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Synthesis and Bonding Characteristics of Copper Nanoparticle Pastes Coated with Carboxylic Acids

Copper nanoparticles (CuNPs), owing to their high surface area-to-volume ratio and elevated surface energy at the nanoscale, exhibit distinct mechanical, thermal, electrical, and chemical properties compared to bulk copper. In this study, surface modification of Cu NPs was achieved using three types of carboxylic acids, such as hexanoic acid, to enhance dispersion, suppress agglomeration, and prevent oxidation. These modified nanoparticles were then used to formulate Cu NP pastes with triethanolamine (TEA).

Copper nanoparticles were synthesized via the liquid phase chemical reduction of CuO micropowder in an organic solvent containing carboxylic acids. The resulting CuNPs were collected and re-dispersed in TEA to prepare Cu NP pastes with concentrations ranging from 80 to 90 wt% in 2 wt% increments. These pastes were applied to copper substrates and subjected to pressure sintering at 200°C under 15 MPa using a home made fixture with a commercial hot press. Post-sintering, shear strength was measured, and the fracture surfaces and nanoparticle morphology were analyzed via SEM to assess the dispersion and structural characteristics.

It was found that the type of carboxylic acid had a noticeable effect on the crystal grain size and morphology of the Cu NPs. Longer carbon chains in the carboxylic acids tended to produce smaller and more variably sized grains. In terms of bonding strength, all types of carboxylic acid coatings showed improved strength at higher NP concentrations, likely due to increased viscosity. Interestingly, while high-concentration pastes could not be formulated with dodecanoic acid, samples prepared at lower concentrations still exhibited high bonding strength, indicating a distinctive effect of this acid on particle interaction and sintering behavior.