Tin-Lead Plating

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Applications

Tin-lead alloys (10 to 40 percent by weight tin) are plated on wire to protect the base metal from oxidizing and to enhance solderability; on printed wiring boards (60 percent tin) to act as an etch resist and preserve solderability; and on electrical contacts for solderability enhancement and corrosion protection. Tin-lead alloy compositions in the range of 90 to 98 percent by weight tin are electroplated on semiconductor device leads to preserve solderability and eliminate potential spontaneous metallic whisker growth. Although the major uses for tin-lead alloy plating are for electronic applications, the alloy is also used as an overlay on bearings and as “terne plate,” which provides corrosion protection for steel. For these applications, the tin content of the deposit is less than 12 percent by weight.

As a rule, the higher the tin content of the deposit, the greater the ease of solderability.

Tin-lead can also be applied by hot dipping, but this method has become virtually extinct due to advances in electroplating technology.

Processes

There are two basic electroplating processes currently available for plating tin-lead alloy deposits: Acid fluoborate and acid sulfonate. The former process is the more widely used, although the latter is receiving increased attention from the environmental standpoint.

The fluoborate electrolyte must contain free fluoboric acid to provide solution conductivity, boric acid to prevent breakdown of the fluoboric acid into free fluoride (which would cause the unwanted precipitation of lead as lead fluoride), tin fluoborate (as a source of tin ions), lead fluoborate (as a source of lead ions), and a suitable grain refiner. The simplest grain refiners, based on gelatin and glue, will provide smooth, tight-grained deposits. Proprietary additives are also available and provide certain advantages, such as stability and ease of control, that the gelatin and glue formulations do not provide.

The acid sulfonate electrolyte is based on alkanesulfonic acid, tin alkanesulfonate, lead alkanesulfonate, and an organic addition agent. The alkanesulfonic acid provides solution conductivity, while the tin and lead alkanesulfonates provide the metal ions. The organic addition agent performs the same function as its fluoborate counterpart. In general, the organic addition agents employed in the fluoborate processes are not compatible with the acid sulfonate processes.

Typical chemical makeups and operating conditions for both the fluoborate and nonfluoborate (acid sulfonate) processes are listed in Tables 1 and 2.

It is important to note that the composition of tin and lead in the deposit is influenced by (a) the ratio of tin metal to total metal in solution, (b) the cathode current density, and (c) the type and concentration of the addition agent. The tin content in the deposit increases with an increase in the ratio of tin to total metal, and with an increase in cathode current density. Certain additives, such as wetting agents, glue, or peptone, will also raise the tin content in the deposit.

These rules governing the alloy composition apply to both types of tin-lead electrolytes. Both the fluoborate and acid sulfonate processes are relatively easy to control and operate at 100 percent cathode and anode efficiencies.

Table 1
Fluoborate Plating Solution

	Solution composition,* g/L	
Component	**Type 1**	**Type 2**
Tin	15	15
Lead	236	10
Free fluoboric acid	40	400
Free boric acid	25	30
Addition agent	As required	As required
Operating temp., °C	50	22
Cathode current density, A/dm^2	Up to 80	1 to 2.5
Anode current density, A/dm^2	Up to 80	2
Agitation	Solution movement	Cathode bar movement

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*Type 1—high speed plating solution (deposit contains 10 percent tin); Type 2—high throw solution for printed wiring boards (deposit contains 60 percent tin).

Table 2
Acid Sulfonate Plating Solution

	Solution composition,* g/L	
Component	**Type 1**	**Type 2**
Tin	18	16
Lead	236	10
Free acid	23% v/v	20% v/v
Addition agent	As required	As required
Operating temp., °C	25	25
Cathode current density, A/dm^2	1 to 4	1 to 4
Anode current density, A/dm^2	1 to 4	1 to 4
Agitation	Cathode bar movement	Cathode bar movement

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*Type 1—plating solution for semiconductor lead devices (deposit contains 90 percent tin); Type 2—high throw solution for printed wiring board (deposit contains 60 percent tin).

In general, deposits produced from the tin-lead electrolyte are semibright to matte. However, with careful control of the electrolyte and the addition of aldehyde/amine brightening additives, a bright, lustrous tin-lead deposit can be obtained. Although the bright tin-lead coatings do not require flow-melting or fusing to cosmetically enhance the finish, the process requires tight control of these organic brighteners.

It is important to note that organic addition agents act as a controlled impurity in the tin-lead electrolyte. A certain percentage of the organic material is incorporated into the plated deposit. Excessive levels of organic material can be detrimental, causing solderability problems. Some military specifications call for only matte deposits, with the organic content to be as low as possible.

Post-plating

In the electronics industry, the preservation of solderability is the major reason that tin-lead electrodeposits are used. Printed wiring boards are reflowed, or fused, to enhance solderability and improve the cosmetics of matte tin-lead deposits. In this process, the parts are first coated with a flux, which cleans and activates the tin-lead surface. Heat is then applied to the parts. The heat can be supplied by a number of sources: Hot vapor, hot oil or infrared. Temperatures above 400 °F cause the tin-lead deposit to melt, forming a true alloy more commonly known as solder. The composition of the deposit is critical for the reflow operation, with an ideal deposit content of 63 percent tin and 37 percent lead. Tin-lead plated copper wire can be brightened by drawing the wire through dies, by fusing or flow melting, or by using one of the brightened tin-lead processes.

Health Impact

Although tin is considered nontoxic, lead is very toxic. Lead compounds are also listed as hazards and proper care should be taken when working around the plating solutions. When handling the acid fluoborate or acid sulfonate electrolytes, protective clothing and proper eye protection should be worn, as the electrolytes are corrosive.

Environmental Status

Wastewater limits under EPA’s Metal Finishing Regulations (to include all electroplating, electroless plating and printed wiring board manufacturing) must not exceed 0.67 ppm lead for any one day, with the average daily discharge not to exceed 0.23 ppm lead for any 30-day period. Two exceptions to this regulation will be for the indirectly discharging jobshop electroplater and the independent printed wiring board manufacturer. These two will remain under the Electroplating Category PSES, which limits the discharge of lead for any one day to 0.6 ppm and 0.4 ppm (average daily volume) for consecutive monitoring days.*

Tin is currently not regulated. Some states currently regulate fluorides and other state regulatory agencies are looking at fluoride and boron (generated by the fluoborate electrolytes) as targets of possible regulation.

The EPA has enacted restrictions relating to the land filling of metal hydroxide sludges. This regulation (EPA F006) limits the amount of sludge in a waste extract that is destined for land disposal to 0.53 ppm.

Trends

The use of tin-lead electroplating technology is expected to grow at an annual rate of 7 to 10 percent (the next five years, due to continued growth in the electronics industry). However, the actual use of lead decline as environmental regulations are tightened.

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*Robert S. Capaccio, “Wastewater Treatment for the Electronics Industry,” *Proc. AES 10th Symposium on Plating in the Electronics Industry* (1983).