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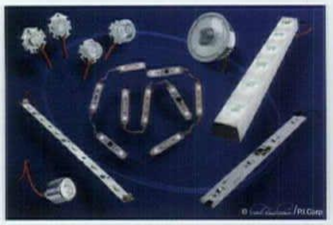

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LED Product

Light Output (Lumens)	146
Watts	3
Lumens per Watt (Efficacy)	42
Color Accuracy Color Rendering Index (CRI)	84

Light Color Correlated Color Temperature (CCT) — 3094 (Bright White)

Warm White | Bright White | Daylight
2700K 3000K 4500K 6500K

Visit www.lightingfacts.com for the *Label Reference Guide.*

All results are according to IESNA LM-79-2008: *Approved Method for the Electrical and Photometric Testing of Solid-State Lighting.*

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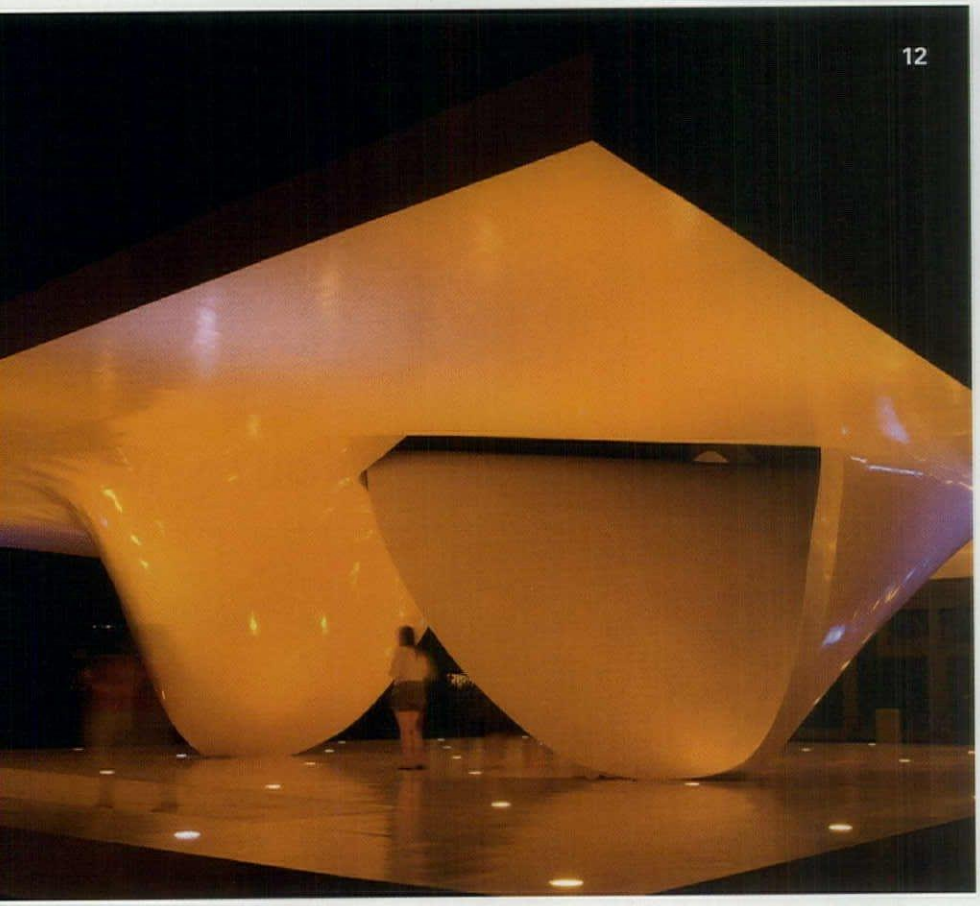


Solid-state lighting is at a crossroads. While designers wait for LED technology to realize its potential, they are caught between clients' requests to use LEDs and a lack of confidence in manufacturers' claims and ability to provide the necessary specification documentation. And yet the marketplace is flooded with LED lighting products. This was in evidence at Lightfair 2009, not just in terms of the number of LED luminaires on exhibit but the number of new companies on hand. The question in this ever-changing landscape: Will these companies still exist in six months or a year? The installations and applications that have the ability to succeed in this uncertain environment are those that have a focus on design married to technical innovation—those that incorporate LEDs because they are the best light source for the job, not just because they exist. The LED forecast? Wait and see.

ELIZABETH DONOFF
EDITOR

Departments

Features

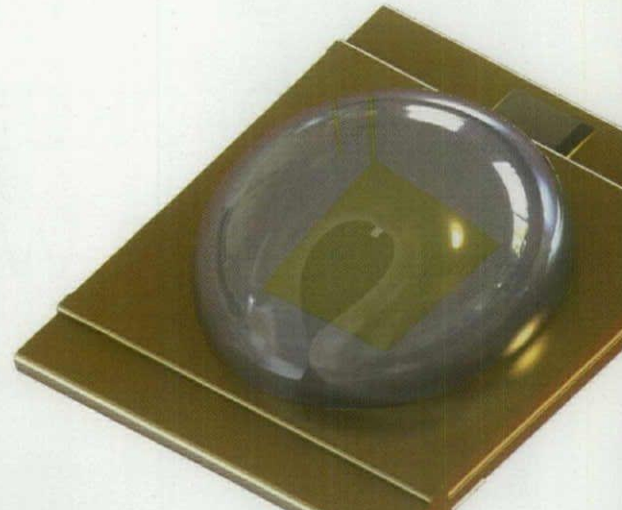
Cover: LEDs light up Baumschlager Eberle's Nordwesthaus boating pavilion.
PHOTO EDUARD HUEBER, COURTESY ZUMTOBEL LIGHTING

This page: UNStudio's pavilion for Chicago's celebration of the Burnham Centennial; Nordwesthaus's interior.
PHOTO BEN DICKMANN, COURTESY ILUMINARC; EDUARD HUEBER, COURTESY ZUMTOBEL LIGHTING

SSL'S LATEST

MOLEX RM2 REFLECTOR MODULE
The RM2 reflector module from Molex is part of the company's new Transcend line. Using Seoul Semiconductor's Acriche 4W AC LED, the 2-inch Transcend RM2 plugs directly into the AC line voltage, providing directional light with a range of beam intensity and angular distribution. The RM2 uses plated polymer and aluminum heat-sink technology to dissipate accumulated heat. Available in 15-degree spot, 25-degree medium flood, and 25-degree tight medium flood distributions, the RM2 uses a standard GU24 socket. The module is available with two color rendering indexes depending on color temperature: 80 CRI for 3000K warm white and 65 CRI for 5100K daylight. • *molexssl.com* • CIRCLE 100

BRIDGELUX LED ARRAYS
This suite of LED arrays simplifies system integration and reduces costs, while matching standard incandescent, halogen, compact fluorescent, and high-intensity discharge lamp performance. The LEDs range from 400 to 2,000 lumens, and are available in warm, neutral, and cool white color temperatures. The array can be used for a variety of applications including task, accent, spot, track, downlight, wide-area, and security lighting. • *bridgelux.com* • CIRCLE 102



PRESCOLITE AKT6LED TRACK HEAD
Prescolite's AKT6LED track head consumes 14W and, according to the manufacturer, provides 70 percent average lumen maintenance at 50,000 hours. Configurable optics allow for multiple beam spreads of 18, 25, and 35 degrees. The AKT6LED offers an alternative to metal halide, halogen, and fluorescent sources, and claims to be more environmentally friendly, due to its use of LED technology and nonhazardous materials. Suggested applications include different types of retail settings including checkout areas and supermarket produce sections. • *prescolite.com* • CIRCLE 101

SEOUL SEMICONDUCTOR
LCW100Z1 LED
The new LCW100Z1 LED delivers more than 120 lumens per watt—up to 7.8 lumens at 20mA and 14.3 lumens at 40mA. With a viewing angle of 120 degrees, the LED measures 3.5 millimeters by 2.8 millimeters by 1.6 millimeters. Three color temperatures are available: pure white, warm white, and natural white. The company boasts the LED's improved luminous efficiency and enhanced heat transfer. Seoul Semiconductor expects the LED to be adopted for fluorescent lamps as well as surface light source lamps. • *acriche.com* • CIRCLE 103

MARTIN FLEXDOT S1 LED STRING

Martin Professional's FlexDot S1 flexible LED string provides designers with a new way to integrate LED video technology into stage sets, clubs, retail, and outdoor environments artistically. The customizable and DMX512-controllable FlexDot is a lightweight string of full-color LED pixels mounted on a flexible cable. Each pixel consists of an RGB LED driven by its own processor and is individually addressable for independent control of color, effects, and animation. Standard pixel spacing is 100 millimeters or 200 millimeters with each string comprising 100 pixels, at 2.5 candela per pixel. One string of FlexDots can extend to 120 pixels. • *martin.com* • CIRCLE 104

AMERLUX LINEAR WALL GRAZER

Amerlux Lighting Solutions' new Linear Wall Grazer is a polished extruded aluminum fixture, which can be mounted in most ceiling applications. With a color temperature of 2700K, the luminaire houses five 8W or 12W high-output white LEDs per linear foot. The recessed fixture features a 2-inch aperture, is available in 4- and 8-foot lengths and, according to the manufacturer, consumes less than 12W per foot. • *amerlux.com* • CIRCLE 106

LEDENGINE LUXDOT MR16 LAMP

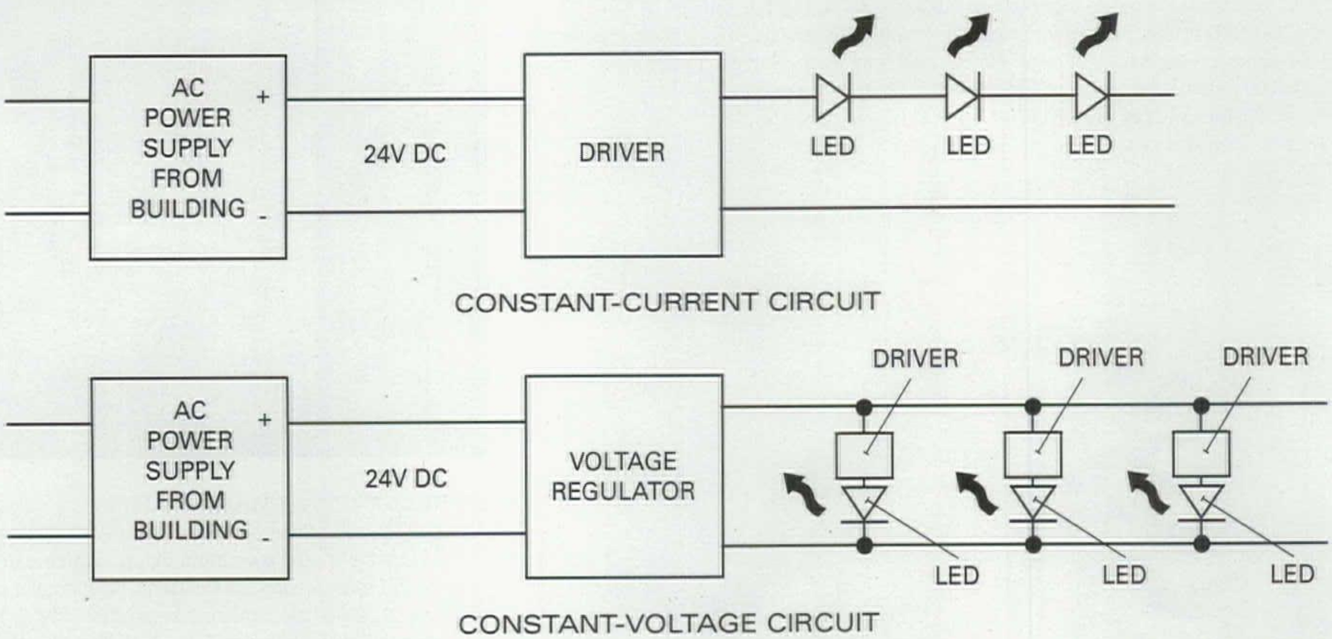
LedEngine's new LuxDot white LED MR16 lamp is, according to the manufacturer, designed to produce the lighting equivalent of a conventional 35W halogen lamp, but with power savings of 80 percent and a service life of 10 times longer. Appropriate for spot, accent, track, or downlighting applications due to its 22-degree beam angle, the LuxDot is dimmable and works with most magnetic and electronic transformers. Three color temperatures are available—2900K, 3100K, and 4100K—as well as three light outputs: 160 lumens, 180 lumens, and 220 lumens. • *luxdot.net* • CIRCLE 105

ELDOLED ECODRIVE LED DRIVER

The ECOdrive Series from eldoLED is a four-channel constant-current LED driver for networked or stand-alone LED luminaires requiring power output of up to 45W. With an input voltage range of 12V to 32V DC, the ECOdrive has a power efficiency of 95 percent and allows the LED current to be set to any value between 200mA and 1.4A in 50mA steps. The driver is compatible with both DMX and zero-to-10V networks, and is available in three wattages: 15W, 30W, and 45W. • *eldoled.com* • CIRCLE 107

Drivin' Them LEDs

JIM BENYA LOOKS AT BASIC LED CIRCUITS



Diagrams illustrating the relationship of the power supply, LED driver, and individual LEDs for a constant-current circuit (top) and a constant-voltage circuit (above).

In the brutal world of high-voltage, high-amperage energy systems operating at high temperatures, there stands alone one small but very useful device—the light-emitting diode (LED), also known as solid-state lighting (SSL). Compared to traditional light sources, LEDs are relatively small and particularly sensitive to voltage, heat, and amps. Realizing all of the promise of LED lighting depends on controlling the thermal and electrical environment much more carefully than we have with any previous light source.

Historically, electrical engineers, contractors, and electricians are used to a brute force sense of energy as it relates to lighting. The typical building electrical system operates at either 120V or 277V AC in the U.S., and the most conventional lighting fixtures connect directly to it. However, LEDs and LED drivers are low-voltage electronic devices, typically operated in systems of less than 30 volts. Somewhere in every LED lighting system there must be voltage transformation, driver current control, and in some cases, a way to dim the LED.

LED BASICS

A diode is a solid-state electronics device used in all types of electronic equipment to convert AC power to DC power. A typical lighting application is in electronic ballasts, where the building power is rectified to DC using diodes so that the electronic circuits of transistors and other devices can use it. Without the conversion, driver design is difficult. In a normal diode, there is a small energy loss of about 0.7 watt per amp that is dissipated as heat. An LED is a different version that will consume 2.5 to 3.5 watts per amp. Some of this is dissipated as heat, but most of it becomes light.

Unlike fluorescent lighting, where up to 600V of AC may occur at the lamp, the voltage across an LED is usually between 2.5V and 4V DC. The first step in using solid-state lighting is to convert building power to low-voltage DC, which either can occur using a power supply or as part of the driver's electronics. Voltage conversion is a primary reason for the formation of the EMerge Alliance in 2008, "an open industry association promoting the rapid adoption of safe, low-voltage DC power distribution and use in commercial building interiors." Converting high-voltage AC to low-voltage DC adds to the physical size, electrical safety provisions, and cost of LED lighting systems. If a building provided low-voltage DC power, SSL lighting systems would be cheaper and easier to use. Another benefit is being able to use low-cost, Class II wiring, which does not require conduit or armored cable.

DRIVERS

Once converted to low-voltage DC, power then passes through the LED to generate light. But as with a fluorescent lamp, there must first be a circuit that regulates the amount of energy—or the lamp will blow up. For a fluorescent lamp this circuit is called a ballast; for solid-state lighting it is called a driver. The typical contemporary white LED is designed to operate at either 0.35A, 0.70A, or 1A depending on watts, brand, and model. It is the driver's job to regulate the DC power for the specific LED. An added complication is that seldom in lighting is one LED enough, and it is common to have several LEDs mounted and wired together. For example, a basic downlight might employ 20 or more 0.25W or 0.5W LEDs.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Regulating the current through each LED is essential because the light output, lamp life, and light color are all affected. An LED is optimized to produce light meeting the desired lumen output, efficacy, and color at an appropriate level that, with proper heat sinking, will also provide normal functionality. Change either amps or temperature and the LED performs differently.

Drivers vary tremendously. The simplest driver is nothing more than a resistor that restricts current. This is used in simple SSL strings such as holiday lights. However, this is an inefficient system in which the resistor loses more than half of the energy as heat. More commonly, an electronic circuit using integrated circuits, transistors, and other components regulates the current to an LED by rapidly switching the lamp on and off. These more-advanced electronic circuits allow significantly more precise control of the diode itself, but the efficiency of the electronic driver is still only 70 percent.

In application, there are two primary circuit types: constant-current and constant-voltage. In a constant-current system, the driver delivers a regulated current of either 0.35A, 0.70A, or 1.05A and it is up to the luminaire designer to wire individual LEDs in series and/or parallel to ensure that the correct amount of current reaches each diode. For example, when connecting three 0.35A diodes in parallel, a 1.05A driver will be sufficient; or a 0.35A driver can be used with the same diodes in series. Either way, each LED gets 0.35A. Constant-current drivers are best for high-power (0.5W and greater) white LEDs.

In a constant-voltage system, there is a power supply that produces a fixed DC voltage, typically 8V to 24V. Each LED then has a dedicated driver next to it on the circuit board. Constant-voltage circuits are more commonly used for lighting systems with varying numbers of LEDs such as string lights—if you cut the string anywhere, the system will continue to work. For reasons of cost and simplicity, constant-voltage systems are generally used with low-wattage LEDs.

DIMMING AND RGB/RGBA

Both dimming and RGB/RGBA control requires varying the current to each LED. The process of dimming LEDs is not as simple as installing an incandescent dimmer. Most SSL dimming systems are special versions of drivers in which the ratio of "on-off" time is varied; the longer the "on" time, the brighter the LED.

LED color-varying systems use either RGB (red-green-blue) or RGBA (red-green-blue-amber) color mixing of LED lamps of each color. RGB/RGBA control is similar to dimming, except that a dimmable driver must be provided for each color in each pixel. A pixel is the smallest addressable cluster of red, green, blue, and amber LEDs. In order for SSL systems to "chase" or display low-resolution video, this means you need to employ many drivers as well as require communications wiring and electronics.

For the purpose of architectural lighting, some manufacturers of SSL luminaires use drivers that can be dimmed with ordinary incandescent-style dimmers. But because simple incandescent circuits can experience interaction problems with SSL power supplies, better dimming range and smoothness often can best be obtained using dimmable drivers that are controlled by DALI, 0- to 10-volt, or DMX (theatrical) control circuits. Note that most of these circuits use special dimming circuits that are installed between the constant-voltage driver and those LEDs that the circuit is intended to regulate.

MAKE IT SIMPLE, PLEASE

Just as in the early days of compact fluorescent lamps, the LED industry is a long way from standardization. For the time being it will be up to the individual lighting designer, engineer, or contractor to figure out the intent of the often poorly written literature from the manufacturer. We are sometimes seduced by attractive, state-of-the-art products only to discover that it takes an electronics engineer to make the lighting perform properly. But it is hard to blame the luminaire manufacturers when the problem lies with the makers of the components.

We need standards in solid-state lighting that go well beyond the lumen measurement, efficacy, and life testing that have dominated solid-state lighting discussions to date. For instance, due to their poor 70 percent efficiency, drivers are often avoided when the energy efficiency of solid-state lighting is discussed. This is unfortunate. If we're going to take full advantage of LEDs, we need standardized and more manageable control components that make sense in the existing world of 120V and 277V AC power, the National Electric Code, energy codes, and the skills of electricians and contractors. As it is, LEDs have already developed a reputation for failing to meet rated performance and life. If the wiring and dimming remains complicated, there will be an almighty push back that will make us all hope for the invention of a high-efficiency incandescent lamp. JAMES R. BENYA

AD INDEX

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UNSTUDIO BURNHAM PAVILION, CHICAGO

AN INTERACTIVE LIGHTING EXPERIENCE CELEBRATES DANIEL BURNHAM'S CHICAGO LEGACY

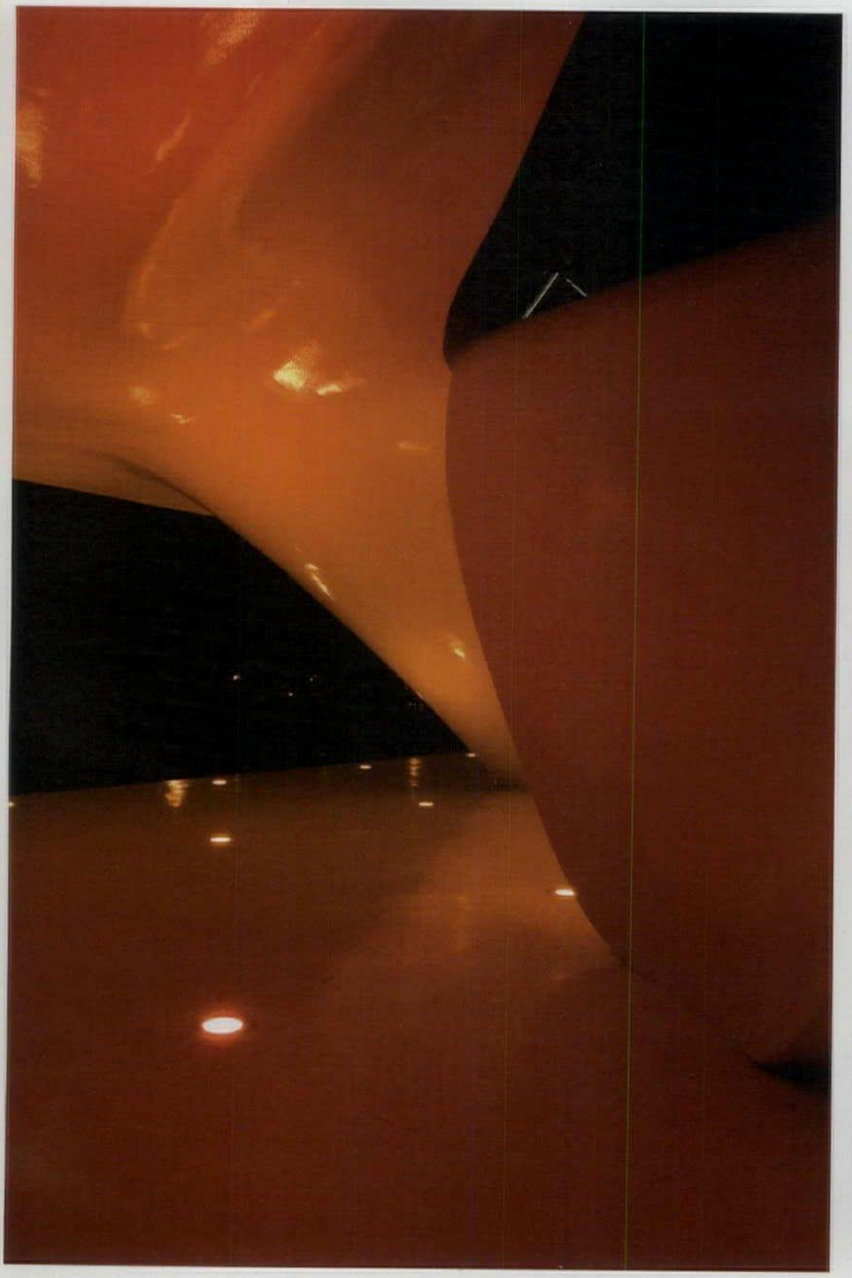
Project Burnham Pavilion, Chicago **Design Team** UNStudio, Amsterdam (design architect); Garofalo Architects, Chicago (architect of record); Third Coast Construction, Chicago (fabricator); Rockey Structures, Chicago (structural engineer); DEAR Productions, Chicago (lighting design); Daniel Sauter, Chicago (interactive lighting concept) **Photographer** Ben Dickmann. Images courtesy Iluminarc **Project Size** 6,400 square feet **Manufacturer** Iluminarc

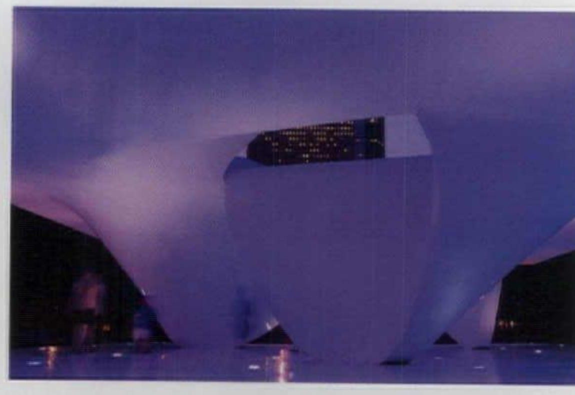
UNStudio's pavilion celebrates the centennial of Daniel Burnham's Chicago master plan by creating city vistas and recalling a color palette reminiscent of Burnham's original drawings.

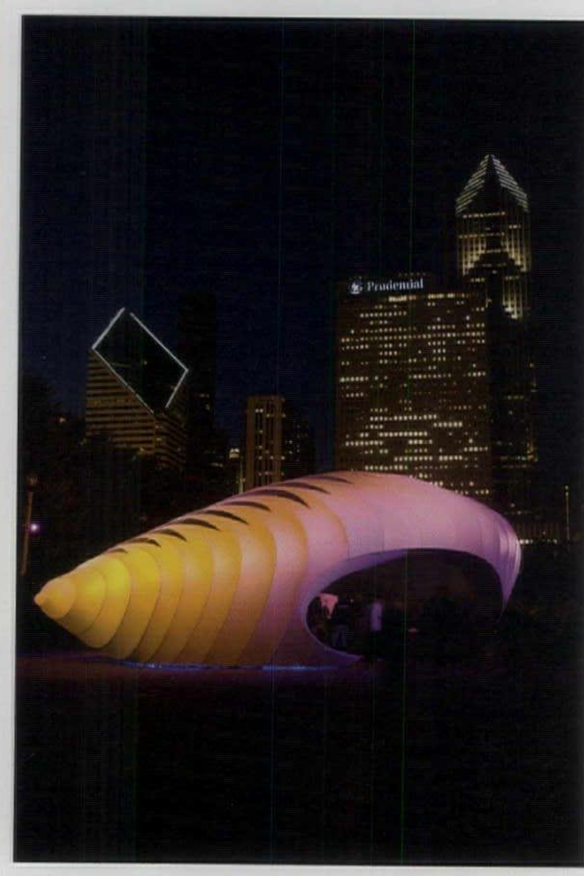
Ben van Berkel of UNStudio didn't have to look far for inspiration when the city of Chicago commissioned his firm to design one of two pavilions (Zaha Hadid Architects has designed the other one) in honor of the 100-year anniversary of Daniel Burnham's famous Chicago plan: It was all right there before him in brown ink on sepia-toned paper. Burnham's map opened up the teeming city of 1909 by slashing its orthogonal grid with avenues that ran diagonally out from the center of town. Berkel's pavilion has a square floor and ceiling, which is scooped in parts to form a supporting structure. These drooping elements open up vistas of the city and allow for a roofed structure without walls that invites the public to step aboard.

Continuing these civic-minded gestures, lighting designer Tracy Dear of DEAR Productions and artist Daniel Sauter were asked to devise an interactive lighting scheme that would engage visitors. "The question was how to get the light in without creating a lot of light pollution in the surrounding foliage," explains Dear, referring to the nearby trees of the installation's Millennium Park location. "The solution is what I call a 'light sandwich,' which goes between the roof and the floor of the pavilion."

The designers embedded 42 LED uplights into the structure's floor, each containing 36 1W color-changing LEDs. While Dear wanted to custom place the luminaires to best obtain an even distribution of light, UNStudio had



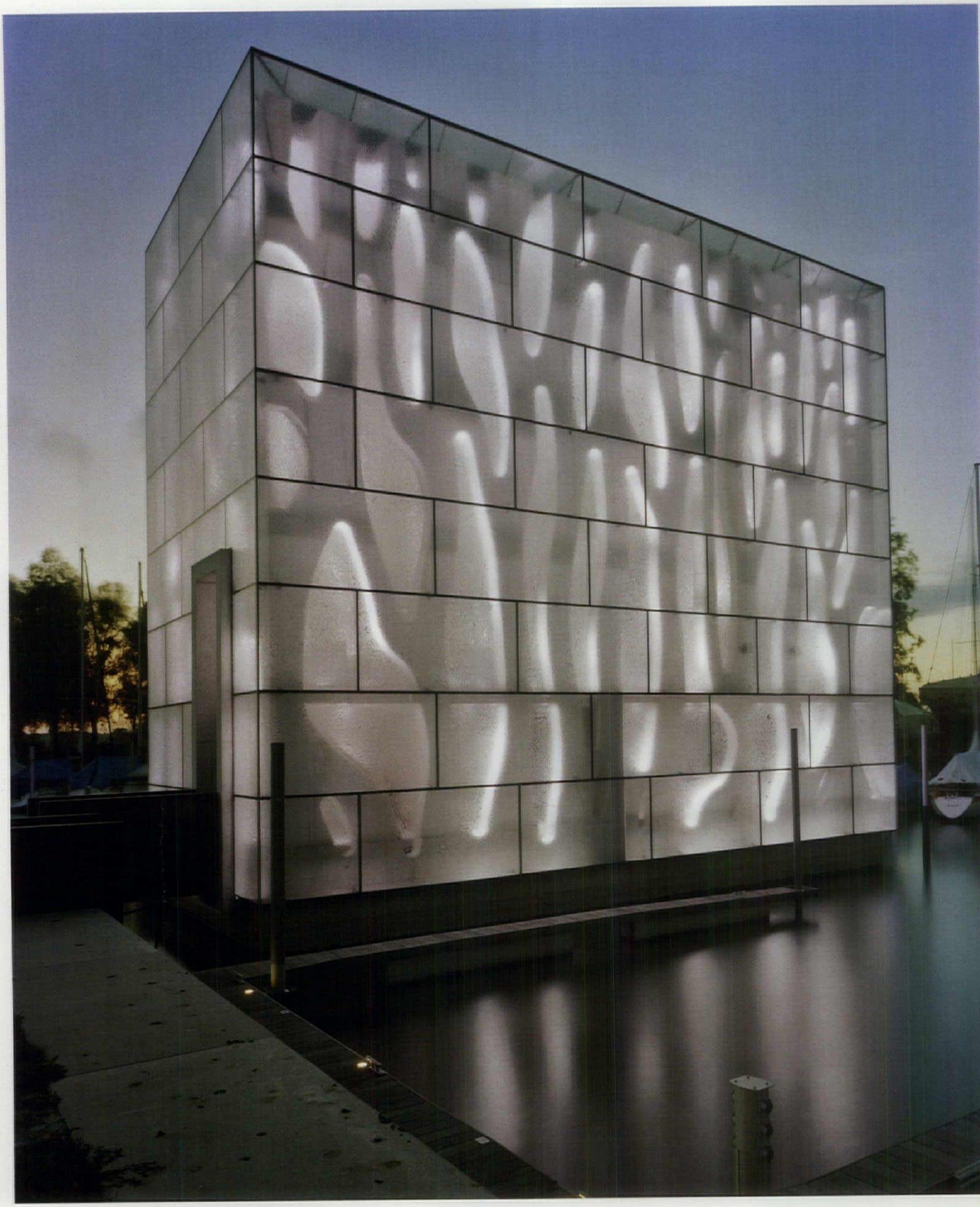




Fourty-two floor-recessed LED uplights illuminate the pavilion's glossy white surfaces (above left). Motion detectors trigger the lighting design's color-changing capabilities (top right). Using the same LED fixtures, but to different effect, DEAR Productions was also responsible for the lighting design of Zaha Hadid Architects' fabric-covered pavilion (bottom right).

another idea. The firm insisted on a rigid six-by-seven grid to further reference Burnham's plan. In answer to this demand, the lighting team varied the beam spreads: They removed the lenses on the fixtures in the center to achieve the widest beam-angle distribution possible, and narrowed those on the perimeter to 30 degrees. Frosted glass rings, set in the floor plane and 3 inches above each recessed light source, diffuse the beams to avoid creating hot spots on the pavilion's white-painted surfaces.

The entire system is wired serially, both for power and data, which proved a boon when integrating it into the congested steel and plywood framework of the pavilion floor. Each luminaire is outfitted with a motion detector, and sets off a scroll of color throughout the pavilion when activated. The color-changing evolves slowly so as not to become muddy and confused. The color palette was derived from Burnham's plan, which is based on the tones of a century ago: muted green and blue, burgundy, and orange. The LEDs provided enough range to match these hues fairly well, and the fact that they generate substantially less heat than conventional light sources put to rest concerns that hot lamps might burn visitors. "We had to use all LEDs," said Dear. "Their energy efficiency and color rendering properties can't be beat. They're the only source that makes sense at this point. Burnham would have encouraged that." **AARON SEWARD**



NORDWESTHAUS BOATING PAVILION, FUSSACH, AUSTRIA

A VIBRANT BEACON OF LIGHT EMERGES FROM THE SHORES OF LAKE CONSTANCE

Project Nordwesthaus, Fussach, Austria **Design Team** Baumschlager Eberle, Lochau, Austria (architect and lighting designer); Zumtobel Lighting (technical lighting consultant) **Photographer** Eduard Hueber, Brooklyn, N.Y. Images provided courtesy Zumtobel Lighting **Project Size** 1,259 square feet **Manufacturer** Zumtobel Lighting

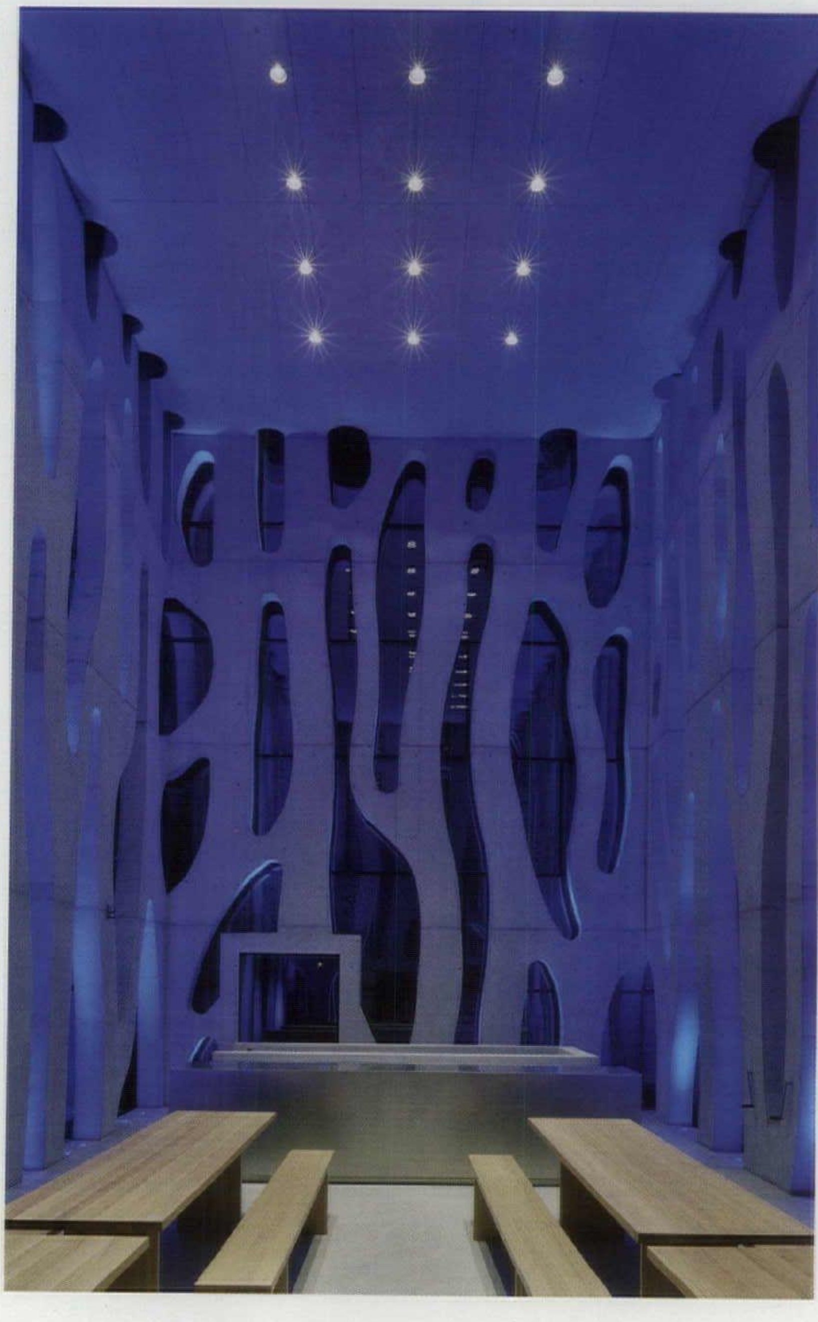
The third phase of a master plan that has transformed a former gravel pit into a picturesque destination on the Austrian shore of Lake Constance, the Nordwesthaus boating pavilion provides a dynamic focal point at the head of Port Rohner harbor. Rising just over 45 feet tall, the pavilion sits at the level of the port basin and provides easy access for boat storage and maintenance, while also serving as an event venue for parties and workshops. The superstructure of the cube-like building consists of irregularly shaped porous concrete walls, which are enveloped by a glaze of semitransparent textured glass. During the day, this outer skin sparkles in the sunlight and has a lively interplay with the reflections from the water below. In order to create a continuous eye-catching presence for their "boat-box" at night, the architects—Austrian firm Baumschlager Eberle (BE)—were tasked with developing a fully-integrated lighting solution that would simultaneously draw people in and establish a pleasing interior atmosphere that is both vibrant and non-intrusive.

The concrete support structure that creates the inner membrane for this ambitious architecture is illuminated by 125 compact luminaires recessed into the floor of the clubhouse as well as into the sills of the openings in the concrete walls. These custom LED spotlights were developed by BE in collaboration with lighting manufacturer Zumtobel, with whom they have had a long-standing working relationship. According to BE managing partner Dietmar Eberle, creating a rich light display during the day and at night was a focus of the project's design from the start. "We chose LEDs because, in connection with DMX control, they made the programming of different light displays possible," says Eberle. "Light displays were programmed in a way that lets the building pulse and be awake at night."

The concealed uplights have a special feature: an asymmetrical light distribution combined with an unconventional arrangement of LEDs. This spreads the light wide into the pattern of voids formed by the concrete walls, while also focusing the light to the sides of the room and outside. According to Bernd Clauss, the Zumtobel project engineer who worked with BE on Nordwesthaus, there is no symmetric organization in the LED circuit board design. Rather, the LEDs are positioned randomly. "This means that despite asymmetrical elliptic distribution, a perfect color mix is perceived, even at a short distance," explains Clauss. "We had to do this to create a uniform color image around the 'holes in the wall.'"

The use of color creates a variety of changing light atmospheres during scheduled event times. The 12 integrated RGB LEDs in each luminaire offer a virtually limitless spectrum of more than 16 million colors that can easily be controlled and manipulated through the process of color mixing. Using the DMX 512 standard as a controller for this project, a series of visual effects was choreographed for the façade, ranging from a fiery glow to reeds swaying in the breeze. Far from ordinary, the Nordwesthaus boating pavilion is a beacon of light that serves as an attractive new landmark for sailors and architecture lovers alike. MEGAN CASEY

Concrete, glass, and light create a dynamic play of materials and textures at the Nordwesthaus boating pavilion on Lake Constance (left). Architects Baumschlager Eberle collaborated with Zumtobel Lighting to develop a custom LED spotlight. The 125 fixtures are recessed in the floor and concrete walls. The asymmetrical light distribution and irregular arrangement of LEDs on the circuit board spreads the light wide across the concrete lattice walls. Halogen fixtures in the ceiling round out the lighting (below).



George Mueller

FORGING ENTREPRENEURSHIP AND TECHNOLOGY WITH LIGHTING

For someone who professes not to be a "lighting person," George Mueller has been awfully successful in the lighting arena—the solid-state lighting arena to be exact. Co-founder of Color Kinetics (in 1997) with Carnegie Mellon engineering classmate Ihor Lys, Mueller led the company to astounding success, culminating in its sale to Philips in 2007. Not one to rest on his laurels, Mueller launched EcoSense Lighting in May 2009. This time around his focus is on white light, fueled by a continued desire to bring credibility to an industry whose light-speed growth is its best—and worst—attribute. A passionate entrepreneur and an inquisitive technologist, Mueller seems poised for the next round of success. ELIZABETH DONOFF

What excites you about SSL?
The opportunity that this new semiconductor-based technology presents; it's replacing the old brass, gas, and glass.

Is SSL under a different kind of scrutiny than other light sources?
It's considered a disruptive technology, meaning it has usurped market share. Over the next five, 10, 20 years the traditional lighting market is going to give way to LEDs in some significant manner.

How does sustainability factor into the SSL discussion?
I look at it from the efficiency angle and the ability to cut down on the replacement of hundreds of bulbs over the lifetime of a comparable LED product.

Why does SSL appear to be resilient in this economy?
There is a significant opportunity to be more energy efficient right now. Today's corporate mandate requires companies respond to "green." If you can save on operational costs, large companies are going to take notice.

What do you say to designers who are frustrated by LEDs?
When you have a reputation for quality and delivering on the performance that you achieve, then you gain the respect and trust of the designer. That's what we are looking to carry over into the new company, EcoSense.

What can be done to maintain good faith in this technology?
Bolstering testing procedures and standards is a first step. The difficulty is that the road map is moving so quickly, and yet, that's the excitement of it; we'll have more efficient, better performing fixtures in as little as a year.