DEVELOPMENT OF DIFFUSION BARRIER LAYER ON COPPER-PRINTED CIRCUIT BOARD USING ELECTROLESS PLATING METHOD

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ABSTRACT
In this paper, the nickel–phosphorus (Ni–P) diffusion barrier layer between Sn–4Ag–0.5Cu solder alloy and copper-printed circuit board was developed. The electroless plating technique was used to develop Ni–P diffusion barrier layer with different percentage of phosphorus content, which are 1–5 wt% (low), 5–8 wt% (medium) and above 8 wt% (high). The results reveal that the high phosphorus content in nickel layer acts as a good diffusion barrier for Sn–4Ag–0.5Cu since it can suppress the intermetallic compound formation. This is because in higher phosphorus content, the grain boundaries were found to be eliminated. Hence, resulted in thinner intermetallic compound thickness.
Keywords: diffusion barrier layer; intermetallic compound; nickel–phosphorus.

1 INTRODUCTION

Printed circuit boards are generally fabricated in a surface-finished condition by board manufacturers and then shipped to an assembly house. There are some parts of the board, which are made of copper, left exposed for subsequent soldering. Hence, it needs protection by applying surface finish to avoid further oxidation and at the same time to maintain its solderability capability [1]. Among all metals, nickel (Ni) layer is one of the most suitable surface finish to be used as a diffusion barrier layer between copper (Cu) and tin (Sn) due to its slower diffusion rate in Sn as compared to Cu [2–4]. This situation results in producing thinner intermetallic compound (IMC) layer.

As reported in [5], nickel has been recognized as a diffusion barrier in the top surface morphology (TSM) system due to its relatively low diffusion rate through Au and Cu. Of all the Ni-plating processes, the most cost-effective option is electroless nickel–phosphorus (Ni–P). However, the phosphorus content in the electroless Ni greatly influences the interfacial reactions with solders. During reflow soldering, a new P-rich Ni layer is formed between the interfacial IMC and original electroless Ni–P layer [6, 7]. The formation of this P-rich compound is a new issue to be considered for the solder joint reliability.

In other works mentioned by previous researchers in [8–10], the crystallized Ni_3P phase has a polycrystalline columnar structure that appears to contain defects. During reflow soldering, Kirkendall voids would form as a by-product of P-rich layer formation and these voids are claimed to be detrimental on joint reliability by resulting in brittle fracture. Besides, previous work also shows that the nature of deposit such as P content and thickness of electroless Ni–P layer might affect the fracture mode of solder joint by performing shear test [11,12].

Other than that, Kim et al. [13] and Yoon et al. [14] who used Sn–3.5Ag solder alloy mentioned that the thickness of IMC was affected by the P content, whereby lower P content

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