

Copper Etching Standard Operating Procedure

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1. Purpose and application

Copper Etchants are ferric chloride solutions formulated with proprietary wetting antifoam plus chelating additives to optimize etching performance. Ferric chloride solutions are the most widely used etchants for copper, copper alloys and Kovar in printed circuit board applications. The etchants are highly compatible with commonly used photoresists.

Its use is recommended for spray etching techniques and will provide precision etching at controlled rates. At 40°C, the Copper will etch at a rate of approximately 212 nm/sec. Recommended operating temperature is 40 – 60 °C [1, 2].

2. Equipment, Chemicals and Supplies

Copper etchant is composed out of three chemicals:

1. 30 – 50 wt.% Iron trichloride
2. 1 – 5 wt.% Hydrochloric Acid
3. 45 – 69 wt.% Water

Mixture is purchased from Sigma Aldrich.

<https://www.sigmaaldrich.com/catalog/product/aldrich/667528?lang=en®ion=NL>

3. Personal Protective Equipment (PPE)

The following equipment should be used:

- Eye protection: Safety glasses, (optional with face shield).
- Protective gloves: Black nitrile gloves. Check gloves for leaks before use.
- Protective clothing or equipment: Apron.

4. Operational Procedures

1. Get three glass beakers or envelopes which will fit your sample and place them in the bench.
2. Write down your name and type of chemical for every beaker/envelope.
3. Carefully pour some Copper Etchant in the first beaker/envelope such that it will cover your sample.
4. Fill the other two beaker/envelopes with DI water such that it will cover your sample. DI water is used for rinsing the etchant.

5. Calculate the etch time for your sample. You will need to know the thickness of your copper layer. At 40°C, the Copper will etch at a rate of approximately 212 nm/sec. This may not be exact! It is recommended to test this for yourself.
6. Put your wafer into the etchant and soak for the appropriate amount of time calculated in the previous step. *If etchant at the surface becomes saturated and fresh etchant cannot reach the surface, then etching will slow down. Agitation can be used to bring etchant to the surface and promote etching.* In this case use a magnetic stirrer and carefully swirl your etchant to accelerate the etch and improve uniformity.

DI water rinse

1. When the etch is complete, transfer the sample carefully to the first DI water rinse beaker/envelope and move the sample for 5 minutes.
2. If you use tweezers to move the sample, make sure you rinse your tweezers as well.
3. Transfer the sample to the second DI rinse beaker, and rinse for another 5 minutes while moving your sample.

Sample dry

1. After the water rinse is finished, remove your samples and blow them dry with the N₂ gun.
2. Inspect wafer for traces un-etched copper. If features are small, use an optical microscope. If more etch time is required, place wafer back into the beaker with the etchant for another 30 seconds while swirling. Repeat rinse and drying procedure.

Clean-up

1. Let the etchant cool down to room temperature.
2. When the used etchant is at room temperature, pour it carefully over the other two beakers/envelopes filled with DI water.
3. Fill the beaker/envelope where you had your etchant with DI water.
4. Use the venturi to remove the waste from all the beakers/envelopes.
5. Rinse all the beakers/envelopes three times with DI water.
6. Turn all the beakers/envelopes upside down, wash the outside with DI water and blow them dry with the N₂ gun.
7. Return all labware to its proper location.
8. Clean the area and rinse it with DI water.
9. Wash your black gloves and leave them in the bench.

5. Primary Hazards

Strongly corrosive. Vapour inhalation burns mucous membranes; causes coughing, dyspnoea. Inhalation may lead to oedemas in the respiratory tract. Burns skin, eyes (risk of blindness). Swallowing results in damage to mouth esophagus, and gastrointestinal tract; risk of perforation; bloody vomiting; death.

6. Engineering Controls to Prevent and Mitigate Hazards

Carry out the procedure in a wet bench. Store bottles of chemicals (sealed tightly) in the inorganic cabinets. Work area should contain an eye wash, safety shower and a bottle of diphoterine. Check where you could find this in your neighbourhood.

The chemicals are in the medium risk category:

- Processing during afterhours requires the presence of a buddy, mixing of chemicals is not allowed (prepare your solution beforehand) and the maximum quantity of liquid is 100 ml.
- If one of these points is not fulfilled the process is considered to be high risk and it must be done during office hours.

7. First Aid and Emergency Procedures

Eye Contact: Immediately flush with diphoterine while lifting upper and lower eyelids occasionally (use the complete 500 ml for one eye and remove contact lenses if possible). After using diphoterine, flush with water for at least 15 minutes. May cause blindness. Get immediate medical attention. Press the evacuation button.

Skin Contact: Remove contaminated clothing, wash skin with diphoterine. After using diphoterine, wash with water. Obtain medical attention. Press the evacuation button.

Inhalation: Remove to fresh air. Resuscitate if necessary. Take care not to inhale any fumes released from the victim's lungs. The quick response team has to use the "Eerste Hulp Zuurstof Tas". Get immediate medical attention. Press the evacuation button.

Ingestion: Do not induce vomiting. Get immediate medical attention. Press the evacuation button.

In case of a spill: Press the evacuation button.

In case of a fire: Press the fire button. Use the CO₂ extinguisher to extinguish the fire.

Literature

- [1] "Printed Circuit Copper Etchants," Transene Company, Inc., 2018. [Online]. Available: <http://transene.com/cu-etchant/>. [Accessed 2018].
- [2] "Copper Etchant," 2018. [Online]. Available: <https://www.sigmaaldrich.com/catalog/product/aldrich/667528?lang=en®ion=NL> . [Accessed April 2018].
- [3] "Etchant/Metal Compatibility Chart," Transene Company, Inc., 2018. [Online]. Available: <http://transene.com/etch-compatibility/>.

8. Appendix

Table 1 Etchant/Metal Compatibility Chart [3].

Metal	
Al	Etch
Al ₂ O ₃	Ok
Au	Ok
C	Ok
Co	Etch
Cr	Slight
Cu	Etch
Fe	Etch
GaAs	Etch
Mg	Etch
MgO	Etch
Nb	Ok
Ni	Etch
Pd	Etch
Pt	Ok
Ru	Ok
Si	Ok
Si ₃ N ₄	Ok
SiO ₂	Ok
Steel	Etch
Ta/TaN	Ok
Ti	Slight
W	Ok
ZnO	Etch

Legend : etch = significant attack, slight = selectivity less than 20:1, ok = more than 20:1 selectivity or no etching, surf ox = surface oxidation, corrode = surface corrosion.