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Thermal characteristics for chip on metal package of LED lighting module

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ABSTRACT

The insulator of the metal printed circuit board (PCB) area layer, where a chip is packaged in the metal PCB structure of the chip on board (COB) package, is removed in order to propose a chip on metal (COM) package that allows the direct packaging of the chip to the PCB metal layer. In order to analyze the thermal characteristics from the chip, both COB and COM packages were fabricated during the operation to measure the chip junction temperatures (T_j) and thermal resistances of both specimens. According to the T_j measurement result, T_j=34.64 °C for the COM package with the removed insulator and T_j=45.28 °C for the COB package, showing that the COM package had an approximately 10 °C less thermal distribution. Similarly, the thermal resistance of the COM package was 0.7 °C/W, which was about 1 °C/W less than the COB package thermal resistance of 1.67 °C/W. Also, by comparatively analyzing the changes in the spectrum, color coordinates, and speed of light according to the driving time, it was found that luminous color stabilization may have contributed to the luminescence properties of the COM package, which has lower thermal resistance, and the degradation of the chip and packaging material can be minimized.

1. Introduction

The commercialization of light emitting diodes (LED) with their application to general lighting has led to an increase in demand for high power LED packages. The basic conditions that need to be met by LED packages include excellent light extraction efficiency [1] and a heat dissipation structure for the package, which releases the heat created from the chip die during operation to outside the package [2,3]. As the light extraction efficiency and heat dissipation structure are not independent of each other, photons and heat are produced from the chip active area when power is supplied to the LED package. Except for some photons that are extracted outside the package, most photons are dissipated as heat. Thus, effectively expelled heat produced from the chip enhances the extraction efficiency and reliability of the LED package. Conventional LED lighting modules can be categorized into a structure where the LED package is attached to the printed circuit board (PCB) using the surface mount technology (SMT) process and a chip on board (COB) structure where the LED device is attached directly to the PCB board [4–6]. The LED light source module applied to the SMT process has numerous thermal nodes that are structurally complex. Therefore, an increase in the thermal resistance of each thermal node is inevitable in order to release the heat produced by the chip to the surrounding air. Although the COB structure has less thermal nodes in comparison to the LED light source module with the SMT process applied, the thermal resistance of the insulating layer was installed in the PCB structure where the LED die is located. This resistance increase hinders the release of heat caused by the LED die. Previous studies reported up to now the LED junction temperature, which is directly related to

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the optical characteristics of the LED package [7–10]. However, studies on heat dissipation structures, where the insulating layer between the LED device and the base metal of the board is partially removed, as well as an analysis of the thermal characteristics of this kind of structure have yet to be published.

In this paper, after removing the insulator of the PCB area layer where the chip was packaged to minimize the thermal nodes, and directly packaging the chip to the PCB metal layer, a chip on metal (COM) package heat dissipation structure is proposed in order to effectively dissipate the heat produced by the chip during operation. Both COB and COM package types were fabricated to analyze the thermal characteristics of the proposed COM package. The chip junction temperature and thermal resistance for each specimen were measured. Furthermore, the change in spectrum, color coordinates, and speed of light were comparatively analyzed according to the driving time.

2. Experimental method

The fabrication: The COB package has a structure where the chip is packaged to the metal PCB. The COB package also has five thermal nodes in order to simplify the complicated manufacturing process, reduce costs, and simplify the complex heat dissipation structure of SMT type LED modules. However, the metal PCB structure of COB includes a dielectric layer between the Cu layer where the chip is packaged and an aluminum plate, as shown in Fig. 1. This causes a thermal resistance increase due to the low thermal conductivity of the insulating layer. Thus, the structure hinders the dissipation of heat from the chip.

The proposed COM package, as shown in Fig. 2, has the dielectric layer of the COB package metal PCB removed to directly install the chip to the aluminum metal base surface. This is so the heat produced from the chip can be directly absorbed by the aluminum metal base. The package configuration is a low thermal resistance LED package structure with the simplest configuration of three thermal nodes. The test specimens used in this research were the COB and COM packages that were fabricated in the same conditions. The chips for the COB and COM packages were of InGaN/Sapphire type 1.1 mm × 1.1 mm and 1 W and 16 chips were arranged in a multi array structure with 4 in parallel position and 4 in serial position. For the metal PCB, 2 types of COB PCB and COM PCB were fabricated as shown in Fig. 3. The chip was directly installed on the Cu layer for the COB and on the aluminum plate for the COM. The adhesive used between the PCB and the chip was Ag epoxy, which has a thermal conductivity of 20 W/mK. Table 1 organizes the properties of the material used in the manufacture of the LED. Fig. 4 shows the COM package assembly process.

3. Results and discussion

For the fabricated COB and COM packages, the chip junction temperature and thermal resistance of the 2 LED package types were measured. The parameters during the measurement were as shown in Table 2 where the input current was 1 A. For the COM package, the forward voltage was 12.13 V, the input power dissipation was 12.13 W, and the COM package chip junction temperature was 34.65 °C when the ambient temperature was 26.25 °C. A temperature difference of 8.4 °C between the ambient temperature and chip junction temperature was observed. For the COB

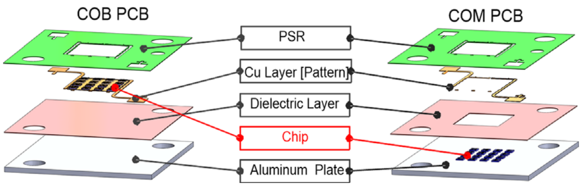

Fig. 3. Comparison of COB PCB and COM PCB structure.

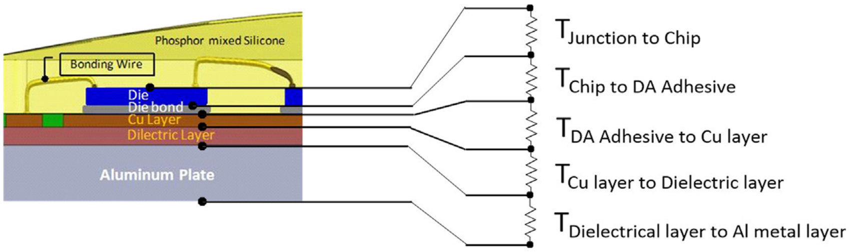

Fig. 1. COB type thermal node.

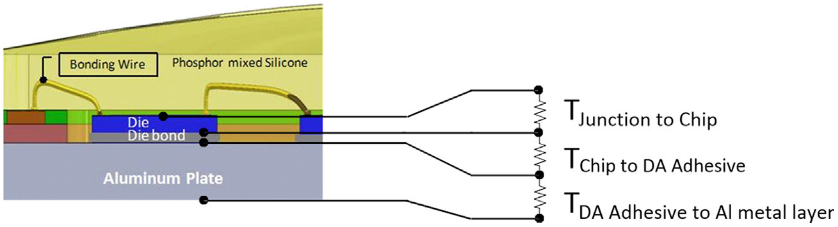

Fig. 2. COM type thermal node.