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The Large-area TIM using Sn-Cu-Ni-Sb quaternary IMC joint material

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Abstract— **We have been developing Sn-Cu-Ni ternary IMC (intermetallic Composition) joint materials for high heat-resistant die attach applications preventing Sn allotropic transformation and suppress the formation of Kirkendall void. In this study, we have developed Sn-Cu-Ni-Sb quaternary IMC joint materials with improved high heat resistance (liquidus point temperature as 230℃) while maintaining high thermal conductivity (43W/m·K), which is applicable to a new application field of TIM (Thermal Interface Material).**

Keywords— Intermetallic Compound, IMC, TIM, Thermal Interface Material

I. Introduction

Thermal Interface Material (TIM), which forms a thermal conduction path between the backside of semiconductor chips and heat sink (HS), is becoming increasingly important. The formation of heat dissipation paths for power semiconductors has been an issue in system design. In addition to this, the recent trend to make use of “chiplet” for large-scale integrated circuit packaging requires a heat dissipation system that can handle a large area, which in turn requires new materials and technologies for the TIM.

II. Investigation

a) Ternary composed IMC

We have been developing high heat-resistant joint materials using Sn-Cu-Ni ternary intermetallic compound (IMC). The characteristics of this composition were to suppress volume change due to Sn allotropic transformation and Kirkendall void formation [1]. The joint materials have been made by IMC particles of ternary composition. Each particle has two regions inside which are IMC colonies' region of $(Cu, Ni)_6Sn_5$ and basal-phase region of Sn-4Cu having low melting point. When IMC joint materials get into sintering process, the basal phase region of each particle to be melt and release the IMC colonies into joint region and the colonies formed a tough and stable IMC skeleton structure by interconnecting to each other.

b) Quaternary composed IMC

With a view to utilizing IMC joint materials in TIM application, we have selected quaternary composed IMC to achieve even higher heat resistance. We focused on the basal-phase region of the Sn-4Cu which determines the melting properties as a joint material. We have made IMC fine particles of Sn-Cu-Ni-Sb quaternary composition and processed them into sheet or paste to be applicable as die bond materials and TIM. The additive Sb is not included in the IMC skeleton structure, but only in the basal phase region (Fig.1) [2]. This allowed for selective distribution of Sb and increased the melting point temperature of the IMC joint material. Sn-8Cu-5Sb-0.1Ni was selected as the appropriate composition in this study.

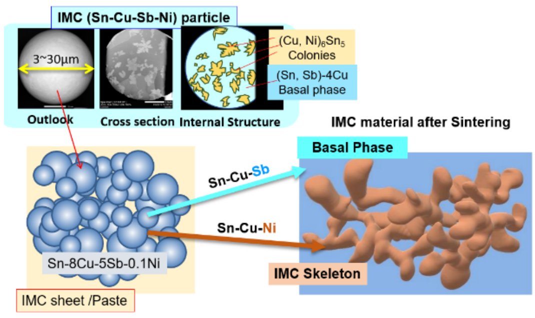

Fig. 1 The distribution of Sn-Cu-Sb-Ni composition

c) Large area bonding

There are several issues when using IMC joint materials for TIM applications on large area heat generating surfaces such as backside of chiplets.

c-1) Heat Sink (HS) surface roughness:
TIM has two targets of joints; backside of the chip and HS. The large-area HS is often found to have rough surface in contact with the TIM due to electroless Ni plating on Cu plates. IMC-TIM must be able to bond to this rough surface.

c-2) Chip height difference in multiple die mount:
When TIM is bonded to multiple chips in the same package, each chip may have a different mounting height, and the TIM bond line thickness (BLT) for each chip must be able to accommodate this difference. (Fig. 2).

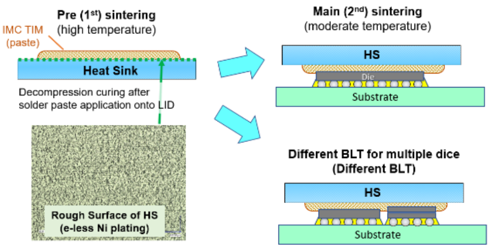

Fig. 2 Surface of HS and two step sintering

We investigated the possibility of using TIM with IMC sheets and IMC paste to address these issues.