Practical Research on Electroless Copper Plating Technology on Ceramic Surface

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Abstract: Deposited electroless copper layer on ceramic matrix by using formaldehyde reduction copper plating system to complete DPC seed layer. Used orthogonal experiment, single factor analysis and other methods to optimize solution parameters, the optimum parameters of electroless copper plating bath are as follows: Cu SO₄ 8g/L, C₆H₅O₆KNa·4H₂O 40g/L, HCHO 10g/L, temperature 35 °C and time 30min respectively. Adopted scotch tape, microstructure, composition analysis, temperature cycling test and a variety of other test methods to comprehensively analyze the performance of the electroless copper layer, it turned out that electroless copper has fine electrical and mechanical performance.

Keywords: Ceramic substrate ;DPC ;Electroless copper plating

1. DPC ceramic substrate manufacturing process

DPC ceramic substrate has excellent thermal conductivity, high line alignment precision, stable chemical properties and high mechanical strength, which is suitable for high power LED packaging process[1]. The whole process flow is shown in Figure 1-1. Firstly, the through-hole fabrication of the ceramic substrate is completed. Usually, the laser technology is used to quickly punch the holes, so as to realize the electrical interconnection in the vertical direction of the substrate. The magnetron sputtering layer of seed layer is generally adopted. Titanium and copper are used as seed layer materials. Titanium as an adhesion layer can improve the bonding strength between the seed layer and the ceramic matrix. In the yellow light environment, a dry film is applied on the surface of the seed layer[2], and exposure and development are required to obtain the desired The advantages of the line and dry film process are that the homogenization process is eliminated, the process is simplified, and the multi-layer stacking is easy to be realized, and the line structure having a thickness of several hundred micrometers can be produced. Even if a single layer of dry film is used, the line thickness can reach about 50 μm. Therefore, the vertical sidewall structure can be obtained when the line is thickened; then the plating[3] thickens the line to improve the conductivity and current impact resistance of the line; the nickel gold process, after the copper layer is thickened, on the surface of the copper layer Complete the nickel-gold layer, you can use the chemical nickel-gold process, or electro-nickel, sputtered gold layer to complete the nickel-gold lay-er, nickel as a barrier layer, to prevent the active copper atoms drift into the gold layer, affecting Layer properties, the gold layer as a protective layer and a solder layer, on the one hand can protect the copper layer from oxidation, on the other hand, gold has very good soldering performance, easy to ensure the strength of gold wire bonding; remove dry film, then use dry film or other The photoresist is made of a layer of protective layer, the excess seed layer is etched away, and the entire DPC ceramic substrate is prepared by gel removal.
The ceramic material has low wetting property and weak reaction ability with metal. How to realize deposition of seed layer on ceramic surface is a difficult problem to be overcome by DPC process. The DPC substrate preparation process flow chart of Figure 1-1 uses magnetron sputtering to complete the metallization of the ceramic surface. The coating has good bonding strength and high purity, which is the most commonly used method. However, magnetron sputtering equipment is expensive, requires a vacuum environment, and has low efficiency, which directly leads to higher price of DPC ceramic substrate, which limits its application range. Electroless copper plating technology is a new scheme for depositing seed layers on ceramic surface. The electroless copper plating layer has excellent performance, good electrical and thermal conductivity, low equipment cost and high deposition efficiency, which can effectively reduce the manufacturing cost of DPC ceramic substrate, so the use of electroless copper plating The completion of the technical completion of the DPC process seed layer is an important research direction for directly plating ceramic substrates.

2. Electroless copper plating process

The electroless copper plating process was first proposed by Narcus in 1947. In the 1950s, a stable commercial plating solution was used, mainly for the through-hole copper sinking of PCB boards. In 1957, Cahill proposed a new type of electroless copper plating solution, tartaric acid. Potassium and sodium are complexing agents and formaldehyde is a reducing agent, which is close to the widely used electroless copper plating formula. PCB hole metallization technology[4] promotes the rapid development and improvement of electroless copper plating technology, and its application fields are continuously promoted. The surface metallization of nanoparticles is completed by electroless copper plating technology, and a new high damping composite material is prepared. Aerospace and other fields; depositing a dense, bright copper layer on the surface of glass, plastics, textiles, etc., greatly enriching the surface decoration effect of the material; achieving metallization on the surface of non-metallic materials, improving its wetting properties, applied to electronics Packaging field[5].

Electroless copper plating[35] refers to the process of reducing the copper ions from solution to copper atoms to form a complete coating on a catalytically active substrate under the action of a suitable reducing agent. Its main feature is that it does not require an applied current, so it is also called electroless copper plating. Electroless copper plating is an autocatalytic redox reaction. Its reaction does not depend on the material properties of the substrate to be plated. As long as the catalytic core induces a redox reaction, the newly produced active copper can continue its subsequent reaction as its own catalyst. Deposit to the desired thickness. According to its process characteristics, the characteristics of electroless copper plating are not limited by the matrix material, metal or non-metal can be realized; without the limitation of the geometry of the substrate, the copper plating process can be completed in the place where the plating
solution can flow; the coating is uniform. The equipment is simple.

The principle of electroless copper plating is similar to electroplating. In essence, the process of copper ions being reduced to copper in the cathode is obtained. The difference is that the electroplating process requires external current drive, while electroless copper plating is not required. A redox reaction occurs to achieve the entire process. The formaldehyde reduction copper plating system has stable properties, excellent plating performance and mature technology. Therefore, it is the most widely used electroless copper plating system. The reaction principle can be expressed by the reaction formula of Figure 2-1[6]:

$$\text{Cu}^{2+} + 2e \rightarrow \text{Cu} \quad (1)$$

$$2\text{HCHO} + 2\text{OH}^{-} \rightarrow 2\text{HCOO}^{-} + \text{H}_2\uparrow + 2e \quad (2)$$

$$\text{Cu}^{2+} + 2\text{HCHO} + 4\text{OH}^{-} \rightarrow \text{Cu} + 2\text{HCOO}^{-} + 2\text{H}_2\text{O} + \text{H}_2\uparrow \quad (3)$$

Figure 2-1 Formaldehyde reduction electroless copper plating reaction

The reaction formula (1) is a process in which Cu2+ is reduced to a simple substance of copper at the cathode, and a cathode reaction formula;

The reaction formula (2) is an electron required for the formaldehyde to release a reaction at the anode, and is an anode reaction type;

The reaction formula (3) is a redox reaction formula of the entire reaction process of electroless copper plating.

The basic conditions for the continuous reaction of formaldehyde reduction copper plating system: the copper plating solution must be alkaline, $p\text{H}>11$, because the reduction of formaldehyde is proportional to the basic value; in the strong alkali environment, sufficient complexing agent is added to prevent the precipitation of Cu(OH)2 in the plating solution; the catalyst must be deposited on the surface of the substrate. Only when the catalyst is induced, the reaction can occur. After the reaction starts, the newly produced active copper can be used as a catalyst for the reaction itself to ensure the continuous reaction.

The complete process of electroless copper plating is shown in Figure 2. The first surface cleaning of the substrate[7] is to remove organic or inorganic impurities such as surface oil and prevent it from blocking the deposition of the catalyst, thus affecting the integrity of the coating. The roughening treatment can etch the surface of the ceramic to obtain a surface morphology favorable for bonding force; the activation-sensitization treatment deposits a layer of catalytic precious metal on the surface of the substrate; finally, the ceramic substrate is placed on the electroless copper plating. The electroless copper plating process is completed in the liquid. The performance of the electroless copper layer is achieved by controlling the bath parameters, and only a continuous optimization of the bath formulation can achieve a good coating.

3. Electroless copper plating experiment arrangement

3.1 Ceramic sample cleaning

The purpose of this experiment is to deposit a layer of seed on the ceramic surface that can be used in the DPC substrate fabrication process by parameter optimization. The main method is to determine the optimal use environment of the plating solution by using single factor analysis. Optimize bath parameters. Ceramic sample preparation: 35mm $\times$ 35mm Al2O3 ceramic, first immersed in deionized water for 10min, to prevent excessive cleaning chemicals from entering the ceramic pores, then the sample is placed in acetone solution, alcohol solution and deionized water for 10min respectively to remove the surface. Organic matter such as oil.

3.2 roughening

The wettability of ceramic materials is poor, the crystal structure and metal materials are quite different, and the chemical force between ceramic and metal plating is very weak. Therefore, the combination mode is physical combination, mainly relying on mechanical occlusion, which is also the “locking effect”. The purpose of roughening is
to properly etch the ceramic surface to enhance the bonding force. The effects of mechanical grinding and chemical corrosion on surface roughness, surface energy and bonding force were compared by Teija Laine-Ma et al.\cite{8} at the University of Tampere, Finland. The results show that the bonding force is not completely proportional to the surface roughness. Mechanical grinding has improved adhesion but the effect is not obvious, and chemical etching can improve the significant plating adhesion. Since the ceramic used in this experiment is relatively rough, the surface of the ceramic sample is etched at a normal temperature for one hour at a concentration of 50 m L/L hydrofluoric acid solution, and the sample is taken out and washed with deionized water to obtain better experimental results.

3.3 sensitization

The purpose of the sensitization treatment is to adsorb a layer of reducing ions on the surface of the substrate for the reduction of catalytic noble metal ions. This experiment uses Sn2+ ions. Because stannous ions are unstable in air, they are easily oxidized into Sn4+ by oxygen in the air, thus losing the ability to reduce precious metal ions. Therefore, when preparing the sensitizing solution, put a little elemental tin in the solution. To prevent it from being oxidized. Stannous chloride has low solubility in water, but it is very soluble in dilute or concentrated hydrochloric acid solution, and stannous chloride has strong reducing ability in acidic environment. Therefore, the sensitization process parameters are determined as shown in Table 3-1. The roughened ceramic is placed in a mixture of stannous chloride and hydrochloric acid, left to stand for 5 minutes, and then the sample is rinsed with deionized water to prevent the excess sensitizing solution from contaminating the next active solution.\cite{9}, affecting the deposition of catalytically noble metal layers.

<table>
<thead>
<tr>
<th>Table 3-1 Sensitization parameter table</th>
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<tr>
<td>Stannous chloride</td>
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<td>hydrochloric acid</td>
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<td>Pure tin strip</td>
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<td>Temperature</td>
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<td>time</td>
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3.4 Activation treatment

Activation treatment is a key process for electroless copper plating. The purpose is to uniformly deposit a layer of catalyst on the surface of the substrate, which can induce the beginning of the electroless copper plating reaction. The reaction process is shown in Figure 3-1. The catalytic effect of formaldehyde electroless copper plating system is better than that of noble metal palladium and silver. Palladium as a catalyst has high catalytic efficiency and good coating performance, but there are two problems: one is that the activation liquid configuration is complicated; the other is that palladium is expensive. Therefore, this experiment uses silver as the catalytic core, and the activation liquid configuration is relatively easy and the price is low. The parameters of the activation solution are shown in Table 3-2. The silver nitrate solution of the desired concentration is placed, and then ammonia water is dropped into the silver nitrate solution by a dropper. A white precipitate is observed, and the ammonia water is continuously dropped until the precipitation completely disappears. Alternatively, the sensitized ceramic sample is placed in a configured silver ammonia solution, taken out after 5 minutes, rinsed with deionized water, preferably blown dry with nitrogen to prevent silver particles from being poorly bonded to the surface of the ceramic sample. The plating solution contaminates the plating solution and affects the effect of electroless plating. After activation, the surface of the sample is evenly yellowish.
3.5 Ceramic surface electroless copper plating

The surface of the ceramic sample that needs to be plated with copper is exposed, and the place where the plating is not needed is protected by high temperature glue or other means, and then the activated sample is uniformly placed in the plating solution, and shaken slightly after a period of time, which is beneficial to the sample. The bubbles on the surface escape and complete the electroless copper plating process. The combination of the ceramic surface and the electroless copper plating layer is a physical combination. Only by controlling the plating liquid parameters and the process conditions, a conductive copper layer with good performance and high reliability can be obtained. Therefore, it is necessary to optimize the basic parameters and process conditions of the electroless copper plating solution.

4. Electroless copper plating process optimization

4.1 plating speed

The stability of the plating solution is a key factor to ensure a smooth chemical reaction. If the stability of the plating solution is poor, the plating quality is poor and the reaction is difficult to continue. However, if the plating solution is too stable, the copper plating rate is too slow, which is not only inefficient but also easy. Leakage phenomenon occurred. The plating rate is an important indicator to measure the stability of the copper plating system. When the plating speed is low, the copper layer will be more dense, but there will be leakage plating. When the plating speed is high, the plating layer will be loose but more efficient. Therefore, the plating rate is a reasonable indicator for measuring the performance of the bath, and it is beneficial to complete the parameter optimization\([39]\). In the case that the coating quality meets the requirements, the plating speed is as fast as possible, reducing the process time and improving the production efficiency. The formula for calculating the plating rate:

$$r = \frac{\Delta w \times 10^4}{\rho \times S \times t}$$

(4.1)

Where: \(r\)-copper plating rate (\(\mu m/h\)); \(w\) - poor quality before and after plating (g); \(\rho\)-copper density (8.93g/cm3); \(S\)-copper area (cm2); \(t\)-plating time (h)

4.2 Temperature

The chemical reaction is sensitive to temperature changes, so a suitable temperature plays an important role in stabilizing the plating rate and forming a good coating morphology. The temperature is lower, the reaction is too slow, the copper plating rate is relatively low, and the plating may occur. When the temperature is too high, the side reaction speed of the plating solution is accelerated, the decomposition speed of the plating solution is accelerated, and the plating speed is increased, but the solution is fast. It becomes cloudy, cannot be used, and the \(C_{CuO}\) reaction is
intensified, the coating becomes dark, and the quality is degraded. In this experiment, four temperature nodes were selected: 25°C, 30°C, 35°C, 40°C. The water bath was used to maintain the constant temperature reaction environment. The experimental results are shown in Figure 4-1:

![Figure 4-1 Relationship between plating speed and temperature](image)

As shown in Figure 4-1, as the temperature rises, the plating rate gradually increases. The higher the temperature, the more severe the chemical reaction and the faster the deposition rate. However, when the temperature exceeds 40 °C, the side reaction is intensified and oxidation occurs on the one hand. Cuprous, affecting the grain structure of the coating, resulting in a decrease in the quality of the copper plating layer. On the other hand, the cuprous ion itself disproportionately reacts to form molecular weight copper powder, and these copper powders act as catalytic cores, inducing copper plating reaction around. With these cores, the plating solution quickly becomes cloudy and the plating solution fails. In this experiment, the plating solution began to become turbid after reacting at 40 °C for one hour; when the temperature was lower than 35 °C, the deposition rate was slower and the efficiency was lower, especially at 25 °C, not only the deposition rate was slow, but also some positions. It is plated very late, resulting in a very uneven copper layer and poor quality of the coating. Therefore, considering the copper plating efficiency and coating quality, the optimum temperature for the formaldehyde copper plating system is 35 °C.

4.3 Time

The electroless copper plating layer is mainly used for electroplating of thin copper. The thicker the copper layer, the looser the copper is. Therefore, selecting a reasonable plating time can not only improve the efficiency but also improve the quality of the coating. In addition, in the DPC ceramic substrate process, the seed layer is usually relatively thin, only 0.5μm-1μm, so the thickness of the copper layer meets the needs. The time nodes selected in this experiment are: 10min, 20min, 30min, 40min, 50min, 60min. The temperature is optimized using parameters: 35 °C. The relationship between plating speed and time is shown in Figure 4-2. As time increases, the overall trend of plating speed rises first and then decreases. The reason is that the copper plating reaction in the initial stage of the reaction is surrounded by the reaction of the metal particles, the amount of the catalyst is less, and the reaction is slower; as the reaction progresses, the copper grains grow and form a continuous film, and the newly produced active copper can be used as a catalyst to guide. The autocatalytic redox reaction of copper plating increases the number of catalysts and accelerates the reaction, so the plating rate increases; the reaction continues, copper sulfate is continuously consumed, but the amount of complexing agent is constant, and the complexing effect is more effective than the initial reaction. Well, copper ions are not easily released, and formaldehyde is not only consumed in the reaction, but
formaldehyde itself disproportionately reacts in an alkaline environment, exacerbating the consumption of its own quantity, while consuming sodium hydroxide, reducing the alkaline environment, and reducing formaldehyde. Another reason is that after the production of cuprous oxide, the self-disproportionation reaction forms copper particles, and these particles form a new catalytic core, so that the reaction not only occurs on the surface of the substrate, but also a little reaction in the solution, comprehensive analysis of these factors, plating The speed will slowly decrease after the rising period.

![Figure 4-2 Relationship between plating speed and time](image)

Time not only affects the plating rate, but also directly affects the thickness of the coating. Although the plating rate can be increased to improve the efficiency, the thickness and quality of the copper plating layer must meet the requirements of the seed layer in the DPC process, and the seed layer in the DPC ceramic substrate fabrication process. The thickness is usually above 500 nm. Figure 4-3 shows the relationship between time and copper thickness. As time passes, the thickness of the copper plating layer increases. When the plating time is 20min, the plating speed is the fastest, but at this time, the copper layer is The thickness is relatively thin, and the appearance is poor. When the time reaches 30min, the thickness of the coating is about 0.7μm, which can meet the requirements of the seed layer and the quality of the coating is good. Therefore, the best optimization is obtained in this experiment. The plating time was 30 min, and the thickness of the copper layer was 0.7 μm.

4.4 Orthogonal experiment

The quality of the electroless copper plating layer and the bonding force with the substrate are very dependent on the parameters of the copper plating liquid. Only when the process parameters are strictly selected, the plating layer with excellent performance can be obtained, so it is necessary to optimize the main parameters of the copper plating liquid. Since the range of variation of each parameter is relatively large, if the experiment is designed according to the common arrangement, the number of experiments will be too many. Therefore, considering the orthogonal experiment, the advantage is that it is reasonable to infer the best through fewer experiments. Experimental parameters to improve work efficiency. Combined with the actual situation, this experiment uses three factors and three levels of orthogonal analysis. Table 4-1 shows the three levels of the main parameters of copper plating solution: copper sulfate concentration, formaldehyde concentration and sodium tartrate sodium concentration. The plating speed is used as an index to measure the pros and cons of the plating solution, which is convenient for calculation and analysis. shows the orthogonal experimental table of the experimental design and the experimental results obtained by the range analysis shows the calculation results of the plating rates of each group in the orthogonal experiment, and the results of
the range analysis are included. The experiment shows that the influence of three factors on the plating rate is: copper sulfate > sodium potassium tartrate > formaldehyde; the K value of each factor can be used to obtain the optimal value of single factor. For copper sulfate: K13 > K12 > K11, For sodium potassium tartrate: K23 > K21 > K22, for formaldehyde: K32 > K31 > K33, so the best combination of plating speed is A3B3C2, that is, the main salt copper sulfate concentration is 8g/L, complexing agent tartaric acid The potassium and sodium concentration is 40g/L, and the reducing agent formaldehyde concentration is 10g/L. The optimal combination of this experiment is just in the experiment, which is the No. 9 experiment. Therefore, the best parameter obtained by using the plating rate as the index is No. 9 The parameters used in the experiment.

Increasing the copper plating rate is one of the purposes of this experiment. The more important purpose is to obtain a copper plating layer with excellent performance. The quality of the copper plating layer can be judged by macroscopic morphology. The macroscopic morphology of the copper plating layer can be roughly divided into dark brown, brown, rose red, brick red, dark red, and light pink. The color of the copper plating layer changes gradually, and the quality of the plating layer is gradually improved. Figure 4-4 shows the typical appearance of the nine groups of experiments. The coatings obtained from the three groups of No. 1, No. 2 and No. 3 have similar appearances, the surface is dark, the color is dull, the color is dark brown, and the quality is poor. The coatings obtained by the two groups of No. 4 and No. 5 were similar in appearance, the surface was brighter than No. 2, and the color was brownish; the surface of No. 6 experimental coating was bright, but the surface graininess was strong and the color distribution was uneven; The color of the coating is dark red, but the gloss is low; the surface of the experimental coating No. 8 is bright, the color is white, and the plating speed is too slow, resulting in a thin copper layer; the surface of the coating obtained in the experiment No. 9 is flat, the color is dark red, and the coating quality is better. In the overall analysis, the surface of the No. 8 experimental coating was the brightest, but the plating rate was too low. Although the coating morphology obtained in the No. 9 experiment was not the best, combined with the plating rate analysis, No. 9 could be selected as the experimental parameter for further analysis.

![Figure 4-4](image)

**Figure 4-4** Comparison of the appearance of the copper plating layer in the orthogonal experiment

Using the plating parameters of experiment No. 9, the pH value was controlled within the range of 12.4-12.6. Repeated experiments gave a copper plating layer with better macroscopic morphology. Compared with sputtering, it was found that the gloss removal was slightly inferior to that of sputtered copper. Layers, other macro features are similar to the sputtered copper layer. Figure 4-5 shows the topography of the two under an optical microscope. The results show that both surfaces are flat and bright.
5. Electroless copper plating performance analysis

5.1 Adhesion strength

The binding force of the electroless copper plating layer to the substrate is an important indicator that affects its performance. The CTE of the electroless copper plating layer and the ceramic material have a large difference, so the DPC ceramic substrate is subjected to a large thermal stress during use, and the line does not warp or fall off under the action of thermal stress, which is a basic requirement of the LED package substrate. The Baige method is the easiest way to qualitatively analyze the film bonding force. The test method is to draw a 10×10 square grid of 1cm×1cm on the film by using a hundred grid knife, stick the 3M tape on the grid, and press the tape. There is no air in the middle, keep it for 90±30s, then pull it up to 180° parallel to the surface, observe the state of the film, generally require that the falling area be less than 5% to pass the test. Figure 5-1 shows the effect of the electroless copper plating layer using the hundred-square test. Only a part of the copper particles on the edge of the coating peel off, and the overall effect of the coating is good.
electroless copper plating layer and the substrate, the adhesion strength test was completed by using a uniaxial stretching apparatus. The test results are shown in Fig. 5-2(a), and the copper plating layer can be seen from the figure. The adhesion strength to the substrate is about 2.7 MPa, which meets the requirements of the DPC process for the adhesion of the ceramic substrate. **Figure 5-2(b)** shows the ceramic morphology after the test. It can be seen that there are many grooves in the ceramic surface. The presence of particles, which further proves that the combination of the electroless copper plating layer and the substrate is a physical combination.

![Single-axis tensile test effect diagram](image)

**Figure 5-2** Single-axis tensile test effect diagram

### 5.2 square resistance test

The conductivity of the film is usually expressed by the square resistance. In this test, the square resistance of the electroless copper plating layer was tested by the four-probe method. The results are shown in Table 2-6. The experimental results show that the sheet resistance of the electroless copper plating layer is $0.334 \, \Omega\cdot \text{cm}/\square$ is larger than the sputtered coating ($0.089 \, \Omega\cdot \text{cm}/\square$) because the sputtered copper layer is thinner than the electroless copper plating layer, and the sputtered copper layer is denser, so the sputtered copper layer is electrically conductive. The properties are better, but the conductivity of copper itself is very good, so the conductivity of the electroless copper plating layer meets the electrical properties of the ceramic substrate.

### 5.3 Analysis of microscopic morphology

The grain distribution of the electroless copper plating layer directly affects the performance of the electroless copper plating layer. In this experiment, the scanning electron microscope (SEM) was used to analyze the microscopic morphology of the electroless copper plating layer. **Figure 5-3** shows the orthogonal experiment. SEM images of three groups of electroless copper plating layers with typical appearance. It can be seen that the No. 6 and No. 8 grains are granular, and that the No. 6 copper plating layer has coarse grains and large pores, and No. 8 copper layer crystal The grain size is much smaller than that of No. 6, but the crystal distribution is not uniform, and the No. 7 grain has a dendritic structure. The dendritic structure is more likely to produce a large amount of pores than the granular structure, resulting in a decrease in the density of the copper plating layer.
Figure 5-4 shows the electroless copper plating layer obtained by parameter optimization. Although some grains are agglomerated together, the grain size is fine, the distribution is uniform, and the compactness is good. No pores are produced. The results of other groups of experiments, after optimization of parameters, the copper layer is more excellent in micro-morphology, and the coating performance is improved.

5.4 Analysis of composition of electroless copper plating

In this experiment, the electroless copper plating layer (EDS) and X-ray fluorescent probe (XRF) were used to analyze the composition of the electroless copper plating layer. The purpose was to investigate whether there were oxygen elements and other impurity elements harmful to the plating layer in the coating. The results of EDS experiments show that there is trace oxygen in the electroless copper plating layer, which is unavoidable by electroless copper plating; XRF experimental results are shown in Figure 5-5. The electroless copper plating layer contains 100% copper and the remaining impurity atoms are low. At 0.1%, the coating is of good purity.
5.5 Thermal Shock Test

The purpose of the thermal shock test is to test the ability of the electroless copper plating layer to bond with the ceramic substrate under thermal stress. The temperature range is -40 °C - 125 °C, the conversion time is less than 30 s, and the electroless copper plating layer is observed by ultrasonic scanning microscopy after 20 cycles. Whether there are bubbles, pores and other defects between the substrate and the substrate, the results are shown in Figure 5-6. The experimental results show that the electroless copper plating layer has good reliability.

![Figure 5-6](image)

6. Conclusion

In this paper, the single-factor analysis method is used to determine the best use conditions of electroless copper plating: the use temperature is 35 °C, the plating time is 30 min; then the orthogonal parameters are used to optimize the parameters of the copper plating solution, and the best parameters of the copper plating solution are obtained. The concentration of copper sulfate is 8g/L, the concentration of sodium potassium tartrate is 40g/L, and the concentration of formaldehyde is 10g/L. The coating with good morphology is obtained by optimization, and the copper plating rate is improved and the efficiency is improved. Finally, the electroless plating is comprehensively investigated. The mechanical, electrical and mechanical properties of the copper layer show that the electroless copper plating layer has high purity, dense crystal grains and good comprehensive performance, which can meet the requirements of the seed layer of DPC substrate fabrication.
References


