Silver Filled Conductive Epoxies

The use of silver-filled electrically conductive epoxy adhesives has been found to be unreliable on some space flight programs due to changes in the conductivity with time, temperature, and environment. In order to provide a sufficiently low electrical resistance path, there must continuity between the discrete silver particles. Unacceptable increases in electrical resistance of the epoxy in a solar-cell application were caused by separation of the individual silver flakes from one another as a result of thermal cycling. However, this has not been substantiated and the problem may be more complicated, as indicated below.

To gain more information on the behavior of silver-filled electrically conductive epoxies, we prepared samples of Eccobond 56C, and Epon 815/Versamid 140 filled with silver flakes. These were used to bond copper wires to various substrates, i.e., indium-oxide-coated glass, aluminum alloy, and copper. Electrical resistance across the contacts was monitored for 135 days in air and in vacuum. The data show that the electrical resistance between the copper wire and the substrate to which it was bonded with the conductive adhesive can vary anywhere from parts of an ohm to hundreds of kilo-ohms.

It was determined that factors such as the epoxy itself, solvents used for thinning the epoxy, epoxy cure time and temperature, substrate material and surface preparation and the exposure environment can significantly influence the electrical properties of the bonded junction.

As there are numerous electrically conductive epoxies available (each one possessing its own unique properties, including flexibility, sensitivity to moisture, useful temperature range, outgassing, etc.), it is important that the user select the one best suited for his specific application(s). In addition, it is imperative that the manufacturer's instructions are strictly followed and that the bond surfaces are properly prepared to ensure good adhesion. Furthermore, it is required practice to use material that is within the manufacturer's specified shelf life. Once the bond has been made and allowed to cure, it is advisable to periodically verify electrical conductivity.

In applications where mechanical stress occurs due to vibration or mismatch in coefficients of thermal expansion, or when bonding to substrates with poor adhesion, or substrates which oxidize rapidly such as aluminum, this technique may not provide the desired mechanical and/or electrical properties. Later studies have shown that silver filled epoxies can undergo very large increases in resistivity due to oxidation of the silver particles.

Even though it is not the intention to discourage the use of electrically conductive epoxies, alternate bonding methods such as soldering or welding should be evaluated for applicability that, in many cases, may prove to be not only feasible, but superior. Note that there are electrically conductive epoxies available that utilize metals other than silver (e.g., gold) that have not been tested by this Branch. Even though they may exhibit superior properties in some respects, the same precautions should be observed when using them.