Tin Plating

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Applications

Tin deposits are widely used in the production of food processing and shipping equipment and containers, pump parts and automotive pistons, copper and steel wire, and in the plating of electrical components and printed wiring boards. Tin is appealing to the food processing industry because tin is a nontoxic, ductile and rather corrosion resistant metal. The excellent ductility of the metal allows a tin coated base metal sheet to be formed into a variety of shapes without damage to the tin itself. When tin is used to protect steel, it is very important that the tin deposit be pore free. If the deposit has scratches or other discontinuities, severe rusting of the base metal will be the result when the part is exposed to moisture. Thicker deposits up to 30 µm are generally required in food processing equipment and shipping containers to prevent corrosion.

Tin is widely used in the electronics industry because of the metal's ability to protect the base metal (typically copper, nickel, and tin-nickel) from oxidation. Tin thus preserves solderability of the base metal, a critical requirement when plating for electronic applications.

It should, however, be emphasized that un-reflowed compressively stressed deposits may grow spontaneous metallic whiskers which may cause electrical shorting of closely spaced components and/or devices. However, tin deposits containing a minimum of 2 percent lead are not prone to the growth of these spontaneous whiskers under the same conditions.

Although tin is used primarily for corrosion resistance and electronic applications and to a minor extent for decorative purposes, the coating is also used in a variety of engineering applications. Thick deposits (50 to 250 µm) are electroplated on pump parts and piston rings. Because of the excellent lubricity of the metal, tin is plated on oil well pipe couplings. The alkaline stannate tin plating process is generally used in this application because of the fear of hydrogen embrittlement with acidic tin plating processes.

Processes

Tin can be deposited on a base metal by hot dipping, electroplating, or by immersion. Electroplating is by far the most widely used of the three methods and will be presented here.

There are four basic choices of electrolytic plating processes that can be used to deposit tin: Alkaline stannate, acid sulfate, acid fluoborate and acid sulfonate. The stannate process is based on either sodium or potassium stannate. For high-speed plating applications, the potassium stannate is used because of its very high solubility as compared to the sodium salt. In order to achieve current densities up to 16 A/dm^2, a formulation containing 210 g/L potassium stannate and 22 g/L potassium hydroxide is used. The potassium stannate concentration can be doubled in order to reach 40 A/dm^2. For barrel plating applications up to 3 A/dm^2, an electrolyte made up at 100 g/L sodium stannate and 10 g/L sodium hydroxide is used. Anode efficiencies in the range of 75 to 95 percent and cathode efficiencies (80 to 90 percent) are typical for the alkaline process.

Of all the tin plating processes, the alkaline process has superior throwing power. The process does not require the use of organic addition agents but must operate at elevated temperatures (70 to 90 °C).

The most important aspect of alkaline tin plating is the critical need for proper control of the anode. If the tin anodes are not properly controlled during the plating process, rough porous deposits will result. A yellow-green film must be present on the anode during the plating operation in order to insure excellent plating.

Plating solutions based on stannous sulfate (7 to 50 g/L) and sulfuric acid (50 to 150 g/L) can deposit either a bright decorative deposit or a matte finish depending on the type of grain refiner/brightening system employed. A semi-bright matte tin finish can be obtained using gelatin and an organic compound, beta-naphthol. A large variety of organic brighteners are commercially available to produce bright, decorative adherent deposits from the stannous sulfate electrolyte. These additives are generally based on aliphatic aldehydes and an aromatic amine. Improved versions of the above consist of wetting agents such as water-soluble polyethylene glycol and a water soluble derivative of ethylene as a primary brightening agent. The bright bath has several advantages over the matte process including improved corrosion resistance, reduced porosity, resistance to fingerprints, improved solderability as well as its cosmetic appearance. The acid sulfate process operates between 20 to 30 °C at essentially 100 percent anode and cathode efficiencies. The acid bath does not require the careful anode monitoring of the alkaline stannate bath but does need organic addition agents. The throwing power of the acid bath is believed by many to have less throwing power when compared to the alkaline stannate process, however.

Another acidic plating process based on tin fluoborate (75 to 115 g/L) and fluoboric acid (50 to 150 g/L) is designed to plate pure matte tin deposits. A major advantage of this process over the tin sulfate is that it can be operated at much higher cathode current densities, up to 100 A/dm^2 (in agitated plating solutions). Gelatin and beta-naphthol are typically used as grain refiners in this process, which is operated in the 20 to 30 °C range. Anode and cathode efficiencies are about 100 percent.

Recently tin plating formulations based on methane-sulfonic acid (15 to 25 percent by volume) have begun to gain acceptance because the solutions require simple waste treatment, contain no fluorides or boron, and are less corrosive than the electrolytes based on fluoboric acid. The methanesulfonic electrolytes, similar to the fluoborate baths, can hold high concentrations of metal in solution (up to 100 g/L tin) permitting plating at high speeds. A major drawback of the methanesulfonic acid process is the chemical makeup cost, which is approximately $10/gal. The fluoborate electrolyte cost is approximately $6/gal and the sulfate tin is less than $3/gal.

All of the acidic tin plating electrolytes mentioned above deposit tin from the divalent state (+2) as compared to the +4 state for the alkaline stannate solutions. The acidic processes thus deposit tin twice as fast as the stannate process and operate at essentially 100 percent cathode efficiency. The acid tin processes are easier to control and maintain than the stannate solution and have the additional advantage of operating at ambient temperatures.

Post-plating

The major uses for tin plating are (1) corrosion protection and (2) the preservation of base metal solderability. When the latter is the prime objective, the tin deposit is usually soldered or reflowed.

The electronics industry requires that semiconductor device leads readily solder into their assemblies. Prior to the actual soldering operation, a flux is applied to the leads to clean and activate the tin surface. Then the part can be soldered into the assembly by applying heat sufficient to melt the tin. Heat can be supplied by hand-soldering the device. Cleanliness of the coating and base metal are extremely important.

The tin deposit can be reflowed by immersion of the part in hot oil (215 to 253 °C), or by supplying heat by means of infrared, hot air or vapor phase sources. Circuit boards have components soldered into the board by passing the board (with components in place) over a molten solder pot (wave soldering). Again, the proper flux must be applied before the soldering/reflow operation begins.

Health Impact

Tin is used in the food processing industry because it is a nontoxic metal, thus, no limits have been placed on exposure to the metal.

Workers exposed to the plating solutions should always wear protective clothing (rubber gloves, boots, eye protection). The fluoborate and sulfate electrolytes are based on strong acids and caution should be exercised when working around these chemicals. Plating tanks must be equipped with proper ventilation.

Environmental Status

Tin is currently not regulated. Some states currently regulate fluoride and boron (generated by the fluoborate electrolytes). This trend will undoubtedly spur the industry to consider the methane-sulfonic acid process, despite the higher cost.

Trends

According to the Tin Research Institute, the use of electrodeposited tin will increase 5.7 percent annually over the next several years. The primary thrust for this projected increase will be the electronics industry.

Environmental concerns over the waste minimization of lead will add to the use of tin deposits as a replacement for tin-lead alloys. P&SF