University of Minnesota Nano Fabrication Center

Standard Operating Procedure

Equipment name:	Xetch e1 series		
Badger name:	Xef_2-etch	**Model:**	e1
Location:	Bay 3	**Revisionist:**	Paul Kimani
Revision #:	1	**Date:**	April 25, 2013

Introduction

This is a system designed to expose samples to xenon di-fluoride (XeF_2) gas in a cyclic or pulsed mode. XeF_2 can be used to istoropically etch Si, Mo, Ge, Nb, polysilicon, Ti and W. XeF_2 can be used to make very long undercuts with little or no degradation of etch stop, mask or device layers. Advantages of using this system include:

- *Selectivity during etching*: XeF_2 shows very high selectivity vs. silicon to photoresist, SiO_2, Si_3N_4, and aluminum. Selectivity of silicon nitride is better than 100:1 and the selectivity to silicon dioxide is better than 1000:1. No external energy or ion bombardment takes place, and this is the reason XeF_2 exhibits high selectivity to many metals, dielectrics and polymers. The etch reaction is exothermic and results in an increase in chamber temperature. A **short dip in BOE** is useful to break through the oxide.
- *No release stiction:* XeF_2 etching is a dry process so no drying is needed which avoids the sticking issues that often plague wet release processes. Since XeF_2 etching is a dry, room temperature process, delicate structures can be released.
- The system can etch silicon from small part to 100mm (4 inch) wafers. The etch rate is dependent on the surface area of the silicon and decreases with increasing area.

Safety

a. XeF_2 gas will form HF in presence of water vapor therefore proper ventilation and standard acid precautions are required when handling the bottle exchange (this is a maintenance task)

Restrictions/Requirements

a. Ensure samples are fairly dry of moisture. Bake of sample prior to loading in the etch chamber is recommended to reduce moisture
b. Must be qualified to use the tool
c. Do not use standard tape with this tool. Kapton or any teflon based tape is okay to use

Required facilities

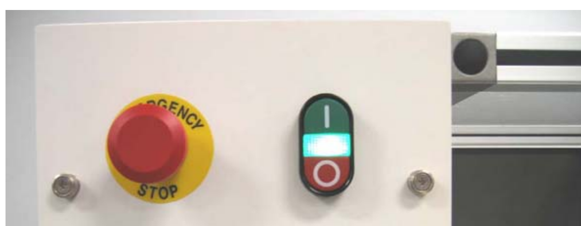
a. Dry compressed air (70 – 100 psi)
b. Vacuum
c. Nitrogen gas
d. 120V AC Electrical power
e. Fume and pump exhaust
f. XeF_2 cylinder
g. Computer and screen

Definitions

a. Xenon di-fluoride (XeF_2): a white crystalline substance resembling rock salt. At room temperature, the vapor pressure of XeF_2 is 3.9 torr.
b. Expansion chamber: Where sublimated XeF_2 and nitrogen collect before entering the process chamber. Note that N_2 is used for venting, purging and is also combined with XeF_2 for etching.
c. Process chamber: Where etching occurs for the amount of time specified by the user.
d. Vacuum pump: pumps gases out of both the process and expansion chambers.
e. Shower head stop:

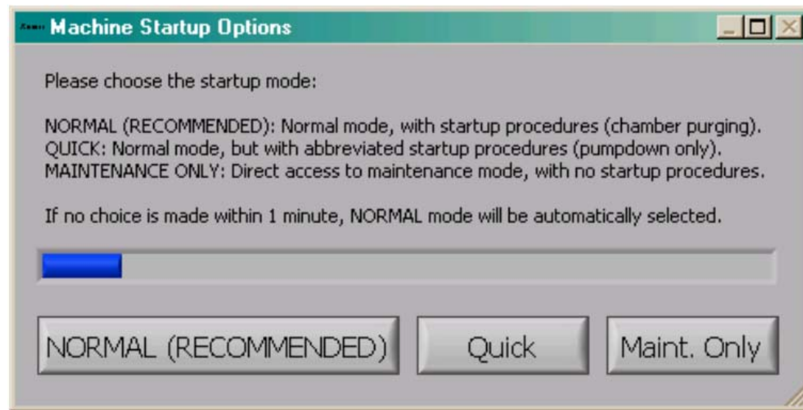
Operation

a. If the system has been off, press the ON (green) button to start the e1 series and the vacuum pump. The system has to warm up for four (4) hours before proceeding. If system is on, proceed to (e) below.



b. Turn on the computer system (if it has been off)
c. The Xetch program will auto start; if it doesn't not Press START- PROGRAMS-XACTIX- Xetch to start it manually.

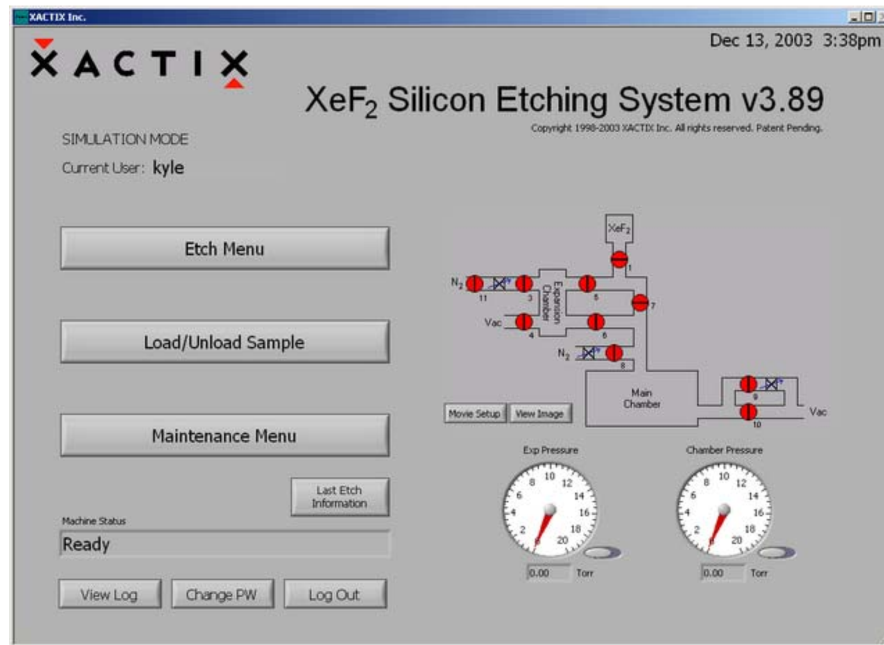
d. After initialization, a dialog box will appear. Press NORMAL startup and allow routine to complete.



e. Enter username and password to proceed. Username is USER and password is 1234.

Sample loading

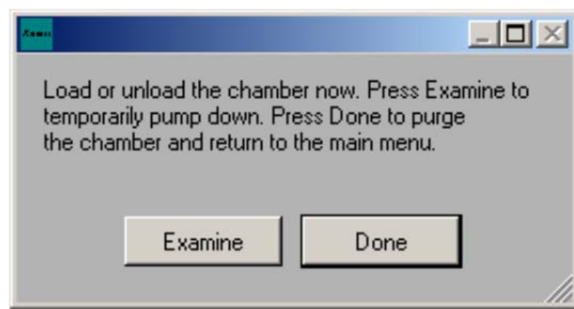
a. Upon successful login, the main menu below will be displayed.



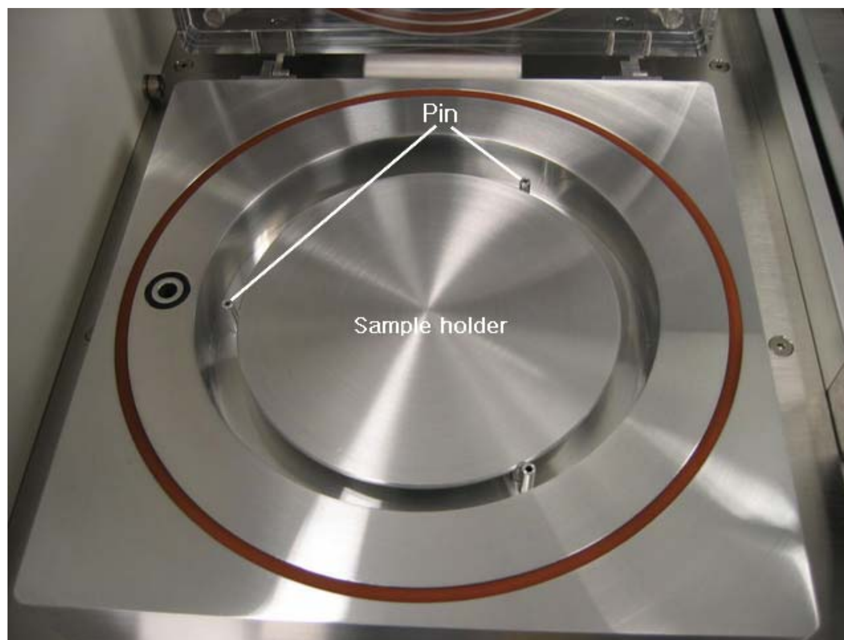
b. Press "Load/Unload Sample". Press "Yes" when prompted, unless you do not wish to load a sample. The system begins chamber purges and flushing cycles to evacuate the chamber.

c. If the chamber ventilation shroud is not pulled forward fully, a request to close the shroud will be displayed before venting the chamber.

d. Open the chamber lid when the dialog box below appears. Do not press any key prior to opening chamber.



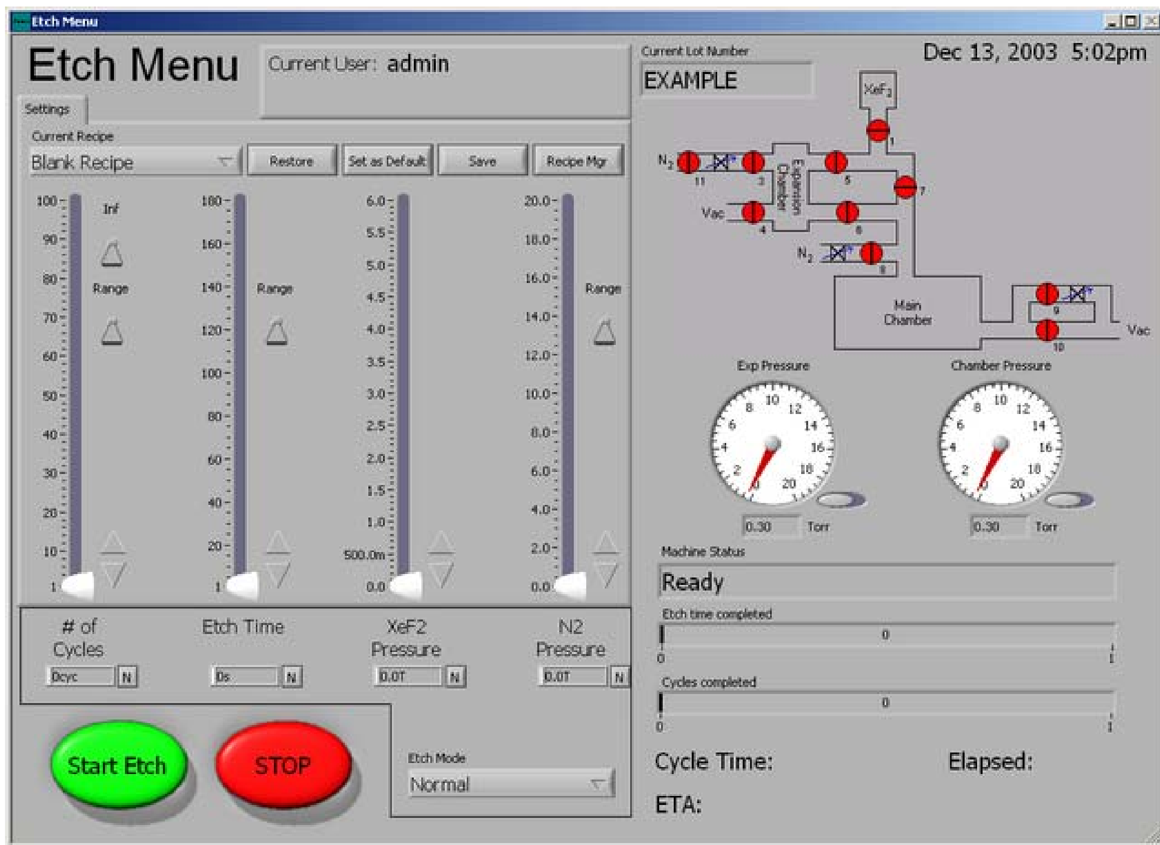
e. Load a sample. The sample holder and pins should as shown below.



f. Close lid
g. Press "Done" on dialog box shown in (c) above. The system will go through a purging cycle prior to chamber pump down.
h. The Examine button only pumps the chamber down, without purges, so that the system can be quickly vented to load the sample. This is very useful when examining a sample away from the system to prevent moisture from accumulating in the chamber. However, it is always necessary to press DONE before etching the sample.

Etching

a. Click on "Etch Menu" in the main menu screen. The screen below appears:
b. Enter lot number for the sample being etched. You can use alphanumeric characters. Press "DONE".
c. Two etch operating modes are available:
    1. Normal mode: utilizes a pulsed etch with a set XeF_2 and N_2 (if desired) pressure and etch time.
    2. Normal with delay mode: same as normal mode but also allows for a chill time for the sample to cool between each cycle.



d. To perform etch in Normal mode: Select normal under "Etch Mode".
   1. Select number of cycles. A cycle consists of the XeF_2 sublimating to the set pressure in the expansion chamber, etching for a set amount of time, and evacuation of the main and expansion chamber
   2. Select etch time: this time comprises the duration between the opening of the valve between the expansion chamber and the process chamber and the opening of the valve between the process chamber and the pump
   3. Set XeF_2 pressure: At room temperature, the upper limit for XeF_2 pressure is 4 torr.
   4. Set N_2 pressure: N_2 can be added into a recipe to improve selectivity

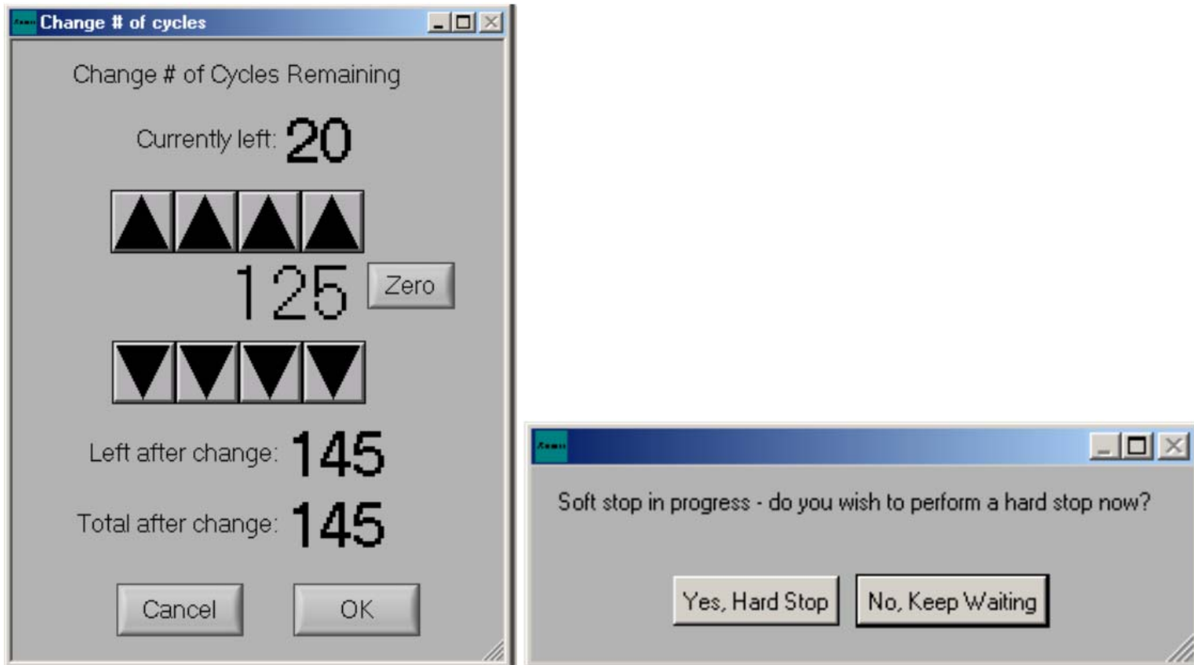
e. Default recipe

# of cycles	Etch time (sec)	XeF2 (torr)	N2 (torr)
20	15	1	2

The etch rate for this recipe is about 120nm/min for 50% exposed Si masked with SiO_2 on a 4-inch wafer.

f. To perform etch in Normal with delay mode, in addition to the above selections, set the ETCH DELAY which is the time in seconds that the system waits before beginning the next etching cycle.

g. Press the “START ETCH” button. Progress of the etch can be monitored following the Etch Time Completed and Cycles Completed bars along with the Elapsed Cycle Time and the ETA.
h. “CHANGE CYCLES” tab can be used at any time during an etch to adjust the number of cycles. It appears on the screen only when etching has been started. When selected (see dialog box below), use the top row of arrows to add cycles or the bottom row of arrows to remove cycles.



i. Press STOP to end the etching. The current cycle will be completed before ending the entire etch. If the “STOP” button is pressed twice, the Xetch will prompt the above. Choosing “Yes, Hard Stop” will end the etch cycle immediately and return the user to the main menu. If “No, Keep Waiting” is chosen only the current cycle will be completed before returning the user to the main menu.

Unloading samples

a. Press LOAD/UNLOAD and follow the steps as in 8 above.
b. Unload your samples
c. Press DONE to pump down the chamber.

Viewing Detailed Etch Information

a. The Detailed Etch Information log may be viewed by clicking on the VIEW LOG button on the Main Menu.
b. The log file is a database that is queried by beginning date and ending date. The “Today”: button will automatically set the dates to the current month, day, and year. The lot number, username, recipe, note’s keyword(s) and/or etching mode used can further

specify your search. Wildcard characters (*,?) may be used to fully specify the search criteria.

Creating or Changing a Recipe

a. Creating or changing recipes is done from the ETCH MENU screen.
b. Make the appropriate recipe changes
c. Save the recipe by clicking on the save button located near the top of the "perform etch screen".
d. The save new recipe screen will appear.

e. Global Recipes are starting recipe templates available to all users.
f. Using the toggle switch in the middle of the screen users can save the new recipe to their Personal Directory or the accessible Global Recipes.
g. Type in the name of your new recipe and Click on the SAVE button.