Abstract of the Papers Presented

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Gold Plating of Printed Circuit Boards Processed with Solvent Soluble and Fully Aqueous Resists

The processing of printed circuit boards (PCB's) often includes the application of light - sensitive dry film resists (also called photo resists) which are of major importance when boards have to be full body plated with gold. If the gold electrolyte develops large amounts of hydrogen, an undesired under-migration and also liftoff of the resist is the consequence. The effect can be observed particularly when hard gold has to be deposited on contact areas of PCB's.

There are several possiblities of avoiding this problem by using appropriate bath types with high current efficiency.

Sufficiently wear resistant gold deposits can be achieved by codeposition of small amounts of the alloying metals - Co, Ni or Fe. Bath and deposit characteristics of Au/Co and Au/Ni-electrolytes are compatible with resists applied usually. The electrolytes exhibit current efficiencies of about 70%. The deposits show Vickers hardness values of 180 HV or 150 HV respectively.

Gold electrolytes (with a pH value in the range 6-7) reach current efficiencies of 90%. By the addition of a non-metallic additive, the hardness is increased up to 250 HV. Subsequently these deposits qualify for low-voltage connector applications.

For fully aqueous photo resists (which are very sensitive to a too high pH-value), a gold bath with an extremely low pH of 0.6 and a current efficiency of 85% is recommended. The deposit with about 0.8% of Sn as an alloying partner has a hardness of about 230 HV.

The properties of the baths "Auruna 528, 529, 556 and 332" and the deposits achieved from these are suitable for plating on contact areas on PCB's. An undermigration of the resist by hydrogen is avioded.

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Fine Gold Baths for Application in Electronics

The term "fine gold" always means primarily that the gold layer has a fine content of approximately 24 carats. In practice, layers are included here that contain at least 99.9% Au. Fine gold is used to a limited extent in the form of hard gold layers for contacts, but mainly in the form of soft fine gold, for bonding applications.

MIL specification-MIL-G-45204 B, amendment 2 of 26 February 1971- classifies the purity of gold layers into three classes (Type I, II and III and four defined grades of hardness A,B,C and D) (Table 1). This specification says nothing regarding the hardness that layers of different types can or should have. In principle the possiblity exists that all four defined grades of hardness (i.e. grade A,B,C,D) can apply to fine gold type III.

Hard fine gold for connector applications

Hard fine gold is mainly used for connectors in the field of printed circuit technology. Here a resist compatible gold bath with a high current yield is required for photoresist layered printed circuit boards within the framework of full body gold plating of contact areas (i.e. for separable contacts), which supplies layers that are still sufficiently abrasion resistant.

Table 1

MIL - SPECIFICATION
MIL-G-45204 B AMENDMENT 2, 26 FEB. 1971

CHART 1

PURITY
TYPE I : > 99.7% Au
TYPE II: > 99.0% Au
TYPE III: > 99.9% Au

HARDNESS (KN = 1.15 x HV)
Grade A: < 90 KN (Knoop)
Grade B: 91 - 129 KN
Grade C: 130-201 KN
Grade D: > 201 KN

FREE CORRELATION OF PURITY AND HARDNESS

CHART 2

CORRELATION OF PURITY AND HARDNESS
RECOMMENDED BUT NOT COMPULSORY
TYPE I + Grade (A), B or C
TYPE II + Grade B, (C) or D
TYPE III + Grade (A)

CHART 3

DEFINITION
FINE GOLD - TYPE III (> 99.9% Au)
HARD FINE GOLD (FOR CONNECTOR FUNCTIONS) - TYPE III Grade C / D
SOFT FINE GOLD (BONDGOLD, PURE SOFT GOLD) - TYPE III Grade A

It is essential in this type of full body gold plating that the resist - whether solvent or alkaline soluble - should not be undermigrated by the development of hydrogen or damaged by too high a pH-value: this would make the printed circuit board unusable.

The purity of the hard fine gold layers is 99.9%; the hardness is around 250 HV. Thus the layer can be classified as type III, grade D according to the MIL specification MIL-G-45204 B. Despite the high level of hardness, the layers have excellent ductility. This is advantageous where printed circuit boards are processed mechanically at a later stage, i.e. where contours are mill cut. Internal stress is low. Tensile stress values are around + 10 N/mm^2. The layers have a very low and constant contact resistance.

The relatively low abrasion resistance can be improved within certain limits by a subsequent very thin coating with hard gold in a conventional Au/Co bath.

It should be mentioned here that in some cases special Au/Co and Au/Ni baths (like Auruna 556, 528 or 529) are suitable for the application described above. These have a current yield of 65-75% as a result of their pH values of 4.7 to 4.9 and their bath composition. Layers with a caratage of about 23.9 can be achieved with these baths and are superior to hard fine gold with regard to their abrasion reistance, but the Au/Co and Au/Ni baths are inferior to the fine gold bath with a hardening agent with regard to the current yield, i.e. with regard to the development of hydrogen.

Soft fine gold for bonding applications

The term "bonding" is used to cover certain types of combining components in electronic module. A distinction needs to be made between chip bonding and wire bonding; in the latter, a connection of the contact surfaces on the chips is made to the lead-frame using wires. For the new fine gold baths for bonding purposes presented here, the use of wire bonding is at the focus of interest. Differentiation of the various procedures is made with wire bonding according to the mechanical strucure of the bonding device, the type of wire and the connecting mechanism. Further details can be found in the relevant specialist literature.

Wires used in wire bonding are usually gold or aluminum. Bonding takes place onto base made of electroplated gold, silver or sputtered aluminium. The concern here will only be with bases layered with fine gold.

Bond gold layers from a new type of bath show similar qualities for thick wire bonding with Al wire as layers from classic, very widely used baths containing arsenic/hydrazine. The main advantage of this new type of bath is that considerably higher deposition speeds can be achieved through the possiblity of using higher current densities. Furthermore, the new type of bath contains neither arsenic nor hydrazine, so that a better bath stability and thereby easier bath operation is guaranteed. All additives can be detected through analysis. The absence of thallium and lead means that failures arising from the segregation at grain boundarels of these grain refiners can be ruled out.

The effects of bath impurities such as Cu, Ni, Fe, Zn etc. on the bonding capabilities of the new type of fine gold layers and the durability of wedge-wedge bonds are the subject of further investigations, which are to be published at a later date. The influence of pulse plating on the strucutre of the layers and temper qualities have also not yet been investigated.

Immersion Gold and Electroless Gold

For the deposition of metals from solutions containing metal salts, negative electrical charges are required which convert the positively charged metal ion into the zero-valent state, i.e. into the metallic form. In the case of electrolytic metal deposition, a rectifier provides the necessary charges for the reduction at the cathode. In electroless gold deposition, charges are either supplied by charge exchange reactions or derived from chemical reduction agents.

In the case of a charge exchange (Auruna 510, Auruna 511), the lesser noble metal, usually the base material, dissolves, while the more noble metal ion in the solution is reduced and deposited on the substrate. Apart from charge exchange, this process is also called **exchange process, immersion gold-plating** or **cementation.** The layer thickness of immersion plating is limited to about 0.1 to 0.2 µm.

In the case of "electroless metal deposition" , a suitable chemical compound (a reducing agent), supplies the necessary negative charges. The reducing agent is oxidized at the same time. It is also called reductive or autocatalytic goldplating.

The following requirements are essential for a bath:
-high bath stability
-relatively low self-decomposition of the reducing agent, therefore use of DMAB = Dimethylaminoborane
-deposition speed as high as possible and constantly maintainable
-low tendency to random deposition
-long lifetime (metal turnovers)
-simple bath maintenance
-low sensitivity to metallic contaminants

Auruna 515 satisfied these requirements with the exception of the sensitivity to metallic contaminants, particularly to Ni and Sn ions. This can be overcome, however, by previously inserting a charge exchange process before the actual chemical gold-plating. This previously inserted process traps the nickel ions gone into solution from the substrate and thus makes for a long lifetime of the chemical gold bath.

This new electroless gold electrolyte has an ideal combination of opposite properties as stability on the one hand and relatively high deposition speed on the other hand, combined with a long lifetime of the bath. Per litre of bath, in rack operation up to 14 metal turnovers are possible if the bath is suitably maintained i.e. 14 x 2.5 g/l = 35 g of Au per litre of bath can be deposited.

The speed of 2.5 µm/h can be kept constant during the lifetime of the bath by adding an accelerator compensating the pile-up of cyanide.

Random deposition and bath decomposition do not occur during the whole lifetime of the bath, if the drag-in of nickel and tin ions is avoided. This is possible by simply inserting a previous charge exchange (immersion) bath. A clean way of working must be observed.

During the lifetime of the electrolyte no significant change occur with regard to the deposition characteristics of the bath and the coating properties. The bath maintenance may be called easy.

Electroless reductive gold-plating are mostly used in the electronics industry, e.g. on printed circuit boards and in semiconductor electronics. Contact areas are to be named here - bonding surfaces on chip carriers, particularly of ceramics, parts with glass-insulated bushings, transistor parts, cases and many others.

New Environmentally -Friendly, Anti-Tarnish Process for Silver not Containing any Halogenated Hydrocarbons as Solvent

Unprotected silver and silver-plated surfaces easily tarnish in air due to sulphur-containing compounds in the air forming silver sulphide and cause the discolouration.

Conventional anti tarnishing processes are based on chromate or on systems consisting of halogenated hydrocarbons and organic sulphur compounds. Due to changes in environmental legislation, new developments became necessary - especially to aviod the usage of halogenated hydrocarbons or fluorohydrocarbons as solvents.

A new aqueous system called Antitarnish 613 contains a water soluable, totally environmentally friendly, organic sulphur compound and can be used to protect either dry parts or wet parts. The new process is a completely novel immersion process on an aqueous basis to avoid tarnish effects on silver. The protective effect is at least as good as that of the systems used customarily up to now using vaporizable organic solvents or electrolytical chromatizing. The immersion solution does not contain any components harmful to the environment, particularly no chlorinated hydrocarbons or chomium compounds. If treated correctly, silver-plated articles are provided with a safe storage protection which is to some extent fast to handling and rubbing but is not washer-proof.

Solderability and surface resistivity of electrical contacts are not influenced by the protective layer. The protected silver coatings can be bonded. The new process is in fact predominantly intended for use with electrotechnical, silverplated components (contacts); the process, however, can also be used for decorative applications, because the protective film adversely affects neither the brightness nor the colour of silver.

The Antitarnish 613 also protects copper against oxidative discolouration and prevents silver migration on thinly gold-plated silver.

The protective capacity can not be tested by immersing the protected articles in solutions of potassium sulphide (potassium polysulphide, liver of sulphur). This alkaline-aqueous solution would remove the protective layer. Gas tests with a hydrogen sulphide component are suitable.

The thioacetamide test (TAA-test), e.g. according to ISO 4538 can be recommended. The parts to be tested are placed in a desiccator, in the bottom part of which there is a dish containing 3 parts by weight of sodium acetate trihydrate and 1 part by weight of water (saturated solution) and in the upper part there is a dish containing thioacetamide (powder). The test pieces are kept in the desiccator for several days at room temperature. An unprotected silver-plated part serves as an object of comparison. The protected articles will not discolour for at least 3 days in this test.

The test can be hastened up very much and accelerated by keeping the article in a drying cabinet at 40° C for a period of 16 hours (corresponds to approx. 3-5 days at room temperature).

Well-protected articles do not show any or at least only minimal discolouration; in comparison unprotected silver will take on a dark-violet tarnish.

The anti-tarnish protection can be completely removed by cathodic degreasing in an alkaline degreasing bath.

The active ingredient is not a hazardous substance as defined by the hazardous substances regulation. It can be adsorbed by activated carbon and can be burnt with it. The spent solutions can be disposed off by stirring these with 4 g/l of activated carbon at room temperature for several hours and to filter them subsequently. The filtrate (water) can be discharged into the works waste waters.