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Effect of Thickness and Phosphorus Content on Au/Pd/Ni(P) Metal Finish of Printed Circuit Board

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Electroless nickel/electroless palladium/immersion gold [Au/Pd/Ni(P) or ENEPIG] pads consisting of layers of Ni(P) (200 μin), pure palladium (Pd) or palladium phosphorus (PdP) (2 μin, 4 μin or 6 μin), and gold (Au) (2 μin or 4 μin) were prepared using two different processes (wire bonding and lead-free soldering). Each of these processes was done with zero- or two-time reflow. Different tests on solderability, wettability, wire-bonding capacity, and corrosion resistance were performed on different combinations of ENEPIG pads formed using different combinations of processes and conditions. Scanning electron microscopy was also performed to examine the surface characteristics of the pads. It was found that the ENEPIG pad sample with the 4-μin-thick Au and 4-μin-thick PdP layers possessed stable wire-bonding capacity and excellent lead-free solder reliability. In addition, the ENEPIG–PdP systems showed better corrosion resistance, which is attributed to the presence of the amorphous PdP layer protecting the nickel layer.

Key words: ENEPIG, PCB, corrosion, wire bonding, lead-free soldering

INTRODUCTION

Of the five types of metal finish used on printed circuit board (PCB) in the electronics industry—hot-air solder level, immersion tin, immersion silver, organic solderability preservatives, and electroless nickel/immersion gold [Au/Ni(P) or ENIG]—the last one (ENIG) has been the most widely used. However, the immersion gold process has been reported to cause corrosion on the nickel layer (i.e., oxidation of Ni^0 by Au^{2+}), resulting in the formation of so-called *black pads*.[1–5] The black-pad defect is problematic because it can result in solder joint failure and low shear strength after assembly. Nonetheless, after understanding the black-pad phenomenon and the virtual elimination of black-pad defects, the ENIG process still persisted.[6] Recently, however, the electroless nickel/electroless palladium/immersion gold [Au/Pd/Ni(P) or ENEPIG] process has provided an alternative to ENIG. This can improve the stability of the wire-bonding process, and can limit Ni(P) corrosion by depositing a Pd layer over the Ni layer (i.e., between Ni and Au bilayers)[7,8] to prevent oxidation of Ni^0 by Au^{2+}. In addition to all the advantages of the ENIG process,[9] the ENEPIG process offers the following advantages: thinner Au layer, flat pad surface, excellent shelf life, good contact connection of pad, excellent lead-free solder reliability, stable wire-bonding capacity, and prevention of formation of black pads.[7,10] In this study, we investigated the effects on the properties of ENEPIG metal finish of the following: presence of phosphorus (P) in the Pd layer, thickness of Pd layer, thickness of Au layer, and aging [i.e., heating by infrared (IR) reflow oven]. The investigated properties of the metal finish were wettability, solderability, wire-bonding capacity, and corrosion resistance.

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