Superconducting Parallel Plate Capacitors with High Kinetic Inductance

Nano-Nugget: *Post-metal etch clean*

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Hydrofluoric Acid process development

While etching our patterns in niobium films on sapphire (clear) substrate, we noticed that the areas where we expected the entire niobium to be etched away (hence clear) are covered with some unknown residue (the " dark green" area in Figure 1). This can be a problem in the path to creating clean devices for various experiments.

Figure 1. Microscope picture of post-metal etch residue on sapphire between two Nb areas

In order to learn more about the composition of the residue and ways to remove it, we have studied three different methods for sample cleaning:

1. Solvent Clean with Acetone and 2-propanol
2. SRS-100 and PRS-1000
3. Hydrofluoric Acid

The cleaning procedures in 1,2 were not successful. So, we decided to move on to **10:1 diluted hydrofluoric acid (HF)** clean, which can potentially remove any oxygen-containing compounds/organic byproducts from the resist added from our etching recipe. Although, for this cleaning method to work, **make sure that neither the substrate nor any material in the sample is attacked by wet HF**.

The procedure involves a 3-min 10:1 HF solution clean followed by a standard 2-stage water rinse yielded results is presented in Figure 2. Picture (A) shows the state of a sample after resist stripping, inset shows the sidewall profile, picture (B) shows sample after 3 minutes clean in 10:1 diluted hydrofluoric acid. It can be seen that the HF solution helps to remove the entire residual film from the sapphire substrate, but leaves small, black particles.

To successfully remove the small black particles and get even better results, we further explored ozone cleaning, using the *Samco UV Ozone Cleaner* in Stanford Nanopatterning Cleanroom. We put the acid-treated samples into the cleaner at 60°C and an oxygen flow rate of 0.75 L/min the 20-minute long Ozone clean procedure, it can be seen that it removes residual particles effectively.

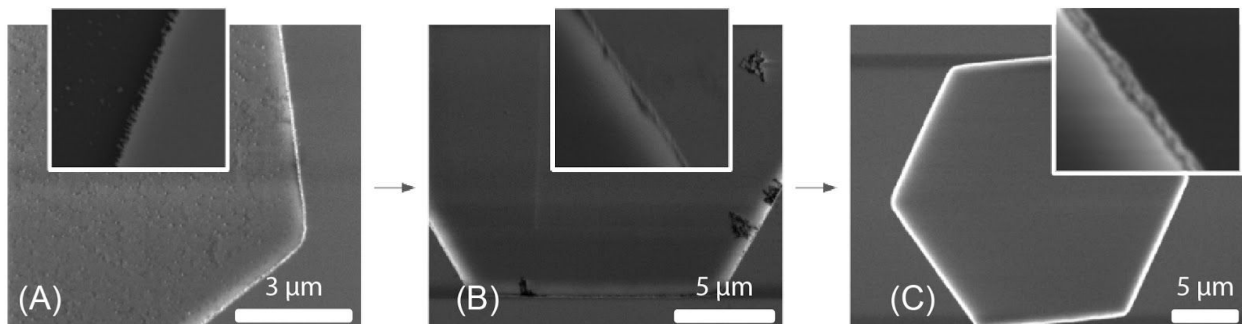

Figure 2. (A) Sample contamination after metal etch and solvent resist stripping; (B) Surface after 3 minutes of 10:1 diluted hydrofluoric acid solution clean; (C) Surface after additional 20 minutes UV Ozone procedure at 60°C, gas flow 0.75 L/min.

Step-by-step clean procedure

- ***Oxygen plasma clean****:* Indirect ashing ("*floating*" bottom electrode) with power: 100, oxygen-flow rate: 10sccm, time: 120s [**Tool**: *Asher*; **Location**: *Flexible Cleanroom]*

- ***Solvent resist stripping:*** Spray acetone and 2-propanol for 30s each [**Tool**: *Solvent bench*; **Location**: *Any cleanroom]*

- ***Ultrasonic acetone bath:*** Put the sample in a short beaker filled with fresh acetone ultrasonic bath for 5 minutes, at low power (~2). Then N2 blowdry after completion [**Tool**: *Solvent bench*; **Location**: *Stanford Nanopatterning Cleanroom]*

- ***Hydrofluoric acid clean:*** 10:1 diluted HF at room temperature, 100ml DI water + 10ml HF, add acid to the water beaker. Mount the sample on a Teflon holder, rinse for 3-min in HF, followed by 2-stage water rinse for 30s each. Flow fresh water over the sample when done, blow dry after removing from the holder [**Tool**: *Acid bench*; **Location**: *Any cleanroom]*

- ***Ozone clean:*** 0.75 L/min, 60C, UV on Ozone on, 20 min [**Tool**: *Samco Ozone Cleaner*; **Location**: *Stanford Nanopatterning Cleanroom]*