Development, Validation, and Application of Thermal Modeling for a MCM Power Package

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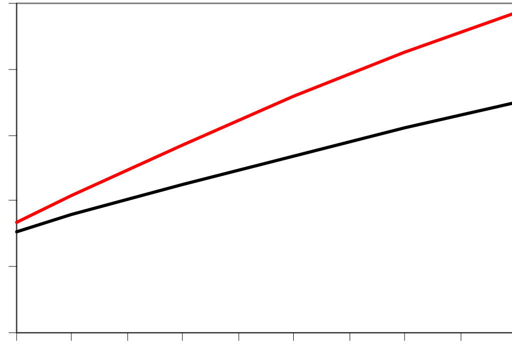
Abstract

This paper addresses the differences in thermal characterization and modeling for a multi-chip package with respect to a single-chip package. Since no thermal measurement system is commercially available to power more than one device during the test, the thermal model can be validated only with a single-heat source. Wires, which are used to connect the package under the test to the measurement system, should be included in thermal model to account for the heat sinking effect. The modeling results from the validated thermal model showed that the thermal behavior of

2 Validation of the Detailed Thermal Model for a Multi-Chip Micro-Leadframe Package

The measurement of junction temperatures was performed first for the MCM package shown in Fig. 1, with the thermal analyzer (e.g. ref. [4]). Due to the complexity of the inter-connections among three chips, cautions should be made to obtain the correct test data from the experiment. Our experiences indicated that, unless all pins of IC chip are shorted to ground for the package under study, the junction temperatures of synchronous MOSFET and control MOSFET chips, which are extracted from the forward voltage-drop with a small sense current, were almost 100% higher than when pins are all shorted to ground.

Table 1 lists the test results of the junction temperatures rise and thermal resistance, with heating the synchronous FET chip, for the package attached to the 1in^2 2 oz Cu on FR-4 board with the recommended layout [3], subject to the still air chamber. The results from Table 1 showed the repeatability of the test. It can be seen that the hilts of thto



$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x_i}(\rho u_i) = 0 \qquad (2)$$

The conservation of momentum

$$\frac{\partial}{\partial t}(\rho u_j) + \frac{\partial}{\partial x_i}(\rho u_i u_j) = \frac{\partial}{\partial x_i}(\mu \frac{\partial u_j}{\partial x_i}) - \frac{\partial p}{\partial x_j} + S_j \qquad (3)$$

and, the conservation of energy

$$\frac{\partial}{\partial t}(\rho c_p T) + \frac{\partial}{\partial x_i}(\rho u_i T) = \frac{\partial}{\partial x_i}(k \frac{\partial T}{\partial x_i}) + P \qquad (4)$$

where ρ is the density; u_i the velocity vector (i=1,2, and 3), p the pressure, T the temperature, S_j the body force, P the heat source, and μ is viscosity. The nonlinear effect of radiation can be written as

$$-q = \alpha (T^4 - T_0^4) \qquad (5)$$

where α is the coefficient of radiation and q is the heat flux through the radiation area, and T_0 is the ambient temperature.

Let's now confine our attention to the heat transfer through the solid part of the system, i.e., the interior package. In this case, if we assume that the thermal properties of package materials are linear, the governing equation can be re-written as following

$$c_p \frac{T}{t} \quad k \frac{}{x_i}(\frac{\partial T}{\partial x_i}) + P(X)$$

ΔT_{31}: temperature rise of driver IC chip with P W heating from synchronous FET

ΔT_{12}: temperature rise of synchronous FET with P W heating from control FET

ΔT_{22}: temperature rise of control FET with P W heating from control FET

ΔT_{32}: temperature rise of driver IC chip with P W heating from control FET

ΔT_{13}: temperature rise of synchronous FET with P W heating from driver IC

ΔT_{23}: temperature rise of control FET with P W heating from driver IC

ΔT_{33}: temperature rise of driver IC chip with P W heating from driver IC

which are obtained from the measurement with maintaining

3. Philips Semiconductors, PIP201-12M: DC to DC converter powertrain: preliminary data sheet*, Rev. 01-23*, January 2002.
4. Sofia, John, “Fundamentals of Thermal Resistance Testing”, http://w