Solder reaction between electroless Ni-Sn-P and Sn-3.5Ag

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Abstract

In the present study electroless Ni-Sn-P (6-7 wt.% P and 19-21 wt.% Sn) coating was prepared on copper plates using an alkaline bath. Solder reaction with lead-free Sn-3.5Ag was investigated and compared with Ni-P (6-7 wt.%). Joint strength was studied by forming Ni-P/Sn-3.5Ag and Ni-Sn-P/Sn-3.5Ag micro tensile test specimens. Both Ni-P/Sn-3.5Ag and Ni-Sn-P/Sn-3.5Ag joints were thermally-aged at 180 °C up to 600 h to study their interfacial reactions and tensile properties upon aging. Formation of two interfacial compounds such as Ni$_3$Sn$_4$ and Ni$_{13}$Sn$_8$P$_3$ was observed during the Ni-Sn-P/Sn-3.5Ag solder reaction. It was found that Sn atoms from the solder diffuse through the formed Ni$_3$Sn$_4$ layer to reach the Ni$_3$Sn$_4$/Ni-Sn-P interface, and react with the Ni-depleted region of the Ni-Sn-P layer to form the second IMC, Ni$_{13}$Sn$_8$P$_3$. The tensile strength of the as-reflowed Ni-Sn-P/Sn-3.5Ag solder joints was found to be comparable to that of the as-reflowed Ni-P/Sn-3.5Ag solder joints. Both types of as-reflowed solder joints experience ductile failure in the bulk solder. The strength of Ni-P/Sn-3.5Ag joints drops significantly after aging for 400 h, while the strength of Ni-Sn-P/Sn-3.5A joints drops significantly after aging for 300 h. The Ni-P/Sn-3.5Ag solder joints aged for 400 h and 600 h experience brittle fracture at the Ni$_3$Sn$_4$/solder interface. The Ni-Sn-P/Sn-3.5Ag joints aged for 300 h, 400 h and 600 h experience brittle fracture not only at the Ni$_3$Sn$_4$/solder interface, but also through all of the interfacial layers (Ni$_3$Sn$_4$, Ni$_{13}$Sn$_8$P$_3$ and Ni-Sn-P layers). It was also found that cracking of the metallization at some locations during long-term ageing has led to fast Sn diffusion and accelerated IMC growth at these locations which is responsible for the fast degradation of the Ni-Sn-P/solder joint strength.

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