Corrosion and electrochemical migration evolution of oxidized Ag_3Sn and β-Sn in halogen environment

Wei Dai, Yiming Jiang, Jin Li, Yangting Sun*

Department of Materials Science, Fudan University, Shanghai 200438, China

Wdai20@fudan.edu.cn

Abstract

Flux residues and marine service conditions expose lead-free solder joints to environments containing halide ions, which can induce corrosion and electrochemical migration[1,2]. The role of silver (Ag) in electrochemical migration within Ag-containing lead-free solders remains under investigation[3]. In this study, we synthesized an Ag-60Sn alloy with approximately 20% Ag_3Sn content and examined the effects of high-temperature and high-humidity oxidation, as well as various halides, on the corrosion and electrochemical migration behaviors of Ag_3Sn and β-Sn. Following high-temperature and humidity exposure, selective oxidation of Ag_3Sn led to the formation of pure Ag. Both before and after oxidation, β-Sn showed preferential corrosion in NaCl, NaBr, and Na_2SO_4 solutions, with minimal corrosion of Ag_3Sn. Conversely, Ag_3Sn corroded in NaI solution prior to oxidation, whereas after oxidation, Ag corroded and β-Sn remained unaffected. In terms of electrochemical migration, Sn dendrites consistently formed in NaCl and NaBr solutions, irrespective of oxidation state, while Ag dendrites appeared in NaI environments after oxidation. No dendritic growth was observed in Na_2SO_4 solutions. This study identified critical corrosion conditions for Ag_3Sn and used X-ray Photoelectron Spectroscopy (XPS) to analyze dendrite composition. Based on these results, we developed an electrochemical migration model for Ag_3Sn and β-Sn in halide media.

Keywords

Lead-free solder, Ag_3Sn, Selective oxidation, Electrochemical migration, Ag dendrite, Sn dendrite

Reference

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