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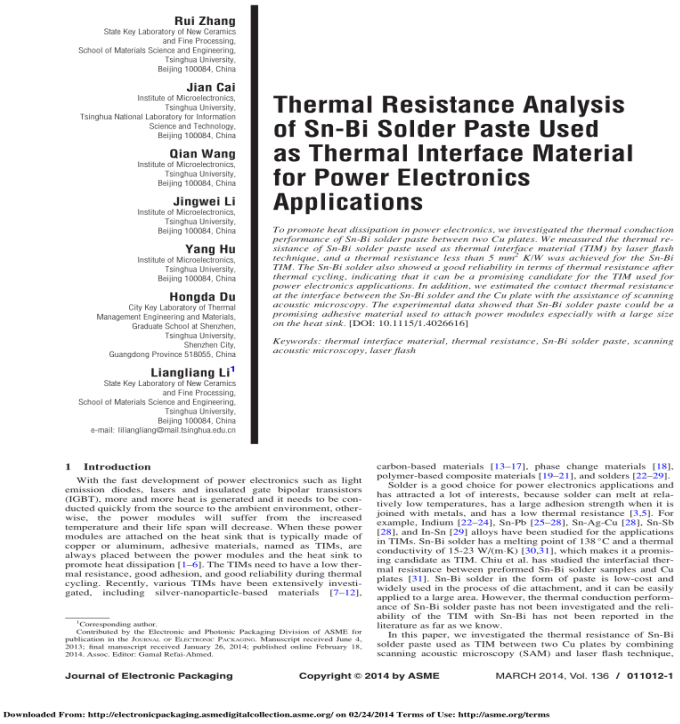

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Thermal Resistance Analysis of Sn-Bi Solder Paste Used as Thermal Interface Material for Power Electronics Applications

To promote heat dissipation in power electronics, we investigated the thermal conduction performance of Sn-Bi solder paste between two Cu plates. We measured the thermal resistance of Sn-Bi solder paste used as thermal interface material (TIM) by laser flash technique, and a thermal resistance less than 5 mm² K/W was achieved for the Sn-Bi TIM. The Sn-Bi solder also showed a good reliability in terms of thermal resistance after thermal cycling, indicating that it can be a promising candidate for the TIM used for power electronics applications. In addition, we estimated the contact thermal resistance at the interface between the Sn-Bi solder and the Cu plate with the assistance of scanning acoustic microscopy. The experimental data showed that Sn-Bi solder paste could be a promising adhesive material used to attach power modules especially with a large size on the heat sink. [DOI: 10.1115/1.4026616]

Keywords: thermal interface material, thermal resistance, Sn-Bi solder paste, scanning acoustic microscopy, laser flash

1 Introduction

With the fast development of power electronics such as light emission diodes, lasers and insulated gate bipolar transistors (IGBT), more and more heat is generated and it needs to be conducted quickly from the source to the ambient environment, otherwise, the power modules will suffer from the increased temperature and their life span will decrease. When these power modules are attached on the heat sink that is typically made of copper or aluminum, adhesive materials, named as TIMs, are always placed between the power modules and the heat sink to promote heat dissipation [1–6]. The TIMs need to have a low thermal resistance, good adhesion, and good reliability during thermal cycling. Recently, various TIMs have been extensively investigated, including silver-nanoparticle-based materials [7–12], carbon-based materials [13–17], phase change materials [18], polymer-based composite materials [19–21], and solders [22–29].

Solder is a good choice for power electronics applications and has attracted a lot of interests, because solder can melt at relatively low temperatures, has a large adhesion strength when it is joined with metals, and has a low thermal resistance [3,5]. For example, Indium [22–24], Sn-Pb [25–28], Sn-Ag-Cu [28], Sn-Sb [28], and In-Sn [29] alloys have been studied for the applications in TIMs. Sn-Bi solder has a melting point of 138 °C and a thermal conductivity of 15-23 W/(m·K) [30,31], which makes it a promising candidate as TIM. Chiu et al. has studied the interfacial thermal resistance between preformed Sn-Bi solder samples and Cu plates [31]. Sn-Bi solder in the form of paste is low-cost and widely used in the process of die attachment, and it can be easily applied to a large area. However, the thermal conduction performance of Sn-Bi solder paste has not been investigated and the reliability of the TIM with Sn-Bi has not been reported in the literature as far as we know.

In this paper, we investigated the thermal resistance of Sn-Bi solder paste used as TIM between two Cu plates by combining scanning acoustic microscopy (SAM) and laser flash technique,

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