Assembly and Handling Precautions for the NVMUR020A UV LEDs

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**Key Features**

**Overview**
This LED uses a newer LED package technology that integrates multiple bare LED die in a single package. For most conventional LEDs, it is necessary to solder LEDs to PCBs before attaching LED assemblies to heat sinks. However, since these LEDs are designed to be directly attached to heat sinks, neither soldering nor PCBs are required. Additionally, light sources using these LEDs require fewer LEDs to produce the same amount of output as those using conventional LEDs due to the mechanical feature of these LEDs (i.e. being multi-chip packaged). This enables the light source size to be reduced.

This application note provides general technical information on how to use/handle the UV LEDs.

**Basic structure**
Refer to Figure 1 below for the basic structure of the UV LEDs.

![Basic structure of a NVMUR020A UV LED](image)

*Figure 1. Basic structure of a NVMUR020A UV LED*
Thermal Management

- Since the absolute maximum junction temperature must not be exceeded under any circumstances, consider the operating conditions/environment that both the system/assembly and the UV LEDs are exposed to when calculating the junction temperature \( T_J \) for the chosen application.

- The following two methods can be used to calculate the \( T_J \):
  1. Calculating the \( T_J \) using the thermal resistance from junction to \( T_C \) measurement point\(^1\) (i.e. \( R_{\theta JC} \))
  2. Calculating the \( T_J \) using the thermal resistance from junction to \( T_{MP} \) measurement point (i.e. \( R_{\theta JMP} \))

For the position of the \( T_{MP} \) measurement point, see Figure 2 below. For more details on these \( T_J \) calculation methods, refer to page 6 and page 7.

![T_{MP} Measurement Point](image.png)

Figure 2. Position of the \( T_{MP} \) measurement point

Note:

\(^1\) The \( T_C \) measurement point is on the back of the ceramic substrate. For more information, see Figure 3 or the specification for the UV LEDs.
How to Calculate the Junction Temperature (\(T_J\)) Using the \(R_{\theta JC}\)

Once the UV LEDs have been attached to a heat sink, it is difficult to measure \(T_C\) due to the location of the \(T_C\) measurement point. When calculating the junction temperature (\(T_J\)) using the \(R_{\theta JC}\), the temperature of the heat sink (\(T_{HS}\))\(^2\) should be used. Note that this \(T_J\) calculation method may require simulation runs using material properties (e.g. thermal conductivity, etc.) of components being used with the UV LEDs in addition to the \(R_{\theta JC}\) values shown below. If this method is not convenient for the chosen application, refer to the method on the next page.

\[
T_J = \text{LED Junction Temperature: } ^\circ C
\]

\[
R_{\theta JC} = \text{Thermal resistance from junction to } T_C \text{ measurement point: } ^\circ C/W
\]

\[
T_C = \text{Case temperature: } ^\circ C
\]

\[
R_{\theta CHS} = \text{Thermal Resistance from } T_C \text{ measurement point to } T_{HS} \text{ measurement point}^3: ^\circ C/W
\]

\[
T_{MP} = \text{Temperature of the Heat Sink}^2
\]

Table 2. \(R_{\theta JC}\) value of the UV LEDs

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Thermal Resistance</th>
<th>Typical</th>
<th>Max.</th>
<th>Unit</th>
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<tr>
<td>NVMUR020A</td>
<td>(R_{\theta JC})</td>
<td>0.10</td>
<td>0.12</td>
<td>(^\circ C/W)</td>
</tr>
</tbody>
</table>

Equation (1)\(^4,5\): \(T_J (^\circ C) = T_{HS} (^\circ C) + R_{\theta JHS} (^\circ C/W) \times \text{Input Power (W)}\)

Note:
2 For water cooling, use the set temperature of the cooling water (i.e. \(T_W\)) as the \(T_{HS}\); for air cooling, measure the temperature of the heat sink and use that measurement as the \(T_{HS}\). For information on how to measure the heat sink, consult appropriate literature (e.g. manufacturer’s technical document) or contact the manufacturer directly.
3 If the actual \(R_{\theta CHS}\) in the chosen system/assembly is not available, consult appropriate literature (e.g. manufacturer’s technical document) or contact the manufacturer directly.
4 \(R_{\theta JHS} = R_{\theta JC} + R_{\theta CHS}\)
5 Input Power: \(W = V_F + I_F\)
How to Calculate the Junction Temperature ($T_J$) Using the $R_{\theta JMP}$

The UV LEDs have a $T_{MP}$ measurement point that allows $T_J$ calculation by measuring at that specific point. To determine the $T_J$ of the UV LEDs, first measure the $T_{MP}$ and it will be possible to calculate the $R_{\theta JMP}$ with the following data/equations shown in Figure 5. Then, use all these values (i.e. $T_{MP}$ and $R_{\theta JMP}$), the input power ($W$)\(^6\), and equation (2) below to calculate the $T_J$.

\[
\text{Equation (2): } y = 0.19 \, e^{3.18 \, x}
\]

\[
\begin{align*}
R_{\theta JMP} \quad [°C/W] \\
\hline
\text{Change in the } T_{MP} / \text{Input Power (W)} \quad [°C/W] \\
\end{align*}
\]

\[
\text{Equation (3): } T_J (°C) = T_{MP} (°C) + R_{\theta JMP} (°C/W) \times \text{Input Power (W)}
\]

Note:

\(^6\) Change in the $T_{MP}$: $\Delta T_{MP} = \text{The change in } T_{MP} \text{ once the } T_{MP} \text{ has stabilized.}
Derating Characteristics

When designing, the derating characteristics (i.e. $T_{MP}$ vs. Allowable Forward Current $[I_F]$) must be considered. The increase in the temperature of an LED while in operation may vary depending on the heat sink's thermal resistance and the density of LEDs in the system/assembly. Ensure that when using the LEDs for the chosen application, heat is not concentrated in an area and properly managed in the system/assembly to ensure the derating characteristics during actual use.

![Derating Characteristics Graph](image)
Precautions Against Condensation

- When using the UV LEDs, do not design them into applications where condensation may occur. If the UV LEDs are stored/operated in these environments, it may cause issues (e.g. current leaks that cause the radiant flux to decrease).

- **Cautions for use with a water cooling system:**
  If the water temperature is lower than the ambient temperature, it may cause condensation on both the outer and inner surfaces of the UV LED and its surrounding surfaces. Adjust the water temperature to suit the operating environment (i.e. temperature and humidity) to prevent condensation from occurring.

- **Example:**
  The water jacket surrounding the assembly/system may be covered with dew when used under the following conditions:

  Water temperature: \( \leq 26°C \)
  Ambient temperature \( (T_A) \): \( 30°C \)
  Relative humidity \( (RH) \): \( 80% \)

Note:
7 The actual amount of water vapor in the air (i.e. absolute humidity) can be calculated to be 24g/m³ with the \( T_A \) and RH values.
Example of How to Design the UV LEDs into an Assembly/System

Refer to Figure 8 below for an example of an assembly using 11 NVMUR020A UV LEDs. For the parts/components used in the assembly, refer to Figures 9 through 11.

Cautions/Suggestions:
1. Since the UV LEDs are not designed to be soldered, the assembly above uses a metal terminal to exert a downward force on the UV LED to prevent the UV LED from moving. This is only an example for how to use the UV LEDs.
2. If two or more UV LEDs are connected in parallel, refer to “Precautions When Using UV LEDs in a Parallel Circuit” in Nichia’s application note: Assembly and Handling Precautions for UV LEDs.
How to Apply Thermal Grease

• Ensure that thermal grease is applied evenly and in an adequate amount (see Correct example in Figure 13 below).
  ◦ If the amount is too low – especially if it does not fully cover the back side of the emission area of the UV LEDs (see Incorrect example in Figure 14 below), heat from the UV LED die may not be efficiently dissipated.
  ◦ If the amount is too high, the excess thermal grease may contaminate the UV LED’s top surface causing the output power to decrease.

Thermal grease:
TC-5622 manufactured by Dow Corning Toray Co., Ltd.
Stencil thickness:
t=0.1mm

Thermal grease applied with the stencil mask
Thermal grease after the UV LED is attached to a heat sink

Correct example
Emission Area
Fully covered

Incorrect example
Emission Area
Uncovered spaces

Thermal grease after the UV LED is attached to a heat sink
Thermal grease applied without a stencil mask

Figure 12. Stencil mask aperture pattern
Figure 13. Thermal grease applied to the back of the UV LEDs

• To determine the procedure/conditions for applying the thermal grease (e.g. stencil design, volume, etc.), perform sufficient verification on the chosen system fully assembled with all parts/materials properly in place. If the thermal grease has been applied incorrectly, it may significantly affect the heat dissipation. To ensure that there are no issues with the application, use the $T_J$ calculation method on page 7 to determine the actual $T_J$ and verify it against the designed/intended $T_J$.

Note:
8 The thermal grease stencil mask is designed and used only for Nichia’s evaluation of the NVMUR020A UV LEDs. The specifications for the thermal grease/stencil mask are provided for reference purposes only.
Cautions/Suggestions for Attaching the UV LEDs to a Heat Sink

- If there are issues with the contact surface of the heat sink (i.e. uneven surface, hole/recess, burr/flash, etc.), it may significantly reduce the thermal conductivity.
- If there are issues with the thermal interface material (e.g. insufficient coverage, excessive thickness, etc.), it may cause heat not to sufficiently transfer to the heat sink and in some cases, damage to the UV LEDs. Additionally, excessively thick thermal films/sheets are more likely to lead to assembly issues (e.g. damage to the ceramic substrate) when excessive pressure is applied to the UV LEDs. Nichia recommends using thermal grease.
- If the heat sink has a foreign material and/or burr/flash on the contact surface as indicated in Figure 14-I and Figure 14-J, there is a possibility that the UV LED may be damaged when a metal terminal is attached to the PCB to supply power to the UV LED since it exerts a downward force on the UV LED to prevent the UV LED from moving.
- For more issues with the heat sink/thermal interface material, refer to Figures 14-A through 14-J below.

![Diagram showing correct and incorrect application of thermal grease between UV LEDs and heat sinks.](image-url)
How to Supply Power to the UV LEDs

The NVMUR020A UV LEDs are designed to be used with a metal terminal for electrical connection. Nichia uses a metal terminal specially designed for the UV LEDs and provides the details of this metal terminal as follows for reference purposes only.

- Material: Phosphor bronze (C5210R-H)
- Surface finish: Nickel plating (t ≥ 1μm), gold plating (t ≥ 0.05μm)
- Bending height: ≥ 0.4mm

Figure 15. Drawings and specifications for a metal terminal (for reference only)

Figure 16. Example of the placement of the metal terminal with the UV LEDs
Nichia has observed a UV LED failure during a developmental reliability test caused by improper use/attachment of the metal terminal.

**Test Conditions:**
UV LED P/N: NVMUR020A  
Wavelength Rank: U365  
Operating Conditions: $T_A=25^\circ$C, $T_W=30^\circ$C, $I_F=24$A (i.e. Absolute maximum rating current)

**Failure Description/Findings:**
During the test, a UV LED failed to meet the criteria for the power output at 2,500 hours. On a close examination, one of the metal terminals used with this UV LED was discolored (see Figure 17 and Figure 18 below for the appearances of the discolored metal terminal and a normal metal terminal). Since no other anomalies were observed in the UV LED, a lighting check was performed after replacing the metal terminal with a new one; Nichia confirmed that the UV LED emitted normally and met the criteria.

**Conclusion/Recommendations:**
The UV LED failure was caused by poor electrical connection between the metal terminal and the electrode of the UV LED. This caused the metal terminal to become excessively hot leading to the discoloration. To avoid the issue, select/design a proper metal terminal for the chosen application and use/attach it correctly. Additionally, ensure that there are no foreign materials on the contact surface that may affect the electrical connection.
Assembly/Handling Precautions for the NVMUR020A UV LEDs

Assembly Precautions
- Ensure that the nozzle does not come in contact with the lens when it picks up the UV LED. If this occurs, it may cause damage to the lens (e.g., cuts, scratches, chips, cracks, delamination, and deformation) and the wire to break causing a catastrophic failure (i.e., the UV LED not to illuminate).
- The nozzle should only touch the ceramic substrate to hold the UV LED.

Handling Precautions with Tweezers
- Nichia recommends using special tweezers (e.g., vacuum tweezers) to handle the UV LEDs. However, use care to ensure:
  - the tweezers do not touch the lens,
  - excessive force is not applied to the UV LED.
Otherwise, it may cause damage to the lens and/or the ceramic substrate (e.g., cuts, scratches, chips, cracks, delamination, and deformation) and the wire to break causing a catastrophic failure (i.e., the UV LED not to illuminate).

CAUTION: Do not allow the nozzle to touch the lens.

Handling Precautions with Bare Hands
- Do not handle the UV LEDs with bare hands:
  - this may contaminate the UV LED surface and have an effect on the optical characteristics,
  - the lens may cause injuries since the edges are sharp.
- Dropping may cause damage to the lens, ceramic substrate, and in some cases the internal wires causing a catastrophic failure (i.e., the UV LED not to illuminate).

CAUTION: Do not drop. Handle with care.

CAUTION: Do not allow the nozzle to touch the lens.

CAUTION: Do not handle the UV LEDs with bare hands.

CAUTION: Ensure that the tweezers do not damage the LED (e.g., lens).

CAUTION: Do not stack the UV LEDs on top each other.

CAUTION: Do not allow the nozzle to touch the lens.

Miscellaneous
- Do not stack the UV LEDs on top of one another, regardless of whether the UV LEDs are attached to heat sinks or not. Otherwise, it may cause damage to the lens and the ceramic substrate (e.g., cuts, scratches, chips, cracks, delamination, and deformation) and the wire to break causing a catastrophic failure (i.e., the UV LED not to illuminate).

CAUTION: Do not stack the UV LEDs on top each other.