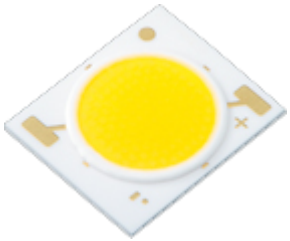
Light Emitting Diode

Assembly and Handling Precautions for COB LEDs



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(SE-AP00003G)
Oct. 5, 2017

1. Overview

This application note provides general information on how to use/handle Nichia Chip on Board (COB) LEDs to install them to luminaires.

2. General Structure and Features of Nichia COB LEDs

The abbreviation COB refers to Chip On Board. COB LEDs have dice directly attached to the substrate. For the typical COB LED structure, see Figure 1.

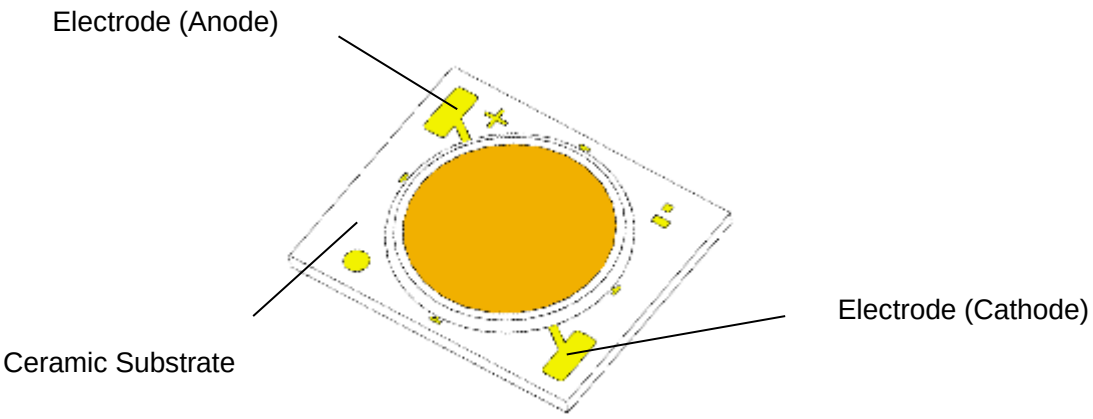


Figure 1. COB LED Structure (e.g. NFCxL060B)

The following are key features of COB LEDs.

1) Able to attach directly to a Heat Sink.
Most conventional LEDs are soldered to a PCB first and then the PCB mounted with the LEDs is attached to a heat sink. In the case of COB LEDs, it is possible to directly attach a COB LED to a heat sink (see Figure 2). As a result, COB LEDs do not require PCBs in order to install LEDs into a luminaire and the subsequent reflow process is no longer necessary. Additionally, compared with conventional LED models, COB LEDs offer a better heat dissipation performance since the COB LED substrate has low thermal resistance and no PCB is required for installation.

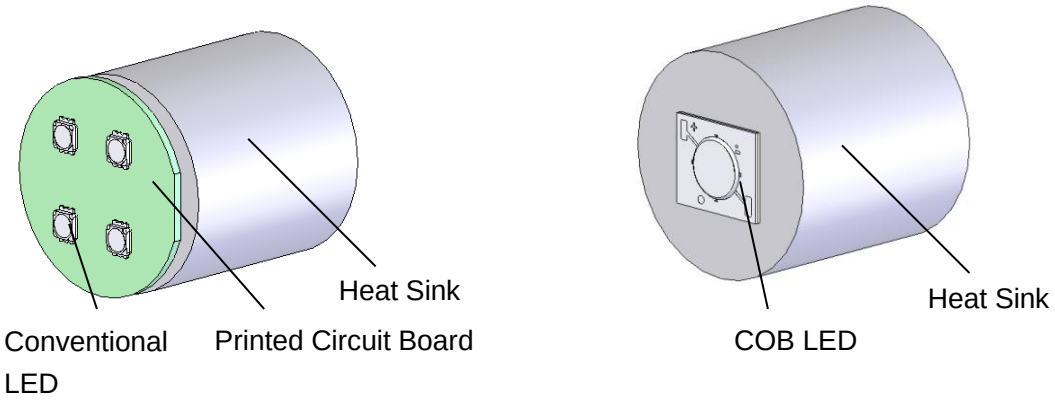


Figure 2. Difference in the Attachment Method to Heat Sink

2) Potential to reduce the size of Lighting Fixtures

To design a high power lighting fixture, one COB LED of 10W installed in a lighting fixture can achieve a similar light output as compared to multiple conventional LEDs of several watts. As a result, installing a COB LED can enable the number of parts to be reduced, leading to a smaller size for the overall lighting fixture.

3. Typical Applications

Street Light

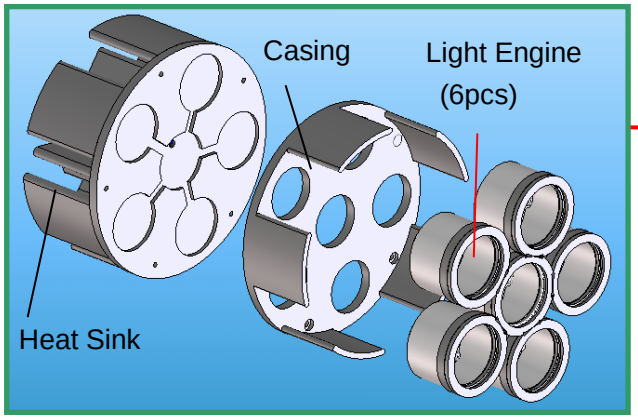
Down Light

Spot light

Figure 3 Applications for COB LEDs

COB LEDs are used for many applications such as street lights, down lights, and spot lights. The following shows the typical structure of a spot light with COB LEDs mounted inside it.

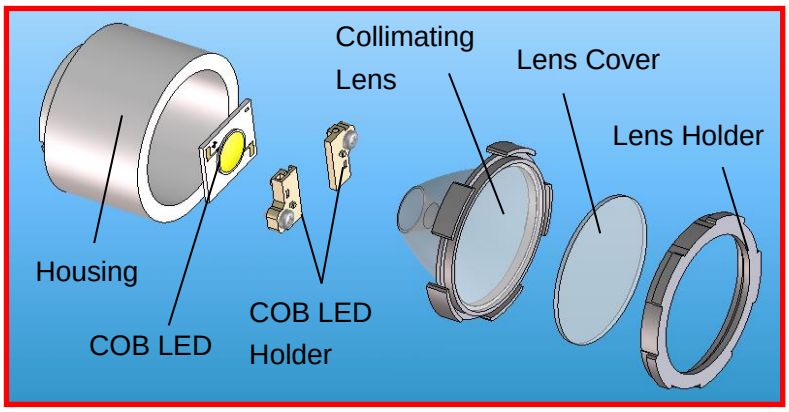
Overview (Outer)



Overview (Inner)

Spot Light Specification (For Reference)

Outline Dimension	Φ120mm×90mm
COB LED	NFCLL036B×6
Luminous Flux	6,000lm
Color Temperature	3,000K
Full-Angle Half-Power	28°
Power Consumption	60W



Structure of COB LED Module (Light Engine)

Figure 4. Example Application: Structure of Spot Light with Collimating Lens

The spot light in Figure 4 has six COB LEDs installed with a collimating lens. The COB LEDs are directly attached to the housing with holders, and then the collimating lens, the lens cover, and the lens holder are attached to it in order. The spot light comprises of a set of 6 light engines attached to the heat sink.

When COB LEDs are hermetically sealed in an assembly, note that there is a potential for the COB LEDs to become discolored. Refer to the application note “The Impact of enclosed/hermetically-sealed Lighting Fixtures on LEDs” for more details.

4. How to Attach Nichia COB LEDs to a Luminaire

4.1 Heat Dissipating Sheet and Thermal Grease

Nichia recommends using a heat dissipating sheet or thermal grease between the COB LEDs and the housing since the heat dissipation performance may be poorer without it. Refer to Table 1 for the verification results for some brands of heat dissipating sheets/greases.

Table 1 Verification Result of Heat Dissipating Materials

Material	Type	Manufacturer	Part Number	Thermal Conductivity (W/mK)*	URL
Heat Dissipating Sheet	Sheet	Sumitomo 3M Limited	5590H	3.0	http://www.3m.com/
		Dexerials	UX3002D	3.0	http://www.dexerials.jp/
	Gel Sheet	FUJI POLYMER INDUSTRIES CO., LTD.	GR45A-00-50GY	4.5	http://www.fujipoly.co.jp/
			GR80A-08H-50GY	8.0	
Heat Dissipating Gel	Paste	KANEKA CORPORATION	RV027	1.1	http://www.kaneka.co.jp/
		FUJI POLYMER INDUSTRIES CO., LTD.	SPG-30B	3.1	http://www.fujipoly.co.jp/
	Glue	ThreeBond Co., Ltd.	2955	3.0	http://www.threebond.co.jp/

Customers should select the heat dissipation materials which fit best with the application and the fixture. Customers should also confirm whether any corrosive gas might be generated by the dissipation materials in order to evaluate the compatibility of all materials before use.
Good heat dissipation can be achieved by increasing the adhesion strength between the COB LEDs and the housing. In general, the COB LED holders are attached to the COB LEDs with screws; the tightening torque significantly impacts the adhesion strength. As the tightening torque is increased, to some extent, the Tc (T_J) becomes stable; however, the heat dissipation performance will not continue to improve beyond a specific tightening torque. Note that excessive stress applied to the ceramic substrate and/or foreign substances permeating the adhesion area, may result in a lack of flatness, causing the ceramic substrate to crack. Refer to the application note "Heat Dissipation Performance according to the Adhesion Strength of COB LED and Housing" for the torque and additional details.

4.2 Soldering an Electric Wire to a COB LED

Customers must attach the wires by soldering and taking note of the following precautions:

1) Hand soldering must be performed with an iron at 380°C or less within 5 seconds (Do not perform hand soldering more than once.)
2) Do not exert stress on the COB LEDs during the soldering process for while the COB LED is still hot from the process.
3) Do not correct/repair the soldering area after soldering. If repairing is unavoidable, prior to repairing, evaluate whether the correction will affect the characteristics.
4) Be sure to fix the wire before applying heat and to prevent stress from being applied to the soldering area.

When the solder wetting area is long, the electrode is vulnerable to stress, resulting in the detachment of the electrode. Additionally, if a wire that is not flexible and easy to bend (e.g. a single wire) is used, it may increase the possibility of the electrode becoming detached when stress is applied. Refer to Figure 5 for how the electrode delamination occurs.

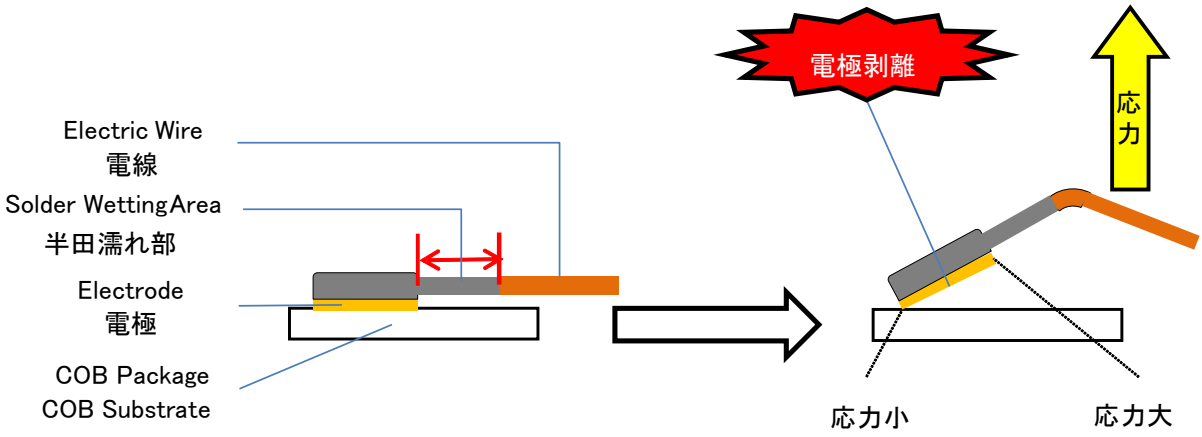


Figure 5. Mechanism of Electrode Detachment by Stress

Refer to the application note “Precautions when attaching lead wires to COB LEDs” for more details.

5. Handling Precautions

1) Do not handle the COB LEDs with bare hands.
Especially do not touch the emitting surfaces with bare hands. Otherwise, the emitting surfaces will become contaminated, affecting the optical characteristics.
Additionally, in some cases, the COB LEDs may become deformed and/or the bonding wires may break, leading to emission failure (See Figure 6).

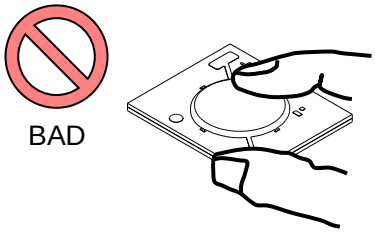


Figure 6. Do not handle the COB with bare hands.

2) Usage of Tweezers
When using tweezers, do not apply excessive stress to the COB LEDs. Otherwise, the resin will become cracked, chipped, detached, the COB LEDs may become deformed, and/or the bonding wires may break, resulting in emission failure (See Figure 7).

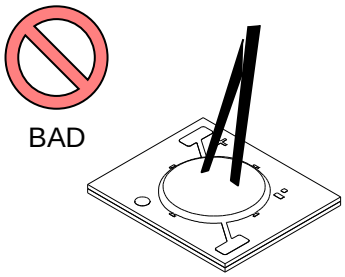


Figure 7. Usage of Tweezers

3) Do not drop the COB LEDs.
When dropped, the COB LEDs may become deformed (See Figure 8).

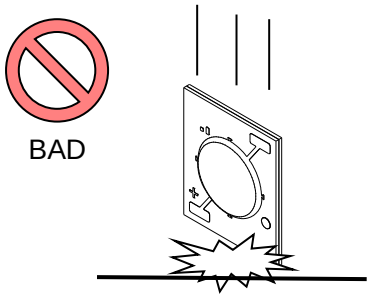


Figure 8. Do not drop the COB LEDs.

4) Do not stack the COB LEDs on top of each other.
When the COB LEDs are stacked on top of each other, the resin is vulnerable to shock, resulting in cracks, chips, and/or detachment. Additionally, the COB LEDs may become deformed and the bonding wires may break, leading to emission failure (See Figure 9).

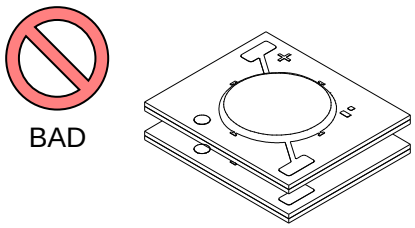


Figure 9. Do not stack the COB LEDs on top of each other.

6. Thermal Management

6.1 How to Determine the Junction Temperature

When using this product, ensure that proper thermal management is provided and the die temperature does not exceed the maximum Junction Temperature (T_J).
The junction temperature (T_J) can be calculated using the following equation:

$T_J=T_c+R_{\theta JC}\cdot W$
*T_J=LED junction temperature: °C
T_c=Case temperature: °C
$R_{\theta JC}$=Thermal resistance from junction to T_c measuring point: °C/W
*In the case of NFCxL060B, RθJC=1.4°C
W=Input power ($I_F \times V_F$): W
(IF=Forward Current, VF=Forward Voltage)

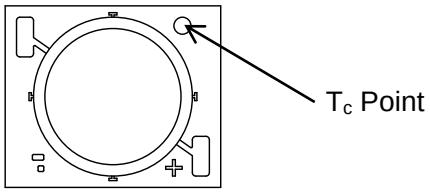


Figure 10. T_c measurement point

$R_{\theta JC}$ may change depending on the properties for both the dissipating material used (e.g. film, gel sheet, paste, or glue) and the heat sink/housing and the surface state of those materials. When mounting the COB LEDs on to the heat sink/housing, the following must be considered:

- Heat dissipating materials with a low thermal resistance should be used for the interface between the COB LED and heat sink/housing.
- The surface of the heat sink used with the COB LEDs must not have any small recesses, cavities or holes; if necessary, the surface must be leveled before mounting the COB LEDs.
- If a holder and/or heat dissipating material are used, ensure that these materials are properly used and the heat is effectively dissipated.

During use if the heat dissipating material deteriorates due to heat and the dimensions change and/or the properties degrade, it may cause these materials not to dissipate the heat property; this may cause the COB LED to be damaged. Ensure that reliability verification is performed for the chosen application.

To determine the temperature of the COB LEDs, a non-contact temperature measurement instrument (e.g. thermal imaging camera) is useful. These measurement results may be able to be used for the heat dissipation design of the chosen application.

6.2 How to Attach the COB LEDs to a Heat Sink

If the surface of a heat sink that the COB LEDs are attached to is not smooth or even (e.g. holes/recesses, burrs/flashes, etc.), it may cause the heat sink's thermal conductivity to decrease significantly. Additionally, if a thermal dissipating film/gel sheet is used between the COB LED and heat sink/housing, it may prevent heat from escaping from the COB LED depending on the thickness of the film/sheet. This same issue may occur if an excessive amount of thermal paste/glue is used; Nichia recommends using an appropriate amount of thermal paste/glue.
For acceptable/unacceptable examples of how the COB LEDs are attached to a heat sink, see Figures 11 through 20.

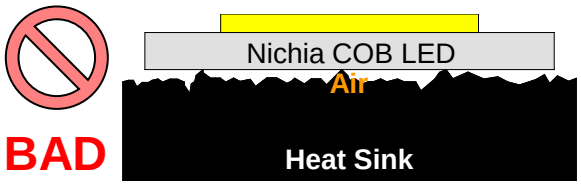


Figure 11. Heat Sinks with Uneven Contact Surfaces

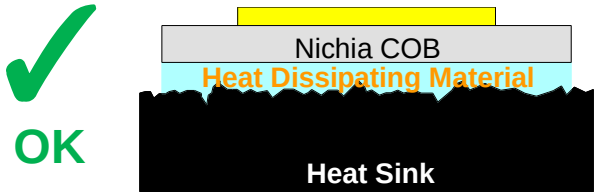


Figure 12. Heat Sinks with Uneven Contact Surfaces and Sufficient Heat Dissipating Material

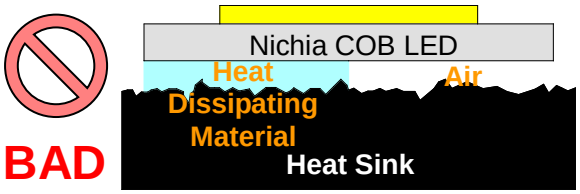


Figure 13. Heat Sinks with Uneven Contact Surfaces and Insufficient Heat Dissipating Material

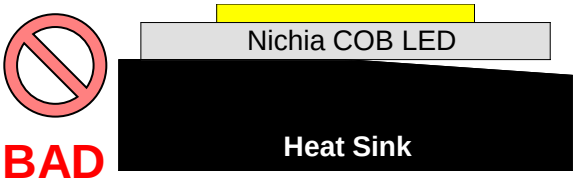


Figure 14. Insufficient Flatness for the Heat Sink Contact Surface

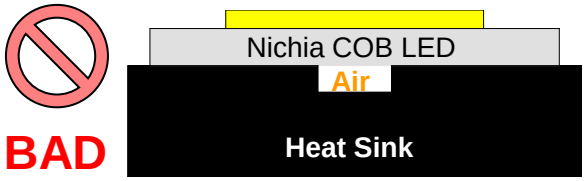


Figure 15. Heat Sinks with Holes/Recesses on the Contact Surface

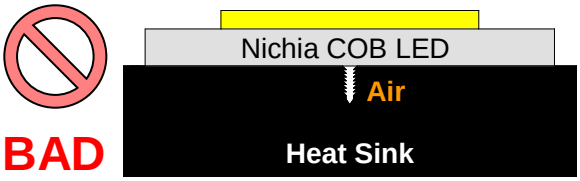


Figure 16. Heat Sinks with Screw Holes on the Contact Surface

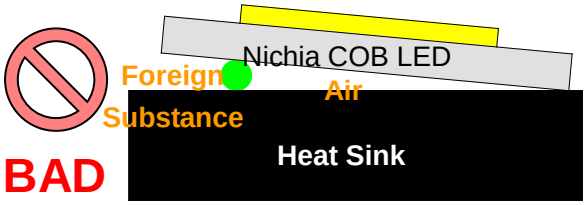


Figure 17. Heat Sinks with Foreign Material on the Contact Surface

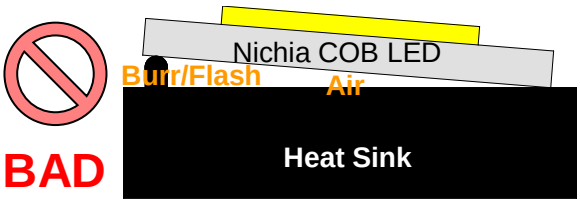


Figure 18. Heat Sinks with Burrs/Flashes on the Contact Surface

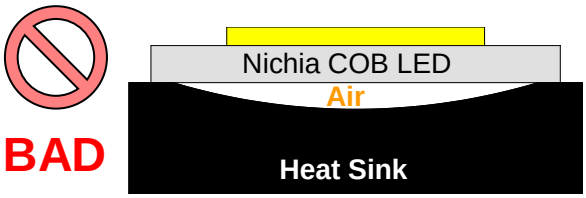


Figure 19. Heat Sinks with Curved Surfaces

Figure 20. Excessively Thick Heat Dissipating Materials between the LEDs and Heat Sink

Attach the COB LEDs to a heat sink correctly and check the condition/temperatures of attached COB LEDs during operation to ensure there are no issues.

7. Design Consideration - Adverse effects caused by connecting the LEDs in parallel

In a multiple array of COB LEDs, Nichia recommends that the COB LEDs are connected in series with each other or that each is operated at a constant current. If they are connected in parallel with each other, the current flow to each one can vary depending on the V_F variation among them. This may lead to a current over the absolute maximum rating applied to some COB LEDs, affecting the reliability performance of the product. As a result, parallel connection should be avoided for COB LEDs.

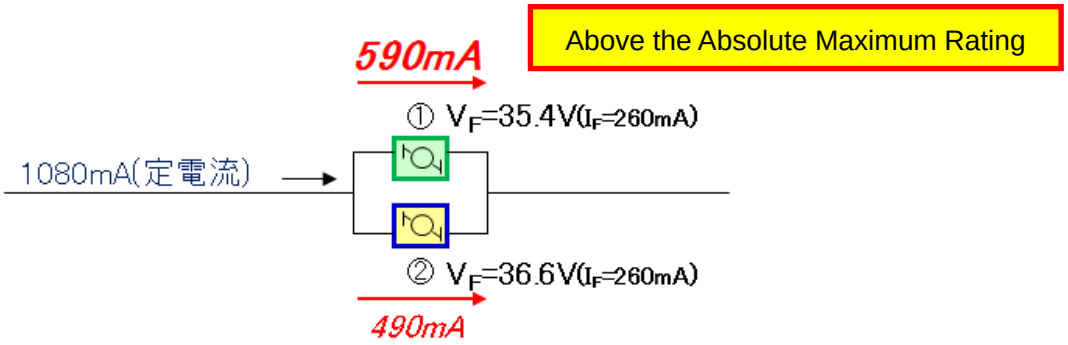
Nichia used two COB LEDs with different V_F values and verified the values of the current flowing through the COB LEDs when connected in parallel.

Verification Results

COB品種	V_F	
	Sorting Current: I_F=260mA	
NFCWL036B	①	35.4V
	②	36.6V

NFCWL036B's Absolute Maximum Rating: I_F=540mA

- Input Current: 1080mA (Operated at Constant Current)
- Verification Results (Performed at T_J=25°C)



As the above measurement results show, there is a difference between the two COB LEDs in the current flowing through the COB: the current flowing through one of the COB LEDs has exceeded the absolute maximum rating. This does not comply with the specification/conditions of use. In addition to the possibility of using COB LEDs at currents exceeding the absolute maximum rating, there is a concern that there could be a difference in the optical characteristics among them. As a result, parallel connection should be avoided for COB LEDs.

8. Summary

This application note contains important information; ensure that it is followed when designing with and handling COB LEDs. Otherwise, the optical characteristics of the COB LEDs will deteriorate; in the worst case, this would result in LED emission failure.