

Substrate Metallization Considerations For Soldering

APPLICATION NOTE

Sufficient thought should be given to the substrate metallizations used in a soldering application to insure adequate wettability and reliability. This Application Note will discuss some of those considerations.

**Au/Sn Intermetallic Formation**

With tin-bearing solder alloys and gold metallizations commonly used, it is necessary to consider the issue of compatibility. It is known that the tin in solder rapidly dissolves gold during reflow. The amount of gold dissolution is dependant on the percentage of tin in the solder, the gold thickness, and the time and temperature at liquidus. Excessive scavenging of gold results in the formation of a Au/Sn intermetallic that, when present in sufficient quantity, can embrittle the joint. Such embrittlement can cause joint cracking and failures upon thermal cycling of the assembly. There are two basic approaches used to avoid embrittlement.

- 1) Often, gold is used primarily as a layer that will protect and reduce the oxidation of an underlying metallization, such as nickel. As a rule of thumb, a gold layer that is 15 microinches thick or less is safe to use with a tin-bearing solder. (Studies have shown that when using Sn63 the amount of gold that dissolves into the solder should not exceed 3% by weight. When that amount is exceeded, the embrittling effect of the Au/Sn intermetallic becomes evident in mechanical testing.<sup>1)</sup>
- 2) Other processes may require that the gold be thick (50 microinches or greater). In such cases, tin-bearing alloys should be avoided all together. (Exceptions may be allowable when tin is a minor constituent of the alloy such as when using Pb95/Sn5 solder). The most common solution is to use an alloy that substitutes indium for the tin in the solder. Some replacements for Sn63Pb37 are In70/Pb30 and In60/Pb40, both having liquidus temperatures in the range of Sn63. Indium-lead alloys are available in other melting ranges as well.

**Fluxless Soldering of Gold Substrates**

Gold, being a noble metal, has minimal surface oxide, which can allow for the use of a fluxless soldering technique using a precious metal solder such as Au80/Sn20. Gold is normally electroplated over a minimum of 50 microinches of nickel, the nickel functioning as a barrier layer between the base metallization and the gold. An inert gas such as argon or nitrogen is used as a cover gas to aid in wetting. This application is often used in sealing ceramic packages to a nickel/gold electroplated kovar lid.

**Avoid Soldering Directly to Metallizations that Exhibit Poor Wetting**

Certain metallizations, such as nickel, are very difficult to directly solder due to the tenacious nickel oxide that is formed. Nickel metallizations are preferably electroplated with more solderable metals to avoid the use of a higher activity flux. Solder pastes with their relatively mild no-clean or water wash flux formulations, do not wet well to metallizations such as nickel. If it is necessary to solder directly to nickel, solid solder in the form of wire, ribbon or perform, along with an RA or organic acid flux, would be the appropriate choice.

Other materials that are difficult to solder to include: rhodium, cadmium, brass, bronze, beryllium/copper, lead, oxidized copper, tin-nickel, kovar, aluminum, stainless steel, high chromium super steel, inconel, monel, zinc and mild steel. There are liquid fluxes available that are effective for these materials. However, they are aggressive and the flux residues must be thoroughly removed by appropriate cleaning. Some of the more corrosive fluxes are not recommended for use in electronics applications. Solder paste, with their relatively mild flux compositions, are not suitable for these metallizations.

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**Substrate Metallization Considerations For Soldering**

**Special Consideration when using an Indium Containing Alloy on Copper**

Copper and high copper alloys diffuse into indium, which forms a copper-indium intermetallic that may compromise the mechanical integrity of the joint.

Copper diffuses into indium even at room temperature when solid, a process known as solid state diffusion. The copper-indium intermetallic can result in a weakening of joint strength and may result in joint failure under certain circumstances. Because this phenomenon is a function of temperature and time, the weakening effect of the diffusion may not be immediately evident. One effective method to prevent this diffusion is to have a barrier layer of a minimum of 50 microinches of nickel plated between the copper and indium. Metallizations, such as gold, can then be plated on top of the nickel to create a more solderable surface.

<sup>1</sup>Effect Of Au On The Reliability Of Fine Pitch Surface Mount Solder Joints by Judith Glazer (Hewlett Packard Company, Palo Alto, California) and Pamela A. Kramer and J.W. Morris, Jr. (Department of Material Science and Mineral Engineering, University of California and Materials Science Division Lawrence Berkeley Laboratory, Berkeley, California)

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