Electrothermal performance of Ag-filled stretchable conductive ink

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ABSTRACT – The purpose of this investigation is to explore the relationship between thermal effect and sheet resistance of conductive ink. Scanning Electron Microscopy (SEM) is used to study the microstructure when the ink was exposed to heat. The SCI specimen was exposed to high temperature has low resistance compared to the specimen at room temperature (RT). Morphology SCI will be observed using Scanning Electron Microscopy (SEM) to investigate the thermal effect on microstructure.

1. INTRODUCTION

Nowadays, electronic industries focus on Stretchable Conductive Ink (SCI) technology to replace with the conventional printed circuit board technology. One of an advantages using SCI is low fabrication cost compare to the conventional printing method [1]. A screen printing method is used for printing the SCI on the substrate and a stainless stencil or screen mesh to form conductive line.

This paper investigates the thermal effect of SCI to examine the effect of sheet resistance of SCI at variant temperature on SCI surface. The aim of this investigation is to assess the effects of thermal in electrical properties of SCI and to study the microstructure of SCI when ink surface exposed to heat.

2. RESEARCH METHODOLOGY

2.1 Samples preparation

Commercial SCI was required in this experiment. The SCI ink was printed as a specimen as shown in Figure 2.1 by screen printing method. The length of specimen is 20.0 mm and 0.15mm of ink thickness. The specimens need to cure in oven at 80°C for 1 hour. Three times of reading were taken at 5 points.

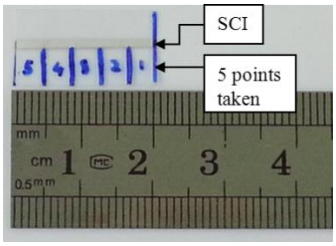

Figure 2.1 Specimen

The specimens were exposed to heat at 40°C, 60°C and 100°C and the specimen in room temperature (RT) condition was provide as a control data for this experiment. The experimental setup was arranged as shown in Figure 2.2.

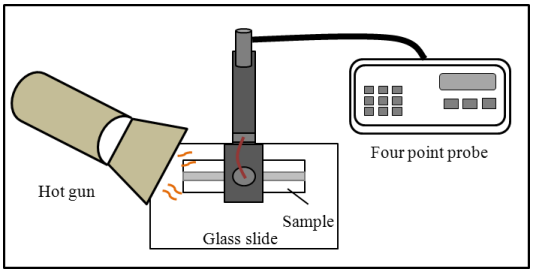

Figure 2.2 Experimental setup

2.2 Samples characterization

A four point probe technique was performed to observe the electrical properties of specimens at different room temperature. The probe head have four pins with spacing 1.00 mm. A hot gun was used to provide heat on the specimens and thermal image analyzer was used to identify the surface temperature of ink when heat applied onto the ink. Scanning Electron Microscopy (SEM) was used to analyze microstructure of SCI in each specimen.

3. RESULTS AND DISCUSSION

A decrease pattern in resistivity shows in figure 3.1. The sheet resistance for the specimen at RT was 0.09 Ω/sq., 0.12 Ω/sq. for specimen at 40°C, 0.11 Ω/sq. for specimen exposed to 60°C and lastly 0.05 Ω/sq. for the sample subjected to 100°C. The decrease resistivity occurs due to coefficient of thermal expansion of Ag particles.

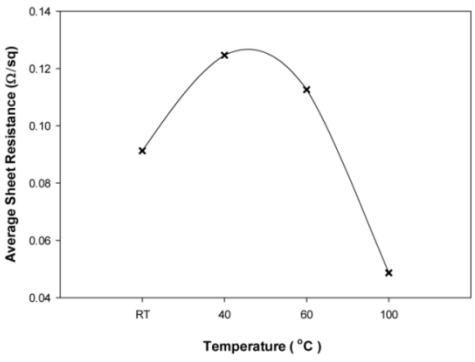

Figure 3.1 Sheet resistances versus temperature

The Ag particles in the SCI were expanding [2] when the particles exposed to the heat. Based on [3], the CTE value for Ag is 19.68 ppm/°C. During expansion process, the Ag particles became larger and it helps to cover a gap between Ag particles. An increasing of particles contact between Ag particles to particles is simply created

electrical paths compare with Ag particles at RT condition [4].

From the SEM images in Figure 3.2 until 3.5, the morphology shows that the gaps between Ag particles become closer and decrease when the SCI exposed to high temperature. It is because Ag molecule will expand the particles sizes and the gaps between Ag particles to particles were covered. For sintered specimen, the sintered Ag particles mixed with larger particles and touched each other. In SCI, the electrical paths are useful to allow electrons to flow easily from negative to positive charges [5]. The increasing of electrical paths on SCI will reduce the sheet resistance and improved the conductivity of SCI. But, fewer electrical paths in SCI will increase the value of sheet resistance and the conductivity of ink.

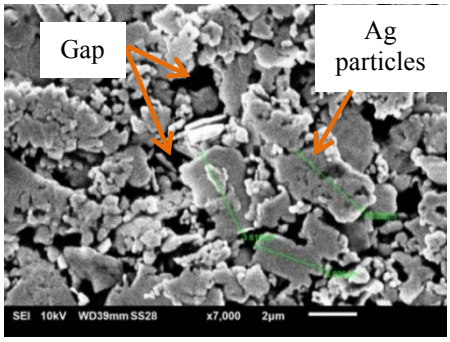

Figure 3.2 SEM image of Ag particles exposed on RT condition. Many gaps appear on the ink surface.

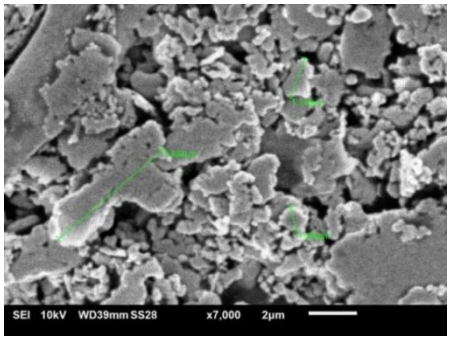

Figure 3.3 SEM image of Ag particles exposed to heat at 40°C

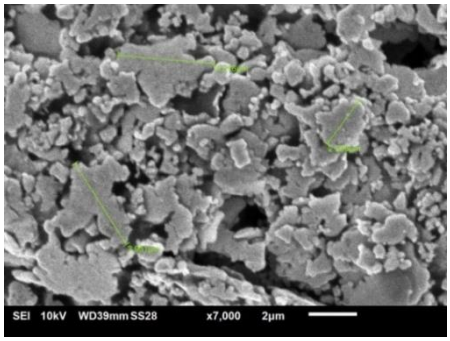

Figure 3.4 SEM image of Ag particles exposed to heat at 60°C

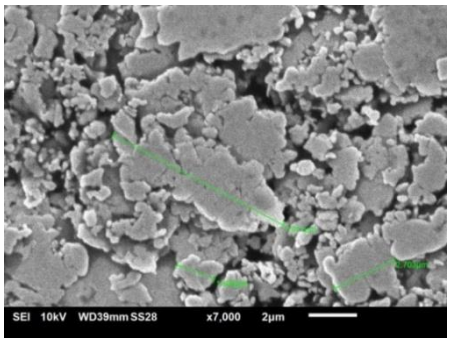

Figure 3.5 SEM image of Ag particles exposed to heat at 100°C shows that the gap become closer and decreased

4. SUMMARY

This experiment was performed to study the effects of electrothermal on SCI. The electrical properties of the SCI were measured by a four probe point and SEM micrograph shows the microstructure of SCI at different temperature condition. The sheet resistance of SCI at high temperature is lower compared to RT due to coefficient thermal expansion of Ag and decreased the gap between Ag particles to particles.

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