CORAL Name: VaporEtch-XeF2

Location: Bay U4, Room 12-3110A
Category: Etching
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Information



This tool is an isotropic silicon etcher. It will etch silicon, silicon germanium, molybdenum, titanium, and tungsten. It is highly selective to oxide, and does not etch photoresist, silicon nitride, acrylic, gallium, nickel, platinum, gold, silicon carbide, or aluminum.

The etcher accepts any size substrate from small pieces up to a 200 mm wafer. The system has three chambers: Source, Expansion, and Etch. The Source chamber is where the bulk of the xenon difluoride (XeF_2) is stored. At the beginning of the etch process, a valve opens between the expansion and etch chambers. When the etch pressure rises to 2000 millitorr (mT) the valve closes, and the etching of the sample begins. Finally, the etch chamber is evacuated and the entire process is repeated, as programed. There are four programmable timers that control these operations. Use the (+) and (-) keys to modify these controllers.

The typical reaction is 2XeF2 + Si → SiF4 + 2Xe (gas).

Safety

Xenon difluoride (XeF_2) is a solid compound and is both toxic and a strong oxidizer. During the etch process, it sublimates and forms fluorine gas, both toxic and corrosive. It is also sensitive to moisture in the air and will hydrolyze to hydrogen fluoride (HF). The Toxic Gas Monitoring System (TGMS) monitors the ambient air and exhaust for HF. Therefore, do not load wet samples or wipe out the chamber with a wet fabwipe.

There are two buttons to raise and lower the chamber, one for each hand. This is designed to keep your hands away from the moving parts. Please keep your hands on the buttons until the motion of the bell jar has stopped!

This tool has multiple hazards: electrical, chemical, pneumatics, and possible pinch po ints during bell jar motion. Do not remove any machine panels or go behind the machine. Do not try to defeat any of the system interlocks.

If you encounter any problems while operating this machine, report them immediately in CORAL. The staff in charge will address them in a timely fashion.

Before using this machine, you should learn the location of the Emergency Machine Off (EMO) button on the front panel of the tool. If the tool is behaving dangerously, or making loud noises, then press the red EMO button. If you press the EMO button, alert the staff, do not attempt to re-energize the tool,
Note: The EMO button does not turn off the vacuum pump, but it will close all the valves.

User Qualifications and Responsibilities

- During training, you will learn to write a recipe and run a process. You must receive training before using the XeF2 etcher.
- When you're finished with the XeF2, close the chamber lid and pump it down. If the Source pressure is lower than 2000 mT, then please report it as a problem in CORAL.

Operating Procedures

1. Check reservations in CORAL to ensure you have reserved the correct machine for the correct time. Engage the tool in CORAL. This is necessary in order to open the Etch Chamber.
2. Buttons **[VPUMP]** and **[V1]** should be on. **See Figure A.**

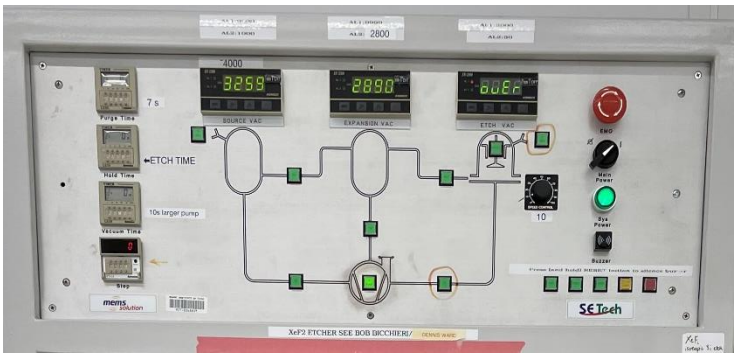


Figure A

3. **Stop pumping the Etch Chamber.** Press and hold the **[V1]** button until the light goes off. Simultaneously the **[STBY]** light will flash on and off. **Note:** All the buttons on this tool are 'press and hold' (not momentary).
4. **Vent the Etch Chamber.** Press the Etch Vent button **[EVENT],** until the light goes on. The etch chamber will vent to atmospheric pressure (~5 seconds). Then the **[EVENT]** light will go off to indicate the chamber has vented.
5. **Open the Etch Chamber.** Simultaneously push both green buttons located on either side of the etching chamber, and the chamber will rise.
6. **Load your Sample(s).** Place and center the sample(s) on the chuck.
7. **Close the Etch Chamber**. Push both green buttons located on either side of the etching chamber simultaneously, and the chamber will lower.
8. **Start pumping the Etch Chamber.** Press and hold the **[V1]** button until it lights. Simultaneously, the **[STBY]** light will go off.
9. **Setting the Purge Time.** The gas purge timer adjusts the time for the pulse of XeF2 to diffuse throughout the chamber. Currently, the purge time is 7 seconds and should not need modification. **Note:** The valve will shut before the programmed time expires or when the pressure in the etch chamber gets to 2000 mT.

10. **Setting the Hold Time.** This is the actual etching time. Normally, it is between 30 and 180 seconds, but 60 seconds is typical. The starting pressure should be about 2000 mT. You should see a gradual, fairly constant, increase in the etch chamber pressure during this time. This is due to the production of silicon tetrafluoride (SiF4) gas as the XeF2 etches Silicon. **Note:** The etch chamber pressure must be below 25 mT to start the process in the AUTOMATIC mode.
11. **Setting the Vacuum Time.** Currently, the pumping time is 10 seconds and should not need modification. This step allows the byproducts of the reaction to be evacuated before another etch cycle starts. **Note:** If the vacuum time is too long and the pressure goes below 30 mT, the tool perceives an error has occurred and will not count the cycle!
12. **Setting the Step Number.** This represents how many cycles (of purge, hold, and vacuum) will be repeated. It is dependent on the etch rate and total etch depth desired.
13. **Record data in the Tool Logbook.** Enter the date, your CORAL name, the starting pressures for source and expansion chambers, the number of cycles, the etch time, and any relevant comments.
14. **Checking the Chamber Pressure.** By now, the pressure should be less than 25 mT.
    a. Turn off **[V1]** and observe the rate of rise (ROR). A low ROR indicates a good vacuum (i.e. low moisture). We cycle-purge with dry nitrogen to displace any moisture adsorbed onto surfaces and improve the ROR.
    b. To manually cycle-purge: quickly turn on **[EVENT]**, and then quickly turn off **[EVENT]**, then turn on **[V1]**.
    c. Repeat up to three times.
    d. Then turn off **[V1],** and simultaneously the **[STBY]** light will be flashing on and off.
15. **Change to Automatic Mode.** When the stand-by **[STBY]** lamp is flashing, you can change the mode from manual to automatic. Press the **[A/M]** button until it lights. Simultaneously, the **[STBY]** light will go off. The tool is now in the automatic mode.
16. **Executing the program**. The process begins after you press the **[START]** button.

    Note: The pressure in the etch chamber must be below 25 mT before processing begins.
17. **When the Program is Complete.** The buzzer sounds. Press the **[RESET]** button to stop the beeping. The etch chamber has been automatically cycle-purged three times and left under vacuum.
18. **Change to Manual Mode.** Press the **[A/M]** button until it turns off. Simultaneously, the **[STBY]** light will start flashing. The tool is now in the manual mode.
19. **Vent the Etch Chamber.** Press the Etch Vent button **[EVENT],** until the light goes on. The etch chamber will vent to atmospheric pressure (~5 seconds). Then the **[EVENT]** light will go off to indicate the chamber has vented.
20. **Open the Etch Chamber.** Push both green buttons located on either side of the etching chamber simultaneously, and the chamber will rise.
21. **Unload your Sample(s).**
22. **Close the Etch Chamber**. Push both green buttons located on either side of the etching chamber simultaneously, and the chamber will close.
23. **Start pumping the Etch Chamber.** Press and hold the **[V1]** button until it lights. Simultaneously, the **[STBY]** light will go off. The tool is now how you found it. **See Figure A.**
24. **Disengage the tool in CORAL** Enter the correct data in the report fields.

Appendices

Tips:

- Please remember that the XeF2 is a solid source and sublimates to a gas to reach equilibrium at low pressures. It takes time for the pressure to recover after long or multiple etches or users. This tool cannot be used all day, every day! Please reserve the tool in CORAL so other users can monitor the usage and plan accordingly!
- The “dose” of XeF2 delivered is pressure dependent, not volume dependent like most other etch tools with gases; so, if the **[SV1]** (valve between source and expansion chambers) remains lit during the etch step, it is an indication that the system is struggling to meet the programmed parameters, and the etch rate will decrease!
- This tool does not readily etch native oxide. It is suggested to do at least three cycles (five is better for deeper etches) before checking the etch rate. Otherwise, you risk calculating a very conservative (and incorrect) etch rate that may result in over-etching of your sample.
- If you have an etch-stop layer (such as a buried oxide), you will notice that the rise in etch pressure is slowing down as the number of cycles progresses. This is a good indication that your sample is close to being etched.