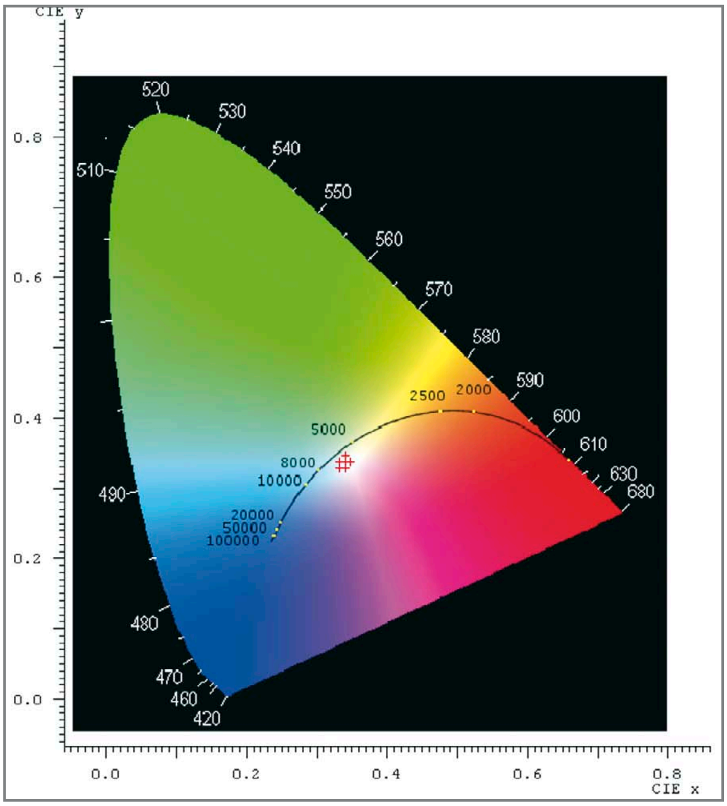

Figure 5: Colour uniformity in the CIE XY diagram. Each pixel on the receiver at the exit of the light guide is marked by a cross in the colour triangle

Free-form mirror for wall washing

This example combines colour mixing with free-form optics in an application for general illumination. A 3D tailored mirror is used in combination with a mixing rod to evenly illuminate a rectangle of 2 m by 1 m in size. The light comes from a multi-chip LED, which has four chips close together in one package. The volume of the optical system shown in Figure 6 is about 88 mm x 75 mm x 65 mm.

A rendering with three identical systems with slightly adapted LED colour control (Figure 8) shows the effect of colour change and the quality of colour mixing in this system. The rectangular target area is illuminated uniformly and well distinguished. The efficiency of this setup is 80% assuming high quality reflector material. The intensity distribution of the luminaire has been exported to a Eulumdat file for direct use in light design software (Figure 7). ■

Figure 6: Luminaire with 3D tailored free-form mirror. The LED with mixing optics is integrated in the little vertical bar. The free form mirror is tailored to yield uniform illumination across an area of 2 m by 1 m

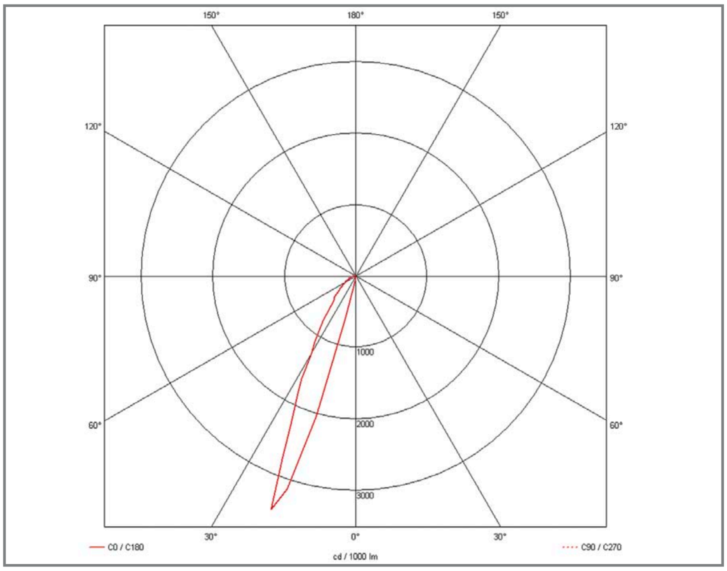

Figure 7: Intensity distribution of the luminaire exported from LightTools to Eulumdat for use in lighting design software. The asymmetric intensity pattern is typical for wall washing

Figure 8: Three luminaires with different colour setting in a room, photorealistic rendering in LightTools

Freeform Optics with 3D Tailoring

The term 'tailoring' has been established for a set of constructive design methods for illumination. Tailoring techniques translate the given task into a set of mathematical equations. The local slope and the local curvature of a surface determine how light is redirected. Together with conditions for the envelope of the surface, these relations are translated into a set of differential equations. The solution to these equations is the optical free-form surface. The picture shows a plastic lens with a 3D tailored free-form surface producing a precisely prescribed illuminance pattern.

ADVERTISING & ARTICLES

Issue	Editiorial Focus	Space Close	Material Close	Publication
May/Jun 2008	**Review Light & Building 2008 Preview Lightfair 2008**	May 2	May 9	May 16
Jul/Aug 2008	**LED / Solar systems**	Jul 11	Jul 18	Jul 31
Sep/Oct 2008	**LED and luminary optics**	Sep 12	Sep 19	Sep 30
Nov/Dec 2008	**LED system simulation and testing**	Nov 7	Nov 14	Nov 28

Editorial Calendar 2008

High Efficiency 200W LED Ballast

> Dr. Michael Weirich, Fairchild Semiconductor GmbH

Introduction

Currently the high power LED is leaving its niche and is used in more and more in 'mainstream' lighting applications. Some of these, like street lighting and similar applications, need power levels of more than 100W. As usual in lighting electronics, the ballast must have low harmonic line current, high energy efficiency and small dimensions.

A design example of such an electronic ballast with an output power of up to 200W is given in this article. The ballast consists mainly of three distinct stages: a power factor controller with preceding EMI filter and rectification, a DC-DC converter based on LLC topology followed by three switch-mode current sources.

The design as described below is able to drive about 105 power LEDs in total with an overall efficiency of 90%. For PFC and DC-DC converters the efficiency is even close to 95%.

Power Factor Correction

The PFC pre-regulator is - as usual - implemented in boost topology and uses the FAN7529 PFC controller that operates in critical conduction mode, as well called boundary- or transition mode. For a power of 150 to 200W maximum this is considered the most economic solution. In critical mode the peak current through the boost inductor is controlled in such a way, that it is proportional to the instantaneous rectified input voltage. During off-time, the current goes back to zero and this zero crossing (i.e. de-magnetization of the inductor) is detected and initiates the next switching cycle. It is easy to see that the average inductor current is proportional to the input voltage, the needed result.

The FAN7529 operates in so called voltage mode, where the conduction time of the MOSFET is kept constant during at least one power line half-cycle. Keeping on-time constant, peak switch current is proportional to the input voltage as can be easily derived from the basic differential equation dI/dt = V/L. The output voltage of the boost converter is sensed and regulated by adjusting the MOSFET's on-time. The advantage of voltage mode compared to current mode is that there is no need for sensing the rectified input voltage in order to generate a reference signal. This simplifies the controller itself and reduces component count.

A big advantage of the critical mode is that sensing the de-magnetization of the boost inductor before the next switching cycle starts results in zero current turn-on of the MOSFET. Thus switching losses are quite low and efficiency will be high, especially since reverse recovery of the rectifier diode is not an issue as well. On the other hand peak input current is higher than in a continuous conduction mode (CCM) PFC and may make the EMI filtering more complicated.

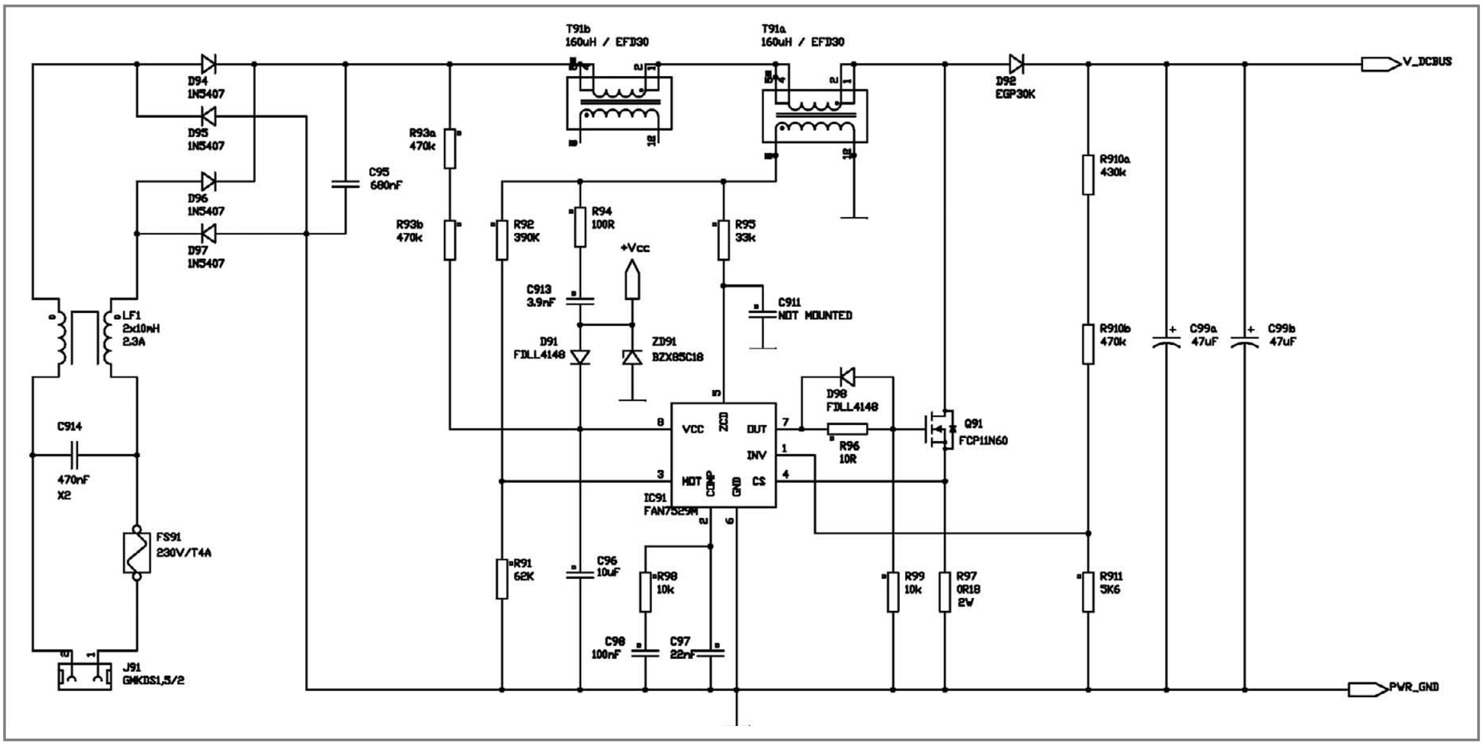

Figure 1: Schematic of 200W DCM voltage mode PFC

The schematic of the PFC and the input stages is given in Figure 1. When the application is powered up, C96 is charged via R93a and R93b. As soon as the start voltage of IC91 is reached, normal operation starts. The gate of the MOSFET is driven through the network R96, D98 and R99 that enables fast turn-off and slower turn-on of the latter. The boost inductor consists of two distinct inductors since the universal input demands for a high current and high inductance device that can not be implemented with a single low profile core. The current through the MOSFET is monitored at the CS input of the controller in order to achieve pulse by pulse over-current protection. The output voltage is scaled by the divider R910a & b and R911 and fed to the chip's error amplifier that is frequency compensated by the network connected to the COM pin. The output of the error amplifier sets the on-time of the MOSFET accordingly. De-magnetization of the inductors is detected by monitoring the voltage across a secondary winding of one of the inductors that is fed to the ZCD input. The power supply of the controller during normal operation comes from this secondary as well and is rectified and limited by the network R94, C913, ZD91 and D90. Resistor 91 sets the maximum on-time of the MOSFET such that is not more than the time needed at full load and minimum input voltage. The purpose of R92 is to add some modulation of the on-time with the input voltage to improve THD.

The PFC pre-regulator as described generates a DC output voltage of 400V that is fed to the DC-DC controller.

Isolated DC-DC Converter

As already mentioned in the previous section an excellent approach for achieving high efficiency is to reduce switching losses. If the goal is high power density as well, the topology of choice will be one that utilizes the magnetic components in both directions of magnetization i.e. a half- or full-bridge topology. Reduced switching losses are generally accomplished by zero current and/or zero voltage switching, which can be achieved by using resonant networks. The converter with a "simple" LC resonant tank has some disadvantages, as will be explained later, and a configuration called LLC series resonant converter is more favorable. On the left of Figure 2 a simplified schematic of this type of converter is shown.

The MOSFETs Q1 and Q2 are driven by two complementary square wave signals with almost 50% duty-cycle and a variable frequency. As usual in half bridge topologies, there must be a small dead time between low side and high side gate signals to prevent cross conduction. The generated square wave signal is fed into the resonant network consisting of Lr, Cr and Lm, the magnetizing inductance of the transformer. As will become clear below the voltage across Lm is almost sinusoidal. This voltage is transformed, rectified, filtered and fed to the load RL. So far the converter looks like a standard LC resonant converter. In an LLC converter Lm is much smaller than usual and in the same order of magnitude as Lr, thus changing the characteristic of the resonant network from essentially second to third order.

To simplify the further analysis of the characteristic of the resonant tank, the load together with the rectifier can be transformed into an equivalent load resistance Rac on the primary side of the transformer. As shown in the equivalent schematic on the right hand side of Figure 2, the equivalent load is in parallel to the transformers magnetizing inductance. Network analysis finally gives a third order bandpas transfer function that is characterized by the following three parameters:

$$\omega_0 = \frac{1}{\sqrt{L_r \cdot C_r}} \qquad \omega_P = \frac{1}{\sqrt{(L_m + L_r) \cdot C_r}} \qquad and \qquad Q = \frac{\sqrt{L_r / C_r}}{R_a}$$

A typical plot of the gain versus frequency is shown in Figure 3 for a network with Cr = 22nF, Lr = 100uH and Lm = 500uH and different values of Rac between 200Ω (green) and 2kΩ (yellow) i.e. Q = 0.033 .. 0.33

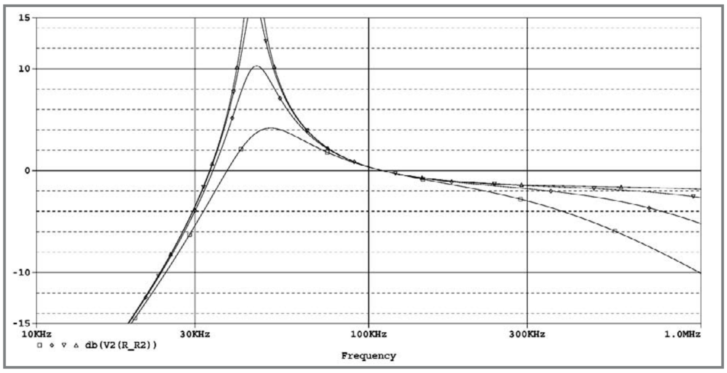

Figure 3: Gain [dB]of the LLC network for different values of Rac

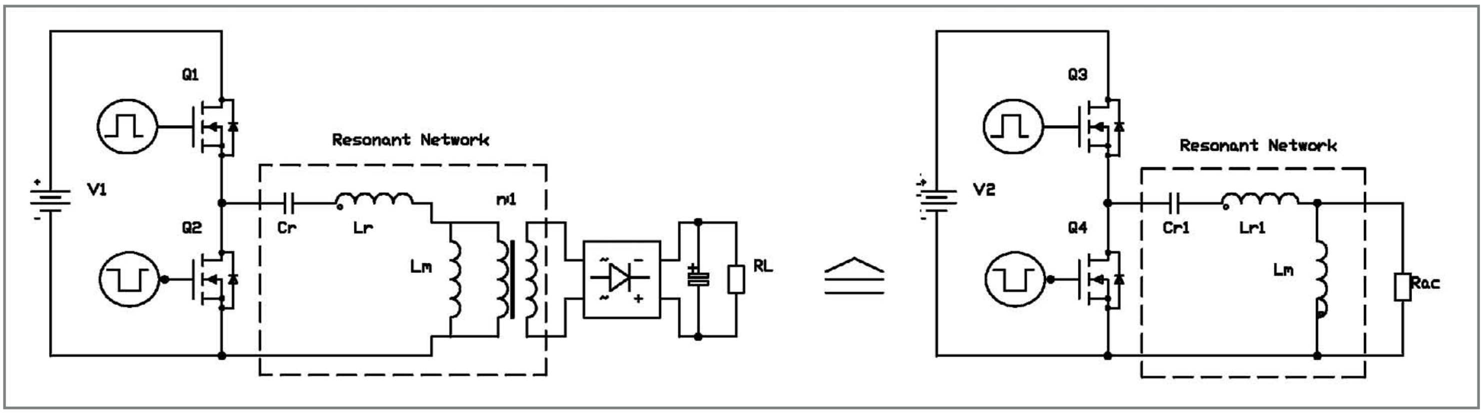

Figure 2: Simplified schematic of LLC converter (left) and electrical equivalent

The plot emphasizes two important features of the LLC network:

- The gain of the network at ω_0 is always unity
- There is a relatively broad frequency range around ω_0 with only weak load dependence.

The second finding is very important since it indicates that changes in load resistance don't result in large changes of the switching frequency as they do in a conventional LC series resonant converter. The latter may show frequency variations by a factor of ten and even more when going from full to light load. Such a wide frequency range very likely leads to problems with EMI.

Analysis of the actual waveforms in time domain shows that zero current switching at turn-on of the MOSFET is achieved when the operating frequency is above ω_P. Even with full load Q values between 0.2 and 1 the transfer has a sufficient narrow bandwidth to assume that the fundamental harmonic of the current dominates. Thus generally the driving square wave is replaced by it's fundamental sinusoidal component for analysis and calculation of the LLC converter. It is worth to mention that a considerable amount of the current that has to be handled by the two MOSFETs is reactive and therefore the current load of these is much higher than in a hard switched converter. In addition it is favorable to use MOSFETs with fast recovery body diode in resonant converters [1].

A detailed description of the theory and design procedure of LLC converter is given in [2]. This application note describes the how to use the leakage inductance of the transformer as resonant inductor Lr. While this approach eliminates the need for an additional inductor it necessarily increases the size of the transformer itself. The desired ratio of Lm/Lr of 4 ..10 can only be achieved with larger transformers and very loosely coupled primary and secondary windings. The high power LED ballast on the other hand had a target height well below 20mm which led to the use of a EFD shaped transformer and an "external" inductor.

Figure 4 shows the schematic of the DC-DC converter. It has been designed around the integrated LLC controller module FSFR2100. This module contains the controller itself with a precision CCO, a high voltage gate drive circuit and two MOSFETs with fast recovery body diode.

The startup current of the module is delivered from the PFC power supply. When the startup voltage is reached, the device starts to operate with a frequency determined by R107 then and drops - since C107 is charged by and by - to the nominal operating frequency with a slope that is determined by C107 (Soft-Start).

The LLC network consists of L101, TR1 and C102a & b. On the secondary side the transformed voltage is rectified by D201 - D204 and filtered with C201. A second lower output voltage is generated with D201, R201, C201 and D206.

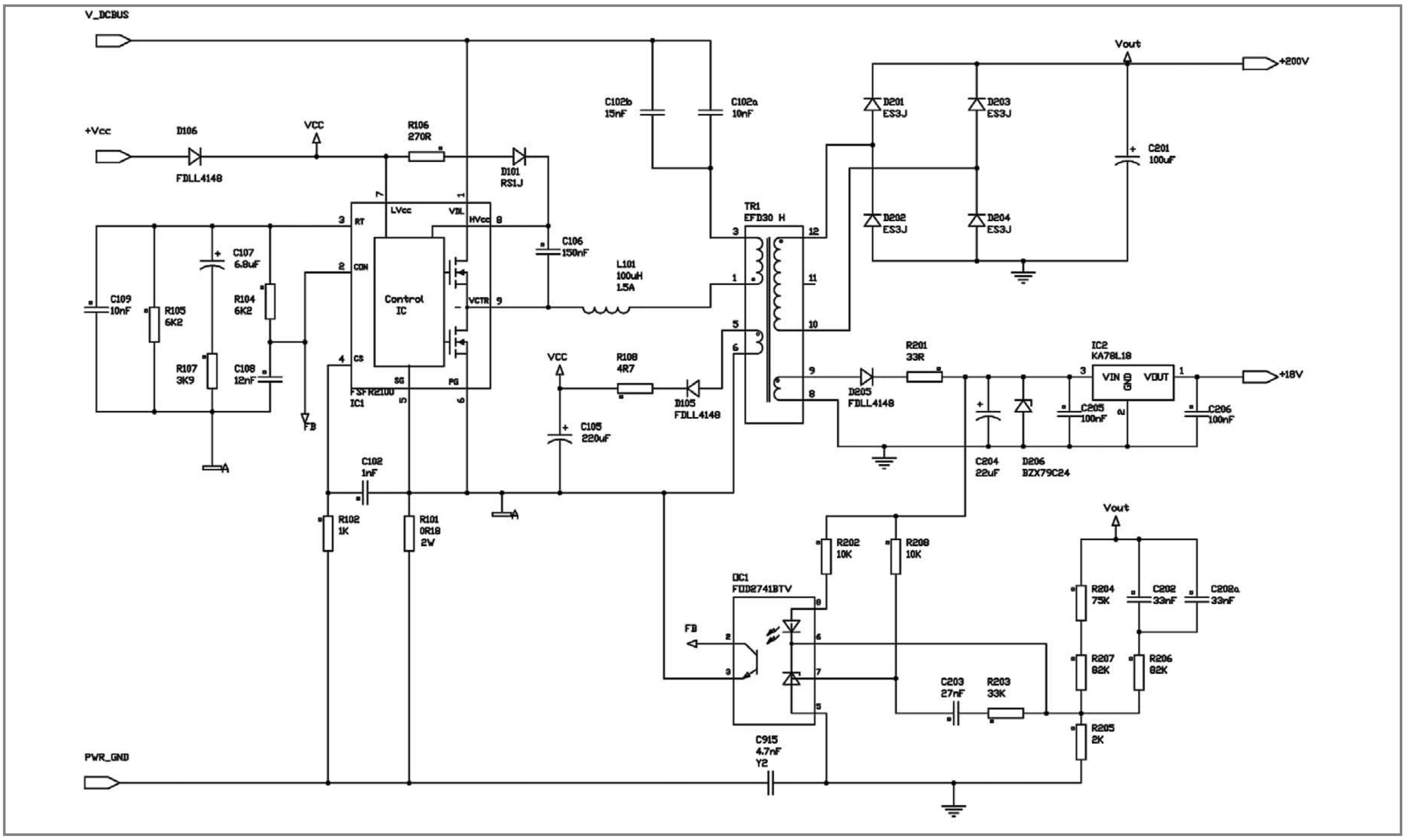

Figure 4: Schematic of the isolated converter 400 VDC → 200 VDC

R204, C202, R207 etc. and OC1 form the feedback loop to stabilize the output voltage. The BJT of the optocoupler together with R104 forms a variable resistor that is in parallel to R105, the resistor determining the minimum operating frequency, and adjust the frequency accordingly.

D105, R108, C105 and D102 deliver the supply current for IC1 during normal operation The supply voltage for the high-side driver of the half bridge is generated with the bootstrap circuit consisting of R106, D101 and C106.

The current through the lower MOSFET is measured with R101, the signal is filtered with the network R102/C102 and fed to the 'CS' pin. This pin accepts a signal that is negative respect to the ground-pin of the chip. If a level of -0.6V is met at this pin, the half-bridge is switched of until the next cycle. If -0.9V are met, the device is shut down (AOCP). The latter mode is latched and only reset after the Vcc of the chip fell below 5V typical.

Current Sources

The three identical current sources that follow the DC-DC converter are using buck topology and based on the SG6859 current mode PWM controller. The schematic of one of these sources is shown in Figure 5. The peak current through the inductor L102 is converted to a voltage level with the shunt resistors R13 and this voltage is fed to the current sense pin of the controller. Thus the controller keeps the peak inductor current constant. R10 sets the current sense level and R7 determine the operating frequency that is about 70kHz in this application.

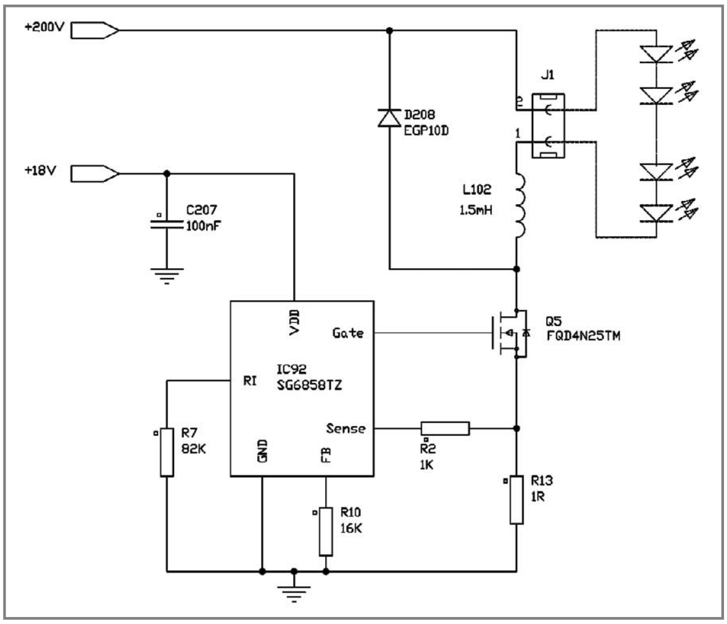

Figure 5: Schematic of the sources that stabilize LED current

References:

1 Fast Body Diode MOSFET' by Sampat Shekhawat, Power Systems Design Europe, October 2005

2 Half-bridge LLC Resonant Converter Design Using FSFR-series Fairchild Power Switch (FPS™), Application Note AN-4151, Fairchild Semiconductor, 2007

Actually the LED current is not perfectly constant if different numbers of LEDs are connected to the output since duty cycle and thus average current vary slightly with the output voltage. But the deeper in CCM the converter is operated i.e. the higher the value of L102 the more constant is the current. In most applications the number of attached LEDs doesn't vary at all. The variations of output voltage or better to say the forward voltage of the diodes is relative small and the current will be pretty stable. With a worst case maximum duty cycle of 70% each current source can drive about 35 LEDs maximum.

Driving RGB High Power LEDs

> Ulrich Kirchenberger and Pavel Koutensky, STMicroelectronics

Introduction

New high power and high brightness Red, Green, and Blue (RGB) LEDs are used in many different lighting applications as Backlighting, Architectural Lighting and "Wall Washing", General lighting systems, Traffic signals, Automotive, Mood lighting, Advertising, etc. They are becoming popular mainly because it is possible to generate easily multicolor light with special lighting effects and their brightness can be easily changed.

High Power LEDs are considered to have a current of 350mA or higher and power levels equal and above 1W. Very often 2 green LEDs with 1 red LED and 1 blue LED, with same driving current, are used to create a RGGB color light source. This meets the human eye characteristics.

This leads to the requirement of a four channel LED driver. In the following a LED driver solution using the STP04CM05, a 4 channel linear current source with SPI interface, a microcontroller and a voltage pre-regulator is described.

Driving concept for RGB LEDs

LEDs emit their nominal wavelength and color at a defined current value. Therefore an optimal drive of LEDs is provided by a current source. A continuous color spectrum within the color gamut can be achieved by mixing of colors. If RGB LEDs are used, all colors within the triangle built by the natural colors red, green, and blue can be created. The mixed colors are achieved by tuning the brightness of each color. Brightness modulation however is not achieved by linear variation of the current, which would also vary the color of each LED, but by PWM modulation of the current. In Figure 1 an application circuit using a 4 channel Power LED driver STP04CM05 with current sink and shift register and a ST7Lite09 microcontroller is shown. In the output stage of the Power LED driver, four regulated linear current sources provide 80-500mA constant current, adjusted by just one resistor for all channels. The LED supply voltage is connected to the anodes of the LEDs or LED strings (series connection of LEDs) and the cathodes of the LEDs or LED strings are connected to the open collector drivers, that serve as current source. The supply voltage value is very important in order to keep the dissipation in the linear current sources at a minimum. The LED supply is adjusted by an integrated switch mode DC/DC converter L4973D3.3 that delivers up to 3A and the voltage is selected to be the forward voltage of the LEDs plus the drop-out voltage, - typically 0.7V -, of the constant current source.

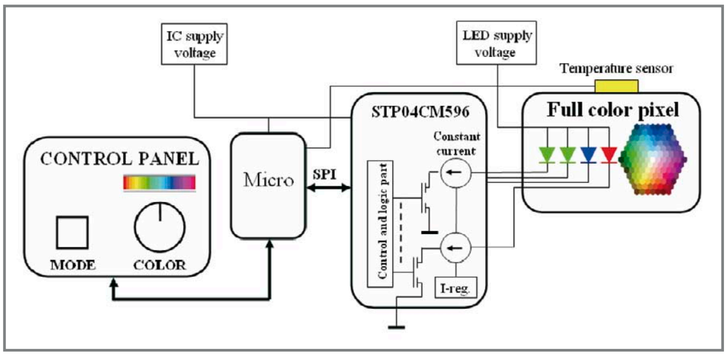

Figure 1: Driving concept for RGGB LEDs

Due to different technologies the forward voltage of Power LEDs is different depending on the color. If all LEDs are supplied by same supply voltage higher power dissipation will occur on the channel driving the lowest voltage drop (red or amber) LEDs. In order to keep the losses in the linear current source driver STP04CM05 minimal either different supply voltages are provided, not just one as shown in Figure 1, or a resistance is added in series to the LEDs which have the lowest voltage drop. The maximum number of LEDs in series in one string on one driver output of STP04CM05 is defined by the maximum voltage of the driver of 20V. In general this means up to 4 LEDs in series can be driven.

The control unit in this application is a microcontroller, which sends data through the serial peripheral interface (SPI) or serial data interface (SDI) to the shift registers inside the STP04CM05. If more than 4 channels are required the drivers can be cascaded. The data are shifted bit by bit to the next driver in a cascade with falling edge of the clock frequency (the maximum communication frequency for this SPI interface is 30MHz). When all data are transmitted to the drivers through SPI, the micro sets the latch input terminal (LE) pin "log 1" to rewrite the data to the storage registers and to turn on or off the LEDs. More details on timings and features are shown and described in AN2141 (refer to [1]) and datasheet of the STP04CM05 (refer to [2]).

Increasing the driving current

Especially some new developments of Power LEDs require an operating current above 400mA, the current source capability of each channel of the STP04CM05. Due to the current source nature it is possible to parallel several channels of the driver in common drain configuration in order to achieve the required drive current. E.g. for the load of an OSTAR projection LED with 4 LEDs, each 700mA, 2 drivers STP04CM05 with total 8 channels can be used to drive the LEDs. Each 2 of the output channels are connected in parallel (2x350mA).

Power Dissipation

The drivers are assembled in different SMD packages in order to allow for the right form factor. There is also a special TSSOP16 package available with exposed metal to have an optimal connection to the PCP as heatsink. with exposed pad has a low Rthja = 37.5°C/W. To maintain the maximum junction temperature Ptot < Pdmax has to be ensured by design.

Color Control

The most important feature for the user is the flexible color setting. Already in the introduction it has been highlighted that an almost infinite number of color variants can be set by mixing the basic colors RGB. In Figure 2 it is shown how the brightness of each basic color is set by a string of data sent on the SPI interface.

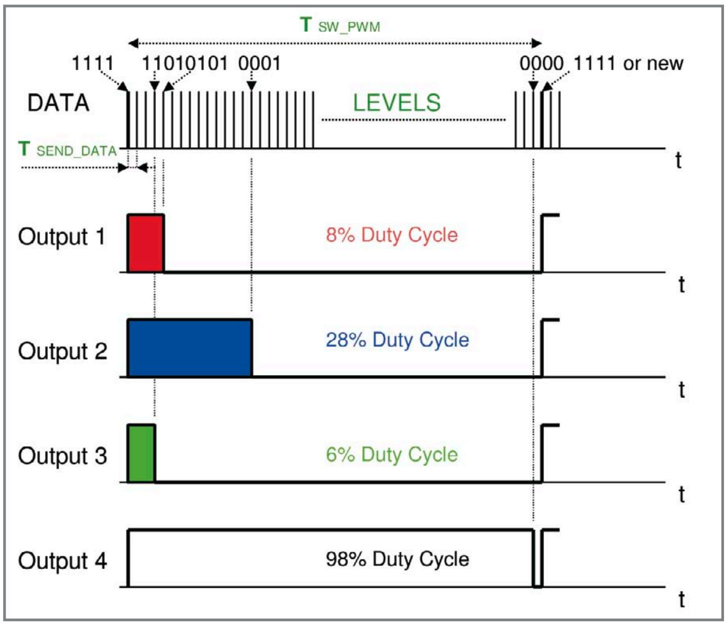

Figure 2: Color control by pulse width modulation

Depending on the number of LEDs to be driven, the PWM frequency required and the SPI frequency, the PWM resolution and thereby the color resolution can be determined.

With the ST7Lite09, a small 8-bit micro, a SPI frequency of only 2MHz and 8 channels, a resolution of 256 levels per channel can be reached. In this assumption, more than the 90% of CPU power is used for supervision and calculation of lighting modes.

In Figure 3 a demonstrator board (15cm x 4.8cm) is shown, that incorporates all functions described above: DC/DC converter for an input voltage of 8 to 30V, 2 Drivers STP04CM05 for 8 LED channels, ST7Flite09 and some status LEDs to show the selected operation mode. Different LED boards can be attached to this driver board. Figure 4 shows a driven LED.

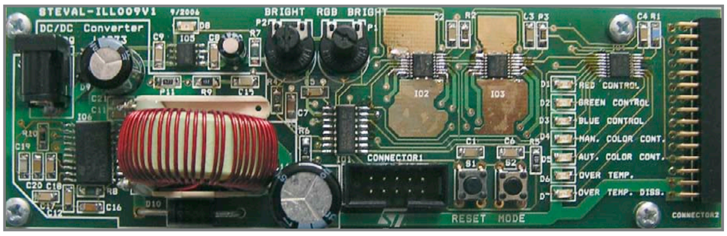

Figure 3: Demonstrator board STEVAL-ILL009V1

References:

[1] STMicroelectronics, AN2141, LEDs Array Reference Board Design http://www.st.com
[2] STMicroelectronics, STP04CM05, 4-bit constant current for power-LED sink driver, datasheet; http://www.st.com
[3] STMicroelectronics, AN2531, Generating multicolor light using RGB LEDs, to be published on http://www.st.com

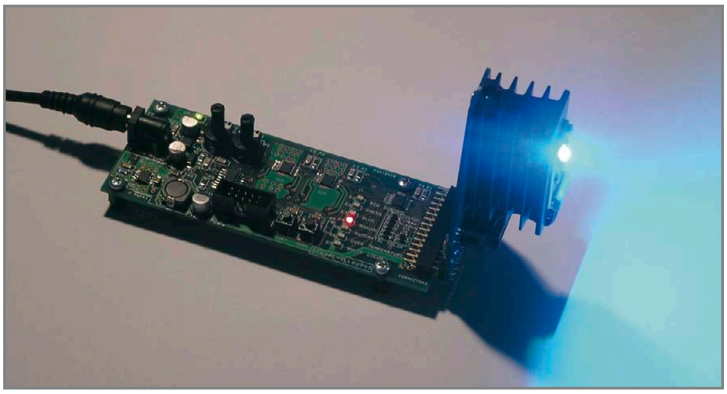

Figure 4: Generating different colors with RGB LEDs

Summary

With ever higher efficient High Power LEDs flexible drivers are required to use the advantage of such LEDs. Here a flexible and efficient way to drive RGB LEDs by user programmable current sources based on the current source driver STP04CM05 has been shown. Additional features like over-temperature protection and over-voltage protection are also implemented in the shown demonstration board in order to maximize the live time of the driven LEDs. ■

High-Brightness-LED Control

> Peter Green, International Rectifier

A variety of lighting applications are adopting HBLEDs (high-brightness light-emitting diodes), making them the fastest growing light source worldwide. Today's advanced devices boast luminous efficacies in the 35-to-50-lm/W (lumens-per-Watt) range. Prototype devices emit more than 100 lm/W.

Current trends suggest that ongoing improvements in LED technology can produce devices with greater luminous efficacy than fluorescent lamps and eventually, will match HID lamp outputs. HBLEDs already surpass incandescent and halogen lamps' and provide longer life, greater reliability, smaller size, and superior low-temperature characteristics. Additionally, LEDs are solid-state devices containing neither toxic gases nor filaments.

Designers are increasingly using HBLEDs in architectural lighting, street lighting, decorative lighting, signage, and backlighting for high-end televisions and monitors. These applications must derive a regulated DC current from the AC line or DC-voltage supply.

International Rectifier's IRS2540 control IC implements a constant-current source for non-isolated applications. These include, for example, where a low-voltage isolated power supply already exists or where a class-2 fixture houses the LEDs in an inaccessible location, as is the case with traffic lights. This arrangement is similar to electronic ballasts for fluorescent or HID lamps, which typically do not provide galvanic isolation.

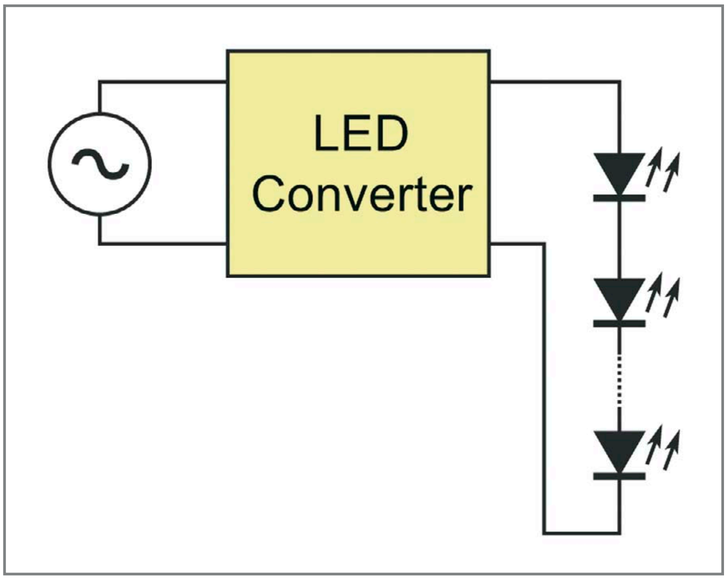

Figure 1: A basic LED converter provides constant current to series strings of LEDs

Buck converters are suitable for applications where the input voltage is greater than the output voltage, which includes most signage, decorative, and architectural lighting. Typical arrays use series-connected LED stacks to ensure equal current through all devices (Figure 1). The series connection avoids the additional circuitry that would otherwise be necessary to maintain equal currents in parallel strings. Nonetheless, large arrays require parallel strings when the forward voltage across a single series stack would exceed either the available compliance voltage or the converter's maximum operating voltage.

The most common LED failure mode is a short circuit. When an LED fails in a series string, the others will all continue to operate normally. A failure of LEDs in parallel, however, prevents the remaining LEDs from operating. The combined forward voltage drop for series LEDs varies with temperature and with LED color. The forward voltage also has a wide tolerance in production.

Many applications require dimming. Combinations of primary-color LEDs can create any color in the spectrum by adjusting the intensities of each color, allowing many possibilities for display lighting, signage, and mood lighting. A buck regulator system based on the IRS2540 can dim over the full range from a logic-level PWM control signal.

The low-frequency PWM signal switches the average LED current by driving the converter in burst mode, changing the light intensity (Figure 2). Unlike current modulation, PWM accomplishes the dimming without changing the LED's color. The PWM frequency is sufficient to prevent visible flicker.

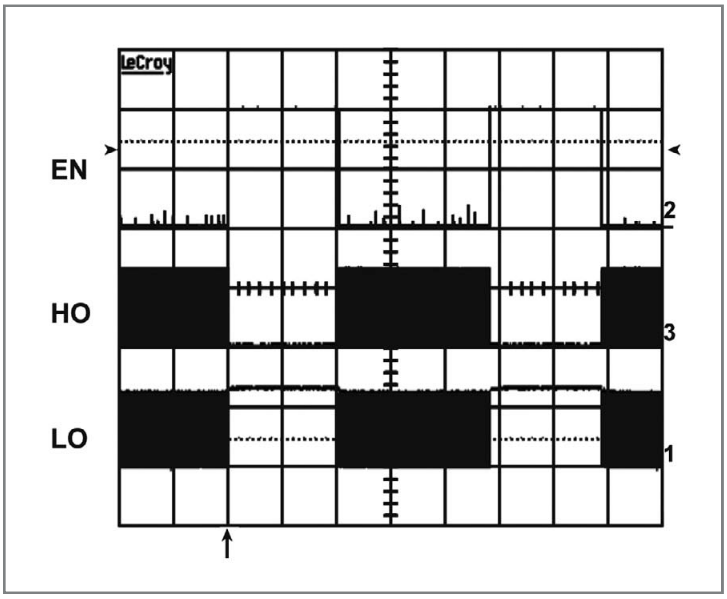

Figure 2: Burst-mode dimming provides excellent control of the LED string's light output while maintaining excellent color fidelity

HBLEDs enable architects, designers, specifiers, and manufacturers to create never-before-possible lighting effects and design luminaires for theaters, studios, nightclubs, restaurants, and other high-visibility venues. Digital scene controls and protocols such as DMX512 provide means for dramatic and dynamic lighting displays. The IRS2540 suits these applications allowing simple interfacing with microcontroller-based dimming circuitry.

LED light sources also naturally lend themselves to landscape and outdoor lighting, offering longer life correspondingly lower maintenance costs than incandescent and fluorescent lamps. LEDs are also less vulnerable to moisture ingression. Unlike conventional bulbs, LEDs have no fragile components to break, even when roughly handled. Flexible digital-control systems can produce dramatic lighting effects as they do in interior applications Lighting schemes can change without rewiring or installing new systems.

Lighting designers are increasingly turning to high-power LEDs for their long life, ruggedness, flexibility, small size, and energy efficiency. They now have access to larger LEDs than those available just a few years ago—1, 3, and 5 W/package—that operate on currents up to 1.5 A.

By integrating a floating high-side driver, IRS2540 is able to use a current-sensing scheme that continuously monitors LED current (Figure 3). Other controllers are limited to monitoring the current only during the time when the buck-converter switch is on. This allows the IRS2540 to realize average-current control as opposed to peak-current control and provides an inherently stable regulation that operates over a wider line and load range without running into design limitations.

The converter IC accurately regulates the current by means of its patented time-delayed hysteretic-control method. The overall system is simple, flexible, and able to power LEDs from a DC bus or directly from a rectified AC line. Controlling current accurately is a challenge when the forward voltage of each LED has a large manufacturing tolerance. For example, in the case of Lumiled's popular Luxeon III emitter, the forward voltage, VF, varies around a nominal of 3.70V from 3.03 to 4.47V for white, green, or blue, per the manufacturer's datasheet. This slightly asymmetrical tolerance allows a -18%, +20% variation in the device's forward voltage at 700 mA. The VF also varies over temperature, with a negative temperature coefficient of -2mV/C. At 100C, this is another 0.15V voltage change. Typical strings of multiple LEDs further magnify these variations, requiring medium to high bus voltages.

The IRS2540 achieves accurate current control with a simple design that is inherently stable and requires no complex circuit analysis. Because this method uses continuous-current mode, the design must limit stress during hard switching. It achieves this simply by controlling the control-circuits' delays. The design's peak currents are far smaller than in a peak-current control-mode topology. As a result, the LED converter can use smaller, more efficient MOSFET switches and a smaller inductor.

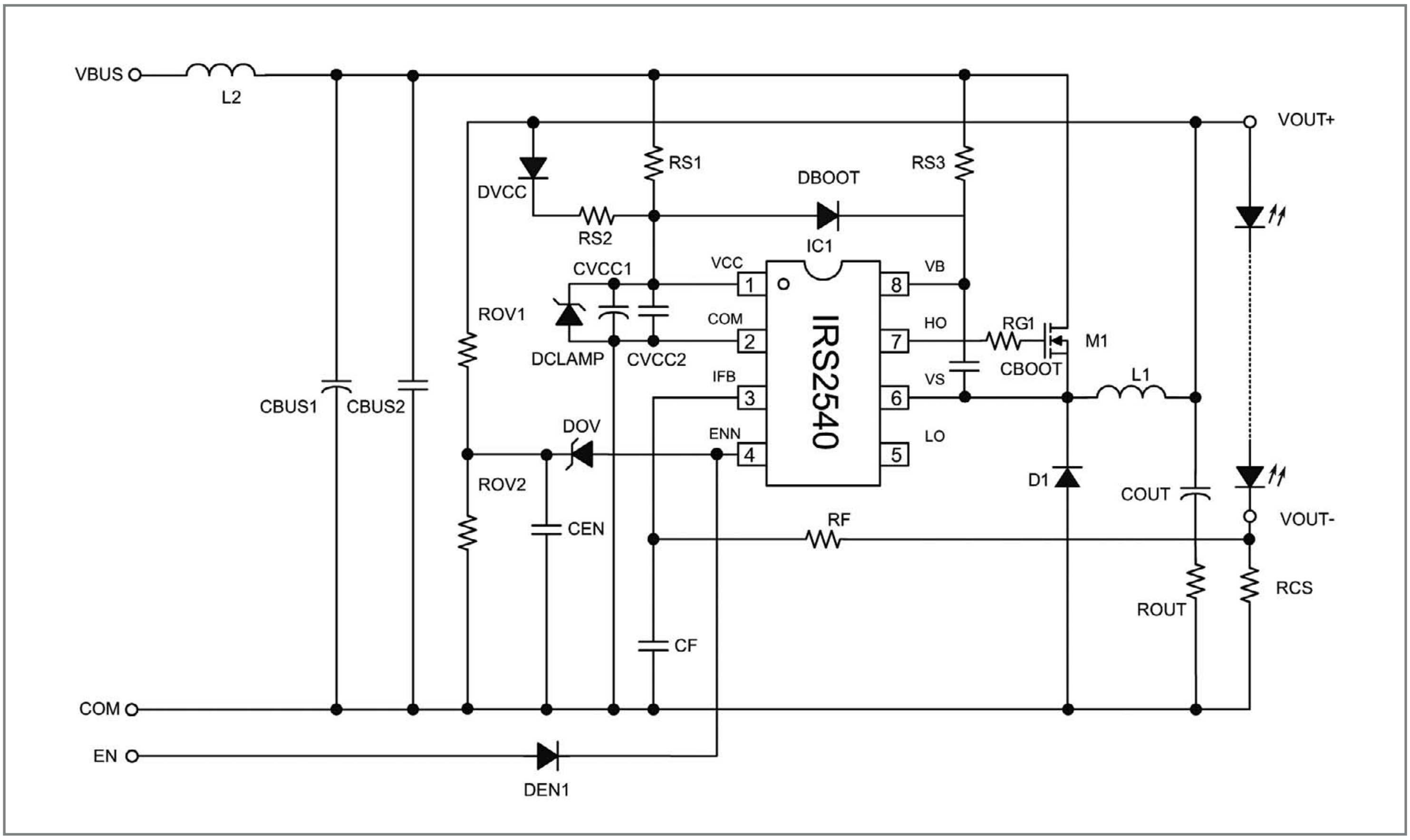

Figure 3: The IRS2540 provides conversion continuous-time current monitoring for true average current control.

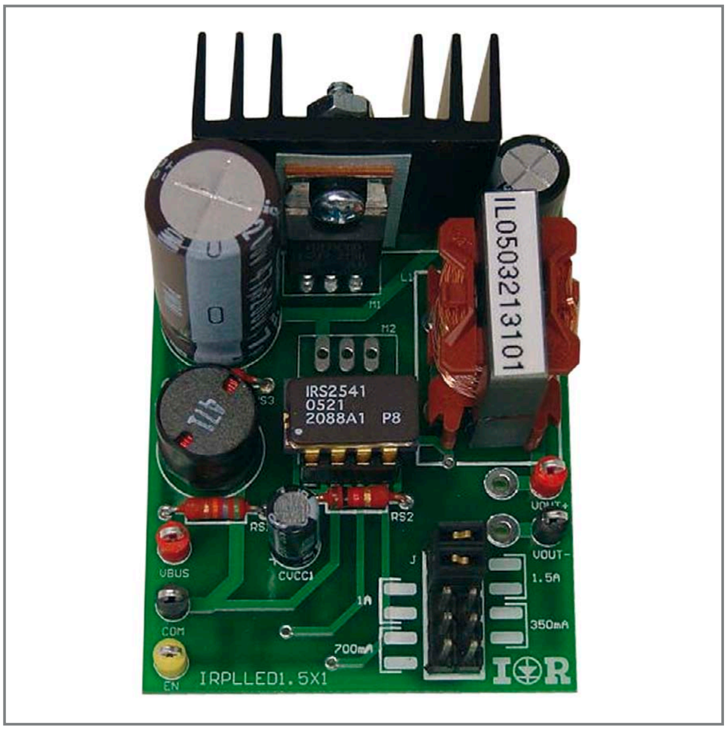

Figure 4: The IRS2540 and its sibling, the IRS2541, support bus voltages as large as 200 and 600 V, respectively

The control-circuit delays do cause a current ripple in the inductor, but an output capacitor in parallel with the load reduces the ripple current. The output capacitor also reduces the frequency by adding delays to the current feedback, which improves the system's efficiency by reducing switching losses. Overload and short-circuit protection are inherent to this configuration. Implementing open-load protection and PWM dimming is also easy.

Two variations of the high-voltage LED-converter IC drive LED strings with forward voltages as great as 200 V (IRS2540) and 600 V (IRS2541). The design achieves efficiencies greater than 85% at 175 kHz (Figure 4). The converter operates at PWM duty cycles to 100% with no stability issues above 50% as can occur in peak-current-controlled systems.

Manufacturers of LCD Televisions, monitors, laptop displays, and various custom-sized panels are now replacing CCFL (cold-cathode fluorescent lamp) with LED backlighting sources, which offer substantial advantages. The LED-based backlighting system expands the palette of reproducible hues by as much as 45 percent. LED-based systems have already achieved 105% reproduction of the NTSC color space compared with the best CCFL lit LCD TVs, which only reproduce 65-75%. Not even a CRT (cathode-ray tube) display can match the color reproduction and brightness of an LED-based system. An LED-based system also has the potential for dynamic tuning to reproduce images with even greater accuracy. ■


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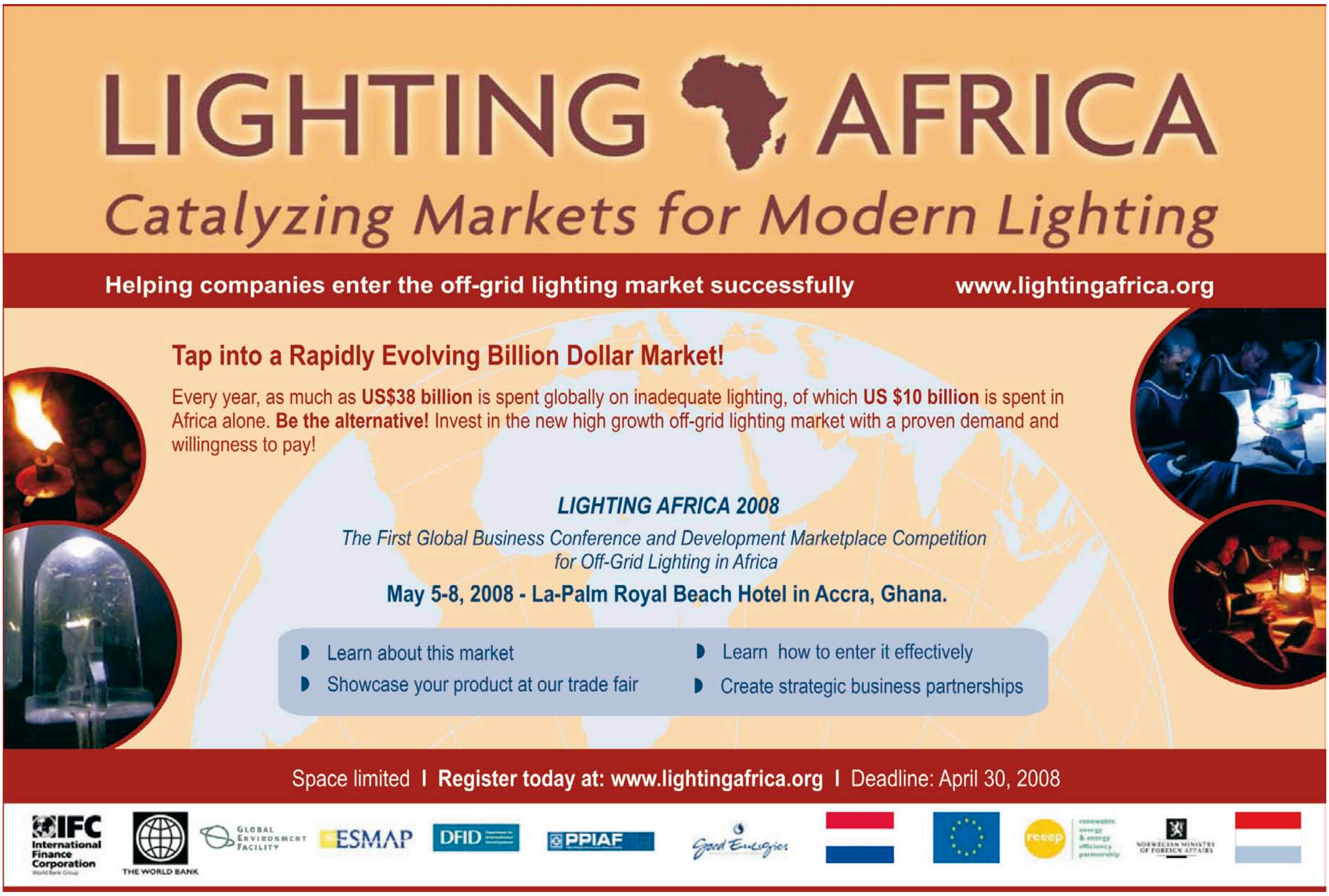
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Improved LED Modules for General Lighting Market

> Christoph Cox, PM LED, VS-Optoelectronic

LEDs are becoming increasingly commonplace in the field of lighting technology. The advantages provided by blending red, green and blue LED light are already benefiting the fields that LEDs are predominantly found in, such as architectural lighting. The low energy consumption of LED applications as well as their long service life guarantees high savings in operating costs, especially when dealing with difficult-to-reach installations. In addition, due to the high degree of colour saturation, blending primary LED colours no longer requires any mechanical filters, which are not only cost-intensive, but also reduce the efficiency of the lighting system.

White LED light is now also gaining popularity for architectural, decorative and general lighting applications. Thanks to the availability of so-called high-power LEDs, which operate at ratings of more than 1 W per LED and by now promise efficiencies of more than 80 lm/W, this trend is certain to continue.

Figure 1: Application example - Shop Illumination

However, in the field of general lighting, there are still a number of challenges regarding the brightness, colour rendering index, efficiency and above all quality of white-light LEDs that have to be addressed. The accuracy of values specified for the luminous flux, colour temperature and chromaticity location of white light varies for technological reasons. In addition, luminous flux and chromaticity locations change throughout the service life of an LED. Furthermore, it has to date remained impossible to guarantee that different LEDs or LED modules always and reproducibly generate the same chromaticity locations, which is particularly visible with white-light applications. However, these are all decisive factors for lighting designers, whose work depends on reliable data.

An innovation from Japan has now revolutionised the market for general lighting applications involving LED technology. The Japanese corporation Matsushita Electric Works has presented two brand new LED modules that meet the requirements of luminary manufacturers and lighting designers with regard to the quality of white light.

Available in a spotlight version (diameter: 47 mm; height: 19 mm) and a downlight version (diameter 59 mm; height: 15.7 mm), the so-called VS-P3 modules.

The new technological design of the modules makes countless binnings – i.e. different chromaticity locations as a result of minor production variations – a thing of the past and instead produces two narrowly defined cool white and warm white colour bins. The average human eye cannot discern any colour differences within these chromaticity locations. In addition to this, the VS-P3 modules are characterised by a high colour rendering index of Ra > 90 as well as very positive thermal properties. Finally, a modified secondary optics serves to precisely define the light's radiation angle.

The modules are each produced with eight (downlight version) and four (spotlight version) 2 W LED chips. The basic module structure differs completely from the surface mounted device (SMD) technology in common use in the LED market. VS-P3 modules are directly produced as a compact, ready-to-install "module package" that requires no further soldering of external components such as power supply cables (Figure 2).

Figure 2: VS-P3 Series

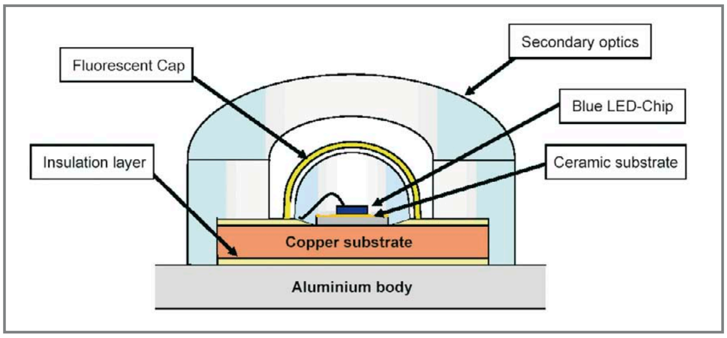

Figure 3: Basic Design

Figure 3 illustrates the thermally and electrically optimised design of the P3 series. The very low thermal resistance of ~3.6 K/W from the LED junction (the light emitting crystal layer inside the LED-chip) up to the underside of the Al body is achieved by soldering the blue LED chip onto a ceramics layer with excellent heat-conducting properties. This, in turn, is soldered onto a copper substrate to optimally distribute the generated heat. Finally, a further thermally conductive and electrically insulating layer discharges the heat onto the Al body.

This double electrical insulation of the LED chip (ceramics substrate and insulating layer) provides optimal protection against electrostatic discharge (ESD protection > 4 kV).

The design diagram in Figure 3 also shows that white light is generated with the help of a special fluorescent (phosphorous) cap that is fitted onto the blue LED chip and converts blue into white light. The negligible fluctuations in chromaticity location are achieved by using these caps, which are characterised by excellent reproducibility during production. Matching caps are fitted to suit the respective chip wavelength so that a warm white or cool white chromaticity location is achieved every time. Instead of numerous "colour bins", this design innovation guarantees only two narrowly defined colour selections.

The two VS-P3 packages are rounded off by a fixed secondary optics that offer beam angles of 30°, 45° and 70° and structurally reinforces internal module design. The secondary optics are designed to produce an extremely homogeneous light spot.

Apart from the two narrowly defined colour selections, the quality of the white light is also characterised by its very high colour rendering index. Thanks to using a red, green and yellow phosphorous blend, a colour spectrum is achieved that differs from the spectrum produced by typical white LEDs (Figure 4). Depending on the specific colour blend, the additional green and red spectral shares generate cool white or warm white light that is very pleasant for the human eye and ensures virtually true-to-life colour rendering. Consequently, these modules constitute a first developmental step in the direction of "feel-good LED lighting".

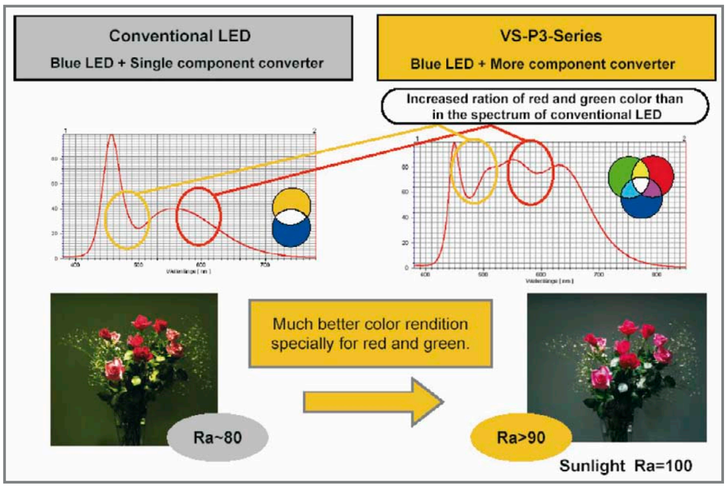

Figure 4: Different spectrums – Standard LEDs and VS-P3 Modules

LED manufacturers typically quote technical parameters like luminous flux (lm) and chromaticity locations (cx/cy coordinates in the CIE diagram) for a junction-temperature within the LED chip of 25°C. However, lighting applications with high-power LEDs often heat the LED-junction to a temperature of > 80°C in practice (dependent on the level of cooling). Higher junction-temperatures result in a substantial decrease in luminous flux and shorten service life. As a result, many users conduct theoretical calculations and/or complicated measurements of the junction-temperature in order to determine the actual luminous flux of installed LEDs (Table 1).

	If=350mA	If=500mA	If=700mA	If=1050mA
Brightness acc. LED data sheet (80lm Bin)	**80 lm @ Tj=25°C**	**104 lm @ Tj=25°C**	**128 lm @ Tj=25°C**	**175 lm @ Tj=25°C**
Max. power consumption	1,4 W	2,0 W	2,9 W	4,4 W
PCB-temperature at fixed thermal design and driving conditions	66°C	80°C	96°C	128°C
Temparature difference between LED-junction and PCB at assumed thermal resistance of Rth=11K/W (LED+PCB): $\Delta T=R_{TH}*P_{MAX}$	15°C	21 °C	32°C	50°C
Junction temperature T_j of the chip at present PCB-temperature	81°C	101°C	128°C	178°C
Brightness losses acc. LED data-sheet by heating up to the mentioned junction temperature	-14,5%	-19,6%	-26,7%	**Critical temperature for Tj exceeded! (Tj max = 145°C)**
Secondary optics loses	-10%	-10%	-10%	-
Brightness of the lamp after heating-up	**62 lm @ Tj=81°C**	**75 lm @ Tj=101°C**	**84 lm @ Tj=128°C**	**Cooling of PCB is not sufficient**
Difference between datasheet values at Tj=25°C and real driving conditions + optics	**-22%**	**-28%**	**-34%**	-

Table1: Brightness losses due to heating of a typical HighPower LED on an Al-PCB; example calculation

In contrast, the new VS-P3 modules guarantee a reliable luminous flux with realistic data sheet values of typically 432 lm and a minimum of 390 lm given at usual real-life operating temperature of 80°C at the Al body. Moreover, the modules have an operating life of 40,000 hours at an Al-body temperature of 80°C.

This attention to detail responds to the frequent demand for accuracy voiced by luminary manufacturers and lighting designers with regard to chromaticity locations and luminous flux values.

Due to the long service life, excellent colour rendering properties and low energy consumption (when compared to conventional lamps) of VS-P3 modules, they make an ideal choice for applications such as general, shop and display case lighting.

In the next five to 10 years, LEDs are both expected to attain efficiencies of up to 150lm/W and become direct competition for inexpensive fluorescent lamps. LED technology is generally seen as the future of lighting thanks to constantly falling maintenance and energy costs – two particularly key factors in view of the great importance attached to reducing CO2 emissions at the present time. ■

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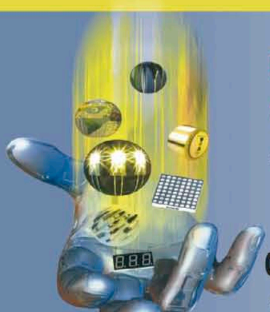

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