Conductive Resin Alternatives

Polymer substitutes for solder can be implemented in two main ways:

- direct solder replacement using an Isotropic Conductive Adhesive (ICA)
- alternative configurations using Anisotropic Conductive Adhesives (ACAs)

Isotropic Conductive Adhesives

ICAs are so called because they conduct equally in all directions, and are mixtures of metal in fine powder form in a polymer base. The conductive path is formed by contact between metal particles after curing. Typical ICAs are silver-loaded one-part epoxy compounds supplied uncured.

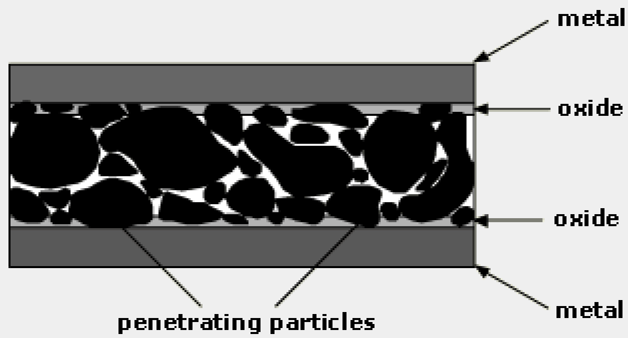
ICAs are applied in the same way as conventional solder paste, but cured rather than reflow. There is, however, no behaviour similar to solder reflow, because the surface tension forces are entirely different.

ICA properties vary with the percentage of metal, being limited by the viscosity of the resulting compound, as with solder paste. Compared with unloaded resin, they exhibit significantly increased thermal conductivity, but the electrical conductivity values for silver and copper-loaded resins are several orders of magnitude below those for the metals themselves.

ICAs have been evaluated as potential replacements for lead-containing solders. Unfortunately, whilst most adhesives form a stable junction with precious metal-coated components, most are incompatible with the base metal finishes found on SMDs and boards!

Alpha Metals have developed materials that reportedly exhibit greatly increased stability under heat and humidity ageing using an adhesive formulated to encourage oxide penetration by small conductive particles as the polymer hardens and shrinks, as shown in Figure 1.

Figure 1: Oxide penetration by particles during resin shrinkage enhances connection reliability



The main problem with any kind of conductive adhesive is the stability both of the bonds between particles and between particles and contact surfaces, and of the resin itself. This is particularly the case at elevated temperatures, where most of the resins used will creep and lose adhesion. Much work has been carried out to improve performance by stabilising the resin and, by including anti-oxidants, to reduce the rate of build-up of oxides on the contact surfaces within the joint structure.

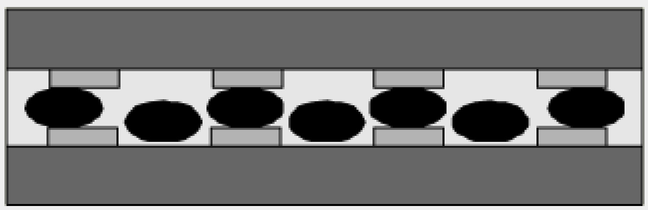
Note: Whilst the use of ICAs for solder replacement is a major challenge, be aware that silver-loaded resins have been used for chip attach for over 30 years, proving highly reliable in making joints between non-fusible surfaces.

Anisotropic Conductive Adhesives

ACAs were developed in the 1950s as dielectric coatings with randomly dispersed particles that made electrical connections only in the vertical direction. Such ‘Z-axis’ bonding films have been used since the 1980s to make connections to Liquid Crystal Displays.

ACAs have a low loading of conductive particles, so that individual particles do not contact one another and there are no unwanted electrical paths in the X-Y plane. When sandwiched between conductors, non-conductive polymer is squeezed out, allowing a mono-layer of conductive particles to bridge the gap, as shown in Figure 2.

Figure 2: Schematic cross-section of anisotropic conductive adhesive



With particles typically less than 25 µm in diameter, non-coplanarity must be very tightly controlled. For this reason, ACAs generally perform best when one adherend is compliant, and have thus found particular favour with users of flexible printed circuits. The coplanarity problem can be reduced by using compressible conductive particles such as metal-coated elastomeric spheres which deform under bonding pressure, an action which also helps maintain force on the pressure contacts forming the junctions.

The main problem with ACAs lies in their method of use, because pressure must be applied until curing is complete. For this reason, ongoing developments in ACAs include replacing pressure contacts by particles which bond to the substrate, as well as placing particles in an array, rather than at random, to enhance electrical performance.

Source : http://www.ami.ac.uk/courses/topics/0116_coni/index.html