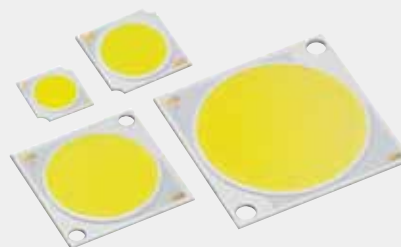


# Heat Dissipation Design



## Standard Type Ver.3 CLU024, CLU034, CLU044, CLU054

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.

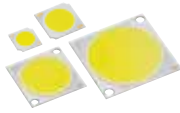
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# Heat dissipation structure that can conduct heat radiated from LEDs efficiently

## 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  $T_j$  is important. The  $T_j$  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 )  $T_c$  [°C] is normally measured.  $T_j$  [°C] is calculated using the thermal resistance between the junction and the case  $R_{j-c}$  [°C/W], and the emitted heat amount that is nearly equal to the input power  $P_i$  [W]. The heat generated at the light-emitting diode can be conducted to the external radiator efficiently because the package structure for the COB LED package minimizes the thermal resistance  $R_{j-c}$ . This document describes the detailed heat dissipation structure of the COB LED package 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 LED package 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 the TIM(Thermal interface material). 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 TIM. The thermal resistance between the junction section of the light-emitting diode and

the aluminum substrate side of the package outer shell is  $R_{j-c}$ , and the specific thermal resistance value of the package. Therefore, the following formula is used

$$T_j = R_{j-c} \cdot P_i + T_c$$

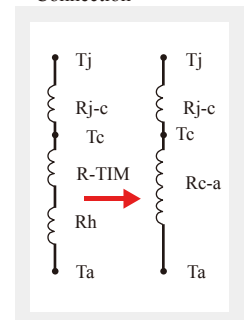
In addition, the thermal resistance of the TIM outside the package is  $R_{-TIM}$ [°C/W], the thermal resistance with the heat sink is  $R_h$  [°C/W], and the ambient temperature is  $T_a$  [°C].

Figure-1 ( b ) indicates the equivalent thermal resistance along the cross-sectional diagram in Figure-1 ( a ).

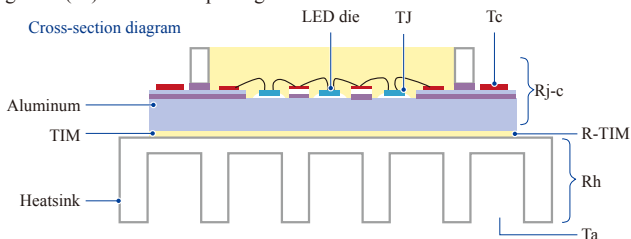
As indicated, the thermal resistances  $R_{j-c}$ ,  $R_b$ , and  $R_h$  are connected in series between the junction temperature  $T_j$  and the ambient temperature  $T_a$ . The thermal resistances outside the package  $R_{-TIM}$  and  $R_h$  can be integrated into the thermal resistance  $R_{c-a}$  at this point. Thus, the following formula is also used:

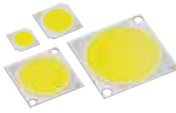
$$T_j = ( R_{j-c} + R_{c-a} ) \cdot P_i + T_a$$

■Figure-1 ( b )  
Thermal Resistance Connection



■Figure-1 ( a ) COB LED package





# 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 thermal resistance outside the package  $R_{c-a}$  [ $^{\circ}\text{C}/\text{W}$ ], which is the combination of the heat-dissipation the TIM and the heat sink, is limited by the input power  $P_d$  [ $\text{W}$ ], the ambient temperature  $T_a$  [ $^{\circ}\text{C}$ ], and the thermal resistance of the package  $R_{j-c}$  [ $^{\circ}\text{C}/\text{W}$ ], i.e.,

$$T_j = (R_{j-c} + R_{c-a}) \cdot P_i + T_a \rightarrow R_{c-a} = (T_j - T_a) / P_i - R_{j-c}$$

$T_a$  function converted from the above formula is

$$R_{c-a} = -T_a / P_i + T_j / P_i - R_{j-c}$$

and it is a straight line with the slope of  $-1 / P_i$  and the intercept of  $T_j / P_i - R_{j-c}$ .

Figure-2 is the chart showing the relationship between the ambient temperature  $T_a$  and the thermal resistance outside the package  $R_{c-a}$  indicated by driving current, where  $T_j$  is assumed to be the absolute maximum rating value in the specifications for the

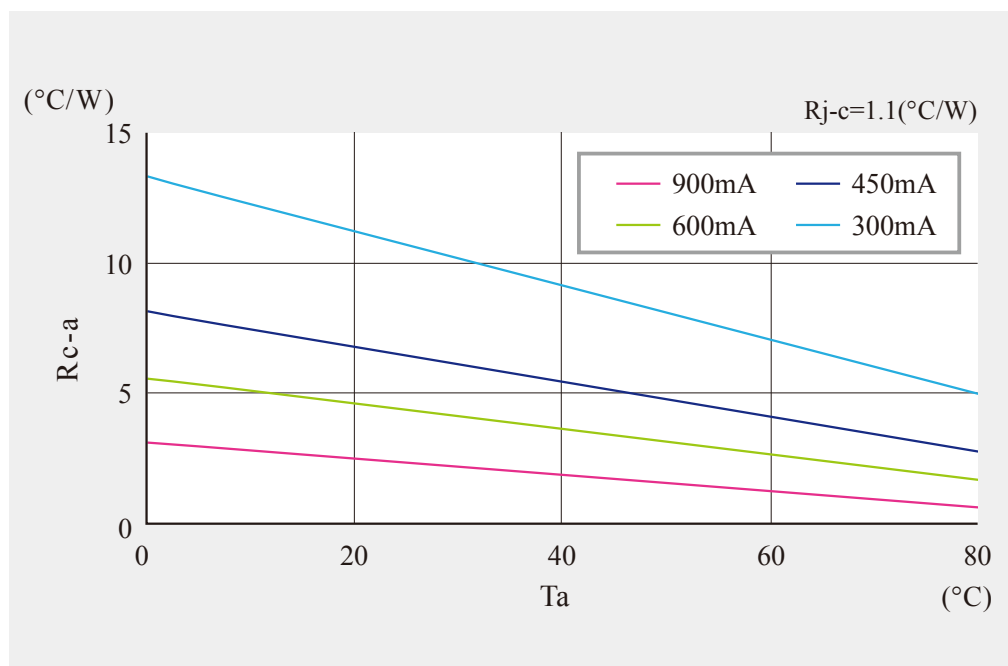
COB LED package. (As an example, the data of CLU034-1205B8 is showing below.)

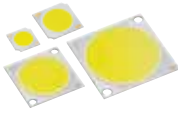
The higher the ambient temperature  $T_a$  and the larger the driving current, the smaller the allowable thermal resistance outside the package  $R_{c-a} = R_{\text{TIM}} + R_h$ .

In brief, the TIM and the heat sink, with smaller thermal resistance ( this means better heat dissipation ), are required in order to keep  $T_j$  from exceeding, the absolute maximum rating in the specifications, if the ambient temperature becomes higher and/or the driving current is larger. Therefore, use Figure-2 as a guide when selecting the external heat dissipation parts, and ultimately conduct thermal verification on actual devices.

The equivalent charts for each package is showing in the last part of this document.

Figure-2  $T_a - R_{c-a}$  (CLU034-1205 B8)





## 4. Simulation

### For efficient thermal design

A simulation is an effective procedure with regard to the thermal design. Simulation results from when COB LED package was connected to the heat sink with a heat conductive sheet are shown in Fig.3 ( a ), ( b ).( As an example, the data of CLU034-1205B8 is showing below.)

The results of the simulation for each package is showing in the last part of this document.

#### Boundary conditions

Environmental conditions :  $T_a = 25^{\circ}\text{C}$

Analysis space :  $400\text{mm} \times 400\text{mm} \times (350+L)\text{mm}$

Wall condition : Top=Open, Others= $25^{\circ}\text{C}$

Heat dispersion conditions : Natural convection

#### Model conditions

Thermal conductivity of Thermal conductive sheet :  $4.5\text{W/m.K}$

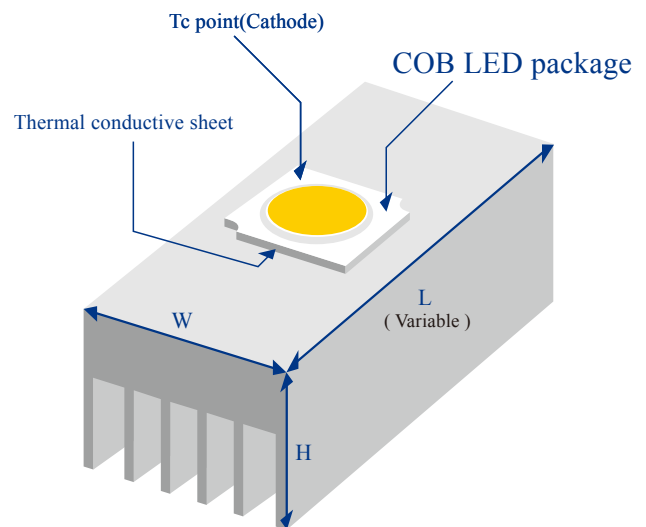
Thickness of the heat conductive sheet :  $t=0.12\text{mm}$

Material of the heat sink : Aluminum ( Number of the fin : 6 )

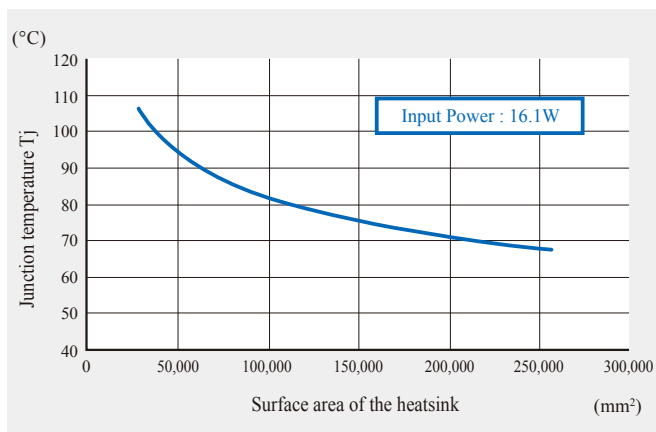
Outline dimensions of the heat sink :  $W 64\text{mm} \times H 40\text{mm}$

\*Note : sectional area  $1108\text{mm}^2$ , Dimension“L” is variable

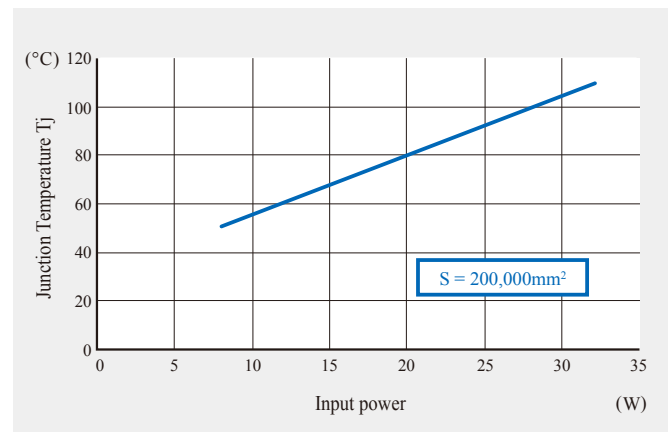
Structure figure of analytical model



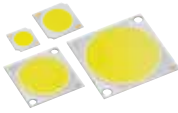
■ Figure-3 ( a ) Heat sink surface area - junction temperature  $T_j$  (CLU034-1205B8)



■ Figure-3 ( b ) Input power - junction temperature  $T_j$  (CLU034-1205B8)



\* Above data represents simulation values and is not guaranteed to represent actual measurement values.  
Evaluation and verification shall be conducted under the conditions of actual use.



# Appendix

## CLU024-1201B8



Figure2-1 Ta - Rc-a (CLU024-1201B8)

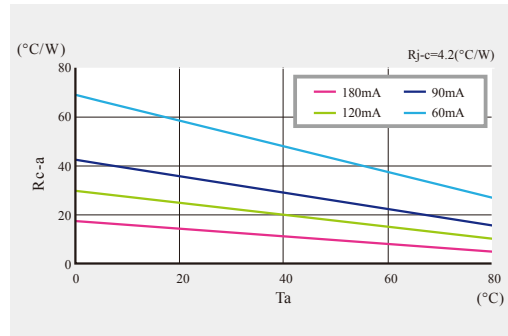


Figure3 (a)-1 Heat sink surface area - junction temperature Tj (CLU024-1201B8)

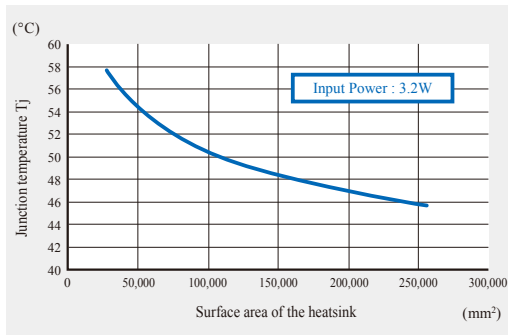
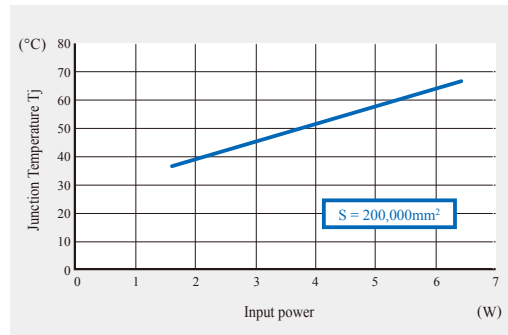


Figure3 (b)-1 Input power - junction temperature Tj (CLU024-1201B8)



## CLU024-1202B8



Figure2-2 Ta - Rc-a (CLU024-1202B8)

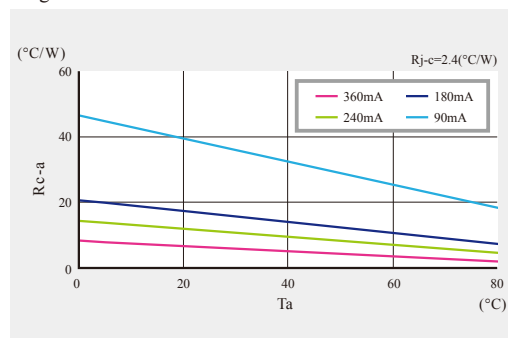


Figure3 (a)-2 Heat sink surface area - junction temperature Tj (CLU024-1202B8)

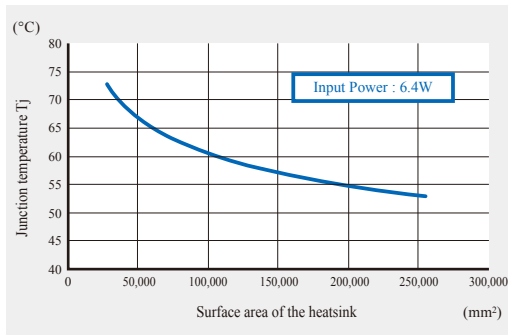
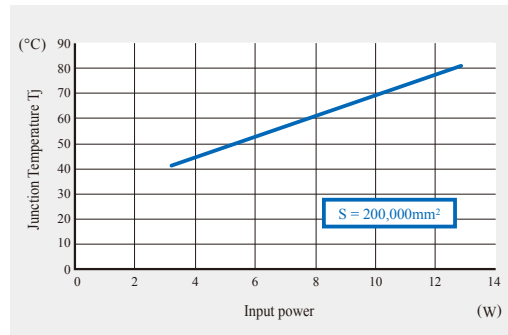
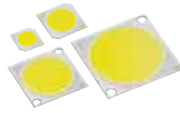


Figure3 (b)-2 Input power - junction temperature Tj (CLU024-1202B8)





## CLU024-1203B8



Figure2-3 Ta - Rc-a (CLU024-1203B8)

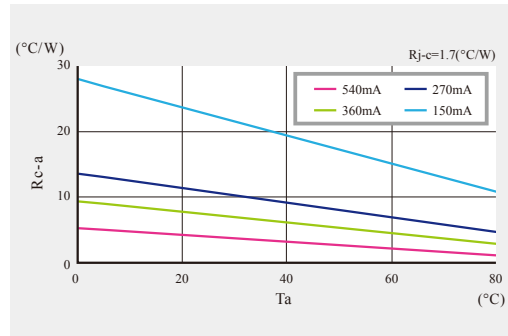


Figure3 (a)-3 Heat sink surface area - junction temperature Tj (CLU024-1203B8)

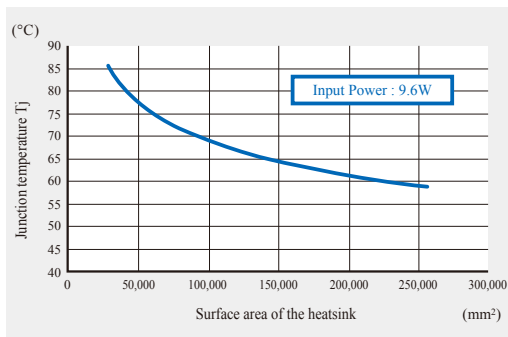
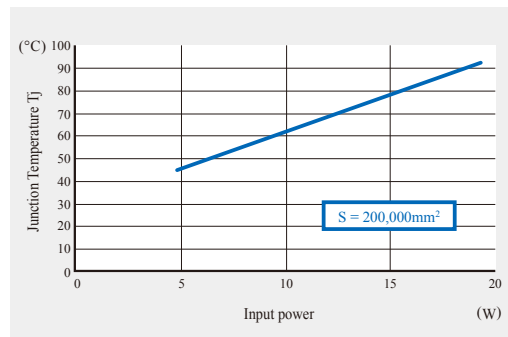


Figure3 (b)-3 Input power - junction temperature Tj (CLU024-1203B8)



## CLU024-1204B8

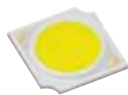


Figure2-4 Ta - Rc-a (CLU024-1204B8)

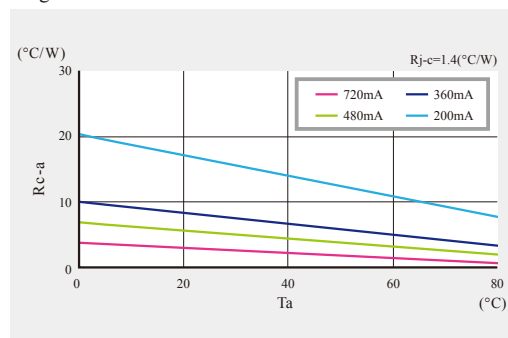


Figure3 (a)-4 Heat sink surface area - junction temperature Tj (CLU024-1204B8)

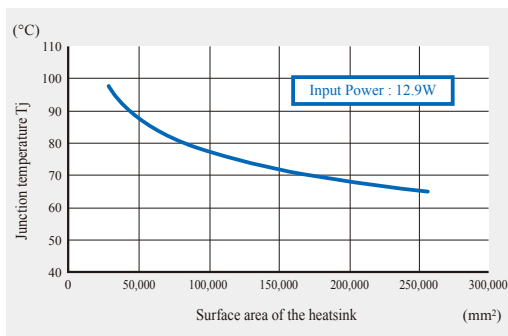
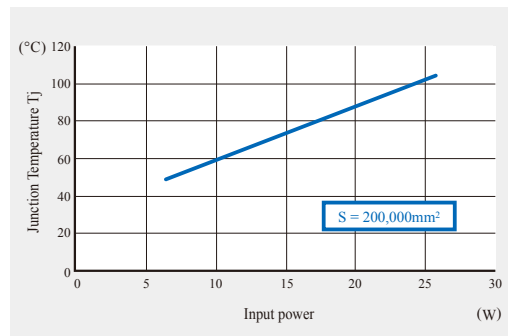
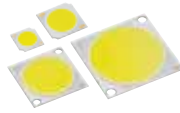


Figure3 (b)-4 Input power - junction temperature Tj (CLU024-1204B8)





## CLU034-1205B8

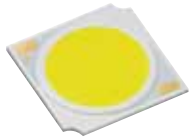


Figure2-5 Ta - Rc-a (CLU034-1205B8)

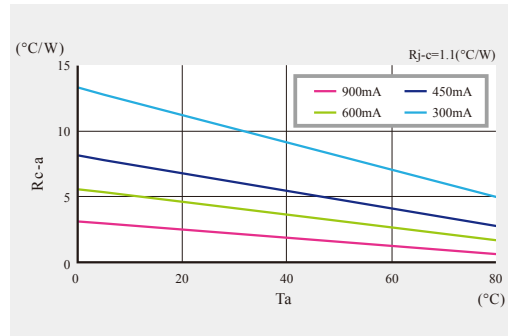


Figure3 (a)-5 Heat sink surface area - junction temperature Tj (CLU034-1205B8)

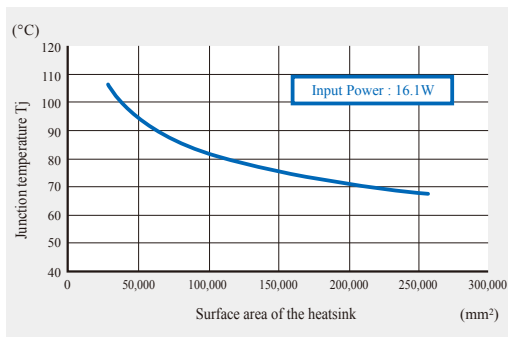
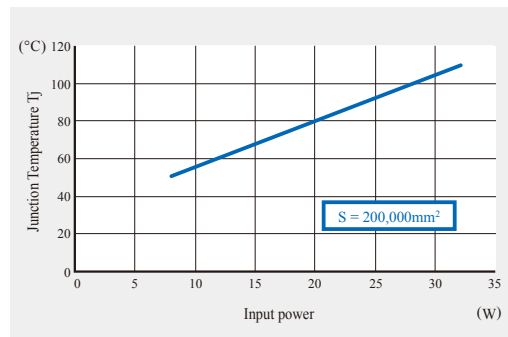


Figure3 (b)-5 Input power - junction temperature Tj (CLU034-1205B8)



## CLU034-1206B8

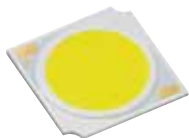


Figure2-6 Ta - Rc-a (CLU034-1206B8)

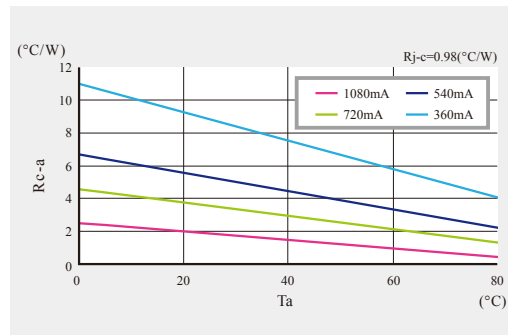


Figure3 (a)-6 Heat sink surface area - junction temperature Tj (CLU034-1206B8)

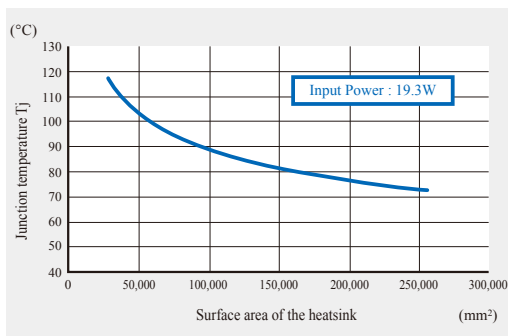
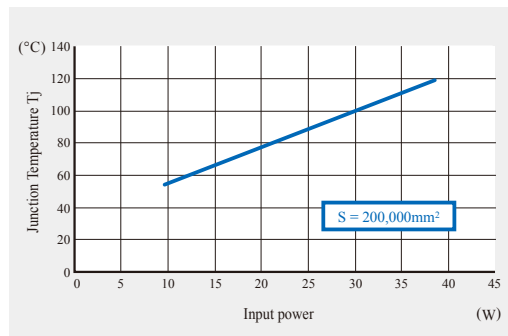
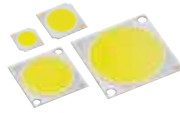


Figure3 (b)-6 Input power - junction temperature Tj (CLU034-1206B8)





## CLU034-1208B8

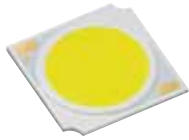


Figure2-7 Ta - Rc-a (CLU034-1208B8)

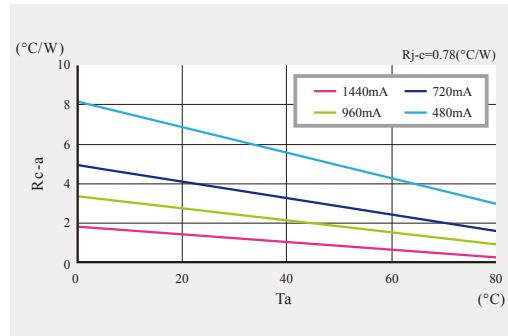


Figure3 (a)-7 Heat sink surface area - junction temperature Tj (CLU034-1208B8)

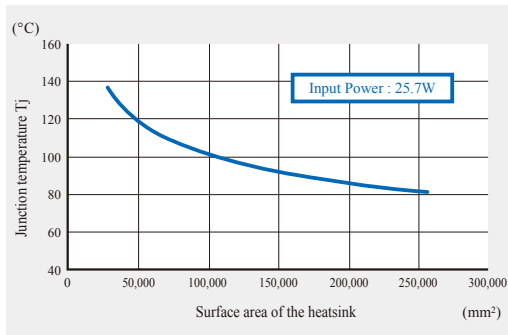
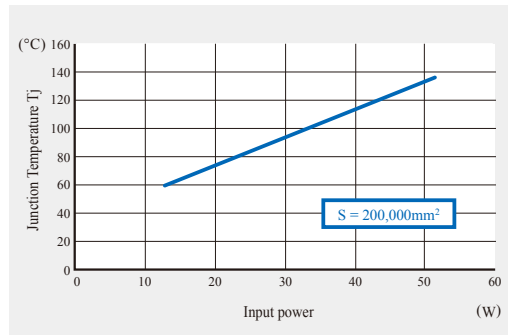


Figure3 (b)-7 Input power - junction temperature Tj (CLU034-1208B8)



## CLU044-1212B8



Figure2-8 Ta - Rc-a (CLU044-1212B8)

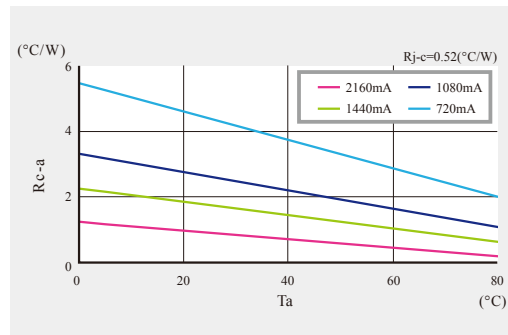


Figure3 (a)-8 Heat sink surface area - junction temperature Tj (CLU044-1212B8)

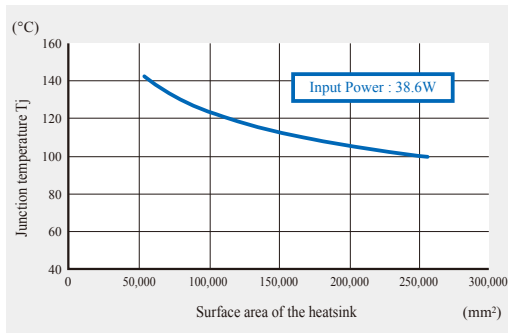
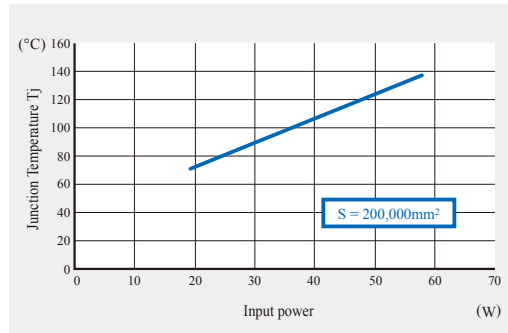
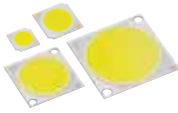


Figure3 (b)-8 Input power - junction temperature Tj (CLU044-1212B8)







### CLU044-1812B8



Figure2-9 Ta - Rc-a (CLU044-1812B8)

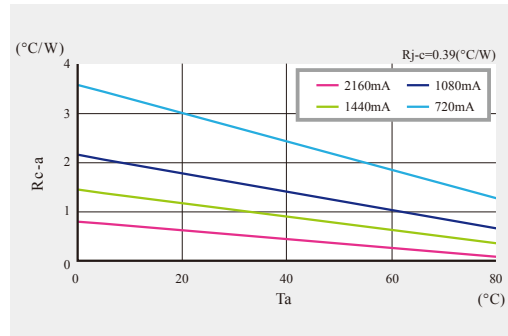


Figure3 (a)-9 Heat sink surface area - junction temperature Tj (CLU044-1812B8)

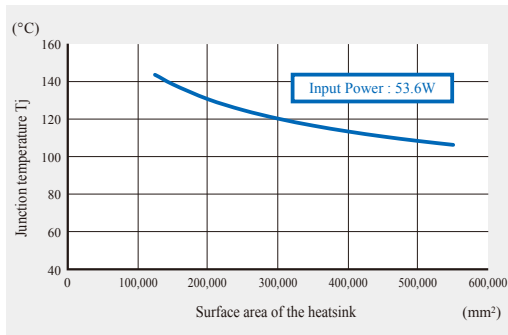
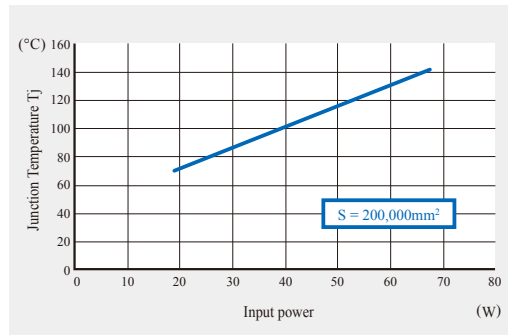


Figure3 (b)-9 Input power - junction temperature Tj (CLU044-1812B8)



### CLU044-1818B8



Figure2-10 Ta - Rc-a (CLU044-1818B8)

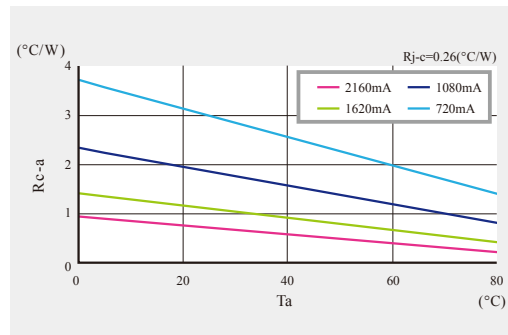


Figure3 (a)-10 Heat sink surface area - junction temperature Tj (CLU044-1818B8)

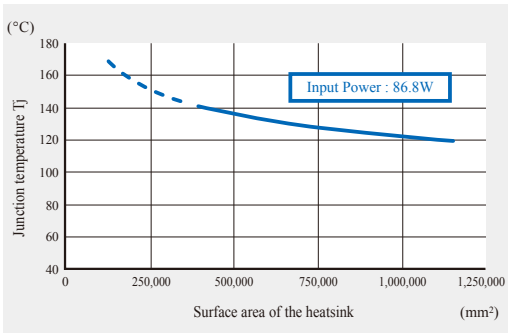
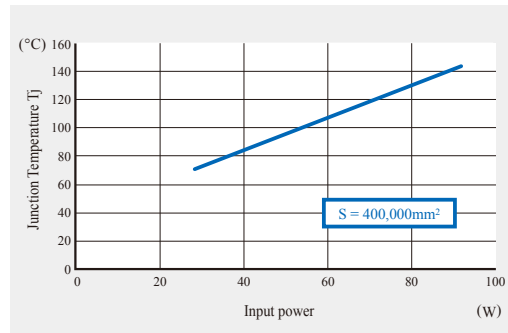
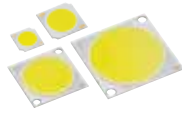


Figure3 (b)-10 Input power - junction temperature Tj (CLU044-1818B8)





## CLU054-1825B8



Figure2-11 Ta - Rc-a (CLU054-1825B8)

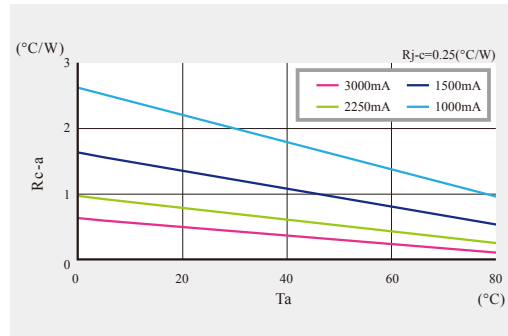


Figure3 (a)-11 Heat sink surface area - junction temperature  $T_j$  (CLU054-1825B8)

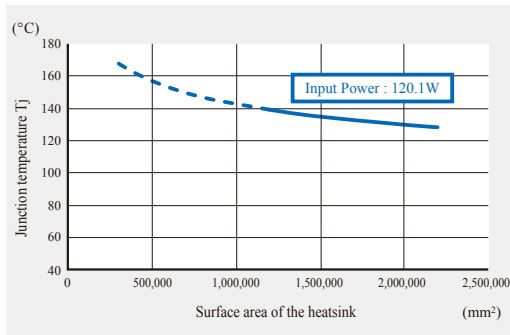
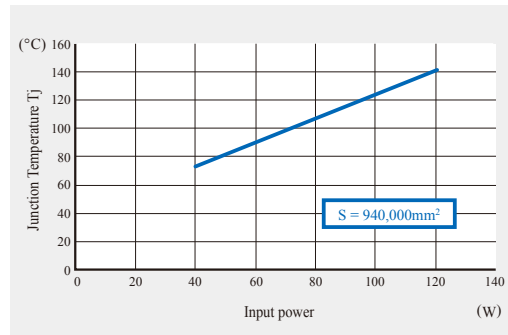


Figure3 (b)-11 Input power - junction temperature  $T_j$  (CLU054-1825B8)



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