

Standard Operating Procedure: Xenon Difluoride Etcher

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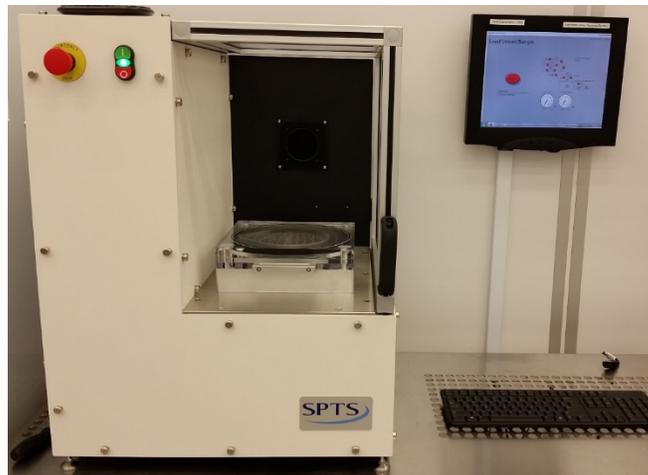
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Hardware Description and Principle of Operation

SPTS Xactix E1 Xenon Difluoride Etcher

The SPTS Xenon Difluoride Etcher can be used to isotropically etch Si, Ge, and Mo films. The XeF₂ etch chemistry offers excellent selectivity to a wide range of materials, such as Al, SiO₂, ZnO, Si₃N₄ and photoresist, affording the possibility of using thin masks and incorporating etch-stop layers for undercutting.



Material Requirements

Equipment: substrate and tweezers

Personal Protective Equipment: nitrile gloves and safety glasses

Processing Notes

- XeF₂ etching is a chemical diffusion process, so the etch rate and etch profiles can be highly dependent on loading effects. Etch rate differences can be observed between the center and the edge of wafers with large open areas. Patterns with differences in feature sizes can show different etch rates dependent on the feature size or to the proximity of two adjacent features.
- Surface preparation prior to etch is important in achieving smooth etch surfaces. Etch roughness occurs through a mechanism similar to micro masking in dry etch. XeF₂ etches native silicon dioxide, but at a much lower rate than silicon. Any surface contamination or variation in removal of the native oxide can lead to surface roughness.

Procedure

Estimated Time:

Load Sample

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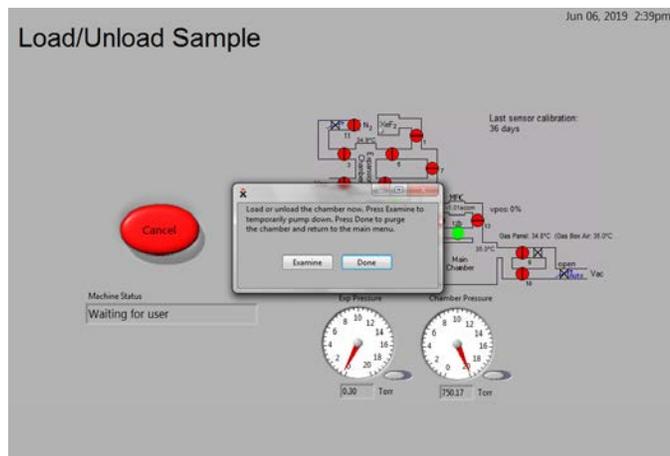
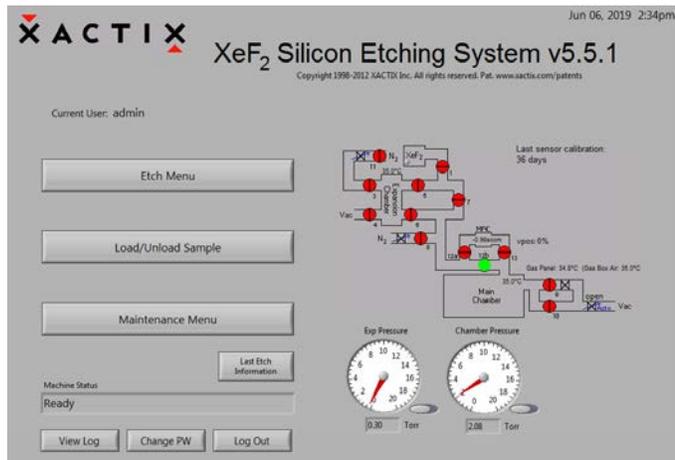
1. Select **Load/Unload Sample** on the Main Menu screen.
2. Select **Yes** to confirm. The system will begin chamber purges and flushing cycles to evacuate the chamber.

- a. *Note:* If the chamber ventilation shroud covering the chamber is not pulled fully forward, a request to close the shroud will be displayed before venting the chamber. Move the shroud forward and acknowledge the prompt.

3. When the chamber is vented, a dialog box will appear and you can open the chamber.

- a. *Note:* If you are removing a sample to examine it in between etches, remove the sample, close the chamber and select **Examine**. This will pump the chamber in order to leave it at vacuum while you examine your sample and allow for faster venting. Select **Vent** to vent the chamber when you're ready to reload the sample.

4. Load your sample, close the chamber and select **Done**. The system will go through a purging cycle prior to pumping down.

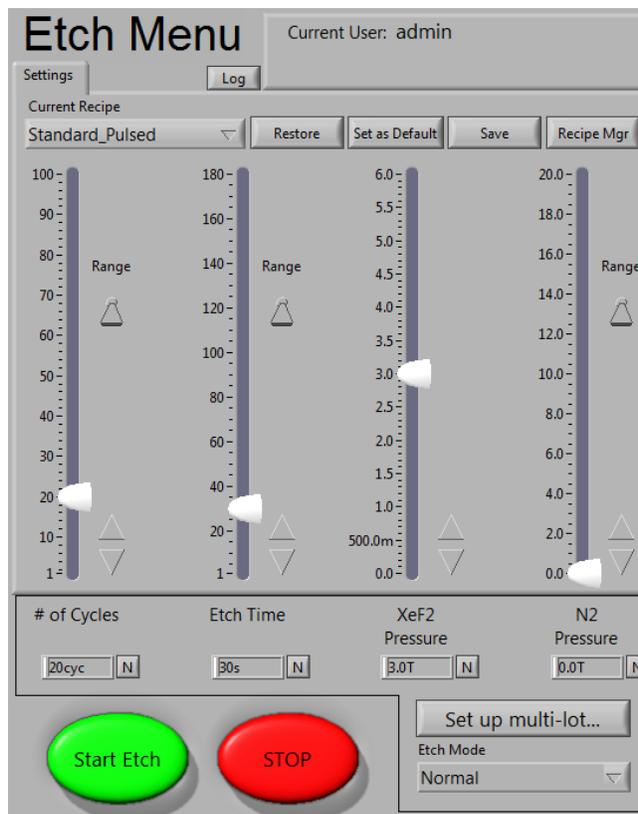


Recipe Set-Up

1. Select **Etch Menu** on the Main Menu screen.

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2. When prompted, enter a lot number and select **Done**. The Etch Menu will appear.
3. Under the Current Recipe pull-down, select the required recipe or a blank recipe.
4. Under the Etch Mode pull-down, select **Normal**, or **Normal with Delays** if you want a delay step between each etch cycle. *Note: there is also a Continuous mode, but users are not allowed to use this mode and so it should never be selected.*
5. Set the number of cycles, the etch time for each cycle, the XeF₂ pressure, the N₂ pressure, and the delay time if applicable.

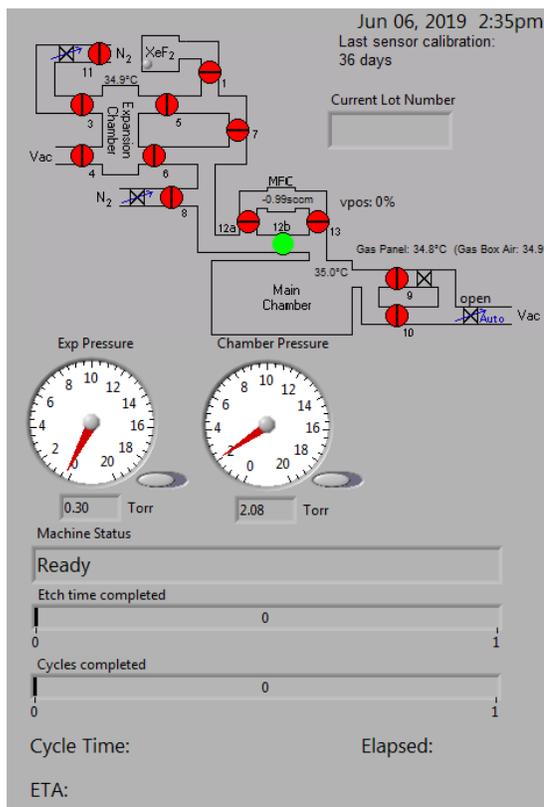


- a. Number of Cycles: Typical etches are pulsed xenon difluoride etching so the duration of etch is determined by the number of cycles times the etch time. A cycle consists of the xenon difluoride sublimating to the set pressure in the expansion chamber, etching the sample for the set amount of time and evacuation of the main chamber and expansion chamber.
- b. Etch Time: When the valve between the main chamber and expansion chamber is opened, the pressure equilibrates and the etching process begins. The etch time is the time between the opening of the valve and the evacuation of the process chamber and expansion chamber.
- c. XeF₂: A set pressure charge of xenon difluoride will be delivered to the expansion chamber, and because xenon difluoride has a vapor pressure of ~4 Torr at room temperature, the upper limit for the XeF₂ pressure is approximately 4 Torr.
- d. N₂ Pressure: Nitrogen can be added into a recipe to improve selectivity. The pressure obtained in the expansion chamber controls the amount of nitrogen introduced into the process chamber.
- e. Delay Time: The XeF₂-Si reaction is exothermic, so a delay time between cycles can be used to cool the wafer between etch cycles to minimize any observed thermal issues.

Etching Procedure

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1. Once the recipe is ready, select **Start Etch**.
2. The system will begin pre-etch cycles to test the precision of filling the expansion chamber. If you wish to skip the pre-etch cycles, select **Stop** and the system will move on to the etching.
3. Etch progress can be monitored following the Etch Time Completed and Etch Cycles Completed bars along with the Elapsed Time Cycle and the ETA.
4. Once the etching cycles have started, you can change the number of cycles by selecting **Change Cycles** and then arrowing up or down to a new number of cycles. Select **OK** to return to the Etch Menu screen.
5. If you wish to end your etch process after the current cycle, select **Stop**. The system will finish the current etch cycle and then end the etch process.
6. If you wish to end your etch process immediately without waiting until the end of the current cycle, select **Stop** twice. The system will end the etch process.
7. Once your etch process is finished, the system will return to the Mani Menu screen.
8. A detailed etch information log can be viewed by selecting **View Log**.



Unload Sample

1. Select **Load/Unload Sample** on the Main Menu screen.
2. Select **Yes** to confirm. The system will begin chamber purges and flushing cycles to evacuate the chamber.
 - a. *Note:* If the chamber ventilation shroud covering the chamber is not pulled fully forward, a request to close the shroud will be displayed before venting the chamber. Move the shroud forward and acknowledge the prompt.
3. When the chamber is vented, a dialog box will appear and you can open the chamber.
4. Unload your sample, close the chamber and select **Done**. The system will go through a purging cycle prior to pumping down.



Emergency Stop

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- If you wish to end an etch process immediately without waiting until the end of the current cycle, select **Stop** twice.
- In the case of an emergency where a tool malfunction puts users in imminent danger, press the red EMO button on the tool. This is only to be used as a last resort.

Allowed Activities

- Most materials are acceptable as etch masks, including photoresist.

Disallowed Activities

- Do not use Continuous Etch Mode. It is a useless waste of gas.

What to watch out for during operation

- If the chambers are not pumping down to base pressure, notify staff immediately. This may mean that the pump or gauges need to be serviced.
- If the expansion chamber is not able to fill up with xenon difluoride to the set pressure, notify staff immediately. This may mean that the xenon difluoride is low.

Common Troubleshooting Tips

- If the mask being used on a sample is cracking or peeling, it may be an issue of the sample overheating. Try using the Normal with Delays Etch Mode and add a delay time between cycles to allow the sample to cool between etches.

When to call staff?

- The xenon difluoride is low or empty.
- The chamber is taking too long to pump or unable to pump to pressure.

Badger Criteria

Report Problem:

- It takes an uncharacteristically long time to pump the chamber to pressure.
- The xenon difluoride cylinder is running low.

Shutdown:

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- The chamber is unable to pump to pressure.
- The xenon difluoride cylinder is empty.

Revision History: