ACD Co-P for Lead-free Soldering in Microelectronics

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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.

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. Presence of tin intermetallic compounds within the nickel layer was also observed.

Figure 2 show the concentration line profiles of Cu-CoP/Au-SnAgCu joints after soldering and heat treatment, respectively. The formation of a very thin interlayer was observed, 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, Fig. 2, while those for SnPb and SnAgCu on NiP/Au were about 5° and 15° respectively.

Mechanical joint strength of BGA soldered with Sn-Ag-Cu and Sn-Pb solder paste on Ni-P/Au and Co-P/Au board finishes was evaluated measuring the shear force imposed by a probe of 960 g free falling from a height of 11.5 mm and impacting at board pad-ball interface. A piezoelectric transducer output forces as voltage values: the higher the joint mechanical strength, the higher the voltage value. The average strength value and standard deviation, resulting from sixteen measurements, were respectively for Co-P/Au and Ni-P/Au 67 ± 15 mV and 61 ± 35 mV with Sn-Ag-Cu and 115 ± 27 mV and 130 ± 57 mV with Sn-Pb eutectic alloy.

The higher standard deviation given by Ni-P with the two alloys can be explained with the more irregular intermetallic structure and the lower wettability, as reported in the previous sections. However these two factors do not have the same significant effect on the average value.

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.

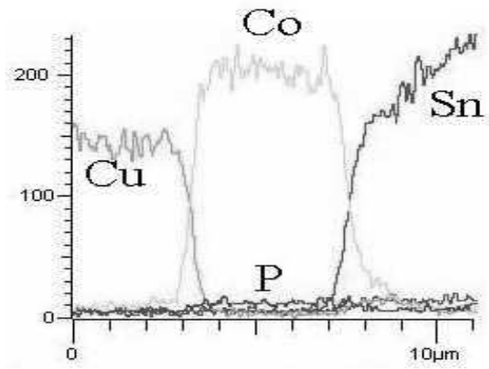
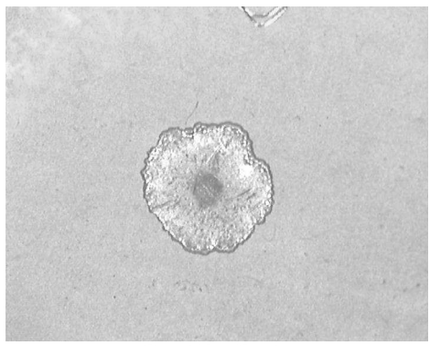
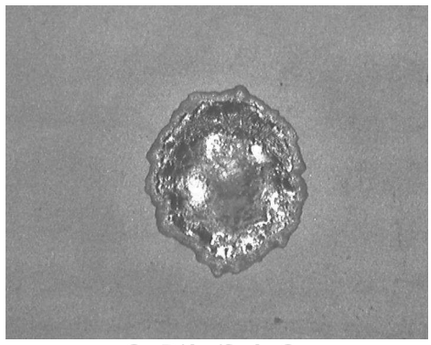


Fig. 1 – SEM cross section (upper) and concentration line profiles (lower) of Cu-CoP/Au-SnAgCu joint after soldering and heat treatment at 150 °C for 15 minutes.



Co-P/Au/SnPb



Co-P/Au/SnAgCu

Fig. 2 - Solder balls after reflow