講演番号 082

High Precision 3D Thermal Analysis of Printed Circuit Board Components using Transient Heat Generation obtained from Circuit Simulation

Haruki Takei [1)] Nakaomi Sawada [2)] Minoru Shibutani [3)] Masanari Ueda [4)] Yoshiko Ikeda [5)]

Ryuta Yoshida [6)] Osamu Seya [6)] Kazunari Hashimoto [7)] Keita Inoue [7)] Takuya Shinoda [7)]

1) Siemens K.K. Shinyokohama Square Bldg. 16F, 2-3-12 Shinyokohama, Kohoku-ku, Yokohama, Kanagawa, 220-0033, Japan (E-mail: haruki.takei@siemens.com)

2) PERSOL CROSS TECHNOLOGY CO., LTD., 51F Shinjuku Mitsui Bldg., 2-1-1 Nishishinjuku, Shinjuku-ku, Tokyo 163-0451, Japan

3) Kozo Keikaku Engineering Inc., 38-13 Honcho 4-chome, Nakano-ku, Tokyo, 164-0012, Japan

4) Siemens EDA Japan K.K., 4-7-35 Kitashinagawa, Shinagawa-ku, Tokyo, 140-0001, Japan

5) Toshiba Electronic Devices & Storage Corporation, 1 Komukai-Toshiba-cho, Saiwai-ku, Kawasaki, Kanagawa, 212-8583, Japan

6) Institute of Science Tokyo, 2-12-1 Ookayama, Meguro-ku, Tokyo, 152-8550, Japan

7) DENSO CORPORATION, 1-1 Showa-cho, Kariya, Aichi, 448-8661, Japan

KEY WORDS: **electronics and control, electronic device, power device, electronic control unit, simulation [E1]**

The number of electrical components installed in automobiles is increasing due to the popularization of electric vehicles (EVs), advanced driving assistance systems (ADAS), and other state-of-the-art technologies. It is known that high operating temperatures of electrical components can lead to performance, reliability, and safety issues. Conducting thermal simulations to predict component operating temperatures in thermal design is common. However, temperature predictions have traditionally been limited to steady-state conditions. In recent years, there has been a growing demand for high-accuracy transient temperature prediction to enhance product competitiveness. Conducting transient thermal simulations poses several challenges, including obtaining detailed heat generation profiles for components, selecting appropriate thermal models that can predict transient temperatures, and reducing computational costs. In this study, by using detailed heat generation profiles obtained from electrical circuit simulations, we investigated the differences in predicted temperature between a simple component model and a detailed model, and the effectiveness of using average power instead of instantaneous power.

Several types of modeling methods for components are commonly used, namely the simple model and the detailed model, as shown in Fig. 1. The simple model consists of a cuboid, and thermal properties inside the component are expressed as equivalent thermal conductivity. On the other hand, the detailed model consists of several cuboids, and thermal properties inside the component are represented accurately by thermal conductivity and outlines defined within these cuboids. Figure 2 shows the periodic heat generation of a metal-oxide-semiconductor field-effect transistor (MOSFET) obtained from circuit simulations. MOSFETs are used as switches, and their heat generation consists of switching losses due to switching operations and on-state losses due to on-resistance. Since these losses vary with the MOSFET's switching frequency, transient thermal simulations with very fine time steps are required to accurately predict its operating temperature. Figure 3 shows the time dependence of temperature rise both for the detailed model and the simple model. As can be seen, while the detailed model can accurately predict temperatures reflecting time variations in heat generation, the simple model fails to reproduce the fine temporal variation in temperature. This is attributed to the difference in the reproducibility of temperature variations against heat generation fluctuations, depending on the modeling method. This highlights the importance of choosing a suitable modeling method for the component to accurately predict the transient temperature.

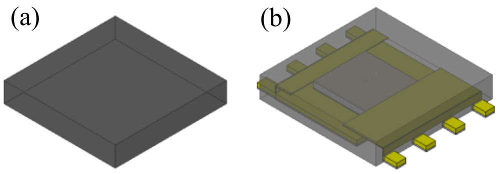

Fig.1 (a)Simple model and (b) detailed model

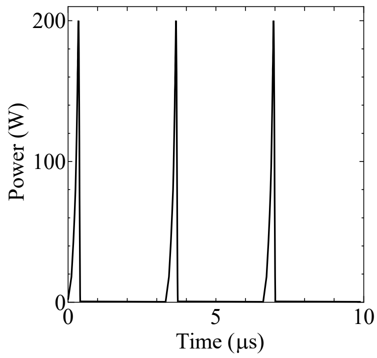

Fig.2 Transient generation power obtained from electrical circuit simulations

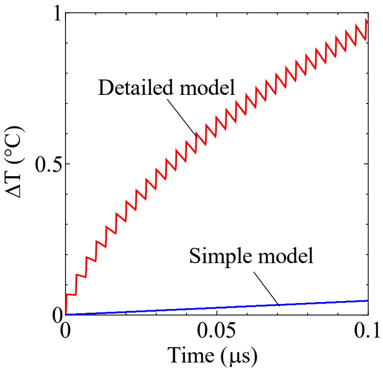

Fig.3 Time dependence of temperature rise for the detailed model and the simple model