Autocatalytic Cobalt as Barrier Metallization for Tin Solder Alloys

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Soldering process in microelectronics is normally made with eutectic or near eutectic tin-lead solders. The new legislation restricts the use of lead, due to environmental and toxicological concerns.

Environmental friendly lead-free solders are proposed as alternative to traditional tin-lead alloys, among them tin-silver-copper is considered a good choice. Copper surface finishes showed a lack of reliability, when soldered with tin-reach lead-free alloys. The autocatalytic nickel/immersion gold finish is affected by failures, related to tin-nickel intermetallic compound formation in the tin layer and Ni_3P formation in the NiP layer.

In this work, autocatalytic cobalt is proposed as a barrier metallization for copper in lead-free soldering. Results about solder reaction and diffusion of autocatalytic cobalt with Sn-Ag-Cu and Sn-Pb alloys are presented. Bonding and solderability of autocatalytic cobalt are discussed.

Autocatalytic deposition of cobalt was performed in an hypophosphite containing electrolyte at 90 °C. Cobalt layers, 2-4 µm thick, were obtained. Immersion gold, 0.1-0.2 µm thick, was deposited on cobalt as final layer. Standard finish, autocatalytic nickel/immersion gold, with commercial electrolytes was tested for comparison.

Solder reaction and diffusion were studied after soldering with Sn95.5-Ag3.8-Cu0.7 and Sn63-Pb37 alloys, performed in air, and after a further heat treatment, carried out in air at 150 °C for 15 min. Solder reaction of autocatalytic cobalt with eutectic tin-lead and tin-silver-copper alloys is characterized by the formation of an homogeneous interface with thin interdiffusion layer. Figures 1 shows the cross sections and concentration line profiles of Cu-CoP/Au-SnPb joints after soldering and heat treatment, respectively. Figure 2 shows the comparison of the thickness of the interdiffusion layer for NiP/Au and CoP/Au with different P content. A thick interdiffusion layer is observed between NiP and solder alloy, with formation of brittle intermetallic compounds, mainly Ni_3Sn_4 and Ni_3P. EDS line profiles on the cross section show large diffusion between nickel and tin, with phosphorus enrichment at the interface between the nickel-phosphorus layer and the solder alloy. Ni and Sn interaction is greater than Co and Sn interaction, particularly for lead-free solders, Ni/Sn intermetallic compounds are formed just after soldering. The formation of a very thin interlayer was observed in the case of the cobalt finish, showing a much lower cobalt and tin interdiffusion. The Au layer has a minor role on the soldering behavior of Ni and Co with Sn. Similar results are obtained with BGA balling

Autocatalytic cobalt has an increased solderability with respect to nickel, particularly in the case of lead-free solders. The contact angle of Sn-Pb and Sn-Ag-Cu on CoP/Au after soldering was about 5° in the two cases, while those for SnPb and SnAgCu on NiP/Au were about 5° and 15° respectively.

Autocatalytic CoP/Au finish strongly limits interdiffusion and intermetallic compounds formation with respect to the NiP/Au finish with both examined alloys. Contact angle of Sn-Pb solder alloy with NiP and CoP layers is comparable, whilst in the case of Sn-Ag-Cu alloy the angle is much lower for CoP than for NiP layers. Wetting time is lower for CoP than for NiP for both solder alloys.

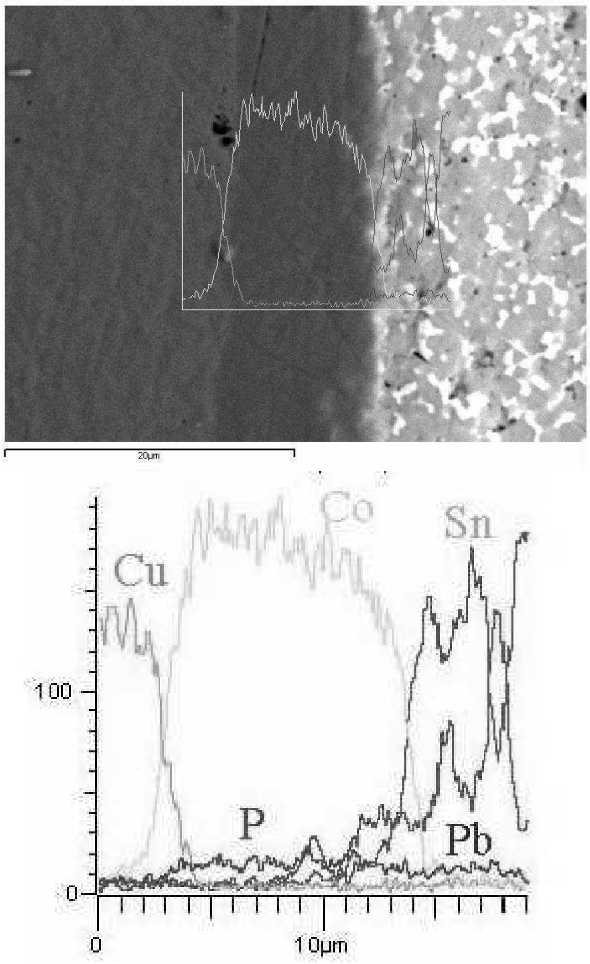

Fig. 1 – SEM cross section (upper) and concentration line profiles (lower) of Cu-CoP/Au-SnPb joint after soldering and heat treatment at 150 °C for 15 minutes.

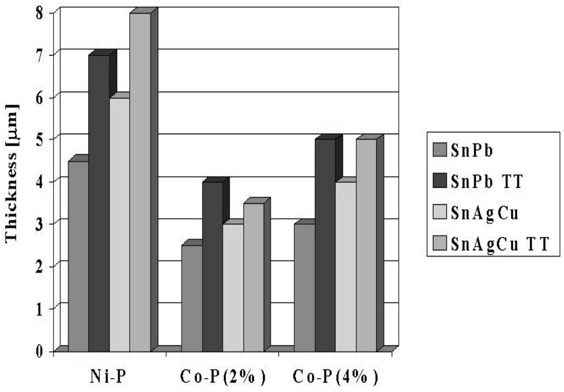

Fig. 2 – Intermetallic layer thickness for CoP/Au and NiP/Au metallizations.