Ticer Technologies, providing innovative products and quality services to printed circuit board fabricators and laminators worldwide.

TCR® Thin Film Embedded Resistor Foil
Etching Process Recommendations Using Potassium Permanganate for Nickel Chromium (NiCr) Resistive Material

TECHNICAL BULLETIN

Nickel chromium resistive material can be selectively removed with various chemistries to give a clean, well defined resistor. Most circuit fabricators use acid etchants, most commonly cupric chloride, for primary image and resistive layer width definition. A second etch step to define the resistor length requires a different chemistry to ensure copper removal without resistive layer etch or degradation. The nickel chromium resistive material layer will exhibit a matte grey finish after defining the resistor image. The processing can be properly controlled provided attention is paid to several considerations.

What to Consider

The first consideration is ensuring proper chemistries for the resistor defining processing. Commercially available cupric chloride and hydrochloric acid or ammoniacal etchants are recommended for copper during resistor width definition. The chemistry removes the copper and minimizes the amount of undercut of the copper.

The second consideration is ensuring proper chemistries for the resistor defining processing of the NiCr. A solution made up of concentrated hydrochloric acid and potassium permanganate is one of the preferred chemistries for this process. The chemistry removes the NiCr and minimizes the amount of undercut of the copper and NiCr.

The third consideration is the proper chemistries for selective copper removal to define resistor length. A solution made up of commercially available ammoniacal etchant is the preferred chemistry for this process. The ammoniacal chemistry selectively etches the copper leaving the resistive layer intact.

The last consideration is the method of application of the etching chemistry. The removal of the copper and NiCr can be performed in either a spray chamber or dip tank. The spray chamber method is preferred to better control etch rates and circuit definition. The temperature and dwell time in the chemistry is solution dependent.

Conclusions

The copper and NiCr components can be completely removed with excellent circuit definition when care is taken to follow the considerations.

Other chemistries are known etchants of copper and nickel chromium. When using other chemistries to remove copper and Nickel Chromium other than recommended above, consult the Ticer Technologies Technical Marketing or Research and Development.
Copper and NiCr Resistive Material Removal
Chemistry and Processing Parameters

| Etch 1 Solution | Copper removal | 267g/l NH₄Cl  
|                 | Resistor Width definition | 1 g/l ortho-phosphoric acid  
|                 |                         | 392 ml NH₄OH  
|                 |                         | 10 g/l CuCl₂  
| Temperature:    | 130 - 140° F (54 - 60° C)  
| Method:         | Spray chamber or dip tank  
| Time:           | Adjust for proper etching of copper weight  
| Etch 2 Solution | Selective NiCr removal | 90 - 95 g/l KMnO₄  
|                 | Resistor Width definition | pH 2.2 – 2.4 Adjust pH by adding HCl  
| Temperature:    | 120 – 125 ° F (49 - 52 ° C)  
| Method:         | Dip tank  
| Time:           | 2 - 4 min, Adjust for proper etching of NiCr ohms/square  
|                 | For low ohms/sq NiCr, repeated etch is required  
| Neutralizer Solution | Neutralizer for Etch 2 Solution | 25 - 30 g/l Oxalic Acid  
| Temperature:    | Room Temperature (25°C)  
| Method:         | Dip tank  
| Time:           | 1 – 2 min. Sufficient to remove brown manganese dioxide on layer  
|                 | For low ohms/sq NiCr, repeated etch 2 and neutralizer processes are required  
| Etch 3 Solution | Selective Copper removal | 267g/l NH₄Cl  
|                 | Resistor length definition | 1 g/l ortho-phosphoric acid  
|                 |                         | 392 ml NH₄OH  
|                 |                         | 10 g/l CuCl₂  
| Temperature:    | 130 - 140° F (54 - 60° C)  
| Method:         | Spray chamber or dip tank  
| Time:           | Adjust for proper etching of copper weight  

**Potassium Permanganate Resistor Etch Solution Makeup:**

For makeup of 10 gallon acidic resistor etch solution put 5 gallon of DI water into a 10 gallon container at room temperature (25°C) maintain gentle agitation with stir bar or equivalent. Cautiously add 3,407 grams of Potassium Permanganate. Top off with DI water to 10 gallons. With consistent agitation, adjust pH with dilute hydrochloric acid (1:3 v/v HCl:H₂O) to pH 2.3 (add about 5 g/l HCl). Heat to 120°F. Maintain pH of solution after ample solution use.

**Neutralizer Solution Makeup:**

For makeup of 10 gallon neutralize solution put 5 gallon of DI water into a 10 gallon container at room temperature (25°C) maintain gentle agitation with stir bar or equivalent. Cautiously add 946 grams of oxalic acid. Top off with DI water to 10 gallons.

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Processing Notes

- Etching time is dependent on sheet resistance (the lower the sheet resistance, the thicker the NiCr layer).
- For low ohms/sq NiCr material, repeatedly immersing panel into etch 2 solution, neutralizer solution, and rinse between are required to speed up etching.
- Increasing solution temperature increases etching rate. However, KMnO₄ salts out quicker for 90g/l KMnO₄ solution due to water evaporation.
- Decreasing the concentration of KMnO₄ do not decrease etching rate significantly. However, low KMnO₄ concentration solution will slightly etch or oxidize copper surface when it is not covered by photoresist.
- High KMnO₄ concentration solution does not etch or oxidize shiny side of copper, but it will etch off the treatment on RTC foil when it is not covered by photoresist.
- Leave photoresist on panel is not necessary for etching standard copper resistive foil, but it protects treatment on RTC resistive foil.
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