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Effect of Ni-Coated Carbon Nanotubes on the Corrosion Behavior of Sn-Ag-Cu Solder

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In this study, the effect of Ni-coated carbon nanotubes (Ni-CNTs) on the corrosion resistance of 95.8Sn-3.5Ag-0.7Cu (SAC) solder at ambient temperature in 3.5 wt.% NaCl solution was investigated using the potentiodynamic polarization method. The corrosion products were analyzed by field-emission scanning electron microscopy (S4800), energy-dispersive spectroscopy, and x-ray diffraction. The results showed that addition of Ni-CNTs enhanced the corrosion resistance of the SAC solder and that increasing the content of Ni-CNTs made the effect more evident. The mechanism of the corrosion resistance improvement is the formation of a compact corrosion layer of Ni-CNTs that provides an inert physical barrier to the initiation and development of corrosion. Furthermore, in the corrosion microcell produced by the Ni-CNTs dispersed in the SAC solder, the Ni-CNTs act as a third phase (electrode) which contributes to reducing the galvanic corrosion between Sn anode and Ag_3Sn cathode. Hence, the corrosion resistance of the composite solders was improved.

Key words: SAC solder, Ni-CNTs, corrosion resistance

INTRODUCTION

Due to health and environmental concerns regarding the toxicity of lead, lead-free solders have been widely used.[1] The development of tin-based solders has motivated some new selections for applications in the electronic packaging industry. Tin-based Sn-Ag-Cu (SAC) solder alloys such as Sn-3.5Ag-0.7Cu and Sn-4.7Ag-1.7Cu, which have relatively low melting temperatures (compared with Sn-Ag and Sn-Cu binary eutectic lead-free solders) and good compatibility with common commercial components, are some of the leading alternatives to substitute the widely used Sn-Pb solders.[2,3] However, conventional solder technology can no longer guarantee the satisfaction of the increasing demands of applications. To meet these ever-stricter requirements, new interconnect solder materials which possess a combination of good mechanical, electrical, and thermal properties are desired.[4–6]

It has been proven that an effective way to strengthen a solder material is to introduce foreign reinforcements into the base material, synthesizing a composite solder. Many researchers have studied the effects of reinforcement on the microstructural, mechanical, thermal, and electrical properties.[7–9] Carbon nanotubes (CNTs) have been widely studied in recent years.[10] It has been discovered that, by adding CNTs into conventional solder alloy, the overall performance can be convincingly improved.[11–14] The interaction between the metal matrix and the CNTs plays an important role in achieving this significant improvement in the properties. Several researchers have discovered a weak interaction between Sn and CNTs.[15,16] In order to strengthen the interfacial interaction, appropriate surface coatings can be applied onto the nanotubes.[17,18] Ni is an appropriate choice of coating because of the stable phases (Ni_3Sn_4) formed in

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