UNITED LUMEN, LLC

High Efficiency – Low Cost High Brightness LED for Lighting Applications

A patent pending High Brightness LED optimized for white light extraction that nets an exceptional 55% gain in performance over benchmark industry product.

Contacts:

Harold Brunt	*hbrunt@lumenflow.com*	*(269) 795-9007*
Brian Zatzke	*bzatzke@lumenflow.com*	*(269) 795-9007*
Mark Leonard	*markl@venntis.com*	*(616) 395-8254*

MSSLA | Michigan Solid-State Lighting Association

1261 S. Waverly Rd.
Holland, MI 49423
(616) 582-3161

UNITED LUMEN, LLC

High Efficiency – Low Cost High Brightness LED for Lighting Applications

LumenFlow with joint venture partner Venntis Technologies has formed *United Lumen, LLC* for the purpose of commercializing a new High Efficiency – Low Cost High Brightness LED for Lighting Applications. The skill sets of the founding members are complimentary in that LumenFlow brings the optical technology and intellectual property, while Venntis Technologies brings a wealth of expertise in circuit board assembly, chip placement and wire bonding, and power supply design.

MSSLA | Michigan Solid-State Lighting Association

1261 S. Waverly Rd.
Holland, MI 49423
(616) 582-3161

The High Brightness LED down-conversion optic can have several configurations each optimized for the application. The optic can be configured for direct down-conversion of a deep-blue source to a chosen color temperature of white or for secondary down-conversion of a cool white LED to warm white.

LumenFlow High Efficiency
Optical Coupler (HEOC) – Patents Pending
Captures 35% more of the Source light

LumenFlow Constrained Folded Path White Light
Scintillator – Patents Pending
Builds on the HEOC for up to 55% more output

The end product is a High Brightness LED or "Light Engine" which would be offered to customers for assembly into light fixtures or bulbs.

UNITED LUMEN, LLC

MSSLA | Michigan Solid-State Lighting Association

1261 S. Waverly Rd.
Holland, MI 49423
(616) 582-3161

While LEDs last longer, use less energy and are more environmentally friendly than current alternatives, lighting products based on the technology have a *higher initial cost*, and are *not as efficient as they could be*.

Shown:

- *GE energy smart® LED at $49.95 which uses six Cree® XP-G LEDs*
- *Sylvania Ultra LED™ at $49.95 which uses 12 OSRAM OSLON LEDs*
- *Philips AmbientLED at $39.95 which uses 18 LUXEON® Rebel LEDs*

The replacement light bulb provides a well known product for discussion though application challenges are common for bulbs to street lights. Any one of these bulbs could be made more efficient and less costly by using the United Lumen High-Brightness LED.

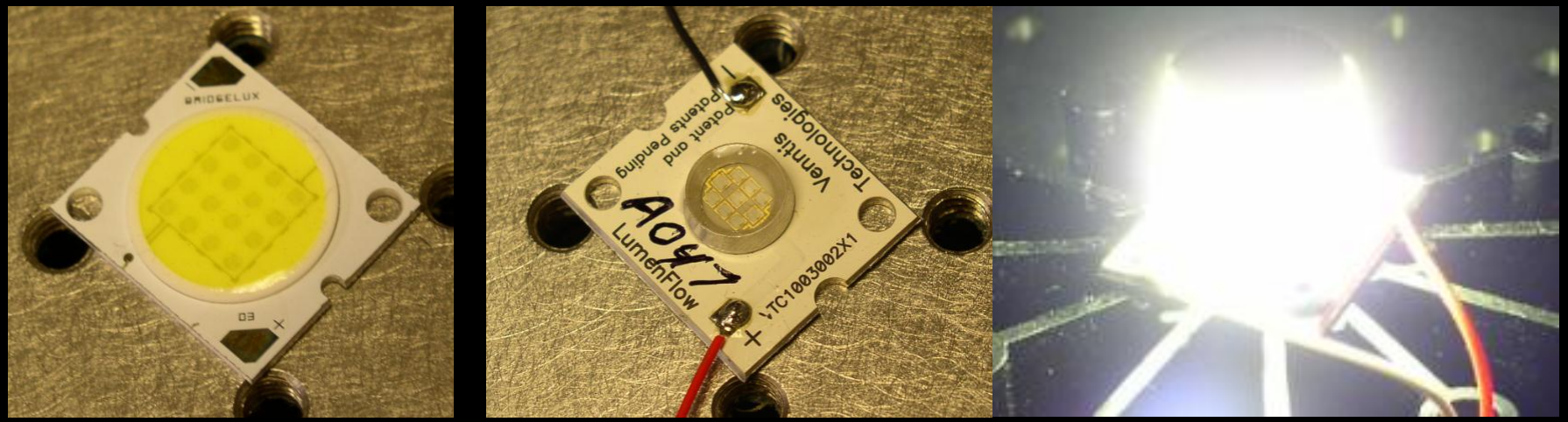
UNITED LUMEN, LLC

MSSLA | Michigan Solid-State Lighting Association

1261 S. Waverly Rd.
Holland, MI 49423
(616) 582-3161

The United Lumen LED:

- Captures the low angle light from the source and reforms that light for a more efficient conversion to usable white light.



Bridgelux® BXRA-W1200 LED 16 die (4 X 4 array, left) as compared to the United Lumen PCB with Bridgelux BXCA-4545 9 die (3 X 3 array, center) and with optic (right).
At 350mA per die, the United Lumen HB LED matched the output of the Bridgelux® LED with 1100lm.

Greater efficiency results in equal luminous output with fewer LED die. Fewer die means less cost and reduced heat sinking demands. Total performance improvements over benchmark industry products approach 55%.

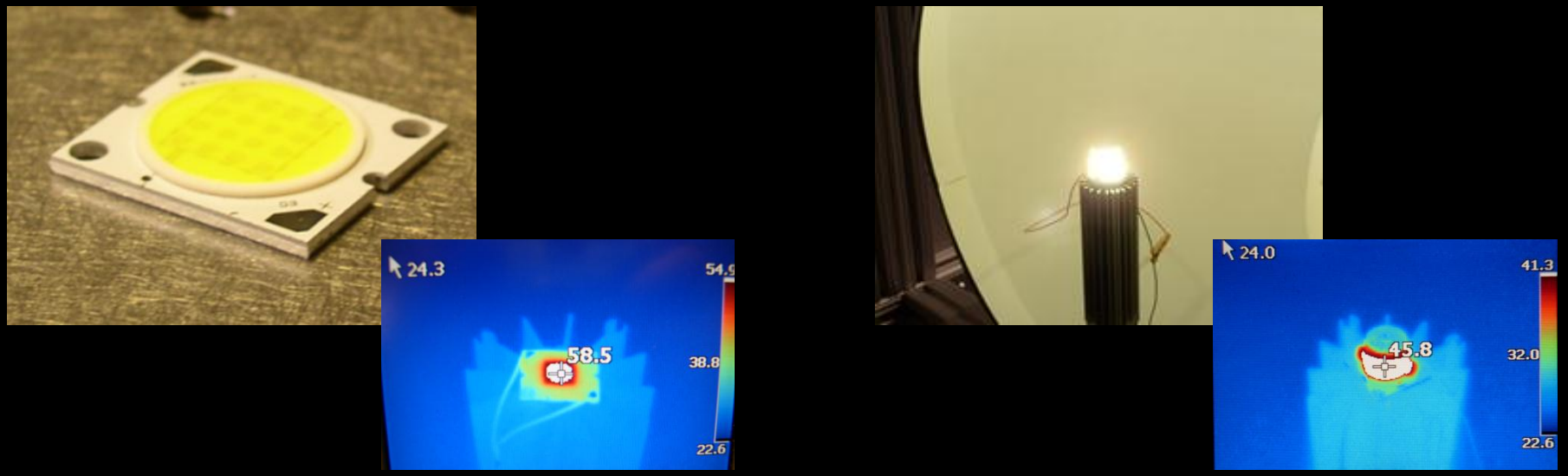
UNITED LUMEN, LLC

MSSLA Michigan Solid-State Lighting Association

1261 S. Waverly Rd.
Holland, MI 49423
(616) 582-3161

The United Lumen LED:

- Is a remote phosphor light source. The phosphor is located away from the heat generating LED junction.



Bridgelux® BXRA-W1200 LED with phosphor layer immediate to die (left) creating a "thermal blanket" as compared to the United Lumen Remote phosphor (right).

Isolating the phosphor will increase the expected life of the LED chip and slow the degradation of the phosphor.

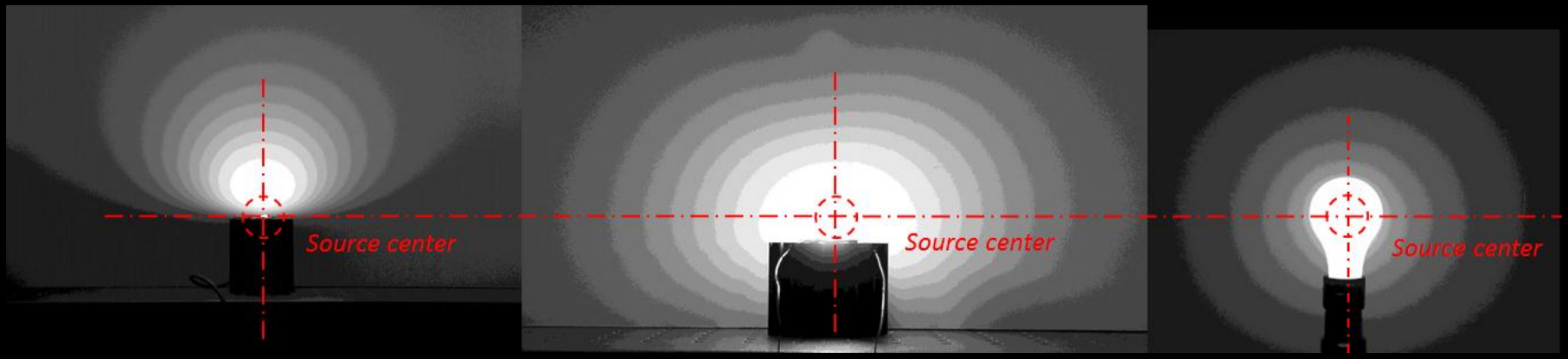
UNITED LUMEN, LLC

MSSLA | Michigan Solid-State Lighting Association

1261 S. Waverly Rd.
Holland, MI 49423
(616) 582-3161

The United Lumen LED:

- Has a radiation pattern that is a true filament replacement . The profile closely replicates the profiles of standard incandescent bulbs thereby making the retrofit of existing structures more straight forward.



Bridgelux® BXRA-W1200 is typical of LEDs used in Lighting applications, there is no light below the source center (left) as compared to the United Lumen High Brightness LED (center) and A19 incandescent bulb (right).

High intensity LED sources have an output that is nearly hemispherical in shape resulting in a directional output pattern. The output of the United Lumen LED closely matches that of an incandescent bulb.

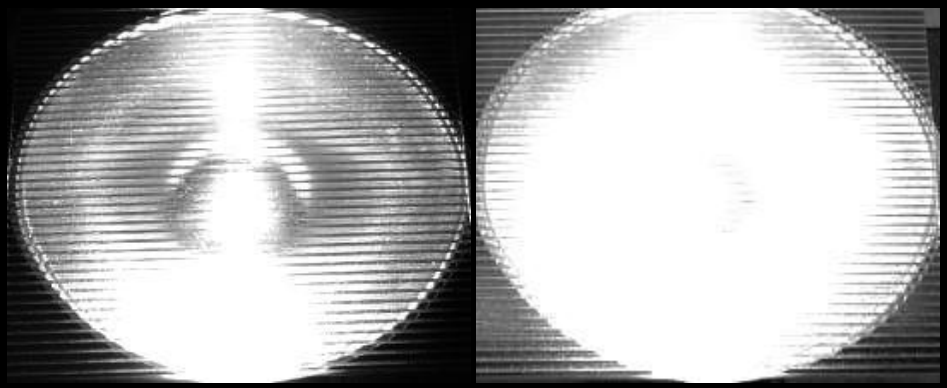
UNITED LUMEN, LLC

MSSLA | Michigan Solid-State Lighting Association

1261 S. Waverly Rd.
Holland, MI 49423
(616) 582-3161

The United Lumen LED:

- Has an output pattern that is more diffuse reducing the glare inherent with point source LEDs.



Cree® XM-L shows typical High Brightness LED glare with a high output and small emitter (left) as compared to the United Lumen High Brightness LED (right).

High output LED sources with small emitters are inherently bright and uncomfortable to the human eye. The effect is known as “glare” and is reduced by radiating the light from a large volume.

UNITED LUMEN, LLC

MSSLA | Michigan Solid-State Lighting Association

1261 S. Waverly Rd.
Holland, MI 49423
(616) 582-3161

The United Lumen LED:

- Has an output pattern that is more diffuse when used with standard reflectors.

UTILITECH PRO™ PAR38 shows typical multiple shadows from small emitter LEDs combined with TIR optics (left) as compared to a standard GE halogen 90 PAR38 (center) and the United Lumen High Brightness LED in a PAR38 (right).

Typical LED PAR replacement products are manufactured using multiple individual LEDs. Individual devices create multiple shadows which is displeasing in most applications and completely unacceptable in many.

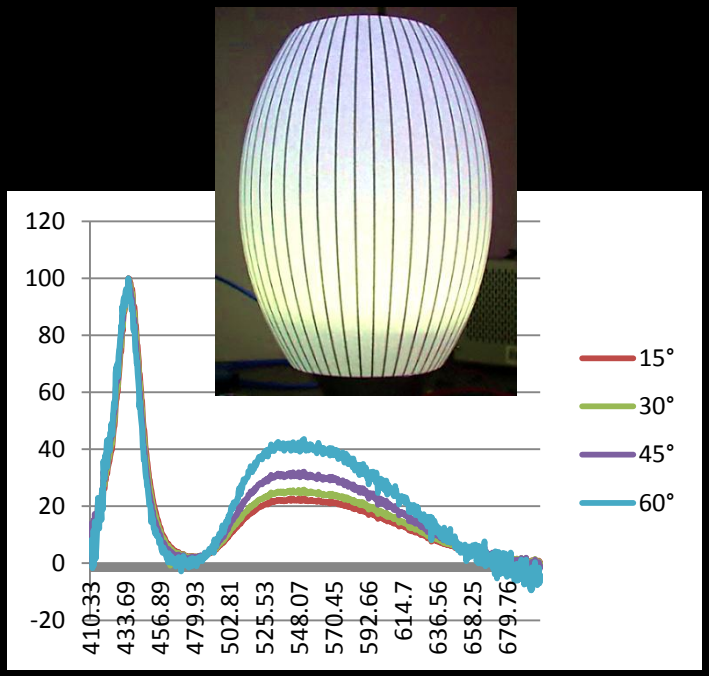
UNITED LUMEN, LLC

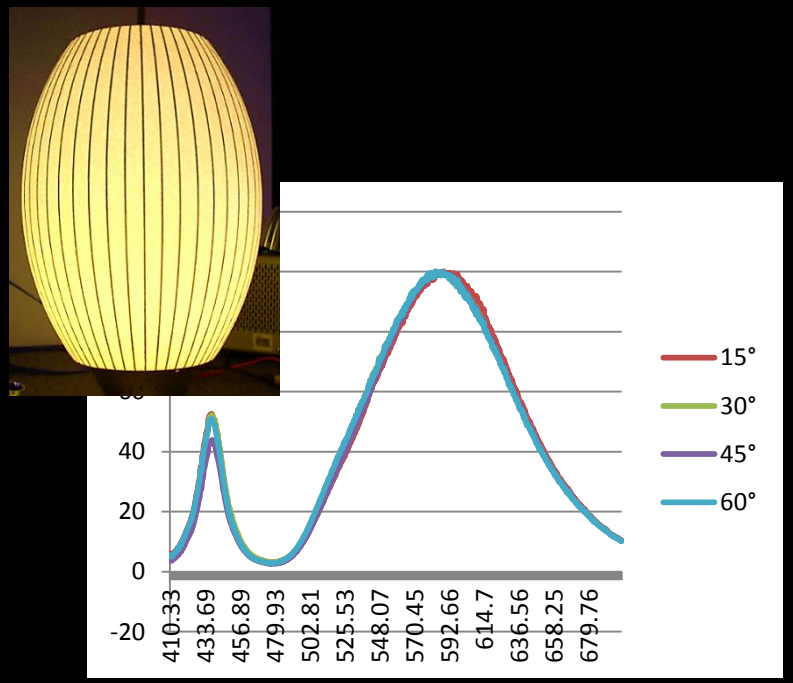
MSSLA | Michigan Solid-State Lighting Association

1261 S. Waverly Rd.
Holland, MI 49423
(616) 582-3161

The United Lumen LED:

- Produces a uniform spectral radiation pattern when viewed on or off the optical axis.





Cree® XM-L data and illuminated shade (left) shows a 4000 K white to blue color change over 45° of the viewing axis. The Same LED with United Lumen Optic (right) shows 100 K change over the same 45°.

The color of the light from the United Lumen High Brightness LED does not vary significantly with viewing angle.

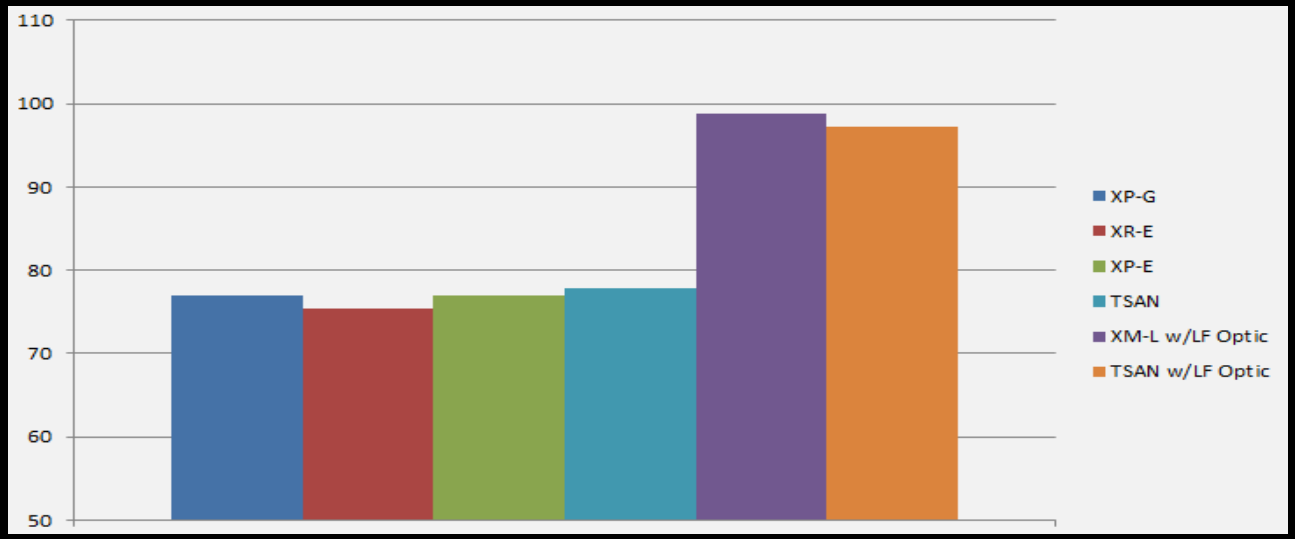
UNITED LUMEN, LLC

MSSLA | Michigan Solid-State Lighting Association

1261 S. Waverly Rd.
Holland, MI 49423
(616) 582-3161

The United Lumen LED:

- Can be configured for down conversion of a deep blue source light or for secondary conversion of a cool white source to warm or neutral white.



Cree® and Everlight specs. Reduction in output for the same model LED in cool white and warm white (1 – 4). Cool white LEDs with secondary down-conversion to warm white using United Lumen technology (5 & 6).

When moving from the Cool White (6500 K CCT) to the desired Warm White (3700 K CCT) for consumer lighting, the output for a given LED is typically 75% of the cooler white output. The United Lumen Optic performs the secondary down-conversion at greater than 95%.

UNITED LUMEN, LLC

MSSLA | Michigan Solid-State Lighting Association

1261 S. Waverly Rd.
Holland, MI 49423
(616) 582-3161

The United Lumen LED exploits several methods for optimized white light extraction:

- Captures the low angle light from the source and reforms that light for a more efficient conversion to usable white light.
- Is a remote phosphor light source. The phosphor is located away from the heat generating LED junction.
- A radiation pattern that is a true filament replacement .
  - The profile closely replicates the profiles of standard incandescent bulbs
  - The output pattern is more diffuse reducing the glare inherent with point source LEDs.
- Produces a uniform spectral radiation pattern when viewed on or off the optical axis.
- Can be configured for down conversion of a deep blue source light or for secondary conversion of a cool white source to warm or neutral white.

The United Lumen High Brightness LED optic can be produced inexpensively by existing injection molding or casting processes and is compatible with most high output deep blue to cool white sources.

If you would like to know how our product could benefit your application, contact United Lumen for details.

UNITED LUMEN, LLC

MSSLA | Michigan Solid-State Lighting Association

1261 S. Waverly Rd.
Holland, MI 49423
(616) 582-3161