Thermal Management of CL-L102

1. Introduction

The light-emitting element of an LED 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 to the atmosphere. An external radiator such as heat sinks is thus required. The heat release configuration for the connection portion of the external radiator mainly uses heat conduction.

Regarding LED packages, to control the junction temperature of the light-emitting element *Tj* is important. *Tj* must be kept from exceeding the absolute maximum rating in the specifications under any condition. Because direct measurement of the junction temperature of a light-emitting element inside a package is seldom possible, the temperature of a particular part on the package outer shell (the case temperature) *Tc* [deg C] is normally measured. *Tj* [deg C] is calculated from the thermal resistance between the junction and the case, *Rj-c* [deg C/W] and the amount of emitted heat, which is nearly equal to the input power *Pd* [W]. The package structure of the CL-L102 series minimizes the thermal resistance *Rj-c,* and the heat generated at the light-emitting element can be conducted to the external radiator efficiently.

This document describes the detailed heat release configuration of the CL-L102 series and provides necessary data for thermal design of lighting apparatus, which leads to optimal utilization of LED performance.

2. Package configuration and thermal resistance

Fig. 1 (a) illustrates the example of the cross-section structure where the package of the CL-L102 series is connected to an external heat sink. The package is composed of an aluminum substrate and the laminated structure of insulating layers and conductive copper foil patterns.

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

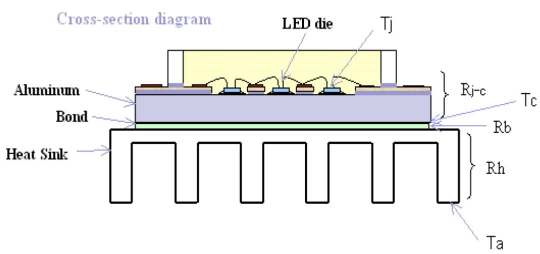


Fig. 1 (a)

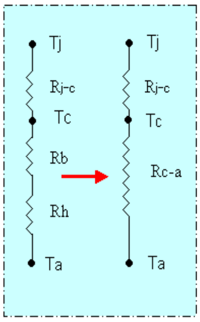


Fig. 1 (b)

The aluminum substrate side of the package outer shell thermally connects to the heat sink via heat-dissipative grease (or adhesive). As described above, the heat generated in the junction section of the light-emitting element is mainly transferred as conductive heat from the light-emitting element via element-mount adhesive, the aluminum substrate, and grease (adhesive) to the heat sink. The thermal resistance from the junction section of the light-emitting element to the aluminum substrate side of the package outer shell is *Rj-c*, which is the specific thermal resistance value of the package. Hence, the following equation makes sense.

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

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

Fig. 1 (b) shows the equivalent thermal resistance along the cross-section diagram on Fig. 1 (a). The thermal resistances *Rj-c*, *Rb,* and *Rh* are connected in series between the junction temperature *Tj* and the ambient temperature *Ta*. Now the thermal resistances outside the package *Rb* and *Rh* can be integrated into the thermal resistance Rc-a, which leads to the following equation.

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

3. Thermal design outside the package

The thermal resistance outside the package *Rc-a* [dig C/W], which is the combination of those of the heat-dissipative grease (adhesive) and the heat sink, is limited by the input power *Pd* [W], the ambient temperature *Ta* [deg C], and the thermal resistance of the package *Rj-c* [deg C/W], i.e.,

$$Tj = (Rj\text{-}c + Rc\text{-}a) \times Pd + Ta \quad \rightarrow \quad Rc\text{-}a = (Tj - Ta) / Pd - Rj\text{-}c$$

The formula can be converted into the function of *Tj* as follows:

$$Rc\text{-}a = -Ta / Pd + Tj / Pd - Rj\text{-}c,$$

which indicates the straight line with the slope of -1 / *Pd* and the intercept of *Tj* / *Pd* - *Rj-c*.

Fig. 2 is the chart on the CL-L102-C4 package that shows the relationship between the ambient temperature *Ta* and the thermal resistance outside the package *Rc-a* with variations of driving current, where *Tj* is assumed to be 120°C, the absolute maximum rating value in the specifications.

The higher the ambient temperature *Ta* and the larger the driving current, the smaller the allowable thermal resistance outside the package *Rc-a* = *Rb* + *Rh*.

This means that the grease (adhesive) and heat sink with smaller thermal resistance (in other similar words, better heat dissipation) are required in order to keep *Tj* from exceeding the absolute maximum rating in the specifications of 120°C, if the ambient temperature becomes higher and/or the driving current is larger. Therefore, use Fig. 2 as a guide when selecting the external heat radiation part, and conduct thermal verification on actual devices at the end.

For reference, Fig. 3 shows the equivalent chart on the CL-L102-C6 package.

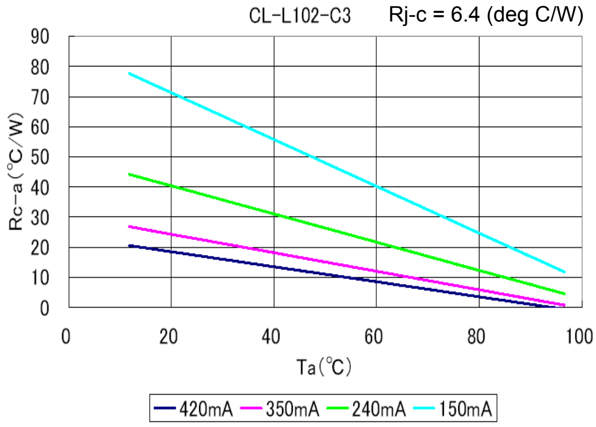


Fig. 2

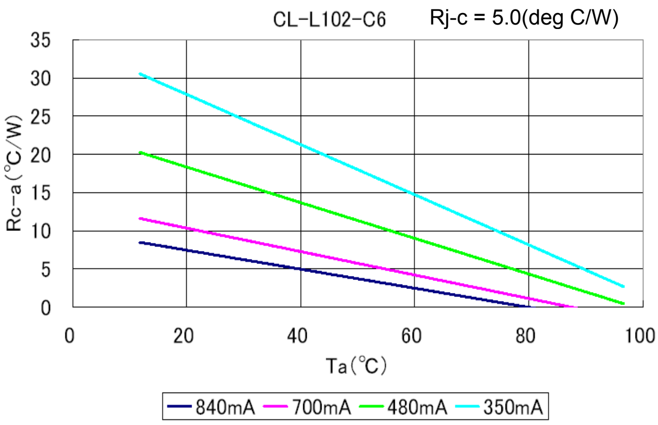
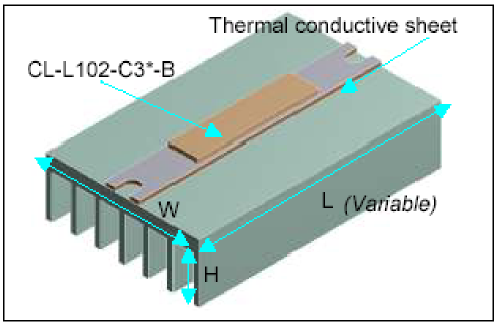


Fig. 3

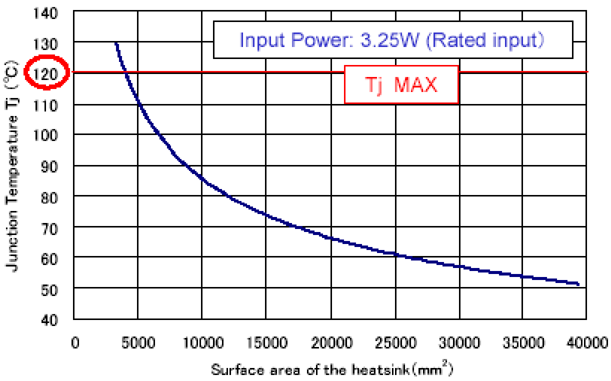
4. Simulation

Simulation is one of the effective means for thermal design. Fig. 4 (a) and (b) indicate the simulation results under the following conditions where the CL-L102-C3 package is connected to a heat sink using a thermal conductive sheet. Use them for reference.



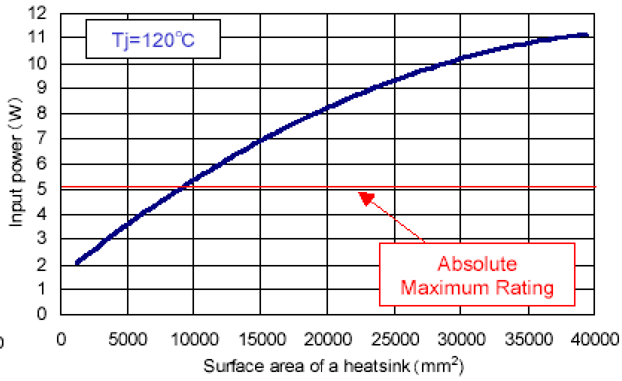
Structure figure of analytical model

- Boundary conditions
  - Ambient temperature: Ta = 25°C
  - Thermal conductivity: 5 W/m·K
  - Heat release coefficient of the heat sink: 0.2
  - Connection resistance: Out of consideration
- Model conditions
  - Thermal conductivity of the thermal conductive sheet: 1.2 W/m·K
  - Thickness of the thermal conductive sheet: t = 0.12 mm
  - Material of the heat sink: Aluminum
  - Dimensions: 31.5 mm W x 12 mm H x L mm (variable)



Characteristic of heat sink surface area - junction temperature Tj

Fig. 4 (a)



Characteristic of heat sink surface area - input power

Fig. 4 (b)