Heat Dissipation Design

CITILED
The Light Engine

COB Series

Heat dissipation design is a precondition in order to maximize the performance of the LED. In this document, the data that is deemed necessary in the detailed heat dissipation structure of the products and the heat dissipation design of the lighting apparatus is provided as a reference for the appropriate thermal design.

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Heat dissipation structure that can conduct heat radiated from LEDs efficiently

1. Introduction

Significance of the heat dissipation structure

The light-emitting diode of an LED package radiates light and heat according to the input power. However, the surface area of an LED package is quite small, and the package itself is expected to release little heat into the atmosphere. An external radiator such as a heat sink is thus required. The heat dissipation structure up to the connection portion of the external radiator uses mainly heat conduction.

Regarding LED packages, to control the junction temperature of the light-emitting diode Tj is important. The Tj must be kept from exceeding the absolute maximum rating in the specifications under any conditions. As direct measurement of the junction temperature of a light-emitting diode inside a package is difficult, the temperature of a particular part on the external package (the case temperature) Tc [°C] is normally measured. Tj [°C] is calculated using the thermal resistance between the junction and the case Rj-c [°C/W], and the emitted heat amount that is nearly equal to the input power Pd [W]. The heat generated at the light-emitting diode can be conducted to the external radiator efficiently because the package structure for the COB series minimizes the thermal resistance Rj-c.

This document describes the detailed heat dissipation structure of the COBseries and provides data necessary for thermal design of the lighting apparatus to maximize LED performance.

2. Package structure and thermal resistance

Understanding the junction temperature

The cross-sectional structure example, where the package of the COB series is connected to an external heat sink, is shown in Figure-1 (a). The package has a laminated structure of an aluminum substrate, insulating layers and conductive copper foil patterns.

A distinctive point is that the light-emitting diode is mounted directly on the well conductive aluminum substrate not on the insulating layer, which has low thermal conductivity. Thus, the heat generated at the light-emitting diode can be efficiently conducted to the outside of the package.

The aluminum substrate side of the package outer shell is thermally connected to the heat sink via heat-dissipation grease (or adhesive). As described above, the heat generated in the junction section of the light-emitting diode is transferred mainly to the heat sink using heat conduction, through the light-emitting diode to the adhesive for die-mounting to the aluminum substrate to the grease (adhesive). The thermal resistance between the junction section of the light-emitting diode and the aluminum substrate side of the package outer shell is Rj-c, and the specific thermal resistance value of the package.

Therefore, the following formula is used

$$Tj = Rj\text{-}c \cdot Pd + Tc$$

In addition, the thermal resistance of the grease (adhesive) outside the package is Rb [°C/W], the thermal resistance with the heat sink is Rh [°C/W], and the ambient temperature is Ta [°C].

Figure-2 (b) indicates the equivalent thermal resistance along the cross-sectional diagram in Figure-2 (a). As indicated, the thermal resistances Rj-c, Rb, and Rh are connected in series between the junction temperature Tj and the ambient temperature Ta. The thermal resistances outside the package Rb and Rh can be integrated into the thermal resistance Rc-a at this point.

Thus, the following formula is also used:

$$Tj = (Rj\text{-}c + Rc\text{-}a) \cdot Pd + Ta$$

Figure-1 (a) Cross Section

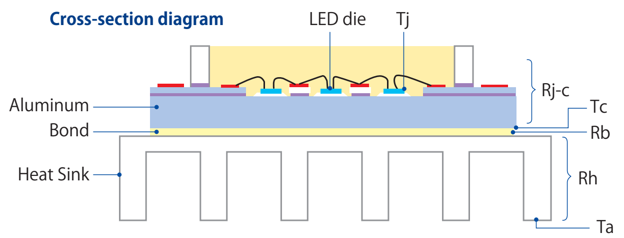
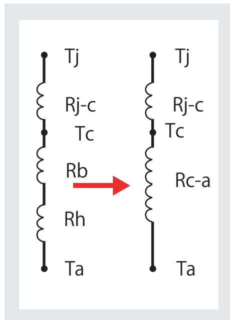


Figure-2 (a) Thermal Resistance Connection



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Use the correlation between the thermal resistance and the ambient temperature for design of the external heat dissipation mechanism

3. Thermal design of the outside the package

Point of the external heat dissipation mechanism

The following calculation will give you a rough guide as to the external heat dissipation structure that keeps Tj and Tc of the package at or below the standard temperature.
The thermal resistance outside the package Rc-a [C/W], which is the combination of the heat-dissipation grease (adhesive) and the heat sink, is limited by the input power Pd [W], the ambient temperature Ta [C], and the thermal resistance of the package Rj-c [C/W], i.e.,

Tj = (Rj-c + Rc-a)• Pd + Ta ➡ Rc-a =(Tj - Ta) / Pd - Rj-c

This can be converted into

Rc-a = -Ta / Pd + Tj / Pd - Rj-c

This Rc-a, obtained when Tj is at the maximum (Tj max), is a rough estimate that keeps Tj at or below the standard temperature. On the other hand, the relationship between Rc-a and Tc can be expressed by the following formula.

Tc = Rc-a • Pd + Ta

This can be converted into

Rc-a = (Tc -Ta) / Pd

This Rc-a, obtained when Tc is at the maximum (Tc max), is a rough estimate that keeps Tc at or below the standard temperature. Of the twe Rc-a's, the lower one may be used as an estimate to keep the Tj and Tc of the package at or below the standard temperature. Therefore, use the above calculation as a guide when selecting the external heat dissipation parts, and ultimately conduct thermal verification on actual devices.

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