34. Characterization and Numerical Simulation of LEDs

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SUMMARY

Light emitting diodes (LEDs) offer many advantages over regular incandescent light sources, including more compact forms, higher efficiency, lower energy consumption, lifetime and greater robustness. They can be used in applications as diverse as automotive and aerospace lighting, indicators and signs, general lighting (particularly in sustainable building designs), and consumer electronics. For example, most commercially available tablet devices, televisions and video projectors now incorporate LED backlighting.

Their principal drawback is that they are generally more thermally sensitive than more traditional lighting sources. Common problems associated with elevated LED die temperatures include reduced efficacy, mechanical stress, delamination or fracture of the die, etc. This means that they require stricter thermal design, involving more structural and behavioral knowledge, and innovative heat management techniques. This is especially the case in applications such as automotive applications where they are integral parts of sealed systems and are therefore difficult and expensive to replace - the cost of LEDs, while decreasing steadily, is still high in comparison to other traditional light sources.

This paper presents the use of various tools, including both hardware and software that can be used to characterize the LEDs, and also to effectively design applications with them as central components. In the case of hardware, it will be shown that thermal transient testing of LEDs that includes photometric and radiometric measurement will produce highly accurate and repeatable real thermal resistance measurements. The basis of the characterization is the recently introduced JEDEC standard JESD51-14, but also incorporates JESD51-1. Further, Highly Accelerated Life Testing (HALT) helps to select the best suitable LED for the designed product with high reliability over the products life.

The experimental measurements can then be converted into thermal resistor-capacitor models for use in Concurrent Computational Fluid Dynamics (CFD) simulations. Through effective used of this simulation technique, the thermal environment for the LEDs can be optimized, leading to guaranteed favorable conditions for the lifetime of the unit. In this paper, an example of a LED headlight in an automotive application is shown. The example provided is from a prestige automotive German OEM. The simulations also allow for reduced design times and physical prototyping and testing costs, ensuring quicker time-to-market.