ABSTRACT

Electroplating in the instrument. Development of technological process of preliminary galvanic copper plating of printed circuit boards.

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The project has developed a technological process of pre-galvanic copper plating of printed circuit boards with a capacity of 80 thousand units / year.

Printed circuit boards are the main element of electronic equipment, performing the functions of the supporting structure and switching device.

Printed circuit Board □ a product consists of a flat insulation base with holes, grooves, cutouts and a system of conductive strips of metal (conductors), which is used for installation and switching of electro-radio products (ERP) and functional units.

Two-sided printed circuit Board □ printed circuit board, on both sides of which the elements of the conductive pattern and all the necessary connections are made. Electrical connection between the parties is carried out by means of metallic holes. ERP can be placed on one or two sides of the printed circuit board. Two-sided printed circuit board is used in measuring equipment, control systems, automatic control.

The boards are produced by the combined positive method. Foil dielectrics are used for the manufacture of boards. Further formation of the pattern of conductors occurs by galvanic deposition of copper using photomasks.

Advantages of the combined positive method: the ability to create elements of the printed image with high accuracy.

Disadvantages of the combined positive method: the presence of digestion operations leads to the appearance of lateral etching of conductors. This limits the resolution of the process.

Galvanic (electrolytic) copper plating is a process in which a conductive layer of the printed circuit board is formed, which determines its operational properties, such as resistance to thermal shock (fast heating and cooling of the Board in the temperature range -20...+240C), cyclic change of temperature, resoldering, maintainability. Copper coating is the most common as the main material in the application of current-carrying tracks, as it has good electrical conductivity and price-quality ratio. The thickness of the galvanic tightening should not exceed 6 microns.

In connection with the operating conditions of printed circuit boards, copper coating lead to certain requirements:

- cryptocrystalline;
- brilliantly;
- no defects;
- plastic;
- good adhesion;
- additional strength to the board.

To meet these requirements, the surface of the printed circuit board must be carefully prepared before application.

Such operations include:

1. chemical degreasing;
2. digestion;
3. combined activation;
4. acceleration;
5. chemical copper plating;
6. activation;
7. several stages of washing.

Chemical degreasing is used to remove organic contaminants and as a result improve adhesion. Degreasing circuit boards is carried out in solution:

$NaOH$ □ 10-15 g/l

Na_2CO_3 □ 20-30 g/l

Na_3PO_4 □ 50-60 g/l

Na_2SiO_3 □ 3-5 g/l

The processing time is 1-3 minutes, at a temperature of 50°C. After degreasing, it is necessary to wash the board in warm water, then in cold water to remove the reagents from the surface.

The next stage is digestion. It is carried out to remove oxide films and give the surface a special microrelief.

Solution:

$(NH_4)_2S_2O_8$ □ 200-250 g/l

H_2SO_4 □ 10-20 g/l

Processing time □ 0.5-1 minutes, at room temperature with vibration.

Mechanism of digestion:

$$(NH_4)_2S_2O_8 + Cu \rightarrow CuSO_4 + (NH_4)_2SO_4;$$

$$H_2SO_4 + CuO \rightarrow CuSO_4 + H_2O;$$

Then the combined activation is carried out, it provides the creation of catalytically active centers on the dielectric before the chemical copper plating process.

Solution:

$PdCl_2$ □ 0.2-0.5 g/l

$SnCl_2$ □ 10-15 g/l

HCl □ 20-25 g/l

$NaCl$ □ 180-200 g/l

Na_2SO_4 □ 65-70 g/l

The processing time is 7-10 minutes, at room temperature.

The mechanism takes place in 4 stages:

1. The first stage occurs in the activation solution. The filling of the catalyst of microcavity and its adsorption on the surface.

2. The second stage □ hydrolysis □ occurs during the subsequent washing of the boards. As a result of washing, hydrolysis of complex salts occurs.

$$PdSnCl + H_2O \rightarrow Sn(OH)Cl + PdCl_2.$$

3. The third stage is treatment in an acceleration solution (NaOH □ 20-35 g/l). Recovering palladium and the removal of the tin salts.

4. The fourth stage is flushing in running water, as a result of the tin salt(IV) are washed off and adsorbed palladium particles remain on the dielectric surface.

To ensure the continuity of the metal layer, a chemical copper 1 μm thick is applied.

Solution:

$CuSO_4 \cdot 5H_2O$ □ 10-15 g/l

$KNaC_4H_6O_6 \cdot H_2O$ □ 50-60 g/l

NaOH □ 10-15 g/l

Na_2CO_3 □ 2-4 g/l

HCHO (37%) □ 10-15 g/l

$Na_2S_2O_3$ □ 1-2 g/l

CH_3OH □ 0.1 g/l

Processing time 20-30 min, at room temperature, pH = 12,6-12,8 .

The mechanism of copper deposition:

$$Cu^{2+} + 2HCHO + 4OH^- = Cu + 2HCOO^- + H_2 + 2H_2O;$$

adverse reaction:

$$HCHO + H2O \leftrightarrow CH_2(OH)_2;$$

$$2HCHO + OH^- = HCOO^- + CH_3OH.$$

Before the process of galvanic copper plating is necessary to remove the layer of copper oxide films , which could be formed by the interaction of solutions of prior training with a copper surface.

Solution:

H_2SO_4 □ 50-100 g/l

The processing time of 0.3-0.5 min, at room temperature.

For electrolytes from which the copper coating is applied, the conditions are put forward:

- stability of the electrolyte;
- the possibility of using high current density;
- high scattering capacity;
- must be non-toxic;
- no expensive components.

For copper plating is used:

- pyrophosphate electrolyte;
- bortollotti electrolyte;
- sulfate electrolyte.

The sulfate electrolyte of next composition is used in this work:

$CuSO4 \cdot 5H_2O$ □ 60-80 g/l

H_2SO_4 □ 150-160 g/l

NaCl □ 0,03-0,05 g/l

Liconda Cu-R □ 4-7 ml/l

OC-20 □ 0,4-0,6 g/l

The electrolysis i_k = 1,5-3,5 A/dm^2 , at room temperature, the processing time 8-18 min.

Electrolysis occurs using a movable rod, bubbling, continuous electrolyte filtration. Anodes are used low phosphorus anodes.

The electrolyte is characterized by a higher content of sulfuric acid with a reduced concentration of copper sulfate. This circumstance causes the highest scattering power among acid electrolytes, which is close to the scattering power of pyrophosphate electrolytes. Precipitation of copper is smooth and shiny.

Sulphate copper plating electrolyte is prepared as follows. In the bath, filled with 2/3 of the working volume of demineralized water, poured with stirring sulfate acid. Then, in the heated solution, copper sulfate is added with stirring, its volume is adjusted to the required volume and the remaining components are introduced in accordance with the formulation.

The final operations after the pre-galvanic copper plating process are represented by washing and drying.

The drying process is carried out in a drying cabinet at a temperature of 65-70°C, for 7-9 minutes.

At the end of the final operations, the fee is subject to control. External inspection, check the thickness of the coating, surface roughness.

The coating of the Board should be clear, uniform, without blisters, delaminations and tears. Not allowed bumps on the edges, spot etching.

High quality of coatings is achieved by the use of copper anodes of low phosphorus anodes.

The addition of phosphorus performs three functions:

1. Reduces the sliming upon dissolution of the anode;

2. phosphorus binds monovalent copper into an insoluble C_3P compound, which forms a dark film on the anode. The film prevents the reaction of disproportion, but does not prevent dissolution to Cu^{2+};

3. the film prevents oxidation of surfactants at the anode.

To prevent the accumulation of anode sludge requires constant or periodic filtration of the electrolyte. Anodes are used in covers made of special acid-resistant fully synthetic material.

For wastewater treatment, the company uses a reagent treatment method. Cleaning shall be alkaline wastewater (operations: degreasing, acceleration), acidic wastewater (operations: digestion, pickling) and acid with a content of Cu^{2+}.

Waste water treatment from copper ions is carried out by converting copper ions into slightly soluble compounds (hydroxides or basic carbonates) in the neutralization of waste water using a variety of alkaline reagents (calcium hydroxides, sodium, magnesium, calcium oxides, sodium carbonate, calcium, magnesium).

$$Cu^{2+} + 2OH^- \rightarrow Cu(OH)_2\downarrow$$

A periodic cleaning scheme is used.

1) Acidic and alkaline effluents are fed into the reactor averagings, where depending on the pH value is added to the alkaline or acidic agent. At the output of the average pH is 6.5 – 8. Then the water enters the storage tank, because it needs demineralization.

2) The transfer of copper ions into a slightly soluble compound occurs in a neutralizer reactor with the addition of an alkaline agent to pH = 9 □ 10. The duration of settling is not less than 2 hours. The sludge moisture content is 98-99,5%.

3) The precipitate is fed to a mechanical filter, where it is separated from the liquid.

4) The Liquid passes through the coal filter and enters the container for accumulation, the sediment goes for disposal.

5) Water with high salinity from the storage tank enters the reverse osmosis.

6) Purified water is returned to the production cycle.

The main advantage of the reagent method is effective neutralization of acid-base effluents of different volumes with any given concentration of heavy metal ions.

Disadvantages: significant consumption of reagents, obtaining sludge that must be disposed of, increasing the salinity of wastewater requiring additional treatment, significant operating costs.

In the chemical industry, automation is given a lot of attention, because automated lines provide higher performance of the equipment and have a significant number of advantages:

• reduction of manual labor costs, which is an important factor in working conditions in toxic and aggressive environments;

• compliance with clear regulations of the technological process;

• reduced power consumption;

• reduction of irretrievable losses of non-ferrous and precious metals.

Thus, the galvanic baths in the automatic line are equipped with sensors and devices for monitoring and regulating the values of parameters:

• temperature;

• level;

• number of additives in the electrolyte;

• voltage;

• current.

In automated systems, temperature measurement is carried out on the basis of the physical properties of bodies functionally related to the temperature of the latter. The process of preliminary galvanic copper plating is carried out at room temperature 15...25 °C. The temperature can be measured by different types of thermometers.

During the application of copper coating may vary the composition of the electrolyte, its volume. The volume of the electrolyte may vary when it is sprayed during unloading of parts.

No less important parameter of the copper plating process is the current density. With a decrease in the current density, the metal deposition rate decreases, and with an increase in the coating will be spongy, powdery.

Control of the amount of additives in the electrolyte is no less important, because they provide uniform deposition of the coating, gloss and plasticity.

In this project, the main technical and economic indicators were calculated:

1. Price □ 4080000 UAH/year;
2. The number of employees is 8 employees;
3. Cost □ 2717023,69 UAH/year;
4. Profit □ 1362720 UAH/year;
5. Investment □ 6581819,736 UAH;
6. Profitability of production □ 50%;
7. The period of return of investments □ 4.83 years;
8. Economic efficiency □ 0.21
9. Capital productivity □ 0.88 UAH/UAH;
10. Capital intensity □ 1,136 UAH/UAH.

During the calculations revealed that the shop is cost-effective and economical. The period of return on investment is 4.83 years, which indicates the demand for goods in the market and their competitiveness.

Safety measures at work on galvanic production provided by the project:

- elimination of direct contact of employees with the initial materials, blanks, semi-finished products, finished products and production waste that has a dangerous effect;
- complex mechanization and automation of production;
- application of collective protection of employees;
- rational organization of work and rest in order to prevent monotony, as well as reducing the severity of labor;
- timely receipt of information on the occurrence of dangerous and harmful production factors on separate technological operations;
- implementation of process control systems, which provide workers protection and emergency shutdown production equipment.

Key words: pre-copper plating, a sulfate electrolyte, the low phosphorus anodes, bubbling, galvanic bath, the waste water, the scheme of automation.