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Published: 01/01/2004

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Download date: 11. Dec. 2018
Failure of SAC solder under thermal cycling

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Introduction

$\beta$-Sn in eutectic Sn-Ag-Cu (SAC) solder exhibits anisotropy in its elastic and thermal expansion properties that may induce a significant amount of stress at Sn-grain boundaries during thermal cycling [1]. Damage can initiate at boundaries with maximum induced normal/shear stress. Therefore, details investigation of failure in solder joints under thermal cycling has a paramount importance for the reliability concern of microelectronics devices.

Experimental techniques

Shown in Fig. 1 (a) is a solder joint (height = 0.3 mm, length = 5 mm) prepared using commercial solder pastes (Multicore Ltd., UK). Copper blocks of dimensions 25 mm $\times$ 10 mm $\times$ 1 mm were used as substrates.

The specimens were thermally cycled within three temperature ranges ($\Delta T$) of 253 K to 353 K, 293 K to 353 K, and 253 K to 401 K using Linkam stage (Fig. 1 (b)). Backscatter-electron microscopy, polarizing light microscopy and orientation imaging microscopy (OIM) were performed for characterization purpose.

Results and discussion

Fig. 2 shows optical micrographs from an identical area of a solder interconnection before and after thermal cycling within 253 K to 353 K ($\Delta T = 100$ K). Cracks formation along grain boundary can be observed after thermal cycling (TC) (see Fig. 2 (b)).

BSE micrograph obtained from the same area after TC is presented in Fig. 3 (a). One can see localized damage along grain boundaries and near to the interface between solder and substrates. Another observation from a joint thermally cycled between 293 K to 353 K for 1000 cycles also shows sliding (SL)/separation (SP) of grain boundaries (see magnified image of marked area “2” in Fig. 3 (b)). Two arrows in the micrograph of magnified image of marked area “3” indicate propagation of microcracks that linked together. It also depicts some prominent shear bands.

Conclusions

Grain-boundary sliding/separation and shear band formation are the predominant damage phenomena in solder under thermal cycling. Amount of induced damage increases with increase in $\Delta T$.

References:

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