Performance When Changing Heat Sink Orientation

Introduction

Optimal Thermal Solutions BV used the 6SigmaET simulation software to examine the effect of the orientation of an LED heatsink on thermal performance. The two heat sinks investigated included an extruded heat sink (ModuLED9980) and a pin fin heatsink (LPF11180-ZHE). The simulation results were compared with measured values, and the maximum difference between the test and simulation data was found to be 1.9 K or 5%.

How Difficult Can LED Lighting Be?

LED lighting can be an effective method to reduce the operating cost of a building. However, unlike traditional lighting solutions, LEDs have a maximum junction temperature of around 100 °C whilst incandescent lighting solutions will still operate at around 2,000 °C. This means that for LED lighting, there needs to be an effective heat transfer path to the ambient air; a thermal design challenge to say the least.

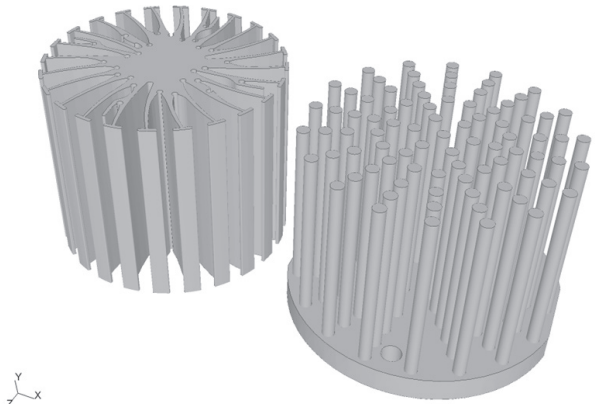
Typically, heat sinks for light emitting diodes (LED) chip-on-board (COB) are designed for, and tested in ,orientations where the light is emitted vertically downwards. In this experiment, the heat sink thermal performance is characterized when the LED is rotated, such that the light is no longer vertically down.

Investigation

The heat sinks used in this investigation are the MechaTronix LPF11180-ZHE and the MechaTronix ModuLED9980. The LPF11180-ZHE is a 111 mm diameter pin fin heat sink that is 80 mm high.

The ModuLED9980 is a 99 mm diameter extruded heat sink and is also 80 mm high. Although dissimilar in size, the two heat sinks have a similarly-quoted performance by manufacturer, namely: 1.07 K/W for the LPF11180-ZHE and the 1.02 K/W for the ModuLED9980.

Although the electrical power input to a COB is easy to measure, the same cannot be said for the dissipated power if using non-specialised light measurement tools. The dissipated power is dependent on the COB's light efficiency. This, in turn, is related to the absolute junction temperature of the COB, as well as the forward current. In order to decrease the number of unknown variables, it was decided to conduct both the experimental and numerical methods with known power dissipation in a power MOSFET.

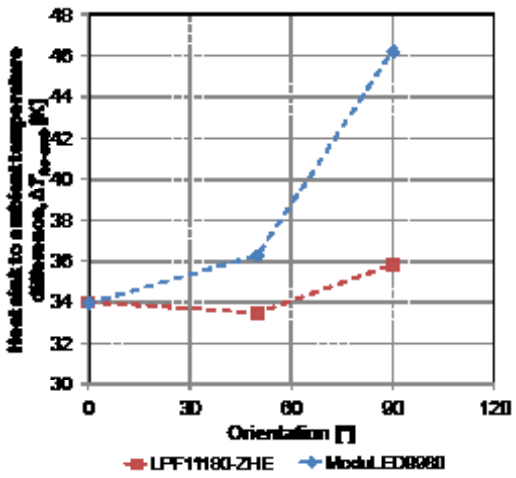


CAD models of the ModuLED9980 (left) and LPF11180-ZHE (right)

The heatsinks were mounted in free air at ambient temperature, with thermocouples placed in the centre on top of the base of the LPF11180, and against the core at the bottom of the ModuLED9980. For all orientations, the power dissipation was set to 30 W.

The Results

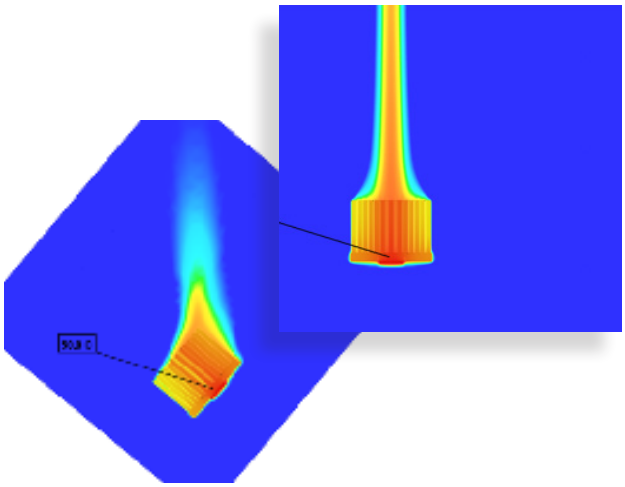
For the extruded heat sink (ModuLED9980) at 30 W power dissipation, rotating the heat sink by 50° resulted in a 2 °C increase in temperature difference between the heat sink base and the ambient. At 90° or horizontal, there was an 11 °C increase in the temperature difference. For the pin fin (LPF11180-ZHE) tested at 30 W power dissipation, there was no significant increase in the heat sink base to ambient temperature difference: maximum decrease of 0.8 K and a maximum increase of 1.6 °C.



CFD Simulation

A CFD simulation of each heat sink was performed using 6SigmaET. A CAD model of each heatsink was imported and placed in an open environment. To optimize the speed of the simulation the heatsink was not rotated in the test chamber. Instead the direction of gravity was modified, which has the same effect as rotating the heatsink.

Comparing the simulated and measured results for the temperature differences shows a maximum discrepancy of 1.9 °C. This yields a percentage discrepancty of only 5%, indicating that that there is a good comparison between the simulation model and the test results.



6SigmaET generated images of the pin fin heat sink at 45° (left) and vertical (right)

6SigmaET, a computational fluid dynamics (CFD) simulation tool, brings new levels of productivity to electronics cooling design. Thanks to its ease-of-use, it overcomes many of the problems that have plagued analysis tools from the beginning. Boasting substantial automation and intelligence, 6SigmaET is already being used by a global community of design engineers.

Optimal Thermal Solutions is a Dutch engineering firm specializing in thermal management of electronics. With over seventy years of combined experience, OTS has solved many problems for a large variety of customers. From chip- up to system level, OTS has been involved in the development and verification to get the most optimal solution possible.