Phase identification and interface evolution of ENIG/Cu-core SAC305/ENIG solder joints after the thermal electrical coupling reliability test

Zhih-You Wu, Collin Fleshman, Rui-Wen Song and Jenq-Gong Duh
Department of Materials Science and Engineering, National Tsing Hua University

Abstract
Cu-core solder joints are promising interconnections for high power devices. The joints possess a long lifetime under thermal-electrical coupling reliability tests. Due to the Cu core structure in the joint, there are two short paths for electrons and atoms to migrate during electromigration tests. Besides, complicated phase evolution was revealed at the interfaces in the joint. In this study, Cu core solder joints underwent a 750-hour thermal-electrical test. Subsequently, elemental analyses were carried out to probe the phase distribution and to interpret the evolution at the interfaces in tested joints.

Materials and methods

Cu-core solder balls were reflowed at the peak temperature of 245 °C for 40 s to form flip-chipped ENIG/Cu-core SAC305/ENIG solder joints. Then the attached sample was placed in an oven with the temperature set at 150 °C. A current of 3 A was applied to the specimen for 750 h.

Microstructure of as-bonded and tested samples

Images and elemental distributions / 150 °C, 3A 750hr with opposite direction

Images and elemental distributions / 150 °C, 3A 750hr

• At spot A, Ni dissolves from the Ni-P layer into the solder and voids form in the layer. The sufficient Ni forms bulks of Ni₃Sn₄ at the interface of ENIG/solder.
• At spot B, the Ni₃Sn₄ layer is slightly thickened due to the accumulation of atoms.
• At spot D, massive (Ni₃Cu₆)₃Sn₄ forms due to the accumulation of Ni atom brought from the Ni coating on the Cu-core.

Acknowledgement
Financial support from the MOST, Taiwan, under the Contrast No. 107-2221-E-007-090- is much appreciated.

Conclusion
• When the interface of ENIG/solder serves as a cathode, the microstructure depends on the consumption of the Ni-P layer.
• The amount of IMCs formed at this corner can affect the thickness of (Ni₃Cu₆)₃Sn₄ at the anode interface of Cu-core/ solder.
• While the interface of Cu-core/solder acts as a cathode, a fascinating interfacial evolution is detected.
• Cu diffusing out from the Cu-core can influence the occurrence of (Cu₃Ni₆)₃Sn₄ at the anode corner of solder/ENIG.

References