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The effect of annealing on the morphologies and conductivities of sub-micrometer sized nickel particles used for electrically conductive adhesive

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Abstract

The development of Electrically Conductive Adhesives (ECA) as an alternative to solder balls has received extensive attention in flip chip assembly as it offers an array of advantages like finer pitch interconnect, green process, lower cost and low temperature processing. Nickel with its lower cost than silver and better thermal stability than copper, appears to be the most suitable material used for making ECA particles. However, according to our previous research, a spiky surface morphology of the Ni particle synthesized by means of a hydrothermal reduction method was clearly observed. The spiky surface morphology may have a detrimental effect on both the thermal and electrical conductivity of the ECA flip chip interconnects due to its smaller contact surface. In this paper, we investigated the annealing effect on the surface morphologies of Ni particles. It was found that the surface structure of the nickel changes with the annealing conditions. A smooth surface has been observed after annealing the Ni particle for 4 h at a temperature of 360 °C. It was observed that the morphology changes brought about by heat treatment had contributed to the improved thermal and electrical conductivity of the Ni particles.

Keywords: Electrically conductive adhesives; Nickel particles; Annealing; Thermal & electrical conductivity

1. Introduction

Electrically conductive adhesives (ECAs) are playing an increasing important role in the design and production of electronic packages. Their advantages over the solder connection technology include fewer and cleaner processing steps and lower curing temperatures [1,2]. ECAs consist of a polymeric matrix with conductive fillers. Nickel is an excellent candidate because of the numerous advantages it possesses. It shows chemical stability and oxidizes relatively slower compared to copper. Although it has a higher electrical resistance compared to silver (about 25% of silver), silver is much more cost prohibitive [2].

A number of physical and chemical techniques can be used to produce metal particles in the nanosize regime. Some examples include photolytic reduction, radiolytic reduction, solvent extraction reduction, hydrothermal reduction and microemulsion technique [3–5]. Among the chemical methods, the

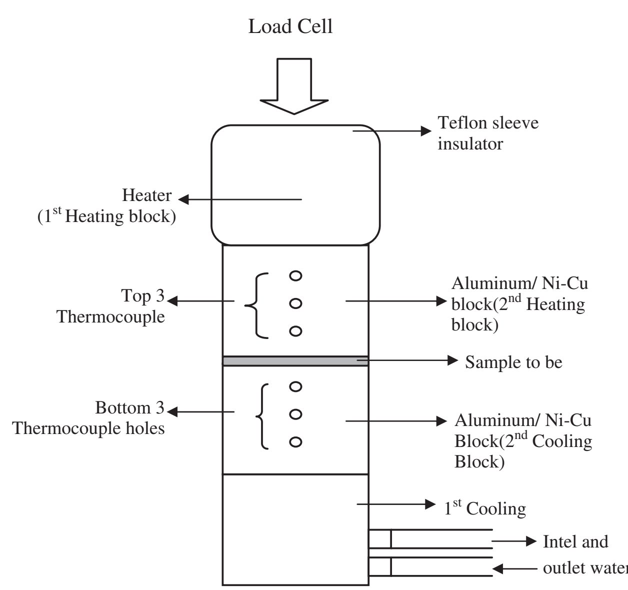

Fig. 1. Schematic diagram of experimental setup for both thermal and electrical resistance measurements.

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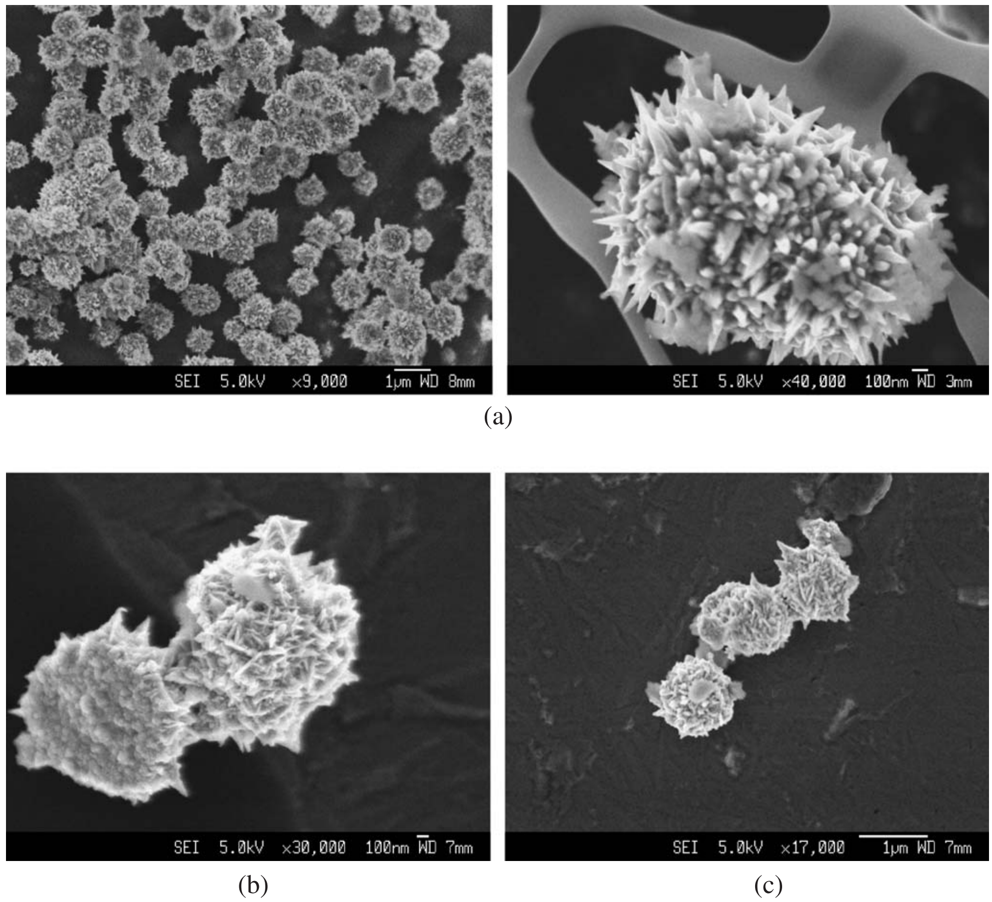

Fig. 2. FESEM micrograph of Ni particles prepared from Ni salt with different concentrations: (a) 0.05, (b) 0.025, and (c) 0.01 M.

reduction of a metal salt or oxide by an appropriate reducing agent is frequently employed. Properties of the product are strongly influenced by the reactants which include the metallic precursor, the reducing agent and the solvent medium. According to our previous research [6], a spiky surface morphology of the Ni particle synthesized was clearly observed. The spiky morphology may have a detrimental effect on the electrical and thermal conductivity of the ACA flip chip interconnects due to its smaller contact surface. This paper reports on the subsequent heat treatment process on the prepared Ni particles using the hydrothermal reaction and also its effect on the electrical and thermal properties.

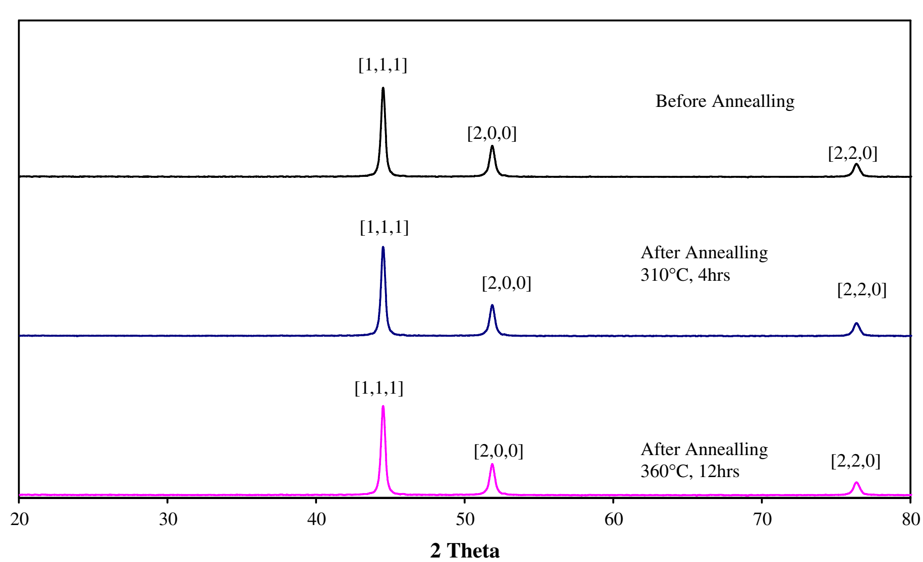

Fig. 3. XRD patterns of the Ni particles before and after annealing.