James P. Langan
J.P. Langan & Associates, Inc.
7 Mayflower Drive
Red Bank, NJ 07701
908/842-3741

Immersion Tin—A Low-cost Alternative to HASL

The high I/O interconnections required by recent innovation in component technology are causing electronic manufacturers to re-evaluate existing assembly techniques. Fine-pitch integrated circuit packages with >200 I/Os and MCM-Ls are creating a need for improvements in placement and bonding techniques.

Currently, most specifications call for an HASL surface finish because of its reputation for solderability. If the finish is bright and shiny with no visible evidence of de-wetting and meets thickness specifications, solderability is assured—even with “leave on” fluxes.

With fine-pitch components (<0.38 mm/0.015 in.), however, problems with placement and bridging appear. This is caused by the meniscus formed when molten tin-lead solidifies, and by thickness variations that result from thermal non-uniformity. In addition, some advanced bonding procedures—such as wire bonding—are not compatible with HASL.

A Recent Development For HASL Alternative

The flat pad requisite for accurate placement of ultra-fine pitch components has initiated research to circumvent the disadvantages of an immersion tin surface finish. Immersion deposition of tin on copper is a displacement reaction that has been employed for minor applications within the PWB industry. Some examples include plating track edges prior to solder reflow and providing a tin-rich surface to the tin-lead plate (to prevent oxidation of the lead during processing) in ammoniacal etchants.

Its major disadvantage has been the low thickness of the deposit (0.1–1.5 microns). A tin deposit has a tendency to alloy with copper, forming a very insolderable copper-tin alloy. For preserving solderability, it has been limited to applications where PCB assembly quickly followed PWB fabrication.

Pure tin coatings also have been associated with “whisker” growth. This is a phenomenon related to internal stress in the deposit that, under certain environmental conditions of temperature and humidity, can develop long fibrous growths. These thin “whiskers” can grow to several millimeters and have an impact on electrical shorts.

Immersion tin could be a low-cost alternative to HASL if the formulation could be modified to negate these deterrents that have, so far, limited its use on PWBs. It is a process that might assist PWB fabricators in streamlining manufacturing, and could satisfy an assembly requirement for wire bondable flat pads.

Immersion plating is a displacement reaction with the base metal (copper) and the metal ions (tin) in solution. The tin is deposited on the surface of the copper, but the reaction begins to self-limit as soon as the tin coating prevents any further transfer of copper into solution. The thiourea is used to drive the reverse potential needed as copper builds up in the solution. The deposit is thin (0.1–1.0 microns) and is dependent on concentration, temperature and porosity of deposit. A typical formulation is:

Stannous chloride	16 g/L
Thiourea	50 g/L
Hydrochloric acid	20 mL/L

A recent formulation has modified the process to provide autocatalytic deposition of tin to supplement the immersion deposit thickness. This novel approach incorporates the basic thiourea reverse potential reaction, but also utilizes a unique organometallic co-deposition mechanism that retards the formation of copper-tin intermetallic, and also modifies the deposit to prevent dendritic growth and conditions the tin surface to retard oxidation.*

Recommended Process Cycle

1. Acid cleaner 50 °C (122 °F)
2. Cascade rinse R.T.
3. Micro-etch 30 °C (80 °F)
4. Cascade rinse R.T.
5. Sulfuric acid dip 1% R.T.
6. Tin immersion 65 °C (149 °F) Flooded immersion module
7. Water rinse 43 °C (110 °F)
8. Cascade rinse R.T.
9. Hot-air dry

The purpose of the micro-etch is to remove imbedded particles from previous pumice or dry abrasive procedures. After the micro-etch, the copper is in a highly oxidizable state, mandating the subsequent mild acid dip. Cascade rinsing is required to avoid contamination and pH control of ensuing solutions in the process sequence.

Thorough hot-air drying is critical to ensure that all moisture has been removed from plated through-holes. It should be noted that this process is similar to other non-electroplating procedures for attaining flat pads (*e.g.*, electroless Ni-Au, immersion Ag and OSPs) in that the cleaning, coating and drying steps must be carefully controlled. It is also a fragile coating and requires special handling.

What is lacking in all HASL alternatives is a nondestructive quality control test to assure solderability. Current investigations using sequential electrochemical reduction analysis (SERA) may lead to a nondestructive quantitative measure of solderability.

This process has found some commercial success in Europe and is now being evaluated by several companies in the U.S. If data from production trials remain positive, this approach could rival electroless nickel-gold, immersion silver and OSPs as a low-cost alternative to HASL. **P&SF**

* *David Ormerod, "The Development & Use of a Modified Immersion Tin as a High-performance Solderable Finish,"* Proc. of IPC Conf. on PWB Surface Finishes & Solderability, *Bloomington, MN (Sept. 1997).*