Aluminum Plasma Etch Guide in the Trion Metal Etcher

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Disclaimer: The information below is to act as a starting point for etching your aluminum. Expect variation in etch rates dependent on area etched, feature sizes and the precise details of your sample.

1. Contact clean room staff before performing the etch to make sure BCl_3 and Cl_2 lines are charged. Have staff set the chiller to 35°C to prevent BCl_3 condensation and all BCl_3 lines are heated.
2. General notes concerning chlorine based etching of aluminum[1-5]
    - Aluminum forms a native oxide that is not etched by pure chlorine chemistry thus BCl_3 is used to break through the oxide.
    - The general etch byproduct is $AlCl_3$
    - $AlCl_3$ is hydroscopic and the material is not very volatile
    - $AlCl_3$ will react with water vapor, resist and pump oil
    - BCl_3 is added to the plasma to remove the aluminum oxide and scavenge oxides formed from residual water or oxygen
    - Resist exposed to BCl_3 or Cl_2 will become resistant to oxygen plasma etching or solvation after they've been exposed to air/water vapor. This may be due to the conversion of $AlCl_3$ to Al_2O_3.
    - Aluminum alloys such as Al-Si-Cu or Al-Si have significantly different etch properties than pure aluminum.
    - Addition of He to the plasma may help to improve resist selectivity
    - If the percentage of Cl_2 is lowered to 5% in a mixture with BCl_3 the lateral etch rate will be reduced. [1]
    - Addition of NH_3 may also decrease undercut[6]
3. **Aluminum silicon etching**

    The <u>recipe for plasma etching aluminum is dependent on the type and method of aluminum deposition</u>. For example, Al-Si 1% etches much slower than pure aluminum and electron beam evaporated Al probably etches at a different rate than sputtered metal.

    The recipe for etching Al-Si 1% occurs in 2 steps. The first etches the aluminum and the second step passivates the photo resist (which is loaded with chlorine) from ambient water vapor. The passivation step helps to ensure that the photo resist can be removed in common organic solvents such as acetone or NMP. Note that other recipes indicate that He can be used to improve selectivity to photoresist[4]. Unfortunately, the CF_4 will also etch silicon oxide, thus we minimize the plasma time and in future recipes it may be helpful to minimize DC bias for this step. The high bias voltage in the first step helps to remove redeposition of the silicon in the metal layer. Further, it is necessary to run the chuck holding the sample at 35°C to prevent condensation of BCl_3 and etch byproducts.

Recipe: Al_Best_Etch_AlSi
Etch Rate: 3.89 nm/sec, 350 nm in 90 sec
Step 1 Etch Step
Chiller Temperature set to 35°C
BCl_3: 15 sccm Cl_2: 35 sccm, Pressure: 20 mTorr
ICP: 350W RFL: <25, RIE 250 RFL: <25 DC BIAS: -400V to -500 V
He Cooling: 5 Torr

Step 2 Passivation Step
CF_4: 40 sccm, Pressure: 25 mTorr
ICP RF:400 W, RIE RF:100 W, DC Bias: -125 V
He Cooling: 0 Torr
Time: 20 to 40 seconds
Or
O_2: 50 sccm, Press: 50 mT
ICP: 300W+-25 RFL: <10 RIE: 75W+-25 RFL: <15 DC Bias: ~- 100V
He Cooling: 0 Torr
Time 120 sec

It may also be possible to remove the resist with an oxygen plasma etch as long as the sample has not been exposed to air.

4. **Pure aluminum etching**

The recipe for etching pure aluminum is less aggressive than the aluminum-silicon etch as a high bias voltage is used to prevent silicon redeposition on the etched area.

Recipe: Al_Best_Etch
Etch Rate: 12.08 nm/sec
Step 1
BCl_3: 15 sccm Cl_2: 35 sccm, Pressure: 20 mTorr
ICP: 350W RFL: <25, RIE 150 RFL: <25 DC BIAS: -400V to -500 V
He Cooling: 5 Torr

Step 2
CF_4: 40 sccm, Pressure: 25 mTorr
ICP RF:400 W, RIE RF:100 W, DC Bias: -125 V
He Cooling: 0 Torr
Time: 20 to 40 seconds
Or

O_2: 50 sccm, Press: 50 mT
ICP: 300W+-25 RFL: <10 RIE: 75W+-25 RFL: <15 DC Bias: ~- 100V
He Cooling: 0 Torr
Time 120 sec

5. **Etching Al-Si-Cu**

Etching of this common alloy may require a second wet etch to remove traces of copper as compounds of copper with fluorine and chlorine are nonvolatile.

References

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