''ज्ञान, विज्ञान आणि सुसंस्कार यांसाठी शिक्षण प्रसार'' - शिलंगणगुरु डॉ. बापूजी साळुंखे
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Electro Deposition of Metals

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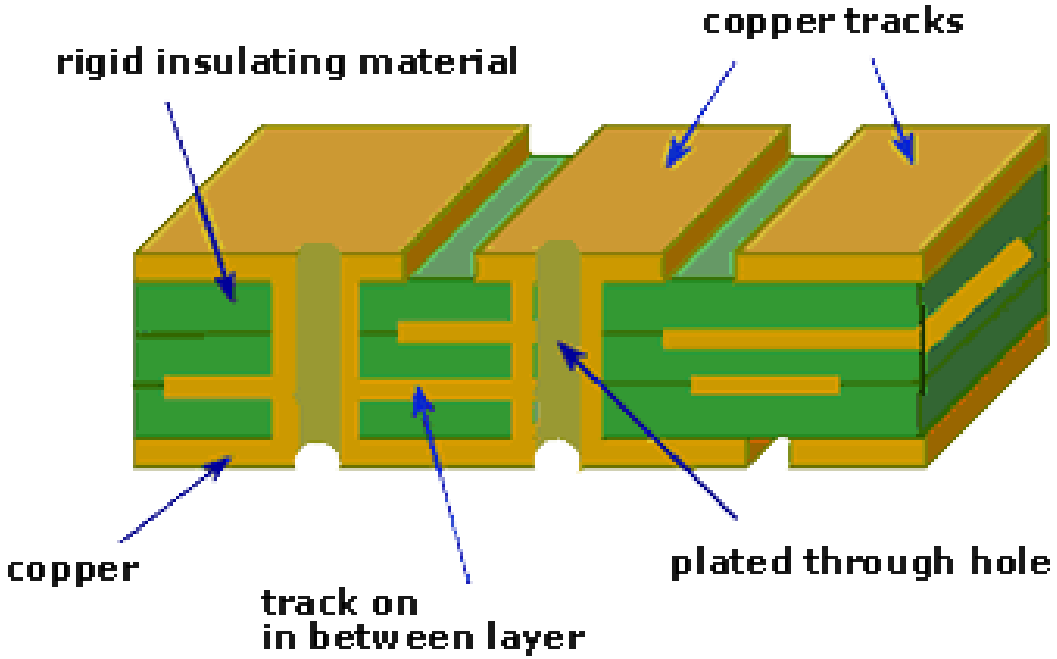
Electrodeposition of Metals

On the multilayer PCB Board, holes are drilled through the stacked layers. Individual layers have to be electrically interconnected to others – how is this done?

How is the Copper foil itself made prior to it being bonded to form the PCB laminate?

ELECTRODEPOSITION

Multilayer Board



Electrodeposition of Metals

History – Electrodeposition can be traced back to 1805

Luigi Brugnatelli demonstrated that a thin layer of gold could be deposited onto silver by a voltaic pile method.

By 1839 copper plating processes developed for printing plates in Britain & Russia

By 1840 Cyanide based systems developed for Gold and Silver

By 1850 Techniques being applied for Brass, Nickel, Tin, Zinc in engineering.

Electrodeposition of Metals

1870 – 1940 Processes refined and improved for large scale production

1950 – 1970 – Developments on acidic plating techniques as opposed to strongly poisonous cyanide ones pursued.

1970 – Present – Industry forced more and more to comply with regulatory laws governing waste, pollution etc.

Electrodeposition of Metals

Typical Applications

Jewellery & Decorative Objects

Engineering – corrosion resistance, abrasion resistance, soft metal coating on threads (copper)

Electronics – Copper, Tin, Gold and Silver use for good electrical conductivity, oxidation resistance.

Electrodeposition

Generally Subdivided Into

Electroless Plating

&

Electroplating

ELECTROPLATING

Generally requires a conductive surface for deposition onto, i.e. a continuous conductive path for all surfaces to be plated.

Conductive path also has to be connected to an electrode which has a voltage applied between it and another opposing electrode.

Electrodes and parts for plating are generally submerged in a suitable solution – i.e. a sea of ions. Current passed through solution,

Common metals for plating include; copper, nickel, chromium, silver, gold etc.

ELECTROLESS PLATING

Doesn’t require a continuous conductive path for plating onto – Plating can be done straight onto plastics and other substrates.

Generally 2 mechanisms for electroless deposition – galvanic displacement reaction or autocatalytic

Galvanic displacement relies on relative positions in electrochemical series.

Autocatalytic requires the employment of a catalytic metal to kickstart and aid sustainment of the reaction

ELECTROLESS PLATING

Initial deposition is rapid

Process does however slow down after a certain thickness is reached – e.g. a few hundreds of nanometres for silver, a few microns for copper.

Metal ions in solution may have to be replenished for it to remain active.

ELECTROPLATING is generally applied after ELECTROLESS PLATING to build up thickness.

Common electroless metals are; copper, nickel/phosphor, silver and gold

ELECTROLESS PLATING

Electroless Plating by galvanic displacement

This technology has been known for many years and was exploited in the development of batteries. A battery generally has electrodes that are made of different metals (different electrode potentials) and an electrolyte – i.e. a sea of ions

The technology has also been exploited for metal plating such as a process for silvering mirrors.

ELECTROLESS PLATING

Steps of a process for the silvering of mirrors

Flat glass substrate is immersed in stannous (tin) chloride and rinsed – a small dispersion of tin ions remain on the surface

The substrate is then immersed in a solution containing silver nitrate and other chemicals e.g., ammonia, hydrochloric acid, IPA.

A small amount of formaldehyde is added to the solution and the reduction occurs of silver ions in the nitrate to silver metal on the surface where the tin is present.

ELECTROLESS PLATING

Reaction relies on the reduction of silver ions to silver metal. This is caused by the presence of tin in the stannous chloride which is coated over the surface prior to plating. This is due to the position of tin compared to silver in the electrochemical series.

Electrochemical Series

a serial arrangement of metallic elements or ions according to their electrode potentials determined under specified conditions The order shows the tendency of one metal to reduce the ions of any other metal below it in the series

ELECTROLESS PLATING

Standard Electode Potentials (Volts)

Iron -0.44
Nickel -0.24
Tin -0.14
Lead -0.13
Hydrogen +0.00
Copper +0.34
Iodine +0.54
Silver +0.80
Gold +0.80

ELECTROLESS PLATING

Tin -0.14

Hydrogen +0.00

Silver +0.80

Tin is more negative than silver and because of this it will cause silver ions to be reduced to silver metal from the silver nitrate solution

ELECTROLESS PLATING

With this silver plating process, a thickness of only a few hundred nanometres (a few tenths of a micron) can be deposited before the process stops.

Process is often referred to as an immersion plating process

Solutions can often be unstable (this one goes cloudy & brown & full of silver after a few minutes)

ELECTROLESS PLATING

Autocatalytic Electroless Plating became common around 1965, when plating on plastic objects achieved a significant development.

Being advantageous in many respects such as uniform precipitation coating, hardness, abrasion resistance, chemical resistance and corrosion resistance, electroless plating became increasingly common especially in precision-machinery industries.

ELECTROLESS PLATING

The demand for electroless nickel plating later increased in such applications as automobiles, intelligent office equipment and optical equipment.

Electroless copper plating is essential in the production of printed circuit boards today.

ELECTROLESS PLATING

Plating solutions generally include organic substances as metal-ion complexing agents and stabilizers.

Of electroless copper plating methods, the Rochelle-salt bath is commonly used to plate plastic objects cosmetically, and the ethylenediaminetetraacetic-acid (EDTA) bath to plate printed-circuit boards. Complexing agents are essential to produce good plating.

Typical copper loading is 2 to 3g per litre of solution

ELECTROLESS PLATING - Autocatalytic

Autocatalytic process requires the presence of a catalyst

Palladium is a popular choice. Platinum and other noble metals have also been used.

In electroless copper, palladium is generally used to kickstart the reduction of copper ions to copper metal from ions in solution

Copper itself is also catalytic (although much less active than palladium)

Hence the term Autocatalytic – once palladium used up, the copper itself acts as the catalyst to sustain the process – deposition slows down though

ELECTROLESS PLATING

Typical Copper Plating solution – e.g. Shipley 3350 will contain chemicals such as; copper sulphate, hydrochloric acid, tetrasodium EDTA (complexing agent), sodium hydroxide.

3 part solution that is mixed prior to plating and remains fresh for typically a few days.

Copper has to be replenished into solution to replace that taken out.

Palladium chloride typically used as the catalytic solution

ELECTROLESS COPPER STAGES APPLIED TO A PCB LAMINATE

1. Conditioning – This ensures that all surfaces are clean and free from grease or metal contaminants – usually done by immersing the substrate in a chemical agent. Deburring of holes also done with rotating brushes

ELECTROLESS COPPER STAGES APPLIED TO A PCB LAMINATE

2. Etching – Also known as Pickling to differentiate it from etching of the copper tracks. Prepares the surface for deposition and removes any deformities left from previous stage. Heated sulphuric acid and hydrogen peroxide solutions are commonly used here.

ELECTROLESS COPPER STAGES APPLIED TO A PCB LAMINATE

3. Activating – To create a chemically reducing surface. 2 processes traditionally used – first of all the laminate is sensitized with stannous chloride solution to leave stannous (tin) ions on the board. Secondly the board is seeded by dipping in acidic palladium chloride. Palladium ions reduced to a colloidal state during reaction with stannous ions.

ELECTROLESS COPPER STAGES APPLIED TO A PCB LAMINATE

4. Deposition – The board is dipped into a solution containing copper ions. The chemically reducing surface of the board (colloidal palladium) causes a reaction and copper is deposited onto the board. Typical thickness is 1 to 5 microns. 25 microns is possible though for high build applications

ELECTROLESS COPPER STAGES APPLIED TO A PCB LAMINATE

A similar process can be performed for the deposition of a nickel/phosphor coating. This is a common engineering process for producing a hard, abrasion resistant coating on components.

Copper can be deposited onto a nickel layer

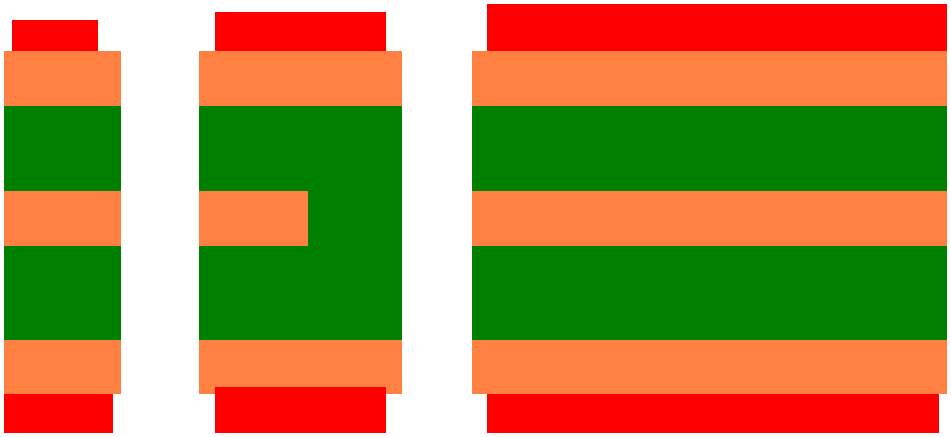
ELECTROLESS COPPER STAGES APPLIED TO A PCB LAMINATE

When multilayer boards are drilled, resin smear can occur – caused by the drill bit heating and softening the resin and laminate. This resin smear can cover regions of the copper beside the holes and therefore insulate. Dipping in a suitable etchant ‘etchback’ etches back the base material between copper layers to expose the copper prior to plating.

ELECTROLESS COPPER STAGES APPLIED TO A PCB LAMINATE

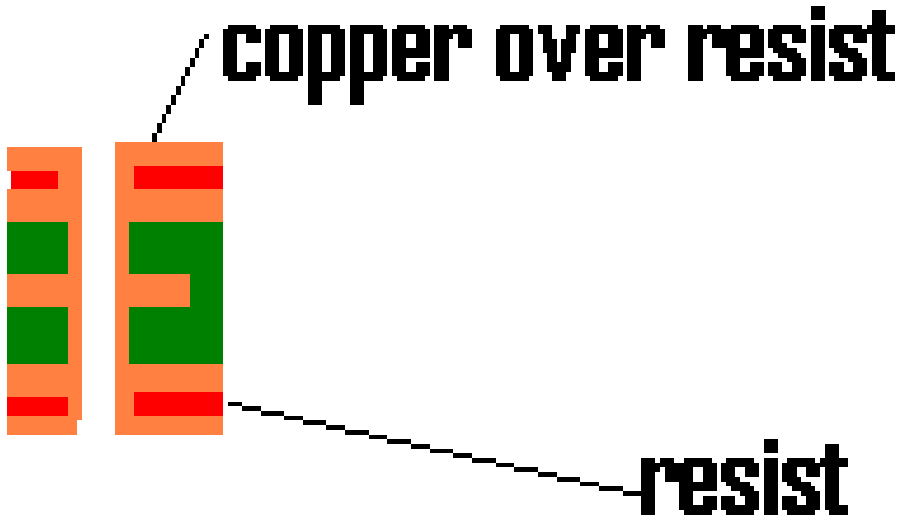
During the electroless plating stage, for the interconnection of the multiple layers by the means of vias, a resist is also used on the top and bottom layer to prevent plating over unwanted areas.

Use of Resist in Plating Through Hole Interconnects



Resist

Use of Resist in Plating Through Hole Interconnects



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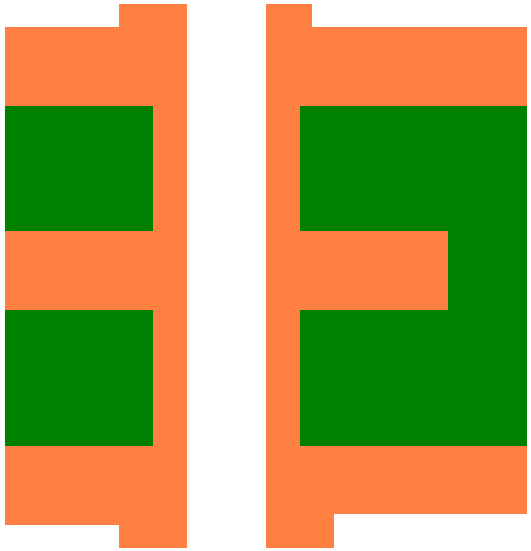
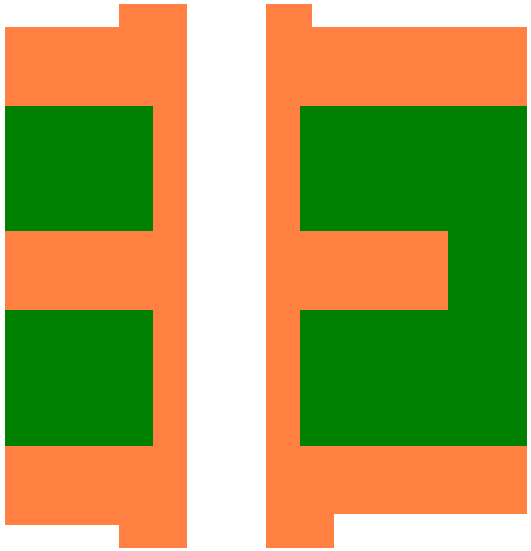


Resist Then Removed to Leave Copper Interconnections

Copper thickness can be built up if required by subsequent electroplating

Use of Resist in Plating Through Hole Interconnects



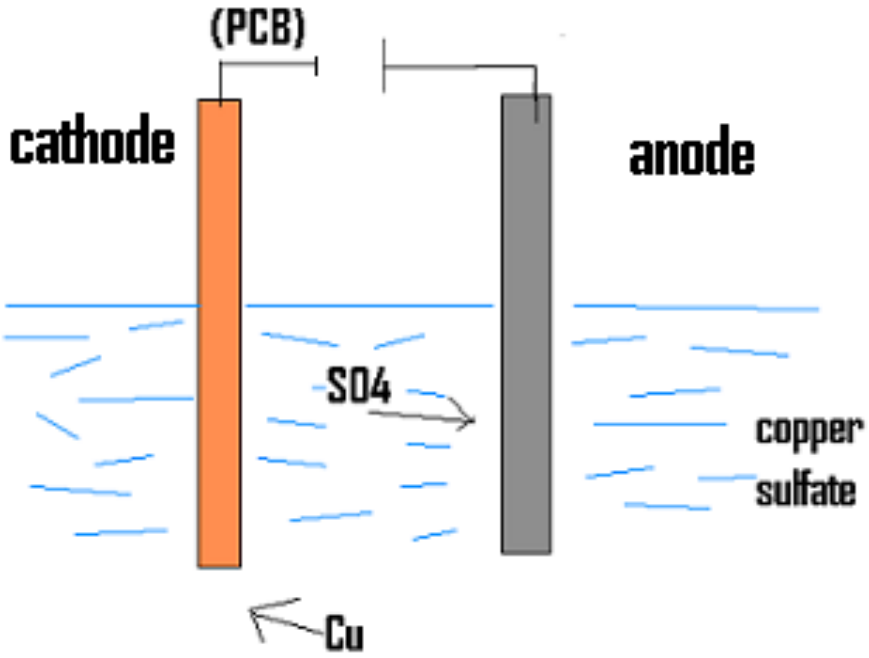
Resist Then Removed to Leave Copper Interconnections

Copper thickness can be built up if required by subsequent electroplating

Electroplating

Copper PCB is used as a cathode (negative charge)
Positively charged copper ions from copper sulfate are attracted to it

SO_4 ions attracted to anode



Electroplating

There must be a continuous conductive path around all circuitry and interconnections on the PCB board when acting as the cathode.

‘Breaks’ then have to be made to isolate parts of the circuitry after the electroplating has been complete.

These ‘Breaks’ will be produced via photolithography and etching as described before.

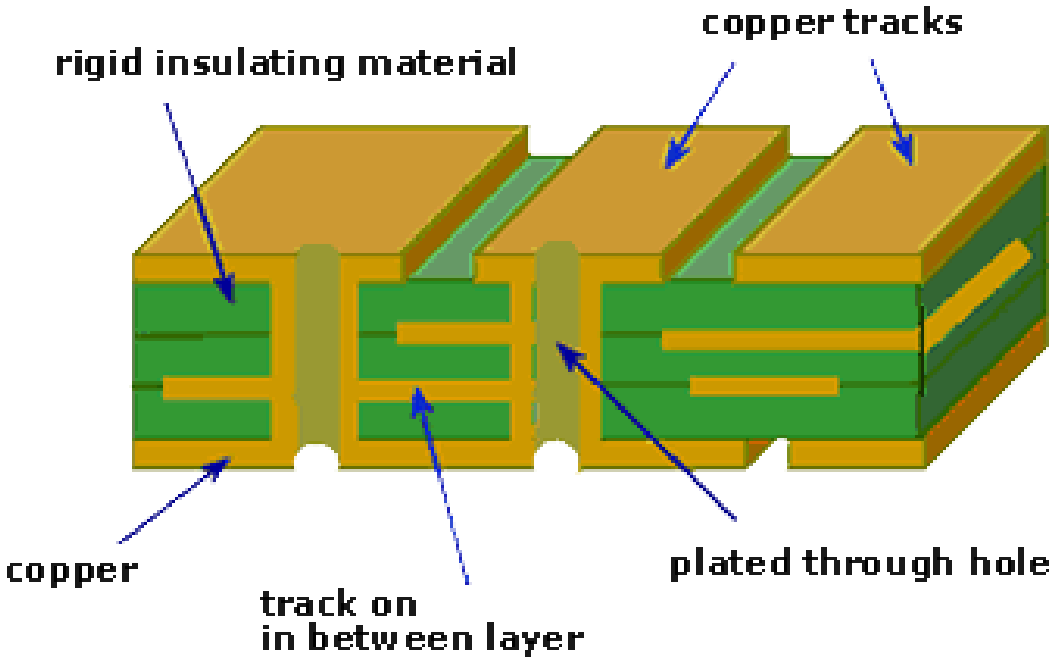
Electroplating

Electroplating is used to build up a much thicker metal layer, i.e. to much greater thickness than a few microns.

Common electroplated metals include, copper, nickel, chromium, zinc, gold, silver

Speed of deposition is related to the concentration of the solution and the voltage applied between cathode and anode, i.e. current density through the solution.

Completed Metallised Board



Completed Metallised Board

Solder paste can now be applied to the regions where components are to be surface mounted.

Typically this will be done by applying the solder paste in a screen printing process over the board (top and underside for a double sided board)

Solder Mask can also be used to prevent solder from coating undesired regions – again this can be screen printed or patterned by lithography.

THANK YOU