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Review

LpR

The leading worldwide authority for LED & OLED lighting technology information

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Tech-Talks BREGENZ: Walter Werner

Advanced Primary Optics

LED Light Spectrum Enhancement

Discomfort Glare Perception

System Reliability "PLUS"

This issue of LED professional Review focuses on different aspects of the design and reliability of LED lighting systems from electronic topics up to engineering approaches of optics designs.

As you probably already know, LED professional has started an interview series called "Tech-Talks BREGENZ". The goal of this initiative is to provide the global SSL purchasers of LED and OLED materials, components, systems and services, orientation and help in the areas of technology developments and trends. This time we talked with Dr. Walter Werner, former System Architect at Zumtobel Group, and we wanted to know from him what system reliability really means.

At this point I want to emphasize two aspects he brought into the discussion, which I refer to here as System Reliability "PLUS". This includes its deployment and maintenance. Without question, the basis for every high-quality system starts at the material and component level. Without doing the right engineering job at that level, systems will always fail too early or they will not perform as expected according to the target specifications. When it comes to a system based on components and modules, interactions between system parts and partitioned functionalities has become very complex.

But why should deployment and maintenance be the "PLUS" topics? Is it because SSL is long lasting and easy to use?

Dr. Werner explained, for example, that a study which was done for wireless control systems showed that less then 1% of the installed systems worked properly. The first big challenge of lighting systems including control units is the deployment phase. Which knowledge, experience and background information is necessary to install a system? Do the system functionalities depend on the building environments such as materials, electrical installation, dimensions, etc.? Do we need a software or IT expert to install a system, because more and more tasks are managed through software codes? The "PLUS" challenge means that SSL providers should look for advanced system approaches and processes for easy and reliable deployment. The second "PLUS" is in the maintenance phase. Assuming a system part fails, what will the consequences be? Who will adjust and maintain the system years after the first installation?

We think that deployment and maintenance issues haven't been covered enough in the overall discussion about reliability and design of LED and OLED lighting systems. These are big challenges to cover and the lighting industry has tried to solve these issues for a long time - but without any fundamentally new approaches. Reliability "PLUS" should be a main engineering topic on every development roadmap and lots of new innovations should come out if it.

Turn to the Tech-Talks BREGENZ article in this issue to read the entire discussion with Dr. Werner.

Have a great read!

Yours Sincerely,

Siegfried Luger
CEO, Luger Research e.U.
Publisher, LED professional

Content

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Danilo Paleari

Danilo Paleari received his Bachelors Degree in Electronics Engineering and his Master Degree in Lighting Design from the Politecnico di Milano. In 2009 he founded the Studio Associato Quantis, a consulting firm specializing in the design and prototyping of LED lighting fixtures. From 2011 the professional activity has been accompanied by educational, teaching and research activities on Solid State Lighting at the Laboratorio Luce of the Politecnico di Milano. He is currently a professor of LED technology at Master in Lighting Design of Politecnico di Milano.

QUALITY OF LIGHT - THE NEW APPROACH TO RELIABILITY OF SOLID STATE LIGHTING

When a new technology breaks into a consolidated market, as was the case for the LEDs in the lighting industry, there are many factors to take into consideration for the success of its adoption. In times like these that are strongly linked to issues such as energy saving, the two key success factors that have guided the development of Solid State Lighting in its early stages are definitely high efficiency and long lifetimes.

To ensure the benefits promised from these new sources and to make obvious the advantages of using them instead of traditional sources it was necessary to work hard on reliability (the probability that a system will perform its intended function under stated conditions for a specified period of time without failures). This means that in the first stage of Solid State Lighting adoption, reliability was mainly focused on parameters such as lumen per watt, lumen maintenance and lumen depreciation and the design of lighting fixtures (from an optical, thermal and electrical point of view) was mainly driven by factors related to the increase of efficacy and efficiency.

After the first stage of SSL adoption, over the years LEDs have started to be used in application environments that require a qualitative approach rather than a quantitative one (consider the example of retail lighting or residential lighting).

In these applications high efficiency and long lifetimes are still important factors but the focus of lighting designers shifts to parameters related to the quality of the light; color rendering, color constancy and color stability become the critical success factors for the adoption of Solid State Lighting. These new applications have highlighted the fact that LEDs are devices with inherent variability when we consider aspects linked to the quality of the light emitted, and that it is much more difficult for luminaire manufacturers to ensure the claimed performance of their products in terms of color stability or color consistency than in terms of efficiency and lumen maintenance. At this time it is still quite difficult to predict or specify and guarantee color specifications for luminaire products but the market is demanding these key parameters ever more insistently.

This means that in this new phase of Solid State Lighting adoption, focused on the quality of the light, we need to change the way of conceiving the concept of LED luminaire reliability. In the future it will be necessary to develop standards and specifications that take into account these qualitative aspects of light.

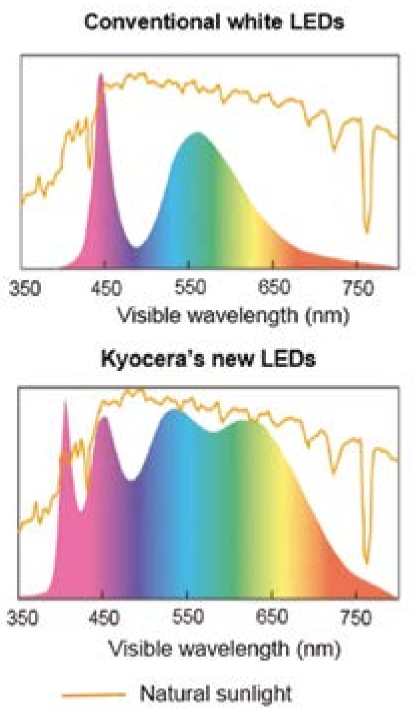
Luminaire manufacturers will have to focus their design efforts and carefully check and select LED sources, materials and secondary optics to ensure that the market demands, in term of quality, will be fully met and that the stated specifications will be completely reached and maintained.

Color consistency and color stability over time will be the key success factors in the future on which luminaire manufacturers will focus their attention to meet the market demands and to give more confidence to the lighting designer. ■

D.P.

Kyocera Develops Compact LEDs with Excellent Daylight Spectrum Rendering

Kyocera Corp. announced that it has developed a new type of LED that produces a color spectrum very close to natural sunlight — making it ideal for color-inspection applications. The new products offer low power consumption and extremely long life in an array of lighting options, including fluorescent tubes, standing lights and compact handheld lamps — making them a perfect alternative to large, heat-producing xenon lamps.



Kyocera's new LEDs render a wider and more intense spectrum of light than conventional LEDs, approximating natural sunlight

Kyocera's LEDs render a wider and more evenly distributed spectrum of light than conventional LEDs or fluorescent lighting. In this way, they make a color rendering possible that approximates natural sunlight. These characteristics are highly desirable in any environment — and essential in applications requiring accurate color reproduction, such as paint manufacturing, commercial printing and automotive color inspection.

Kyocera's unique material technologies are applied throughout the new LED modules to facilitate outstanding performance. The new LEDs are rated for 100,000 hours of service, equal to more than 11 years of continuous operation, with extremely low power consumption. Additionally, the proprietary material technology has yielded a ceramic package with higher reflectivity than conventional materials, resulting in brighter light output.

Kyocera is marketing the new LED products in multiple lighting options for diverse applications, including a handheld portable device for inspecting large objects, like automobiles; standing lights for inspection workstations; and fluorescent tubes for illuminating entire rooms or enclosed areas. Kyocera can supply LED modules individually or in finished products of the aforementioned configurations. The LEDs can also be supplied in battery-powered versions for enhanced portability.

The new products expand Kyocera's line of high-quality, long-life and environment-friendly LED lighting solutions. Kyocera's LEDs are designed for environments that demand the ultimate accuracy in color reproduction, and/or general aesthetics — ranging from fine-art museums and fashion retailing to hospital operating rooms and high-tech manufacturing. ■

Lextar Introduced 4-75 W CoB Lineup

Lextar Electronics, a vertically-integrated LED company from Taiwan, introduced its CoB (Chip-on-Board) "Nimbus" series that feature high CRI (90), LM-80 quality and Hot Color Targeting. The Company also released Flip Chip CoB "Nimbus-P" series. Lextar has deployed the widest CoB product line in the industry and has shown this new CoB collection at 2014 Guangzhou International Lighting Exhibition for the first time.

Lextar Electronics Polaris "Nimbus-P" series flip chip CoB

Lextar's CoB "Nimbus" series, ranging from 4 watt to 75 watt, can be widely applied to various lighting applications including bulbs, spot lights, downlights, and bay lights. It delivers condensed light output without multi shadow, giving high quality light and making a good choice for commercial and professional lighting. Lextar's Nimbus offers three services, including high CRI, LM-80 high quality and Hot Color Targeting, to enhance added-value to its customers.

Lextar also debuted its latest Flip Chip CoB: Polaris (Nimbus-P) series, a new extension of Lextar's flip chip package for lighting applications. The Nimbus-P series not only bears better over-drive capability but also intensifies product stability by using ceramic substrate. To add to that, minimizes LES (light emitting area) and therefore features high lumen density. The LES can be reduced by 50% compared to that of conventional CoB; hence this product is especially suitable for professional lighting where high brightness and concentrated lighting angle are necessary, such as PAR lamps and track lights.

"The launch of Nimbus-P has demonstrated Lextar's technology through its vertically integrated operation; it also delivers the excellence of Lextar's CoB line," noted Francis Wong, Director of Lighting Business Unit of Lextar. The company also provides customers a selection of CoB including professional use, high quality and cost-effective models, as well as peripheral solutions that contain lenses, reflectors and holders supplied by global brands. Apart from the Nimbus CoB series, Lextar will also debut various new products and technologies including high-voltage LEDs, AC-in DOB (Driver on Board), CSP (Chip Scale Package) module and so forth. ■

SSC's New Acrich Is Optimized for Outdoor Area Lighting

Seoul Semiconductor, a global leader in LED technology, has announced the release of a new generation of Acrich MJT 5050 LEDs, with high lumen output, reliability, and cost performance optimized for the outdoor lighting market.

QFN LED FEATURES

- EMC lead frame
- Small size
- Typical Rth:10℃/W.
- High power
- Max Ta:105℃

QFN-2835 series 1W

QFN-3020 series 0.5W

QFN-4014 series 0.8W

QFN-3030 series 1W、2W

REFOND

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Microbiog

Seoul Semiconductor's latest Acrich series member offers optimized technology for street and area lighting applications that require high light output, reliability, and resonable costs

This new Acrich series has dimensions of 5.0mm × 5.0mm, delivering a typical luminous flux of 180 lumens at 20mA, 64V, 25°C, 5000K and can be driven to a maximum current of 60mA delivering up to 440lm.

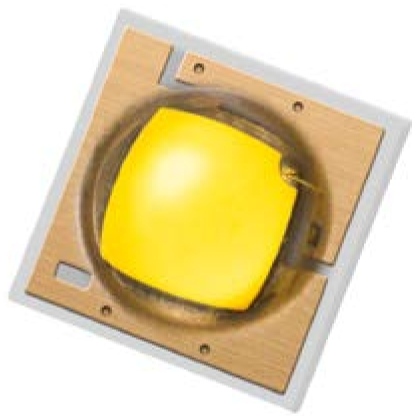
The new Acrich series delivers an unprecedented combination of high lumen output, efficacy, outstanding reliability and lm/$ all in one package. This high performance package results in designs where fewer LEDs are used, which leads to smaller and lighter fixtures enabling cost savings on a system level. This Acrich series delivers high performance without sacrificing on reliability or cost. It is an ideal LED for the outdoor lighting market where high efficacy and lifetime are critical.

Utilizing Seoul Semiconductor's proven and reliable high voltage architecture, Acrich MJT "Multi-Junction chip Technology", the Acrich LED eliminates the tradeoff between size and efficacy. Designers can take advantage of the high efficiency of high-voltage DC drivers or eliminate the driver by driving the LEDs directly on AC using the Acrich IC.

SSC Executive Vice President of Lighting sales division, Jay Kim has stated that, "In addition to high efficacy and reliability the TCO (Total Cost of Ownership) is an important metric for the street and area lighting market. This product will enable the market to come up with the next generation of high quality, efficient and competitively priced LED retrofit lamps." He added, "The payback period especially for streetlights can be significantly reduced with new Acrich LED without compromising on reliability or efficiency. In the future, Seoul Semiconductor will introduce more products to penetrate the outdoor area lighting market."

Samsung Presents New CoB LEDs and LED Modules with Improved CRI

Samsung Electronics Co., Ltd. announced that it has improved the light quality of its LED packages and modules based on a 90 CRI (Color Rendering Index) for use in advanced lighting applications. Samsung was showcasing these LED components at the LIGHTFAIR International trade show.



Samsung improved CRI for most of its high and mid power LEDs as well as for their modules; here the LH351A

"With our improved color rendering, Samsung's LED packages and modules now provide LED lighting makers with light quality that far surpasses that of conventional lighting applications, while adding to the energy efficiency of our LED lighting line-up," said Bangwon Oh, senior vice president of strategic marketing team, LED Business, Samsung Electronics. "With more than 90 CRI, the enhanced color reproducibility of our best product platforms will make them even more attractive to lighting designers worldwide."

Samsung's LED product platforms include mid-power, high-power and chip-on-board (COB) packages as well as LED modules. With the improved CRI, Samsung LM561B and other mid-power LED packages can be used in a wider range of retrofit LED bulbs and downlights by reproducing colors comparable to those seen under natural sunlight. In addition, the improved high power LED LH351 series is suitable for MR, PAR and other spotlights that require high color rendering, along with high light output.

Samsung's LED modules enhanced with 90 CRI include the LT-A302 module comprised of mid-power LED packages, and the SLE series, which uses COB-type packages. The LT-A302 is a linear, lens-attached module (LAM) with a thin, 21 millimeter-wide form factor. The SLE series modules are suitable for spotlights and track lighting that prioritize high light output.

Philips Lumileds CoB Arrays Hit 10,000 lm at 100 lpW

Philips Lumileds is now delivering the highest flux and most efficient LED arrays in higher lumen packages. The new LUXEON CoB 1211 is perfect for industrial and outdoor applications and is an ideal replacement for 70W and 100W equivalent ceramic discharge metal halide (CDM) lamps. As the latest addition to Philips Lumileds LUXEON CoB arrays portfolio, the LUXEON CoB 1211 delivers efficacy of 100-130 lm/W, depending on color temperature and CRI of the luminaire.

Philips Lumileds' new CoB LED is especially designed to replace 70 W & 100 W equivalent ceramic discharge metal halide (CDM) lamps

The LUXEON CoB 1211 achieves cool white output exceeding 10,000 lm and 100 lm/W at 70CRI, while achieving a light emitting surface (LES) of only 19 mm.

"The LUXEON CoB 1211 has the best combination of a small Light Emitting Surface and high efficacy at its specific lumen package," said Eric Senders, Product Line Director at Philips Lumileds.

LUXEON CoB products enable low cost luminaire design that results in the highest flux LEDs with low thermal resistance substrates. They reduce heat sink needs and with an existing ecosystem of compatible holders, drivers and optics, LUXEON CoBs enable faster time to market.

New Duris S 5 LEDs Offer 90+ CRI

Osram Opto Semiconductors adds two further models with excellent color rendering to the Duris S 5 family. The new LEDs are ideal for the home, installed in downlights or LED retrofit lamps, for example.

With a CRI of more than 90, Osram Opto's two versions of Duris S 5 offer natural color rendering

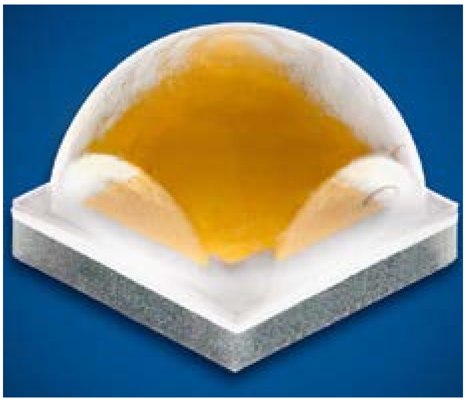
"The Duris portfolio has been expanded with the addition of two new LEDs with an impressive CRI of more than 90. This product family now offers customers even greater flexibility in terms of performance, areas of application and technology than ever before", said Janick Ihringer, Product Manager for General Illumination at Osram Opto Semiconductors. The previous Duris S 5 versions already had a high color rendering index of more than 80, but the additions are even better in this respect. The new LEDs are ideal particularly for applications where the colors have to appear as natural as possible. Their main use will therefore be in the home. The light from the new Duris S 5 models make the colors of wooden dining tables and flooring for example look rich and natural. Natural color rendering also plays an important role in shop lighting, whether for clothing or food.

The new Duris S 5 also offers impressive output. The two-chip version has a high luminous flux value of 83 lm at 150 mA (typically at 3000 K). Its typical forward voltage is 6.35 V.

Duris product family with LEDs for all output ranges:
The new Osram light emitting diodes are part of the renowned Duris product family. The E, P and S series contain LED versions in different qualities of light and for all output ranges (high-power, mid-power, and low-power) which are suitable for numerous lighting applications. A robust plastic package, a compact design and a particularly homogeneous distribution of light are other properties common to all members of the family. All the products in the Duris S range also have an impressive price performance ratio, coupled with enormous versatility and efficiency. ■

Cree's Next Generation XP LED Delivers 200 lpW

Cree, Inc. introduces the XLamp® XP-L LED, the first commercially available single-die LED to achieve breakthrough efficacy of up to 200 lumens per watt (LPW) at 350 mA. Delivering up to 1226 lumens in a 3.45 mm x 3.45 mm package, the game-changing Cree® XLamp XP-L LED enables an immediate performance increase of 50 percent or more as a drop-in upgrade for lighting designs based on Cree's market-leading XLamp XP-G LEDs.



Cree's new XLamp® XP-L in a 3.45 x 3.45 mm package can deliver up to 1226 lm. Driven at 350 mA it achieves 200 lumens per watt

"We're excited about the new XLamp® XP-L LED because its next-level performance enables us to create the next generation of light output and efficacy for our directional lighting products," said Mike Joye, president, Auroralight. "Since XP-L uses the existing XP footprint, we can expand our product lineup quickly and without the burden of increased development time and cost that would be expected for such a significant performance enhancement."

As the brightest member of the industry's only family of high-density class discrete LEDs, the new XP-L LED also touts the industry's highest optical control factor (OCF), a measurement of the impact that LED size and performance have on directional lighting applications. With its high OCF, the XP-L will enable lighting manufacturers to improve the performance of existing lighting designs in the XP footprint, reduce the size and cost of new designs and create innovative new solutions to address applications ranging from lamps to stadium lighting.

"We evaluated many high power LEDs before deciding on Cree's new high-density discrete LEDs," said Jason Gerard, group GM, engineering, Gerard Lighting Group. "Cree's high-density LEDs enable us to develop a core design that was not possible with previous LEDs for our given design targets. We're excited that we can use the newest of Cree's innovations to make our products stand apart from everyone else's."

Characterized and binned at 1050 mA, 85°C, the XP-L LED is available in up to 90 CRI and color temperatures ranging from 2700 K to 8300 K. As a "successor" product to the XLamp XM-L2, lighting manufacturers seeking ENERGY STAR® qualification can use just 3,000 hours of LM-80 data, potentially saving up to four months in the approval process. ■

Osram Optos Extremely Low-Profile Synios E4014 LEDs

Compact mid-power LED from Osram Opto Semiconductors is ideal for injecting light into light guides. The low-profile rectangular shape of the new Synios E4014 from Osram Opto Semiconductors enables the light from this LED to be injected into light guides so that a wide range of design ideas can turned into reality. These mid-power light emitting diodes also have an impressively robust plastic package, a particularly uniform distribution of light and an excellent price performance ratio. The LEDs are intended primarily for visually enhancing "white goods" and for lighting systems in vehicles and displays.

Osram Opto's Synios E4014 offers an excellent price/performance ratio for light guide solutions of any kind

The extremely low height of the Synios of only 0.57 mm and its footprint of 4 mm x 1.4 mm provide the ideal basis for low-profile elongated luminaire and lighting designs – such as ones for backlighting displays. The LEDs are not equipped with a lens so they can easily be used for injecting light into light guides. The new E4014 opens up a whole range of design-oriented lighting solutions, such as integration in the glass shelving in refrigerators and other white goods, car interior lighting, and strip lighting on the floors of buses and trains.

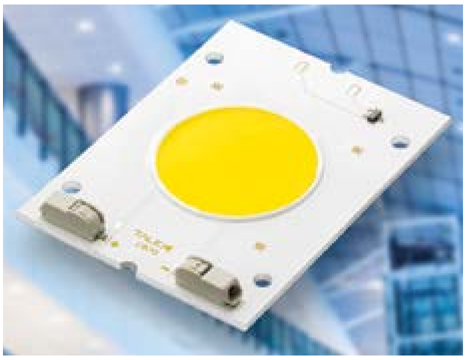
"Refrigerators and washing machines are not exactly renowned for their exciting designs. The new Synios is ideal for enhancing their looks and even meeting high requirements in terms of lighting design. For similar lighting tasks, but at a lower performance level, we already have the Topled E3014 in our portfolio", said Volker Mertens, Marketing LED at Osram Opto Semiconductors.

Where each of the two light emitting diodes is used depends on the requirements of the particular application. If brightness and color fidelity are needed then Synios at 41 lm and a color rendering index (CRI) of 80 is the right choice. If brightness is not as important then the Topled with 7.3 lm at 20 mA is ideal.

The color temperatures of Synios are between 4000 and 5000 K and can therefore be tailored perfectly to the particular application. The robust plastic package is one of the benefits of the new Synios in addition to the extremely uniform distribution of light, high efficiency, excellent flexibility and long life of around 50,000 hours. In view of the intended applications, the ESD stability is 5 kV.

TALEXXengine STARK FLE: High Lumen Value and High Efficiency

Tridonic has developed the TALEXXengine STARK FLE LED system specifically for illuminating high-ceiling rooms. It consists of an LED module and corresponding converter and, depending on the size of the light-emitting surface (LES), offers impressively bright light of up to 10,000 or 18,600 lm under real operating conditions (tp = 65°C), and a long life of up to 50,000 hours.



Tridonic's LED system for floodlighting comprises a TALEXXconverter and the TALEXXengine STARK FLE, offering up to 18,600 lumen at tp=65°C

Main Features:

- Luminous flux range from 4,500 – 21,100 lm
- High LED module efficiency up to 142 lm/W
- High system efficiency up to 115 lm/W at tp = 65 °C
- High color consistency (MacAdam 3)
- Excellent thermal management by CoB technology
- KTY 82/210 for temperature control
- Uniform radiation with Dam&Fill technology
- Fixing holes for M3 screws
- Built-in LED module
- Cooling required
- Flexible operating mode
- 5-year guarantee

TALEXXengine STARK FLE is an LED floodlight system consisting of LED modules with an LES of 30 or 40 mm and appropriate dimmable or non-dimmable converters. Modules with an LES of 30 mm achieve a typical brightness of up to 10,000 lm; modules with an LES of 40 mm up to 18,600 lm. Behind these high lumen values lies powerful chip-on-mirror technology, which is also responsible for the high module efficiency of up to 142 lm/W for the LED module. System efficiency is as high as 115 lm/W under real operating conditions. Depending on the operating mode – high efficiency, standard or high brightness – luminous flux values of 4,500 to 18,600 lm are possible. Quality of the light is high, with a color rendering index greater than 80 at color temperatures of 3000 and 4000 K, and greater than 70 for cold white light with a color temperature of 6500 K. Reproducible constant color rendering corresponds to MacAdam 3.

The 100 to 1% dimmable converters in the ECO series have an output of 100 W and are designed for LED operating currents of 900 to 1750 mA, or in the case of the industry version for operating currents of 350 to 900 mA. Integrated DALI, DSI and switchDIM interfaces and the corridorFUNCTION enable the light to be controlled via a digital control signal, standard switches or motion sensors. Converters without a dimming function are available with an output of 100 W or 240 W. The 100 W versions cover an operating voltage range of 900 to 1750 mA, and from 350 to 900 mA in the case of the industry version. The 240 W version covers an operating current range of 2250 to 4450 mA.

These properties make the LED system ideal for industrial building lighting, airports and shopping centers.

Samsung Introduces New LED Modules for Flat Lighting Applications

Samsung Electronics Co., introduced a new line-up of LED modules called the M-series for use in flat LED lighting applications, such as troffers and linear luminaires.

Samsung's M-series is especially designed for flat lighting applications

"The Samsung M-series offers tremendous convenience to LED lighting fixture makers with one of the most reliable and design-friendly feature-sets in the industry," said Bangwon Oh, senior vice president, strategic marketing team, LED Business, Samsung Electronics. "Through the new M-series and future Samsung LED solutions, we will increase our support for the LED marketplace by providing greater differentiated value and reducing the time to market for LED lighting makers, while accelerating market innovations for LED lighting components.

Ledlink Optics,Inc.

LedLink
Linking LEDs to The Real World

New Products

Solder free connectors
Citizen CLL020/ 030
Cree CXA 15xx/ 18xx/ 25xx
Sharp Mega Zenigata

Easy to use connectors
Cree CXA 13xx/ 15xx/ 18xx/ 25xx/ 30xx
Luminus CXM-xx

LL01CR-BGCxxR49-BKG15L02
DxH(mm) 75 x 45
FWHM 15° 24° 38°
For Cree 1816/ 1830
★ No glare, good color mixing

LL01CR-BIYxxR49-BIZ120L02
DxH(mm) 100 x 57
FWHM 13° 24°
For Cree 1816/ 1830
★ No glare, good color mixing

LL01CR-BDJ80R49
DxH(mm) 90x40
FWHM 80°
For Cree CXA1816/ 1820

LL01CR-BLU03L06
DxH(mm) 35x20.8
FWHM 3°
For Cree XPE2
★ Very small angle

LL01CT-BUBxxL02
DxH(mm) 74.1x5.92
FWHM 24° 38°
For Citizen CLL020

LL01CT-BUCxxL02
DxH(mm) 84.6x4.5
FWHM 24° 38°
For Citizen CLL030
★ Fresnel Lens for PAR30/38

LL01CT-AZWxxL02-P
DxH(mm) 76.1x12.7
FWHM 24° 38°
Cree CXA 15xx
Citizen CLL020
Sharp Mini Zenigata

LL01CT-AZNxxL02-P
DxH(mm) 88.5x15
FWHM 24° 38°
Cree CXA 25xx
Citizen CLL030
Sharp Mini /Mega Zenigata
★ Halogen-like appearance

Our Services

- R & D
- Precision Mould
- Manufacture
- Component solution
- Customerization

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

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

Underscoring their reliability, the M-series modules feature Samsung's LM561B LED package, which has successfully completed 6,000 hours of LM-80 testing.

The M-series includes three modules, the LT-M552A, M552B and M552C that have the same dimensions – 18x550x6 mm. By offering identical measurements and delivering a variety of light output options, the three modules simplify the task of designing LED luminaires.

In addition, the 18 mm width of M-series readily replaces T5 light fixtures, which usually have a diameter of around 0.6 inches or 1 6 mm. It results in more design flexibility when replacing conventional fluorescent tubes or LEDs in the same luminaire.

The Samsung M-series covers a lumen range from 1500 lm to 2500 lm based on a light efficacy level of up to 152 lm/W. By combining up to four M-series modules, a total light output of 2000 lm to 7000 lm can be achieved for luminaires. For example, if a luminaire requires 3500 lm, combining two LT-M552B will provide approximately 4120 lm, when assuming an optical efficiency level of 85 percent. ■

Aladdin MCoB LED Light Source on Ceramic Substrate

Aladdin introduces updated and improved MCoB LED light source on ceramic substrate that offer higher efficiency than their predecessors, world class thermal properties and voltage insulation if required.

Aladdin MCoB LED light source on ceramic substrate linecard overview

The improved "MCoB of LED light source on ceramic substrate" series product offers a light efficacy of 115 lm/W at 3000 K CCT (Correlated Color Temperature) and 125 lm/W at 5000 K with a CRI (Color Rendering Index) over 80. This represents a significant improvement from 100 lm/W at 3000 K and 110 lm/W at 5000 K respectively, the light efficacy levels. Using its leading-edge phosphor technology and chip fabrication techniques, ALADDIN developed the MCoB of LED light source on ceramic substrate series enhancement to provide greater differentiated value to its customers.

Aladdin MCoB of LED light source on ceramic substrate makes the packages highly convenient in assembling most LED lighting products. By enabling exceptional design efficiency for LED lighting, MCoB of LED light source on ceramic substrate series is expected to be applied in a wide range of interior LED lighting applications including downlights, spotlights and directional retrofits such as MR/PAR lamps. ■

Forge Europa Offers Expert-Customized LED Optics

Set yourself apart from the competition with a unique LED optic as part of the development and volume manufacture of your complete LED lighting solution, with Forge Europa. Forge Europa can generate a target light distribution specification, provide optic simulation and deliver production quality optic prototypes to validate a design before committing to tooling.

With this new service to customizing LED optics, Forge Europa helps to achieve optimal lighting performance

The custom LED optic capability is available to our customers as part of our A-LED service: Forge Europa will design and engineer the optic together with your LED Lighting Solution or LED PCB Assembly and volume manufacture the complete solution for you.

Grant Huck, Business Development Manager explains: "Customizing your LED optic helps you to achieve optimal lighting performance meeting your specifications and creating a unique selling point for you to market. With over 21 years' experience in customized LED lighting solutions, we have simply made the process easy and affordable to help our customers access and benefit from the advantages that optics can deliver".

David Scott-Maxwell, Technical Director adds: "Forge Europa is uniquely knowledgeable of the 'LED landscape' i.e. what LED is best in terms of value and efficiency, in respect to each application, and additionally we have full-range design skills from optic simulation, modelling, mechanical engineering, electronics engineering all in-house. This ensures optimally designed optics are expertly integrated into the complete solution."

"I think that this is just another great example of the work Forge Europa can do." Mark Pinkney, Regional Sales Manager UK and Ireland, Cree. ■

MechaTronix Offers Cooling for New Xicato XIM and XTM LED Modules

When Xicato recently introduced their new XIM Xicato Intelligent Module and XTM Xicato Thin Module, MechaTronix as preferred LED-cooling partner immediately faced the challenge of developing a full new range of LED coolers for these LED platforms.

MechaTronix's latest range of LED coolers especially support the adoption of Xicato's XIM and XTM modules

In these new developments, not only the mechanical changes were covered now the power and communication cable from the Xicato LED modules comes as a side feed, but MechaTronix also kept the latest design tendencies in mind. "Lighting designers want to go smaller and more elegant," according

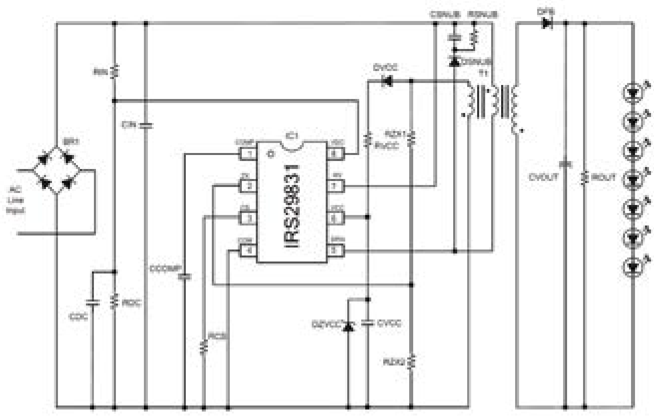
Koen Vangorp, General Manager at MechaTronix, “and the passive LED coolers were still a kind of an obstruction to achieve this. Therefore we have been spending thousands of hours on investigating how to get more cooling out of smaller diameters. As a result, today we get about 20% to 30% more efficiency out of our latest generation LED coolers, which immediately translates itself as smaller LED coolers for the same lumen outputs.”

MechaTronix launches 8 new star shaped models for the Xicato XIM and XTM, all with the sibling looks of their famous ModuLED LED coolers which already garnered a lot of attention and positive reviews in the LED market. The new star LED coolers start at a diameter of 47 mm, suitable for luminaire designs up to 1,750 lumen, while the new diameter 70 mm LED star cooler does the job up to 2,500 lumen.

A new revolution is for sure the new Xicato pin fin cooler diameter 47 mm. MechaTronix was able to reach a thermal resistance as low as 3.9°C/W in this design which has never been witnessed before in this small diameter. With this revolution in efficiency, a lighting designer can develop a 2,000 lumen design tomorrow in a diameter as small as an MR16 lamp. ■

IR Introduces Highly Integrated LED Drivers Control IC

International Rectifier, IR®, a world leader in power management technology, introduced the highly integrated IRS29831 LEDrivIR™ control IC optimized for single stage Flyback and Buck-Boost topologies used in LED drivers including LED bulb replacement, LED tube lighting and down lights.



Typical non-dimming application schematic using the IRS29831

Features:

- Flyback LED Driver
- Integrated 700 V MOSFET
- Critical-conduction / Transition mode operation
- Primary constant power control
- Burst mode operation at light load
- Over-current protection
- Micro power startup (150 µA)
- Low quiescent current (2.5 mA)
- Latch immunity and ESD protection
- Open load / Over voltage protection
- Compatible with Triac Dimmers

The IRS29831 provides an extremely competitive and efficient solution for both isolated and non-isolated Flyback LED drivers. The device offers single stage primary side regulation with a high power factor and low Total Harmonic Distortion (THD) along with open and short circuit protection.

Employing accurate primary side power regulation, the IRS29831 integrates an LED driver control IC and power MOSFET utilizing 700V technology, and features high-voltage start up to offer a simple cost-effective single stage solution while maintaining a high power factor and low Total Harmonic Distortion (THD) for improved efficiency.

“The IRS29831 provides an extremely competitive and efficient solution for both isolated and non-isolated Flyback LED drivers. The device offers single stage primary side regulation with a high power factor and low Total Harmonic Distortion (THD) along with open and short circuit protection,” said Peter Green, LED Group Manager, IR’s Energy Saving Products Business Unit.

IRS29831-based LED driver circuits also offer smooth, flicker-free dimming with triac based dimmers. The device can also operate over a wide input voltage range. Protection features include hiccup mode open-load/over-voltage protection, cycle-by-cycle primary over-current limiting, and output short circuit protection.

The IRS29831 also features critical-conduction mode operation with discontinuous and burst modes at light load as well as the ability to allow users to configure isolated designs without an opto-coupler. Available in an 8-pin DIP package, the IRS29831 has a fast startup, low quiescent current, ESD protection and noise immunity. ■

Molex Releases Plastic Substrate Interconnect for LED CoB Array Holders

Molex Incorporated continues to be a leader in the Solid State Lighting (SSL) interconnect field with the addition of its Plastic Substrate Interconnect (PSI) for LED Chip-on-Board (COB) Arrays. These customizable interconnects feature a low-profile harness interface that delivers power to the array through a simple and reliable connection to a holder, or plastic substrate. With a low overall package height of ~2.00mm, Molex PSI provides a slim design for space-limited applications while minimizing substrate costs. By employing the Pico-EZmate™ harness system, the solution integrates the electrical and mechanical features with the array for a simple, solderless connection.

Plastic Substrate Interconnect for LED Chip-on-Board (COB) Arrays

“Space constraints have driven lighting manufacturers to focus on providing greater light output in smaller packages,” said Dave Rios, new product development manager, Molex. “The Molex PSI solution is unique in that it not only offers a low profile that allows optics to be placed more closely to the LED, it also easily and reliably connects power to the array.”

The PSI system is ideal for high-density and high-light output applications such as downlighting (track, pendants and linear) and area lighting (roadways, parking lots and wall packs). LED Chip-on-Board technology ensures strong future development capabilities by allowing integration of additional components.

The system supports a variety of potential PSI designs including:

- Circular: 22.50 by 22.50mm CoB size; 36.00mm outer diameter and 2.0mm height profile
- Rectangular: 22.50 by 22.50 mm CoB size; 36.50 by 28.50 mm outer dimension and 2.00 mm height profile
- Customizable shapes, sizes, mounting hole patterns and interconnects

The solderless Pico-EZmate harness attaches to the LED array holder with no special processes or tools for an efficient connection that minimizes contact with the array to reduce the risk of damage. The vertical snap-to-mate connection, positive-lock latching feature and gold plated contacts deliver superior reliability. The harnesses will be offered in three wire gauge configurations and various lengths for a range of initial harness options based on application needs. ■

New Hazardous Location-Rated LED Drivers from TRP

Thomas Research Products, a leading manufacturer of SSL power solutions, has introduced two new LED Drivers designed for use in hazardous location fixtures.

Thomas Research Products’ new 40 W & 25 W LED drivers are designed to be installed in hazardous locations

The new LED-HL series 25W and 40W drivers are based on TRP’s popular standard LED series models. These units add V5A cases and internal thermal protection, enabling them to receive Type HL rating from UL. The new drivers are also IP66, rated for dry and damp locations.

LED-HL models are available in constant-current, dimming, and constant-voltage versions. They also offer the option of leads that exit through the bottom or the side.

TRP’s new drivers provide all the same features as their standard LED drivers, including 100-277V universal input voltage, Black Magic Thermal Advantage™ plastic enclosures, and over-voltage, over-current and short circuit protection with automatic recovery. LED-HL series drivers carry the company’s standard 5 year warranty.

All LED Drivers from TRP offer high quality, long life, high efficiency and are cost-competitive. Information can be found on the company’s website. Both the LED25W-HL and LED40W-HL are available now. ■

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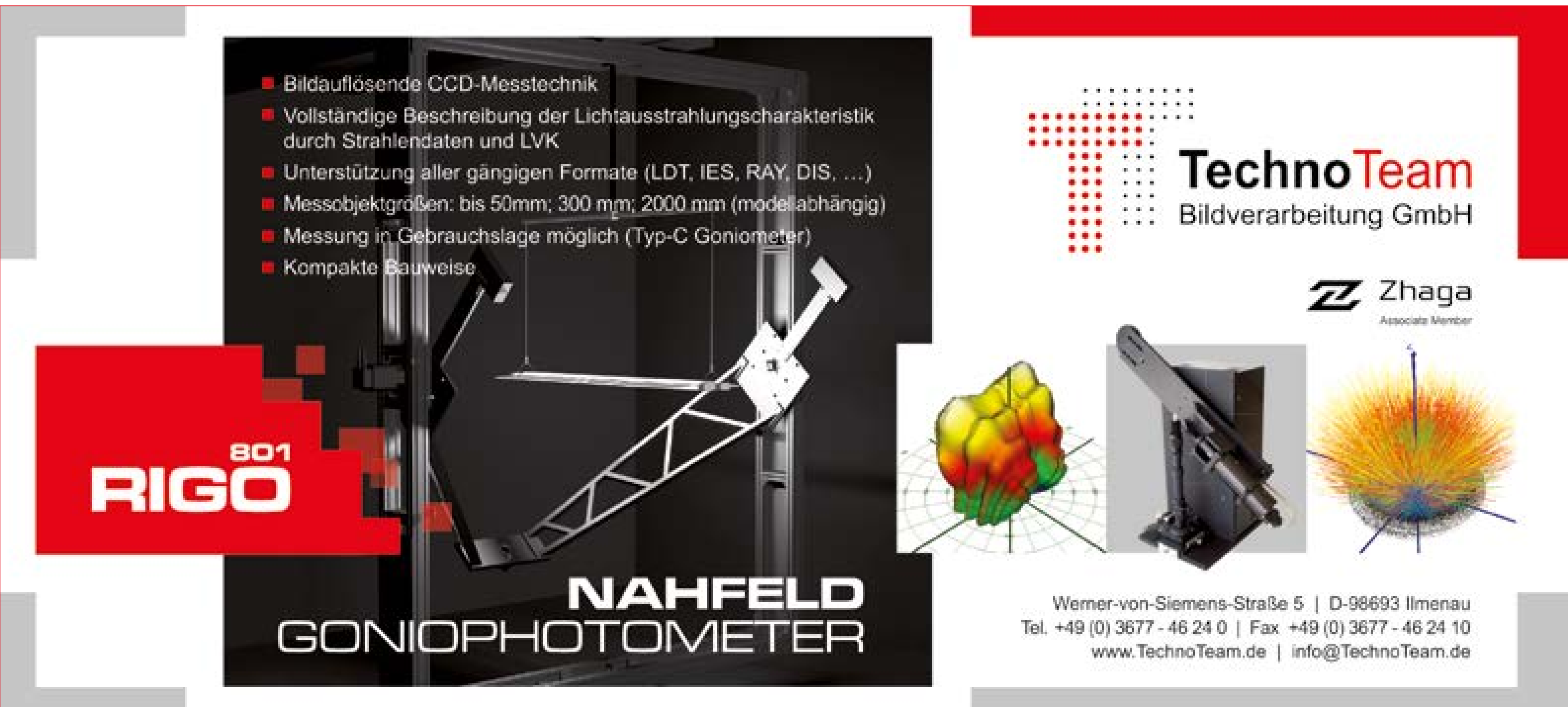

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Lutron Smart, Connected Home and Lighting System

Creating a smarter and more connected home has never been easier. Lutron Electronics, the leading manufacturer of energy-saving, wireless lighting and motorized shades, announced the introduction of the Lutron Smart Bridge and the Lutron app — its smart, connected home mobile solution for the do-it-yourself or do-it-for-me consumer.

The main components of Lutron's smart, connected home and lighting system

The Lutron Smart Bridge and app is not just giving the consumer the ability to control their lights and shades, but rather, a reliable, energy saving, long-term investment that also provides peace of mind.

This unique product is a wireless bridge and software application that connects Lutron's Caséta® Wireless dimmers, Pico® remote controls, Serena™ remote-controlled shades, and other third-party devices, while providing convenient home control from any iOS or Android-based smart phone or tablet. The Caséta Wireless system gives consumers the ability to control lights and shades inside or outside the home — either from a remote control or the Lutron app.

"This new solution gives consumers the opportunity to transform their homes quickly, easily and affordably into a smart and connected one," said Matt Swatsky, Caséta Wireless product manager at Lutron. "With the Lutron Smart Bridge and app, we are not just giving them the ability to control their lights and shades, but rather, a reliable, energy saving, long-term investment that also provides peace of mind."

How it Works

The Lutron Smart Bridge, which uses Lutron's proprietary ClearConnect® Wireless technology, plugs easily and directly into a home's Wi-Fi router. Installed and set up in less than 30 minutes, the product sends wireless, radio frequency (RF) communication signals to compatible Lutron devices inside the home.

Lutron Smart Bridge-Compatible Products:

- Caséta Wireless in-wall dimmers control overhead lights and work with the newest energy-saving bulbs, including dimmable LEDs, dimmable CFLs, halogens, and incandescents. They do not require a neutral wire, so they easily replace any existing light switch.
- Caséta Wireless lamp dimmers plug into a standard wall receptacle and provide control of table and floor lamps that use the newest energy-saving bulbs, including dimmable LEDs, dimmable CFLs, halogens, and incandescents. They are designed to control two lamps simultaneously with dual plug-in receptacles.
- The Lutron app has a simple user interface to provide consumers with a one-touch solution. They can adjust and check-in on their lights, shades, and temperature from the office, the beach, or anywhere in the world. They can also set up preset scenes for the perfect lighting for their home theatre, dining room, or bedroom.
- With an integrated time clock, the Smart Bridge allows consumers to schedule lights and shades to adjust automatically by time of day. They can close their shades 20 minutes before sunset every day, or turn the front porch light on at dusk and off at midnight every evening.
- The telligent™ LED bulb by GE® is embedded with Lutron's ClearConnect Wireless technology and controlled by a Pico wireless remote. The bulb will be available late 2014.

Do-it-yourselfers can purchase the Smart Bridge (US $150 suggested list price) starting September 1 on SerenaShades. For homeowners seeking professional installation, the Lutron Smart Bridge Pro will be available from local electricians, residential system providers, security professionals and lighting showrooms starting June 30. The Lutron Caséta Wireless package, featuring a Pico remote control with a dimmer (either wall or lamp), has a suggested list price of US $80 and is available now. ■

Mentor Graphics Launches MicReD Industrial Power Tester 1500A

Mentor Graphics Corporation announced the new MicReD® Industrial Power Tester 1500A for power cycling and thermal testing of electronics components to simulate and measure lifetime performance. The MicReD Industrial Power Tester 1500A tests the reliability of power electronic components that are increasingly used in industries. It is the only commercially available thermal testing product that combines both power cycling and thermal transient measurements with structure function analysis while providing data for real-time failure-cause diagnostics.

Mentor Graphics' MicReD Power Tester 1500A is based on the established T3Ster® advanced thermal tester

Key Advantages and Key Benefits:

- Continuous power cycling until failure which saves time because the component doesn't need to be removed, taken for lab testing then back to tester for more cycles.
- Enables multiple samples to be tested concurrently.
- Different powering strategies (constant power on/off time, constant case temperature swing, and constant junction temperature rise) can be applied during operation.
- Provides "real-time" structure function diagnostics to show failure in progress, number of cycles, and failure cause.
- Eliminates the need for lab post-mortem (x-ray, ultrasonic, visual) or destructive failure analysis.
- Features touch-screen setup and controls enabling use by both specialists and production personnel.

Power components are used for applications in which electrical energy is generated, converted, or controlled and where very high reliability is required during many years of constant operation. This new product is built for industrial electronic manufacturers to test reliability by examining the thermally induced degradations within the module stack-up. Both power cycling and thermal transient measurements are conducted on the MicReD Power Tester 1500A, without needing to remove the components from the test environment. A technician or engineer is able to see the failure as it progresses and determine the exact time/cycle and cause.

Reliability is a prime concern in many industries that use high-power electronics, so accelerated testing of these modules through a lifetime of cycles is a must for the component supplier, the system supplier, and the OEM. The MicReD Power Tester 1500A can power modules through tens of thousands—potentially millions—of cycles while providing "real-time" failure-in-progress data for diagnostics. This significantly reduces test and lab diagnosis time and eliminates the need for post-mortem or destructive failure analysis. Common thermally-induced mechanical failures that the Power Tester 1500A analyzes in "real time" include die-attach wire bond separations, die and package stack-up delamination and cracks, and solder fatigue.

"The ability to pinpoint and quantify degradation in the thermal stack for all semiconductor devices during development will greatly assist in the development of cost-optimized packaging solutions currently hampered by package-reliability concerns," said Mark Johnson, professor of advanced power conversion, faculty of engineering, University of Nottingham. "Mentor's Power Tester 1500A should be an invaluable tool for investigating thermal path degradation in all types of power modules."

The MicReD Power Tester 1500A is based on the Mentor Graphics® T3Ster® advanced thermal tester used in industries worldwide for accurate thermal characterization of semiconductor device packages and LEDs. The Power Tester 1500A is the first product in the MicReD Industrial line and it provides fully automated power cycling and testing (both thermal and electrical measurement) of power modules to provide comprehensive data for failure cause assessment. This enables organizations to make product improvements for reliability and extended performance. The MicReD industrial products incorporate the laboratory-level accuracy of the T3Ster product in robust machines for operators to use inside manufacturing facilities.

The MicReD Industrial Power Tester 1500A can perform power cycling tests of metal-oxide semiconductor field-effect transistors (MOSFETs), insulated-gate bipolar transistors (IGBTs) and power diodes. The MicReD Power Tester 1500A provides a user-friendly touch-screen interface and can record a broad range of information during test, such as current, voltage and die temperature sensing; and detailed structure function analysis to record changes in the package's thermal structure. This makes it an ideal platform for package development and quality checking of incoming parts before production. ■

GE 100 W LED Replacement Lamp Achieves 100 lpW

GE Lighting engineered its 100-watt A-line replacement Energy Star® LED to achieve 100 lumens per watt (LPW), making it the lighting industry's most efficient Energy Star 100-watt LED replacement. This bulb is one of 40 new LED bulbs and fixtures hitting the market this summer as consumer LED lighting adoption reaches its tipping point.

GE Lighting engineered its 100-watt A-line replacement ENERGY STAR® LED to achieve 100 lumens per watt (LPW), making it the lighting industry's most efficient Energy Star 100-watt LED replacement

"We have a team of dedicated engineers across the globe constantly working to reach optimal efficiency and quality of light with GE LED lighting," says Linda Pastor, GE LED Lighting product manager. "Our 100-watt replacement LED provides the same soft white light, dimming capabilities and familiar A-line shape consumers love, but it gives them LED options with more brightness. Plus, at a rated life of more than 22 years, consumers can put this bulb in and forget about it."

At 1600 lumens and 16 watts, consumers looking for brighter LED bulbs for reading lamps or task lighting now have a realistic energy-efficient LED lighting solution, providing optimal energy savings for their monthly energy bill. Already very competitively priced, consumers will have utility rebate offers in select markets, making this bulb even more affordable; and better yet, it will pay for itself in the short term. Over the life of this bulb, or more than 22 years at three hours of use per day, consumers can expect to save more than $230.

GE Lighting debuted its first generation design of a 100-watt LED in 2012. This original design utilized a synthetic jet (an alternative to a fan), which helped manage the thermal load. As LED lighting design has dramatically evolved over the past few years, GE perfected the design to manage thermal loads using fins, closely emulating the shape and design of a traditional incandescent bulb.

To calculate a home's energy-saving potential by switching to LED lighting, GE Lighting has developed a new tool, an LED energy-saving calculator. This tool translates energy savings into relatable terms for consumers. ■

LED Luminaire with Minimalistic Design and Pleasant Light Quality

The brand new Peerless® Open LED luminaires from Acuity Brands, Inc. have been acknowledged as the sole recipient of the annual Most Innovative Product of the Year award from the LIGHTFAIR® International 2014 awards competition. The LFI Innovation Awards®, judged by an independent panel of esteemed lighting professionals, recognize the best innovations from more than 500 of the world's leading manufacturers across the lighting industry.

Peerless Open luminaires' reduced design use constructive occlusion to reflect and diffuse LED light instead of lenses for soft and pleasant lighting

"The Peerless Open luminaire represents a significant advancement in lighting," said Jimalee Beno, Acuity Brands Lighting Vice President and Peerless Value Stream Leader. "It clearly shows we are no longer limited by form factor when designing and engineering LED luminaires. We set out to engineer an LED luminaire that did not require a lens and would solve the challenge of eliminating dirt, dust and even dead bugs settling on the lens' surface. Our new Open luminaire shows that LED solutions have tremendous potential beyond reducing energy use and maintenance. Best of all, this luminaire is just one example of how Acuity Brands is driving LED lighting innovation."

Peerless Open luminaires use constructive occlusion to reflect and diffuse LED light across an inner arch and back down to produce soft, comfortable Illumination from a lens-free linear form. Open luminaires can be specified with an integrated sensor and control module for daylight dimming, occupancy detection, lumen management and system networking. The uplight and downlight portions of the luminaire can be controlled separately, expanding the ability to tailor the light output for a broad range of applications. The luminaires are available in suspended, recessed and surface forms. ■

ALTLED Uniqube Square Downlight

It's clean, neat, and square - the very unique ALTLED® Uniqube™ is an elegant series featuring square-shaped recessed downlight with apertures from 2-inch, 4-inch to 6-inch, perfect for replacing traditional MR16s, 4-inch round downlights and AR111 duos (or trios and quads), respectively. ALTLED® Uniqube™ is a luminaire-in-one downlight that provides interior designers a younger and more modern option. Customization available.

Besides a broad range of CCTs, ALT's new Uniqube™ downlight series offer outstanding features like highest efficiency and lumens

Main Applications:
- Boutique lighting
- Branded shops
- High-end jewelry stores
- Five or six star hotels
- Luxury homes

Features:
- High CRI option or brightest downlight option
- CCTranges from golden-toned 2200 K to bright true white at 10,000 K
- Stable quality Cree, LUXEON, Osram chips
- Brightest downlight 6000 lm 130 lm/w (chipset lumen), 4200 lm 91 lm/w (lamp lumen)
- Perfect AR111 duo, tri or even quad replacement
- High density aluminum increase heat dissipation which stabilizes product performance and product life
- Sleek design with high quality polished chrome finish
- Radial glow, creating a nebula-like effect
- Especially designed for boutique lighting and luxury home settings or yachts
- Global 3-year warranty

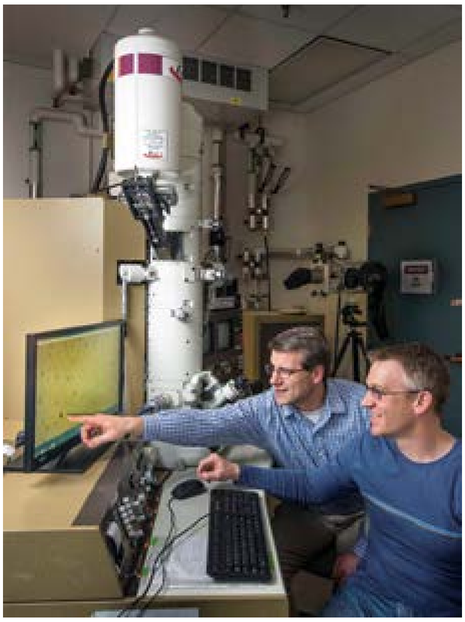
ALTLED® Orion Uniqube series is a unique series featuring 2 to 6 inch aperture square recessed downlights. The unconventional luminaire-in-one downlight features high quality construction and state-of-the-art, patent-protected heat dissipation design with pure aluminum fins built into the fixture to allow massive heat sink functions. This will provide long product life and guarantee reliable and quality lighting.

The Uniqube is especially designed for new or renovation projects on luxury venues requiring high brightness. Combining ALT's patented heat dissipation technique and power driver skills, and partnering with top chipset manufacturers will ensure the longevity and stability of the product.

The ALTLED® Uniqube quietly emits quality light with a sleek exterior design with an option of faint radial-glowing frame (color options available), creating a nebula-effect. The Uniqube is categorized under the Orion Series, which symbolizes brightness and reliability, a reflection of the notable constellation in the night sky by the same name.

Novel Nanoparticle Production Method Could Lead to Better LED Lights

Sandia National Laboratories has come up with an inexpensive way to synthesize titanium-dioxide nanoparticles and is seeking partners who can demonstrate the process at industrial scale for everything from solar cells to LEDs. Titanium-dioxide (TiO_2) nanoparticles show great promise as fillers to tune the refractive index of anti-reflective coatings on signs and optical encapsulants for LEDs, solar cells and other optical devices.



Sandia National Laboratories researchers Dale Huber, left, and Todd Monson, right, have come up with an inexpensive way to synthesize titanium-dioxide nanoparticles, which could be used in everything from solar cells to light-emitting diodes (Photo by Randy Montoya)

Optical encapsulants are coverings or coatings, usually made of silicone, that protect a device. Industry has largely shunned TiO_2 nanoparticles because they've been difficult and expensive to make, and current methods produce particles that are too large. Sandia became interested in TiO_2 for optical encapsulants because of its work on LED materials for solid-state lighting.

Current production methods for TiO_2 often require high-temperature processing or costly surfactants — molecules that bind to something to make it soluble in another material, like dish soap does with fat. Those methods produce less-than-ideal nanoparticles that are very expensive, can vary widely in size and show significant particle clumping, called agglomeration. Sandia's technique, on the other hand, uses readily available, low-cost materials and results in nanoparticles that are small, roughly uniform in size and don't clump.

"We wanted something that was low cost and scalable, and that made particles that were very small," said researcher Todd Monson, who along with principal investigator Dale Huber patented the process in mid-2011 as "High-yield synthesis of brookite TiO_2 nanoparticles."

Their method produces nanoparticles roughly 5 nm in diameter, approximately 100 times smaller than the wavelength of visible light, so there's little light scattering, Monson said: "That's the advantage of nanoparticles — not just nanoparticles, but small nanoparticles."

Scattering decreases the amount of light transmission. Less scattering also can help extract more light, in the case of an LED, or capture more light, in the case of a solar cell. TiO_2 can increase the refractive index of materials, such as silicone in lenses or optical encapsulants. Refractive index is the ability of material to bend light. Eyeglass lenses, for example, have a high refractive index. Practical nanoparticles must be able to handle different surfactants so they're soluble in a wide range of solvents. Different applications require different solvents for processing.

"If someone wants to use TiO_2 nanoparticles in a range of different polymers and applications, it's convenient to have your particles be suspension-stable in a wide range of solvents as well," Monson said. "Some biological applications may require stability in aqueous-based solvents, so it could be very useful to have surfactants available that can make the particles stable in water."

The researchers came up with their synthesis technique by pooling their backgrounds — Huber's expertise in nanoparticle synthesis and polymer chemistry and Monson's knowledge of materials physics.

"The original project goals were to investigate the basic science of nanoparticle dispersions, but when this synthesis was developed near the end of the project, the commercial applications were obvious," Huber said. The process has been refined subsequently to make particles easier to manufacture.

Existing synthesis methods for TiO2 particles were too costly and difficult to scale up production. In addition, chemical suppliers ship titanium-dioxide nanoparticles dried and without surfactants, so particles clump together and are impossible to break up. "Then you no longer have the properties you want," Monson said.

The researchers tried various types of alcohol as an inexpensive solvent to see if they could get a common titanium source, titanium isopropoxide, to react with water and alcohol. The biggest challenge was figuring out how to control the reaction, since adding water to titanium isopropoxide most often results in a fast reaction that produces large chunks of TiO_2, rather than nanoparticles. "So the trick was to control the reaction by controlling the addition of water to that reaction," he said.

Some textbooks dismissed the titanium isopropoxide-water-alcohol method as a way of making TiO_2 nanoparticles. Huber and Monson, however, persisted until they discovered how to add water very slowly by putting it into a dilute solution of alcohol. "As we tweaked the synthesis conditions, we were able to synthesize nanoparticles," Monson said.

The next step is to demonstrate synthesis at an industrial scale, which will require a commercial partner. Monson, who presented the work at Sandia's fall Science and Technology Showcase, said Sandia has received inquiries from companies interested in commercializing the technology.

"Here at Sandia we're not set up to produce the particles on a commercial scale," he said. "We want them to pick it up and run with it and start producing these on a wide enough scale to sell to the end user." Sandia would synthesize a small number of particles, then work with a partner company to form composites and evaluate them to see if they can be used as better encapsulants for LEDs, flexible high-index refraction composites for lenses or solar concentrators. "I think it can meet quite a few needs," Monson said.

Sandia National Laboratories is a multi-program laboratory operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corp., for the U.S. Department of Energy's National Nuclear Security Administration.

electronica 2014: Top-Class Program for 50th Anniversary

For the past 50 years, international exhibitors have been presenting the future of the electronics industry at electronica in Munich. From November 11 to 14, 2014, electronica will open its gates once again. Visitors can gather information from the product and service portfolios in the electronic industry: from components and systems to electronic applications and services. This year's international trade fair revolves around automotive, embedded systems, medical electronics and lighting, as well as the overarching themes of security and energy efficiency. The program of conferences and forums will explore these exhibition topics in greater depth.

International exhibitors and trade visitors

In 2012, almost half of the 73,051 visitors and 63 percent of the 2,669 exhibitors were from abroad. This year's electronica will again be providing the latest information about technologies, products, services and trends in the industry. A highlight of the show, the CEO roundtable, will be devoted to the topic: "Internet of Things: Possibilities, Challenges and the Question of Security". The focus of the trade show will be on automotive, embedded systems, medical electronics and lighting, as well as the cross-cutting issues of security and energy efficiency. This is reflected, among other things, in the electronica Forum, in panel discussions and lectures.

Comprehensive forums program

In the exhibition halls, several forums invite you to exchange ideas and dialog. The range of topics of the forums - automotive, embedded, electronica and Exhibitor Forum as well as the PCB & Components Market Place - is application-oriented and allows visitors to learn about current and future issues. These topics will be explored in greater depth within the conference program of electronica.

Inaugural Light Forum

The 'Light forum' organized by Luger Research e.U, publisher of LED professional, will be held on 13th November for the first time. The forum, based on the theme of the 'International Year of Light – 2015', will highlight key strategies and technologies for future lighting and focus on current and future trends in LED and OLED lighting. Keynote speeches and two panel discussions will bring together experts from industry, universities and organizations for insights and interesting discussions on lighting and connectivity.

electronica automotive conference

The electronica automotive conference, supported by ZVEI, will be held on November 10 at the ICM – Internationales Congress Center München. The conference will investigate the major technology trends and strategies of the international automotive industry. Speakers are representatives of the following companies: Audi, BMW, Daimler, Freescale, Infineon, Intel, Osram, Renesas and Visteon, among others. This year, the focus is on lighting, sensor fusion and connectivity.

embedded platforms conference

For the second time, the embedded platforms conference will be looking at new technologies, concrete solution approaches and services for the development of embedded systems. The conference will take place on November 12 and 13, in parallel with electronica, at the Press Center East of the Messe München.

Wireless Congress

At the Wireless Congress 'Systems & Application', organized by "Elektronik" magazine, ZVEI and electronica at the ICM - Internationales Congress Center Munich on November 12 and 13, industry experts will discuss the technical aspects of present and future wireless technologies, primarily for industrial use.

WEBINARS

LED Luminaire Design: Optimization and Analysis

Beginning with an LED model built in SolidWorks, you will learn how to import the model using the TracePro Bridge for SolidWorks, set up the model in TracePro including the LED sources and an optimized reflector design, and see how the optimizer can be used to select the best diffuser from a catalog of properties to meet illumination and uniformity goals. You will also get a first-hand look at how to use the tools in TracePro to visualize and analyze the results including use of an IES file and the IES/LDT Analysis Utility.

To view the webinar, register at www.led-professional.com/webinar-2

TracePro

What's Next for Mid-Power LEDs in Lighting Applications

MP LEDs are uniquely suited for linear and distributed lighting applications such as LED tube lighting and troffers. MP LEDs are now gaining popularity for deployment in other lighting applications with specific needs which can be met when designed with the end application in mind. An example would be a high efficacy MP LED with good quality of light (min 90 CRI) for use in retail shops. K. Lee, M. Chang and D. Kane from Philips Lumileds will take a close look at MP LEDs, the factors that have led to their use in lighting applications and what we can expect in terms of their proposition and usage in the future.

To view the webinar, register at www.led-professional.com/webinar-1

PHILIPS LUMILEDS

LpS 2014 – Design and Engineering for Future LED Lighting Systems

With more than 60 lectures and over 100 exhibitors, the international LED professional Symposium +Expo will take place for the fourth time in a row. 1,300 visitors are expected from Sept. 30th to Oct. 2nd in Bregenz, Austria. Latest lighting system design presented in a new interactive lecture concept and an expanded exhibition area make the event highly relevant for everybody involved in the design and engineering of future LED lighting systems.

Lighting system design based on LED and OLED technologies is challenging. Preferred solutions have to incorporate the latest technologies, smart systems, new standards, advanced functionalities and new user behaviors. Therefore, a holistic design and engineering approach is required in order to develop successful LED Lighting Systems for the future.

Event program

The LpS 2014 covers the most important trends and visions in future LED lighting systems, from LED light sources and materials to manufacturing processes and system designs. Furthermore, the reliability and lifetime of LED lighting systems, as well as practical design approaches, will be discussed.

One of the lecture presentations will be about the development of a new color fidelity index, called CRI2012, presented by Dr. Kevin A.G. Smet from the Research Council, Flanders. Attendees will learn the theory and practical use of the new color metrics. Traditionally, the CIE color rendering index (CRI) has been used to describe the color rendition of white light sources. However the CRI index fails to accurately predict the color rendition of narrow-band or spiked spectra. This has increasingly become a problem with the advent of Solid-State Lighting, as the inability to correctly assess the color rendition of these light sources might hinder the acceptance of this new lighting technology.

Another interesting presentation will be from Ralph Christopher Tuttle, Application Engineering Manager at Cree. He will present insights into the problem of the color shifts of LED packages, and will also cover the important topic of failure mechanisms in Solid-State Lighting. “High temperature results can be used to accurately model LED behavior at lower temperatures”, says Mr. Tuttle.

Human Centric Lighting (HCL) is a key topic in the lighting industry nowadays, promising a lot of future business potential. Dr. Walter Werner is a former System Architect at the Zumtobel Group and will present the challenges of HCL with a focus on components, controls and the networking environment. “We have some more steps to take before humans are back in the center of interest when it comes to lighting”, he says.

For a better understanding of lighting effects on system designs, Bartenbach Lichtlabor will run a workshop covering theory and practical demonstrations on visual perception.

These are just some examples of the many lectures presented in five parallel tracks during the three event days. The full event program is available on www.LpS2014.com/program.

The 4th LpS will again offer a broad range of lectures on LED lighting technologies and hands-on workshops

New in 2014

The new session structure enables attendees to get information and inspiration during the first two days in order to apply their knowledge in different workshops and discussions on the third day. The exhibition space has been extended for this year, and 100 world-renowned exhibitors, such as Samsung, Cree, Infineon, Wago, Fischer, Bayer MaterialScience, UL, Arrow, and OEC will present their latest technologies, products and services. Technical experts will be available to answer specific questions and for in-depth discussions with visitors. The LED professional Scientific Award will be presented for the first time at the LpS 2014 to promote global lighting research. The best scientific paper in the areas of LED and OLED light sources will be honored. As in past years, exciting networking events will be organized for the attendees.

“For this year, attendees will find a basically restructured LpS event, mainly to increase the content quality, to add more interactive program elements, and to offer more time and space for the exhibition. Workshop and symposium attendees will be inspired to create new designs and to bring innovations to the next level,“ said Siegfried Luger, organizer of the LpS 2014. ■

Weblinks:

LpS Website: www.LpS2014.com
LpS Journal: www.LpS2014.com/LpS-Journal
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Tech-Talks BREGENZ - Walter Werner Werner Mgmt. Services, CEO

Walter Werner

Dr. Walter Werner is head of the Werner Management Services, a consultancy company in the field of lighting and the Internet of Things. He worked as Head of System Architecture at the Austrian lighting enterprise Zumtobel Group from 2011 until 2014. From 2009 to 2011 he worked as an Innovation Consulter and parallel to that taught at the Institution for Higher Education in Rankweil, Austria. From 2006 to 2008 he was the Managing Director of a Swiss software startup company called mivune, situated in Zurich. He was employed at Moeller of Germany as Technical Manager Switchgear from 2004 – 2006 and prior to that, formed the smart lighting agenda of Zumtobel in the years 1985 to 2004. Dr. Werner completed his studies at Innsbruck University in Experimental Physics with a PhD.

The transition from traditional light sources to solid-state light sources has also affected lighting controls. Nowadays we talk about smart lighting, human centric lighting and software dominated lighting concepts. Dr. Walter Werner from Werner Management Services, a highly experienced lighting controls expert, discussed the major trends in lighting controls with LED professional, as part of the Tech-Talks BREGENZ series.

LED professional: Dr. Werner, let's start this Tech-Talk BREGENZ with a question about the meaning of Smart Lighting. How can Smart Lighting be defined?

Walter Werner: I don't think that there's one universal definition for Smart Lighting. Typically, there are three elements involved in this area: One is automation, the second one is manual lighting controls and Smart Lighting is third. If we look at the words "Smart Lighting", they imply that the lighting system is intelligent and that it could help the user to establish their optimal environment. Smart Lighting does things by itself, hopefully the right things! It should include a smart layout, the right types of luminaires and the right colors to light the environment intelligently and user-friendly.

But it starts with having more than one end-user. There is the end-user that uses smart or controlled lighting to light up the environment, there is another end-user that basically looks after the energy bills and the third one (possibly the building service personnel) that looks after the maintenance issues.

LED professional: How does Solid-State Lighting influence Smart Lighting and what are the interactions between the new light sources and controls?

Walter Werner: The majority of lighting controls vendors haven't been doing a good job over the past 15 years. They annoy end users, electricians, and the people within the building automation services as well as those in building management services. Most of what was sold did not work the way the users expected. "Smart Lighting" is a new word invented by the people in Marketing to cover and hide what everyone already knows: lighting controls isn't doing a good job. The word "Smart Lighting" is, therefore, pure marketing.

LED professional: Let's have a closer look at the interactions. How do businesses interact between Solid-State Lighting and Controls?

Walter Werner: For more than 10 years we have been hearing business consultancies telling the lighting industry that lighting controls will take off - but it just hasn't happened.

What has happened is that the further market development of lighting controls has practically stopped. The reason for this is the construction budgets. 20 years ago lighting controls was allotted as part of the lighting budget of a new or refurbished building, but now, these extra budgets for lighting run totally into the LEDification. LED luminaires are much more expensive than traditional lights and the construction budgets are not increasing. The only way to get more money for LED lighting is to take it away from somewhere else. As it turns out, the money has been taken away from controls. In the past, controls were mainly sold for energy savings and partly for comfort. The energy savings argument has been taken over completely by LEDification. However, what people don't realize is that in office building spaces the energy bill for lighting can be cut by an additional factor of two if a sophisticated lighting controls system is installed.

LED professional: What about the interactions on technological levels?

Walter Werner: With LEDs, it is much easier to influence the light source then it was with halogens and fluorescent lights. The LED is super when you want to dim the lights effectively, but it was a bit of a surprise that LED technology had some color temperature issues associated with dimming. It's much easier to dim LEDs than it used to be with the old technology, and the needed electronics competence to achieve nice LED dimming is widely available.

LED professional: You talk about controls and projects for bigger buildings and environments. But there is also the idea of bringing more sophisticated controls into residential applications with more emotional issues. What are your thoughts on that?

Walter Werner: Generally, this approach isn't new but LED technology provides much more freedom. We've had controls for living rooms for many years with phase-cutting dimmers. But people were unhappy with the solutions, especially if they had fluorescent lamps. So now we have LEDs coming in but the main trouble with the LEDs is refurbishment. This is especially true when incandescent lamps are replaced with LED-based ones where phase-cutting dimmers have already been installed.

Nowadays we are mainly moving towards non-manual control so there's a market for that, but I don't think that this is going to be a mass-market in the near future.

Yes, with LED there are many more things available, such as color-control and brightness-control to real zero, to name just two. Residential is where I think RF systems will play a major role in the future. There are nice applications and we can forget about the humming wall-dimmers and replace them with a wireless, smartphone-controlled lighting system and still have the mains switch on the wall.

These new concepts will push smart lighting for living rooms. And we shouldn't forget the millions of people that look for solutions like that as they like to play around with their personal environment.

LED professional: Let's look at the other side. There are also new technologies and components available on the controls side. How did these new developments influence the luminaries and light sources?

Walter Werner: I think sophisticated control is pushing towards color luminaires or tunable white ones that wouldn't exist without controls. If we go for light bulbs it may be a little bit different. In the end, though, you end up with a light bulb that is controlled and it's easy to spot the light-bulbs in different whites. In terms of components we see new systems around systems like ZigBee Light Link, BTLE, 6WloPan and many more. I could give you 30 other names. The trouble is that the complexity of an office system is still not mastered by most of what is sold, but living rooms are well covered. If you need highly reliable advanced features we have to overcome problems with the system-installation, the integration steps, and operational issues like link availability and latency.

LED professional: You have also worked in the field of building management software integration where you researched how to link systems like Backnet, LON, KNX. What were the results of your research when looking for overall control solutions?

Walter Werner: We shouldn't forget CANopen along with some 20 other systems. The trouble is that these systems work as long as they are on their own. But I don't see a way to create a real uniform system. The reason is "heritage". You just can't convince the investors to refurbish their buildings that have been operating for the last 20 years with a specific system into a new one just to have a uniform system. They will press their suppliers to maintain these old systems and to support the old methods and effects.

It's possible that the future will bring uniform systems for new buildings but it could take up to 20 years before we have them. And even if we had one, I'm not convinced that it would work, because it might end up as a boring and insufficient monoculture. Let me put it this way: There is an old trend that will also be important in the future of controls. It is Internetization, and Internetization also stands for diversity. I think that all future systems will be equipped with Internet nodes and therefore what is needed is a kind of building management software layer that provides basic uniform methods for all the different systems in order to bring them to life, keep them alive and maintain them.

LED professional: Internetization would bring with it the problem of security, wouldn't it?

Walter Werner: An Internet system can be used with or without any connection to the outside world, like intranet. Internetization is more about the methods that can be used such as TCP/IP and HTTP protocols. Security issues are not solved at all by not using Internet methods.

LED professional: Let's look one step deeper into the system level. In the area of modules and drivers, for example, we are talking about device interfaces such as DALI. Furthermore, there are different physical ways of operation available like wired or wireless connections. How do you see these interfaces evolving?

Walter Werner: Wireless is a very good issue if you go for living room control and especially for mobile device connections. I do see a greater importance of Power-Line Control (PLC) for professional systems in the future. If the technology step that RF took in the past, is transported to PLC we could end-up with very smart and reliable systems. There is already PLC technology available that can do the job even better than RF systems. Remember that „LAN over mains" is commercially available with enhanced properties compared to WIFI. Also at the Light + Building this year we saw some examples of Power over Ethernet, which follows the same thoughts but still needs special infrastructure.

LED professional: The Connected Lighting Alliance (TCLA) selected ZigBee Light Link as the preferred system for use in residential applications. Now they are working on an RFI system for office applications. Do you think we'll find a kind of standard through the TCLA activities?

Walter Werner: Let's have a look at DALI first. There are at least 10 different enhanced DALI versions available; none of which are compatible or can satisfy new requirements. This is a result of not being able to overcome problems in the original DALI specification. So any standardization framework has to make sure that further development will not be blocked and is open enough for future developments and innovations. I think that a common interface on a module level should be achievable. ZigBee Light Link more or less does the job for residential applications for manual controls and it fits well there. For professional lighting it is different; there are some 500 installations in Spain applying this ZigBee technology into professional lighting applications such as offices. To my knowledge only two of these installations work properly. The trouble is not really the technology, but lack of knowledge. Set-up and the maintenance issues have been too difficult to be handled sufficiently in professional buildings.

Fascinated by Dr. Walter Werner's deep insights, Arno Grabher-Meyer, LED professional's Chief Editor and Technology Manager, had a number of questions concerning technical issues

LED professional: So are you saying that the argument for RFI systems being flexible is contradictory to the installation set-up and also to the complexity in maintenance?

Walter Werner: There are just too many challenges and difficulties. You need perfect engineering on-site regarding antennas, positions, repeaters, layout, routing techniques and commissioning. In case of a change you would need the same person there or you should have very good system documentation but there's no format given for this and the process does not really push it. Remember even the comparatively simple wired systems nowadays are too complicated for most of the electrical staff on site.

LED professional: A luminary manufacturer told us at the Light + Building that in the end, lighting controls will be all about software and algorithms. Do you agree with this?

Walter Werner: If we're talking about controls this is already the case. The hardware differences are negligible and don't make a real difference. The difference is in the features a system can offer and these are mainly based on software, algorithms and human interface design. The general-purpose hardware is getting more and more standard; just have a look at the computer industry. The key point is the handling process and solving the deployment problem. The logistics are easy compared to the deployment of maintained features, and this is the real key point for success. I do see some automatic deployment systems for the future, though, but it will be a long way.

LED professional: You mentioned the human interface as an important factor that should be considered. How has this changed when taking the new types of mobile devices we have nowadays into consideration?

Walter Werner: The human interface for smart lighting is an open issue. All the solutions in regards to mobile devices are nice but there is nothing close to a dominant design. If you test available interfaces on different persons, some or most of them will struggle with them. This means that we don't have a useful and generally accepted design in the area of human interface for lighting. Dominant designs are accepted concepts that are used globally in the same way. Smart lighting shows that there is a need for a dominant design of the human interface and a lot of developmental work needs to be done here.

LED professional: In your consultancy business you focus on the area of Internet of Things (IoT). Where do you see IoT applications in lighting?

Walter Werner: In the future we'll have much more information available; more than we'll ever be able to use, out of IoT. This could be a revolution, not an evolution in lighting. More and more things will have their sensor or interface data propagated in an open environment. So, for example, we'll have information about the position of chairs in a room and on which chairs people are sitting. We'll have sensors telling us where people are and use them to light up things.

The main questions will be how do we integrate the information and how do we design interactions with these things? In-door navigation will be a topic that will require additional networking capabilities for sensors as well.

The problem here again is that the technology is very advanced but it's a question of what we're able to use. Furthermore, I have to mention that we're talking about lighting but in a building we also have ventilation and heating systems to name just two. All of the systems will have IoT capabilities and they will have to interact as well. So if we start looking at the details here it gets difficult. Not so much complicated, but in its diversity really difficult.

LED professional: What about the market forecast of solid-state lighting controls in general?

Walter Werner: Heritage is the most important factor slowing the growth of SSL applications. You can't throw away existing installations. If 25 years is the average usage of an existing lighting installation there's no chance that SSL will reach a 50% market share within the next 10 years. Even if the percentage of newly sold LED-based luminaires is approaching a major figure we have this limitation because we're talking about an investment business and not a consumer business. The same thing applies to controls.

LED professional: You also have a good impression of light source technologies. What about LEDs, OLEDs or other light source technologies?

Walter Werner: This may seem like a tough statement but the LED, including LED Lasers, is the last light source we'll see for point lighting. There's nothing after the LED. The reason is that the LED will get close to the physical limits especially when we go for RGB LEDs in the future. So it will be the LED that lights the future as long as we're talking about point light sources. When we look at diffused light sources this might not be true. The reason for that is that you lose performance and energy by converting a point light source to a diffused light source. The physical limits will not be reached with LEDs and diffusers in front of them. So there's a good chance that a diffused source like the OLEDs will go beyond the efficacy and the constraints of the LEDs.

LED professional: Lately we've been hearing about an old technology again: Namely, lasers. For example, lasers for lighting are being used in cars. What can you tell us about this?

Walter Werner: Lasers and LEDs are pretty close because today solid-state lasers are also LEDs. It's difficult to separate them. There might be some applications where the additional parameters of laser-based light could solve specific engineering problems. As far as I know, one presentation at the LpS 2014 will be on this topic, so I'm looking forward to hearing more about this technology.

LED professional: You personally will give a talk on the second day of the LpS 2014 in Bregenz about Human Centric Lighting (HCL) and the technology changes. Could you please define HCL as you see it?

Walter Werner: HCL means that the human is supported in the best possible way. HCL will exclude, by definition, all building management or maintenance issues as a target. HCL is related to the personal environment and the influences and interactions with lighting. This is precisely what torch lights did. We have it under our true personal control! Installed lighting systems are not doing that at all, so we have a gap to bridge. HCL is more about personal controlled abilities and also much more about the dynamics that people can use. HCL makes the difference between a boring and a stimulating atmosphere, where humans define their own set-up and dynamics.

My talk in Bregenz on October 1st will be about the technology aspects of HCL and the environments needed.

LED professional: Thank you very much for this very interesting talk here in Bregenz! ■


It's the Right Light!
Why Samsung LED Light?
Its award-winning designed spot light
creates moods like never before,
making shopping more lively and pleasant.

Advanced Primary Optics for Improved Light Efficiency and Low Cost

Improvements in efficacy and power capabilities of LEDs allow lighting manufacturers to reduce the number of LEDs to achieve a defined illumination level. However, for some applications, like LED panel lights, this is no simple task. It needs appropriate optical solutions to avoid glare, uneven brightness in the diffuser plate, or other undesired effects. This is usually achieved with secondary optics. Kim Sung-Phil, Senior Research Engineer at LG Innotek, demonstrates how that can be achieved with an LED having a primary optics with batwing characteristics and compares the different approaches.

Since the introduction of LEDs for lighting, there have been huge improvements in the efficiency of LED materials, manufacturing processes, and LED chips. Therefore, the most recent single LED package can produce a much larger amount of light than before with the same amount of power. Accordingly, manufacturing a lighting device with the same brightness as before requires less LED packages. When reducing the number of LED packages, however, a problem with uneven brightness in the diffuser plate can occur because an LED is a point light source unlike fluorescent or incandescent lights. In addition, as the design of the lighting device becomes increasingly important, there is a tendency to make the lighting device slimmer, requiring a cutting-edge technology to achieve even light distribution in the diffuser plate.

Introduction

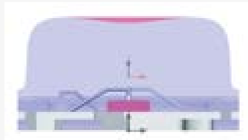
In the case of LED lighting devices, a regular LED package design cannot produce the light distribution that achieves the required evenness of the brightness in the diffuser plate. To obtain the required light distribution, one needs to increase the divergence angle of the light that is emitted from the LED. To do this, it is necessary to use an optical element or consider the optical properties of the lighting device when designing it. Adding a lens to the regular LED package that has a Lambertian viewing angle makes its angle wider. This allows for a reduction in the number of required LED packages, and furthermore the price and power consumption of the lighting device, contributing to the wide usage of LED lightings. The use of a lens to spread the light distribution angle also allows the design of slimmer lighting modules, improving the appearance of the lighting device. There are two types of lenses that can be used to increase the emission angle of an LED depending on the location it is applied to: primary lens and secondary lens.

Primary vs. Secondary Lenses

In the case of a secondary lens, the LED package is mounted on the printed circuit board (PCB) at first, using surface mount technology (SMT). Then a lens manufactured with the injection molding process is added on top of the LED package. This is also called a discrete-type lens. This method allows for a lens larger than the light source and can adjust the thickness of the lens as needed because the lens has two refractive surfaces, providing design flexibility. Due to these advantages, it is possible to produce a very large viewing angle using a secondary lens. However, the price of the lens is relatively high as the lens is made of PMMA using injection molding and incurs a separate manufacturing cost. Also, due to the air gap between the LED package and lens, the efficiency of light extraction may be low. It also requires a device that aligns the lens with the LED properly, decreasing the yield rate and increasing the manufacturing cost.

In the case of a primary lens, the lens is made of silicon and is molded on top of the LED package directly to solve the problems related to the secondary lens, such as high manufacturing costs and low light extraction efficiency. This is also called an integrated optical lens (IOL). The primary lens also works as an encapsulant of the LED package, in addition to its primary role as a lens, as it is made of silicon. The primary lens improves the light extraction efficiency

Table 1: Comparison of 600 mm x 600 mm LED panels using different LEDs and optical solutions

	Regular LED Package	LED Package with Primary Lens	LED Package plus Secondary Lens
Structure			
Viewing angle (FWHM)	120°	135°	145°
LED Quantities	256	100	64
Relative Luminance efficiency	1	1.2	0.8
Relative LED PKG+Lens Cost per LED	1	1.5	3.2
Relative Total LED PKG+Lens Cost	1	0.6	0.8

because there is no air gap between the LED chip and the lens, reducing the difference in refractive index between components. The dome-type IOL takes full advantage of this. However, the dome-type lens cannot produce a viewing angle sufficiently larger than that of a standard LED package due to the lack of advanced optical design technology and restrictions inherent in the dome shape. Therefore, to provide a large viewing angle with high light extraction efficiency, an IOL with a dome shape should be replaced with that of another shape. The hemispherical shape needs to be changed into an aspheric surface and a proper aspheric coefficient using an optical design simulation tool has to be calculated to make an IOL that matches the LED chip and its package.

Table 1 compares three different lighting modules of the same size (600 mm x 600 mm), one using a standard LED package, another using a primary lens with an aspheric surface, and a third using a secondary lens. The comparison demonstrates that the primary lens is more cost effective and has better light extraction efficiency than the other methods.

The primary lens is made of a light-transmitting polymer that has an appropriate refractive property. When selecting the light-transmitting polymer, it is crucial to consider its refractive index, light transmittance, and heat resistance. Especially, as the refractive index dramatically affects the lens design, the lens material has to be defined before starting the design. A primary lens with a high refractive index causes the light path to change significantly according to the shape of the lens and has high light extraction efficiency because its refractive index is not much different from those of LED chip and phosphors.

Designing Primary Lenses

A secondary lens has a larger diameter than that of the LED package (light source) and is separated from the light source by an air gap. In this case, the lens shape can be designed using the ray file of the LED package as a light source. This is different for the primary lens. The primary lens has a similar diameter as the LED chip and phosphor layer. In addition, the light reflected by the lens excites the phosphors again, functioning as another light source. Because of this much more complex behavior, a direct modeling method is necessary to design the lens shape. The direct modeling method includes the elements constituting the LED package as design parameters (Figure 1).

A primary lens, unlike a secondary lens, has only one refractive surface, making it difficult to control the light path. This causes lower design flexibility. Furthermore, it is difficult to design a shape that has a large viewing angle and avoids color separation. Therefore, the designed shape has to increase the viewing angle by utilizing all sides of the lens. The optical simulation with the quite complex calculations requires the use of an appropriate simulation tool. To achieve the desired result, it is necessary to start with proper preconditions like the appropriate lens height and an aspheric shape (Figure 2)

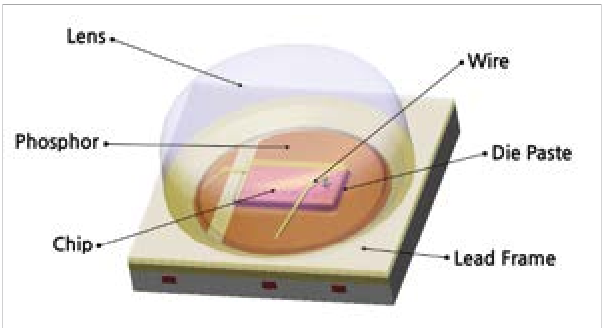


Figure 1: LED package with its main elements used in the direct modeling method

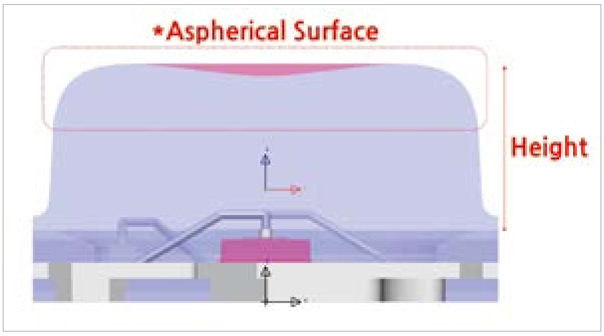
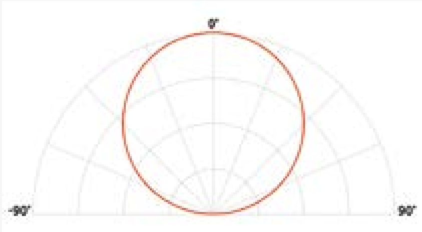
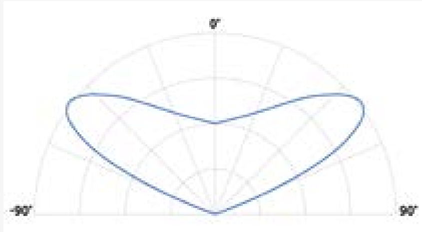
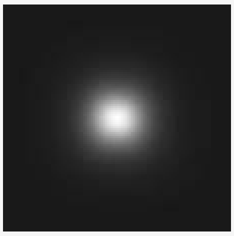
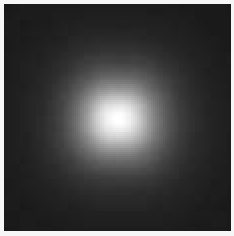
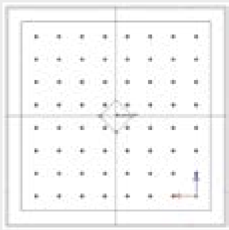
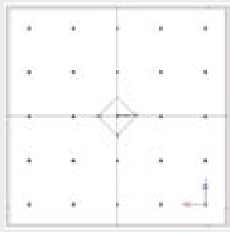
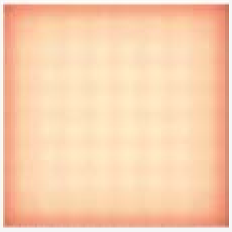
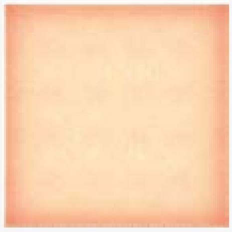


Figure 2: A proper lens height and aspheric shape based on the right aspheric equation are crucial for an accurate simulation

Table 2:
Comparison of a standard LED package with the IOL LED package

	Regular LED package	IOL LED package
Viewing angle		
Viewing angle	120°	135°
Dispersion of illumination		
Module image		
Dispersion of Module illumination		
Uniformity	84.5%	83.5%

for the simulation using a ray tracing simulation software such as LightTools and ASAP that can simulate the light source and LED package structure. With the prototype of the designed lens, potential deviations from the design values can be determined. Once the offset values between the design and actual shape are confirmed, the lens shape can be finalized.

To obtain the optimal lens shape, it is necessary to trace the rays emitted from the LED chip as shown in Figure 3 and determine the light and color distributions for each target position on the diffuser surface before continuing the lens design. When it comes to the light distribution properties, the lens should have a wide viewing angle and even illumination between the center and surrounding areas. Also, it should be designed in a way that does not cause color separation by considering the refractive properties of each surface.

Table 2 compares the standard LED package with the IOL LED package. The IOL package with the primary lens provides a wider viewing angle and a much more even light dispersion.

Primary Lens Manufacturing

In the case of a primary lens, however, the lens is integrated in the LED package requiring a different method than the production of a secondary lens. Compression molding and transfer molding are the two most important methods for manufacturing a primary lens. Compression molding is characterized by little loss of liquid silicon, low-pressure molding, and low contamination of the mold thanks to the use of release film. But it is difficult to transcribe the lens shape to the mold.

Transfer molding is characterized by the lack of release film and high-pressure molding, compensating for the loss due to material compression and producing the lens shape that closely matches the mold. But it causes high loss of the material and cannot use a material that has adhesive properties. This increases the manufacturing cost. Compression molding is widely used for manufacturing primary lenses that are integrated in LED packages. This is because the primer coating process can be excluded by using silicon both as the lens material (different refractive indices can be obtained depending on the silicon type) and as the encapsulant with adhesive properties.

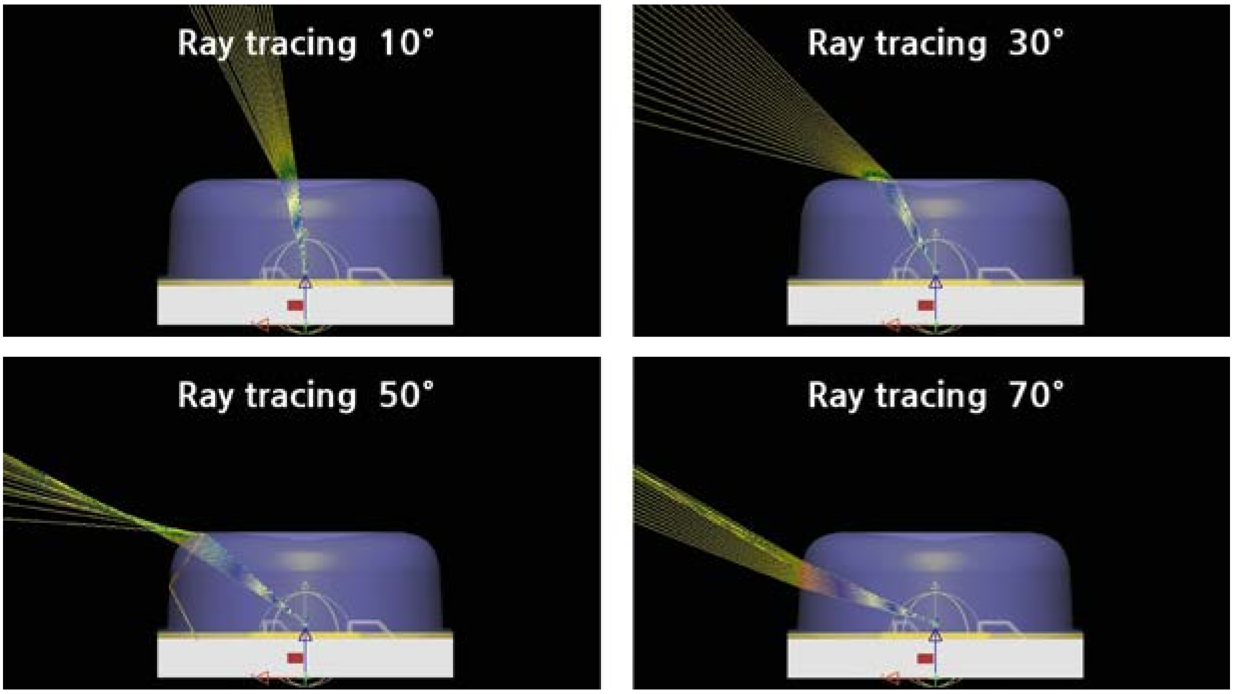


Figure 3: **Ray tracing graphics for different angles from 10°, 30°, 50° and 70°**

Figure 4: **LG Innotek's 3030 IOL is a model product for incorporating advanced primary optics**

Conclusions

Recently, leading companies, such as LG Innotek with its 3030 LED package, have produced primary lenses using low-cost compression molding and also developed optimized silicon materials and packaging technology. However, particularly the aspheric lens shape solution provides even light distribution with less LED packages. Compared to LEDs with Lambertian light distribution without secondary lenses, this technology reduces the number of LED chips for a 600 mm × 600 mm flat lighting panel by half and in parallel allows a solution that reduces the thickness of the module by 30%.

In the future, not only the flat module market may benefit from this technology. Developing an LED package that also utilizes the primary lens technology for other applications may provide more valuable and more efficient LED lighting solutions to the customers. ■

LED Light Spectrum Enhancement with Transparent Pigmented Glazes

While LED bulbs have the distinct economic advantages of using less energy, producing less heat and lasting years longer than traditional incandescent bulbs, when objects are viewed under LED light, they frequently appear to be of different colors than when viewed in sunlight or with incandescent lights. Jan-Marie A Spanard from Light Spectrum Glazes proposes and explains an approach to optimize the spectral distribution of LED light to overcome this weakness.

"White light," is the visible uncolored light which allows the human eye and brain to maximize the perception and recognition of extant color values when viewing objects. Recognized sources of white light are the sun and stars, incandescent lights, and some specialty light bulbs. We officially define white light as being made up of red, orange, yellow, green, blue, indigo, and violet light, which corresponds to the assumption that all humans are trichromatic beings. With increasingly refined measurement capability of human vision in recent years, we now know that all not humans have trichromatic vision. Researchers have identified a range of human color vision capability that stretches from absolute color-deficiency at one end of the continuum to tetrachromacy or pentachromacy and beyond. Non-trichromatic humans are now thought to make up as much as one-third of the world's population. Recent colorimetric research in human vision has shown that white light is processed as either a broader or narrower assortment of visible wavelengths by individual humans with non-trichromatic vision. This is relevant to our understanding of how to create and measure the quality of LED light for as many viewers as possible.

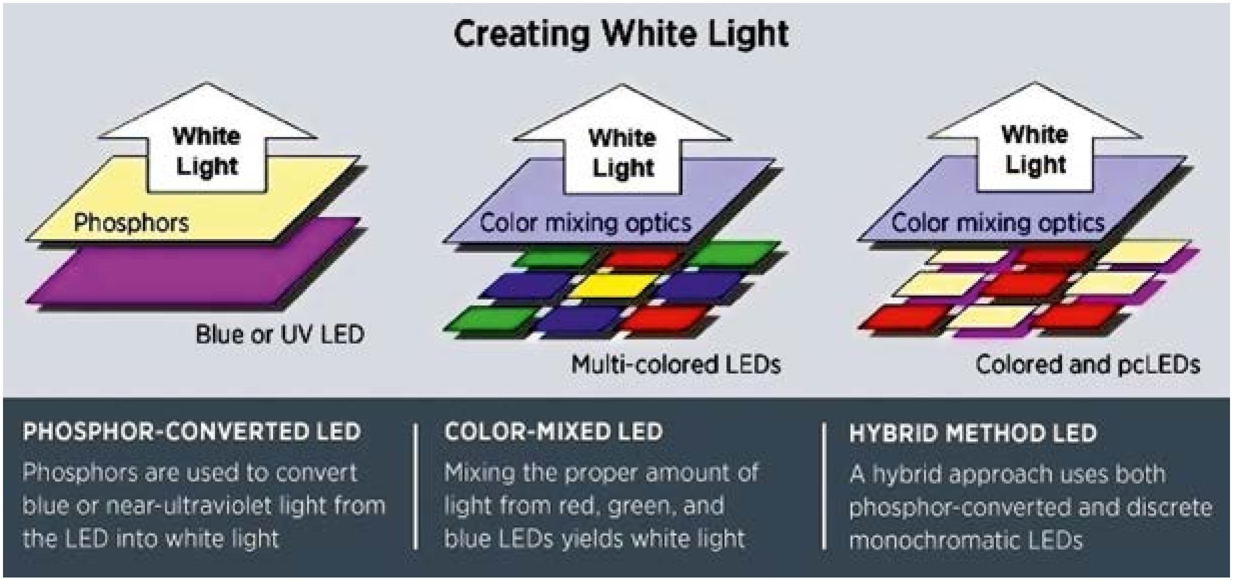


Figure 1: **Creating white light with LEDs, U.S. Department of Energy, Energy Efficiency and Renewable Energy Division**

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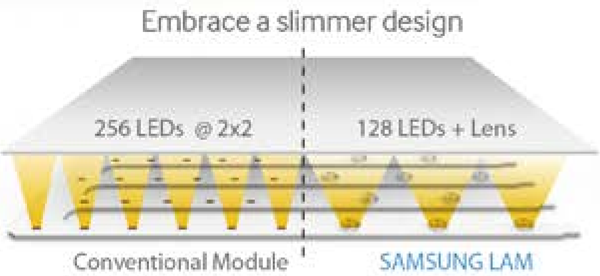
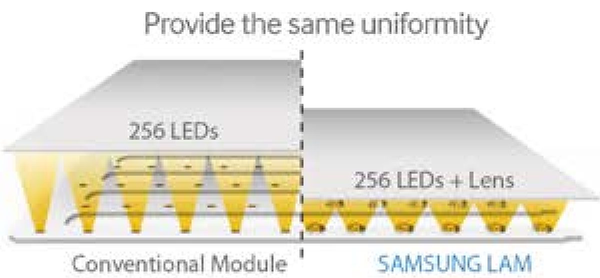
Samsung LAM [læm] Solution

Applying global No.1 semiconductor technology to lighting





Samsung's LAM solution provides more design flexibility to a wide range of luminaires

Samsung's LAM series embraces a new concept in LED modules.
The LAM solutions are created by attaching lenses right on top of the LED packages in each module. The lenses add wide beam angles for their light sources using advanced optic technology, so that each LED package can brighten a space larger than that of conventional packages.

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Creating LED Generated White Light

Manufacturing low cost LEDs with "whiter" white light

Manufacturers have had limited success in producing inexpensive "white light" bulbs. Affordable LED bulbs cannot yet accurately portray the full range of tints, tones, and colors of objects. More expensive technologies have had better success, but the manufacturing costs put these bulbs out of the price range of household shoppers. There are mainly three LED light tempering techniques used in inexpensive to moderately priced, mass-market LED bulbs (Figure 1).

Phosphor film and resin-embedded solutions are the dominant method of warming the naturally cool light of an LED chip to more closely mimic white light. This adjusts the Kelvin temperature of the light into the warmer range, but the LED is still missing many wavelengths of the white light spectrum. Both the low cost of this technology and the general adequacy of the light color make this invention the most commonly used in manufacturing LED bulbs. Multiple LED chip solutions combine three or more individual LED chips of different colors into one multi-chromatic bulb and blend their output to replicate white light. Newer bulbs that permit users to adjust the color temperature of a multi-chip LED bulb generally entail maximizing or minimizing the output of a warm-white converted chip and a second cool-white converted chip, but the spectrum of wavelengths emitted is still limited to the spectral emission of the two embedded chips. The most successful attempts with this process have used six or more different LED chips, each emitting a different wavelength of light, in order to more closely approximate natural light. This can be a more effective, but much more expensive solution to creating LED white light. Hybrid of using both multiple phosphors and multiple chips involves marrying these two partially successful techniques into one bulb.

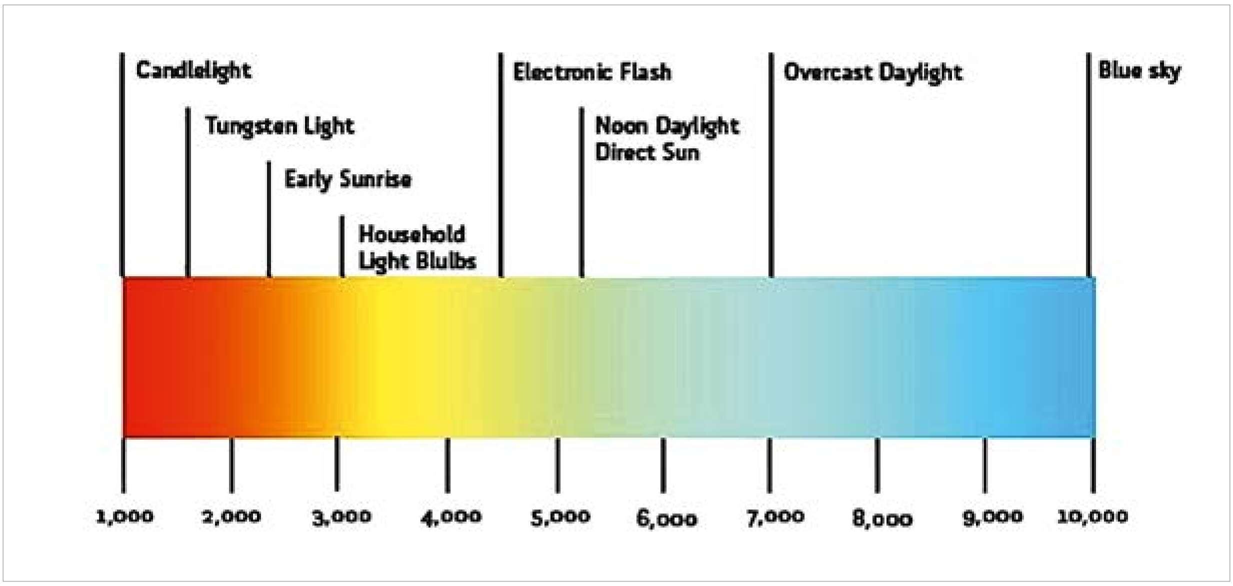
Measuring a bulb's ability to produce white light

The Kelvin temperature rating of LED bulbs provides no useful information about the color quality of that light although it is the most prevalent measure on retail packages for consumer decision making. The Kelvin temperature tells us nothing about the spectrum of wavelengths emitted and hence the lamp's ability to permit viewers to accurately identify or experience the same colors that they would find if viewing an object in white light. The Kelvin temperature rating is essentially a flat measure of coolness or warmth that does not differentiate between a single, narrow color spike or a broader, better quality color range.

Mechanical measures of LED light quality such as the Color Rendering Index (CRI), the Color Quality Scale (CQS) and the Metamerism index (MI) are meant to rate a lamp's ability to produce light that will faithfully reveal the colors of various objects as they are seen under white light conditions. The CRI is calculated by determining how well any lamp renders a very small sample of eight bland colors in the visible spectrum. It makes no difference to the CRI score if a lamp can produce a light that will render any of the other seven to ten million colors a tri-chromatic human is thought to perceive. The CQS attempts to evaluate the faithfulness of illuminated color with several additional calculations and an increase in the color sample palette to 15 Munsell color samples from the CRI's eight. Most recently developed, the MI matches the visual perception of a color between two light sources through a series of mechanical measurements and calculations. All three of these measures are based on the trichromatic basis of colorimetry. While the accuracy of these three measurement systems are of varying use in predicting the visual experience for those humans who are tri-chromatic, they are of extremely limited usefulness for the other, large, non-trichromatic segments of the human population.

If we cannot know how non-trichromatic viewers will perceive the colors of objects, the only truly accurate measure of whether a lamp

Figure 2: Kelvin color temperature scale showing readings for various levels of daylight and incandescent lights



will produce a faithful rendition of the color of an object as seen under white light is to create a bulb that produces a fuller spectrum of light waves, a 'whiter' white light. Without knowing how much of the visible light spectrum each person can interpret, the greater the range of wavelengths that are present, the better the perceived quality of light will be for all viewers. A spectrogram of emitted light from any LED source is the only true test for whether a lamp will produce a full range of light waves that will permit viewers of all abilities to identify colors that are consistent with those seen under white light.

Color range of light sources in nanometers

The broader the production of all color wavelengths, the better the perceived quality of light for all viewers. Sunlight, as depicted in figure 3, below, emits a rich spectral array of wavelengths that allows the eye, human or animal, to maximize the perception and differentiation of color. Artificial light sources all have a somewhat limited spectral production. When a color looks different under LED lighting than it would in daylight it is simply because some of the light waves that must be present for the human brain to register the object's full color range are not being produced by the LED bulb.

Traditional incandescent light is the indoor light to which we have both (1) grown accustomed, and (2) decorated and furnished our homes, businesses and public places. Incandescent bulbs produce a warm white light with a unique color spectrum. When we replace the bulbs in our buildings with LED bulbs, we have both a cooler light and a light with an abbreviated spectral color output. In short, furnishings, objects, fabrics and even people look different in LED light. Anecdotal evidence identifies LED bulbs as the most likely light source to be purchased, installed in the home, found unappealing and then uninstalled. Many viewers express negative emotional and even visceral responses to the color character of the limited LED spectral palette when used both in interiors: homes, work places and commercial venues, as well as in exterior LED street lights and flood lights. LED lights are viewed by many consumers as the quinoa at the salad bar: we know it's good for us, but it doesn't taste very good.

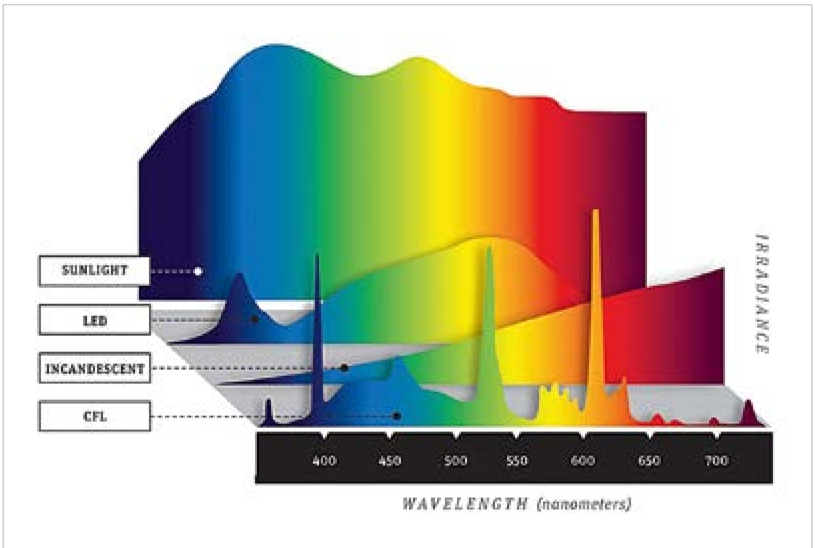


Figure 3: **Color spectrum recognized wavelengths emitted by sunlight, phosphor-doped LED, incandescent and CFL lights (Ultimate Light Bulb test: Incandescent vs. Compact fluorescent vs. LED, Popular Mechanics, November 25, 2012)**

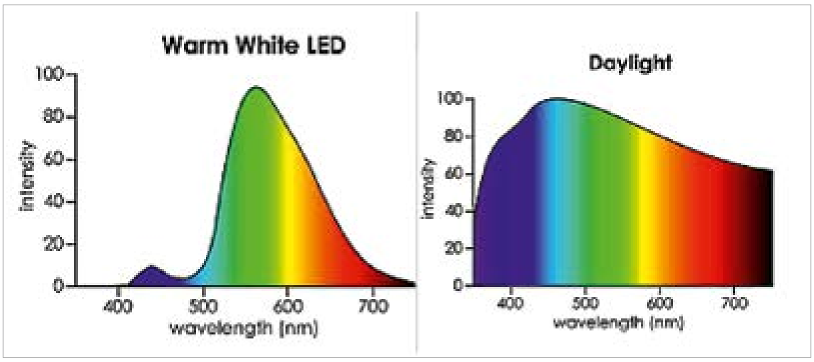


Figure 4: **Comparing light emission from warm white LED (left) and daylight (right)**

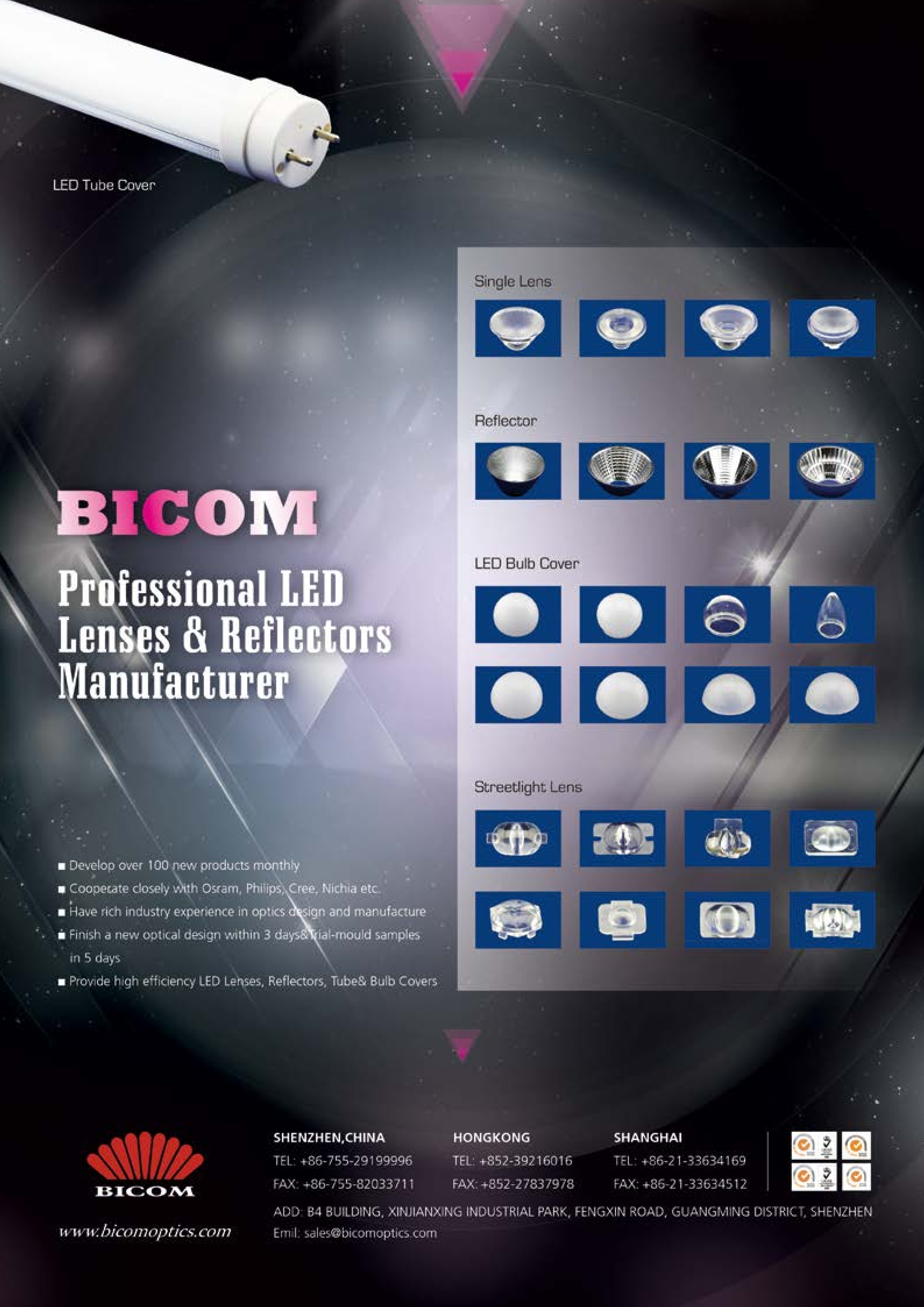
Solutions from Art Restoration Technology

Art restoration is a discipline that requires knowledge of an artwork's visible and material structure, including both the substrate and surface materials. Damaged or age-diminished paintings, sculptures and constructions are treated so as to restore not only their structural integrity but their original visual appearance as well. Artists materials can similarly be used to fine tune the color output of LED lighting devices to more efficiently and cost-effectively attain a fuller light spectrum emission from an LED lamp. In short, artist's pigments can be used to produce a "whiter" white light by tuning the light emitted by the LED bulb. The method of selectively adding transparent color filtering to the emitted light is described below.

Step 1: Compare the chosen light's spectral emission with a desired spectral emission

For this example, we will compare a warm-white LED lamp that is very common on the consumer market and compare it with a sample of natural daylight. Figure 4 shows the emission spectra of the warm white LED lamp and of natural daylight. Note the different array. This has a powerful impact on what we perceive when we view objects under each lighting source.

The primary adjustments needed for the LED emission to better replicate the daylight emission include the addition of light waves in the 380 - 550 nm and the 600 - 750 nm range. So, an approximation of the quantity and distribution of daylight wavelengths missing from the warm white LED that we want to add can be roughly expressed as:


LED Tube Cover
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Single Lens
Reflector
LED Bulb Cover
Streetlight Lens
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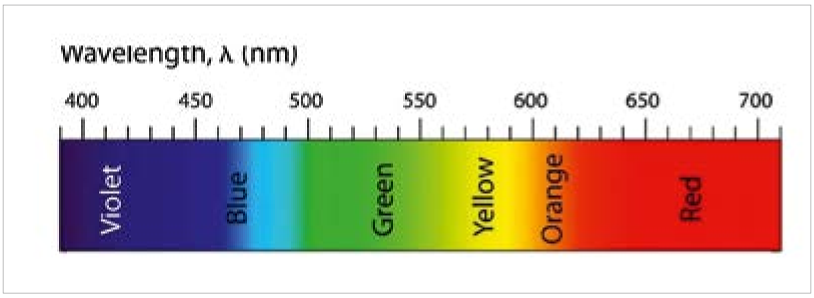
Figure 5:
Visible spectrum wave lengths and light color



+ 24%	380-425 nm
+ 18%	425-460 nm
+ 17%	460-500 nm
+ 18%	590-640 nm
+ 23%	640-730 nm

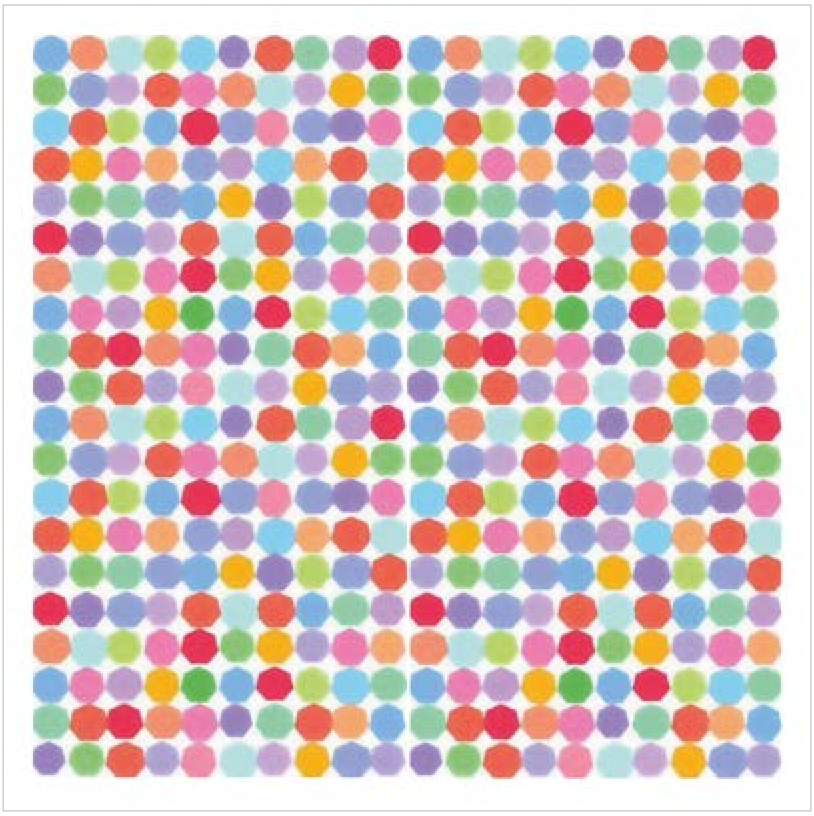
Step 2: Convert the light wavelengths to color

When the human eye perceives light, the brain interprets that light in colors. Figure 5 shows the match between visible light wavelengths and how humans perceive those different wavelengths as colors. Other animals perceive colors in wholly different ways, so this example is only useful for human perception.

Matching the missing light wavelengths with how the human eye and brain convert those wavelengths to perceived color, our correction formula for the light waves can now be expressed as:

+ 24%	violet	380-425 nm
+ 18%	indigo	425-460 nm
+ 17%	blues	460-500 nm
+ 18%	oranges	590-640 nm
+ 23%	reds	640-730 nm

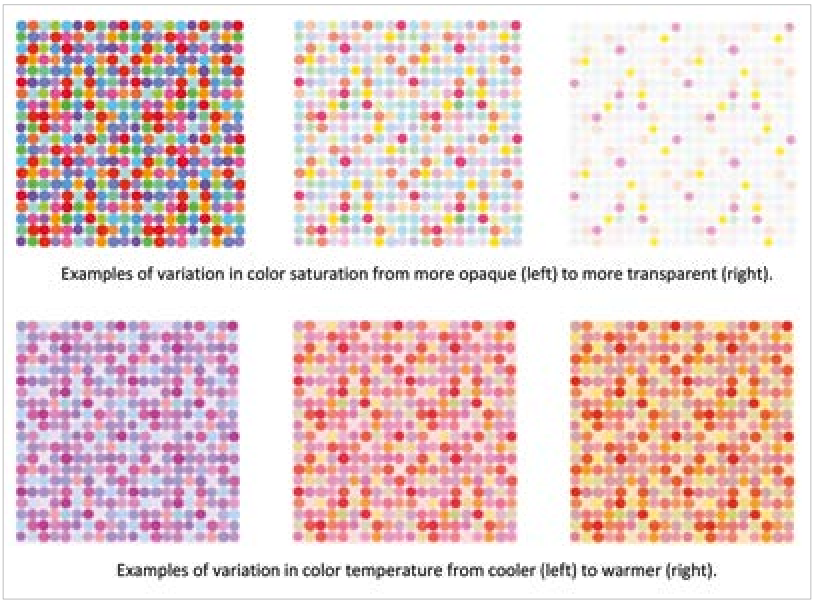
Figure 6:
Pigmented glaze solution for tuning the warm white LED to better replicate daylight (magnified)



Step 3: Create pigmented transparent filter in the solution formula desired

By introducing pixel-sized dots of pigment on a transparent substrate, we can "tint" the light spectrum emitted by the warm white LED bulb to better mimic the daylight emission. Figure 6 is an artist's rendering of what the pigmented glaze color array for our example might look like when magnified.

Figure 7:
Transparent pigmented glazes can be produced in a wide range of pigment saturation and color arrays



Step 4: Balance spectral augmentation with lux maintenance

The greater the saturation of color added, the broader the spectral color array produced. This is good. But the more saturated the density of color added, the greater the loss of luminosity, or lumen output. This is not good. We want to maintain as much luminance as possible while increasing the range of light waves emitted by the bulb. A balance of these two factors, color change and lux maintenance, is key to successfully improving the light quality while maintaining as much luminance as possible.

Determine an acceptable luminosity-loss: color-improvement ratio by varying (1) the opacity/transparency and (2) the color temperature range of

Figure 8: **Possible physical surfaces on interior and/or exterior of lamp apparatus for pigment glaze placement**

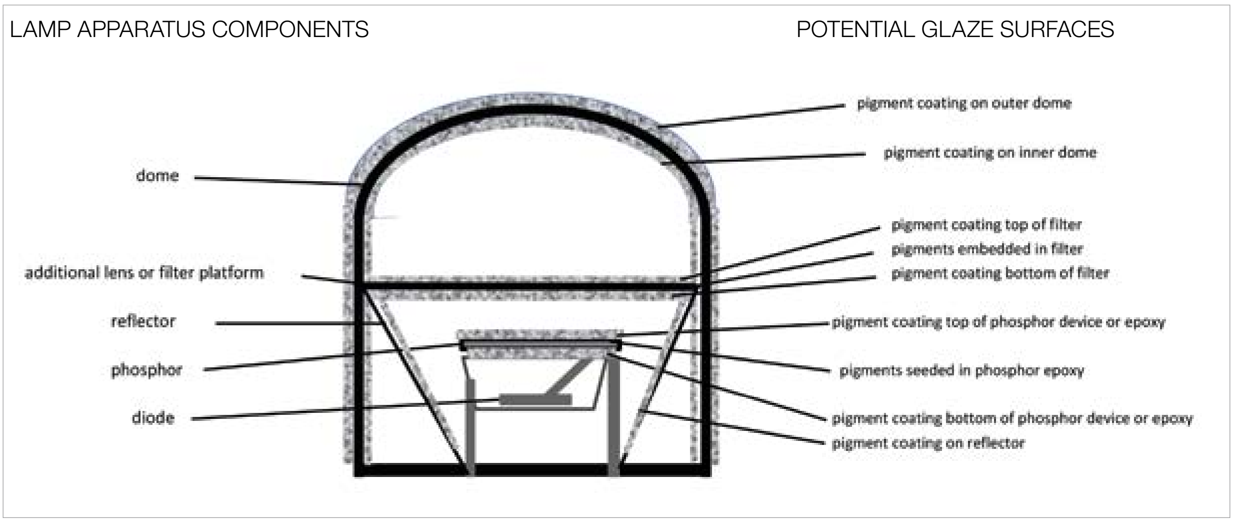
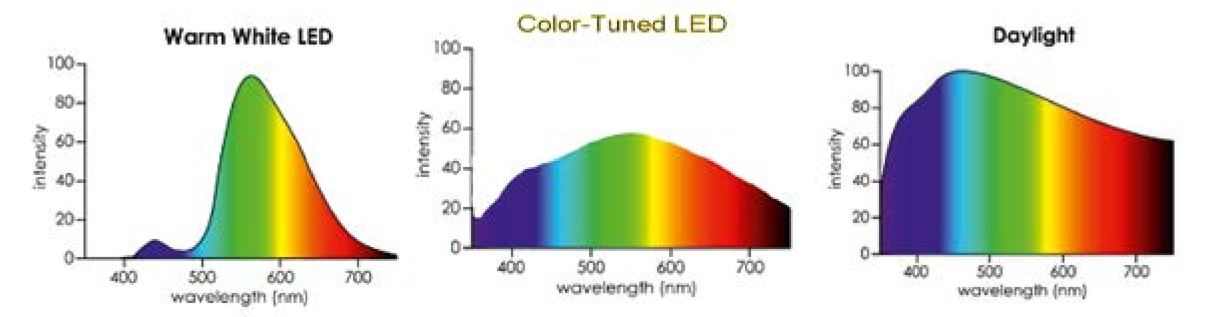


Figure 9: **Warm white LED emission (left), artist's rendering of pigment-tuned light (center), daylight emission (right)**



the pigment mix. The more transparent the color glaze, the more unfiltered light will pass through untreated. Fewer new waves will be produced but lux maintenance will be higher.

Step 5: Select application surface(s) for transparent pigmented glazes

Select one or more placement areas in or on the lamp or lighting device for the pigment addition. In the structure of an LED device, areas where pigments may be added as either a pass-through glaze or as a reflective filter include, but are not limited to the areas in Figure 8.

Step 6: Select an optimal pigment source and a binder (medium)

Pigments can be (1) completely transparent, which are best suited for interior filters, lenses, pass-through surfaces, and exterior bulb surfaces or (2) translucent, better suited for reflective surfaces on the interior of the lamp. Binders which hold the pigments in place, include resins, silicate binders, acrylic polymers, oil-based binders and water-based binders. Different binders offer different physical properties. Poly-resins and potassium silicates provide the most desirable characteristics for use in an LED lighting device. Neither is adversely affected by heat, by humidity at any level, to deterioration over time, or to damage by direct handling. Silicate and resin glazes will not crack, flake, or craze.

Pigments can be applied either as a dry material or a liquid suspension to the lamp surface(s), interior and/or exterior, as selected. The potassium silicate glazes are chemically bonded to the substrate without any further treatment. The resin glazes can be heated to 165 degrees C to permanently thermobond the material to the bulb surface. The liquid tinting compounds are water soluble, non-flammable and non-hazardous.

Pigmented glazes can be applied directly to an extant lamp surface or may be applied, printed or embedded on an additional lens or filter surface placed inside the bulb envelope.

A glaze can be applied to any shape or size bulb because it is in liquid form. The glaze can be used on current bulb forms and any new bulb forms introduced in the future. The pigmented glazing liquid can also be applied in graduating density around the base of a bulb so that when dimmed, the color temperature of the light emitted changes as the light intensity diminishes. The pigments chosen can be adjusted in spectral range. In fact, any color scheme could be used for decorative purposes, creating a soft pink light, for example.

The resins can be mixed as a brilliant glossy transparent tint or can be mixed as an opalescent, light-refracting tint of various complimentary warm yellow and red hues. The silicate glazes can incorporate powdered reflective minerals such as garnet, mica and quartz. The component materials of the glazes mentioned here are currently manufactured and have been tested and approved for use by both LED bulb manufacturers and consumers. The potassium silicate and resin materials are not expensive nor are they difficult to obtain and use.

Step 7: Measure the newly tuned spectral emission

Figure 9 shows our original warm white LED emission on the left, an artist's rendering of the color-tuned emission of the warm white LED light in the center, and the natural daylight emission. Please note that while the spectral array of the color-tuned bulb will more closely approximate the daylight emission, there will be some measure of lux loss in the process.

Step 8: Adjust pigment quantities and colors until desired spectral emission is approximated

If desired, further adjust the spectral vs. lux output by rebalancing the choice of pigment ratios, pigment density and placement in or on the bulb or lamp. This fine tuning would ideally be accomplished with the implementation of a computer program designed to read the initial emission pattern and produce the 'solution' array of pigments and pigment placement areas to match the desired emission spectrum. Each bulb produced by any given manufacturer could, in this way, provide a fuller spectrum of emitted light, either gradually or dramatically, via an inexpensive, permanent and ecologically benign process.
Transparent color glazes can improve the aesthetic quality of the light without increasing heat (which happens when using multiple chips), with minimal expense and without deterioration from heat or humidity over time (which occurs when using single or multiple phosphors).

Summary of Benefits of Transparent Pigmented Glazes on LED Bulbs

The application of transparent pigmented glazes on interior and/or exterior surfaces of any LED lighting fixture provides both (1) an adjustment of light color as measured in Kelvin temperature and (2) the expansion of the range of light color emitted as measured in nanometers. The use of transparent pigmented glazes produce a "whiter" white light by providing more of the missing light waves while minimizing lux reduction in a cost-efficient process. An almost infinite range of color choices, color saturation vs. transparency points, and many pigment and binder vehicle choices are possible. ■

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Note:

Augmentation of LED spectral emission via the selective application of transparent pigmented glazes is a patent protected process.

How To Power and Protect LEDs Properly

LEDs are decidedly the light source of choice or at least will become the lighting source of choice in the near future for virtually any lighting applications. But nevertheless, there are issues to consider. Tony Armstrong, Director of Product Marketing for Power Products at Linear Technology Corp. will explain how to power them and also how to protect them from the hazards they face within their respective implementations using examples of high bay lighting, architectural lighting, outdoor street lighting and even 75 W incandescent bulb replacement.

For many applications, LEDs are still the preferred light source despite the fact that they cost more than incandescent lighting by a factor of 13 to 1. However, even though they are appealing in many respects, there are also disadvantages. To fully benefit from this technology it is necessary to understand what LEDs need to power them, because it's not possible to just screw in an LED into an existing incandescent light fixture if it doesn't have the proper electronics! It is crucial to understand what has to be done to correctly house and power them, and finally it needs to thoroughly take care of avoiding negative impacts for an LED and its LED driver circuit. These are the most important issues that should always be considered when designing an LED lighting product.

What LEDs Want

LEDs are not a "heater" like an incandescent bulb, which is essentially a resistor, they are essentially a diode. As such, they need a fairly tightly regulated current and voltage, which is generally provided by an LED driver circuit. However, this circuit is susceptible to open or short circuit conditions – so care must be taken during the design process to protect against potential occurrences. Also, high temperatures negatively impact an LED's useful light output, so care must be taken when designing both their driver circuit and its housing.

Unlike an incandescent bulb which can take AC mains voltage directly, an LED needs a regulated DC voltage and current. As a result, AC to DC conversion may be necessary depending on the power source. Whenever a conversion process takes place there is always the potential for things to go wrong. In many cases these events can potentially harm, or even kill the LED driver circuit – and without it, the LEDs cannot light themselves! Therefore it is necessary to provide the LED driver circuit with protection from such occurrences. As a result, it would be helpful if driver ICs had LED protection incorporated within them. Some examples of LED driver ICs with protection features built into them so that a long and useful life of LEDs can be attained will be explained below.

LEDs Versus the Alternatives

Table 1 shows the comparison between incandescent, CFL and LED light bulbs. The highlights in this table identify the properties that are good and desirable for each of the respective light sources.

As can be seen, one of the key features of an LED is its efficacy. At 80 lumens per watt of light output it is at least 8 times more power efficient than the incandescent bulb. Or, put another way, it uses one eighth of the electrical power of an incandescent bulb to attain the same light output. This equates to energy cost savings over the life of the installation. The lifespan figures in this table clearly demonstrate that an LED can last at least 25-50 times longer than its incandescent counterpart and approximately 5-25 times longer than a CFL lamp. Therefore, there is a point at which the higher initial cost of the LED bulb is offset by its reduced energy costs. For illustration purposes, by simply replacing the five most used light bulbs in the average home, these energy cost savings can be realized in less than a year. Of course, there are other benefits to using LEDs, such as they contain no toxic material and they have no failure modes - provided that their power supply is designed to power and protect it correctly!

Table 1: Comparison of LEDs, CFL & incandescent light sources

Light Property/Source	LEDs	CFL	Incandescent
Efficacy (lumens/Watt)	80 to 180 Future >200	40 to 70	10 to 15
Watts of Electricity Used (60W bulb equiv.)	8-10	13-15	60
Lifespan (hours)	>50K	2K to 10K	1K to 2K
Driver Power	DC	AC	Offline AC
TRIAC Dimmable	Yes	No	Yes
Instant Turn On	Yes	No	Yes
Power Factor	0.5 without PFC >0.90 with PFC	0.5	1
Sensitive to Power Cycling	No	Yes	Yes
Contains Toxic Mercury	No	Yes	No
Failure Modes	None	Yes, may catch on fire, smoke, or emit an odor	Some
Cost 60W (or equiv.) Bulb	$13	$3	$1

Care & Feeding of LEDs

As already mentioned, an LED is the electrical equivalent of a diode. As such it is a current driven device; therefore, by simply applying the correct amount of current through the LED will allow it to attain its specified light output in lumens per watt. Correspondingly, supplying less current will limit the amount of light output that it is capable of delivering. For a single LED this might not seem like a big deal; however, if there are many LEDs in a series string, and they are not getting uniform current, the light output will vary greatly and be very noticeable.

Of course, it is necessary to overcome an LED's inherent forward voltage drop, which can vary depending on the type of used LED and the fixture configuration. For a typical white LED this forward voltage drop is usually around 3-3.5 V but can be slightly higher at elevated temperatures. As a result, depending on the input power source, a wide range of conversion topologies will probably be needed. This can be further complicated by the different LED string configurations, which include series (LED forward voltage drop additive), parallel (LED current additive) or a combination of series and parallel strings (both LED forward voltage and current additive).

We have now covered what an LED needs for correct operation, but what can happen to negatively impact their operation and that of its driver circuit? Well, the answer is that a lot of things can adversely affect an LED's output, or even lead to its catastrophic failure. These events consist of over voltage, usually occurring during an open LED event, or an over current condition which normally happens during short circuits or the re-plugging of an LED string. Of course, as previously mentioned, poor thermal environments can also adversely affect an LED's useful life and so a good overall thermal design is critical, too. Also, lest we forget, once again the LED driver circuit is also important, and so it is equally imperative that care be taken on its design so that it can protect itself, and therefore the LED, from opens, shorts and poor thermal environments. By the way, all of these issues are commonly found in most automotive, avionic and industrial environments.

A critical aspect of powering an LED is the correct delivery of a tightly regulated current. It is here that the LED driver circuit is key since it must take whatever the input power source is (which will vary widely due to the broad range of applications), and convert it to the required voltage and current levels which best optimize the LED's performance. Since over voltage or current can negatively impact LED life or its light output over time, the tighter they can be regulated the more robust the system will be. Therefore, having +/-5% voltage and current regulation will be beneficial for a long and trouble free operating life.

Another key criterion is to provide over-voltage protection. Therefore, an LED driver circuit which can handle higher transient voltage conditions above those required for normal operation is a pre-requisite. A good example of this is in an automotive environment where load dump might be 42 V, or even higher.

Protecting LEDs from thermal overstress is a little more challenging. Quite often the LED deployment fixture is small and compact with very little in the way of heat sinking – and probably no fans to provide air cooling. Therefore, most to the heat will have to be dealt with via conduction. As a result, good heat sinking must be taken into account at the design stage. Also, having an LED driver circuit that operates with very high conversion efficiency is a great help here since with higher conversion efficiency, less heat is produced as part of the conversion power losses. Thus, LED drivers with low to mid 90% efficiencies will significantly aid good thermal design.

Another interesting way to help with thermals is to have an on-chip temperature sensor as part of the LED driver circuit so that if there is a system microcontroller to monitor this temperature signal, the overall system could throttle back the current so as to allow less heat generation. Of course, this would be at the cost of reduced light output, but this is better than a complete system failure. Once the fault condition goes away, normal operation could resume.

Of course, what's good for the goose is good for the gander, or so they say. Thus, the same practical approaches as discussed for the LED are also, by extension, applicable to the LED driver circuit as well. The bottom line is that having them incorporated in the overall system is a very good idea.

LED Driver Solutions

Now that we have discussed what LEDs need to power them and what must be done to protect them so that they can have long and trouble-free deployments, I would like to spend some time showing a few LED driver ICs which have a lot of the protection mechanisms discussed above incorporated into them.

The first example is a boost topology-based LED driver which also has a number of special features to provide enhanced performance. The first one is called spread spectrum frequency modulation, which is a technique whereby the system clock is dithered so that the noise floor is lowered. The second feature is short circuit protection. Short circuit protection for a boost converter is not easy to implement, unlike a buck converter, where it is inherent due to its step-down topology and its switch between VIN and VOUT. For a boost converter to provide short circuit protection a disconnect FET must be added above the LED string – as shown by M2 in Figure 2. This P-channel MOSFET allows a way to monitor the current flowing through it, since if a short circuit were to occur, the current flowing through M2 would rise very fast. This would potentially kill the LEDs in the downstream string. In order to stop this from happening we need to monitor its current, which can be done with the sense resistor RLED above it. Thus, when a short occurs, in order to protect the LEDs, M2 needs to be turned off very quickly. Although this is not easily done, since it must be done in less than 1 micro-second, the driver can do it as shown in figure 1.

In figure 1, the top trace the is current flowing through the LED string and the middle trace is the current through the P-MOS. The bottom trace represents a transient short between rails. As can be seen, the IC turns off the P-FET, which rises to 12 A peak in just 500 nanoseconds, thereby protecting the LED string from an over current condition. Without this fast response, this current could go as high as 50 A.

The second LED driver IC example is a multi-topology triple output LED driver with an integrated rail-to-rail current sense amplifier with a voltage range of 0 V to 100 V. Each of its three channels can be configured for Buck, Boost or SEPIC mode of operation and each output can be operated autonomously with one another.

This IC adds a few features that give additional system protection, and clearly, short-circuit protection when a channel is operated in boost mode is one of them. Nevertheless, it also incorporates open LED protection which is afforded by the FBH voltage feedback pin. This driver has a wide input range of 2.5 V to 40 V making it ideal for industrial, avionic, medical and automotive LED lighting applications. Furthermore, because it is a controller, current levels in the multiple amps range are attainable.

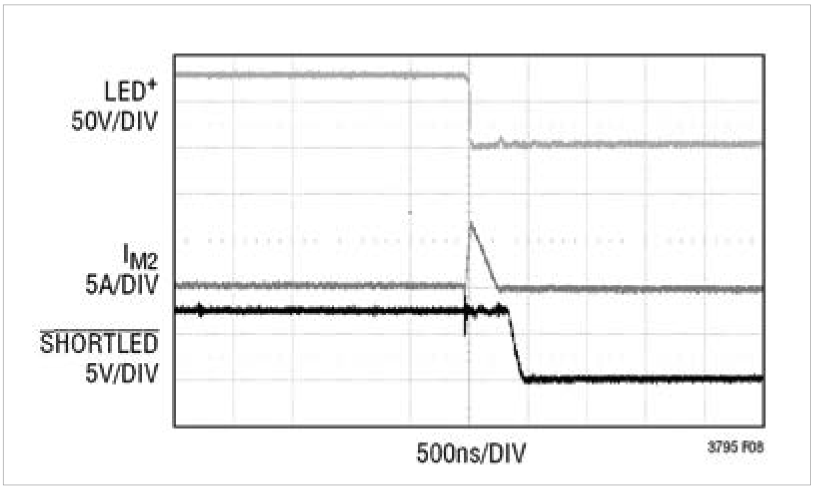

Figure 1: Short-circuit current scope photo for the LT3795

Figure 3 shows the configuration of a triple boost LED driver configuration, so each of its three channels are boost controllers. As can be seen, a P-MOS MOSFET and sense resistor are configured above each LED string. Thus, when a short-circuit condition occurs, it can quickly disconnect the LED string and protect it from being damaged.

The driver allows for latch off of hiccup mode for a restart of each channel. The mode of short-circuit protection restart can be easily programmed with the addition, or omission of R13, between the VREF and SS pins.

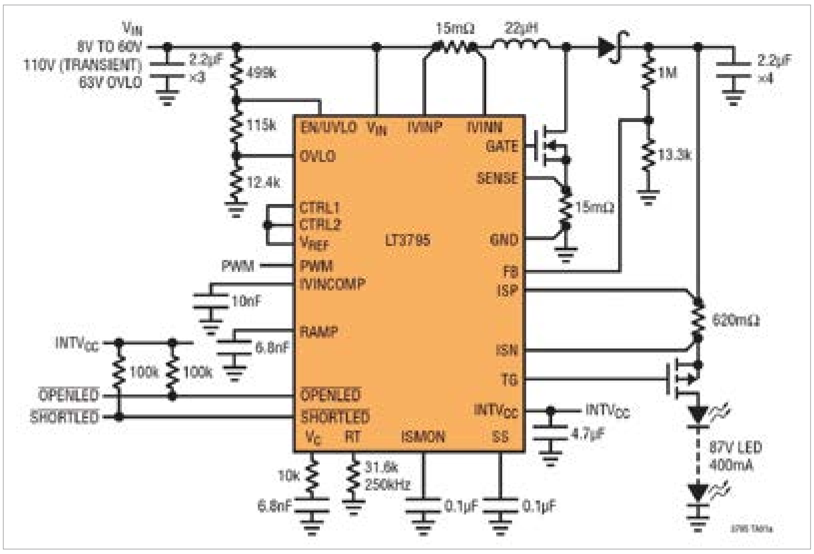

Figure 2: Boost LED driver with input current limit & spread spectrum modulation

Conclusion

It has been demonstrated that there is a great deal to consider when designing a complete system, including voltage, current and thermal constraints. Nevertheless, there are ICs available that can ease and facilitate the design needs while also optimizing all performance matrixes.

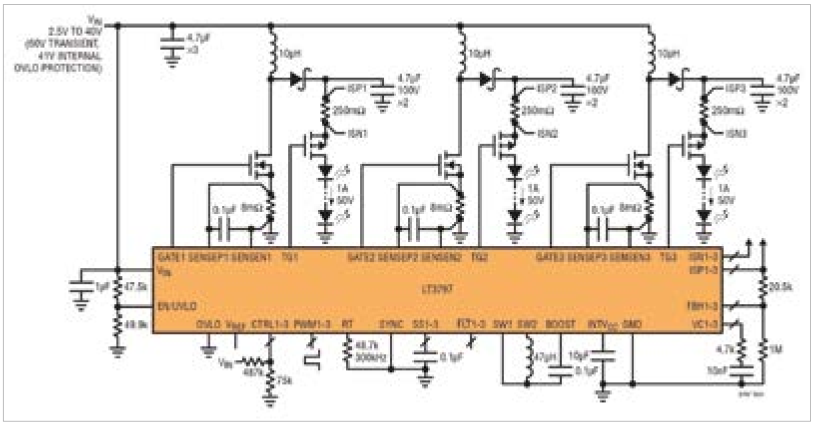

Figure 3: Triple boost LED driver with short-circuit condition protection

Reducing Time to Market for Cost-Effective AC LED Driver ICs

Today, robust and reliable LED driver design is a requirement. Individual, custom specific designs can offer clear advantages. Customized design usually needs time, but in the fast changing world of Solid State Lighting, time to market has proven to be an important issue. Volker Herbig, director of product marketing, and Tilman Metzger, business line manager at X-FAB Silicon Foundries show the method they use for solving this problem.

There are many different circuit topologies for alternating current light-emitting diode (AC-LED) driver integrated circuits (ICs). Besides finding the most suitable circuit topology, designers face other challenges such as bill-of-material limits, electrostatic discharge (ESD) targets and aggressive time-to-market requirements. This article reviews common AC-LED topologies and features such as power factor correction (PFC) and dimming in the context of a new application-specific analog library that uses a 350 nm low-cost, ultra-high-voltage (UHV) CMOS technology. The article highlights how such a silicon-proven analog library can help mitigate some critical challenges and risks for designers.

Introduction

Driving LEDs directly off AC mains power supply can be done in a myriad of topologies depending on application requirements such as size, power factor, drive current, dimming, and others. Two key questions are whether to choose an isolated or non-isolated topology, and whether the MOSFET will be integrated or external. Various driving schemes such as boost, buck-boost, flyback and buck must be considered.

With so many different circuit topologies available for AC-LED driver ICs, designers face the challenge of finding the most suitable one. They also have to deal with bill of material constraints, ESD targets and aggressive time-to-market requirements. No doubt today's AC LED applications are becoming more demanding – with a stable output current with less than three-percent variation, over-temperature protection, and multiple other added features such as PFC, flicker-free and dimming capabilities – all to be delivered at low cost, mandatory for high-volume consumer applications. Yet robustness and high reliability are also key criteria because consumers expect their new LED lights to outlast conventional bulbs.

Requirements on AC-Mains LED Drivers

From a technical foundry process selection perspective, the various AC LED driving schemes have very similar requirements (Fact Box on next page).

In addition, a state-of-the-art design support infrastructure that supports the latest EDA tool suites, and includes extensive device characterization and modeling support, is required. The quality of the Spice models plays a central role in achieving first-time-right success in analog and high-voltage designs. High quality Spice models must be supplemented by extensive device mismatch and characterization data, which includes Safe Operating Area (SOA) and high-temperature characterization of the medium-voltage and ultra-high voltage (UHV) devices. This infrastructure enables designers to create robust and reliable designs with an optimized die size and design margin based on their chosen operating conditions and environment.

COMMON REQUIREMENTS OF AC LED DRIVERS:

- A flexible modular process platform with a low intrinsic mask layer count. It enables chip designers to optimize final process complexity vis-a-vis the process options selected
- High-performance 700 V ultra-high voltage (UHV) devices with low Rdson for area efficiency such as the dual resurf 700 V UHV NDMOS that features an Rdson of only 14 Ω-mm^2. Having a low Rdson device is paramount in designs that integrate the power device because it can occupy up to 85% of the total chip area
- Efficient UHV start-up devices such as junction field-effect transistors (JFETs) or depletion UHV devices that enable low standby current designs
- Optional 400-500 V devices for the 110 V AC power net
- A 5 V low-voltage CMOS with a low-power junction-isolated standard cell library and I/O library support
- 20 V and 40 V medium-voltage devices that are UHV high-side floatable
- UHV resistors
- Precision analog devices such as high resistive poly resistors, standard resistors, capacitors, and bipolar junction transistors (BJTs)
- A reliable trimming solution that doesn't require any extra process modules
- Proven ESD and latch-up solutions and support

The Analog Building Blocks Approach

Risk management is part and parcel of every new product design, and it needs to be managed deliberately and proactively. For new AC LED driver IC designs, risk factors include the challenges of designing in a UHV process, selection of an unknown foundry process due to lack of silicon-proven intellectual property (IP) and familiarity with it, ESD concerns, time-to-market-deadlines, and many others. A newly released application-specific analog library for AC LED and AC/DC switch mode power supply (SMPS) applications addresses some of these issues. It mitigates certain risks and helps to speed up the overall chip design process by providing most of the required basic building blocks for AC LED driver ICs that designers can easily incorporate into their own projects. Therefore, it frees up time and resources, enabling design teams to focus more on their primary areas of product and design differentiation.

The new library supports isolated and non-isolated LED driver IC designs. Both topologies might use external power devices; however, due to the low Ron power devices available, monolithic approaches are conceivable and more cost-effective.

Challenges and advantages of non-isolated LED drivers are widely known. Non-isolated LED light bulb designs are very cost and space efficient, but thermal issues and EMI control are challenges. The libraries allow designers to focus on issues that make a difference. The new library has solved the issues of developing basic, robust analog building blocks for AC LED drivers in noisy environments, such as an IC attached to a rectified AC line, and thermal issues associated with LED light bulb design.

This new application-specific analog library for AC LED and AC/DC switch mode power supply (SMPS) applications comprises 14 complex cells in four groups (see Table 1). All components have been silicon proven and characterized individually and as a complete system in the form of an SMPS demonstrator IC designed by the library creators. This approach provides an additional verification quality level beyond what IP providers typically deliver. A switched mode power supply and isolated or non-isolated LED driver ICs share many of the same building blocks.

Another key objective of the new library was to demonstrate that such systems could be implemented with a minimal mask and process layer count. The majority of the cells require either just the 15 process layers of the core module or merely the optional high-resistive poly resistor module that adds one additional process layer to the core module. The core module includes two metal layers. The highest process complexity is demanded by the UHV start-up cell, which requires the core module, high res poly, the depletion option and, finally, the power metal option that enables 700 V routing on a third metal layer. The complete SMPS demonstrator IC was built with a low complexity process that has just 19 process layers. This layer count includes the UHV metal option as a third metal layer.

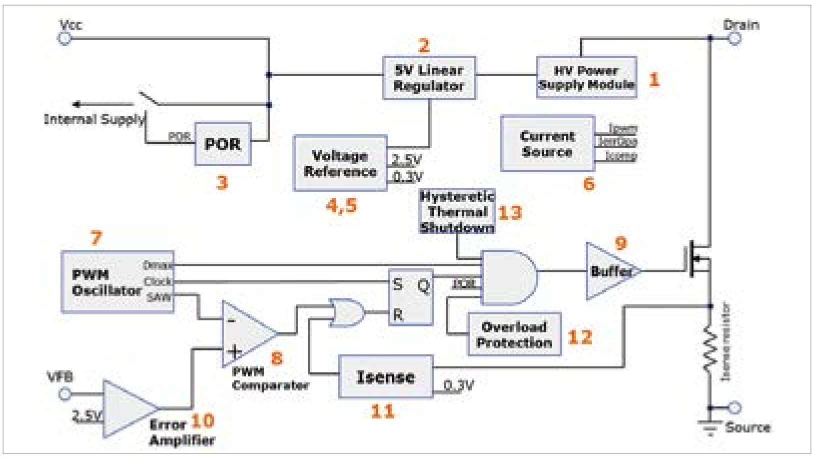

Figure 1: **Block diagram of an AC/ DC converter demonstrator IC that was used to validate the IP cells in the complete system**

Table 1: Overview of available application-specific analog library cells

Cell Group	#	XSMPS Library Cells	Cell Name	Required Modules
Supply Regulation	1	HV power supply module – up to 3mA bleed current cell from HV	xpshvbc01_5V	MOS5, HRPOLY, UHVMET, DEPL
	2	Linear Regulator 5V, 1mA linear regulator	xpslstc01_5V	MOS5, HRPOLY
	3	Power on Reset with hysteresis	xpsporc01_5V	MOS5, HRPOLY, DEPL
Reference and current formers	4	Bandgap Voltage Reference - 2.5V bandgap with high PSRR	xpsbgpc01_5V	MOS5, HRPOLY
	5	Voltage Reference buffer for bandgap	xpsbgbc01_5V	MOS5, HRPOLY
	6	Current Source	xpscsoc01_5V	MOS5, HRPOLY
Oscillators and other core cells	7	PWM Oscillator - 40kHz saw generator with Dmax, Clock and Saw outputs	xpspwmc01_5V	MOS5, HRPOLY
	8	PWM Comparator – core of AC/DC converter	xpscmpc01_5V	MOS5
	9	Output Buffer for HV power MOS	xpsswdc01_5V	MOS5
Protection	10	Error Amplifier with K=100	xpsopac01_5V	MOS5, HRPOLY
	11	Current Sense – Current limiting of HV power MOS (incl LEB)	xpscsmc01_5V	MOS5, HRPOLY
	12	Overload Protection (short-circuit protection)	xpsolp01_5V	MOS5, HRPOLY
	13	Hysteretic Thermal Shutdown - protect chip from overheating (150°C with hysteresis near 10°C)	xpstmpc01_5V	MOS5, HRPOLY

The 13 building blocks of the new library are part of four basic groups: supply regulation cells, reference and current formers, oscillators and other core cells, and protections cells. Among the 13 cells, four key cells have a higher complexity level. These are the UHV startup cell, the 5 V linear regulator cell, the bandgap voltage reference cell and the pulse width modulator (PWM) oscillator cell.

The UHV start-up cell (xpshvbc01_5V) is directly connected to the rectified AC high-voltage line – 220 V or 110 V. Transients are covered up to 750 V (BDSmin = 750 V for the 700 V NDMOS drain pad inside). The UHV start-up device has an option to be turned off after start-up. The 2 kV ESD Human Body Model (HBM) is achieved by self-protection of the UHV device, which leads to a very area-efficient design of this cell. The UHV device is bonded to the same pin as the switching HV device. Typical bleeding current is less than 3 mA.

The 5 V linear regulator cell (xpslstc01_5V) cell uses a quiescent current of 56 µA and is designed for a maximum load current of 1 mA. The output voltage only drops down to 5.036 V at 1 mA load compared to 5.037 V at no-load conditions. High- and low-voltage parts of the linear regulator are isolated from each other to better suppress external noises. The linear regulator cell also has a safety margin for potential voltage spikes up to 22V. Total bleeding current of the UHV start-up and linear regulator cells is minimized to meet regulatory requirements for stand-by currents.

The bandgap voltage reference cell (xpsbgbc01_5V) is based on the basic VBE + PTAT approach with an internal amplifier and improvement regarding precision and noise. The bandgap is designed with completely isolated devices to achieve the required performance despite operating in a noisy environment within the AC LED driver IC. A 70 dB power supply rejection ratio (PSRR) @ 50 kHz with 2.5 V reference voltage was implemented, and a temperature dependence of less than 100 ppm/°C was achieved.

The PWM oscillator cell (xpspwmc01_5V) has a 40 kHz saw generator. The duty cycle can be adjusted between 3 and 70 percent. The PWM oscillator is optimized to avoid noise introduction to the supply and ground lines.

Besides these four complex cells, the library offers a number of cells that provide protection features. The current sense cell (xpscsmc01_5V) ensures operation of the power-switching device in correct and safe mode; the error amplifier cell (xpsopac01_5V) controls stability and precision of output voltage and increases power efficiency. The overload protection cell (xpsolp01_5V) protects against short circuit failures. In addition, the thermal shutdown cell (xpstmpc01_5V) provides protection against critical overheating events.

Conclusions

A proven state-of-the-art UHV process, comprehensive design enablement and a unique silicon-proven application-specific analog library helps AC LED driver IC designers to shrink time to market, make AC-LED driver ICs more cost-effective and reduce the risk of redesigns. The approach generally frees up designers to focus on the more critical topics to achieve first-time-right designs. ■

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Discomfort Glare Perception of Non-Uniform Light Sources in an Office Setting

LED based luminaires with different luminance patterns and recently, with increasingly non-uniform luminance patterns are becoming mainstream. This trend makes discomfort due to glare an important topic. Based on an office setting and the comparison of results from three different regions, L. M. Geerdinck, J. R. Van Gheluwe and M.C.J.M. Vissenberg from Philips Research have reviewed the currently used formulae to predict discomfort glare to ascertain if they are still valid.

Visual comfort is considered as an important quality measure for indoor functional lighting and prevention of discomfort glare is therefore essential. LED based lighting systems offer many different design options and it is no surprise that fixtures with highly non-uniform luminance patterns appear on the market nowadays. The currently used formulae to predict discomfort glare (e.g. Unified Glare Rating, UGR, or Visual Comfort Probability, VCP) are still based on conventional light sources with much more homogeneous luminance patterns. However, studies done in laboratory settings showed that point array LED luminaires may provoke more discomfort glare than uniform sources. The current study was done in an open plan office application, and was repeated at different locations (The Netherlands, China and USA). Notwithstanding minor regional differences, the main results appeared similar in the three regions. In agreement with the laboratory studies, we found that luminaires with non-uniform luminance patterns and high luminance contrasts indeed induce more discomfort glare, which cannot be predicted with UGR. A better understanding of the luminance characteristics and their effects on glare perception is essential and a redefinition of the glare index seems necessary.

Introduction

High quality lighting in offices can contribute to environmental satisfaction and individual performance, making the higher costs of investment in quality lighting worthwhile [1]. Visual comfort is considered as one of the quality measures to be relevant for indoor functional lighting with LED lighting systems [2]. One aspect of visual comfort is discomfort glare, which is the type of glare that occurs when people complain about visual discomfort from bright light sources, even without impairing vision. For indoor lighting, the assessment of discomfort glare based on the Unified Glare Rating (UGR) is widely adopted [3,4]. This rating is a function of the average luminance of the apparent surfaces of the luminaires (Ln), seen from the position of the observer (accounted for by the position index pn), with viewing angle ω, and the background luminance (Lb), as expressed in Formula 1:

$$UGR = 8\log\left(\frac{0.25}{L_B}\sum\frac{L_{av}^2\omega}{p^2}\right) \quad (1)$$

For normal-sized luminaires with a reasonably uniform exit window luminance, UGR is a good predictor for the perception of discomfort glare. However, there is disagreement on how to evaluate glare produced by non-uniform sources. The applicability of UGR and other glare ratings for non-uniform light sources has been studied recently. It was concluded that all formulae are inappropriate to evaluate glare from non-uniform light sources [5].

With the introduction of efficient light emitting diodes (LEDs) in general lighting systems the discussion on glare from non-uniform light sources gained renewed attention. The small size and high brightness of LEDs compared to conventional fluorescent tubes enable lighting fixtures with much higher peak luminances and luminance contrasts than before. Earlier research showed that with equivalent average luminance, discomfort glare from a non-uniform stimulus seems to be greater than that of a uniform stimulus [2]. Most of these studies were done in a laboratory set-up where a bright light source is positioned directly in the line of sight or

Figure 1: **Pictures of the three test locations: simulated open plan office environment in Eindhoven, The Netherlands (left), Briarcliff, USA (middle) and in Shanghai, China (right)**

positioned at a single viewing angle. In a realistic situation, however, multiple light sources are mounted in the ceiling, resulting in many different angles of view of the luminaire, but typically none directly in the line of sight. Furthermore, in many commercially available LED office luminaires, the individual LEDs are not visible as a matrix of bright spots; often the light is concentrated in one or two small bright areas, surrounded by a low-brightness region. Finally, since discomfort glare can only be evaluated subjectively, the setting of the test (both the type of room and the activity of the test person) is expected to influence the glare rating. The aim of this study was therefore to examine glare perception in a representative office environment. A set of typical luminaire design parameters was varied to create relevant light settings. A first study was done in Eindhoven, The Netherlands [6]. The study was repeated in Shanghai, China and Briarcliff, USA, to investigate whether results could be reproduced in other regions.

Method

User research was performed with office employees in a simulated open plan office (see Figure 1), where 12 recessed prototype luminaires were installed. While performing simulated office tasks, participants were exposed to different, randomly offered, light settings that varied in luminance patterns of the exit window, beam shape and desk illuminance. They judged the different light settings by rating to what extent the brightness of the luminaires was acceptable, on a 6-point semantic scale (1=highly unacceptable, 2=unacceptable, 3=slightly unacceptable, 4=slightly acceptable, 5=acceptable, and 6=highly acceptable).

Light Settings

In the first part of the study 30 by 30 cm luminance patterns were offered, resembling luminaires with different degrees of LED visibility, varying from 'homogeneous' to 'spotty', as illustrated in Figure 2 (top row). The maximum luminance varied from ~10 kcd/m2 for the 'homogeneous' pattern up to ~300 kcd/m2 for the 'spotty' pattern. These three patterns were offered at three desk illuminance levels (Edesk = 350, 500 and 700 lux) and with two types of beam shape: 'Lambertian' and 'Cut-off' (Figure 3).

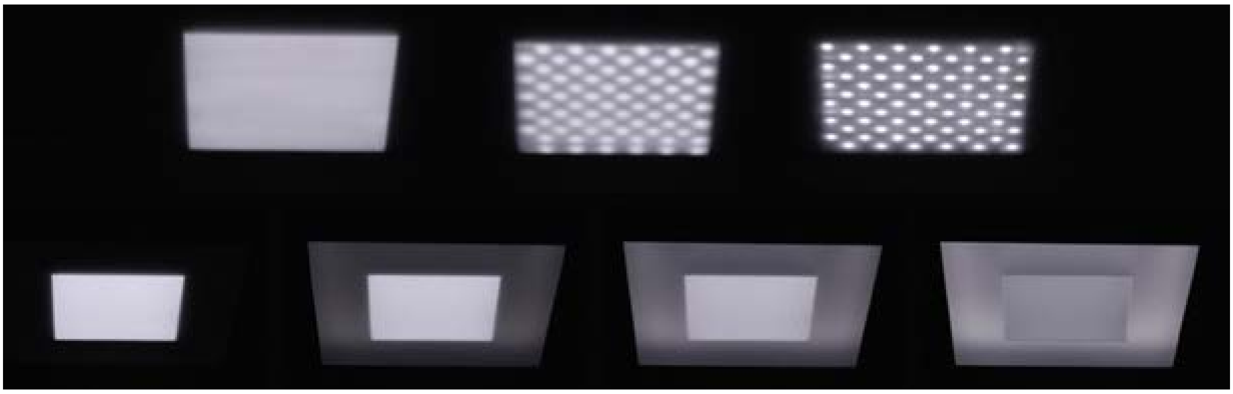


Figure 2: **The different lighting patterns that were used in the analysis**

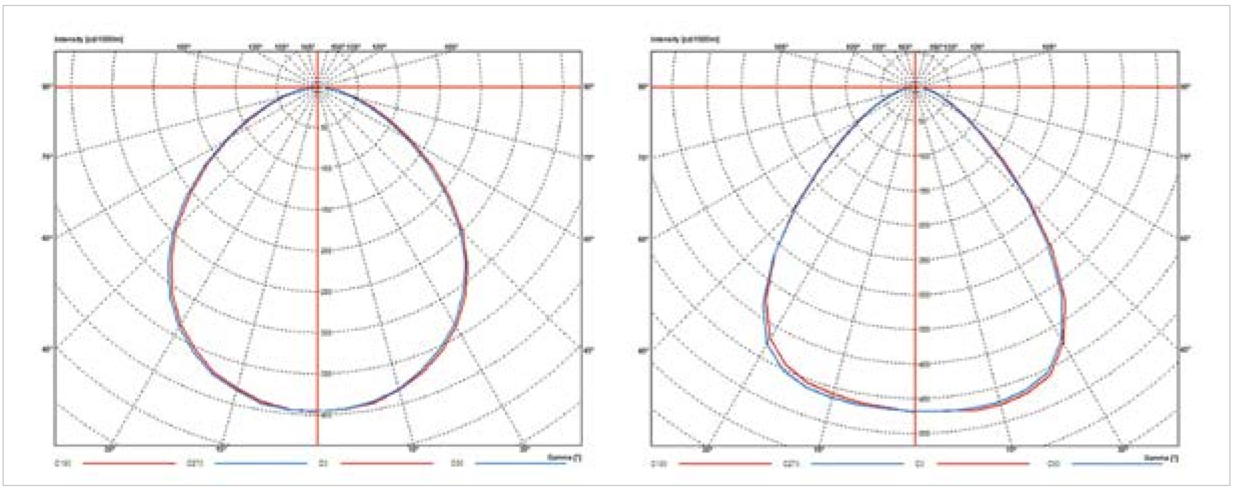


Figure 3: **Polar diagrams of the two different beam shapes used. Left: broad diffuse beam (Lambertian like). Right: beam with reduced intensity at large angles (cut-off)**

In the second part of the study 60 by 60 cm luminance patterns were used, resembling office luminaires consisting of the 30 by 30 cm center surrounded by a luminous rim. During the test the ratio of the luminance of the rim to that of the center was varied in 4 levels:

- no rim
- minimal rim
- middle rim and
- homogeneous (Figure 2, bottom row)

These patterns were offered at two task illuminances (500 and 700 lux). Finally, one setting with a spotty exit window (without a rim) was added in this second test as reference point to the 'spotty' setting from the first part of the test.

Results on Acceptable Brightness

Effect of spottiness

When the exit window changed from homogeneous to spotty, the acceptance of the brightness decreased. This means that glare perception increases with an increasing degree of spottiness. This cannot be derived from UGR calculations, since luminaires of the same size and intensity distribution all have the same UGR. In figure 4 this acceptance (percentage of people) is plotted for the three different degrees of spottiness, for each region where the study was performed (Netherlands, USA and China). This decrease in acceptance is obvious for the data of Netherlands and USA. Moreover, the people in the USA seem to be more critical in general, by showing a lower acceptance compared to the results in the Netherlands. In China however, the degree of spottiness does not seem to have a large effect on the acceptance in this test situation. We do not have a clear explanation for this difference between regions.

Yet, in all regions it was found that the effect of spottiness was more pronounced for the settings with a Lambertian beam shape compared to the settings with a cut-off beam shape. This is understandable since the settings with a Lambertian beam shape have a higher intensity at the viewing angles which are more likely to cause glare (20-30 degrees in our test room) compared to the settings with a

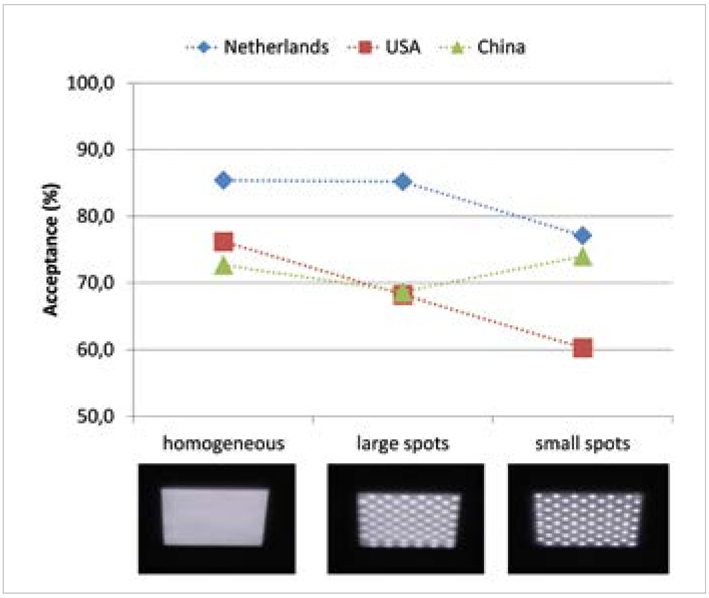


Figure 4: Acceptance of the brightness of the luminaires for three luminance patterns (homogeneous, large spots and small spots) as shown in the first part of the study, for the three different study regions (The Netherlands, USA and China)

Figure 5: **Acceptance of the brightness of the luminaires for four different luminance patterns (no rim, minimal rim, middle rim, homogeneous), as shown in the second part of the study, for the three different study regions (The Netherlands, USA and China)**

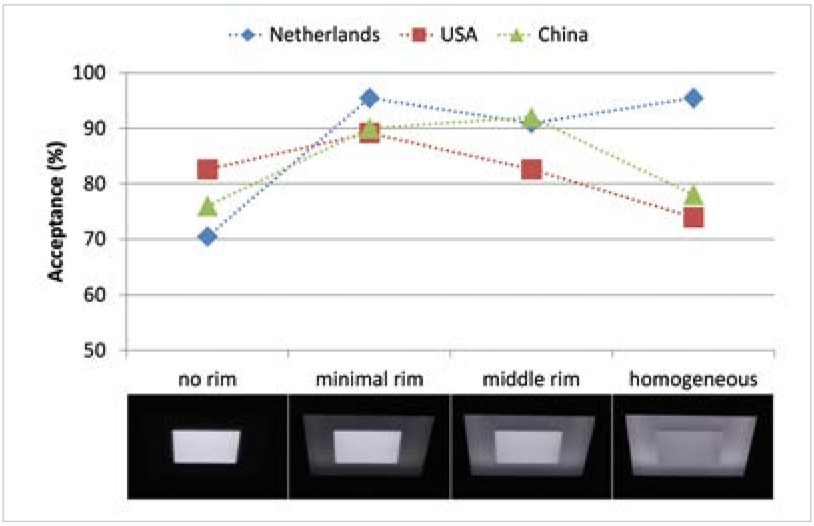
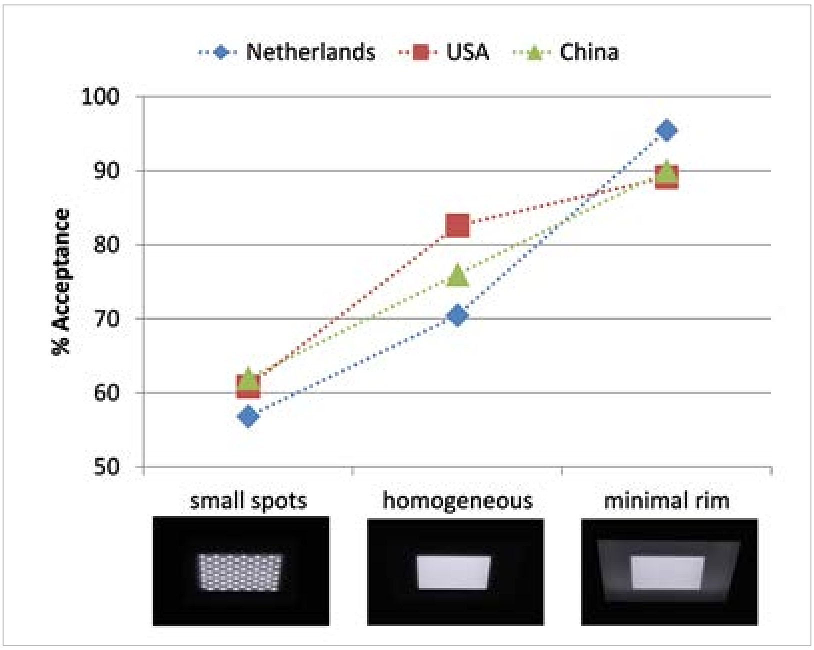


Figure 6: **Acceptance of the brightness of the luminaires for three different luminance patterns (small spots, homogeneous, homogeneous with minimal rim), as shown in the second part of the study, for the three different study regions (The Netherlands, USA and China)**



cut-off beam shape. They also exhibit the associated higher peak luminance and contrast in the exit window. We also found in all regions that the acceptance results of the 350 lux settings were systematically lower than those from the higher illuminance settings (500 and 700 lux), although the peak luminance of the spotty setting was lower and one would therefore expect less glare (and higher acceptance levels). During the study we explicitly asked for people to judge ‘the brightness of the luminaires’, but they may have weighed the darker room appearance in their judgment, by scoring these settings as less acceptable. In conclusion: especially at higher illuminance (500 -700 lux) a spotty exit window is perceived as glarier than a uniform exit window.

Effect of luminous rim

The addition of a minimal luminous rim around the 30x30 cm center ($L_{rim}/L_{center} \approx 1/10$) resulted in an increased acceptance of the brightness, in all regions (Figure 5). This is in agreement with expectations based on UGR calculations since the addition of the rim increases the surface area of the exit window, resulting in a decreased average luminance. Increasing the rim luminance further did not improve the acceptance. The results of the test in the USA and China even seemed to show again a decrease in acceptance, especially for the setting with the same luminance of rim and center. Although we do not have a clear explanation for this result, we believe that also aesthetic aspects started to play a role, since the appearance of the aperture surface was a bit strange (not entirely uniform). People might have taken this aesthetic aspect into account when judging the ‘acceptance of the brightness of the luminaires’, by giving this setting a lower score.

We can conclude that although increasing the size of the of the luminaire exit window reduces perceived glare (in agreement with UGR), the resulting luminance of the exit window does not need to be uniform: adding a low level luminance in the rim may already be sufficient to reduce perceived glare.

Combining both spottiness and luminous rim

In the second part of the study a setting with ‘small spots’ (without rim) was also included as a reference for the first part. Figure 6 summarizes the results of the three relevant luminance patterns: the acceptance significantly increases when changing the luminance pattern from ‘small spots’ to ‘homogeneous’ and the addition of a (minimal) luminance in the rim further significantly increases this acceptance. [6]. These results are consistent throughout the three different regions.

When comparing these results with the graph of the first part of the study, it can be seen that the absolute values of acceptance differ: in the first study, the acceptance of the ‘small spots’ setting is not as low as in this second part. A response bias might explain this effect: while evaluating a lighting setting people use the ‘acceptance’ scale in relation with the frame of reference, rather than as an absolute scale. In the first part of the study the ‘small spots’ setting was compared with a ‘homogeneous setting without rim’ as the most comfortable setting. But in the second part of the study, the additional rim created a much more comfortable setting, resulting in a devaluation of the ‘small spots’ rating. In future experiments one should be aware of this effect. The percentage acceptance can only be interpreted as a relative weighted number. To mitigate this effect, one should consider offering a couple of standard light sources, anchoring scenes, with a known acceptance score.

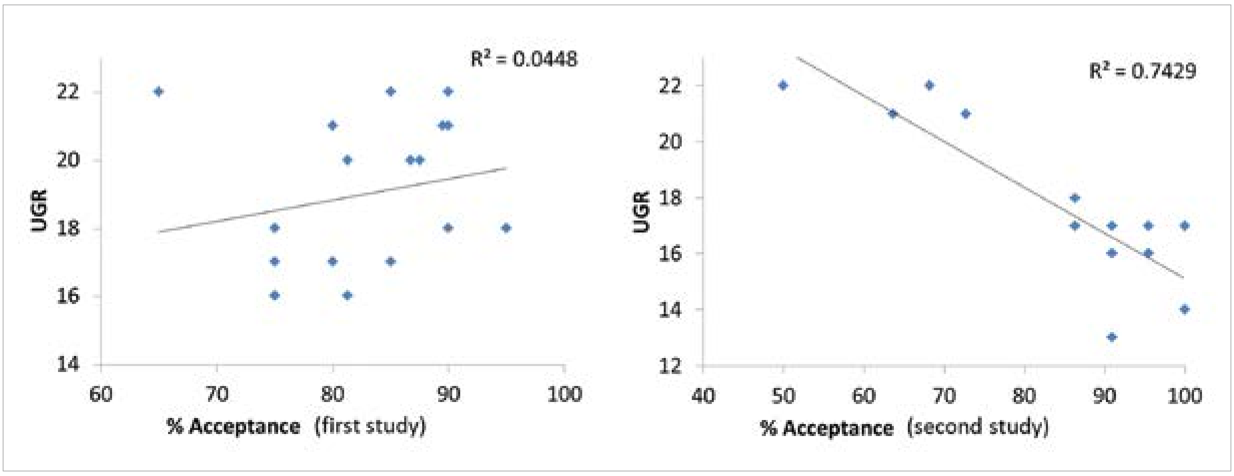


Figure 7: **Calculated UGR of the different settings plotted against the percentage acceptance, for the first part of the study, effect of spottiness (left) and the second part of the study, effect of luminance rim (right)**

Unified Glare Rating (UGR)

For all light settings the UGR was calculated using Dialux [7], using measured luminaire intensity distributions and was found to vary between 13 and 22 (for office environments UGR<19 is recommended). In figure 7, the UGR is plotted for each setting against the obtained data of the subjective glare rating (expressed in the percentage acceptance). The results of the first part of the study (effect of spottiness) did not show any correlation with UGR (R2 = 0.04) clearly indicating that in case of a non-uniform luminance pattern, the UGR is a bad predictor of glare perception. The results of the second part (effect of luminous rim) showed a reasonable correlation with UGR (R2=0.74). Apparently, for center-to-edge luminance variations as applied in our study (limited to contrasts lower than 1:10) the UGR still has predictive value.

Conclusion

There is a need to better understand the influence of the luminance characteristics of non-uniform luminaires on the perception of glare. To what extent do peak luminance, luminance contrast and spatial luminance distribution of non-uniform sources contribute to the increased glare perception? Since the UGR does not take into account non-uniformities, a new or modified glare index seems essential for a reliable prediction of discomfort glare.

Acknowledgements:
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Concept of a Time-Proven LED Luminaire Design and Manufacturing Process

While doing successful business has always been a tough job, it has become even tougher with the introduction of solid-state technology into the lighting industry. Besides high quality criteria, time to market has become a crucial success factor. Innovative processes and tools and, last but not least, a talented and inspired team are necessary. Angela Betancourt presents an approved process used by Lumitec Lighting.

The LED lighting industry is advancing across a variety of platforms. New technologies make it possible for manufacturers to create products suitable for numerous applications. The process of developing and manufacturing LED products has evolved allowing for faster product development and market introduction. Taking an idea and transforming it into a high quality finished product can be done with increased accuracy with the use of machines, prototype tools, and sophisticated computer software.

Introduction

LED lighting technology allows for any specific niche with the vast LED lighting segment to use these resources to their advantage. In the marine LED lighting segment, for example, where products need to be made to withstand a harsh environment, companies like Lumitec rely on their talent and specific tools to conceptualize and manufacture a quality durable product.

Bringing products to market quickly and often is critical to being successful and gaining market share. There are five general phases to this process: idea, design, prototype, production/manufacturing, final product, and packaging.

It begins with an idea that can come from several places of inspiration such as customer feedback, technological improvement, team insight, or personal reference. The customer is a great place from which to draw inspiration for a new product or an improvement to a product. Is there a specific product selling better than others? What has been their feedback? What have they asked for? New ideas can originate by answering these questions. Another place from which to draw new product ideas is within the team.

Generating Ideas

Nearly everyone on the engineering team at Lumitec, a manufacturer of extreme LED lighting solutions, is a boater and the company outings frequently involve fishing or cruising on the company's 63 foot Bertram Sportfish. Playing the role of the customer creates an environment for fresh ideas to develop. What would make a current product better than it already is? What if this light were a different color, size, shape, or waterproof?

Defining the Product

Once the idea is generated it's important to ask what the main function of the light will be. Will it fulfill a specific need or is it just a cool idea? Will there be demand for the product? What problem does it solve? What will it cost to bring this product to market? Thinking about the SWOT analysis is as applicable in any business as it is in the development of LED lighting. Understanding the lights purpose will determine whether it's worth using resources for. What is the financial impact? What is the realistic time it will take to execute this idea to completion? Is now the right time? If it feels right move forward; don't get stuck with analysis paralysis. The next phase is design.

Figure 1: Thorough analysis and evaluation of the mechanical design is done during group meetings. Possible improvements, changes addition or removal of features are discussed

Figure 2: Rapid prototyping equipment like professional 3D printers occasion high initial costs, but allow early evaluation of the design and provide a good ROI due to time savings

Mechanical Design

Designing a visual model of this product can be done using CAD programs or CAE programs. This form of industrial art makes a 2D or 3D computer model that brings the feasibility of the product to life. During this phase, modifications can be made and documented based on engineering analysis; creating a clear layout for the development of the product. This phase is also an opportunity to compare competitive product features and implement or remove a particular aspect that might not evolve into a practical application.

Prototyping

Following the design phase, the prototyping stage begins. Technology has taken prototyping to new levels. The Mojo 3D printer from Stratasys is an example. Used correctly it can be an invaluable tool that saves days, or even weeks that would have normally been used by more traditional manufacturing methods. While the initial cost of the printer is high for a small company, the ROI due to time savings and other factors can quickly add up. This is the optimal time to make changes and adjustments.

3D printing makes it possible to physically hold an early stage version of the light. If something is wrong in the design it can be fixed. Whereas in the past, valuable materials and resources had to be used, and sometimes wasted if things went wrong. Another costly but good investment is in tooling for injection molds or castings. Having these tools on premise reduces time and allows for a faster turnaround.

Electronics Design

While the lights' physical appearances are being tweaked and the final casing designed, the lights' electrical components should also be created. The circuit design can be based on microprocessor technology. Lumitec, for example, uses proprietary control software to ensure reliability. Testing the circuitry against widely accepted military and/or industrial standards is important for a product that needs to withstand challenging environments. Tests can include, EMI, transient voltage, under and over voltage.

Optical Design

The process for the optical design should follow a comparative level of testing. Using an integrating sphere is the optimal way to test overall luminous efficiency and lumen output. The calibrated and NIST-traceable equipment is one of the most sophisticated light measurement devices. Besides that, more detailed information on beam pattern and light color consistency need to be evaluated. Different methods and measurement tools like spectro-goniometers can be applied.
A proprietary approach consisting of a set of cameras in combination with complex image-processing software has been developed in-house to satisfy the company's stringent criteria. The tool uses an array of specially calibrated cameras to capture images of a luminaire in a carefully-controlled environment. A powerful workstation then analyzes more than 20 million data points to help engineers refine and optimize optical systems. While presenting an overwhelming amount of information, it will produce accurate results. This is another expensive investment, but worth having on site for convenient accessibility.

For standard comparisons, there are organizations such as the Illuminating Engineering Society of North America (IESNA) that have developed tests to measure various LED lighting components like the lifespan for LED lighting products. This can serve as a general benchmark for comparisons, dependant on the specific niche the LED light is being developed for.

Figure 3:
Underwater lights belong to the most strained products that have to withstand a very harsh environment. Therefore quality requirements are very high and painstaking testing has to be performed

Figure 4:
Water testing is a standard procedure that needs to be performed for every single piece

Preparation for Production

With the physical design, electrical configuration, and optical testing completed, the product is ready to be produced for market. A process that ensures consistency for each and every product is imperative. Every product needs to be tested in extreme situations similar to those it will be exposed to on the market. Testing every light before it's packaged will weed out defective products and maintain a standard across the board.

Testing and Quality Control

What will this light be used for? The marine industry is one example. LEDs in this segment undergo vigorous water tests including submersion and salt corrosion. If the LED light is meant to be used in an environment of extreme weather; testing it in extreme hot and cold conditions would be appropriate. Finally, all products should be manually inspected before packaging.

Final Thoughts

Challenges and setbacks during this entire process should be expected. Whether in the design phase or the production phase, problems can arise. If this happens, focus on finding a solution as quickly as possible and utilizing machinery and technology to make any necessary changes. Ensure that access to all the supplies and materials needed to get the product completed is easily available and accessible.

The process of taking a product idea and turning it into a high quality product customers will love, depends on a good team and the incorporation of the latest technologies. ■

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Main Image: Arno Grabher-Meyer, LED professional

Product: **Philips MR16 LED spot**

The Philips MR16 LED spot cross-section image shows a state-of-the-art construction for this type of lamp: driver, thermal management, LEDs and optics

Next LpR

Trends & Innovation
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Short Overview

LED Technology:

High Color-Rendering, Full-Visible-Spectrum LEDs

The first wave of conventional white LEDs primarily focused on lumens per Watt. Currently, LEDs are catching up in regards to light quality using different approaches. Based on "Quasi-bulk" GaN substrates, originally developed for the Blu Ray laser diode industry, violet-pumped, full-visible-spectrum LEDs have been developed. Challenges and advantages will be discussed. ■

Tunable Solid-State Lighting to Improve Light Quality

In the hospitality sector, the ability to reproduce natural light and halogen dimming characteristics is paramount. It will be explained how it can be achieved, what the latest approaches are that made this possible, and how accurate state-of-the-art products are. ■

Electronics:

Lighting & Building Automation Technologies

After the transition from traditional lighting technology to LED, the controls market is now the "Wild West". While compromised by incompatibility or complicated setups, controls offer a lot of valuable opportunities. These opportunities will be explained and an overview of the trends towards the interaction of lighting control with other building functions will be given. ■

Thermal Management:

Improving the Lifetime of Components Using Heat Conducting Plastics

Heat conductive plastics have made great progress and now offer great design opportunities when correctly processed. They are available with different properties and can help to extend the lifetime of components and products. The relevant parameters will be explained and it will be shown how to select correctly and apply properly. ■

Optics:

Optics with a Different Bi-Polar Emission Pattern

The market asks for suspended light fixtures that offer a batwing type distribution, for indirect illumination, as well as a semi-Lambertian distribution downward for direct illumination with low glare. The options of a new approach with individual light extraction features will be explained. ■

subject to change

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