E. Fluxless Plasma Soldering of Lead-free Solders

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Introduction

With increasing environmental concerns, the application of lead-free solders and fluxless soldering processes has been attracted attention from the electronic packaging industry. Plasma cleaning and heating can be applied to eliminate the use of soldering flux and hence to prevent environmental pollution caused by chemical flux. Plasma treatment was reported to be effective for removal of oxide from the metal surface, and improvement of sollderability. In this work, a fluxless soldering process using Ar-H_2 plasma cleaning and heating was studied.

Procedure

Two lead-free solders (Sn-3.5wt%Ag and Sn-3.5wt%Ag-0.7wt%Cu) were investigated and one solder containing lead (Sn-37%Pb) was aslo used as a reference. As the plasma reflow has higher soldering temperature than conventional air reflow, the effects of UBM (Under Bump Metallization) thickness on the interfacial reaction and bonding strength can be critical. Therefore, the effects of UBM thickness and plasma cleaning on the soldering characteristics were studied. In experiments, solder balls of 500㎛ in diameter were set on the UBM that was coated on the Si-wafer. The soldering reflow was performed using plasma without flux or hot air with flux. The heating condition of plasma reflow was 150W, and the soldering temperatures were determined as 250C for Sn3.5Ag and Sn3.5Ag0.7Cu, and 230C for Sn37Pb.

Results and Discussion

The experimental results showed that, in the case of the thin UBM layer, Au(20㎚)/Cu(0.3㎛)/Ni(0.4㎛)/Al(0.4㎛), the shear strength of soldered joints was relatively weak (as low as 19-27MPa) and this was caused by the cracks observed along the bonded interface. The cracks were produced by the exhaustion of the thin UBM layer due to the excessive reaction with solder under plasma heating. However, in the case of thick UBM layer, Au(20㎚)/Cu(4㎛)/Ni(4㎛)/Al(0.4㎛), the bonded interface was sound without cracking and the shear strength was about 32-42MPa. Thus, by increasing UBM thickness in this study, the shear strength can be improved by 50-70%. A fluxed reflow soldering under hot air was also carried out as a reference, and the shear strength was about 48-52MPa. Further studies indicated that the joint strength with plasma reflow could be further improved to about 57-65 MPa by plasma cleaning of the substrates before plasma reflow. Thus, the plasma cleaning was quite effective to enhance the bondability of solder balls.

Conclusions

The feasibility of the fluxless soldering using Ar-H_2 plasma was confirmed through this study. The results indicated that increasing the thickness of UBM layer can improve the strength of the solderd joints using fluxless plasma reflow and plasma cleaning of substartes before plasma reflow can further improve the joint strength.