Effect of Deficient Thermal Grease on the Junction Temperature of LEDs Package

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Abstract

Recently, interest in the use of light emitting diodes (LED) for general lighting has been steadily on the rise thanks to enhancement in LED luminous efficiency. Neverthless, 70% of total energy consumed is converted to heat, which increases the junction temperature and affects negatively the performance and the life of LED. So, a good heat dissipation is required to solve this thermal problem. Several research works have focused on increasing the heat transfer rate between the lamp and the outside, by an intervention on the heat sink design [1-5]. They studied the effect of geometric parameters on the heat transfer rate, and the thermal resistance and proposed correlations that predict the average heat transfer coefficient.

The majority of the published studies have been focusing on reducing the junction temperature through the intervention on the heat sink. Nevertheless, it is important to control the contact between radiator and thermal grease. In fact, a deficient thermal grease (ie. there is a thin air layer between thermal grease and heat sink), can widely affect the heat transfer rate, and participate in the lamp degradation, even when using an optimal heat sink design. Figure 1 illustrates the structure of LED package with deficient thermal grease.

In this paper, a LED package with deficient thermal interface material is numerically studied using COMSOL Multiphysics®. The model geometry is illustrated in figure 2. Majority of materials properties used in this modeling are from COMSOL® Material Library. We use heat transfer module to study the effect of the air layer thickness on the rise of the junction temperature of the LED. Thanks to the symmetry option provided by COMSOL, the energy equation is solved for only the quarter of the geometry. In addition, mesh was refined to test the convergence using physics controlled mesh.
The temperature profile of a LED package having good thermal grease is shown in figure 3. Junction temperature is about 70 ˚C thanks to the good heat transfer by natural convection, since the contact between LED and heat sink is perfect.

The effect of the air layer thickness on junction temperature and heat sink average temperature is conducted in figure 4. A higher junction temperature resulted from a thicker air layer, since this decreases heat transfer rate between lamp and radiator. In fact, due to the lower thermal

conductivity of air 0.026W/mK, heat is not properly transmitted to the radiator and is imprisoned in the lamp. However, this is not remarkable from the radiator average temperature. Thus, in this case, convective fan has no effect on transmitting heat to the outside.

In conclusion, an efficient heat sink design is required to enhance the heat transfer rate, but alone, it is not sufficient to solve the thermal problem of LED. This study shows that a bad contact between thermal grease and radiator can produce air layer and increase widely junction temperature.

Reference

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Figures used in the abstract

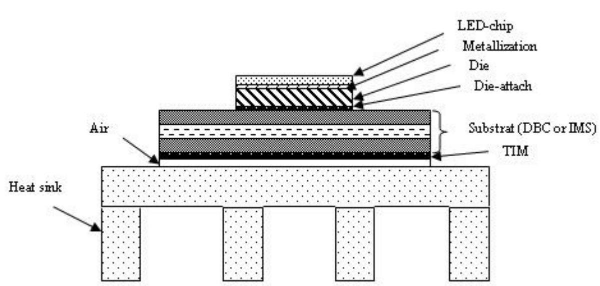

Figure 1: Structure of LED package with deficient thermal grease.

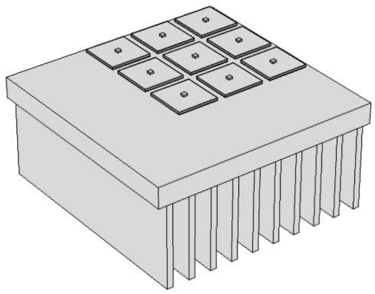

Figure 2: Computational domain.

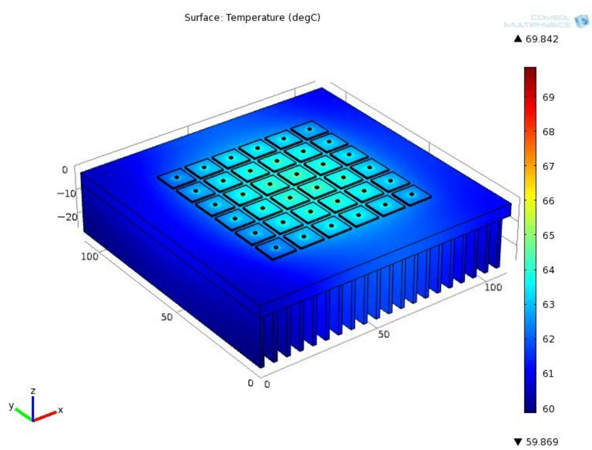

Figure 3: Temperature profile of LED package for the case of ideal contact between thermal grease and heat sink.

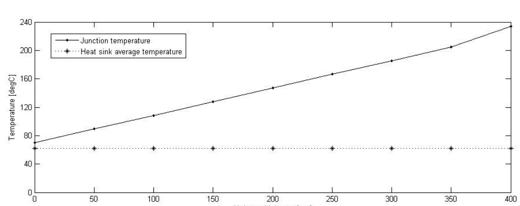

Figure 4: Effect of air layer thickness on junction temperature and heat sink average temperature.