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Spatial Distribution of Metal Particles in Dried Metal Paste

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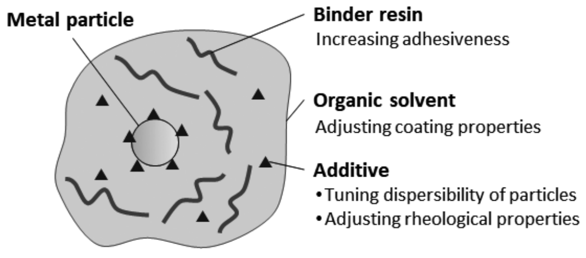
Abstract

Metal paste is a viscous fluid containing polymeric resin as a binder that can bind particles onto a substrate. The spatial distribution of metal particles after the paste dries plays an important role in the properties of the final product. In this study, we focused on whether phase separation of binder resins influences distribution of metal particles in the dried paste. To study this relationship, the spatial distribution of metal particles and resins must be clear. The spatial distribution of metal particles and phase separated resins was studied based on difference in surface moduli among components (particles, resins). To measure the surface modulus of the components, the nano-palpation method with an atomic force microscope (AFM) was used. The result indicated that phase separation of binder resins affected the distribution of metal particles.

Key-words: *Metal paste, Resin, Phase separation, AFM, Nano-palpation*

1. Introduction

Metal paste is a viscous fluid, and is a functional painting material for manufacturing small, high performance electronic components such as conductive printed circuits[1]. As shown in **Scheme 1**, a typical metal paste consists of metal particles, a binder resin, solvent and additives. The binder resin is used to increase the adhesiveness of the paste, which enables the paste to attach to a substrate after the substrate is coated with it and it dries. Organic solvent is used for diluting the paste to adjust the coating properties. A certain type of additive is used to tune the dispersibility of the particles and the rheological properties. The application of metal paste is determined by the type of metal particles in the paste[2]. For example, when using conductive metal particles, such as nickel, copper, or silver, the resulting metal paste can be used for producing conductive components. Other applications are shown in **Table 1**.



Scheme 1 Typical components of metal paste.

Table 1 Application of metal paste depending on type of metal particles.

Types of particles	Constituent element	Application of metal paste
Metal particles	Ni, Cu, Ag, Pt, Au	Electric conductive
	Cu, Ag	Thermal conductive
	Al, Ag	Light scattering
Metallic oxide particles	RuO_2	Electronic resistive
	$BaTiO_3$	Dielectric, piezoelectric

Furthermore, metal paste is classified into two types depending on whether a firing process is employed or not. A firing process produces thin metallic layers which have conductive properties, and in this study we deal with metal paste that requires a firing process. A typical usage of the metal paste is for manufacturing conductive components, and this is described as follows (**Scheme 2**). Firstly, a substrate is coated with metal paste. When coating the substrate with the paste, the printing technique should be chosen carefully (e.g, screen printing, gravure printing, inkjet printing, and so on) because the printing technique determines the structure of the final product, so choosing a suitable printing technique is important[3-5]. After printing, the paste is dried to remove the solvent contained in the paste. After drying, the paste is burned out to remove the binder resin, and then fired. Finally, the only thing that remains is the metal component, which can work as a conductive circuit.

These processes influence the properties of the final product. In particular, the distribution of metal particles in the dried paste is an important factor for the conductivity of

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