



APPLICATION NOTE

Advanced Thermal Management Solutions
for High Power LED Lighting



LED Lighting requires
more efficient thermal
management solutions.





LED lighting is a rapidly growing and developing market. There are many LED sub-segments from indoor to outdoor lighting, from consumer and retail lighting to horticultural, industrial, and stadium lighting. Most of these applications, are driven by optical efficiency, power consumption, and lifespan of the LED chips. To maximize reliability and efficiency of LED products, the role of thermal management is essential.

The component and encapsulation technologies of LED products have been progressing a lot in the last decades. SMD LEDs are still broadly used, but very powerful COB LED are taken bigger and bigger role particularly in the most powerful LED applications. COB technology allows a ten-fold increase in power density over standard SMD LEDs. The powerful COB LEDs can have hundreds of Watts of electrical power (up to 1 kW), and 50% of that can be generated as heat. Hence, thermal management can be a bottleneck in LED lighting applications. The high-power density sets the new demands also for the heat sinks used in LED luminaires. Another big challenge for advanced next generation luminaire is also the weight of the heat sink. In many powerful LED applications, the weight of the luminaire is very critical. The weight is dominated in many cases by the massive heat sinks required to dissipate ever-increasing thermal power.

Challenges of LED Lighting

The biggest challenges of LED lighting are related to ever increasing brightness specifications, increased power densities due to higher packaging densities and more demanding ambient temperatures in many

applications. As a combined effect of these, the design of high-power luminaires is also more challenging than ever before.

Typical examples of the existing challenges of luminaire design are, e.g., stadium lights. The challenge in stadium lights is to optimize the optical performance (lumens) versus weight ratio. The existing stadium lights may generate over 150,000 lumens and this reflects also to the requirements for cooling capacity of the luminaire. However, it must be remembered that in the case of stadium lights, the increase in weight also means that installation becomes more difficult. That is why it is important to be able to create efficient but lightweight cooling elements for high-power LED lighting applications.

Another big challenge in terms of lighting is also the cooling of industrial high-temperature luminaires. Many industrial luminaires are installed in very demanding conditions, where the ambient temperature of the luminaire may be 70–90 °C.. This makes it, of course, difficult to design an extreme efficient luminaire, when the heat budget for the lamp is already limited due to the high temperature of the harsh industrial conditions.



The traditional LED cooling solutions are based on die casting aluminum heat sinks. The more sophisticated structures are based on heat pipe solutions. Traditional aluminum heat sinks are no longer sufficient to meet the cooling power required in the most demanding applications.

Advanced thermal management offer several benefits in the next generation lighting applications by ensuring product optical performance, lightweight structure and reliability.

NEOcore technology offers new tools for thermal management of demanding LED lighting

CooliBlade has developed a next generation thermal management technology NEOcore that offers exceptional thermal conductivity performance in a light-weight package. CooliBlade's NEOcore thermal channels are based on phase change cooling principle. NEOcore's thermal conductivity can be approximately 1000 times better than in standard aluminum heat sinks. CooliBlade systems are wickless which means that the cooling performance is instant and extremely efficient. NEOcore thermal channel modules can be mass-produced which enables us to offer cost-efficient performance even in the most extreme LED luminaire applications.

COMET Series Product

CooliBlade introduces the COMET Series product that provide powerful and compact cooling element for high power LED applications. Compact size combined with cost-efficient structure make COMET a compelling solution for all kind of LED lighting applications. The modular structure and optimized metal-air interface enable COMET to be a lightweight but also the most powerful heat sink element on the market.

The COMET series has an outstanding heat distribution capability provided by NEOcore thermal channel technology. Additionally, superior heat conductivity enables instant and even thermal dissipation in the whole air interface. Unique design of the air interface enables efficient air flow through the COMET. Rapidly moving air removes the heat at the level not seen before.

Key Benefits

- Enables to maximize the efficacy of the luminaire
- Reduce the weight and the size of luminaire
- Easy-to-integrate to all kinds of lighting applications from compact track spots to powerful stadium lights
- Cost-efficient
- Enables design freedom for lighting designers.
- Reducing time-to-market with stand-alone modular units. No or minimum need for special tooling processes.



CooliBlade Stadium Light Design



Compact 50W Track Spot

The essential design requirements for track spotlighting are compact size, modern outlook, powerful radiation, and optimal optical beam.

The optical performance, i.e. high brightness, combined with decorative outlook are the important factors in track spot applications, e.g. retail applications. This is, of course, challenging heat sink performance when the size and weight should be optimized. The more efficient LED chips, like COB, will be used, the higher thermal performance of cooling element is required.

A very powerful 50W track spot is combined with a small size (Ø50x130mm) and lightweight structure (200g) in the CooliBlade's track spot reference design. The reference designs offer excellent cooling power from LED hot spot to air. Efficient COMET module enables to use COB LEDs with smaller LES and this reflects also to the optics size and the cost of Track spot products. All-optical mounting components (e.g., standard Bender+Wirth) can be easily integrated with COMET. Lighting designers will have more design freedom thanks to the compact structure, which allows them to customize and finish the design of their own product.



Ø50mm/ 50 W



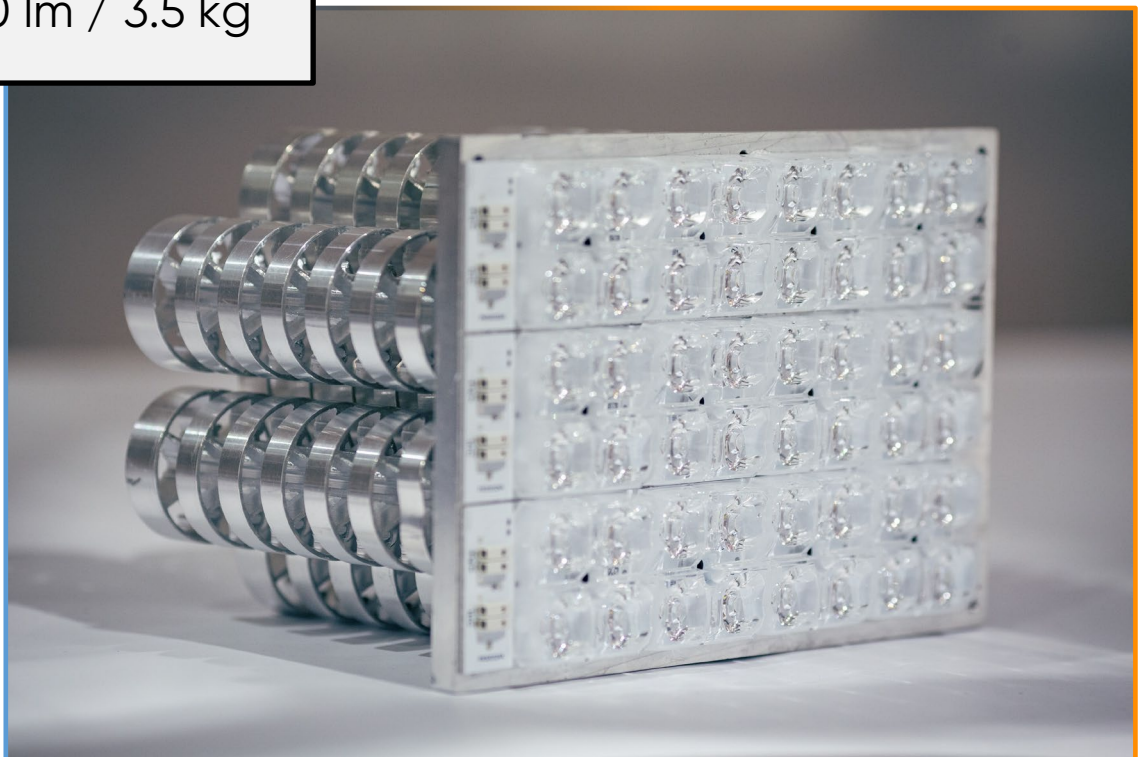
Powerful and Lightweight Stadium Light

CooliBlade has designed a reference stadium luminaire in collaboration with LEDiL and Tepcomp. Stadium light referendce design combines outstanding optical performance with competitive weight.

The reference design consists of 60 Nichia LEDs (NV4WB35AM) at 540W power level. The MCPCB driver electronics applied Tepcomp's PowerPAQ 540W product. LEDiL's sports optics offers an optimal beam angle of 10...12 degrees for the reference design.

The stadium light provides 63'000 lm optical power in a compact package. The stadium light (without mounting mechanics) weighs only 3.5 kg and produces 18'000 lm/kg, which is exceptional compared to current state-of-the-art stadium lighting. The CooliBlade's reference design also achieved a compact front panel size (245 x 165 x 180 mm). CooliBlade solutions achieved a 41 °C lower temperature compared to commercial aluminum heat sink elements in the natural convection test measurements.

63'000 lm / 3.5 kg



10 000 lumens High Bay luminaire for high Temperature applications

One special luminaire product is Industrial high bay LED luminaires. These luminaires are widely used in many industrial environments and the critical features are the optical performance, efficiency, and high temperature resistance.

Typical such environments are e.g. heavy industry manufacturing sites, paper mills and steel industry. The conditions are typically very harsh and setting higher standards also for lighting products. High temperatures, like 70–90°C, heavy dust, and mechanical vibrations, are the special requirements for the high bay industrial luminaires in these applications.

CooliBlade has developed the high bay luminaire reference design which can be used in the high ambient temperature up to 70 °C. The reference design consists of efficient LED chip (Citizen) generating 9'000 lm optical performance. The cooling element based on COMET cooling module ((Ø50x300mm) which enables to achieve excellent performance even in these harsh environments. The luminaire has IP65 classification, and it applies external power supply electronics.



A concept design.

10 000 lm / 70 °C



Conclusion

Thermal management is very critical in advanced, high-power LED lighting applications. NEOcore technology from CooliBlade enables to design efficient and compact lighting ranging from compact track spot to powerful luminaires for high ambient temperatures.

CooliBlade's COMET series' modular structure makes it simple to design cooling units with varying power levels and form factors. A well-designed thermal management solution offers new design freedom to luminaire designers and improves the product performance, makes it possible to design more compact and light-weight products, and significantly increases lifespan of LED components.

With CooliBlade as a thermal management partner, lighting manufacturers can offer innovative lighting solutions with greater design flexibility, allowing them to create limitless lighting effects while meeting lighting efficiency standards.



6 x CooliBlade COMET Evaluation Kit

