Investigation of Phase Formation at the Ni/Sn Interface during the Soldering Process

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Soldering is a well-established method for creating permanent bonds between metal parts, often resulting in the formation of intermetallic compounds. For the purpose of soldering, various elements like Sn, Pb, Bi, Sb, Ag and Cu, or their alloys, are utilized in different compositions based on the respective field of application. The shift towards lead-free solder, driven by environmental regulations, has increased interest in Sn-based solder alloys. However, soldering interconnects involves complex processes related to material transport, phase stability, phase formation, and kinetic aspects of phase transformation. [1, 2]

In the present work, we investigated the interdiffusion and diffusion-controlled phase formation processes in a Sn-Sb solder alloy between a Ni-based layer with a small amount of Si and a Cu substrate using various electron microscopy techniques. Initial scanning electron microscopy analyses of cross-section samples provided an overview of the interfaces, including the Sn-Sb solder alloy. For detailed examination, focused ion beam techniques were employed to create electron-transparent samples for analysis using analytical transmission electron microscopy.

Examination of the untreated states of the Ni-based layer and the solder alloy enables differentiation between the initial microstructure and post-soldering changes. The Ni-based layer exhibited a lamellar-type structure with a uniform elemental distribution perpendicular to the soldered interface, while the raw solder alloy consisted of a tetragonal β-Sn phase as a matrix and a trigonal SbSn phase. Following the soldering process, CuSnNi and SnCu intermetallic compounds are formed with various shapes, surrounded by the β-Sn matrix. The SbSn phase remained as small inclusions throughout the process. Moreover, the Ni-based layer initially shrank due to diffusive interactions with Cu and Sn, resulting in a residual film that displayed an increased Si content compared to its untreated counterpart, eventually leading to complete consumption of the Ni-based layer.

This study highlights the complex processes involved in Cu transport from the substrate through the solder material, emphasizing the significant role of Cu in forming intermetallic compounds. Alongside with Sn, Cu drives the transformation of the Ni-based layer, ultimately to its complete consumption. In addition to elemental influences, microstructures play a crucial role in the Ni consumption process.

References

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