LED Arrays Arrive

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INTRODUCTION

As the LED marketplace matures there has been specialization in form and packaging. LED arrays are one of these specialized packages and they are proving to be both flexible and popular. As the non-directional LED array has evolved, the key advantage is a combination of ease-of-use in assembly, manufacture and drive electronics. These same attributes allow LED arrays to be used in a wide variety of bulb and luminaire products.

While state-of-the art system efficacy is difficult to achieve with this kind of LED packaging, non-directional LED arrays can enable any lighting manufacturers to develop and deliver LED products with very good system efficacy.

Cree's entry into the non-directional LED array sector has delivered the industry's most flexible and highest performing LED array. The CXA2011 LED array delivers the widest operating range of luminous flux, the broadest level of chromaticity choices and color consistency, the widest range supporting 3rd-party products and the highest levels of efficacy for mid-range LED arrays.

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MARKET MATURITY IN LEDS

Specialization of form and function come with product maturity in every technology and so too with LEDs used in illumination products. The original dichotomy of high-power and high-brightness LEDs has given way to a wide variety of component designs. Broadly speaking, for white LEDs used in illumination, there are now four categories, represented by the table below. These are:

LED Type	Directional	Non-Directional
Discrete	• Single Die, clear encapsulant, 50-1000 lumens • Example Cree LEDs: XLamp® XM-L, XP-G	• Single and low-count LED die, often dispersed phosphor encapsulant, 15-350 lumens • Example Cree LEDs: XLamp ML-E, MX-6S
Array	• Multi-die, clear encapsulant, 200-1500 lumens • Example Cree LEDs: XLamp MP-L, MT-G	• Multi-LED, dispersed phosphor encapsulant, 300-5000 lumens • Example Cree LEDs: XLamp CXA2011

Table 1: LED categories

While directional, discrete LEDs have been the mainstay of the high power LED industry, the emergence of directional and non-directional arrays has allowed for larger lumen payloads to be delivered in a single package. Directional LED arrays, for example, have allowed manufacturers to create effective replacements for specialty bulbs like the PAR-38 and MR-16 bulbs. Non-directional arrays, as we will see, are used in the broadest variety of lighting applications.

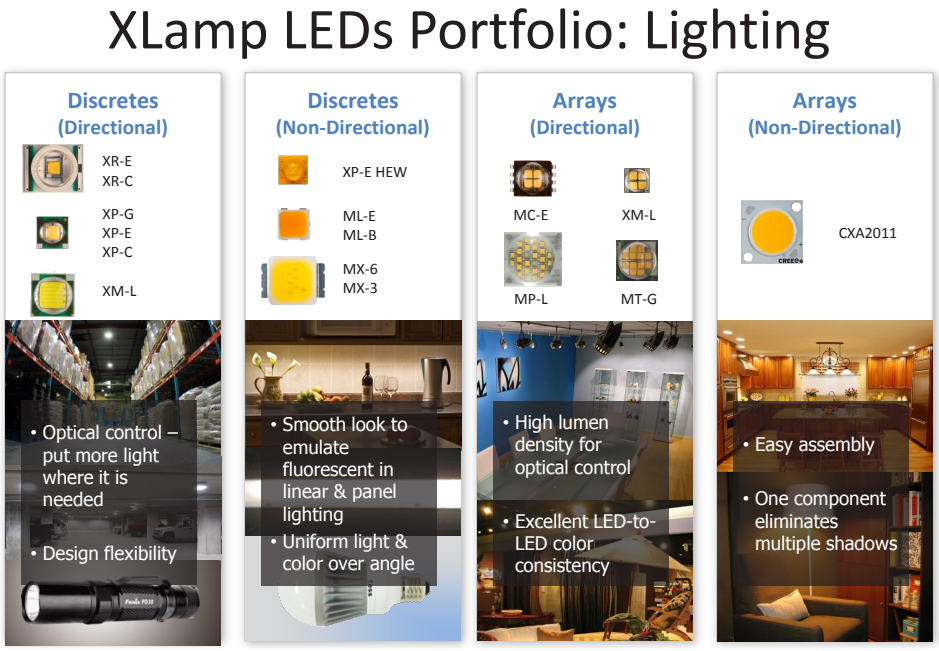


Figure 1: The XLamp LED Portfolio, organized by LED type

Another sign of marketplace maturity is the emergence of related, supporting and ancillary products. In the case of LED arrays, both directional and non-directional, companies like BJB, Molex and Tyco Electronics[1] have all developed parts to allow for the modularized connection of many of Cree's LED arrays, including the XLamp MP-L and the XLamp CXA2011.

PLUG 'N PLAY PRODUCT DEVELOPMENT

Non-directional arrays are the simplest to use LED product. They are large enough to be handled manually. Reflow soldering, the dominant circuit wiring technology for LEDs, is not required. Instead these arrays have on-top solder-pads, allowing for hand assembly or the use of modular holders. The LEDs are typically held in place with screws and thermal transfer is accomplished through back-of-the-package conduction. By contrast, directional and non-directional discrete LEDs are often much smaller, and require reflow soldering for both thermal transfer and circuit completion. The only practical technique for these requirements is robotic placement of the LED and wave soldering, both fairly sophisticated circuit board production techniques.

Figure 2: The Cree XLamp CXA2011

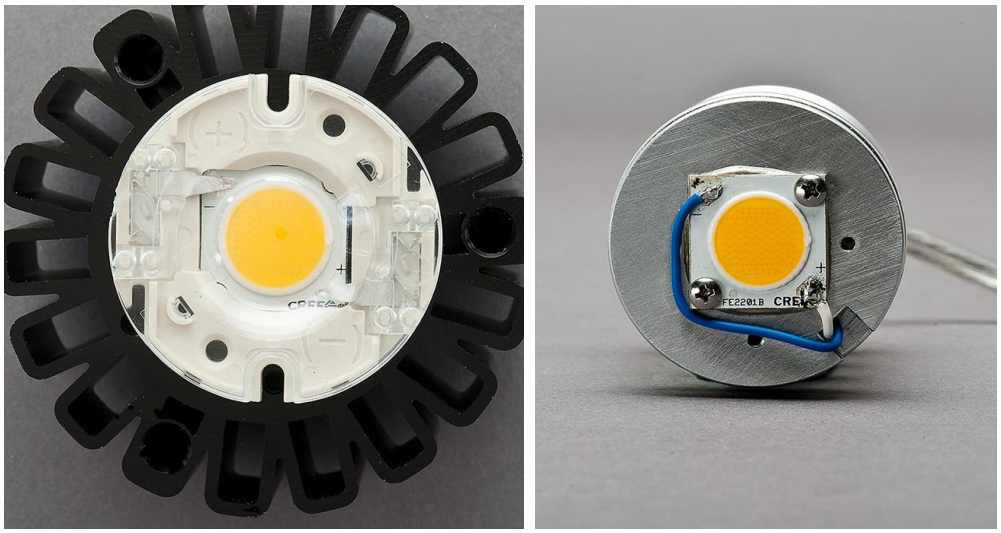


Figure 3: Simplified mounting techniques for the XLamp CXA2011

The multiple die used in LED arrays allows the manufacturer to create high voltage LED components. By interconnecting the die in various combinations of parallel and series circuits the LED component manufacturer can tailor the voltage and current combination of the LED array. In comparison, many multi-LED luminaires achieve high efficiency power supplies by using multiple strings of LEDs in series. These high-voltage, lower current strings of LEDs allow designers to create near-line-voltage electrical devices and therefore more efficient power supplies. The same holds true for multi-die LED

1 www.bjb.com, www.molex.com, www.tyco.com

arrays. By creating high voltage, lower current LED components, the same principles of efficient power supplies can be applied. The XLamp CXA2011 is a 40 V device, a relatively high voltage device in this category of LED components.

Most lighting product designers use non-directional arrays like traditional light sources. They are mostly intended to be one LED component per illumination device. Because of this one-per-system tendency several companies have developed families of LED arrays with flux from 500 to over 5000 lumens. Cree's initial entry into the space, the CXA2011, takes the approach of delivering a broad range of flux, from 500 to almost 4000 lumens from a single part. The single part can be used in a wide variety of fixtures and applications, depending on drive current — all from a single part. The dynamic range of the CXA2011 is unprecedented in non-directional arrays.

LIMITATIONS OF NON-DIRECTIONAL LED ARRAYS

There are two basic limitations on the uses of the non-directional LED arrays: optical control and system efficacy.

Whenever the precise placement of a focused beam of light is required, there are always better choices than a non-directional LED array. The larger size of the non-directional illumination sources requires correspondingly larger secondary optics, such as lenses and reflectors. More cost-effective and better performing optical trains can always be developed with directional LED arrays. This has been the impetus for the development of all of Cree's directional LED arrays, the XLamp MP-L, MT-G, XML-EZW and MC-E.

The CXA2011 is 22 X 22 mm. By contrast the XLamp MT-G is 8.9 X 8.9 mm and the MP-L is 12 X 13 mm.

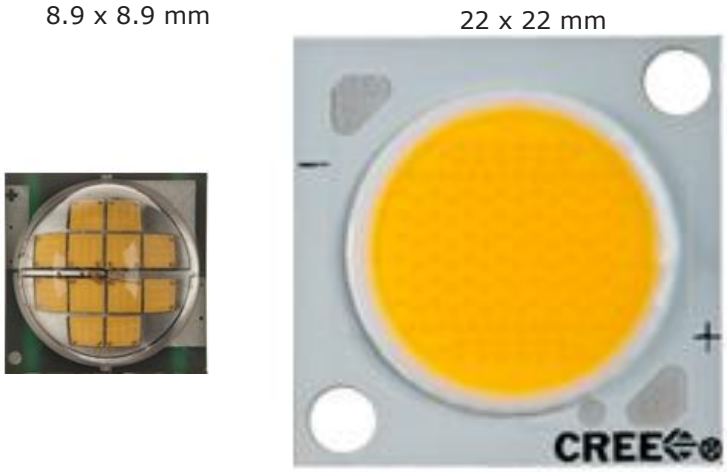


Figure 4: Source-size comparison XLamp MT-G vs. CXA2011

The other limitation of non-directional LED technology is in the area of efficacy and thermal dissipation.

The highest efficacy LED illumination systems on the market today are typically LED streetlights and high-bay fixtures. State-of-the-art system designs of greater than 100 lumens-per-watt are routinely achieved by leading lighting manu-

facturers. They are all created with discrete, directional LEDs. This is because the highest efficacy LEDs come from single die in a thermally and optically optimized package. Multiples of these directional LEDs are distributed over a larger heat sink to achieve optimal thermal dissipation. The concentration of LED die in close proximity to one another in the LED array limits the efficiency of thermal conductivity and therefore system efficacy.

Figure 5: 32 XLamp XM-L LEDs distributed over a large circuit board and heat sink can deliver over 20,000 lumens with very high efficacy

Finally, there are also lighting applications where it is more appropriate to use an LED module such as the Cree LMR4 – which contains LEDs, power supply and optics in a single package. Here the module can be integrated into a metal housing without consideration for drive electronics or component packaging.

Figure 6: Modules, such as Cree's LMR4, offer even higher levels of ease-of-use and integration

EXAMPLES

Non-directional LED arrays are used in a host of LED illumination systems. They offer benefits in ease-of-manufacture and inventory minimization. A collection of illustrations and characteristics in table 2 below shows some of the many applications in which these components can be successfully used.

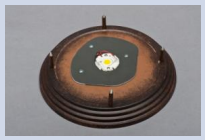
Application			Electro-optic Characteristics					
			Current (mA)	Lumens	Optical Loss	Electrical Loss	Power (W)	Efficacy (L/W)
Overhead Fixture			**400**	**1200**	**15%**	**15%**	**20.25**	**59.4**
Can Light			**400**	**1070**	**15%**	**15%**	**19**	**56**
			650	**1600**			**33**	**49**
			950	**2060**			**49**	**42**
Pendant			**350**	**1060**	**15%**	**10%**	**16.5**	**64.2**
A19 Bulb			**290**	**800**	**15%**	**10%**	**12.8**	**63**
Coach Light			**220**	**750**	**7%**	**15%**	**10.5**	**71.2**

Table 2: Example applications of the XLamp CXA2011

THE CXA2011 LED ARRAYS

There are several important and market leading features in the XLamp CXA2011.[2] Among the most important of these features are:

- The CXA2011 LED array is binned at 85° C for chromaticity and flux; the flux bins are NEMA SSL-3 2011 standard flux bins; chromaticity bins are either EasyWhite 2-step or 4-step bins, or ANSI standard quarter bins all at 2700-K, 3000-K, 3500-K, 4000-K and 5000-K CCT. This characterization and binning data offers unprecedented chromatic choice and consistency.
- Depending on drive current and system design, the CXA2011 can deliver 500-2500 system lumens from a single part.
- The CXA2011 is the first LED array to provide data for chromatic shift over temperature and current, allowing fixture designers new levels of lighting predictability and control.

The CXA2011 is commercially available as of mid-April 2011.

CONCLUSION

Multi-chip, non-directional, LED arrays have been available for several years and come closest to being the LED industry's plug 'n play component. Their key advantage has been a combination of ease-of-use in assembly and manufacture, which has in turn brought this form of LED packaging into a wide variety of lighting applications.

While state-of-the art system efficacy is difficult to achieve with non-directional LED arrays, these components can enable any lighting manufacturers to develop and deliver LED products with very good system efficacy. Early generations of LED arrays have not always delivered acceptable performance or lifetime in chromatic or luminous stability. With the advent of Cree's lighting class LED array, system and product-level improvements in efficacy, chromatic and illumination stability, and (for fixtures being sold into the US marketplace) conformance to Energy Star guidelines are more easily achieved.

2 Consult the XLamp CXA2011 Datasheet for a complete product specification.