Guest Editorial -For Plateworld.com

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PLATING FOR ELECTRONIC APPLICATIONS

Why plating?

Plating, including electroplating and electroless plating of metals and alloys serve many useful functions in electronic devices for example: Corrosion protection, diffusion barriers, conductive circuit elements, via hole filling for semi-conductors, integrated circuits, through hole connections for printed wiring boards, and flexible circuits. Plating is used to fabricate passive devices on dielectric surfaces such as resistors, capacitors, inductors, and to improve conductivity of metallized circuits, that use thick film conductors, or frits on ceramic substrates such as molybdenum, Molybdenum-manganese ("moly-mag"), tungsten and other such materials.

Plating is often used to enhance solderability. Tin, tin-bismuth, various silver alloys, with or without tin, gold and gold alloys, electroless nickel-boron and electroless nickel-phosphorus alloys are common materials used for soldering. Each has advantages and disadvantages. All the choices so far, have higher melting points than 6/40 tin-lead Selection is based on the end use of the component to be soldered. Thus it is important to have components that can withstand the higher soldering temperatures. For example, burn-in devices must withstand high heat excursions. Diffusion barriers are required where copper, gold or silver is used in the circuit. Diffusion of any of these metals to a service can allow oxidation, which alters the desirable characteristics of the device. Even a small amount of diffusion into the plating can alter conductivity. Oxides of copper, silver, nickel and most other metals do not solder well. Copper oxide is a semiconductor that can cause noise in high frequency circuits. Electroless nickels are good diffusion barriers, particularly high phosphorus deposits. Electroplated nickel, cobalt, and palladium can be soldered if aggressive solder fluxes can be used (RMA, or certain organic acids). (ref 1)

Gold is often prescribed for soldering applications. However, it is well known that gold is soluble in most solders. Gold in the tin solders can resulting dull, weak, solder joints when the level of gold contamination is high enough. (ref. 2)

If gold is to be used for soldering or bonding, a diffusion barrier between copper and gold must be used.

Electroplated gold using pulse rectifiers can produce gold deposits with little or no porosity on a properly prepared surface allowing the use of thinner deposits. Immersion gold deposits are used over electroless nickel for soldering for non-critical applications.

Electroless gold has gained popularity because of the ability to plate isolated areas without electrical contact. Electroless gold is difficult to maintain and control to achieve consistent results.

Good diffusion barriers are electroless nickel-phosphorus, electroless nickel-boron, cobalt and electroplated nickel comes a close second. According to AES Project 29 (ref 3) electroplated cobalt and electroless cobalt-5% phosphorus, and electroless nickel-8% Phosphorus performed the best as diffusion barriers. Turn & Owen reported nickel-phosphorus and nickel-boron to be effective barriers after 12 hours at 550 C. (ref 4)

Via hole filling

Very large-scale integrated circuits (VLSI) use multilevel circuit interconnections to provide high density and reliability in a compact structure. Before metallization, It is essential to fill the via holes with a conductor to produce high-reliability interconnections.

During fabrication, a layer of metallization is deposited on the silicon wafer, and conductors are etch-defined. A layer of dielectric is then deposited and windows (via holes) are etched through the dielectric to connect points on the metallization. The next layer of metallized conductors is then applied to form interconnections. Using this technique, the upper layer is not completely planar because of the depth of the via holes. This problem is compounded when additional layers are required to complete all interconnections. It is important to have a planar (flat) surface topography at all stages of production, or stress, etching irregularities and serious problems in lithographic patterning can result. Electroless nickel or electroless copper serve to fill the via holes and achieve a planar surface. (ref 2) Additional reference to via-hoe filling are (ref 3)& (ref 4).

Flip chip devices using electroless nickel and immersion gold have gained popularity. Bumps are electroformed through various masking techniques, using nickel, copper or plated solder, then over plated with immersion gold. For wire bonding to these bumps, (except solder bumps) electroless palladium is plated over the electroless nickel followed by immersion gold.

Corrosion Control

Corrosion of electronic components is destructive in many ways. Loss of surface conductivity, increase in contact resistance, deterioration of the component, broken connections, soldering, brazing and wire bonding are made difficult. Failures in dielectric between metal lines due to accelerated corrosion when voltage gradients are applied. Chang (ref 9) reported that in the absence of a voltage gradient, corrosion was only just apparent after 2000 hours, but corrosion was observed within 50 hours with a 25 volt potential difference, between the two conductors 0.5mm apart. The corrosion rate increases linearly with increasing potential differential. Selecting the right plated coating will lessen or eliminate corrosion under these circumstances. Electroless nickel- phosphorus is a good protector of circuit elements. Electroless nickel and to a lesser extent electroplated nickel plus gold at a thickness to assure the elimination of porosity serves very well. Tin could migrate under potential differences and offers much less corrosion protection.

Ceramic Hybrid's and MCM-C circuits

Metallization materials such as Manganese, molybdenum-manganese, Tungsten, and thick film materials such as silver alloys, copper alloys, etc. all need corrosion protection. Electroless nickels offer excellent protection to all these materials. Combinations of electroless nickel -gold and electroplated nickel-gold offer high quality surfaces. However, a combination of electroplated nickel or electroless nickel-phosphorus plus electroless nickel-boron provides not only corrosion protection, but a solderable, brazable, and wire bondable surface. Using electroless nickel-boron, hermetic brazed seals can be accomplished without fear of cracking or leaks.

EMI Shielding

Plated EMI shielding, although not new, is becoming essential to electronic device protection. Plated electroless copper and electroless nickel offers many advantages over conventional shielding. It can be used to plate non-conductors such as various plastics. The plated shielding has the best shielding characteristics of any of the coatings available.

Electronic connectors

Aluminum hermetic connectors require electroless nickel to provide a hard surface for the aluminum, and corrosion protection. Plastic connectors are made possible by use of electroless nickel deposits to form a hard electrically conductive surface.

Printed circuits

Printed wiring broads (printed circuits) use electroless copper for connecting one side to another ("plated-through hole process"). Additive circuits are also made using electroless copper. Electroless nickel has been used successfully both for plated through holes and for additive circuits. The advantage of electroless nickel-boron for plated through holes is smaller diameter holes can be successfully plated where electroless copper often will not completely plate on all surfaces leaving voids or no connection at all. Elimination of formaldehyde, a hazardous material is another incentive to substitute electroless nickel. Electroless nickel-boron solutions produce a small amount of hydrogen. The gassing draws solution up through the holes and allows uniform deposits. Holes as small as 0.010" 1/2 inch long have been plated with complete connection reliability. Electroless copper failed to connect any of the 300 holes tested. Electroless nickels serve as a good undercoat for all other plating. Plug in fingers are enhanced in hardness and wear resistance by using electroless nickel as an under coat for gold. Sliding contacts are made more reliable with electroless nickel under coating.

Direct plating through holes for two sided and multilayer-printed wiring offers some advantages over the use of catalytic activators and electroless copper. One method uses conductive carbon in the holes followed by copper electroplating. Thus eliminating the hazardous chemicals of electroless copper plating

Electroplated palladium, palladium-nickel alloys and electroless palladium deposits perform as a substitute for gold plating in some applications. Combinations of palladium and electroless nickel fill other applications where wire bonding, die bonding or soldering is required. Aluminum wire can be bonded to electroless nickel-boron without fear of Kirkendall voids, or weak bond joints. Ultrasonic bonding with higher energy than is used for gold makes a long lasting strong aluminum wire bond. Nickel cannot be thermal compression bonded using the present techniques.

Palladium, palladium-nickel alloys and electroless palladium deposits are used for hybrid, DIPs and MCM's for several reasons. An oxide free surface allows palladium to be soldered and wire bonded easily compared with nickel. A thin (0.025-0.05 micro meters) gold over layer is sometimes used to enhance soldering. The solderability of palladium remains good even without the gold layer.

(Process steps for preparation and plating of metallized ceramics can be found in reference 5).

Plating of metals and alloys never before possible to deposit is made possible using pulse plating rectifiers.

Examples are gold- Iron, chromium-Iron, cobalt-nickel-iron, chromium-nickel-iron, Nickel-Titanium-iron and possible others. Further control of the structure of the deposits is possible. For example, "super lattice" alloys can be produced as well as ductile amorphous alloys. Metals which have been reported using pulse plating are: Germanium, Indium, Lanthanum, Lithium, Magnesium, Manganese, Molybdenum, Neodymium, Phosphorus, Praseodymium, Platinum, Rhenium, Ruthenium, Tellurium, Titanium, Thallium, and Zirconium. Commonly plated metals benefit by pulse plating in that more uniform electrodeposits are possible for most metals as well as improved ductility and deposit leveling.

References

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