Concerning the packages for Integrated Circuits

Thermal resistance and thermal characterization parameter

No.AEA-0003 E

Contents

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 T_A

Ambient air temperature

3.2 T_J

Junction temperature

3.3 T_T

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

3.4 θ_{JA}

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

3.5 Ψ_{JT}

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.)

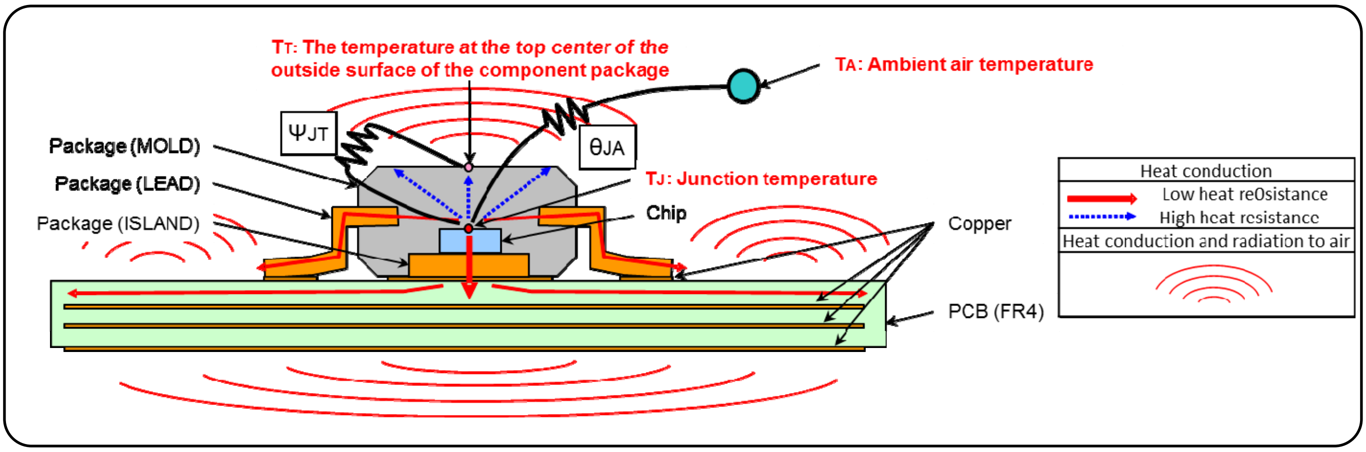


Figure1. The definition of thermal resistance (θ_{JA}) and thermal characterization parameter (Ψ_{JT})
(ex : HTSOP-J8)

Absolute Maximum Ratings (Ta = 25°C)

Parameter	Symbol	Rating	Unit
Supply Voltage	V_{IN}	7	V
Junction Temperature Range	Tj	-40 to +150	°C
Storage Temperature Range	Tstg	-55 to +150	°C

Caution: Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.

Thermal Resistance(NOTE 1)

Parameter	Symbol	Thermal Resistance (Typ)		Unit
		1s(NOTE 3)	2s2p(NOTE 4)	
HTSOP-J8				
Junction to Ambient	θ_{JA}	206.4	45.2	°C/W
Junction to Top Characterization Parameter (NOTE 2)	Ψ_{JT}	21	13	°C/W

(Note 1)Based on JESD51-2A(Still-Air)
(Note 2)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.
(Note 3)Using a PCB board based on JESD51-3.

Layer Number of Measurement Board	Material	Board Size
1s	FR-4	114.3mm x 76.2mm x 1.57mmt

Component trace	
Copper Pattern	Thickness
Component mounting and trace fan-out region	70μm

(Note 4)Using a PCB board based on JESD51-7.

Layer Number of Measurement Board	Material	Board Size	Thermal via(NOTE 5)	
			Pitch	Diameter
2s2p	FR-4	114.3mm x 76.2mm x 1.6mmt	1.20mm	Φ0.30mm

Component trace		Plane		Backside trace	
Copper Pattern	Thickness	Copper Pattern	Thickness	Copper Pattern	Thickness
Component mounting and trace fan-out region	70μm	$74.2mm^2$(Square)	35μm	$74.2mm^2$(Square)	70μm

(Note 5) This through hole via connects with the top copper pattern. The placement and dimensions obey a land pattern.

Figure2. Data sheet example (ex : HTSOP-J8)

4. Test method environmental conditions（JESD51-2A）

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

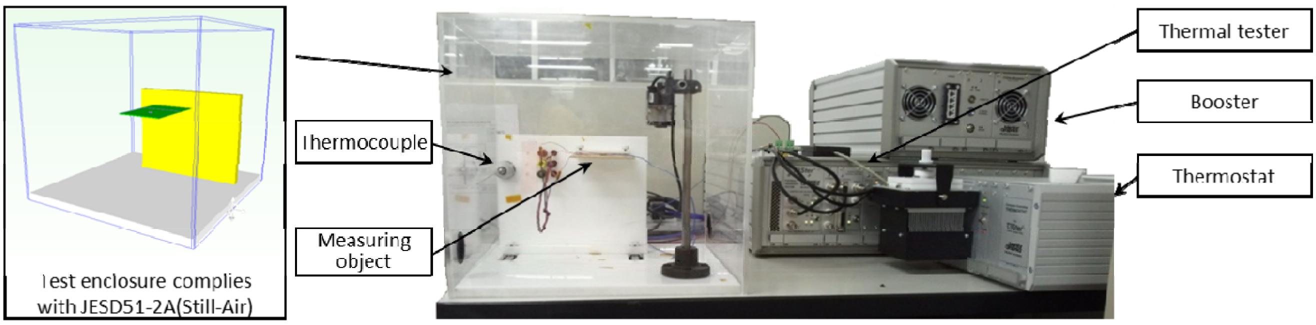


Figure3. Thermal test method environmental conditions

Table1. Measurement equipment for thermal resistance

Measurement equipment	Supplier	Type	Note
Thermal tester for thermal characterization	Mentor Graphics	T3Ster	-
Thermostat	Mentor Graphics	T3Ster	-
Thermocouple(NOTE1)	SAKAGUCHI E.H VOC CORP.	K6010	Class1 / Φ0.1mm

(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.)

	Layer	Material	Board Size	Thermal via (NOTE1)		Through-hole via (NOTE2)
				Pitch	Diameter	Diameter
SMD (PKG size＜27mm)	1s	FR-4	114.3mm x 76.2mm x 1.57mmt	-	-	-
	2s2p		114.3mm x 76.2mm x 1.6mmt	1.20mm	Φ0.30mm	-
BGA,THD (PKG size≦40mm)	1s	FR-4	114.5mm x 101.5mm x 1.6mmt	-	-	Φ0.85mm
	2s2p			1.20mm	Φ0.30mm	Φ0.85mm

	Layer	Component trace		Plane		Backside trace	
		Copper pattern	Thickness	Copper pattern	Thickness	Copper pattern	Thickness
SMD (PKG size＜27mm)	1s	Component mounting and trace fan-out region	70µm	-	-	-	-
	2s2p			74.2mm^2(Square)	35µm	74.2mm^2(Square)	70µm
BGA,THD (PKG size≦40mm)	1s	Component mounting and trace fan-out region	70µm	-	-	-	-
	2s2p			99.5mm^2(Square)	35µm	99.5mm^2(Square)	70µm

(NOTE1) Thermal via : One thermal via will exist for each trace square of a thermal attach area for a universal test board design.
Thermal vias are designed on the thermal attach pad. (Only the package with heatsink)

(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.

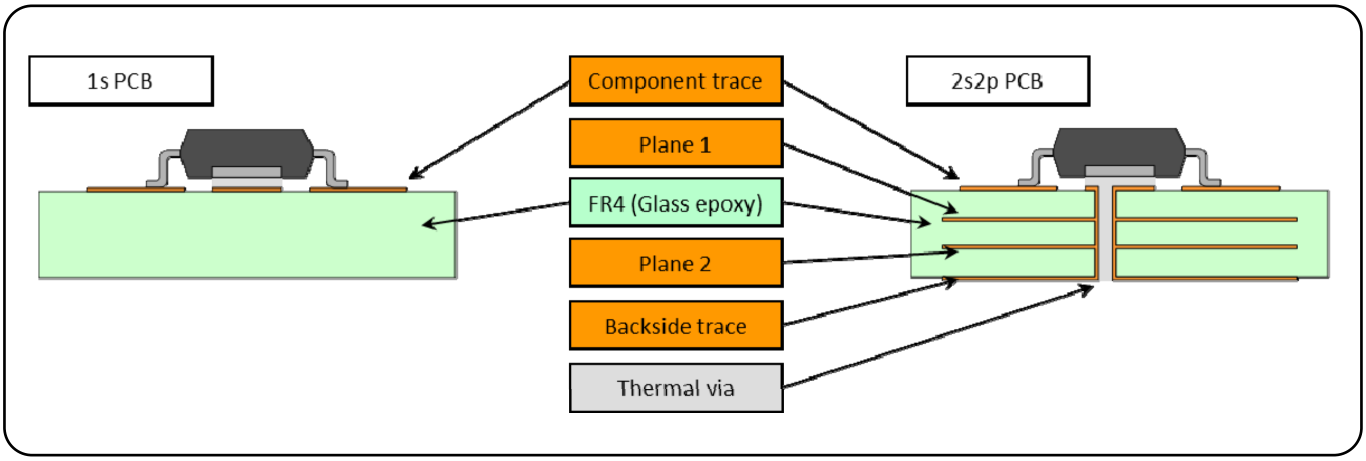


Figure4. Sectional view of the thermal test board (SMD with heat sink)

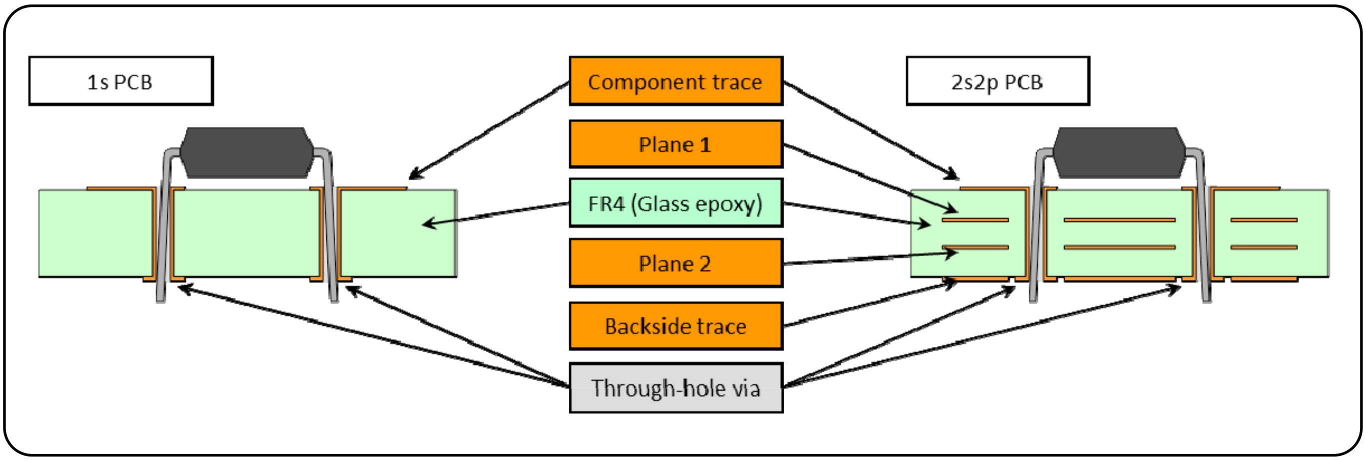


Figure5. Sectional view of the thermal test board (THD : DIP type)

6. Thermal measurement procedure

Below are two methods of thermal measurement for semiconductor;

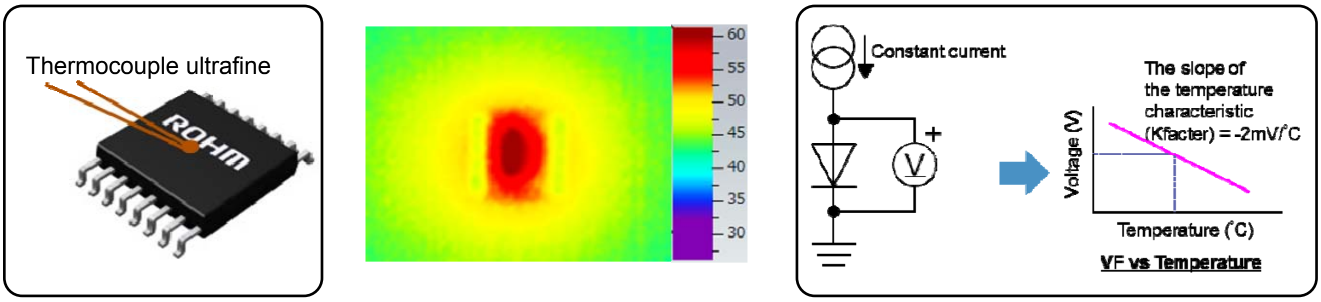
-Thermal measurement at the surface of the package (connected measurement / unconnected measurement)

-Thermal measurement at the PN junction of the chip

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

Table3. The advantages and disadvantages due to differences in measurement method

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



Thermal measurement at the surface Thermocouple (Connected)

Thermal measurement at the surface Thermoviewer (Unconnected)

Thermal measurement at the PN junction of the chip

Figure6. Images of each measurement

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

(Ψ_{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 (θ_{JC}).

An accurate junction temperature can be calculated by using thermal characterization parameter if temperature (T_T) is measured while the thermalcouple 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.)

$$T_J = T_T + \Psi_{JT} ※ P$$

(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 (θ_{JA}).

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

$$T_J = T_A + \theta_{JA} ※ P$$

(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.

$$T_{CMAX} = T_{JMAX} - \Psi_{JT} ※ P$$

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

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