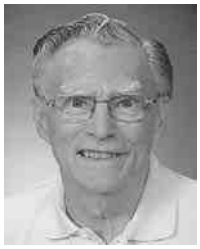
Do's & Don't's



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Copper Plating: Part II

Atomic number 29
Atomic weight 63.546
Melting point 1356.15°K (1083°C; 1981.4°F)
Ionization energy 745.5 kJ/mol
Density 8.933 g/cm^3
Oxidation states +1 and +2,
Electron shell configuration $1s^2 \cdot 2s^2 \cdot 2p^6 \cdot 3s^2 \cdot 3p^6 \cdot 3d^{10} \cdot 4s^1$

This column is a second of two features on copper plating. The first, featured in the September 2006 issue of *P&SF,* covered the nature of copper and the history of copper plating, as well as the various plating solutions with an emphasis on cyanide copper plating. This second part deals with acid copper.

Acid copper plating solutions

Sulfuric acid copper plating solutions provide rapid deposition and less throwing power as compared with cyanide copper and pyrophosphate copper solutions. Acid copper can be made to level and be very bright. Additions agents help microthrowing power when used for through-hole plating on printed circuit boards and for plated plastics prior to bright nickel and chromium. The solution is easy to use and maintain. The chloride content is the only critical ingredient that must be controlled, between 40 and 70 ppm. Therefore it is not wise to use hydrochloric acid prior to acid copper plating. Addition agents are available for leveling, brightening and "high throw" formulations that consist of a lower copper content and higher sulfuric acid. A cyanide or alkaline non-cyanide copper strike is required when plating onto steel, aluminum or zinc die-castings.

For the conventional plating solution, copper sulfate, with five waters of crystallization ($CuSO_4 \cdot 5H_2O$), ranges from 200 to 250 g/L and sulfuric acid ranges from 45 to 90 g/L. The high throw copper uses 60 to 100 g/L copper sulfate (as $CuSO_4 \cdot 5H_2O$), 180 to 270 g/L sulfuric acid and 50 to 100 ppm chloride.

From experience, I have found that adding 50 to 60 ppm chloride is beneficial for conventional acid copper solutions. Chloride reduces anode polarization and aids brightness with or without addition agents. Below 30 ppm chloride, the deposit is large-grained and dull. Above 120 ppm chloride the deposit is grainy and dull.

Anodes

Electrolytic copper sheets have been used for many years for both cyanide and acid copper plating solutions. Cast bars, and rolled copper are also used. High purity-oxygen-free anodes are used because there is less anode sludge to clog the anode bags. However, the very best anodes for acid copper are phosphorized copper anodes that contain from 0.004% to 0.006% phosphorus. Less sludge and particles result. These anodes come in various forms. Common is bagged titanium baskets with copper balls or chunks of copper.

The anode current density should be less than 5.0 A/dm^2. Using vigorous agitation, the anode current density can be higher. The anode area should be about two times the cathode area. Less anode area can result in polarized anodes, generating more particles and reducing the current available for plating.

Impurities

Iron, nickel and zinc do not codeposit at copper plating current densities. Nickel and iron reduce the solution conductivity. Higher copper concentrations can overcome this temporarily. Nickel and iron cannot be removed from the solution. Arsenic and antimony embrittle the deposit, but will plate out at about the same current density as for copper and thus the solution will deplete these impurities as plating continues, as long as no new source of these impurities is introduced. Lead is insoluble in acid copper solutions and forms a lead sulfate precipitate. Organic impurities can be removed by carbon treatment. Impurities can come from anodes. It is important to use high purity anodes and appropriate anode bags, I prefer polypropylene felt or a combination of polypropylene inner bag and felt outer bag. It is important to keep the bags clean to prevent clogging that leads to anode polarization. Periodic cleaning of the bags is highly recommended. ***P&SF***

This column was adapted from an online article written by Mr. Baudrand for the Technical Library in the website *Plateworld –A Directory of Surface Finishing Suppliers & Plating Shops*, www.plateworld.com – *Ed.*

Trouble Shooting Chart – Normal Acid Copper

CAUSE	REMEDY
Rough deposits:	
Particles, grease, buffing compound, dust and dirt	Filter the solution.
Anode to cathode ratio incorrect	Adjust to 2:1 ratio.
Incorrect anodes	Use phosphorized copper anodes. Phosphorus too low.
Current density too high	Lower current density.
Low sulfuric acid	Add sulfuric acid.
Rectifier ripple	Add filter to rectifier, equalize tap switches.
Step plating:	
Chloride too low	Adjust to about 50 ppm
Pitting:	
Substrate contains pits, grease or oil	Filter or carbon treat.
Excessive or non-uniform agitation	Check spargers and correct.
Inadequate cleaning	Improve cleaning.
Burning:	
Low copper content	Add copper.
Chloride is out or range	Adjust chloride to 40 to 60 ppm.
Low temperature	Adjust to 70°F (21°C) or higher.
Poor agitation	Increase agitation.
Brightener low	Add brightener.
Anodes too long	Work should be positioned below the anodes.
Poor throwing power:	
Copper content too low	Raise copper content.
Sulfuric acid too low	Add sulfuric acid.
Temperature too high	Run at 70 to 78°F (21 to 25°C)
Metallic contamination	Analyze and purify if possible Low CD electrolyze (Dummy plate)
Large grain size	
Chloride too low	Adjust to 40 to 50 ppm.
Brightener too low	Add brightener.
Treeing and nodulation:	
Chloride too low	Add chloride to 50 ppm.
Poor brightener response:	
High brightener content, organic contamination	Carbon treat.
High chloride	Reduce chloride.
Anode polarization	Add anodes.
Metallic contamination	Dummy plate at low CD.
Temperature too high	Lower temperature to about 70°F (21°C)
Poor leveling:	
Low brightener or excessive brightener	Adjust brightener.
Low current density	Raise CD.
Organic contamination	Carbon treat.
Streaking:	
High brightener or organic contaminations	Carbon treat.
Poor cleaning or poor rinsing	Adjust cycle.
Deposit too hard:	
Metallic contamination, especially high iron	Dummy plate (Iron is not removed by dummying at low CD).
Organic contamination	Carbon treat.
High sulfuric content	Decant.
Low temperature	Raise to 70°F (21°C).

Trouble Shooting Chart – Acid Copper in Printed Circuitry

CAUSE	REMEDY
Dishing or poor deposit around the holes	
Leaching organics from resist, high brightener and/or other organic contamination	Carbon treat.
Cleaner drag-in	Improve rinsing.
Incorrect agitation	Analyze and adjust.
Nodules in the holes:	
Poor drilling	Use sharp drills.
Temperature out of range	Adjust to suppliers recommendations.
Particulate matter in solution	Filter.
High brightener	Carbon treat and adjust.