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Applying SEM, EPMA and EBSD Analytic Techniques on Solder Joint for Microelectronic Package Development

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The SEI, BEI images and WDS techniques are popular in the field of microelectronic packaging. However, some crucial microstructure might be neglected due to the insufficient Z contrast among observed areas. Also, the unique grain orientations, which significantly affect reliability, presented in solder joints are only observable through EBSD. The above-mentioned techniques will be elaborated and embodied in the following case studies.

In 90um SAC305/Cu and SAC405/Cu solder joints, the distribution of Ag or Ag_3Sn were unambiguously revealed by EPMA color mapping. The BE images in Fig. 1 merely showed various microstructures including the subgrain boundaries and unidentified particles. Since the particles are of nano-scale, the resolutions of EDX color mapping and quantification are not sufficient for exact pinpoint analysis. Moreover, the overall distributions of Ag_3Sn are readily observable by EPMA color mapping.

In Bi-33In/Cu low temperature solder joint, the dual layers at the solder/Cu interface were identified. BE image in Fig. 2 might hint the existence of small Bi particles due to the large Z of Bi. In Fig. 2, the EPMA color mapping not only assured the preference of Bi segregation, but also indicated the dual-phase structure composed of different amount of In. The results helped the deduction of the formation mechanisms of IMC structure.

For the last case, Electron Backscattered Diffraction (EBSD) was employed to analyze the grain size and orientation of the β-Sn phase in Ni-doped joints with Ni-based or Cu-based substrates. Fig. 3 and Fig. 4 show the inverse pole figure and the distribution of boundary angle in the cross-section of solder joints, respectively. Two kind β-Sn structures were inspected in Sn-3.0Ag-0.5Cu-0.1Ni/Cu joint, i.e. the polycrystalline structure and the single crystal structure. Polycrystalline structure of fine grains was observed near the solder/Cu interface, while remains were two bigger grains in [011] and [110] directions. For Sn-3.0Ag0.5Cu-0.1Ni/Ni joints, the whole joint was full of tiny β-Sn grains and clearly shows the polycrystalline structure. These grains uniformly distributed in the solder and oriented in random directions. Fig. 4 revealed the misorientation histogram of the β-Sn grains in the joints. The Sn-3.0Ag-0.5Cu-0.1Ni/Ni joint showed a relative flat profile without any sharp peak in the range from 5° to 95°. By contrast, Sn-3.0Ag-0.5Cu-0.1Ni/Cu joint showed preferred angles near 60° and other angles less than 10° were the small-angle boundaries between subgrains.

With EPMA color mapping technique, the uncertainty of Ag_3Sn distribution in either the SEI or BEI images was eliminated. For complex IMC structure in solder joints, the EPMA color mapping is essential for revealing the dual-layer structure. By means of EBSD analysis, the crystallographic properties, including grain size, orientation and boundary misorientation, of solder joints were effectively characterized. In conclusion, the microstructure, elemental and crystallographic characteristics could be investigated in a systematical way with the aid of SEM, EPMA and EBSD. Above mentioned instruments not only allow the analysis of influence of materials properties on interfacial reaction in solder joints, but help the development in microelectronic package in the future.

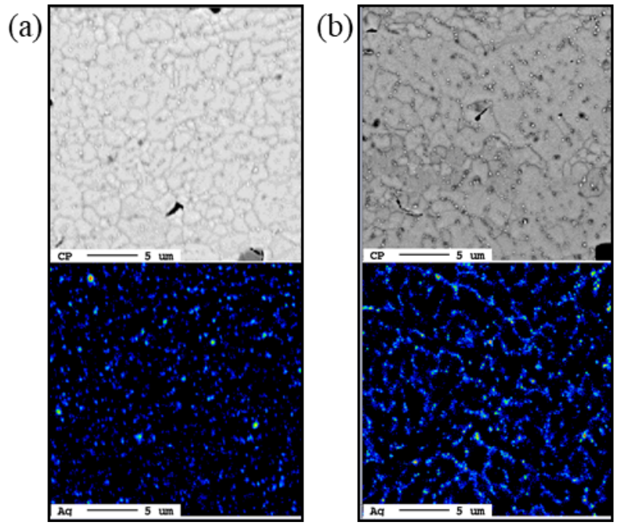

Figure 1. The EPMA elemental mapping of Ag in (a)SAC305/Cu and (b) SAC405/Cu 90um solder joint.

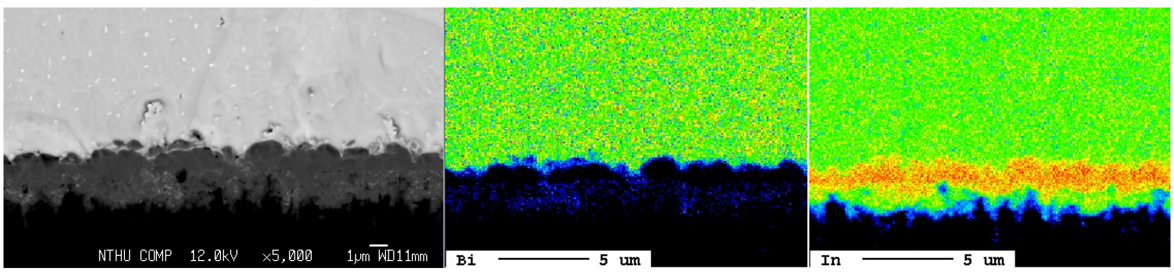

Figure 2. The BE image of interfacial IMC structure of Bi-33In/Cu and the EPMA elemental color mapping of Bi and In.

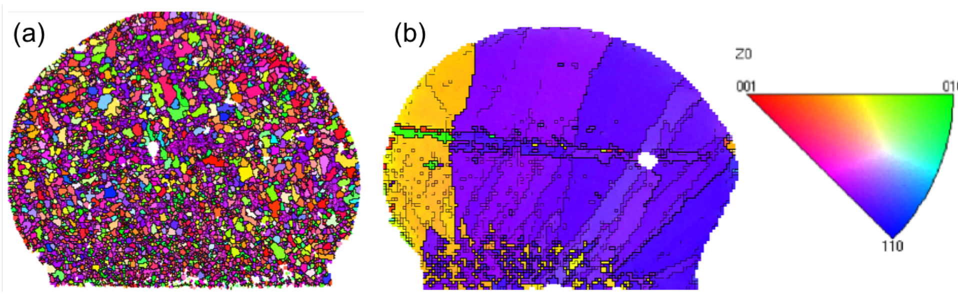

Figure 3. The inverse pole figure of (a)Sn-3.0Ag-0.5Cu-0.1Ni/Ni and (b)Sn-3.0Ag-0.5Cu-0.1Ni/Cu joints evaluated by EBSD.

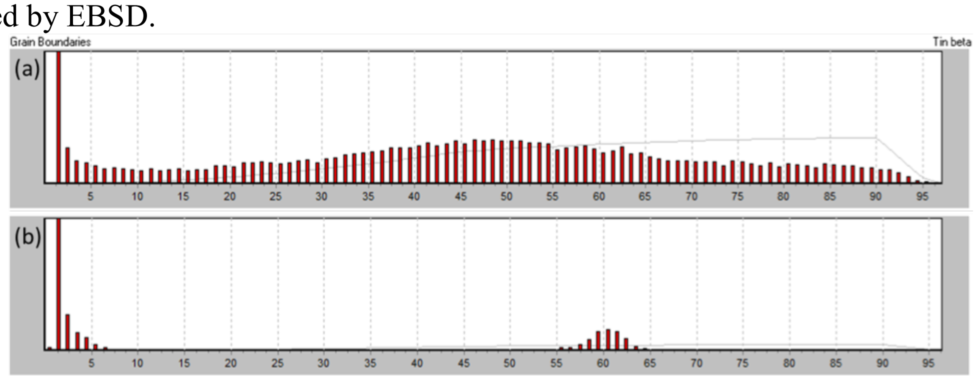

Figure 4. The misorientation histogram in (a)Sn-3.0Ag-0.5Cu-0.1Ni/Ni and (b)Sn-3.0Ag-0.5Cu-0.1Ni/Cu joints evaluated by EBSD.

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