

## Substrate effects on SnAgCu solder joints

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# Substrate Effects on SnAgCu Solder Joints

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## Introduction

Demand of increasing functionality in smaller space is termed as "miniaturization" in microelectronics. Miniaturization led to the development of ball grid arrays (BGA), replacing lead-frame assemblies. The pads on both chip and print circuit board side contain thin films of lamellar metallic layers, the so-called under bump metallization (UBM) with the purpose of:

- Preventing oxidation of copper,
- Wetting of solder to the pad,
- Wetting between individual metal layers.

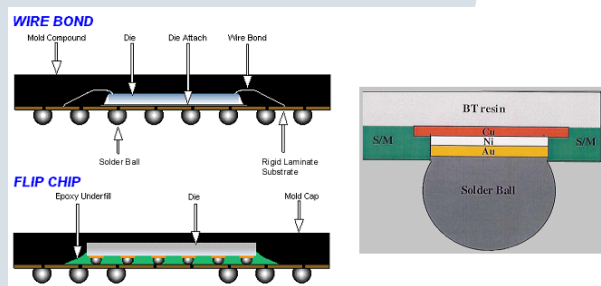


Figure 1 BGA layout and the UBM.

## Objective

Characterizing the interfacial metallurgy and corresponding damage propagation in SnAgCu solder with the substrates Cu and the UBM configuration Ni/Au.

## Interface Metallurgy

Fig.2 shows SnAgCu solder paste reflowed on Cu and Au coated Ni plate at 260°C. The solder reaction immediately forms a number of intermetallic layers at the interface. The morphology changes from layerwise to scallop type from substrate towards solder [1]. Air cooling results in excessive diffusion of substrate atoms into the solder matrix, thus leading to precipitation of large primary intermetallic crystals. Voids are often encountered.

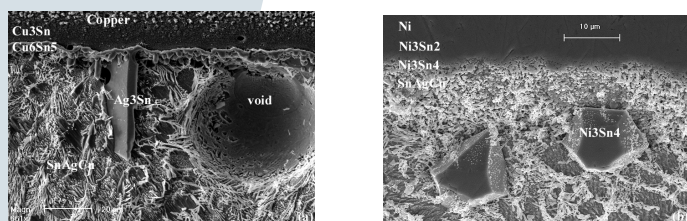


Figure 2 (a) Cu-SAC interface, (b) Ni/Au-SAC interface.

## Crack Paths at Solder/Substrate Interface

The prepared specimens are loaded under pure tension and pure shear (Fig.3,4). In all four schemes, localization of damage is observed at the interfacial regions. With both Cu and

Ni/Au, primary cracking occurs at the substrate/IMC/solder interfaces. Due to the strong adhesion between Ni based interfacial layers and Ni substrate, brittle cracking in the IMC layers is more pronounced in Ni than Cu. Under shear loading, primary crystals act as stress concentrators and cracks start from the edges, which in turn coalesce and failure occurs.

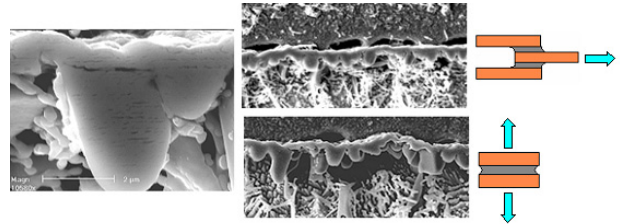


Figure 3 Cu-SnAgCu (a) Voids at Cu/Cu<sub>3</sub>Sn interface, (b) Brittle cracking in Cu<sub>6</sub>Sn<sub>5</sub> layer under shear loading, (c) Delamination at Cu<sub>6</sub>Sn<sub>5</sub>/SnAgCu interface under tensile loading.

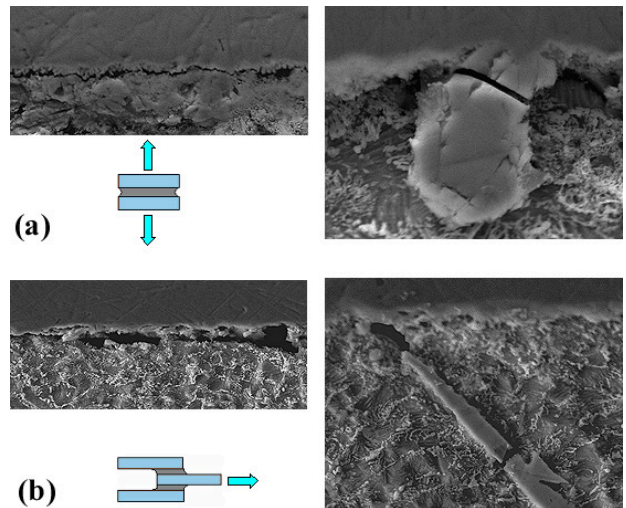
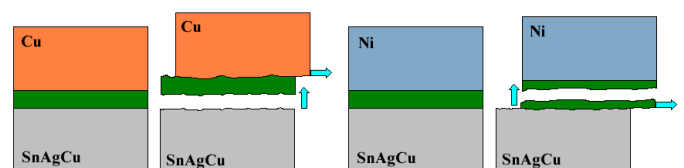


Figure 4 Ni/Au-SnAgCu (a) Brittle cracking in the intermetallic layers between solder and Ni under tensile loading, (b) Decohesion of Ni and Ag based primary crystals from the matrix under shear loading.

## Conclusions

The dominant crack paths at the SnAgCu on Cu and Ni/Au substrate interfaces under tensile and shear loading, corresponding to normal and tangential tractions, can be represented in the following separation schemes:



## References:

- [1] ERINÇ, M., SCHREURS, P.J.G., ZHANG, G.Q., GEERS, M.G.D.: *Microelectronics Reliability* (44:1287-1292, 2004)