COB-based solid-state lamps present cooling tradeoffs

Chris Warner, Executive Editor

 Solid-state lighting has taken its place in the mainstream of illumination, finding uses in a diverse range of industrial and consumer applications. Solid state lamps have shed the initial skepticisms about quality, and although the upfront costs are high, these costs are coming down.

LEDs are living up to their efficiency potential, with lifetimes in the tens of thousands of hours and power consumption just a fraction of traditional lighting sources. They also have a very concentrated beam angle, so only areas intended to be lit receive the light. This makes LEDs attractive in comparison to traditional light sources that may rival LED lamps in light output, but beam light in unwanted directions as well as their housings. Taken as a whole, the efficiency characteristics of LED lamps makes the cost proposition very attractive.

Chip-on-board packaging enables plug and play benefits

As LED lamp technology evolved, so has the fixture's packaging. In fact, packaging is now a key factor in the device's total cost. The most prominent of these packaging types is chip-on-board (COB). With chip on board, several LEDs are mounted directly on the printed circuit board using wire bonds instead of pins associated with surface mounting methods. COB offers manufacturers numerous benefits such as space reduction – more than one LED placed tightly together without the corresponding pins; reduced costs since several LEDs comprise a single part, faster time to market, and desirable heat distribution. This has been a boost for lighting manufacturers, who can put more emphasis on traditional industrial design process such as forming metal and molding. Robbie Paul, lighting sales director at Digi-Key explains the plug and play benefits of COB: "You would take a COB package, you would have an appropriate connection, or you would solder the leads on the package and away you go. So you would not need any electronic processing to come up with a lighting fixture."

What was once a niche packaging technology is now ubiquitous, as most LED vendors offer some sort of COB-based product. With so many players, COB packaging can come in many varieties. Excelitas' ACULED package is based on a "through-looking" mounting design and includes four separately addressable chips and a fully tunable correlated color temperature in a very small footprint. OSRAM Opto Semiconductors' SOLERIQ COB LEDs are targeted at downlight designs thanks to a large flux output. They also feature a small color variation within a 4-step MacAdam ellipse and a CRI of >80. Sharp's Mega Zenigata COB products use an inert, non-reactive ceramic substrate to dissipate heat without discoloring while offering a uniform light emitting surface in a 20-mm x 24-mm package. Philips Lumileds also touts the small, uniform light emitting surface of its LUXEON CoB product family, capable of up to 6000 lm and efficacies of up to 120 lm/W for bright white CRI lights.

One of the more interesting packages belongs to Bridgelux' Vero LED array, which includes an onboard connector port that interfaces with the Molex Pico-EZmate connector for plug & play solder-free electrical interconnectivity. According to Brandon Noska, applications engineer at Bridgelux, "the connector is made from the same plastic and color, so it has the same reflective properties as the housing." With little training necessary to attach the connector, the connections are reliable, repeatable and consistent. The company also helps make things easier by using common (industry standard) driver currents in its LEDs. Noska asserts, "luminaire manufacturers do not have to use unique drivers that are harder to procure, are

more expensive, and cannot be leveraged across other products – causing sku management complexity."

High heat fluxes raise thermal challenges

The tight spacing between the LEDs and small light emitting surface that make chip on board LEDs attractive also present high heat fluxes that must be addressed -- the natural convectional cooling that is present in more traditional solid state lighting is hindered with the small surface area of COB. "The biggest challenge is the power density," notes Lee Jones, director of advanced development at thermal solution provider Nuventix. "COBs create a tough cooling challenge in terms of Watts per square centimeter. These high lumen packages just keep the heat coming." Like any other solid state lighting application, COB-based solutions can pay a price for being pleasing to the eye. Brandon Noska of Bridgelux adds, "The fixture must have aesthetic appeal that can negatively impact thermal management."

To address thermal management with COB-based solutions, lamp manufacturers have to consider a number of variables. There are many cooling options out there, and designers will have to choose between passive cooling strategies – those that spread heat over a large surface area without adding more power to the design, or active cooling strategies involving fans or synthetic jet technology. The environment in which the lamp will ultimately reside should be a consideration (ex. a spotlight in an ambient room, or a high bay many feet above a factory floor), the power involved in the solution, and cost should be a factor. As always, there's tradeoffs.

There's no single formula to cooling COB-based designs

Robbie Paul of Digi-Key notes a cooling strategy does not come down to a simple formula or flowchart. "An active cooling system is more expensive, but a passive cooling system brings raw materials costs into parity. For example, a passive heat sink reaching the parity level at 75 Watts of power will be a foot-by-a-foot area and weigh 40 pounds. Compare this to an active cooling device that may be 25 percent of the size and significantly more expensive. It's smart to evaluate both and figure out what works best in your environment." Paul also notes power as a determining factor – using COB technology becomes much more difficult with passive cooling above approximately 50 Watts, although a highly engineered product – heat sinks that have creative configurations or special materials – can employ passive cooling at higher Watts.

If you decide on an active cooling strategy, fans alone are no longer the most obvious choice. More vendors are coupling fans with heat sinks to create specialized cooling devices. Even traditional heat sinks are becoming active by adding vibratory features to dissipate heat.

One of the exciting advances in active cooling is the synthetic jet, such as a module offered by Nuventix. The SynJet device is based on an oscillating diagram that creates a turbulent airflow which then pulls air within its wake, further increasing the airflow while improving heat transfer out of the heat sink. The air from the wake then “sweeps” the hot air out of the system. Lee Jones of Nuventix asserts synthetic jet cooling is particularly appropriate to designers who need the flexibility to control the junction temperature in their product while incorporating less metal. As for aesthetics, he adds “you aren’t tied to a big clunky heat sink – you can trim it, shape it and sculpt it, to make something special.”

Another cooling strategy manufacturers may wish to consider is the housing itself. Brandon Noska explains, “A new housing can more effectively be used as a thermal management component rather than trying to force fit a LED source into a fixture that is not designed for thermal management. Usually you can get a smaller footprint that is more aesthetically pleasing.”

Don’t forget your partners

The number of solid state lighting parts and vendors can be overwhelming. Digi-Key, for example, is trying to address this by creating more reference designs using the myriad different parts from which the designer must choose. Speaking of Nuventix, Paul says, “We’re trying to put together reference designs for specific applications that pull together a COB LED, certain drivers that push the limit in terms of lumen output, and try to cool it with some of these active cooling heat sinks.” He adds, “As a distributor we view ourselves as a platform where we organize information and products in such a way that it makes it easier for our customers. So it comes down to narrowing selection and making associations that gets them to design and to market faster.”

Finally, be sure to take advantage of the design assistance offered by the solid state

lighting vendors. “We’ve got a team of incredible applications engineers that can answer questions and quickly move you from a concept to a working design,” says Jones. “We love to collaborate and help people accomplish their goals.”