Tech Tip 12

# Compatible Metallization with Electrically Conductive Silver Epoxies

**What >**
Compatible Metallization for Silver Epoxies

**Why >**
Considerations for PCB & circuit assembly when choosing ECAs ahead of solder joining

## Why Silver Epoxies?

Silver epoxy adhesives (ECAs) have been widely used in semiconductor and electronic packaging industries since the 1960s, as a reliable connection method instead of soldering or eutectic joining of metals.

After 2000, as a result of the global transition to lead-free electronics, the majority of the electronic component manufacturers are now using ***pure tin*** or ***tin-rich alloys*** for soldering, SMD terminals and leaded devices. This change has resulted in increased reflow temperature, less ductility and more likelihood of "tin-whisker" formation. It is well known that electrical shorts caused by growth of these tin whiskers (needle-like metal crystals) have knocked out guided missiles and communication satellites, caused heart pacemakers to fail and watches to stop ticking.

These concerns have catapulted silver epoxy (ECA) applications. While the ECAs have advantages over tin rich soldering processes, what they adhere to needs to be chosen carefully. When used for electrical contact, it is important that the metallization has similar potentials to avoid galvanic corrosion and non-conductive oxides.

## What is a "Tin Whisker"?

A tin whisker is a conductive tin crystal, which can spontaneously grow from tin based lead-free finished surfaces even at room temperature, often in a needle-like form. Oxidation in humid conditions, corrosion, intermetallic formation, stress under thermal cycling, and electromigration have all been shown to promote whisker formation.

While pure tin has gained the most notoriety for developing whiskers, these pesky crystalline filaments can also grow from other metals, including cadmium, silver, and zinc.

## Metal & Metal-Oxides

Palladium, platinum and gold are noble metals which will not readily oxidize, due to their electron orbital configuration. Silver is also a noble metal with a similar configuration, but will oxidize under the right conditions. However, even if the silver is oxidized, its oxides are conductive.

Lead and tin are main group metals containing free electrons that will readily form non-conductive oxides and can cause serious conductivity issues. Since these oxides form on the surface of the metal, they can also significantly reduce the shear strength of an adhesive bond.

## Ag, Sn, Al Joints

Silver epoxy should never be used on pre-tinned surfaces for three reasons.

- It is industry legacy and common sense that noble metals like to be joined to other noble metals.
- Silver and tin have dissimilar potentials, leading to galvanic corrosion, via a tarnish or rusting process.
- Silver itself can be a catalyst for tin whisker formation.

Manufacturers should avoid pure tin altogether by plating components with materials that do ***not*** have a tendency to whisker, such as Au, Ag, AgPd, NiPdAu, Pt, Pd, Cu.

Aluminum presents a similar quandary as tin, not producing whiskers, but its likelihood to readily oxidize. Aluminum oxide is an electrical insulator and mechanically it will yield a weaker bond than its non-oxidized form resulting in as much as a 50% difference in lap shear strength.

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## Compatibility Chart

| Market | Sector | Compatible Metals | Comments I Compatibility |
|---|---|---|---|
| **Semiconductor** | wafers | Pd, Ni/Pd/Au | Al plated I/O's must be re-metallized |
| | lead-frame | Cu, Ag, Alloy 42 | die-attach paddles, avoid Sn plated lead frame |
| **Hybrid Micro-Electronics** | die attach | Au | Au plated ceramic substrates, Au backed chips |
| | SMD attach | Au, Ag, AgPd | SMDs can not be Sn/Pb plated |
| | EMI/Rf shield | Brass, SST, Kovar | ohmic contact for grounding purposes |
| **Electronics Assembly** | acoustics | Au, Cu | pads on PCBs |
| | | PZT, or similar | piezo electric materials |
| | PCB level | Au, Cu | never use Sn/Pb or SnAgCu solder pads |
| | RFIDs | Ag, Au | contact pads on substrates |
| | | PTF-Ag ink | antennae coils for RF |
| | SMD caps | Au, Ag, AgPd | cannot be SnAgCu or Sn/Pb terminations |
| | Tantalum Caps | Au | industry standard terminations |
| | Solar cell | SnO, ZnO | Transparent Conductive Oxides - TCO |
| | | Al/Cu, Cu/Sn, Cu/Ag | Ribbon wires |
| | | Mo, Ag, Ni, Cr, TCOs | PV subtrates |
| **Medical Device** | pacemaker | Au/Ceramic | substrates packged in hybrid form-factor |
| | catheters | Pt/Ir | guide wires, fluoroscopy |
| **Opto-electronics** | Fiber Optics | brass, SST, Kovar | metal housings, EMI shielding |
| | | Au/ceramic | opto-circuit, or optical bench |
| | | Lithium Niobate | die attach optical chips |
| | Sensor Optics | SST, brass | EMI shielding |
| | Camera Optics | Au | common interconnections |
| | X-ray optics | Au plated scintillator | electrical bridge to photo-detector arrays |
| | LEDs | Cu, Ag spot lead frame | die attach LED chips, single chip package |
| | | Cu, Au | LED arrays onto PCB |
| | LCD / OLED | ITO | TCO layer |
| | | Au, Cu | electrical bridge to PCB/substrate |

### Silver Epoxy ECA

**+'s**

- Is compatible with Si, GaAs, In, P and MEMs chips
- Can withstand 260˚C lead-free reflow
- Are well matched with Au, Ag, Ag-Pd terminations of capacitors and resistor SMDs
- Will bond well to Pt, Pd, Au, Ag, Ni & Cu surfaces
- Provide an excellent alternative to solder joining
- Yields similar thermal conductivity values as most solder joints

### Silver Epoxy ECA

**-'s**

- Is not compatible with Sn, Al, and SnAgCu solder surfaces
- Should not be used with solder dipped pads on SMDs / PCBs
- In its cured form, can not be ribbon or wire bonded and will not accept solder joints
- Should have oxides removed from Cu and Ni surfaces prior to bonding

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