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## NEWS & ANALYSIS

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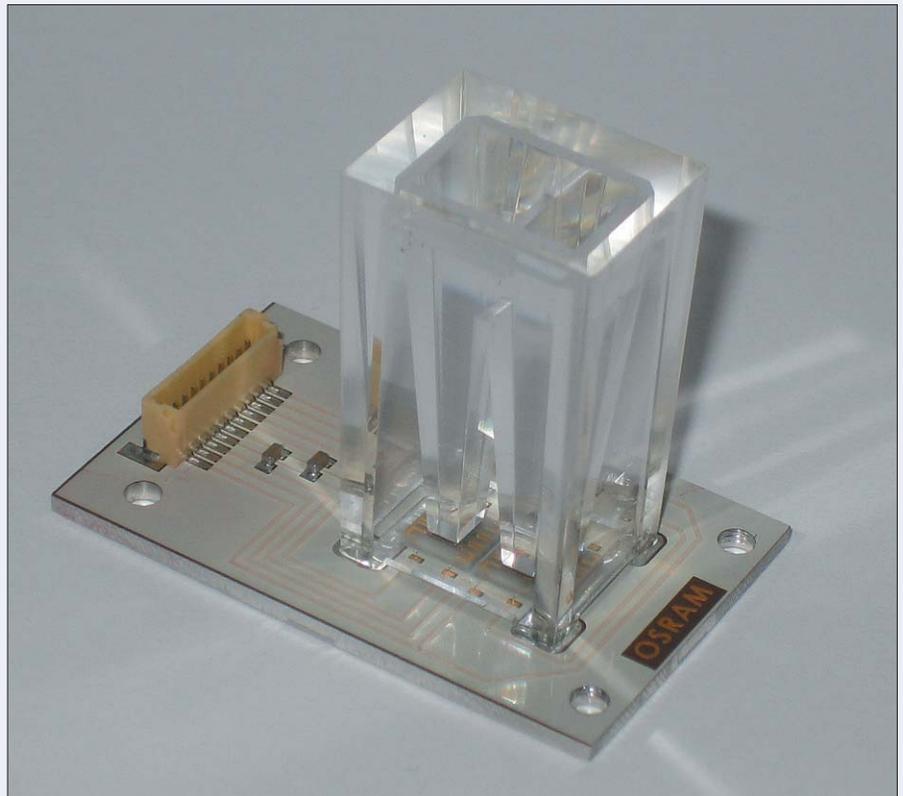
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## SUPPLIERS DIRECTORY

**An Appendix to the LED Suppliers Directory published in our April issue p18**

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Miniaturized projection systems are an emerging market for high-brightness LED light sources. **p21**



The new Boeing 787 Dreamliner makes use of several LED-based lighting systems. **p25**



Journee Lighting introduced a new dimmable LED-based lighting fixture at Lightfair. **p13**

**VEHICLES****Lexus aims to be first with LED headlamp design**

Lexus says that its 2008 LS 600h L hybrid luxury sedan, scheduled for launch in the US in spring 2007, will be the world's first vehicle to use LED headlamps for high-beam and low-beam functions.



Other articles on the **VEHICLES** channel of our website ([www.ledsmagazine.com/articles/features/1/5/4](http://www.ledsmagazine.com/articles/features/1/5/4)) include:

- Ficosa has developed a rear-view mirror for cars that uses LEDs to provide both a turn signal and a front position lamp.
- PerkinElmer has supplied LEDs to Visopia for a Scion concept car, while a new demo vehicle from Saab uses just three Ostar LEDs from Osram for the headlights.
- Articulated Technologies has established a joint development agreement with Grote Industries to manufacture robust LED-based lighting products for vehicles.

**PATENTS****Super Vision dispute with Color Kinetics rumbles on**

Any thoughts that we had seen the end of the patent dispute between Color Kinetics (CK) and Super Vision (SV) were dispelled in April when SV filed a new lawsuit accusing CK of infringing its US patent no. 4 962 687 (the '687 patent) entitled "Variable Color Lighting Systems." Things have been quiet for about six months since SV suffered several legal defeats (see [www.ledsmagazine.com/articles/features/2/10/16](http://www.ledsmagazine.com/articles/features/2/10/16)). A previous lawsuit filed by SV claiming infringement of the '687 patent was dismissed when the court determined that SV, rather than being the owner of the patent, was a non-exclusive licensee. SV has now resolved these issues and is trying again.

The '687 patent provides for broad coverage in its claims for the use of networked, centrally controlled, addressable color-changing lighting systems incorporating pulse width modulation and variable digital control circuitry, which can vary the intensity of individual lamp/light source elements to generate numerous colors. Unfortunately for SV and its many supporters, the patent does not specifically make reference to LEDs.

In May, the US District Court in Massachusetts awarded CK around \$1.4 million in costs and attorneys' fees in its successful patent litigation against SV dating back to August 2005. CK has said that it will not seek damages for willful infringement. SV intends to appeal the award, as well as the original summary judgment decision. As in previous rulings the judge was unequivocal in support of CK, stating "I conclude without hesitation that this case is 'exceptional,' and that Super Vision has perpetrated a 'gross injustice' by its [outstandingly bad] abuses of the discovery phase and [annoying] litigation strategy. An award of attorneys' fees is appropriate to remedy the 'gross injustice' Color Kinetics has suffered."

- More details: [www.ledsmagazine.com/articles/features/1/4/8](http://www.ledsmagazine.com/articles/features/1/4/8)

**Color Kinetics adds more licensees**

Color Kinetics has licensed its worldwide LED patent portfolio to Martin Professional, a leading manufacturer of automated entertainment lighting based in Aarhus, Denmark, which is looking to introduce multicolor LED-based lighting systems in time for the PLASA tradeshow in London this September. Christian Engsted, Martin's president and chief executive officer, said, "We recognize that LEDs will prominently impact on the global lighting market and believe that leveraging Color Kinetics' developed patent portfolio will strengthen our competitive position in this new and highly anticipated market direction for Martin."

As this issue went to press, we learned that the US subsidiary of Dialight plc has become the latest licensee for CK's LED color-mixing patent portfolio.

- More details: [www.ledsmagazine.com/articles/news/3/6/18](http://www.ledsmagazine.com/articles/news/3/6/18)

**LIGHTING****Vertical integration: Osram creates LED Systems division**

German lighting giant Osram has formed a new global LED Systems (LS) division to stand alongside its existing divisions including Opto Semiconductors, one of the world's largest LED manufacturers. The new LS organization is intended to bridge the gap between individual systems components – such as LEDs, heat-sinks and optics – and complete LED lighting systems, and to accelerate the adoption of LED technologies for lighting.

Until now, Osram Opto Semiconductors has sold components and other divisions of Osram have assisted customers in developing products. Now, via the LS organization, Osram will offer a more integrated series of products to OEMs and distributors. The LS product portfolio will include standard as well as custom LED system solutions for Osram's OEM partners. Examples of recently introduced standard products include the Coinlight Ostar, which combines a 6-chip Ostar package with an integrated 38° secondary optic and an integrated thermal management system. The product is dimmable and produces 420 lm. Other examples include the LinearLight Dragon system (see photo (b), p12), which contains 6 Dragon ThinGaN LEDs on a linear board and is available with heat sink and optics accessories, or even mounted inside a linear fixture.

Klaus Ziemssen, who heads the global LS division, told *LEDs Magazine* that Osram's goal is to sell products with the highest possible level of integration. However, some OEMs have the motivation and expertise to integrate components by themselves. To facilitate this



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approach, hopefully using Osram LEDs, the company has also announced its new “LED Light for you” organization, which enables integrators to find partners with expertise in thermal management, optics, drivers and other crucial aspects of building LED systems (see [www.LEDLightForYou.com](http://www.LEDLightForYou.com)).

The introduction of Osram’s LS division puts the company more in line with its great rival, Philips, which now has an in-house LED supplier, Philips Lumileds, and produces solid-state lighting modules and components as well as luminaires. Likewise, lighting manufacturer Zumtobel has achieved vertical integration through the formation of not one but two new companies: Lexedis, an LED manufacturer that is a joint venture between Toyoda Gosei (part of Toyota) and Tri-donicAtco (part of Zumtobel); and Ledon Lighting, which is developing LED-based products for Zumtobel and another of its brands, Thorn, as well as for external companies.

- *Lighting* magazine reports that the Vienna Stock Exchange gave Zumtobel a thumbs-up with a successful initial public offering that valued the company at £625 million (\$1.15 billion). The Zumtobel family will retain 30% of the equity.

### CONFERENCES

## EuroLED conference unites European LED community

Following on from small-scale LED seminars in the past two years, Photonics Cluster (UK) succeeded in creating a forum for the European LED community via its EuroLED conference, which took place on 16–17 May in Birmingham, UK. Next year’s event has already been penciled in for 6–7 June 2007.

Day one concentrated on technology, with contributions from LED makers and packaging companies such as ceramic substrate manufacturer Kyocera (see figure 5, p16) and silicone supplier NuSil Technology. Other sessions focused on optics, test & measurement and safety, as well as competing technologies such as electroluminescence and OLEDs.

Sven Murano of OLED manufacturer Novaled expects the first OLED lighting products to reach the market in 2008 and that, following advances in performance, design and manufacturing, OLED will become a major lighting technology in the next decade.

Keith Scott from Philips Lumileds discussed how to compare apples with apples when selecting LEDs and the trade-offs that need to be considered between luminous flux, efficacy, color-rendering index (CRI) and lifetime. Scott thinks that there could be two separate pathways for the development of warm white LEDs: firstly high CRI (90+) with an output of around 20+ lm that can replace 15–20 W halogens and incandescents, and secondly products where the focus is high flux (30+ lm) with a lower CRI of 70+.

Streetlighting was high up on the agenda, with Mark McClear of Cree identifying this as one of the “big white” applications that are emerging now and will drive the demand for white LEDs. As the efficacy of white LEDs increases, fewer devices are required per fixture, reducing the initial cost, which is often a barrier for LED applications. Another emerging market is low-bay lighting. McClear said that Cree will shortly introduce white XLamp devices with an output of 70 lm and efficacy of 60 lm/W.

In the exhibition area, Advanced LEDs and Whiteley Electronics demonstrated sophisticated white LED-based streetlights with solar



Low-bay lighting seems set to be an early adopter of LEDs. Lighting Science Group has installed its LED-based fixtures over a factory production line at this beta site, replacing conventional fluorescent lighting. LEDs offer longer lifetimes (50,000 versus 4000 hours), which reduces maintenance time and costs, and also have higher overall efficiency, since the LED fixtures are designed to operate without a reflector.



Phillip White of DTI Global Watch Service discusses white LED streetlighting with Dennis Lockwood, MD of Whiteley Electronics, at the recent EuroLED event.

power options. A wide range of other applications – signage, emergency lighting, variable messaging systems, machine vision – were discussed in detail on the second day.

### Missions report from Japan and the USA

The UK’s Department of Trade and Industry (DTI) through its Global Watch Service ([www.globalwatchservice.com](http://www.globalwatchservice.com)) recently sent two missions to Japan and the USA in November 2005 and March 2006, respectively. The team reported their findings on 18 May as a follow-on to EuroLED. Some of the findings from Japan were discussed in a recent article on the *LEDs Magazine* website ([www.ledsmagazine.com/articles/features/3/5/3](http://www.ledsmagazine.com/articles/features/3/5/3)) and the highly detailed reports from both missions can be downloaded as PDF files at [4](http://www.global-</a></p>
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# Leading the lighting revolution.

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47 lumens/watt at  
350mA drive current

Reduced thermal  
resistance to 8°C/watt

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**CREE**   
LED Light



At EuroLED, Radiant Research demonstrated an LED luminaire with a uniform circular beam (far right), showing that LEDs can be used in professional entertainment lighting to replace conventional discharge lamps. The luminaire was a converted Strand Lighting Cantata unit that incorporated special designs for the LED spatial arrangement and heat sink, and a reflector and optical system to collect over 95% of useful light emitted from the LED source.

[watchservice.com/Pages/ThreeColumns.aspx?PageID=102](http://watchservice.com/Pages/ThreeColumns.aspx?PageID=102).

Unlike Europe or the US, the Japanese LED industry is highly organized. The Japanese LEDs Association has over 70 members who share detailed roadmaps and a wide understanding of LED technology. This has even filtered through to public awareness, stemming mainly from the energy-saving potential of LEDs. In the US, energy consumption is not a major driver and US companies tend to be market-driven and focused on short-term objectives. While a number of industry organizations exist, such as NEMA's solid-state lighting group or the NGLIA, membership is not particularly widespread.

### PATENTS

## LED suppliers jostle for prime position in the IP race

More activity has taken place in the patent arena at the LED device level. In April, Toyoda Gosei and Philips Lumileds signed a cross-licensing agreement via which they will "respect and mutually utilize each other's technologies in order to further advance the market for LED products." Both of these major LED suppliers have separate cross-licensing agreements with Nichia dating back to 2002.

Nichia dropped its patent actions against Epistar, saying that its Taiwan-based rival has promised to respect Nichia's IP rights. Nichia also said that it has "put an emphasis on Epistar's merger with United Epitaxy Co. (UEC)" because the latter company has "maintained a good business relationship with Nichia for years."

In May, Seoul Semiconductor signed a \$40 million LED chip supply agreement with Cree and also licensed a significant white LED patent owned by Cree.

In the same month, Nichia initiated patent actions against a Taiwanese manufacturer, Everlight, while Osram Opto Semiconductors is suing Kingbright. Osram claims that Kingbright is

infringing a number of its patents relating to white LEDs and surface-mount devices, with particular emphasis on patents that cover the use of phosphor down-conversion technology used in the manufacture of white LEDs. Significantly, Kingbright recently signed an agreement to license phosphor conversion material from US company Intematix and another agreement to license the above-mentioned white LED patent from Cree. In relation to the latter agreement, *LEDs Magazine* wrote that "Kingbright's license with Cree does not protect Kingbright from claims of infringement by other patent owners," and Osram was eager to stress the same point in its press release.

All of which complicates the task facing the Intellectual Property Secure Lighting Alliance (IPSLA), an industry organization formed by BridgeLux, an LED supplier, and Intematix, a phosphor manufacturer. Companies seeking to join the IPSLA are required to certify that qualified patent attorneys have reviewed their products and processes, with reference to existing IP, and found them to be non-infringing at all levels. The intention is to provide an assurance to customers that the member company's products are not likely to attract any patent litigation. Although we see this as a positive move, the larger LED makers in particular are likely to make their own independent decisions as to whether they think infringement has occurred.

• More details: [www.ledsmagazine.com/articles/features/1/8/21](http://www.ledsmagazine.com/articles/features/1/8/21)

### CONSUMER PRODUCTS

## Sylvania products emphasize benefits of LED lighting

Demonstrating the widespread penetration of LEDs into battery-powered consumer lighting products, Osram Sylvania has launched a new range of LED flashlights and lanterns.



These include the LED Wind Up Flashlight (\$14.99) which, when hand-cranked for one minute, yields up to 30 minutes of bright LED light. The LED Power Failure Light (\$12.99), designed for use during natural disasters and other emergencies, is three lights in one: it acts as a night light, a power failure light that turns on automatically when the power goes out and a bright LED flashlight. The DOT-it™ LED Light (\$9.99) is a portable LED light that can stick to most surfaces and features three bright, white LEDs that deliver 100 h of light.

• More details: [www.ledsmagazine.com/press/12672](http://www.ledsmagazine.com/press/12672)

# LEDs move to the next level at Light+Building

Strong walking shoes and a pair of sunglasses were a good idea for anyone trying to see all the LED-related products at Light+Building...but it was a worthwhile journey, writes **Tim Whitaker**.



Philips introduced an LED spot incorporating a Luxeon K2 LED, with an adjustable projector head only 31 mm in diameter.



The FLY downlight from Italian lighting manufacturer DGA, which illuminated its 130 m<sup>2</sup> booth entirely with white LED fixtures.

Light+Building, the biennial trade fair held this year in Frankfurt, Germany, on April 24–27, is a huge event, but making the effort to see the many companies working with LEDs, from device makers to luminaire manufacturers and everyone in-between, was a valuable experience.

Compared with the same event two years ago, first impressions were positive. There was less emphasis on the flashing, brightly colored and, some might say, tacky-looking lighting fixtures and more emphasis on the areas that are going to help LEDs move gradually into mainstream lighting markets – white LEDs with very high brightness and efficacy, integrated modules and plug-and-play systems, and well-engineered white LED-based lighting products.

## Bridging the gap

Among LED makers, the most extravagant claims were made by Seoul Semiconductor, who promised by the end of the year a single-die white LED producing 98 lm at 350 mA with 84 lm/W efficacy, as well as a warm-white device producing 67 lm at 57 lm/W. However, as a poster on the Lumileds stand highlighted, the important parameters are not the datasheet numbers provided by the LED makers, but the real numbers measured by the user when the LEDs are placed into a system.

This is one aspect of an issue that remains highly prevalent for LEDs

in lighting; there is a huge disconnect between LED makers and lighting companies. There are numerous aspects to this problem, for example the lack of standards for LEDs, and the frustration experienced by lighting manufacturers in not being able to obtain a reliable and long-term supply of LEDs with consistent color properties.

Cycle times are also widely different. Like other semiconductor companies, LED makers regularly make significant improvements to the performance of their devices and may then phase out lower-performing and older devices. However, this creates problems for lighting manufacturers who have brought an LED-based design to market (with all the associated tooling and marketing costs) and want to be able to offer the same product for a number of years.

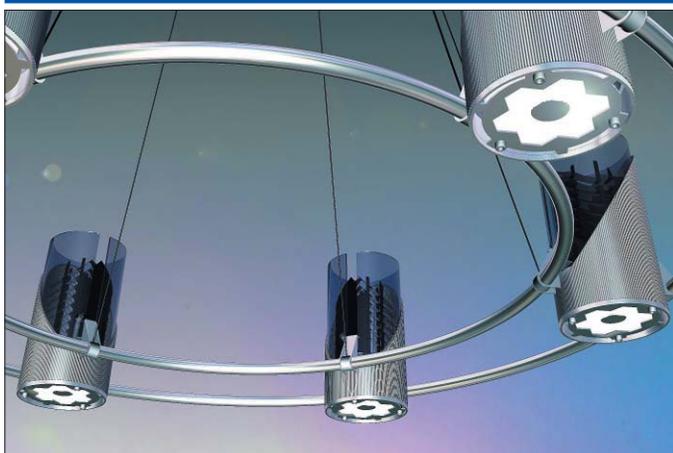
## New business models

No-one wants or expects the LED makers to stop innovating but does this mean that “traditional” lighting companies need to become more nimble and innovative in terms of introducing new designs? As the two worlds of LEDs and lighting gradually converge, perhaps the advantage will shift to LED-specialist companies such as Color Kinetics and others with a similar mindset.

One option for lighting companies is vertical integration to gain control of the LED supply chain. Philips through its acquisition of full con-



(a) LEDs were very much in evidence at Light+Building in Frankfurt, Germany. (b) Philips made a statement with a huge stand. (c) Advanced LEDs showcased its Hammerhead streetlight. (d) The Sixcess LED bulb from CML Innovative Technologies replaces incandescent alternatives. (e) Siteco exhibited a luminaire containing 49 high-power Ostar LEDs, with a combined output of 20,000 lm. (f) Zumtobel showed luminaires based on TIR's Lexel technology. (g) Citizen Electronics provided sunglasses for visitors viewing their ultra-bright LED products. (h) Spectral GmbH showed a flat, circular luminaire containing 30 white and 5 RGB LEDs, and can be configured as a pendant or as a floor luminaire. (i) Color Kinetics unveiled its EssentialWhite series of entry-level white LED fixtures without advanced intelligent control. (j) The brightly colored Neo-Neon booth. (k) IMS won an energy-saving award for its Haze luminaire. More info on these products at [www.ledsmagazine.com/articles/features/3/5/5](http://www.ledsmagazine.com/articles/features/3/5/5).



Spectral GmbH exhibited an LED luminaire based on Lixel technology licensed from TIR Systems. Ledon and Zumtobel also had a similar Lixel-based product.

Control of Lumileds has this vertical integration, and its rival Osram, already a major LED supplier, has now unveiled an LED Systems division which will make products with higher levels of integration (see News, p2).

Zumtobel, another major lighting manufacturer, has gone as far as creating two LED-related subsidiaries. Ledon Lighting is wholly owned by Zumtobel and will develop LED-based products for its parent and for external customers, while Lexedis is a joint venture between

Toyoda Gosei and Tridonic who manufactures high-power light sources. Lexedis is using the name "XED" to denote a second-generation of LED light source that are more suited to the requirements of the lighting industry – driven by the demands of its parent Zumtobel. Lexedis' white products will be offered at certain color temperatures with no binning, using technology that matches the composition of the phosphor with the properties of each LED chip.

### Confidence in LEDs

Cree, who had a super-bright booth lit with their own white LEDs, conducted a survey among 123 trade show exhibitors and found that half thought that LED lighting will represent more than half of their sales or installations by 2009. Also, 61% thought LED lighting would replace fluorescent lighting in office and commercial spaces within five years.

Assuming this to be a representative survey, the lighting industry seems confident that LEDs will become increasingly significant, although some reservations will no doubt remain. We look forward to comparing progress in two years' time (when the organizers have promised to provide bicycles for members of the press). ●

### Links

On our website:

**LEDs in Frankfurt: Light+Building in review**

[www.ledsmagazine.com/articles/features/3/5/4](http://www.ledsmagazine.com/articles/features/3/5/4)



## SMART MULTI WATT LED LIGHT ENGINE TECHNOLOGY

Design, development and manufacture of multi-wavelength LED Light Engines across UV ranges, Visible and NIR-IR wavelength for:

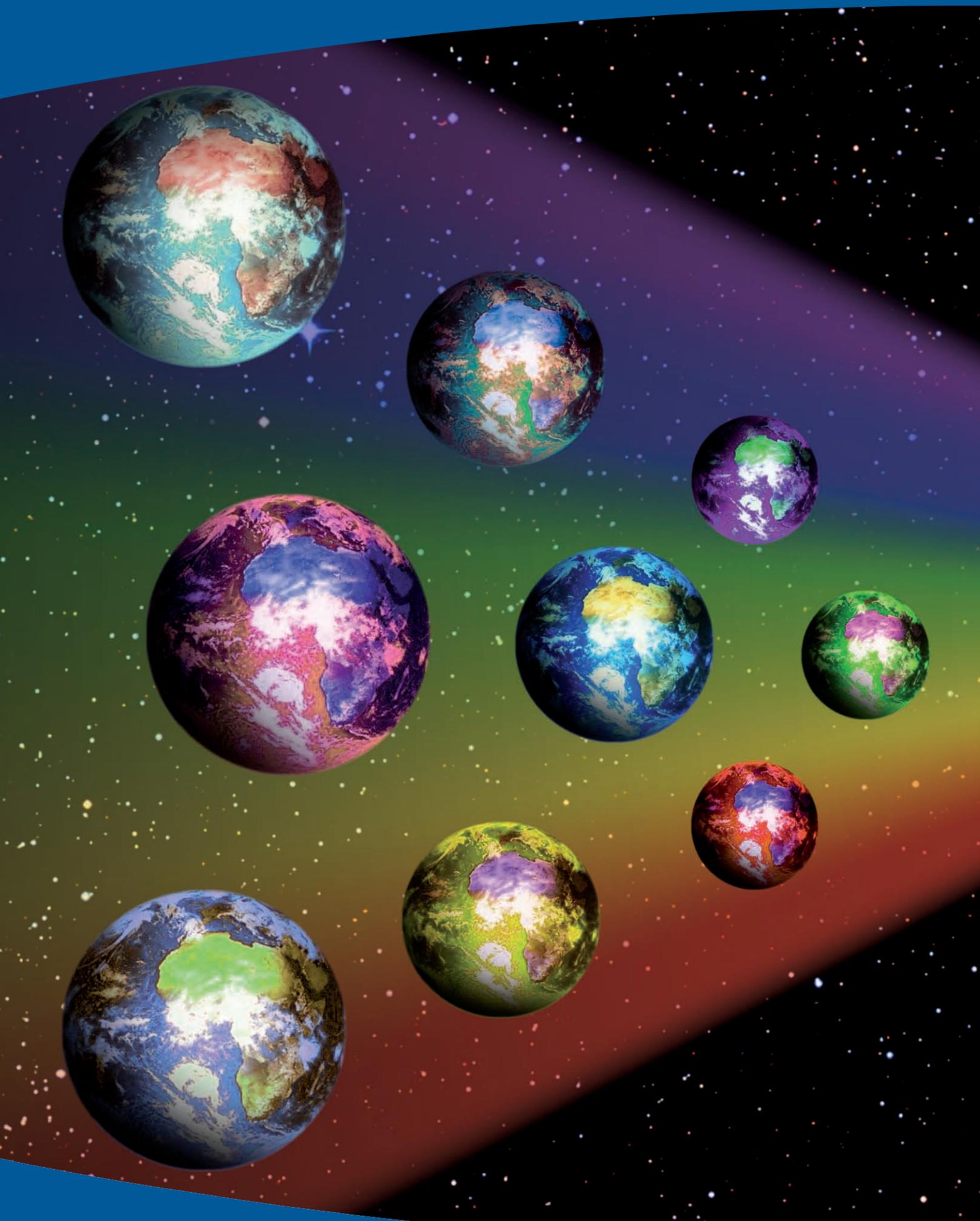
- Entertainment Lighting
- LCD Backlighting
- Projectors and Displays
- Architectural Lighting
- Non-Destructive Testing (NDT)
- Curing of Polymers and Resins
- Forensic Science and Security
- Task Lighting
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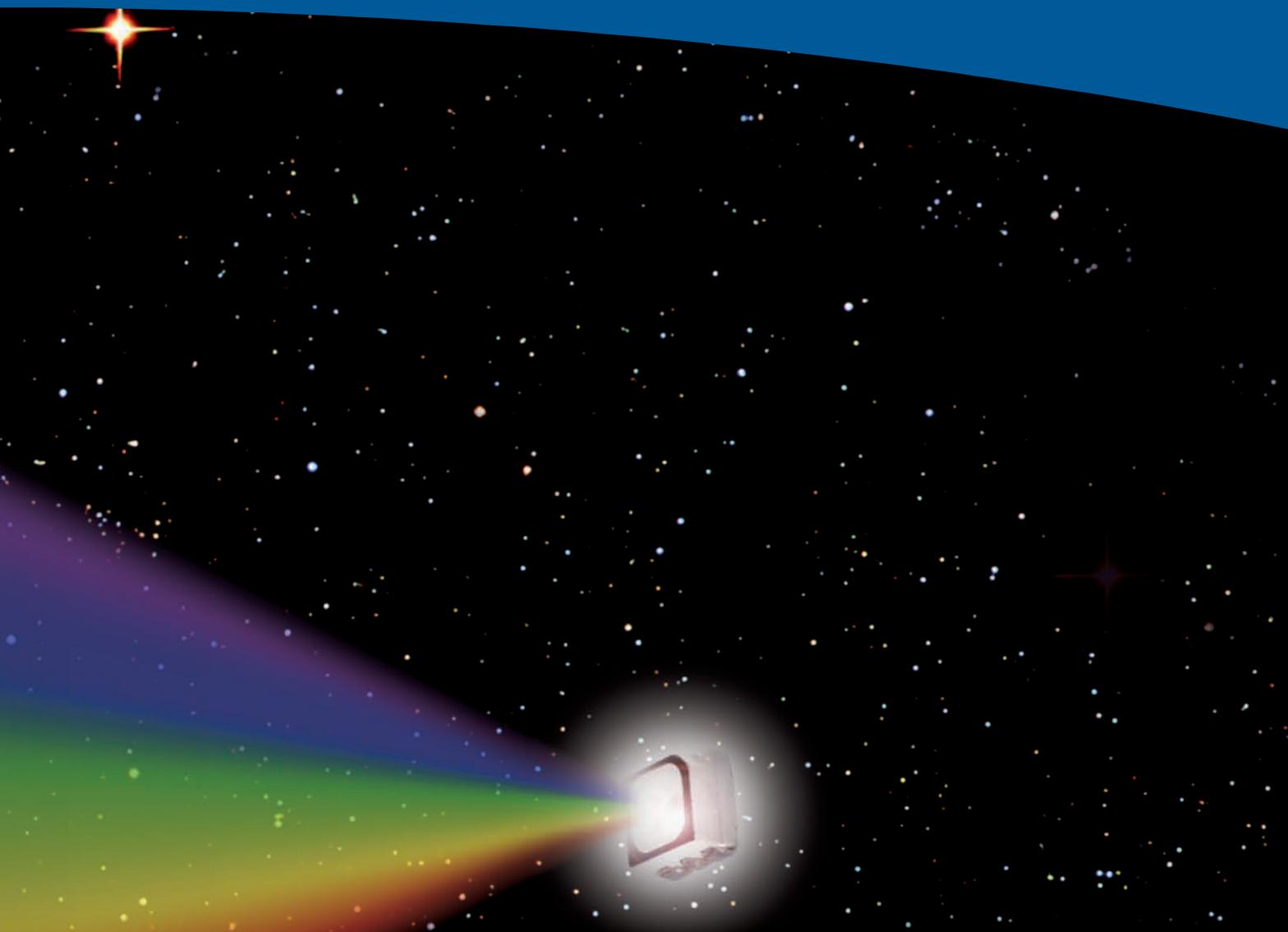
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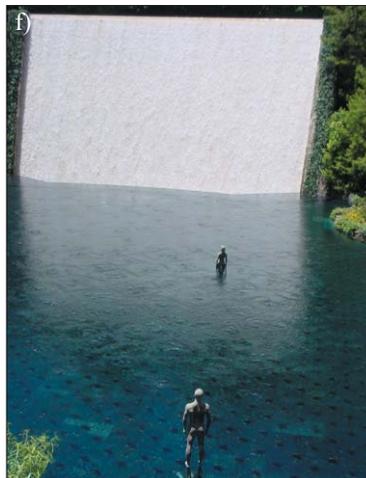
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LEDs in Las Vegas: (a) *Le Rêve*, a show at the Wynn Resort, makes fantastic use of 350 LED lighting fixtures from Color Kinetics. (b) Osram launched a number of LED modules at Lightfair. (c) Renaissance Lighting made a big impression at Lightfair with its Evo lighting fixtures. (d) Lighting Services Inc publicized its new LumeLEX lighting fixture along the Vegas Strip. (e) John and Rick of Nyx Illuminated Clothing show off their LED jacket. (f) The Lake of Dreams contains 4000 submerged LED fixtures – see [www.ledsmagazine.com/articles/news/2/7/9](http://www.ledsmagazine.com/articles/news/2/7/9). (g) Giant LED screen outside the Wynn Resort. (h) Journée Lighting's debuted its Lotus LED fixture with simple onboard control. (i) The layered walls of the Stack bistro at the MGM Grand contain embedded CK LED fixtures. (j) Downtown Vegas is covered by a giant LED screen that comes alive at night – see [www.ledsmagazine.com/articles/news/1/7/6](http://www.ledsmagazine.com/articles/news/1/7/6). (k) Marl International's LED Evangelist Ron Anderson searches for new LED customers.

# LED manufacturers unveil latest advances at lighting shows

Two major lighting shows – Light+Building in Germany and Lightfair International in the US – provided the opportunity for LED manufacturers to demonstrate their progress in developing high-power LEDs for the lighting market, writes **Tim Whitaker**.

Predictably, LEDs were very much in evidence at Light+Building (L+B), the biennial trade show in Frankfurt, Germany, that attracted almost 135,000 visitors, and Lightfair, the much smaller annual US show, held this year in Las Vegas. The European event was notable for the massive scale of its booths especially among major players such as Philips and Osram, who had a much smaller presence in Vegas, and numerous Europe-based companies such as Zumtobel that didn't appear at Lightfair. A review of LED lighting at L+B appears on p7. Many LED suppliers chose to exhibit at one or both events and some of the highlights are described below.

## Citizen Electronics

Anticipating temporary blindness among its booth visitors and L+B, Citizen Electronics provided sunglasses for those wishing to view its high-power LED products. The company has focused on incorporating multiple, smaller (and higher efficacy) LED chips into its various package designs. Its ORION package (CL-652S series) contains eight LED chips and emits up to 85 lm with a power consumption of 1.2 W, equivalent to 70 lm/W.

Citizen also has in development a series of products (CL-L100 series) made up of linear strips containing 24 LED chips. These prototypes were first unveiled in summer 2005 – see [www.ledsmagazine.com/articles/news/2/6/24](http://www.ledsmagazine.com/articles/news/2/6/24). Each strip produces 245 lm and consumes 3.5 W, also equivalent to 70 lm/W.

Citizen showed some possible configurations including a bulb-style arrangement (see photo g, p8), which produces 2450 lm. This could be used for automotive forward lighting when placed within a suitable reflector to direct all the light in the forward direction. The company also showed a linear arrangement, suitable for backlighting displays, with LED strips mounted on individual metal substrates and wired together, as well as an area-lighting prototype.

## CML Innovative Technologies

CML-IT introduced a new range of power LEDs, available in 1, 2.5 and 5 W versions, and in a range of colors. The company also showed a number of innovative products including its Connect&Glo series, designed to make solid-state lighting easy by offering LED lighting units that can be easily connected together. The company's Sixcess range are a drop-in LED replacement for 6S6 filament lamps used in amusement parks (see figure 1). The layout of the LEDs has been designed to mimic the appearance of the filament.

CML-IT has also developed, in collaboration with LED Specialists, a new range of LED lights for up-market marine interiors, which use

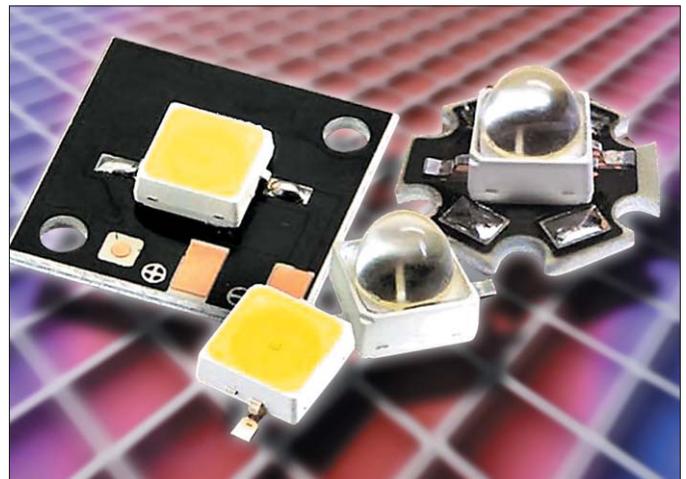


Fig. 1. High-power LED range from CML-Innovative Technologies.

very little power and increases the battery life when the yacht's generator is switched off. The Sydney model is an LED reading light while the Newport spotlight is designed for general overhead lighting. The low-heat output of the devices makes them suitable for mounting inside expensive wood panels or close to other materials that could be damaged by heat.

## Cree LED Lighting

Sunglasses were definitely required on the Cree booth at L+B, which was lit by multiple high-brightness white XLamp LEDs. These previously announced devices yield 57 lm at a drive current of 350 mA, with an efficacy of 47 lm/W. The improved XLamp packages have a reduced thermal resistance of 8 °C/W and an expanded color temperature range of 2700–10,000 K.

Mark McClear, Cree's director of marketing for lighting LEDs, told *LEDs Magazine* that the improved performance of its XLamps has crossed a threshold where they are now appropriate for a number of lighting applications, for example street lighting. "It's now possible to use fewer LEDs, reducing the cost," said McClear. "As with traffic signals, the reduced maintenance costs associated with LED solutions provide a big advantage over other light sources."

In the slightly longer term, low-bay/high-bay lighting, for example in parking garages or warehouses, is also likely to emerge as an important application, driven mainly by reduced power consumption (see News, p4). →

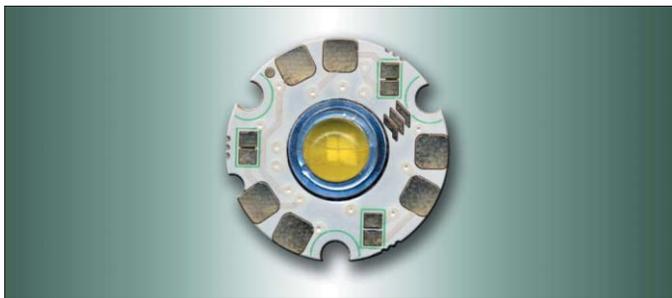


Fig. 2. Lamina's new product lines: Atlas (top);Titan (bottom).



Fig. 3. The powerXED from Lexedis measures 6.5 x 6.5. x 6.0 mm and has a luminous flux of 60 lm at 700 mA.

## GELcore

Predictably, GE Lighting had a low-key presence at L+B but at Lightfair the company took prime position by the main door of the exhibit hall. GELcore had big displays covering its signage products and refrigerator lighting, but it took a bit of effort to see the company's white LED products for lighting. The LEDs were unveiled at last year's Lightfair but have still not been launched commercially; this could happen by the end of 2006 or early next year.

GELcore exhibited 1.2 and 3.6 W LEDs each comprising a 10 mm diameter dome on a 1 inch aluminum PCB. Inside the dome are one and three chips, respectively, emitting at the near UV wavelength of 405 nm together with a phosphor blend that GELcore can tune to give the desired CRI or color temperature.

The 1.2 and 3.6 W LEDs produce 40 and 120 lm, respectively, with a CRI of 80 and a color temperature of 3500 K. A 12 W device with an output of 350 lm had a larger diameter dome, likely containing nine chips. The junction-board thermal resistance is 10 °C/W. GELcore will probably release products at three color temperatures – 3000, 3500 and 4100 K – with CRI values determined by market demand.

## Lamina Ceramics

Lamina Ceramics launched two new ultra-bright LED lighting engines, Atlas and Titan. Atlas, an upgrade to Lamina's BL-4000 product line, can provide 119 lm at 700 mA with 5.4 W power in warm white (3000 K), and 175 lm in daylight white at 4700 K.

Titan was promoted as "the only 3000 K, 25 W warm-white LED-light engine available on the market". The output is over 600 lm in roughly 2 inch<sup>2</sup>, and is equivalent to 50 W PAR-30 wide-angle halogen floodlights. The 4700 K version produces more than 1200 lm within a 60° projection angle.

• More details: [www.ledsmagazine.com/articles/news/3/4/16](http://www.ledsmagazine.com/articles/news/3/4/16) and [www.ledsmagazine.com/press/12440](http://www.ledsmagazine.com/press/12440).

## Lexedis Lighting

Lexedis Lighting, the joint venture between Toyoda Gosei and TridonicAtco, is using all-inorganic packaging and flip-chip mounting in its XED products (see [www.ledsmagazine.com/press/12213](http://www.ledsmagazine.com/press/12213)). These benefit from excellent color stability, thanks to a process that matches the properties of the phosphor layer to the characteristics of each individual chip. Eventually, Lexedis says that it will offer white LEDs at certain fixed color temperatures, without binning.

Lexedis' powerXED is a 3 W diode and is claimed to be the world's smallest at 6.5 x 6.5 x 5 mm, producing a luminous flux of 60 lm at 700 mA. The color-rendering index exceeds 80 and the ceramic packaging has a thermal resistance of 9 °C/W. Two variants with beam characteristics of 40 and 60° are available.

The miniXED (figure 3) measures 3.4 x 2.8 x 1.15 mm and generates 35 lm at a current of 500 mA. In the summer, Lexedis plans to launch the nanoXED, a 600 µm chip inside a 2 x 2 mm package that will produce 20 lm in cool white and 15 lm in warm white, with a current of 150 mA.

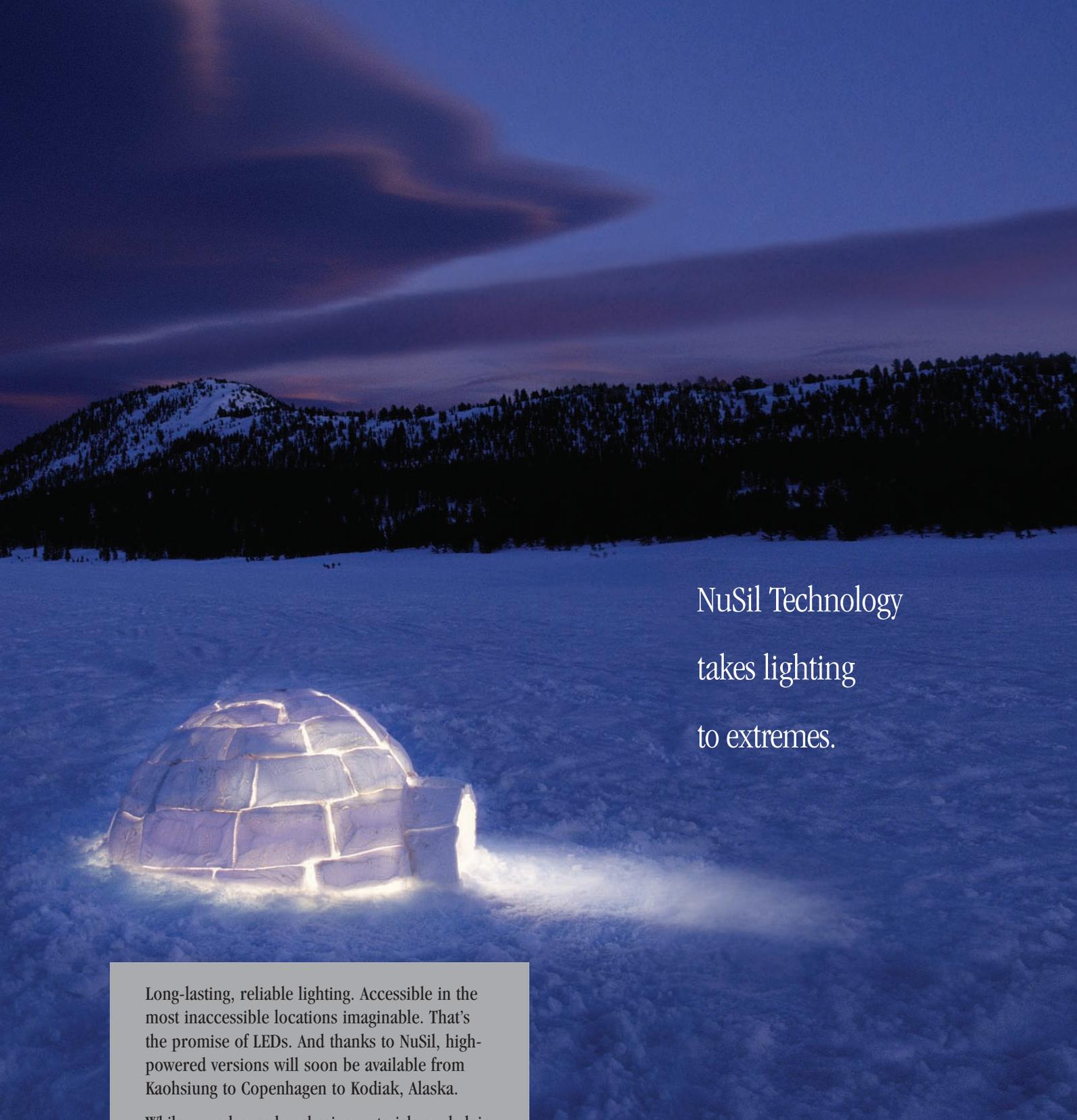
## Lumens Semiconductor Lighting

Lumens Semiconductor Lighting, a Korea-based LED maker, exhibited its C-Core and C-Seed high-power emitters at L+B. Both products have four LEDs mounted onto a metal core PCB. The C-Core produces 120 lm in white with a drive current of 350 mA and has a viewing angle of 120°. The C-Seed, which looks very much like Osram's original Ostar, has a typical intensity of 165 lm at a current of 500 mA.

## Nichia

While some manufacturers have a "one size fits all" approach to their LED portfolio, Nichia has recognized that different applications require different products. The Japanese company plans to introduce not one but three new "1 W" LEDs this summer, beginning in July with its 083 series, aimed at area-lighting applications. This device has extremely high efficacy by virtue of using six small LED chips, each driven at 50 mA. The maximum junction temperature is 120 °C and the thermal resistance is 10 °C. Cool-white devices are expected to produce 65 lm at 300 mA, equivalent to 60 lm/W, while warmer-white versions will produce 60 lm (56 lm/W) at 4600–3800 K, 56 lm (52 lm/W) at 3800–3175 K and 52 lm (48 lm/W) at 3175–2500 K.

In August, Nichia will launch the 075 series Dome-type LED, containing a single 800 µm chip with a conformal phosphor coating. These LEDs are suitable for point-source applications such as spot-lighting or where a collimated beam is required, and produce 45 lm at 38 lm/W

A glowing igloo made of ice blocks sits in a snowy landscape under a twilight sky. The igloo is illuminated from within, casting a warm glow. The background shows snow-covered hills and a forest of evergreen trees.

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in cool white when driven at 350 mA. The maximum junction temperature of this device is 130 °C and the thermal resistance is 11 °C/W.

Later this year, Nichia will upgrade its Rigel product line with a 350 mA, 1.2 W Power Rigel product in a ceramic package, designed for demanding environments such as automotive applications. The current 0.5 W Rigel produces 20 lm (38 lm/W) at 150 mA in cool white and 15 lm (30 lm/W) at 150 mA in warm white.

## Optek Technology

TT Electronics Optek Technology chose Lightfair to unveil several new visible LEDs, including an RGB version of its 10 W Lednium 3D package. The packages are assembled by first placing individual chips into cups and then mounting the cups onto the 3D leadframe. Optek has now adapted these cups into standalone 1 W packages. Designated the OVTL01LGA Series, the 1 W surface-mount LEDs offer high luminance (up to 38 lm), a full 120° viewing angle and are available in amber, blue, green, red and white. They also have a thermal resistance of just 2 °C/W.

• More details: [www.ledsmagazine.com/articles/news/3/6/7](http://www.ledsmagazine.com/articles/news/3/6/7).

## Osram Opto Semiconductors

Osram's big announcements at L+B centered around the launch of its LED Light for You organization, and the LED Systems division, which will offer integrated LED products and bridge the gap between components and complete LED lighting systems (see News, p2).

Tucked away on the Osram stand at Lightfair was Osram Opto's Platinum Dragon, the 4 W version of the Golden Dragon single-chip device. The cool-white Platinum product (warm white is not yet available) contains ThinGaN blue LED chips and can handle up to 1000 mA. The maximum junction temperature is 135 °C (compared with 125 °C for the Golden product) and the thermal resistance has been reduced to 8–11 °C/W from 15 °C/W.

The Osram stand also featured several fixtures using the company's LEDs, including track lights from Lighting Science Group that use Ostar Lighting LEDs. Elsewhere, pendant lights incorporated color-on-demand technology, which allows color to be selected by changing the phosphor blend. Also, the booth featured a prototype 4-inch-aperture downlight from Color Kinetics, containing six Ostars. The dimmable fixture will be available at a color temperature of either 2700, 3000 or 4200 K, and will produce 900–1000 lm.

## Philips and Lumileds

Many customers got their first view of the Luxeon K2 device, that was announced earlier this year. Lumileds was keen to emphasize that the way to compare LEDs is not just to look at datasheet numbers but to evaluate performance in real systems. Coinciding with Lightfair, Lumileds issued a press release extolling the benefits that can be achieved by operating K2 devices at 1000 mA in situations where 350 mA just doesn't provide enough light – see [www.ledsmagazine.com/articles/news/3/6/2](http://www.ledsmagazine.com/articles/news/3/6/2). Lumileds' Keith Scott told *LEDs Magazine* that Lumileds are likely to upgrade the performance of its warm-white LEDs this summer and plans to introduce a warm-white K2 next year.

While Luxeon devices are single-chip high-power packages, Philips announced that it has developed a product in which four chips (red, green, blue and amber) are mounted together onto a board. The "Intuos Multi-die" technology is designed to provide much more effective color mixing, providing a homogenous spot effect without color shadowing.

• More details: [www.ledsmagazine.com/press/12175](http://www.ledsmagazine.com/press/12175).

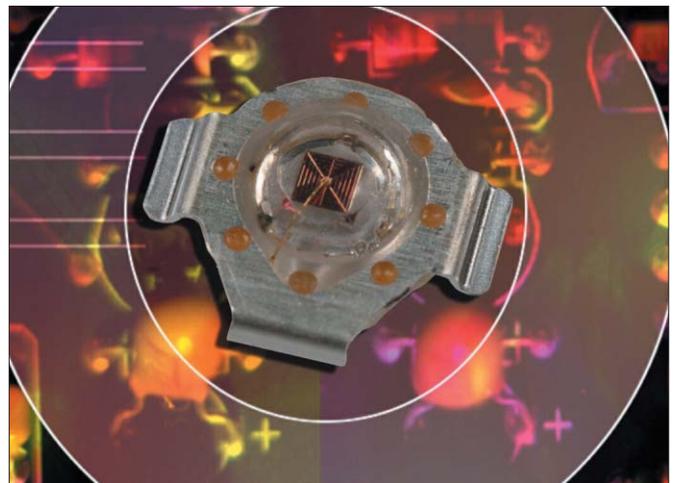


Fig. 4. Optek Technology's OVTL01LGA series of 1W LEDs have a very low thermal resistance of 2 °C/W.



Fig. 5. Kyocera has supplied ceramic substrates for Osram's Ostar as well as multi-watt arrays manufactured by Enfis.

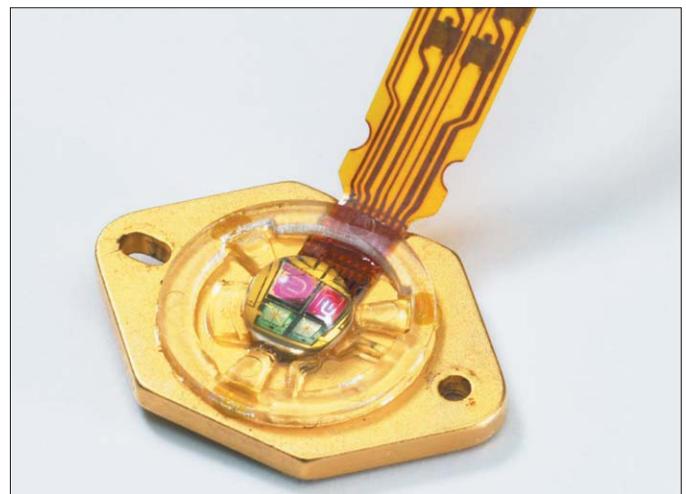


Fig. 6. Philips' Intuos technology combines multiple die on a single package for effective color mixing.



Fig. 7. Tridonic Atco unveiled its second-generation EOS LED modules for lighting applications.

### Seoul Semiconductor

Seoul Semiconductor is claiming that it has developed “the world’s brightest white LED” and “the most efficient single-die power LED package in the world”. In support of these claims, Seoul said that it would introduce by the end of 2006 a white LED producing 98 lm at 350 mA with 84 lm/W efficacy, as well as a warm-white device producing 67 lm at 57 lm/W. Before then, Seoul plans to introduce cool- and warm-white LEDs producing 65 lm and 52 lm, respectively.

At Lightfair, Seoul also exhibited a 0.5 W LED described as “the

world’s brightest 5 mm lamp”, which produces 20 lm (42 lm/W) at 6500 K and 15 lm (31 lm/W) at 3000 K.

### TridonicAtco

Tridonic introduced its second-generation EOS LED modules, using chip-on-board technology to add 1, 4, 9 or 12 chips per module. New K700 converters with different power ratings are capable of driving the LEDs at up to 700 mA, producing up to 70 lm per chip.

The P216 module, measuring 30 × 30 mm, with 12 daylight-white high-power LEDs, provides 480 lm at 350 mA and 840 lm at 700 mA, with power consumption of 14.4 W and 28.6 W, respectively, and efficacy of 33 lm/W and 29 lm/W.

• More details: [www.ledsmagazine.com/press/12170](http://www.ledsmagazine.com/press/12170)

### Links

On our website:

**LEDs in Frankfurt: Light+Building in review**

[www.ledsmagazine.com/articles/features/3/5/4](http://www.ledsmagazine.com/articles/features/3/5/4)

**Lightfair International – no shortage of LEDs in Vegas**

[www.ledsmagazine.com/articles/features/3/6/3](http://www.ledsmagazine.com/articles/features/3/6/3)

**LED companies win awards at Lightfair International**

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# LED Suppliers Directory – Appendix

The 2006 LED Suppliers Directory was first published in the April 2006 issue of *LEDs Magazine Review* and can be downloaded from our website. Another appendix will be published in the August issue and the electronic version of the Directory will be updated later in the year. Please visit [www.LEDSuppliersDirectory.com](http://www.LEDSuppliersDirectory.com) for more information.

● Optics ● Vehicle lighting

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● High-power LEDs ● LED packages ● Light engines & modules ● Packaging ● Multiple applications

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- High-power LEDs ● LED packages ● LED chips
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## Nichia America Corporation

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Nichia produces the highest efficacy white and warm white LEDs, which are fabricated using Nichia's two key technologies – blue LEDs and phosphors. Nichia offers the full range of white color temperatures from 2500 K to 15,000 K. Nichia won the "Technical Innovation Award" at Lightfair 2003 for the introduction of warm white LEDs.

Nichia offers high power LEDs such as the NS6W083 1W and the Rigel 0.5W. These high-efficiency, high-brightness LEDs are ideal for designing LED lighting systems.

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- Test & measurement ● Optics

## Pro-Lite Technology LLP

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## TOSHIBA Electronics Europe GmbH

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- Test & measurement ● Optics

## Radiant Imaging, Inc

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- Radiant Source Models give real-life LED luminous intensity data for optical ray tracing which improves the predictive accuracy of computer-based modeling of LED-based optical systems.
- SIG-300 is the industry-standard source imaging goniometer used to characterize the near-field output of LEDs and create Radiant Source Models.



# Not listed?

E-mail: joanna.hook@iop.org  
 to be included next time.

# LEDs provide light sources for pocket-sized front projectors

Why try to view images on a tiny hand-held screen when you could project the content onto your bedroom ceiling? DLP-based pocket-sized front projectors containing LED light sources are making this possible, writes **Tim Whitaker**.



Fig. 1. Projecting a video game onto a wall is one application for the Samsung SP-P300ME.

Compact front-projection devices, which can take images from a phone handset, gaming console or digital camera and project them onto a wall, screen or even a ceiling, now constitute a small but exciting market for LED light sources.

The devices, commonly known as “pocket” projectors, typically weigh less than 1 lb and can be operated from a DC battery supply. However, the size and weight of the battery are such that consumers will need fairly large pockets to carry the whole system and fairly deep pockets to afford price tags in the €700–1000 bracket.

All pocket projectors currently on the market use LED light sources, and are based on digital light processing (DLP) technology developed by Texas Instruments (TI). Consumer electronics giants such as Samsung, Mitsubishi and Toshiba, along with several other suppliers, already offer pocket projection systems (see figures 1 and 2).

Pacific Media Associates (PMA), a market research firm, believes that the pocket projector segment will reach one million units by 2009,

growing from a few tens of thousands of units in 2006 (see Links on p24). However, at this stage it is difficult to predict how this nascent market will evolve. “In many ways, it’s too early to tell what the volume driver or application for pocket projection is going to be,” says Wolfram Gauglitz, European business development manager for DLP Products at TI. “As an attachment to a mobile phone handset, a digital camera or a gaming console, we think that DLP projectors using LEDs have a real opportunity.”

## DLP technology

DLP technology is based around a digital micro-mirror device (the DLP chip), a microdisplay comprising an array of millions of individual mirrors that tilt back and forth in response to the video input signal. Light reflected from the DLP chip forms an image that is projected through the front lens of the system.

Conventional DLP systems use a UHP lamp in combination with

a moving filter – the color wheel – to provide red, green and blue light in sequence. An LED-based system (see figure 3) uses three separate electronically controlled LED light sources and eliminates the color wheel and other moving parts. The use of a microlens array rather than an integrating rod to achieve illumination uniformity is one factor enabling compact projectors using LEDs. Also, in conventional systems the white point is fixed by the design of the color wheel, but with LEDs the white point can be chosen and tuned at will by changing the luminous flux of each device.

In fact, DLP is the dominant technology in the front projection market, with an estimated share of about 55%. The overall front projector market is likely to reach 10 million units in 2008 and 15 million units in 2010. DLP technology is also used in rear-projection televisions, and the first such products using LED light sources were unveiled in early 2006 (see Links on p24).

### Replacing lamps with LEDs

Larger DLP projectors with UHP lamps operate from an AC power supply and have a much greater light output than the current level of tens of lumens available from pocket projectors. However, LEDs are ideal for compact, lower-power projectors that can run from a DC battery, says TI's Wolfram Gauglitz. "Traditionally, DLP has focused on the mobile presenter market, the 'professional on the go'," he says. "DLP products have always had compact designs, enabling smaller size, and LED technology enables us to take that one step further."

Gauglitz makes it clear that LEDs won't supplant UHP lamps overnight, but are a good alternative for a number of reasons, including long lamp life, which eliminates the need for expensive lamp replacements. "In the future, LED projectors will start to approach the cost of buying a replacement lamp for a non-LED projector," he says.

The power consumption of pocket projectors is in the region of 12–15 W and battery packs are smaller than the projector itself but are still substantial in size. For example, the first-generation Mitsubishi PK-10 DLP PocketProjector™ measures 97 × 123 × 48.2 mm and weighs 465 g, while its battery, typically providing a 2.5-hour lifetime, is the same size with half the thickness, and weighs 340 g.

An important advantage of LEDs is that they broaden the color gamut, or range of colors that can be displayed. Whether this is a selling point for the consumer depends on the application. "As the next generation of products is released and more video content is watched using these devices, better color reproduction will certainly be a strong selling point," says Gauglitz. "For viewing PowerPoint slides, perhaps the consumer will be less demanding."

### LED performance specifics

Current pocket projector products available today have separate red, green and blue LED sources, coupled with a single DLP chip. "We see this as a technical advantage of our technology that we have a single-panel architecture," says Gauglitz. "All the products you will see in the near future will be single-chip DLP-based devices."

One alternative being explored by various companies including Philips and Samsung is 3LCD technology: essentially, this uses three miniature LCD panels, one illuminated by each LED color. The light passes through and is modulated by the transmissive microdisplays, creating three images that are combined by a prism and projected through the front lens.

Gauglitz says that there are a number of important parameters for



Fig. 2. Mitsubishi's second generation LED-based PK-20 PocketProjector™, launched in June 2006, has an ultra-wide lens enabling users to create a 20-inch diagonal screen with just over a foot of projection distance. The suggested retail price is \$899, with the battery pack costing a further \$199.

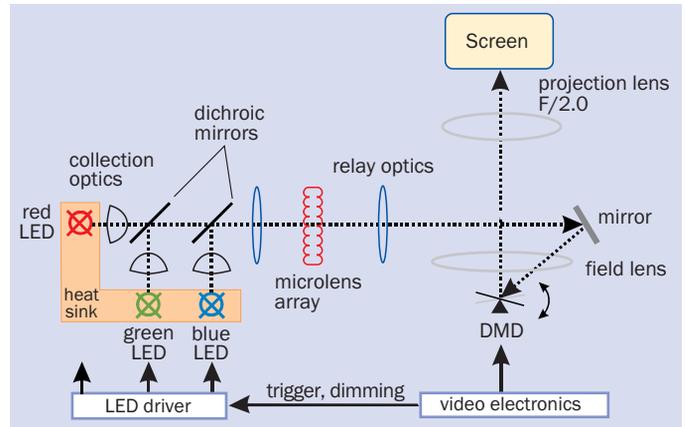


Fig. 3. Schematic layout of an LED-based projection system. Courtesy of Enrico Geißler, Carl Zeiss AG.

LEDs and their associated optical systems in DLP-based front projection applications. The optical system needs to collect light efficiently, so the LEDs are required to emit within a narrow beam angle. Efficient thermal management is also very important in order to maintain the LEDs performance and achieve longer lifetimes.

LED efficiency (lm/W) needs to be improved over time and there is a need to increase the usable lumens per unit area. With high-efficiency light sources it should be possible to drive the LEDs harder and increase the lumen output. Further integration is also required to reduce the size of projector systems. For equivalent shipment volumes, the bill-of-materials of LED-based systems should be equal to, or less, as there is no colorwheel or lamp.

The main LED manufacturers view front projection as a potentially exciting market, and Gauglitz says that TI is working closely with several partners today. "There's a lot of money being invested into LED development in this area and new players are entering the market," he says. "We are intimately involved with the projector manufacturers, who all maintain development efforts with the key LED suppliers."

There are some suggestions to use lasers as a possible light source for projection systems, but Gauglitz is skeptical. "If there's a yellow sticker saying 'Caution: Class 2 laser' then this is probably not yet a

## Challenges for LEDs in projection displays

In a recent paper published by SPIE, Enrico Geißler of Carl Zeiss AG (Jena, Germany) described the challenges of developing LED-based projection displays, the main one being to achieve sufficient brightness. Since LEDs have a luminous flux density that is just at the threshold of acceptance in projection systems, it is only possible to use a fully optimized optical system together with a matched set of LEDs. Many factors must be considered, including the minimum duty cycle of the LEDs, the maximum thermal power dissipation, and the minimum luminous flux at the target white point.

The optimal brightness level can only be achieved when the etendue (sometimes known as optical throughput), aspect ratio and overfill of the LED light sources match those of the DLP chip in the optical system. Overfill is the additional area (usually 10–20% of the DLP chip area) required to be illuminated to compensate for manufacturing tolerances throughout the optical engines, and to avoid chromatic aberrations. Ideally, says Geißler, the system should use customized LEDs with the correct etendue and aspect ratio for a given DLP chip, no gaps between emitting areas, and an angular emission pattern suitable for simple collection optics. The paper describes the use of multi-chip Ostar packages from Osram Opto Semiconductors who collaborated on the project (see figure 4).

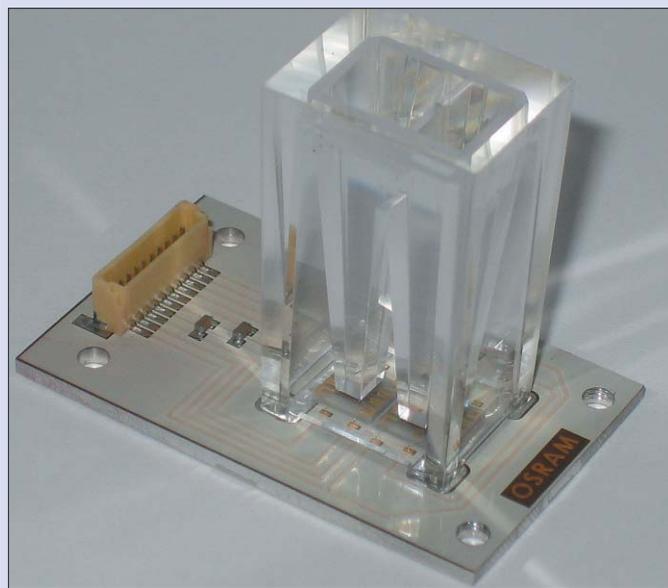


Fig. 4. An LED module consisting of two Ostar packages from Osram Opto Semiconductors, each containing six  $1 \times 1 \text{ mm}^2$  chips. The solid plastic concentrator achieves a large effective emitting area. The LED modules are designed to closely match the etendue and aspect ratio of projectors based on mainstream DLP chips. Courtesy of Anton Moffat, Carl Zeiss AG.

The electro-optic transfer functions (EOTs) of the LEDs provide essential input data for specifying driving conditions (current, duty cycle and temperature) to reduce thermal and ageing effects, while maintaining high luminous flux. The red LEDs are particularly sensitive to temperature and must be controlled using special cooling or a feedback loop. Color sequential operation of the LEDs at a frequency of up to several kilohertz reduces the peak junction temperature, which in turn reduces the thermal load on the plastic concentrator and improves the lifetime of the devices.

The projector white point requires approximately equal radiant power (in watts) for the three primary colors, which usually necessitates a longer duty cycle for the green LEDs. The projection system developed by Carl Zeiss (figure 5) has four green chips and two each of red and blue. Matched sets of red, green and blue LEDs are highly desirable to achieve stable projector luminous flux during mass production.

### Further reading

“Meeting the challenges of developing LED-based projection displays” *SPIE Proceedings* vol. 6196, p1 (April 2006). See <http://spiedl.aip.org/dbt/dbt.jsp?KEY=PSISDG&Volume=6196&Issue=1> (requires payment).

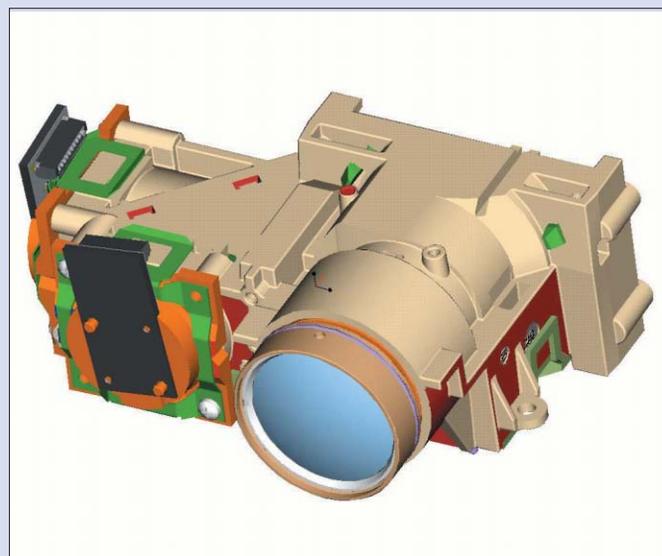


Fig. 5. CAD sketch of an LED-based projection module, which uses only two LED modules (a  $2 \times 2$  red/blue array and a four-chip green array). The optical engine produces a luminous flux of 25 lm in a very compact ( $100 \times 70 \times 40 \text{ mm}$ ) and lightweight package. The projectors are being developed by Syprooptics GmbH, a joint venture between Carl Zeiss and Jabil based in Jena, Germany (see [www.zeiss.de/syprooptics](http://www.zeiss.de/syprooptics)).

## Sony develops LCD-based mini-projector

Although current pocket projectors use DLP technology, an alternative approach is 3LCD, in which three very small, transmissive LCD screens create images, one for each color, that are combined by a prism before being projected. Sony has created

a tiny LED-based projector with a volume of only  $410 \text{ cm}^3$ . The units contains three 0.62-inch LCDs and a total of 14 LEDs – four red, four blue and six green.

● More details [www.ledsmagazine.com/articles/news/3/6/17](http://www.ledsmagazine.com/articles/news/3/6/17)



The Concept CT car developed by Mitsubishi Motors North America has a unique instrument panel create by installing two Mitsubishi PocketProjectors under the front hood. The devices project rearwards onto a translucent acrylic projection screen, providing a wide variety of driver information.

consumer product,” he says. “With rear projection, the light output is more controlled, and no-one is actually staring into the laser itself, so this is less of a concern from a safety perspective.

### Market development

The future development of the pocket projector market is unclear at present. One driver could be that more and more content is pushed towards handsets; for example, T-Mobile, a phone operator, has developed technology to stream World Cup games to handsets on a pay-per-view basis.

DSP chips manufactured by TI are in more than half of all cell-phones, so the company has a good relationship with handset makers. “Phones are becoming a smarter entertainment and information appliance,” says Gauglitz. “Using pocket projectors, we are able to take content from the 2-inch diagonal screen and expand that into a 40 or 60-inch viewing experience.”

Some commentators believe that PMA’s predictions of one million units by 2009 are a little conservative. “It could all hinge on cost,” says Gauglitz. “If costs come down, and you or I can effortlessly connect these devices to a cellphone or games station, then who’s to say how quickly this category could grow.”

### Links

Texas Instruments DLP site: [www.dlp.com](http://www.dlp.com)  
 Toshiba: [www.toshiba-europe.com/projectors](http://www.toshiba-europe.com/projectors)  
 Mitsubishi: [www.mitsubishi-presentations.com/](http://www.mitsubishi-presentations.com/)  
 Samsung: [www.samsung.com/uk/products/projectors](http://www.samsung.com/uk/products/projectors)

On our website:

**Pocket projector market poised for growth**

[www.ledsmagazine.com/articles/news/3/4/22/1](http://www.ledsmagazine.com/articles/news/3/4/22/1)

**CES exhibits herald the arrival of televisions based on LEDs**

[www.ledsmagazine.com/articles/features/3/2/4/1](http://www.ledsmagazine.com/articles/features/3/2/4/1)

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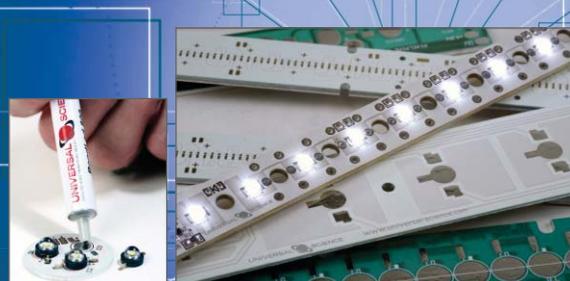
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# Boeing turns to LED lighting for its new 787 Dreamliner

Aircraft such as the new Boeing 787 Dreamliner represent a significant opportunity to replace traditional light sources with LED lighting systems. These offer longer lifetimes, reduced maintenance downtime and lower power consumption, as well as benefits to passengers.

Boeing's new 787 Dreamliner passenger aircraft, expected to enter service in 2008, features many examples of LED lighting systems throughout its interior as well as for exterior position and anti-collision lighting. For example, Boeing has selected Goodrich to supply a white LED-based lighting system for the 787's flight-deck, while Germany's Diehl Luftfahrt Elektronik (DLE) is supplying color-changing LED-based lighting systems for the main cabin.

A spokesperson for Boeing told *LEDs Magazine* that the 787 utilizes LEDs in many systems throughout the airplane, but there are certain major areas where LEDs are significantly contributing to the value of the aircraft.

## Flight-deck lighting

Goodrich is supplying the flight-deck lighting system to Boeing, as shown in figure 1. The system uses white LEDs for task lighting, general illumination and emergency lighting, including map lights, chart lights and dome lights.

Boeing says: "LEDs in this system replace traditional incandescent lamps, primarily for reasons of life and size. The LEDs offer significant improvements in rated life, which contributes to improved component life and a corresponding reduction in required maintenance activity. LEDs also facilitate the incorporation of luminaries in areas of the flight-deck that are very space-constrained. The critical performance parameters of the LEDs are intensity, color and size."

## Flight-deck control panels

Also in the cockpit, Korry Electronics is the main supplier of flight-deck control-panel lighting, including lightplates, switches and annunciators. IDD Aerospace, an LED lighting specialist, has been selected by Korry to provide LED-backlit dimmable lightplates for the pilots'



Fig. 1. Boeing 787 cockpit, showing some of the white LED lighting systems supplied by Goodrich (circled) and back-illuminated panels supplied to Korry by IDD Aerospace (arrowed).



The Boeing 787 Dreamliner, expected to enter service in 2008, features numerous LED lighting systems.



Fig. 2. Boeing 787 passenger cabin. The LED lighting scheme will make it possible to create various moods in the cabin from sunrise to sunset, making travel more comfortable and relaxing.

main overhead panel and other aircraft control functions, totaling 24 panels per aircraft (see box below).

Boeing says: "While the use of LEDs in these systems is not new, the most notable aspect in the Boeing 787 is color. In general, the lightplates and switches are white instead of green, while the annunciators retain their traditional colors based on the system/function criticality. LEDs replace incandescent bulbs, primarily because they provide significant improvements in rated life and also reduced heat loading of

the surrounding components/materials. Both of these contribute to improved component life and a corresponding reduction in required maintenance activity."

### Passenger cabin color-changing lights

Elsewhere in the interior, DLE is supplying LED-based lighting systems for the main cabin of the 787, as shown in figure 2. The system consists of indirect ceiling wash lights, sidewall wash lights, entry lights, galley lights and accent lights based solely on LEDs.

Boeing says: "The application of high-brightness LEDs in these systems replaces the traditional fluorescent lighting systems that are the main source of passenger cabin illumination, as well as incandescent lighting use for localized illumination purposes. With the LED-based system, the passenger cabin illumination can be any desired color, allowing airlines to create various moods and making travel a more comfortable and relaxing experience."

### Emergency lighting

Emergency lighting systems such as ceiling lights, floor proximity lights and exit signs are supplied to Boeing by Luminator.

Boeing says: "LEDs replace traditional incandescent lamps in the overhead emergency lights and in the floor proximity escape-path marking system. The reasons for utilizing LEDs are primarily life and power consumption. The significant improvement in the rated life results in reduced maintenance activities. Since this is an FAA-required system, the higher reliability reduces the probability of airplane dispatch delays. The emergency lighting system is a battery-powered system and the low power consumption of the LEDs allows for fewer batteries and/or longer operating duration when the system is activated."

## IDD Aerospace and LED lightplates

IDD Aerospace, a division of the Zodiac group based in Redmond, WA, has supplied a number of systems for the Boeing 787 to tier-1 manufacturers, such as the illuminated lightplates supplied to Korry Electronics. *LEDs Magazine* spoke with IDD's head of engineering Mike Rumer, who explained that having the same supplier for multiple tier-1 contractors has the benefit of providing consistency of illuminated colors.

"We use commercially available LEDs, but the specifications are very precise in terms of the colors we have to meet," says Rumer, explaining that IDD has an LED selection process and also controls its systems with feedback loops. "LED manufacturers haven't been able to provide the fine binning that we need," he says. "So we purchase the tightest bins we can and from there have a control plan to adjust either the intensity or color as necessary."

IDD supplies acrylic backplates lit with LEDs from Nichia. Most of the panels are painted and the words and symbols are etched out to allow light emission. "The panels that we supply go behind the switches, toggles and rotaries, to outline and illuminate these functions," says Rumer. "Each panel might have somewhere between 6 and 12 such knobs, all for related functions such as 'seat-belts on'."

In the past, such panels were lit with incandescent lamps and filters, but LEDs have now taken over on the newer flight-decks. The main advantages, says Rumer, are lower power consumption

and greater mean time between failure, which means less maintenance is required. Since less heat is produced, there is less stress on the cooling (air-conditioning) systems. "Typically we're running at less than half of the rated current," says Rumer. "Heat dissipation is not a problem and is much less significant than with incandescent sources."

On a new flight-deck, if the power system is set up so that it can accommodate LEDs, then the LED solution tends to be a little more expensive initially. For retrofitting on an existing flight deck, there are other issues related to dimming. "With lower power consumption, less maintenance and less heat generation, LEDs definitely work out less expensive overall," says Rumer.

IDD first installed bright SMD white LEDs about 5-6 years ago, and has supplied Embraer and Bombardier aircraft, as well as the Airbus 380 and the Boeing 787. "All the new flight decks are going over to LEDs and we're the volume supplier in LED panels," says Rumer.

IDD looks for uniformity and consistency over time, for both brightness and color, says Rumer. "One of the problems we keep running into is that the LED makers like to keep making things brighter and brighter, and that's not actually good for us. Once we do a flight-deck, making it brighter doesn't help us because we need to match the same exact consistency whether we build the product this year or five years from now."

● IDD Aerospace: [www.iddaerospace.com](http://www.iddaerospace.com).

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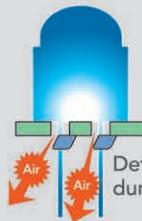


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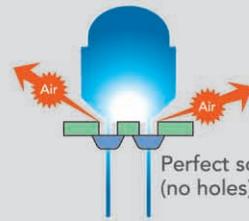
ROHM's pressure release structure prevents pressure build-up during the soldering process when the LED is mounted on the PCB.

#### Conventional Product



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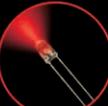


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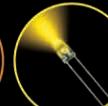
φ 3mm with Pressure Release Structure



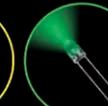
SLI-343URC



SLI-343DC



SLI-343YC

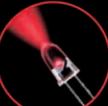


SLR343ECT

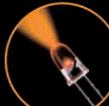


SLR343BCT

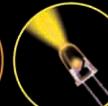
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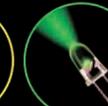
SLI-580UT



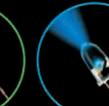
SLI-580DT



SLI-580YT



SLA580ECT



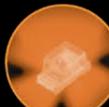
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#### Chip LEDs

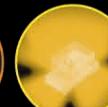
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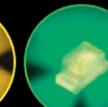
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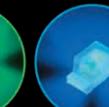
SML-512DW



SML-512WW

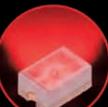


SML312ECT

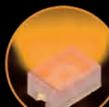


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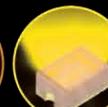
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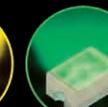
SML-012UT



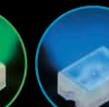
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## Exterior lighting

On the exterior of the airplane, Honeywell is providing several all-new LED lighting products from its Astreon range, including red and green forward position lights, white rear position lights and white and red anti-collision lights, as well as white lights for the cargo hold.

Boeing says: "The application of high brightness LEDs in these colored signal systems replaces the traditional xenon arc lamp technology used in the anticollision lighting systems and the high-intensity incandescent lamps used in the position lighting system. The main benefit of LEDs is an order of magnitude improvement in the rated life leading to reduced maintenance activities. Since these are FAA-required systems, the higher reliability reduces the probability of airplane dispatch delays. An additional benefit is the inherent color of the LEDs, which allows the lenses to be clear glass instead of colored filter glass.

The critical performance parameters of the LEDs are color and the intensity. The colors must remain aviation red, green or white to be compliant with FAA regulations, and the intensity must always remain above the FAA required levels. Those familiar with the details of LED performance characteristics can appreciate the difficulties associated with this application when the wide dynamic temperature ranges and solar loading effects of the commercial jet transport environment are considered."

## Challenges for LED makers

Boeing says: "The LED characteristics that we would like to see improved are lumen maintenance and thermal performance. We

believe that significant improvements in these areas would increase the penetration of LED lighting in the aircraft market and most other markets as well.

Lumen maintenance pertains to the decrease of LED intensity as a function of operational hours. While there are several factors that drive this performance characteristic, this is possibly the most significant item that prevents LED light assemblies (in general) from being maintenance-free equipment that could last for the life of the airplane.

Thermal performance has two aspects. The first is the amount of heat produced by the device during operation. The production of less heat (for the same lumen output) can lead to designs with lower electrical power consumption, reduced weight (since less heat-sinking is required), and a reduced demand on the airplane environmental control system (i.e. air-conditioning required to manage the total heat load in the airplane). Each of these items has a direct impact on an airplane's fuel efficiency.

The second is the large variation in most LED performance characteristics that relate to the LED junction temperature ( $T_j$ ). Minimizing the impact that a change in  $T_j$  will have on such characteristics will enable the applications users to more easily develop designs with credible performance. Ease-of-use and credible performance are key elements necessary for increased market penetration by LEDs." ●

## Links

- Boeing 787: [www.boeing.com/commercial/787family](http://www.boeing.com/commercial/787family)
- VEHICLES: [www.ledsmagazine.com/articles/features/1/5/4](http://www.ledsmagazine.com/articles/features/1/5/4)



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# SID 2006 reinforces emerging role of LEDs in electronic displays

Every LCD display maker or solution provider at the Society of Information Display Meeting showed some type of LED-backlit LCD, reports **Stewart Hough**, and some highly complex backlighting technologies are now being developed using LED light sources.

Two back-to-back exhibitions, Lightfair and Society for Information Display (SID) 2006, provided the latest preview of how the world will be illuminated and informed in the future. Lightfair (Las Vegas, May 28–June 1, see p13) was saturated with LED-related developments and products for solid-state lighting. SID (June 4–9, San Francisco) typically exhibits the electronic display technologies that will be available in 2–5 years in consumer electronics stores. In sharp contrast to Lightfair, SID 2006's more subdued LED technology showing nevertheless revealed LED's strong supporting role in communications, information management and entertainment imaging technology.

Although primarily a technical society conference, SID is also an exhibition forum for the biggest, brightest and best-looking flat panel displays (FPDs). Plasma and LCD displays have reached suitable cost/performance for large-screen television segments, offering larger picture images in more efficient form factors than standard cathode ray tube (CRT) TVs.

LCDs have rapidly taken over the desktop PC market and this subject is no longer the buzz at SID, while CRT-based displays are now virtually nowhere to be found. Plasma displays up to 102-inch diagonal and LCDs up to 100-inch diagonal (see figure 1) battled for bragging rights for largest diagonal size, highest pixel count and brightness, although only as technical concept demonstrators, not consumer-ready devices. While plasma displays emit their own light, LCDs still mainly use cold cathode fluorescent lamps (CCFL) backlights for notebooks and desktop monitors as well as for first generation FPD TVs up to around 36-inch diagonal.

## LEDs in displays

High-brightness (HB) LED technology has now improved to be suitable for LCD display backlights, and this will soon become one of the largest HB-LED applications. Benefits of using LEDs include improved color gamut, longer life, higher brightness and contrast, adaptive dimming and power management, and reduction of hazardous materials. LEDs may ultimately offer LCDs a decidedly compelling advantage over other large screen technologies, especially if the economies of scale that solid-state lighting markets may offer in the manufacturing of HB LEDs and device efficiency improvements continue. In a total TV market of over 150 million sets per year, the possibility of 20–200 LEDs per



Fig. 1. Giant LCDs at SID 2006. LG Electronics exhibited the world's largest LCD TV and Osram demonstrated a 102-inch LED-based backlighting system.

set represents a large value opportunity that, although not immediate, could be nearer term than general lighting.

Every LCD display maker or solution provider at SID showed some type of LED-backlit LCD. Even CCFL backlight suppliers were showing LED backlight options. Many exhibitors proudly displayed their LED backlight LCD demos but hid the identity of the specific LEDs used, apparently to protect their sources as well as the outcome of their inhouse development efforts; the rapid evolution of HB-LED performance and package types has made LED backlight design a time-intensive, short-lived exercise.

## LED manufacturers

Among the few major LED device suppliers at SID, Citizen exhibited an LCD backlight based on its recently released CL-652S series of 70 lm/W white LEDs (see p13). Osram showed a 102-inch LCD direct backlight system using 1732 Golden Dragon Argus LEDs (see figure 1). Four Argus LEDs (RGGB) were arranged in a diamond pattern to form a scalable backlighting system. Using a row-partitioned optical feedback design to maintain color balance over time and temperature, the approach is expected to reduce power consumption and cost through reduced LED count. Argus LEDs use a thin-film LED chip structure designed to provide more forward light output than conventional LED chip designs, improving system efficiency and simplifying backlight optics.

Global Lighting Technologies (GLT) and Luminus demonstrated a 24-inch edge-lit backlight using GLT's MicroLens pixel-based light extraction technology and Luminus' PhlatLight LEDs. Vertically

molded light-guide segments with RGB Phlatlights were used. "Production using horizontally scanned segments is planned for LCD TVs in about eight months," said David DeAgazio, director of worldwide sales at GLT. "The response has been very encouraging, with a number of LCD display makers acknowledging our technology as a clear performance improvement over what is available today." See box below for more details.

### Three levels of dimming

Three levels of LED backlight design were identified in a conference paper entitled "RGB LED backlights for LCD TVs with 0D, 1D, and 2D adaptive dimming" by the University of Electro-Communications and Nippon Leitz, both of Tokyo, Japan, as follows:

- 0D – all LEDs are at the same intensity;
- 1D – LEDs in each row or column are at the same brightness;
- 2D – each LED is individually intensity-adjusted.

These categories provide a practical way to distinguish the different backlight approaches exhibited at SID. The 0D approach is the simplest and most cost-effective embodiment using white or RGB LEDs in direct and edge-lit configurations, with and without color compensation. These were the most commonly exhibited type and appeared as first generation designs from Apollo Displays, American Panel Corporation, Driven Technologies, IDC, JACO Electronics, Optrex, Osram and PDT among others.

1D designs were shown by Philips (Aptura brand), GLT and others. Such systems offer mid-range cost/performance with improved contrast, wider dimming range, lower power consumption and fewer motion artifacts, and may become the baseline for LED-based back-

lights for LCD TV.

Philips demonstrated its "wide color hybrid" approach that combines red LEDs with blue/green hot cathode fluorescent lamps (HCFLs). The company says that this can provide a wide color gamut LCD backlight for a fraction of the price of an all-LED solution.

### 2D individual dimming

2D technical demonstrations using direct RGB LED backlighting with scan adaptive techniques were shown by Brightside Technologies of Canada and ASTRI (Hong Kong Applied Science and Technology) and represent the present technical developmental state of the art. Both approaches use arrays of RGB LED devices that are individually intensity-modulated depending on the respective RGB video signal.

Significantly increased dynamic contrast, lower power consumption (>30% reduction over 0D), improved low grayscale-level image detail (a common problem with LCD technology), reduced motion artifacts and CRT-like peak brightness (still the standard for television performance) are possible. The visual impact is profound, and side-by-side demonstrations with and without this technique are visually compelling.

The Brightside demo used Seoul Semiconductor power SMT LEDs, and Seoul staff were present in the Brightside booth, while the ASTRI demonstrations used Cotco RGB SMT LEDs. The real-time mapping of individual image details to backlight intensity can be seen in the comparison images in figure 2, p31.

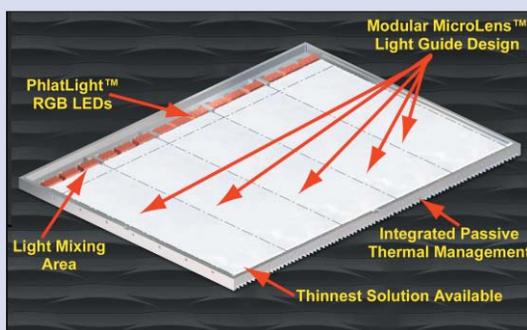
With 2D backlight approaches, the video image is spatially and temporally filtered to identify a spatial intensity map that registers to the array of LEDs used for each color. This intensity map then modulates

## GLT and Luminus unveil LED-based edge-lighting for LCD TVs

Coinciding with SID 2006, Global Lighting Technologies (GLT) Inc of Brecksville, OH, a developer of LCD backlighting technology, announced a partnership with LED manufacturer Luminus Devices, Inc, of Woburn, MA, to produce modular LED-based edge-lighting assemblies for large-screen LCD TVs.

Luminus emerged from stealth mode at the start of 2006 when several TV manufacturers unveiled rear-projection TVs using Luminus PhlatLight™ LED chipsets (see [www.ledsmagazine.com/articles/features/3/2/4](http://www.ledsmagazine.com/articles/features/3/2/4)). Luminus' PhlatLight or Photonic Lattice technology results in very high brightness emitters, and will now be combined with GLT's patented MicroLens™ light guides. GLT's pixel-based light extraction technology is based on micro-optical elements molded directly into a light guide. The elements are optimized to deliver more collimated light, which increases the efficiency of the optical system.

The technology combination enables large-size LCD panels that are edge-lit, as opposed to requiring direct backlighting (light sources distributed across the display backplane). The result is dramatically reduced LED count and simplified color and thermal



**New modular LED-based edge-lighting assemblies for large-size LCD TVs offer dramatically reduced LED count and a range of other benefits compared to conventional LED-based backlighting solutions.**

management compared to conventional LED-based backlighting solutions.

Small-sized color LCD displays, ranging in size from those used in mobile phone handsets to the 11.1-inch screen in some Sony Vaio laptops, use white LEDs arranged on the edges of the display. (Of course, most laptops still use CCFLs.) The small number of desktop monitors and LCD TVs applications with LED-based backlights use RGB LEDs for a wider color gamut. At a size of around 20 inches it becomes necessary to use direct backlighting to achieve the required uniformity and brightness.

At SID 2006, GLT and Luminus demonstrated a 24-inch edge-lit LCD TV backlight prototype. A total of 15 sets of PhlatLight LEDs, each comprising individual red, green and blue devices, were used for edge lighting. The companies believe that their combined technologies will soon enable a 32-inch LCD TV with only 12 RGB PhlatLight LEDs, where this would formerly have required hundreds of LEDs in the backlight.

- Luminus recently received \$38 million in venture funding – see [ledsmagazine.com/articles/news/3/5/3](http://ledsmagazine.com/articles/news/3/5/3) for more details.

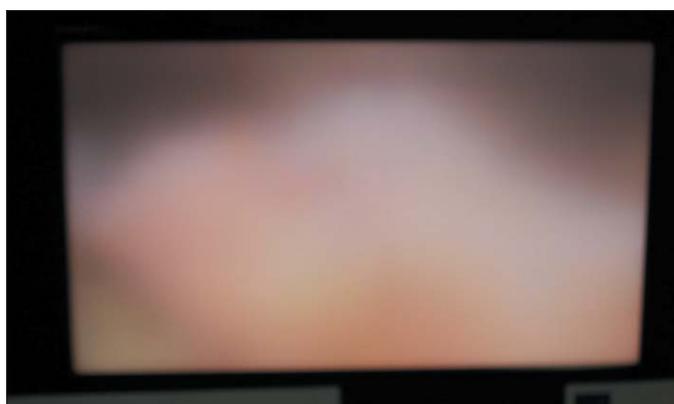
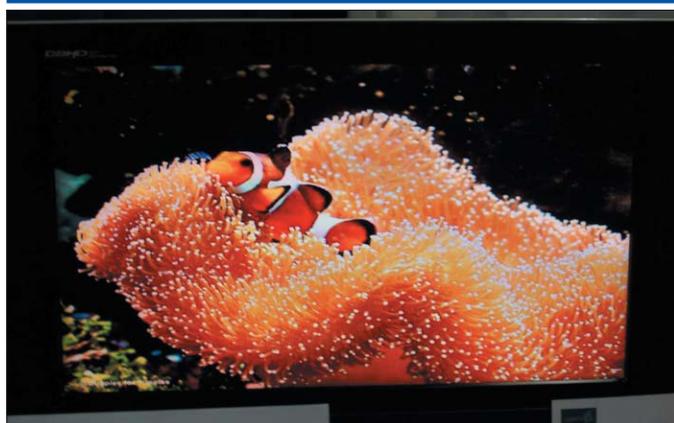


Fig. 2: an LCD image (top) and the corresponding LED backlight intensity map (bottom), as demonstrated on the ASTRI booth. The backlight does not provide uniform intensity like a conventional one, but instead the intensities of individual LEDs are modulated in a dynamic fashion according to the properties of each individual image frame.

the LED intensity for the video image frame. Because the LEDs will “bleed over” due to their emission angle, before the video frame is displayed the intensity map is used to change the grayscale of individual LCD pixels to ensure that only the pixels that are supposed to be brighter are actually brighter.

The sophisticated real-time processing logic needed to accomplish all this can eventually be embedded in silicon to minimize electronics cost, however, the major expense will be in the array of LEDs and individual drive electronics. The balance of component cost and number of display pixels per LED can be adjusted to mitigate drive sophistication and system cost. If the technique can be cost-effectively scaled to volume production, large screen LCDs will be able to offer very competitive TV imaging performance to plasma displays.

Although LEDs are not the prime focus of imaging display technology development, SID 2006 demonstrated that LEDs offer critical performance improvements for the next wave of mainstream electronic display products: large-screen LCD TVs. ●

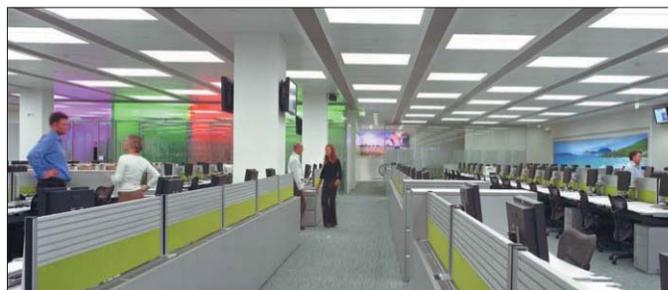
#### About the author

*Stewart Hough has participated in electronic display technology and business for over 20 years, most recently in technology commercialization of LEDs for solid-state lighting and displays.*

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### ARCHITECTURAL



#### Allaays LED Instruments supplies LED fixtures for award-winning BP project

A lighting scheme in the BP headquarters in London uses LEDs to create “vertical illumination” by backlighting a series of scenic wall-panels. LEDs also provide the light sources for color-changing ceiling fixtures that indicate the status of meeting rooms.

### COMPANY PROFILE

#### GrafTech International – Advanced Energy Technology

Advanced Energy Technology, a subsidiary of GrafTech International Ltd, is a proven leader in developing high-performance products for electronics thermal management.

### MARKETS

#### Solid-state lighting set to boost LED growth

Emerging high-volume applications such as solid-state lighting and automotive headlights will drive vigorous growth in the LED market, according to Rob Lineback of IC Insights, who has some interesting suggestions for standards development.

### LEDs IN JAPAN

#### Mission sheds light on LED developments

High brightness and multi-watt LEDs are creating exciting new opportunities for general illumination and novel lighting applications, as a UK DTI Global Watch Mission to Japan discovered.

### DRIVERS

#### Running LEDs from an AC supply

In most applications, LEDs are driven by a DC power supply, but AC offers several significant advantages. Lynk Labs has developed technology that allows LEDs to be driven directly from an AC supply.



● At Lightfair, Lynk Labs revealed that it has teamed with LED suppliers OPTEK Technology and American Bright Optoelectronics to offer a range of “AC LED Total Solutions” including devices, assemblies, drivers and systems. Also, Lynk Labs has formed a venture with UK-based Brillianz to supply fluorescent-replacement lamps using Lynk’s AC LED and BriteDriver technologies. See [www.ledsmagazine.com/articles/news/3/6/16](http://www.ledsmagazine.com/articles/news/3/6/16) for more details.

# LED Quarterly Insights

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## Report 1: High-power LEDs

Efforts are still continuing to increase the total lumen output and improve the efficiency of high-power LEDs. This report analyses the technical innovations being made at both the chip and module levels, as well as the measures being taken to make high-power LEDs more price-competitive with traditional light sources.

## Report 2: Performance and standards

Sustained growth in the LED industry is being hampered by the confusion that surrounds the performance metrics used to characterize LEDs, as well as the many different packages available from LED manufacturers. This issue will analyse the measures that are being taken, and must be taken in the future, in order for the LED community to achieve greater standardization and continued industry growth.

## Report 3: White LEDs

The colour performance of white LEDs continues to be a major concern for lighting-systems developers and LED manufacturers. This report will evaluate current strategies to address such issues as colour variation between LED die; techniques for measuring colour output; colour shift during operation; and methods to produce white light more efficiently and with better spectral properties.

## Report 4: Packaging and optics

This edition of *LED Quarterly Insights* will assess which packaging techniques are most likely to yield practical and affordable LED solutions, and will review new and emerging methods for optical design that will help to deliver the most efficient lighting systems.

*LED Quarterly Insights* is a series of four in-depth reports, providing you with incisive analysis of the crucial technology innovations and commercial opportunities in the fast-moving LED industry. *LED Quarterly Insights* is essential reading for equipment and materials suppliers, LED device and module manufacturers, and lighting-systems developers.

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