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Binder-Free Silver Paste Using the Reactive Monomolecular Layer

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Abstract – A binder-free silver paste using the reactive monomolecular layer containing the epoxy group and the triazole compound has been developed. The silver paste was prepared by forming the epoxy-terminated chemically adsorbed monomolecular layer with 2-(3,4-epoxycyclohexyl)-ethyltrimethoxysilane (ECHxES) on silver particle surfaces, followed by adding 3-mercapto-1.2.4-triazole as the cross-linker into the suspension containing the silver particles modified with ECHxES. When the silver paste was cured at 80 °C for 6h, the pencil hardness and best electrical conductivity obtained with the silver paste film were F and 7.1×10^4 (S/cm), respectively.

Electrically conductive paste is usually composed of metal particle and an organic matrix (binder). Metal particle, such as Ag, Au, or Cu particles, contributes to the electrical conductivity, and the binder, such as epoxy resin, phenol resin and polyimide resin, works as an adhesive. Thus owing to the binder, the paste suffers from the drawbacks like low heat resistance and low electrical conductivity. In this study, a novel silver paste without the binder was developed. The silver paste was composed with the silver particles covered with a reactive monomolecular layer and a cross-linking agent. The reactive monomolecular layer was prepared by adsorbing 2-(3,4-epoxycyclohexyl)-ethyltrimethoxysilane (ECHxES) on silver particle surfaces. And then the particles were cross-linked with 3-mercapto-1.2.4-triazole (MTAZ). All silver pastes were evaluated by electrical conductivity, pencil hardness and scanning electron microscope (SEM).

The electrical conductivity of the silver paste films using 1 μm silver particles and MTAZ before and after curing at 80 °C for 6 h was shown in Fig. 1. The conductivity increased with increasing the concentrations of MTAZ up to 1.8×10^{-5} mol, and moderately-decreased over 1.8×10^{-5} mol. Therefore the optimum concentration of MTAZ was determined 1.8×10^{-5} mol. Moreover, the electrical conductivity of the silver paste films using mixed silver particles (1.0 and 0.5 μm) and MTAZ before and after curing, were shown in Fig. 2. Before and after curing, the conductivity became the highest at the ratio of 7:3 (1.0:0.5 μm). The conductivity was 7.1×10^4 (S/cm) after curing, and the pencil hardness was F after curing. The silver paste films using mixed silver particles and only 1.0 μm silver particles were observed by SEM. It was comfirmed that the silver paste film with mixed silver particles was more densely packed than that with only 1.0 μm silver particles. The small particles fill the spaces made by the large particles in the silver paste film. Thus, the filling factor of the silver particles in the silver paste film increased. This binder-free silver paste should be useful for preparing the electrical wire used on the printed circuit plastic board.

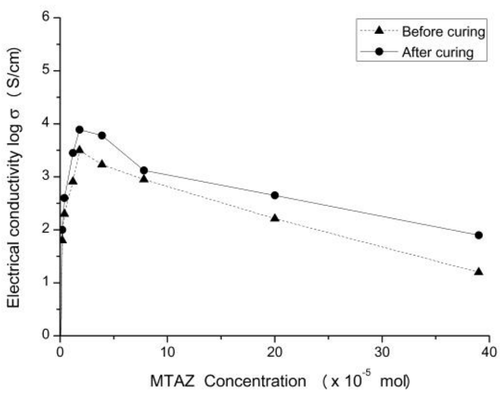

Figure 1: The electrical conductivity of Ag paste films using 1 μm silver particle at different concentrations of MTAZ, before and after curing at 80 °C for 6 h.

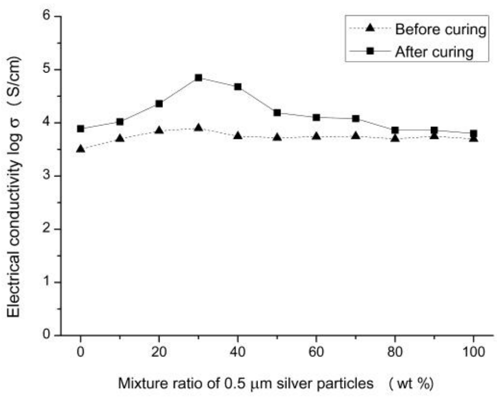

Figure 2: The electrical conductivity of silver paste films using two different diameters of silver particles and MTAZ, before and after curing at 80 °C for 6 h.