Concerning the packages for Integrated Circuits

Thermal resistance
and thermal characterization parameter

No.AEA-0003 E

1. Scope
The definition and how to use thermal resistance and thermal characterization parameter of packages for ROHM’s integrated circuit are described in this application note.

2. Normative references
The contents that has been described in this application note complies with JESD51-2A,3,5,7,9,10(JEDEC).

3. Terms and definitions

3.1 TA
Ambient air temperature

3.2 TJ
Junction temperature

3.3 TT
The temperature at the top center of the outside surface of the component package

3.4 θJA
Thermal resistance from Junction to Ambient (Thermal radiation by plural paths)

3.5 ΨJT
The thermal characterization parameter to report the difference between junction temperature and the temperature at the top center of the outside surface of the component package (This value varies depending on the heat radiation amount to other than the top center of the outside surface of the component package.)

Figure1. The definition of thermal resistance (θJA) and thermal characterization parameter (ΨJT)
(ex : HTSOP-J8)
4. Test method environmental conditions (JESD51-2A)

Thermal test method environmental conditions comply with JESD51-2A (Still-Air) as below.

Table 1. Measurement equipment for thermal resistance

<table>
<thead>
<tr>
<th>Measurement equipment for thermal characterization</th>
<th>Supplier</th>
<th>Type</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal tester</td>
<td>Mentor Graphics</td>
<td>T3Ster</td>
<td>-</td>
</tr>
<tr>
<td>Thermostat</td>
<td>Mentor Graphics</td>
<td>T3Ster</td>
<td>-</td>
</tr>
<tr>
<td>Thermocouple (NOTE1)</td>
<td>SAKAGUCHI E.H VOC CORP.</td>
<td>K6010 Class1 / Φ0.1mm</td>
<td>-</td>
</tr>
</tbody>
</table>

(NOTE1) By fixing the thermocouple to the top center of the outside surface of the component package, the temperature at the top center of the outside surface of the component package is measured.
5. Test board

Thermal test board complies with JESD51-3,5,7,9,10 as below.

Table2. Specified parameters and values used for PCB design. (PKG size is specified by a maximum body length.)

<table>
<thead>
<tr>
<th>Layer</th>
<th>Material</th>
<th>Board Size</th>
<th>Thermal via (NOTE1)</th>
<th>Through-hole via (NOTE2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pitch</td>
<td>Diameter</td>
</tr>
<tr>
<td>SMD</td>
<td>1s</td>
<td>FR-4</td>
<td>114.3mm x 76.2mm x 1.57mmt</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>2s2p</td>
<td></td>
<td>114.3mm x 76.2mm x 1.57mmt</td>
<td>1.20mm</td>
</tr>
<tr>
<td>BGA, THD</td>
<td>1s</td>
<td>FR-4</td>
<td>114.5mm x 101.5mm x 1.6mmt</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>2s2p</td>
<td></td>
<td>114.5mm x 101.5mm x 1.6mmt</td>
<td>1.20mm</td>
</tr>
</tbody>
</table>

(NOTE1) Thermal via: One thermal via will exist for each trace square of a thermal attach area for a universal test board design.

(NOTE2) Through-hole via: Pins that are directly connected to the die pad shall be connected to the top buried copper plane. These pins shall be isolated from the bottom copper plane.

Figure4. Sectional view of the thermal test board (SMD with heat sink)

Figure5. Sectional view of the thermal test board (THD: DIP type)
6. Thermal measurement procedure

Below are two methods of thermal measurement for semiconductor:
- Thermal measurement at the surface of the package (connected measurement / unconnected measurement)
- Thermal measurement at the PN junction of the chip

The advantages and disadvantages of each method are written in the table below;

<table>
<thead>
<tr>
<th>Measurement method</th>
<th>Advantages</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal measurement at the surface of the package</td>
<td>Measurement is easy.</td>
<td>It is likely to contain some errors due to environment because it is not directly monitored.</td>
</tr>
<tr>
<td>Thermal measurement at the PN junction of the chip</td>
<td>Junction temperature is directly measured, resulting in a good accuracy.</td>
<td>The terminal for thermal measurement is needed for semiconductor.</td>
</tr>
</tbody>
</table>

If surface temperature measurement is used in performing the semiconductor temperature measurement, thermal characterization parameter ($\Psi_{JT}$) will be used for the calculation.

($\Psi_{JT}$) is a parameter which defines the temperature difference between junction temperature ($T_J$) and the temperature at the top center of the outside surface of the component package ($T_T$), and it is same as ROHM previously used notation ($\theta_{JC}$).

An accurate junction temperature can be calculated by using thermal characterization parameter if temperature ($T_T$) is measured while the thermocouple is firmly contacted with the top center of the package.

(However, it must be considered that thermal characterization parameter changes depending on heat dissipation performance of the board.)

\[
T_J = T_T + \Psi_{JT} \times P
\]

($T_J$ : Junction temperature, $T_T$ : the temperature at the top center of the outside surface of the component package, $P$ : Power consumption)

In addition, junction temperature can be easily calculated by using thermal resistance ($\theta_{JA}$).

(However, it is likely to be influenced by the difference with JEDEC environment rather than thermal characterization parameter)

\[
T_J = T_A + \theta_{JA} \times P
\]

($T_J$ : Junction temperature, $T_A$ : Ambient temperature, $P$ : Power consumption)

In case of checking the margin to the temperature limit from the package surface temperature, by assuming that $T_c = T_T$, maximum temperature ($T_{CMAX}$) at the top surface of the component package can be calculated as below.

\[
T_{CMAX} = T_{JMAX} - \Psi_{JT} \times P
\]

($T_{CMAX}$ : Maximum temperature at the top surface of the component package, $T_{JMAX}$ : Maximum junction temperature, $P$ : Power consumption)
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