

JEDEC STANDARD

Glossary of Thermal Measurement Terms and Definitions

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GLOSSARY OF THERMAL MEASUREMENT TERMS AND DEFINITIONS

Introduction

In order to facilitate the communication of thermal measurement and data information a clear and well-defined language is necessary. This collection of terms and definitions will help to more accurately describe the thermal performance of various semiconductor packages and packaged devices.

GLOSSARY OF THERMAL MEASUREMENT TERMS AND DEFINITIONS

(From JEDEC Board ballot JCB-09-21, formulated under the cognizance of the JC-15 Committee on Thermal Characterization.)

1 Scope

This document provides a unified collection of the commonly used terms and definitions in the area of semiconductor thermal measurements. The terms and definitions provided herein extend beyond those used in the JESD51 family of documents to include other often used terms and definitions in the area of semiconductor thermal measurements.

2 Normative references

This document is one of a number of JEDEC publications on the thermal characterization of integrated circuit devices. The associated details of test methods, thermal test dice, and test boards are given by the following JEDEC publications:

[1] JESD51, “Methodology for the Thermal Measurement of Component Packages (Single Semiconductor Devices).” This is the overview document for this series of standards and guidelines.

[2] JESD51-1, “Integrated Circuit Thermal Measurement Method - Electrical Test Method”

[3] JESD51-2, “Integrated Circuit Thermal Measurement Method - Environmental Conditions - Natural Convection (Still Air)”

[4] JESD51-3, “Low Effective Thermal Conductivity Test Board for Leaded Surface Mount Packages”

[5] JESD51-4, “Thermal Test Chip Guidelines (Wire Bond-type Chip)”

[6] JESD51-5, “Extension of Thermal Test Board Standards for Packages with Direct Thermal Attachment Mechanisms”

[7] JESD51-6, “Integrated Circuit Thermal Test Method Environmental Conditions - Forced Convection (Moving Air)”

[8] JESD51-7, “High Effective Thermal Conductivity Test Board for Leaded Surface Mount Packages”

[9] JESD51-8, “Integrated Circuit Thermal Test Method Environmental Conditions - Junction-to-Board”

2 Normative references (cont'd)

[10] JESD51-9, "Test Boards for Area Array Surface Mount Package Thermal Measurements"

[11] JESD51-10, "Test Boards for Through-Hole Perimeter Leaded Package Thermal Measurements"

[12] JESD51-11, "Test Boards for Through-Hole Area Array Leaded Package Thermal Measurements"

[13] JESD51-12, "Guidelines for Reporting and Using Electronic Package Thermal Information"

3 Terms and definitions

black body: a perfect radiator or absorber of infrared radiation.

chip attach: see DIE BOND.

cold plate: a heat absorber usually operating at some known or fixed temperature.

die attachment: see DIE BOND.

die bond: the process or method of physically mounting a chip on a surface - package, substrate, header, etc.; also known as DIE ATTACHMENT or CHIP ATTACH.

die bond material: material used to attach the die to rest of the package. The most common material is epoxy; solder is often used for high power devices.

DUT: Device-Under-Test.

electrical test method: a method using electrical signals and measurement to determine junction temperature change as the result of a change in the application of electrical power to the DUT over a specific period of time.

emissivity: the ratio of the radiant energy emitted by a surface to that emitted by a blackbody at the same temperature.

heating current: a current supplied to device-under-test to cause the junction temperature to rise.

heating power: the product of HEATING CURRENT and HEATING VOLTAGE; causing device-under-test junction temperature to rise.

3 Terms and definitions (cont'd)

heating pulse width: the length of time electrical power is applied to the device-under-test to cause the junction temperature to rise.

heating voltage: the voltage across the DUT during the application of HEATING CURRENT.

heat sink: an external object in contact with component package for purposes of removing heat from the component.

junction temperature: the temperature of the operating portion of a semiconductor device.

K Factor: the quotient of junction temperature change to temperature sensitive parameter change in linear region of temperature sensitive parameter - temperature relationship.

K Factor calibration: the measurement and data reduction process that results in values of K factor for the semiconductor device.

measurement current: the current applied to the device-under-test for the measurement of the temperature sensitive parameter.

measurement delay time: time from removal of heating conditions to the start of the measurement sample window.

peak junction temperature: the highest temperature on the semiconductor chip due to power dissipation internal to the semiconductor chip; if there are significant multiple peaks, then location information must be provided.

radiation: the transmission of heat via electromagnetic waves.

sample window time: length of time during which the temperature sensitive parameter is measured after HEATING POWER is removed.

spatial resolution: the diameter of a spot whose size is determined from the half-power points resulting from a point infrared source.

temperature-sensitive parameter: an electrical parameter of a semiconductor device that varies directly with junction temperature in a linear or very nearly linear fashion.

thermal characterization parameter: parameter characterizing the behavior of the package. The two most commonly used thermal characterization parameters are Ψ_{JT} and Ψ_{JB} defined in JESD51-2 and JESD51-6 that measure the temperature relationship between junction-to-top and junction-to-board. While the units are °C/W, they are not resistances because the temperature difference is divided by the total power, not the power flowing between the two areas.

3 Terms and definitions (cont'd)

thermal equilibrium: a condition in which no heat-producing power is applied to the device-under-test and the device junction temperature (T_J) is equal to the ambient temperature (T_A) in the immediate vicinity of the device. (Thermal steady-state at zero applied power)

thermal impedance: a measure of the dynamic heat flow restriction from a point of high temperature to a point of lower temperature. In most cases, dynamic heat-flow means a transient.

thermal resistance: a measure of the steady-state heat flow from a point of higher temperature to a point of lower temperature, calculated by dividing the temperature difference by the heat flow between the two points.

thermal resistance, junction-to-ambient: the thermal resistance from the operating portion of a semiconductor device to a natural convection (still-air) environment surrounding the device.

thermal resistance, junction-to-case: the thermal resistance from the operating portion of a semiconductor device to outside surface of the package (case) closest to the chip mounting area when that same surface is properly heat sunk so as to minimize temperature variation across that surface; the package interface surface can be on either the top or bottom of the package.

thermal resistance, junction-to-fluid: the thermal resistance from the operating portion of a semiconductor device to a fluid environment surrounding the device.

thermal resistance, junction-to-lead: the thermal resistance from the operating portion of a semiconductor device to lead either most closely associated with heat removal or otherwise specified.

thermal resistance, junction-to-moving air: the thermal resistance from the operating portion of a semiconductor device to a forced convection (moving-gas) environment surrounding the device; the gas is assumed to be air unless otherwise defined.

thermal resistance, junction-to-reference point: the thermal resistance from the operating portion of a semiconductor device to a defined reference point within the specified environment surrounding the device.

thermal resistance, junction-to-defined environment: the thermal resistance from the operating portion of a semiconductor device to a defined nonstandard environment surrounding the device.

thermal steady-state: a condition in which the power entering the device-under-test (DUT) is equal to the power leaving the DUT; the device junction temperature (T_J) will have reached a stable value.

4 Symbols and units

Note: Temperature may be expressed in Kelvin (K) or centigrade (°C) units.

Symbol	Units	Description
ΔTSP		The change in the Temperature Sensitive Parameter; units dependent on parameter used
θ_{JA}	K/W	Junction-to-Ambient Thermal Resistance
θ_{JB}	K/W	Junction-to-Board Thermal Resistance
Ψ_{JB}	K/W	Junction-to-Board Thermal Characterization Parameter. A thermal metric derived from the difference in junction temperature (T_J) and board temperature (T_B) divided by total heating power (P_H); applicable to arrayed-connection packages. The thermal environment must be specified.
θ_{JC}	K/W	Junction-to-Case Thermal Resistance
θ_{JCbot}	K/W	Junction-to-Case Thermal Resistance with heat flow through package bottom
θ_{JCtop}	K/W	Junction-to-Case Thermal Resistance with heat flow through package top
θ_{JF}	K/W	Junction-to-Fluid Thermal Resistance
θ_{JL}	K/W	Junction-to-Lead Thermal Resistance
Ψ_{JL}	K/W	Junction-to-Lead Thermal Characterization Parameter. A thermal metric derived from the difference in junction temperature (T_J) and lead temperature (T_L) divided by total heating power (P_H); applicable mostly to leaded device packages. The thermal environment must be specified.
θ_{JMA}	K/W	Junction-to-Moving Air Thermal Resistance
θ_{JR}	K/W	Junction-to-Reference Thermal Resistance
Ψ_{JT}	K/W	Junction-to-Top Thermal Characterization Parameter. A thermal metric derived from the difference in junction temperature (T_J) and package top temperature (T_T) divided by total heating power (P_H). The thermal environment must be specified.
θ_{JX}	K/W	Junction-to-defined point (X) Thermal Resistance
ΔV_F	mV	The change in temperature sensing voltage due to the applied HEATING POWER to the device.
I_H	A	Heating Current
I_M	mA	Measurement Current
K	K/mV K/ Ω	K Factor for diode sensor K Factor for resistive sensor
P_H	W	Heating Power
$R_{\theta JA}$	K/W	Junction-to-Ambient Thermal Resistance
$R_{\theta JC}$	K/W	Junction-to-Case Thermal Resistance
$R_{\theta JL}$	K/W	Junction-to-Lead Thermal Resistance
$R_{\theta JMA}$	K/W	Junction-to-Moving Air Thermal Resistance
$R_{\theta JR}$	K/W	Junction-to-Reference Thermal Resistance

4 Symbols and units (cont'd)

Symbol	Units	Description
$R_{\theta JX}$	K/W	Junction-to-defined point (X) Thermal Resistance
T_A	K	Ambient Temperature
T_B	K	Board Temperature, measured on the board at the package long-side center
T_F	K	Fluid Temperature in immediate area of the package
t_H	s	Heating Time
t_{Hss}	s	Steady State Heating Time
T_J	K	Junction Temperature
ΔT_J	K	Junction Temperature Change
$T_{J(Peak)}$	K	Peak Junction Temperature; if multiple peaks, then term refers to the highest peak
T_L	K	Lead Temperature
t_{MD}	μs	Measurement Delay Time
T_T	K	The device package temperature; usually top-center on the greatest exposed package surface
t_{SW}	μs	Sample Window Time
V_H	V	Heating Voltage
$Z_{\theta JX}$	K/W	Junction-to-defined point (X) Thermal Impedance



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The referenced clause number has proven to be:

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