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Refrigerating liquid prototype for LED's thermal management

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HIGHLIGHTS

- New heat management application of refrigerating liquid on a fabricated LED prototype.
- Thermal models setup and comparison between the classical and the new solutions.
- The impact of refrigerating liquid level on LED thermal and luminous performances.
- The relationship between different levels of liquid with LED prototype performances.

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ABSTRACT

The heat management is the critical factor for high performance operation of LED. A new heat management application of refrigerating liquid integrated within a fabricated prototype is proposed and investigated. A series of experiments considering different heights of liquid level were performed to evaluate the heat dissipation performance and optical characteristics of the refrigerating liquid based prototype. The results reveal that the junction temperature decreases as the level of refrigerating liquid increases. The experimental results report that the refrigerating liquid reduces the junction temperature, and can positively influence the luminous radiation performances. An optimization investigation of the proposed solution was carried out to find an optimum thermal performance. The experiments indicated that refrigerating liquid cooling is a powerful way for heat dissipation of high power LEDs, and the fabrication of prototype was feasible and useful.

1. Introduction

In the last years, the energy requirements became more and more important due to the increase of energy demand and reduction of energy sources availability. Hence, the energy efficiency is becoming the main objective in all the industry sectors.

In the lighting area, the power LED represents a technology with high potential, due to their excellent color saturation and long life characteristics. The LEDs guarantee important energy savings with respect to the common light sources. The most common light sources, like incandescent and halogen lamps, are associated with high energy losses and low efficiency. Nowadays, LED plays an important role in many applications. Applications include LCD displays, visual indicators in instruments and computers, interior and exterior automotive lighting including headlights, displays, signals and luminaries.

The heat management (the luminous efficiency and lifetime greatly reduce with increasing junction temperature) is the critical factor for high performance operation of LED. In fact, the lifetime decrease of LEDs with increasing junction temperature is experimentally demonstrated in [1]. Light emission efficiency of LED as a function of thermal conditions is investigated in [2]; the paper discusses how to choose the desired operating temperature, by examining the effect of varying the thermal boundary conditions on the light emission.

Many heat dissipation solutions have been investigated for the thermal management of LED, mainly from package level to system level.

In particular, considering the package level thermal management - which includes thermal material research, package design optimization - the system dynamics for high power LEDs is investigated in [3] and an electric-heat-optical model to predict the junction temperature variations is derived. Chen et. all [4] establishes a compact-thermal model for LED package under different boundary conditions derived based on temperature and heat flow calculated by the detail finite volume model. The finite element method modeling for simulating the LED package with different

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