Thermal Management of CL-824

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 into the atmosphere. An external radiator such as heat sinks is thus required. The heat release configuration to 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. The *Tj* must be kept from exceeding the absolute maximum rating in the specifications under any conditions. 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 that is nearly equal to the input power *Pd* [W]. The package structure of the CL-824 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-824 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-824 series is connected to an external laminated circuit board. The package structure is composed of a light-emitting element mounted on a substrate that has conductive copper foil patterns and through holes.

A distinctive point is the heat generated at the light-emitting element can be efficiently conducted via through holes to the outside of the package.

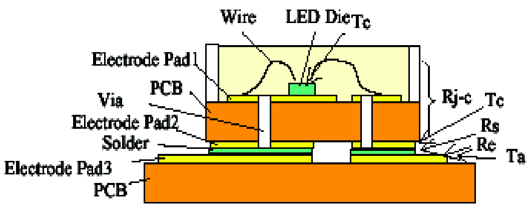

Fig. 1 (a)

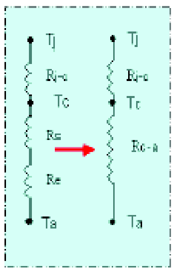

Fig. 1 (b)

The electrode section of the package outer shell is electrically conductive and connects via solder to the electrode on the external circuit board, which also has the function of a heat sink. 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, through holes, electrodes on the outer shell, and solder to the external circuit board, which doubles as the heat sink. The thermal resistance from the junction section of the light-emitting element to the electrode side of the 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 solder outside of the package is *Rs* [deg C/W], that of the electrodes with the heat sink function is *Re* [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*, *Rs,* and *Re* are connected in series between the junction temperature *Tj* and the ambient temperature *Ta*. Now the thermal resistances outside the package *Rs* and *Re* can be integrated into the thermal resistance Rc-a, which leads to the following equation.

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

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 solder and the electrodes with the heat sink function, 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-824-U1 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* = *Rs* + *Re*.

This means that the external heat release mechanism with smaller thermal resistance (in other similar words, better heat dissipation) is 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 in the end.

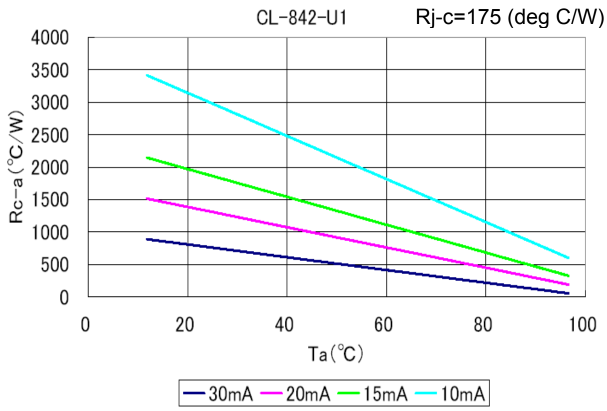

Fig. 2