The minimum of thermal resistance design of high power LED package

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ABSTRACT

This paper reports on the thermal characteristics of the high power light emitting diode (LED) package and numerical optimal analysis is used to design the size of the LED package for the purpose of improving the heat dissipation. The simplified conjugate-gradient method (SCGM) is adopted to combine with the finite element method (FEM) to optimize the shape of the heat sink inside the LED package. SCGM is used to change the value of variables and to call the finite element package, COMSOL, to obtain the results. The results show that the shape of slug changing directly affects the temperature profile of the LED. The heat generated from die can be removed more by the slug. It is obvious that the proposed method is effective on thermal optimization of the LED package.

INTRODUCTION

For the past fifty years, light emitting diodes (LED) have been used for indicator lights generally. With development of blue light LEDs, white light LEDs become available. High power (> 1W) white light LEDs are capable of replacing traditional incandescent and fluorescent. Recently, with the advantages of lower power cost, long lifetime, and high efficiency, the emergence of the high power LEDs have enhanced lighting applications. For instance, LEDs have been used in traffic lights, spot lights, and the backlight of liquid crystal display (LCD). LED is the device of converting the electric power to light and heat. Low light conversion efficiency (< 20%) brings about excess input powers to transform and generates redundant heat that ultimately rises junction temperature [1]. For energy conservation, the more light is emitting, the less heat is generated. Therefore, the issue of thermal management plays an essential role in development and enhancement of LEDs applications.

In recent years, researches about thermal management from LED packages has been discussed all over the world. Kim et al. [2] investigate the temperature distributions of LED die and package by the nematic liquid crystal measurement and the finite element method in the blue LEDs and white LEDs. The finite element method is used to calculate the temperature distributions and shows the good agreement with the experimental results. They also estimate the thermal transient characteristics of die attach in high power LED PKG by using the evaluation of the structure function of the heat flow path. Thus, the high power LED can get lower heat resistance at attach point by using Au/Sn eutectic bonding as bonding material to get better reliability [3]. Park et al. [4] measure the temperature profiles of the visible LED chips by using the nematic liquid crystal measurement with IR laser illumination. The conversion efficiency decreases to 70% when the junction temperature rises from 25°C to 107°C. From this study, we can know that the control of the junction temperature is very important for the LED performance.

Simulation can save money and avoid the mistakes of manufacture. Lin et al. [5] research the packing material of chip level, the substrate of chip covering a layer of copper, and system level, LED illuminator with heat pipe rotating various angles for heat dissipation improvement. Christensen and Graham [6] investigate the package and system level temperature distribution of a high power LED array using numerical heat flow models. A thermal resistor network model is combined with a 3D finite element submodel of an LED structure to predict system and die level temperatures for about analysis. Chi et al. [7] study the thermal characteristics of the high power LED package. They establish a detailed finite element model of the high power LED package with proper input power and boundary condition using the ANSYS finite element analysis software.

Conjugated gradient method (CGM) is one of numerical methods. Applications of conjugated gradient method in inverse heat problem is been surveyed. David et al. [8] propose an inverse algorithm based on the conjugate gradient method to estimate the boundary conditions of the unsteady laminar forced convection in parallel plate channels with wall conduction effects problems. The complexity and tedious in computation of conjugated gradient method make it difficult to implement the CGM for computational purpose. The SCGM, proposed by Cheng and Chang [9], is capable of obtaining the best objective functions easily, and calculating fast than traditional conjugated gradient method. This method is successfully by the same group of authors [10] in the inverse heat convection problem for the shape design optimization.

In this research, the geometry of LED model is established. The heat sink of the LED is the main structure of dissipating heat which is generated from die. That is to say, shape design of the heat sink is dominant for removing more heat. Optimal shape design of the heat sink inside the LED model is investigated in this study. In addition, SCGM is combined with COMSOL to optimize the shape of the heat sink. A multi-physics analysis modeling package, COMSOL is used as the subroutine to solve the thermal-fluid profile during the iterative optimal process.

NUMERICAL ANALYSIS & OPTIMIZATION METHOD

Direct problem-solver

Figure.1 presents a schematic illustration of the LED package considered in the present analysis. As