XACTIX

The MEMS Equipment Company[TM]

Xetch[®] System Manual

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Introduction

Thank you for purchasing the Xetch® xenon difluoride etching system.

XeF_2 (xenon difluoride) isotropic silicon etching is particularly well suited to MEMS applications. XeF_2 vapor phase etching exhibits nearly infinite selectivity of silicon to photo-resist, silicon dioxide, silicon nitride and aluminum. Being a vapor phase etchant, XeF_2 avoids many of the problems typically associated with wet processes. K. Pister discusses the use of xenon difluoride, as an etchant for MEMS applications, in part in US patent number 5,726,480.

The Xetch is the ideal solution for those seeking a cost effective R&D xenon difluoride etch system. Built for high etch uniformity, simplicity, low cost of ownership, and a small footprint, the Xetch is well suited for both industrial users and universities.

This manual covers un-crating, installation, initial start-up, operation, and maintenance of the unit.

To use the Xetch, simply place your wafer, die, or other structure into the etch chamber, close the lid, and press start on the touch screen. The details of the process sequence are captured in the control software, and the user just has to set target etch conditions. Etch progress is easily monitored using the stereomicroscope located above the transparent chamber lid.

Installation is very easy since only 120V AC input; dry compressed air, nitrogen, fast exhaust, and a scrubber line are required. The computer and XeF_2 canisters are contained within the etcher to minimize floor space. The combination of a robust design, tested etchant control software, the best possible components, and experienced workmanship results in a dependable and flexible etching tool for your production and research needs.

Xetch is a system designed to expose samples to xenon difluoride gas in either a cyclic (pulsed) mode in which the etch chamber is repeatedly filled with XeF_2 gas and pumped out again, or (as an option) in a flow through mode where all valves between the source bottle and the vacuum chamber are kept open and the system is periodically pumped out to a predetermined level.

Depending on the model system purchased, the Xetch can be fitted with the following components:

- Multiple process software modules
- Robotic substrate handling
- Electronic image capture of the process chamber
- Remote operating and monitoring software

The major components of the Xetch are:

- XeF$_2$ source bottle contains solid XeF$_2$, a white crystalline substance much resembling rock salt. At room temperature, the vapor pressure of XeF$_2$ is 3.9 Torr.

- N$_2$ source: supplies N$_2$ gas for venting and purging the process chamber, and combining with XeF$_2$ for etching.

- Expansion chambers: sublimated XeF$_2$ and nitrogen gas collect in the expansion chamber before entering the process chamber. The pressure of XeF$_2$ and the pressure of N$_2$ are selected by the user, and gases are allowed into the process chamber only when these pressures have been achieved.

- Process chamber: this is where the etching occurs for the amount of time specified by the user. When time is up, gas is pumped out and another etch cycle begins.

- Roughing pump: this pumps gases out of both the process chamber and the expansion chamber.

- Needle valves for adjusting the flow rates of N$_2$ are located on the left side of the Xetch, on the vacuum manifold. These should not have to be adjusted for normal use, and should remain partially open. Regulation of XeF$_2$ and nitrogen (N$_2$) is accomplished through a series of valves.

- Temperature control of the expansion chambers, gas panel, and the process chamber are located inside the front panel.

- Displays of pressure in the expansion chambers and process chamber are located on the computer screen.

This manual gives physical details of the services and ambient conditions required to accommodate the Xetch xenon difluoride etching system and to allow it to produce the high performance for which it is designed.

It must be emphasized that the time and expense devoted to proper site preparation will be rewarded by the consequent trouble-free, consistent operation and the resulting reduction in downtime.

Delegation of Responsibilities

When the system is delivered to the customer site, the customer is responsible for uncrating and preparing the system for installation.

The customer is solely responsible for proper site preparation. Site preparation entails all the work that has to be done, based on the checklist (see page 9), to prepare the site and make it suitable for installation and operation of the Xetch. In addition, preparation of the route within the customer's site and the transportation of the crated unit within the premises is the responsibility of the customer. All other requirements are fully explained in this manual. The customer is also responsible for coordinating the pre-installation site check.

A checklist of the pertinent conditions is provided below. This list should be completed in full during the site check.

USEFUL CONVERSIONS	
1 US gallon = 3.79 liter	1 liter = 0.26 US gallon
1 lb. = 0.455 kg	1 kg = 2.2 lb.
1 Imp. Gallon = 4.55 liter	1 liter = 0.22 Imp. Gallon
1 inch = 2.54 cm	1 cm = 0.4 inch
°F = (9/5 x °C) + 32	°C = 5/9 x (°F -32)

Installation

Preparation

General Requirements of the Site

A solid laboratory area capable of accommodating the weight of the Xetch must be provided. The floor should be flat and rigid, and allow adequate airflow around the system.

Normal clean room and/or laboratory environmental conditions are adequate for the Xetch.

Because of the weight of the Xetch, ***three or more people are required during the installation*** to remove the unit from the shipping container and to position it into its final position for operation.

Dimensions and Weights

Crated dimensions (W x D x H):   34.5" x 40" x 76"

                                        (86cm x 101cm x 193cm)

Crated weight: ~660 lb (300 kg)

Xetch dimensions (W x D x H):   21" x 26" x 66"

                                        (53cm x 66cm x 168cm)

Xetch weight: ~400 lb (182 kg)

Space Requirements

The Xetch requires free floor space in the clean room or laboratory environment totaling roughly 6 square feet, (0.5 square meters). In addition, sufficient space must be provided behind the unit, or in the clean room chase, for the system's roughing pump.

Physical Data

Minimum door width	40"(102 cm) Crated
	30" (80 cm) Uncrated
Minimum clearance at right side panel:	6.0" (15.25 cm)
Minimum clearance at left side panel:	6.0" (15.25 cm)
Minimum clearance at rear of unit:	12" (30 cm), (for service purposes)
Minimum clearance at front of unit:	24.0" (61 cm), (for operation)
Total weight of unit:	~400 lb (182 kg)

Electrical Services Required

For North American operations only, the Xetch is supplied with an appropriate 110-volt single-phase power cable. For all other countries the unit is delivered with a mains power cable terminating with bare wires as standard. It is the responsibility of the customer to provide a suitable mains connector that complies with the local regulations governing electrical connections.

Mains supply required:	100, 110, 120, 230 or 240 V
	50 or 60 Hz
	Single or two phase
Mains voltage fluctuations:	±10%
Mains connections:	via three-wire mains cable
	AWG #12
	2 phases and earth
	Suitable mains connector is required
Power consumption:	Max. 2400 VA
External fusing:	20 A at 100 or 120 V
	10 A at 230 or 240 V

General Ambient Conditions:

The area accommodating the Xetch should have:

- Adequate space all around the unit for servicing,

- Adequate space behind the unit for proper ventilation, and

- No unnecessary items near the unit.

Maximum ambient temperature to ensure Operation within specifications	85°F (29°C)
Relative humidity at	68°F (20°C) < 80%

WARNING!
Any interruption of the earth connection inside or outside the Xetch is likely to make the unit dangerous. The safety earth connection should fulfill all local safety requirements. Ensure that this is checked during the pre-installation site check.

Process Gas Requirements

- At a minimum, one cylinder of nitrogen gas containing a minimum of 40 cubic feet of gas must be available during installation. Utilizing a wall- or bench-mounted support bracket, this cylinder should be firmly secured to prevent possible damage or explosion of the cylinder and/or cylinder valve. The customer must also provide a suitable pressure regulator (Matheson MA-18 or equivalent) with a shut-off valve for the process gas supply.

- A source of clean dry air, compressed to 70-100 psi is required for operation of the pneumatic valves.

- Two standard cylinders with filled xenon difluoride gas, (not included with the Xetch), should also be available for installation within the Xetch frame. Information on xenon difluoride suppliers can be found on the XACTIX website http://www.xactix.com. A schematic of a typical cylinder (lecture bottle) can be found on page **Error! Bookmark not defined.**.

Exhaust Requirements

WARNING!
The exhaust gas from the output port of the Xetch's roughing pump should be vented into a suitable fume exhaust or centralized exhaust gas ventilation system. Any fittings and/or tubing required should be obtained locally. The customer, to completely vent the system frame, can also optionally supply a recommended 100 cfm fume exhaust, using a 1" diameter hose to the back of the frame.

Installation Material

- Electrical connector as required for local electrical outlet.

- Gas regulator for Nitrogen gas.

- Gas cylinder mounting bracket bench mount, or wall mount.

- Exhaust connector to be supplied as required locally.

- Exhaust tubing to be supplied as required locally, 1" ID tubing. Stainless steel recommended.

Pre-Installation Checklist

Subject	Requirement	Yes	No	Comments
Space requirements	See above			
Room temperature	< 85°F (29°C)			
Relative humidity	< 80%			
Mains supply	100-120 V			
	230 V-240 V			
	Single or two-phase			
	50/60 Hz			
Mains voltage	±10%, includes transient fluctuation			
Mains connection	See above			Consult local requirements
Earthing	See above			Consult local requirements
Process gas				
	40 cu. ft. min, Nitrogen			
	70-100 psi, Compressed dry air			
	Standard lecture bottle, Xenon difluoride			
System exhausting				
	Fume exhaust to roughing pump outlet			
	100 cfm exhaust to chamber area			

ANY DEVIATION FROM THESE INSTALLATION AND SAFETY REQUIREMENTS MAY CAUSE DETERIORATION IN THE XETCH PERFORMANCE AND/OR OPERATION

Cylinders and valve for XeF$_2$

- Cylinder: 0.3 L Seamless Aluminum, 0.6 kg XeF2 capacity.
- Valve   FG-PEL-001, Stainless steel, tied diaphragm, ¼" VCR male outlet, straight pattern.

Uncrating

Inspect the shipping crate for signs of obvious damage encountered during shipment, (dents, scrapes, holes, etc.). Also inspect the "Tip n' tell" gauges and ensure that they have not been tripped. If a gauge has been tripped, this indicates that the crate was handled roughly and/or tilted at high angles during shipment. Please make a note to the shipper and contact XACTIX immediately.

Using a power screwdriver, open the top of the crate, the side panel labeled "Open This Side (1 of 2)" first, and the side panel "(2 of 2)" second.

The Xetch is mounted on wood skids and is located by four wooden planks. Remove these planks with a power screwdriver to remove Xetch. Also found in the crate are various boxes containing accessories for the Xetch, (Xetch microscope, ring light and remote, LCD touch screen monitor, keyboard and mouse, and roughing pump and oil. Remove all separate boxes and accessories from the crate. Inspect everything for signs of obvious movement during shipment.

The Xetch is fitted with industrial casters for ease of movement. Using appropriate manpower, and remembering that the unit weighs 400 lbs, lift the unit off the crate and place on floor. It is recommended that the unit be lifted using the base frame as a pickup point.

Wheel the Xetch and all accessories to its operation location in your processing facility.

Installation Procedure

Once the unit has been placed in its operation location, follow these steps to install the equipment. If an XACTIX installation engineer is present, this person will complete the procedure.

1. Remove the pump from boxes and place behind the system.

2. Connect the compressed dry air (CDA) line to the Swagelok bulkhead fitting at the rear of the frame.

3. Connect the nitrogen line (N2) to the Swagelok bulkhead fitting at the rear of the frame.

4. Using the supplied hoses, connect the vacuum port of the pump to the port (VACUUM) on the back of the system frame. Then connect the exhaust hose to the exhaust port (VENT) on the vacuum pump. The other end of the exhaust hose needs to be vented into an exhaust duct.
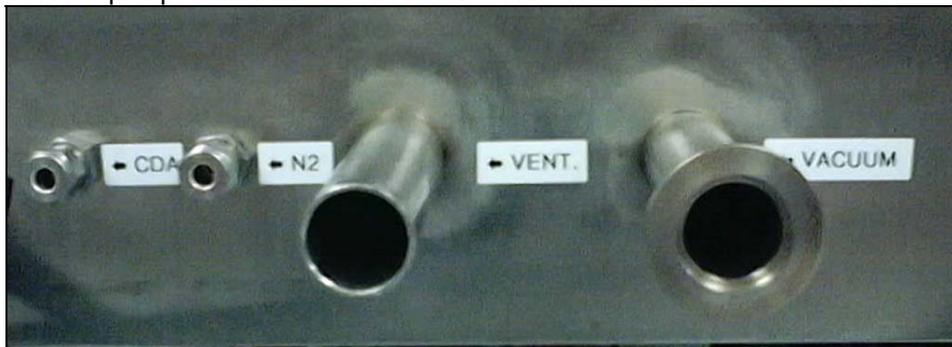
5. Install the LCD monitor on its quick-connect mounting bracket, rotate the securing lever clockwise to open and counter clockwise to close. Be certain the lever has securely fastened the monitor to the bracket before closing. Connect the three monitor cables, (monitor, touch screen, and DC power) from the computer to the monitor.

6. The installation of the optical microscope is described next:

   - Install the microscope onto the mount.

   - Mount the circular light around the microscope neck.

   - Connect the fiber optic cable from the light source to its power supply in the frame. Tighten all mounting screws.

7. Install all side panels if not already done. (Note that on the back of the system, the shorter of the two panels is fitted above the taller one).

8. Note and record the serial number of the system.

9. Remove the protective sheet from the top cover of the vacuum chamber.

10. Turn on the XDS 10 pump.

Figure 2: BOC Edwards XDS10 Dry Scroll Pump

(Image from www.bocedwards.com)

11. Do not install a loaded xenon difluoride bottle at this time. Initial start-up tests are done with an empty bottle.
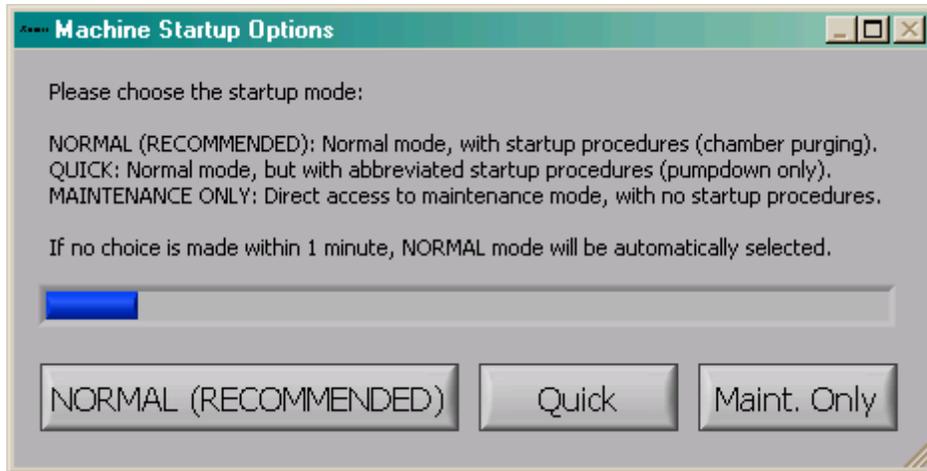
Software Control

Please note, some of this section of the manual describes features that are part of the X3 series system. One item in particular is that computer controlled temperature adjustment is not part of the X2 series and references to it should be ignored.

The Xetch performs several activities when the system is turned on, including initializing hardware, purging the chambers, and preparing the software to run. There are three options displayed after the machine initializes the hardware, and this dialog box is shown below.

- Normal mode is the recommended method of startup for the Xetch. In this mode, the machine pumps and purges all of the machine chambers, assuring the user that the chambers are purged.

- In Quick mode, the chambers are simply pumped down, with no purging performed. This mode is useful when the state of the system is known upon startup, and no purging is necessary.

- In Maintenance only mode, the etch menu and load sample menu are disabled, and only the maintenance menu can be reached. This mode is useful when there is a machine fault that needs to be resolved by a technician.

If no choice is made for one minute, Normal mode is selected by default. This allows the system to start up unattended.

![XACTIX logo] *The MEMS Equipment Company*[TM]

Machine Startup Options

Please choose the startup mode:

NORMAL (RECOMMENDED): Normal mode, with startup procedures (chamber purging).
QUICK: Normal mode, but with abbreviated startup procedures (pumpdown only).
MAINTENANCE ONLY: Direct access to maintenance mode, with no startup procedures.

If no choice is made within 1 minute, NORMAL mode will be automatically selected.

[NORMAL (RECOMMENDED)]   [Quick]   [Maint. Only]

Xetch Log in

The Xetch is set up so that individual users are required to log in to the system. When starting the Xetch the prompt below will be displayed. Each operator is required to input their username and password which will be assigned to them by the system administrator. The KB button beside the Username and Password field can be used to access the on-screen keyboard.

Main menu

The system administrator can log in to the system by inputting "admin" as the username. A password can be created after the initial log in as the administrator (for the first login, the password field should be left blank).
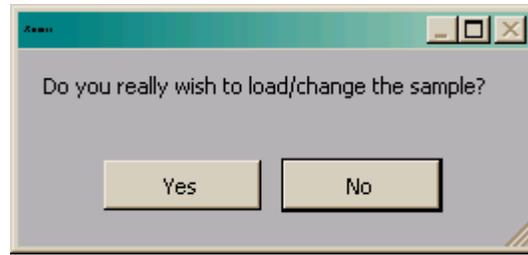
Upon a successful login, the main menu will be displayed as shown below. The machine status is shown in the bottom left corner. When the main menu is displayed, the chamber is under vacuum and ready for use. A schematic for the machine is shown on the right. Red dots denote closed valves, while green dots represent open valves. Pressure gauges for the main chamber, and two expansion chambers are at the bottom right. The three options available on the main menu consist of performing an etch, loading/unloading a sample, and accessing the maintenance menu.
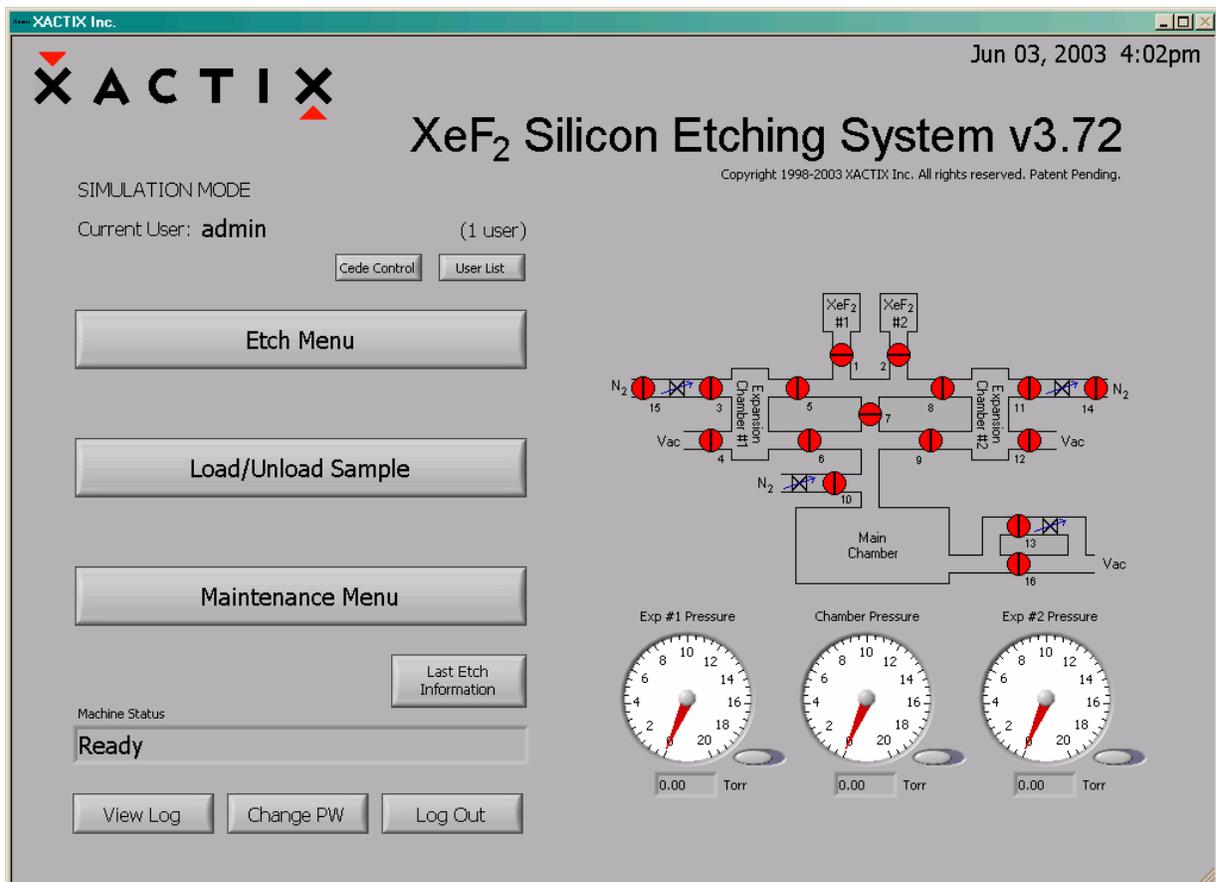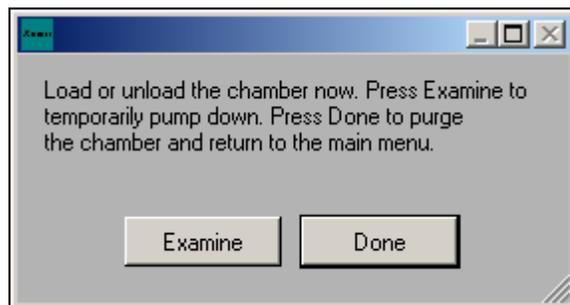

Sample Loading

To load/unload a sample:

1. Press "unload/load sample" on LCD screen. The system will go through prompts to ensure a correct decision: Are you sure? Press YES if you're sure, NO if you're not. This prompt is provided since the load/unload process can be time consuming and is inconvenient if accidentally started. The system begins chamber purges and flushing cycles to evacuate the chamber, shown below.

Do you really wish to load/change the sample?

Yes   No

Load/Unload Sample

Jun 03, 2003 4:05pm

Cancel

Machine Status

Purging Chamber

Exp #1 Pressure   Chamber Pressure   Exp #2 Pressure

0.00   Torr   23.63   Torr   0.00   Torr
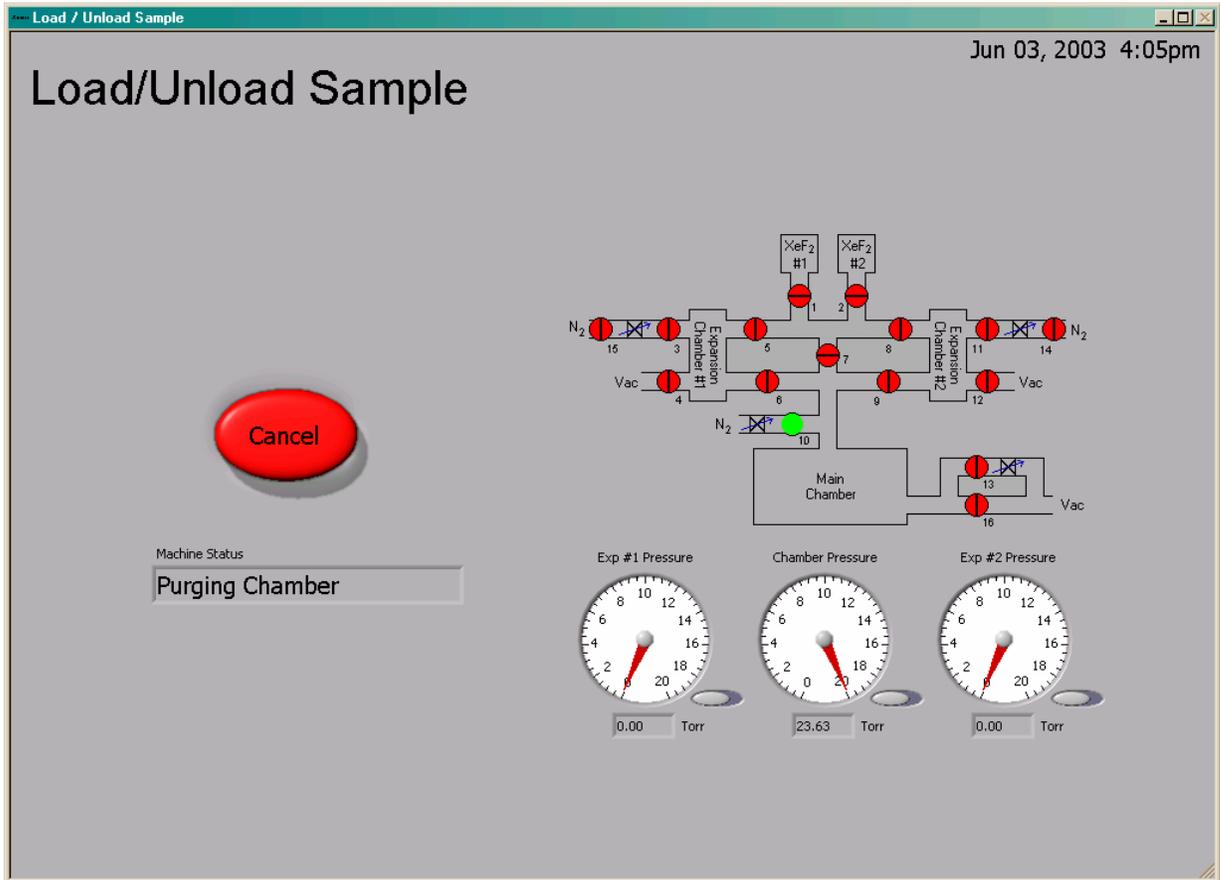
2. Swing the microscope out of the way of the chamber.

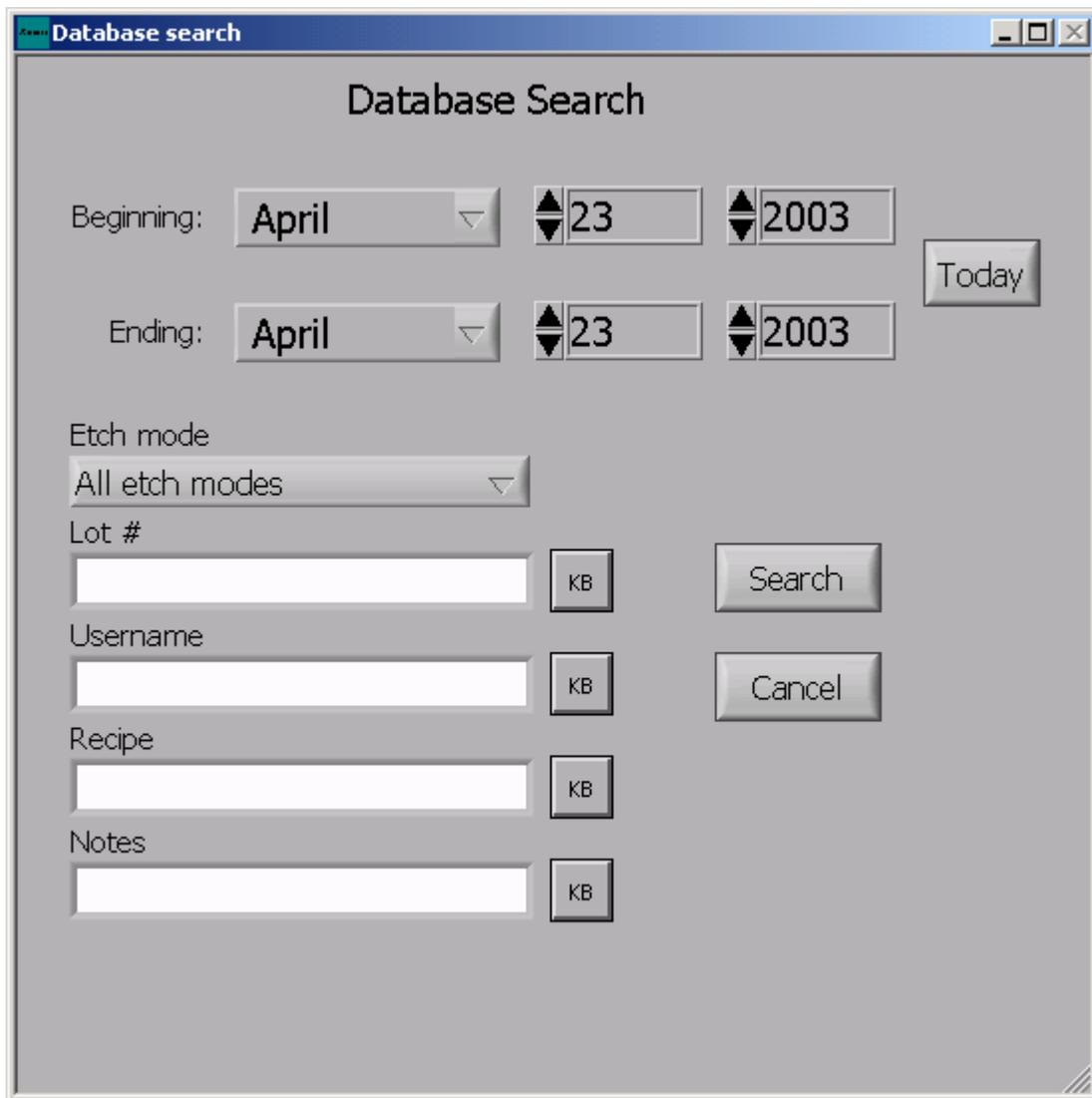3. When the chamber is vented, the dialog box below will appear and you can open the chamber lid. The lid will rest open on the stop behind chamber.
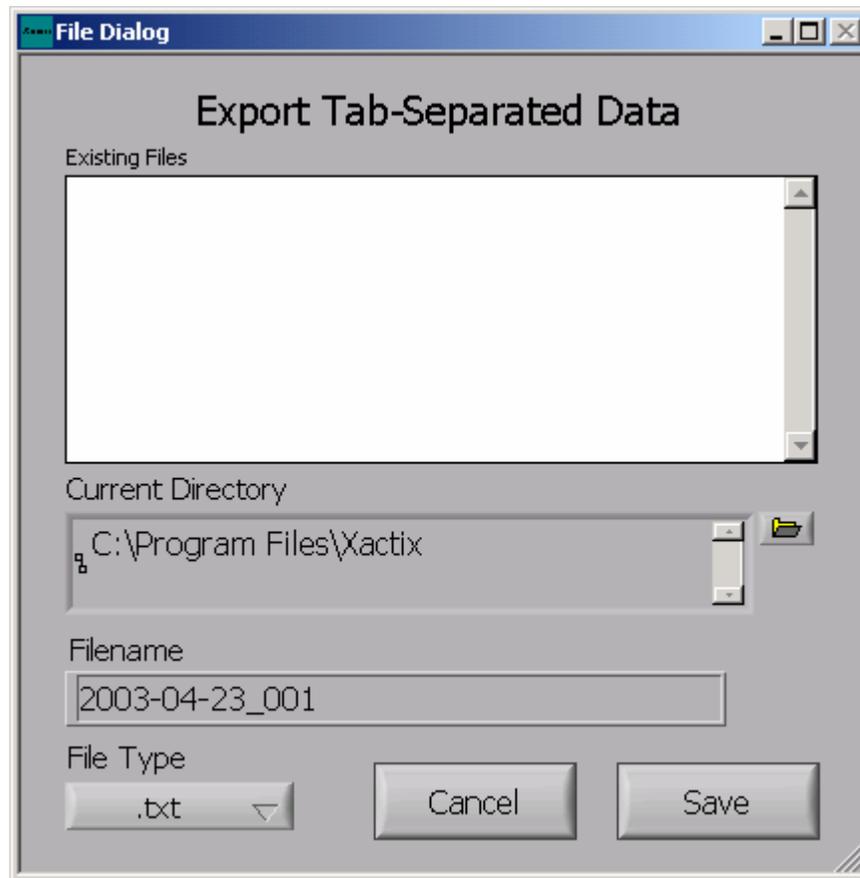
Load or unload the chamber now. Press Examine to temporarily pump down. Press Done to purge the chamber and return to the main menu.

Examine   Done

4. If desired, load a sample.

5. Close the lid.

6. Press "Done" on LCD screen as shown below, the system will go through a purging cycle prior to chamber pump-down. As a side note, 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.

7. During the pumping cycle, a "click" sound will be heard that indicates that the ventilation shroud can be moved.
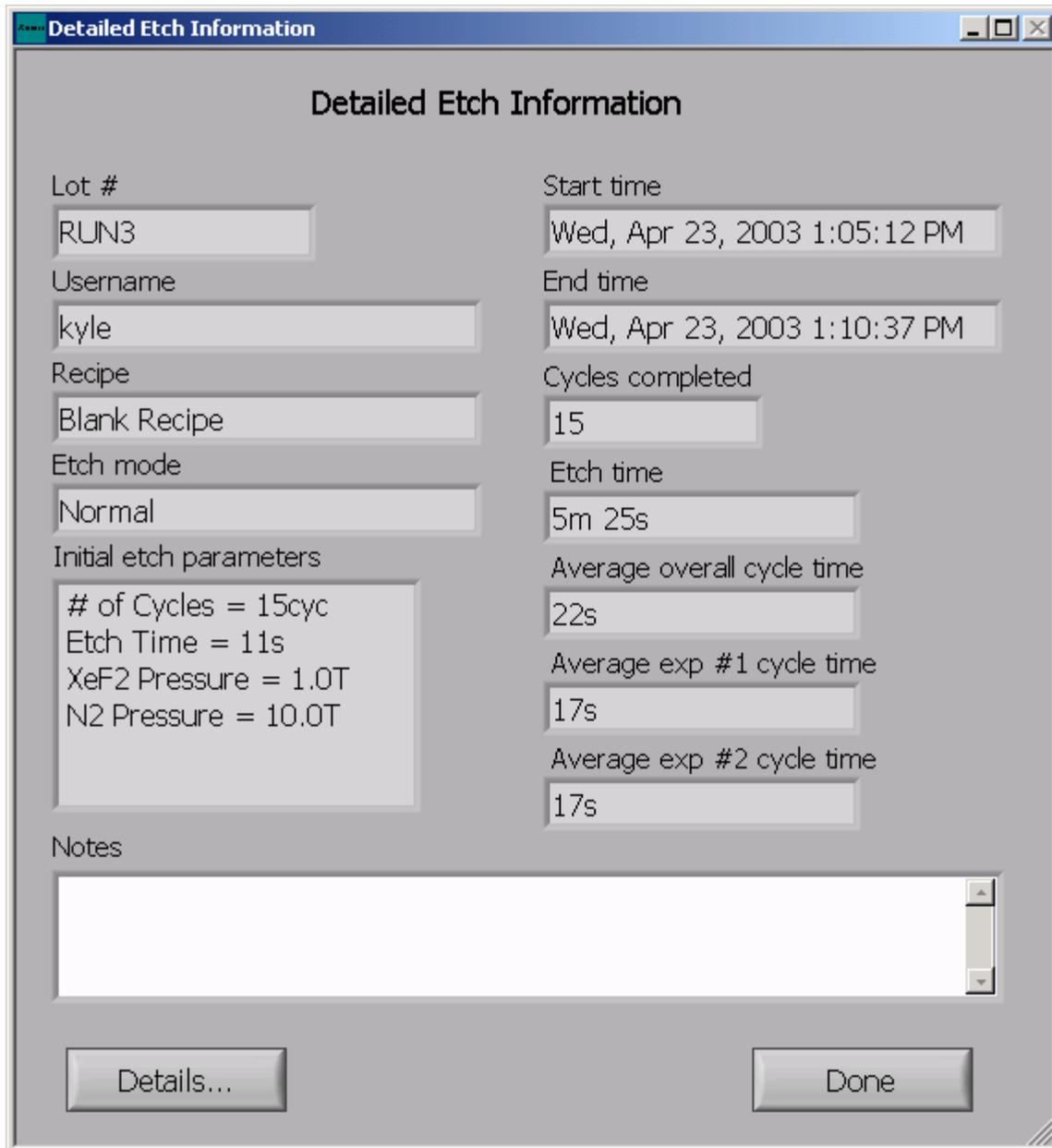
Viewing the Log

The log may be viewed by clicking on the "View Log" button on the maintenance menu. 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.

If the boxes are left blank, clicking the search button will reveal all history info, displayed in a tabular form.

Start Time	Lot #	Recipe	# Cycles	Username
Wed, Apr 23, 2003 8:28:06 AM	test	Blank Recipe	10	admin
Wed, Apr 23, 2003 12:54:16 PM	RUN1	Blank Recipe	20	admin
Wed, Apr 23, 2003 1:00:11 PM	RUN2	Blank Recipe	25	admin
Wed, Apr 23, 2003 1:05:12 PM	RUN3	Blank Recipe	15	kyle

Figure 1. Database Information screen.

The export data button allows you to export all of the information shown in the table to a tab-separated text file that can be opened in the program of your choice, such as Microsoft Excel, Microsoft Access, and Microsoft Word, as shown below. Choosing a destination folder can be done by clicking on the folders icon at right side of the "File Dialog" screen. A default folder for saving log files and photos may be selected in the "System Configuration Menu". File names are automatically entered in this form, (2003-04-23_001.txt). This represents the year, month, day, and the number of the export for that day.

Besides being able to export the information, a selection from the displayed in the "database information" screen (see Figure 2), the information for a particular date and time can be accessed by highlighting the row of information desired and clicking the "detailed info" button. Note that the file is automatically scrolled to the bottom of the file, the "Top" or "Bottom" buttons are used to scroll instantly to the top or to the bottom of the log file. The result of the detailed information display is below. One unique feature of this menu is that comments can be typed into the Notes area (however, the number of characters is limited to 250). One other item to note is that the Average Overall Cycle time is not the average of the expansion chamber cycle times, but is computed by dividing the total run time divided by the number of cycles.

Detailed Etch Information

Lot #	Start time
RUN3	Wed, Apr 23, 2003 1:05:12 PM
Username	End time
kyle	Wed, Apr 23, 2003 1:10:37 PM
Recipe	Cycles completed
Blank Recipe	15
Etch mode	Etch time
Normal	5m 25s
Initial etch parameters	Average overall cycle time
# of Cycles = 15cyc	22s
Etch Time = 11s	Average exp #1 cycle time
XeF2 Pressure = 1.0T	17s
N2 Pressure = 10.0T	Average exp #2 cycle time
	17s

Notes

Details...   Done

Other Main Menu items

At the bottom left side of the main menu are buttons for changing the user's password and logging out. The log shows all of the operations that have been recently performed. The log can also be useful for accessing the exact start and end times of a run. The "change password" button allows a user to change their password by entering their username and previous password. The log-out button is used to exit the system. A prompt will appear once the button has been pressed inquiring if the user wishes to log out. Once the log out has been completed the system returns to the login screen.

Software operation details

Recipe Storage

To save a recipe, click on the save button located near the top of the "perform etch screen". The save new recipe screen is pictured below. By using the toggle switch in the middle of the screen users can save the new recipe to their Personal Directory or the accessible to all users Global Recipes directory (the ability to save recipes to the global directory may be turned off for some users as described below).

Recipe Manager

The recipe manager may be used to copy other users' recipes, located in their personal directory to the current user's personal directory. This option is limited to users with configurable etch access. The current user's personal recipes are displayed in the left box (in this case admin). The personal directory for other users is found in the right box. The pull down bar at the top right can be used to select from the personal recipes of various users. To copy a recipe into the current user's directory, select the desired recipe and click on the left arrow icon between the two directory windows.

A recipe may also be copied from the user's personal directory to the global directory (if the user has global write access). This is done by highlighting a recipe in the user's directory, selecting Global Recipes in the right window and then using the right arrow to copy it to the Global Directory.
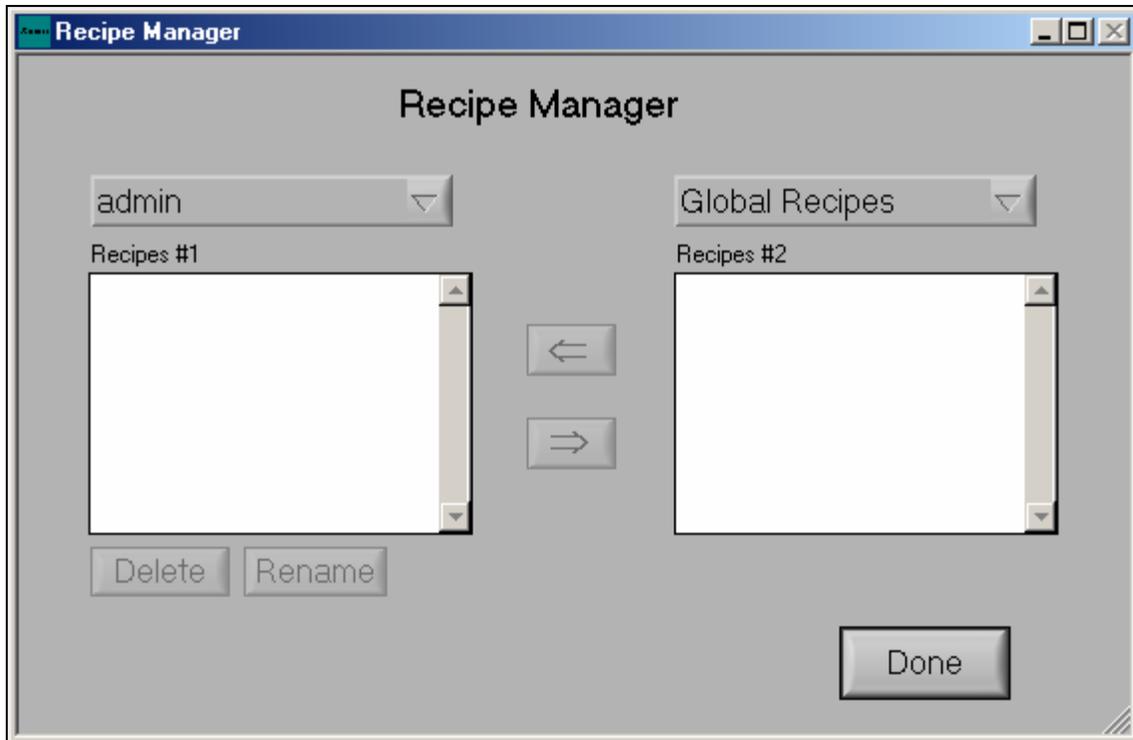
Performing an Etch

In order to perform an etch, the "perform etch" button in the main menu must be selected. The Xetch will prompt you to enter the lot number of the sample being etched. Press done once number is entered. The "perform etch" screen is shown below with lot number, "EXAMPLE" in this case; the screen pictured is for the normal etch mode.

It is important to note that in the "perform etch" screen, some options may not be available to certain users depending on the privileges which were given during the creation of their account.

The Xetch software may be run in one of three operating modes that can be used during an etch. Only one operating mode (Normal) is included with the system. The others are optional upgrades. The etch mode at the bottom middle of the "perform etch" screen can be used to select the etch mode.

- The normal mode, (included at delivery) utilizes a pulsed etch with a set xenon difluoride pressure and etch time.

- An advanced normal etch mode (optional upgrade) allows for the user to set the expansion chamber pump-out pressure between cycles.

- The flow through mode (optional upgrade) creates a continuous flow of xenon difluoride.

All three modes offer unique advantages; therefore the user must determine which etch mode will be best suited for his/her process. Each of these modes is described in detail in the following pages.
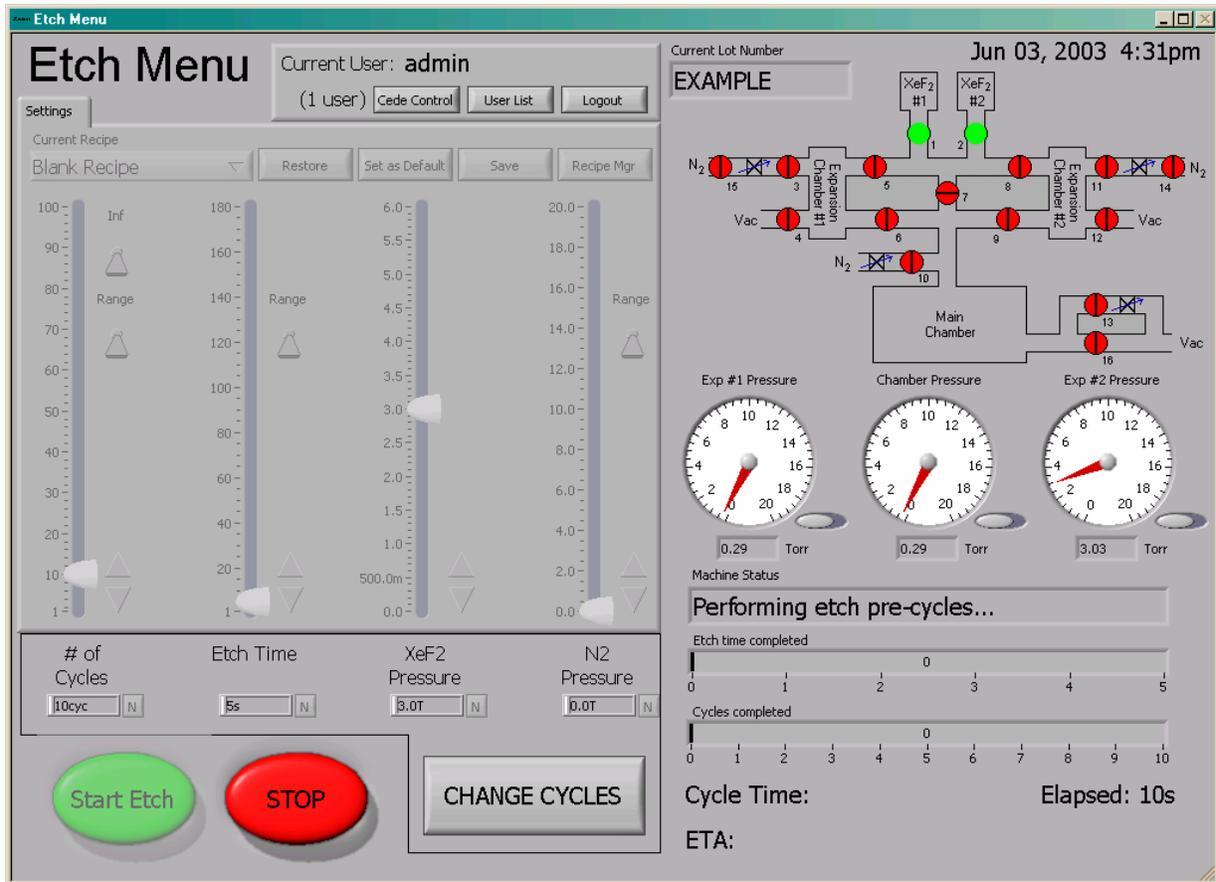
Etch Menu Features

On the right side of the "perform etch" screen a valve schematic of the Xetch is shown so that the user can monitor the machine operation.

In addition to this, at the bottom of the right side of the screen are two counters. The first counter displays how much time has transpired during the etch portion of the cycle. The second counter shows the number of cycles completed.

At the very bottom of the screen; "START ETCH", this is used to begin the etching process; "STOP", this is used to end the etch prematurely; "CHANGE CYCLES" button which at any time during an etch can be used to add cycles to the etch in-progress. Once selected, the "Change # of Cycles" menu on next page, is prompted. The top row of arrows will add cycles in this order, (right to left); ones, tens, hundreds, and thousands; the lower row of arrows, having the same values, will remove cycles. All the user has to do is click on the designated arrow for the desired number of cycles needed to be added to the etch in-progress. For an example, an extra 125 cycles have been added to the etch by clicking the right most arrow (ones) five times, the next right most arrow (tens) twice, and the 2nd from left most arrow (hundreds) once.

NOTE: The "CHANGE CYCLES" button will only appear on the etch screen, if the etch parameter "Soft Stop" is set to "TRUE", and only once etching has been started.
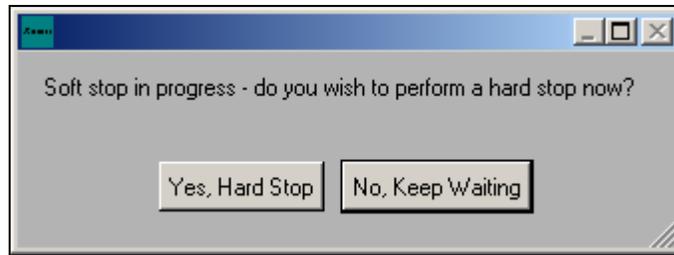
If "Soft Stop" is made "TRUE" in the "Etch Parameters" menu, the Xetch will allow the current cycle to finish before ending the entire etch. If the "STOP" button is pressed twice, the Xetch will prompt the above menu (See also "Soft Stop" on page **Error! Bookmark not defined.**). Choosing "Yes, Hard 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.
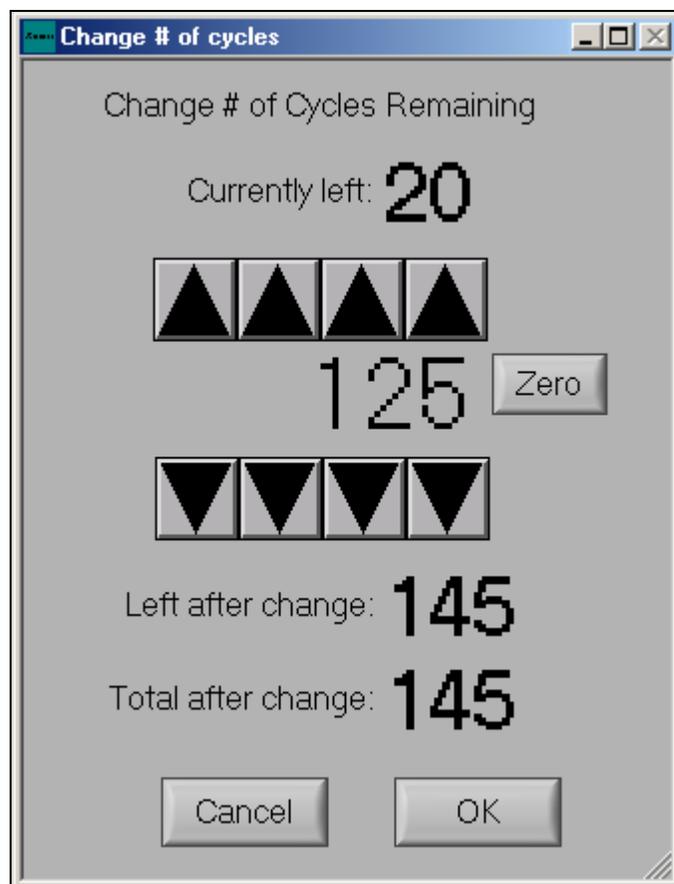
At the bottom of the screen there is a figure labeled ETA. This feature displays the expected completion time. The ETA is continuously updated during the process run.

Once the desired recipe settings have been chosen then etching can be initiated. By pressing the "Start Etch" button at the bottom left, the set values are stored and used to complete the desired etching sequence. At this point all of the controls will be disabled except for the stop button.

At the bottom left side of the main menu are buttons for viewing the Xetch Log, changing the user's password, and logging out.

The log shows all of the operations that have been recently performed. The log can also be useful for accessing etch information, such as the exact start and end times of a run.

The change password button allows a user to change their password by entering their username and previous password.

The log out button is used to exit the system. A prompt will appear once the button has been pressed inquiring if the user wishes to log out. Once the log out has been completed the system returns to the login screen.

Performing an Etch in the Normal Mode

Normal Mode Etching Variables

Number of cycles

Since the Xetch is primarily a pulsed xenon difluoride etching system, the duration of etching is controlled by the number of cycles. A cycle consists of the xenon difluoride sublimating to the set pressure in the expansion chamber, etching for a set amount of time and evacuation of the main chamber and expansion chambers. Since the Xetch utilizes two expansion chambers the time waiting for the filling up of each expansion chamber is minimized.

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 between the expansion chamber and the process chamber and the opening of the valve between the process chamber and the pump.

XeF$_2$ Pressure

In order to introduce the proper amount of xenon difluoride into the main chamber a set pressure charge of xenon difluoride must be delivered to the expansion chamber. Because xenon difluoride has a vapor pressure of ~4T at room temperature the upper limit for the XeF$_2$ pressure is approximately 4T. Due to the slightly elevated temperature inside of the etcher cabinet, you may be able to get considerably higher XeF$_2$ pressures, however.

N$_2$ Pressure

Nitrogen can be added into a recipe to improve selectivity. The pressure obtained in the expansion chamber likewise controls the amount of nitrogen introduced into the process chamber. The above variables can be set either by moving the white slider on the scroll bar or by tapping or depressing on the arrows at the top and bottom of the scroll bar to increment each value or by direct entry through the keyboard. Additionally, a range button is included for the number of cycles, etch time and nitrogen pressure so that the user can input higher values than the default range allows.

The "perform etch screen" is shown below in normal mode.
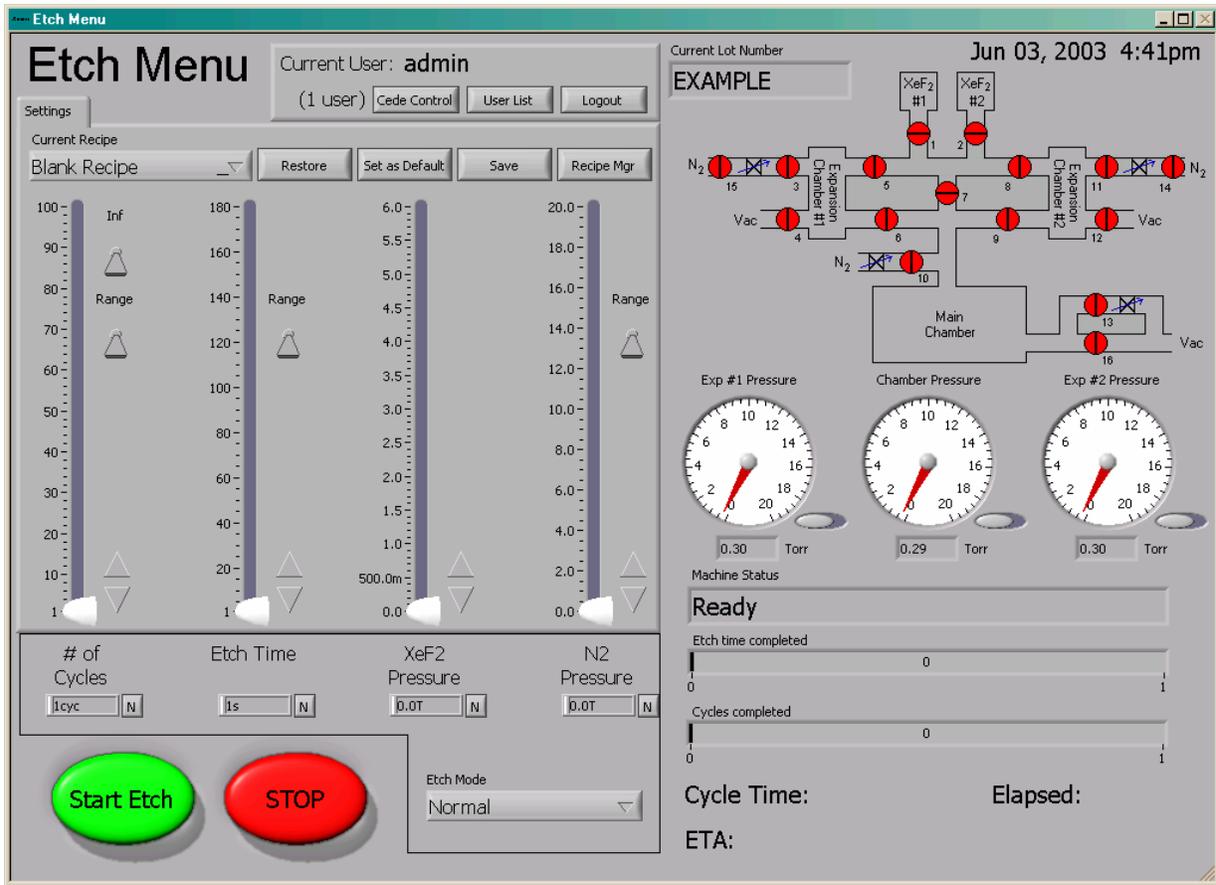
Performing an Etch in the Advanced Normal Mode

The operation of the Xetch in the advanced normal mode (optional upgrade) is similar to the normal mode; however in the advanced mode, which is a XeF2 only process, the user can set the pump-down pressure in the expansion chamber. The advanced normal mode allows for full optimization around the etch rate and cycle time leading to a higher throughput.

Advanced Normal Mode Etching Variables

Number of cycles

Since the Xetch is primarily a pulsed xenon difluoride etching system, the duration of the etch is controlled by the number of cycles. A cycle consists of the xenon difluoride sublimating to the set pressure in the expansion chamber, etching for a set amount of time and evacuation of the main chamber and expansion chamber. Since the Xetch utilizes two expansion chambers the time waiting for the filling up of each expansion chamber is minimized.

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 between the expansion chamber and the process chamber and the opening of the valve between the process chamber and the pump.

XeF$_2$ Pressure

In order to introduce the proper amount of xenon difluoride into the main chamber a set pressure change of xenon difluoride must be delivered to the expansion chamber. Because xenon difluoride has a vapor pressure of ~4T at room temperature the upper limit for the XeF$_2$ pressure is approximately 4T. Due to the slightly elevated temperature inside of the etcher cabinet, you may be able to get considerably higher XeF2 pressures.

Pump-out Pressure

The pump-out pressure allows the user to set the pressure to which the process and expansion chambers are pumped down to during the evacuation portion of the cycle. The above variables can be set either by moving the white slider on the scroll bar or by tapping or depressing on the arrows at the top and bottom of the scroll bar to increment each value exponentially. Additionally, a range button is included for the number of cycles, etch time and nitrogen pressure so that the user can input higher values than the default range allows. The "perform etch" screen is shown on the following page for advanced normal mode etching.

Performing an Etch in the Flow Through Mode

In the flow through mode, (optional upgrade), a continuous flow of xenon difluoride is maintained by keeping V1, V2 and V7 open. As a result the process chamber is always filled with xenon difluoride, which will yield shorter cycle times. The system is controlled by pulsing the roughing pump's vacuum valve according to the etch recipe.

Flow Through Mode Etching Variables

Number of Cycles

In the flow through cycle mode, the xenon difluoride pressure reaching the maximum pressure and the vacuum valve opening long enough to pump the system down to the minimum pressure defines a cycle.

Maximum Pressure

The maximum pressure is the highest pressure of xenon difluoride that is achieved in the process chamber prior to the vacuum valve opening. If the pressure were to reach in excess of 300 T, all valves are closed to prevent over-pressurization leak.

Minimum Pressure

The minimum pressure is the lowest pressure of xenon difluoride in the process chamber prior to the vacuum valve closing.

The above variables can be set either by moving the white slider on the scroll bar or by tapping or depressing on the arrows at the top and bottom of the scroll bar to increment each value exponentially. Additionally, a range button is included for the number of cycles so that the user can input higher values than the default range allows.

The Flow Through Cycle etch screen is shown below for flow through cycle mode etching.

Flow Through mode can also be operated in a Timed mode.

Total Time

In the timed flow through mode, where the total etch time is specified and the etch continues cycling until reaching the etch time. The Timed Flow Through etch screen is shown below.

Maintenance Menu

	WARNING
⚠️	**MAINTENANCE MODE SHOULD ONLY BE USED BY THOSE INDIVIDUALS WHO UNDERSTAND THE RISKS OF EXPOSURE TO XEF2 AND ARE FULLY TRAINED IN THE USE OF THE MAINTENANCE ACTIVITIES FOR THE SYSTEM.**

The maintenance menu may be accessed via the "maintenance menu" button found on the main menu screen. For users without maintenance privileges the maintenance menu will not be accessible.

Within the maintenance menu there are nine options. These options consist of adding and deleting users, editing the configuration menu, leak-back checking the system, purging the main chamber, gauge recalibrating, changing the xenon difluoride bottles (see page 54), exiting the Xetch software, viewing the full Xetch log, and returning to the main menu. Each of these operations will be discussed in the following sections. In addition to the nine options available in the maintenance menu, the approximate amount of xenon difluoride consumed from each bottle is displayed in the middle left section of the screen.

Viewing the Full Log

The full log may be viewed by clicking on the "View Full Log" button within the maintenance menu. 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.

If the boxes are left blank, clicking the search button will reveal all history info, displayed in a tabular form.

Figure 2. Database Information screen.

The export data button allows you to export all of the information shown in the table to a tab-separated text file that can be opened in the program of your choice, such as Microsoft Excel, Microsoft Access, and Microsoft Word, as shown below. Choosing a destination folder can be done by clicking on the folders icon at right side of the "File Dialog" screen. A default folder for saving log files and photos may be selected in the "System Configuration Menu". File names are automatically entered in this form, (2003-04-23_001.txt). This represents the year, month, day, and the number of the export for that day.

Besides being able to export the information, a selection from the displayed in the "database information" screen (see Figure 2), the information for a particular date and time can be accessed by highlighting the row of information desired and clicking the "detailed info" button. Note that the file is automatically scrolled to the bottom of the file, the "Top" or "Bottom" buttons are used to scroll instantly to the top or to the bottom of the log file. The result of the detailed information display is below. One unique feature of this menu is that comments can be typed into the Notes area (however, the number of characters is limited to 250). One other item to note is that the Average Overall Cycle time is not the average of the expansion chamber cycle times, but is computed by dividing the total run time divided by the number of cycles.

Detailed Etch Information

Detailed Etch Information

Lot #
RUN3

Username
kyle

Recipe
Blank Recipe

Etch mode
Normal

Initial etch parameters

```
# of Cycles = 15cyc
Etch Time = 11s
XeF2 Pressure = 1.0T
N2 Pressure = 10.0T
```

Start time
Wed, Apr 23, 2003 1:05:12 PM

End time
Wed, Apr 23, 2003 1:10:37 PM

Cycles completed
15

Etch time
5m 25s

Average overall cycle time
22s

Average exp #1 cycle time
17s

Average exp #2 cycle time
17s

Notes

[Details...]   [Done]

For system errors and maintenance related issues, the full log can offer valuable information. To display the details of the full log, click "details" on the "display detailed etch info" screen, shown on next page, to view the log file in its entirety. In the notepad program, the date, time, and actions executed are displayed as shown below. The level of detail included in the details of the full log is controlled by the settings related to the log file in the System Configuration Menu, which is described later.

User Manager

The user manager can be used to add, delete and assign privileges to various users.

Only the System Administrator can access the "user manager".

Users can be added using the "New" button, while current users can be removed using the "Delete" button. To change a user's privileges the "Edit" button can be used. To exit the User Manager and return to the maintenance menu click on "Done".
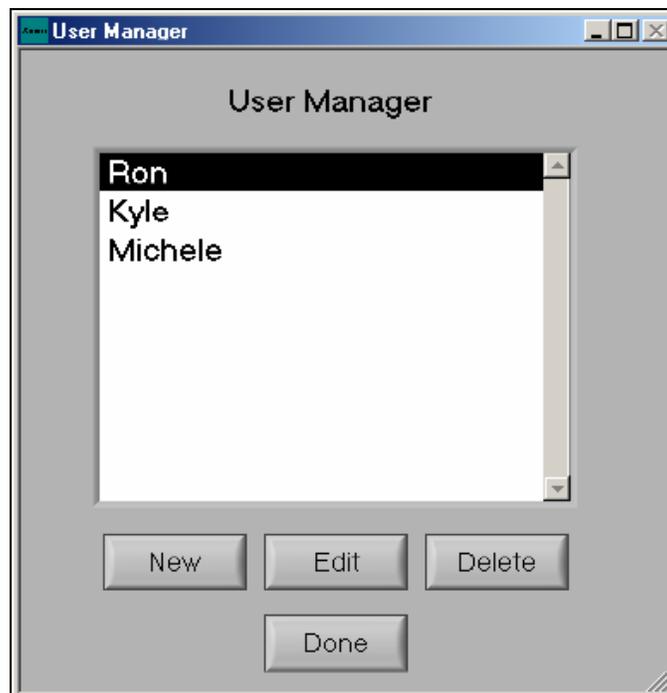
Adding a User

A new user can be added to the system by clicking on the new button within the user manager.

The edit user screen will appear as shown on next page. The name of the user should be entered into the User Name box and a password then entered, if desired. If no password is entered, a reminder message stating that the user has no password will be displayed and if this is OK. The users default recipe can then be selected and the amount of XeF2 can be entered for the user's starting point, if necessary, or is typically left at 0. Later, this value can be examined to show the total quantity of XeF2 used by the user.

Three options (privileges) are available for users. A user can be given permission to access the maintenance menu thus giving them the ability to execute such functions as changing the machine configuration, changing the xenon difluoride bottle, and viewing the full log.

⚠	**WARNING**
	MAINTENANCE MODE SHOULD ONLY BE PROVIDED TO THOSE INDIVIDUALS WHO UNDERSTAND THE RISKS OF EXPOSURE TO XEF2 AND ARE FULLY TRAINED IN THE USE OF THE MAINTENANCE ACTIVITIES FOR THE SYSTEM.

Global Recipe Write Access allows a user to save an etch recipe in the global recipe location so that all other users can select the corresponding etching conditions. This also means that the user could potentially alter the recipes in the global recipe area.

Allow Configurable Etch gives the user the ability to create their own recipe and save it in their file. If none of these options are selected the user may only use the default recipe assigned to them.

Public recipes allows the recipes of the user to be visible to other users.

For users with no privileges a default recipe is required. It is recommended that foundry operator accounts be set up with no privileges. A number of allowed recipes can be given to the user and by checking the box next to the recipe name, it can be enabled. For example, a user without the ability to configure their etch can have, say 20 recipes. However, if only 1 is turned on, they will have access to only that 1 recipe. This is useful for those operators that may have a series of lots to process and the Administrator can enable the appropriate recipe for that operator as needed.
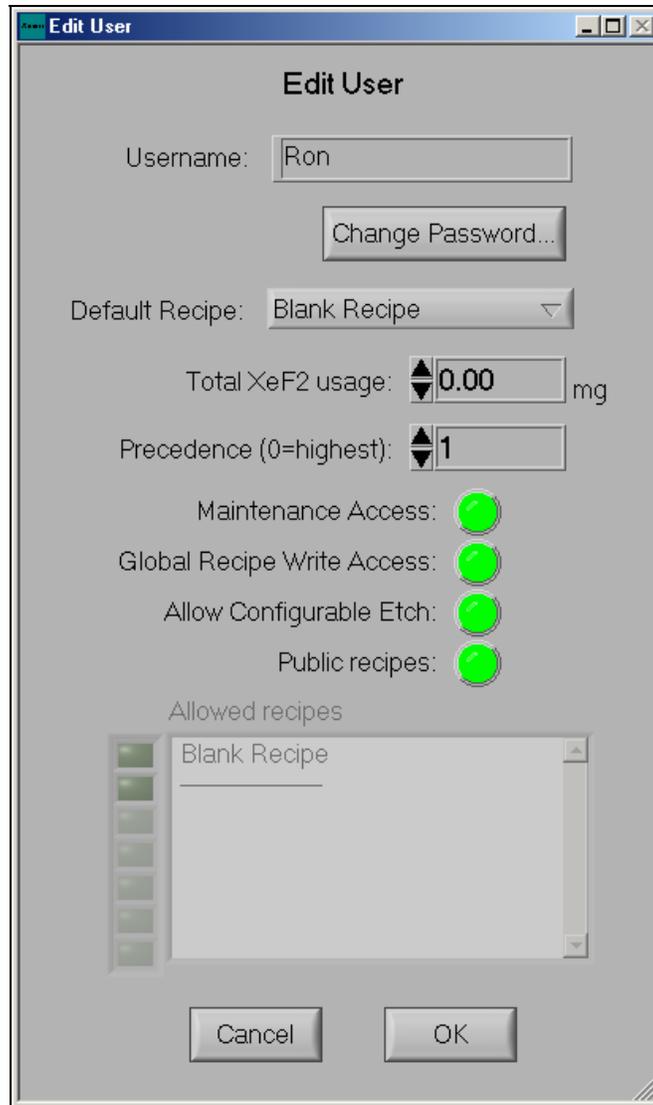
Configuration Menu

The configuration menu can be edited to change various system operations relating to basic system parameters, startup parameters, standby parameters, maintenance parameters, etch parameters, and validation codes; **NOTE**: *The validation code should only be changed by the system administrator.*

To edit the configuration menu select the "Edit CFG" option in the maintenance menu. The following options will appear as follows:
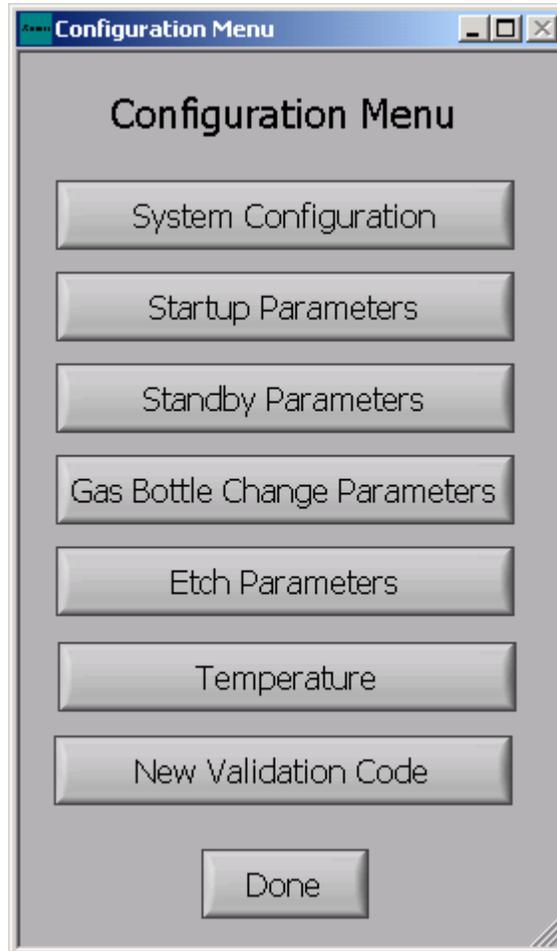
System Configuration Menu

The system configuration options screen is displayed below. Each of the options is briefly explained:
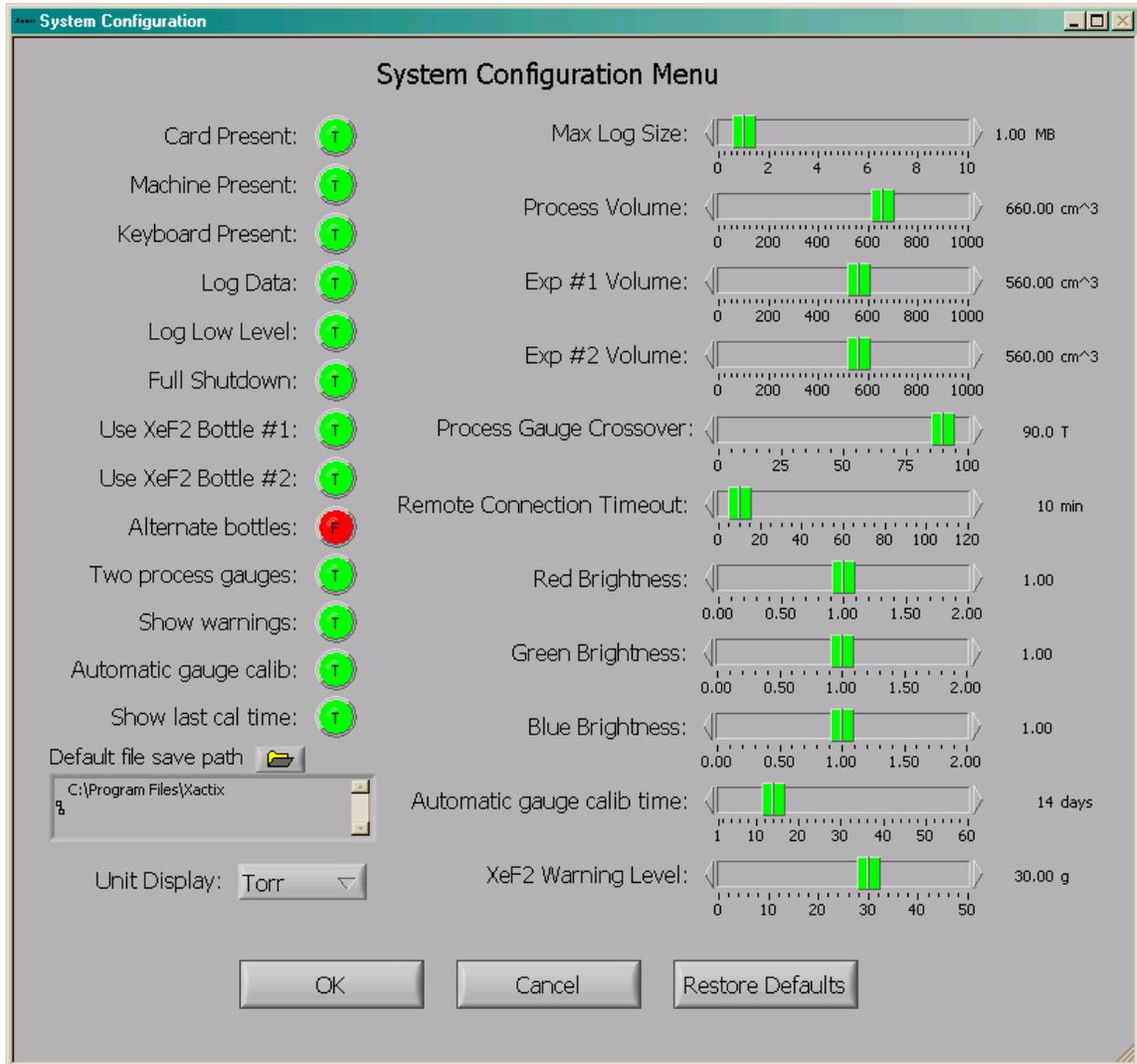
Card Present

Query for the presence of system controller card. This should normally be true for systems. Otherwise, the software will operate in a simulation mode.

Machine Present

Query for the presence of Xetch machine. This should also be normally set to true.

Keyboard Present

Query for the presence of an external keyboard. It is suggested to leave this as false, even if there is a keyboard since setting it to true removes many of the on screen keyboard functions that may be convenient.

Log Data

Keeps track of machine operation for incorporation into the log.

Log Low Level

Keeps track of all operating machine details in the full log.

Full Shutdown

Allows for the entire system to be shutdown when the Xetch software is shutdown.

XeF2 Bottle #1 Filled

Query for the presence of XeF2 lecture bottle #1 (does not have to be full).

XeF2 Bottle #2 Filled

Query for the presence of XeF2 lecture bottle #2 (does not have to be full).

Alternate Bottles

Alternate between XeF2 bottles, or use both at the same time.

Two Process Gauges

Specifies whether there are two process pressure gauges installed on the system. This feature is designed to provide a temporary backup if the lower process pressure gauge fails such that the option can be set to false, hence enabling the system to run on just the higher pressure (atmospheric) pressure gauge. Although the high pressure gauge is not very accurate at lower pressures, it will at least allow the system to run.

Show warnings

Allows the system to display on-screen warnings. Such warnings include vacuum and temperature related warnings.

Automatic Gauge Recalibration

This feature allows the user to decide if and how often a gauge calibration will be executed automatically.

Show Last Calibration Time

Enables system to display how long it has been since last gauge recalibration.

Default File Save Path

Allows the user to define a default folder that log files and images will be saved to.

Maximum Log Size

Maximum space allocated to the log for storage of log data. As the log exceeds this max size, the oldest data is purged. Although it may be tempting to have large log files, they may prove to be difficult to open in most text viewers.

Process Volume

Volume of process chamber. This should be 330 cm^3 for 4 inch systems and 660 cm^3 for 6 inch systems.

Exp. #1 Volume

Volume of expansion chamber #1. This should be typically set to 560 cm^3.

Exp. #2 Volume

Volume of expansion chamber #2. This should be typically set to 560 cm^3.

Process Gauge Crossover

This is the crossover pressure at which to switch between the lower and higher pressure process pressure gauges.

Remote Connection Timeout

If the main system loses network connectivity with a remotely connected machine (optional upgrade) for this amount of time, that machine is automatically disconnected. If this number is set to zero, there is no timeout.

Image Brightness

Red brightness, green brightness, and blue brightness settings (used only for the optional upgrade for the image acquisition system).

Automatic Gauge Calibration Time

Sets the number of days between each automatic gauge calibration.

XeF2 Warning Level

If either XeF2 bottle's estimated remaining XeF2 falls below this set point, a warning is displayed on the Main and Etch menus, in addition, in the Maintenance menu, XeF2 usage is highlighted yellow if it is below the setpoint.

Startup Configuration Menu

The startup parameters options screen is displayed on next page. Each of the options is briefly explained.

Process Purge Cycles

Allows the user to set the number of purge cycles for the process chamber during the machine startup.

Process Purge High

Allows the user to set the nitrogen pressure for the process chamber purge cycles during the machine startup.

Process Purge Low

Allows the user to set the vacuum pressure for the process chamber purge cycles during the machine startup.

Exp. #1 Purge Cycles

Allows the user to set the number of purge cycles for expansion chamber #1 during the machine startup.

Exp. #1 Purge High

Allows the user to set the nitrogen pressure for expansion chamber #1 purge cycles during the machine startup.

Exp. #1 Purge Low

Allows the user to set the vacuum pressure expansion chamber #1 purge cycles during the machine startup.

Exp. #2 Purge Cycles

Allows the user to set the number of purge cycles for expansion chamber #2 during the machine startup.

Exp. #2 Purge High

Allows the user to set the nitrogen pressure for expansion chamber #2 purge cycles during the machine startup.

Exp. #2 Purge Low

Allows the user to set the vacuum pressure expansion chamber #2 purge cycles during the machine startup.

Flush Cycles

Allows the user to set the number of flush cycles during the machine startup.

Flush Time #1

Allows the user to set the amount of time that V7, V5, V8, V3, V11, V15, and V14 are open during the flush cycle.
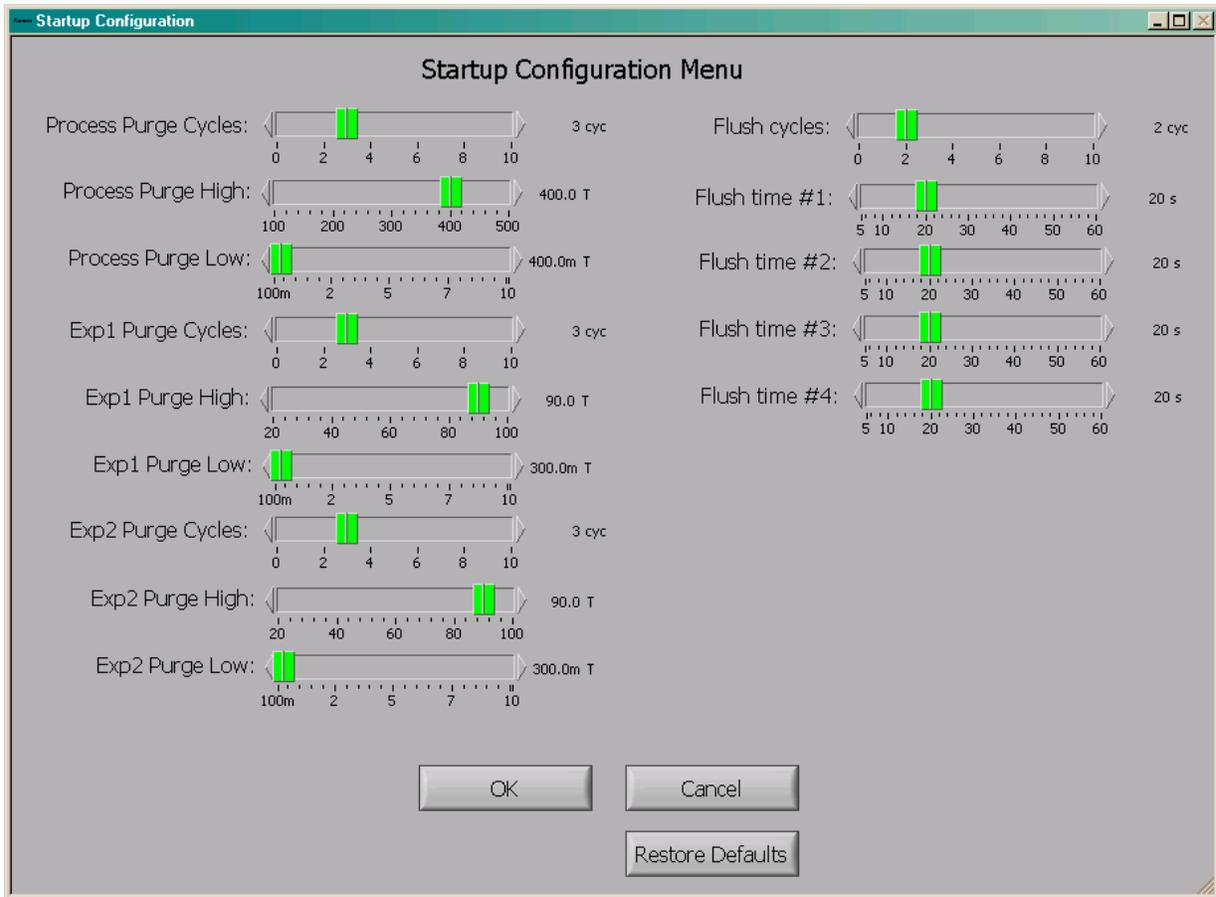
Flush Time #2

Allows the user to set the amount of time that V7, V5, V8, V3, V11, V15, V14, V6, and V9 are open during the flush cycle.

Flush Time #3

Allows the user to set the amount of time that V3, V11, V15, V14, V6 and V9 are open during the flush cycle.

Flush Time #4

Allows the user to set the amount of time that V3, V11, and V10 are open during the flush cycle.

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Standby Configuration Menu

The standby parameters options screen is displayed on next page. Each of the options is briefly explained.

Process Purge High

Allows for the user to set the nitrogen pressure in the process chamber for purging the system during the load/unload cycle.

Process Purge Low

Allows for the user to set the pressure that the process chamber is pumped down to when purging the system during the load/unload cycle.

Process Standby

Allows the user to set the process chamber base pressure for the pump-down process.

Exp. #1 Purge High

Allows for the user to set the nitrogen pressure in expansion chamber #1 for purging the system during the load/unload cycle.

Exp. #1 Purge Low

Allows for the user to set the pressure that expansion chamber #1 is pumped down to when purging the system during the load/unload cycle.

Exp. #1 Standby

Allows the user to set the base pressure in expansion chamber #1 for the pump-down process.

Exp. #2 Purge High

Allows for the user to set the nitrogen pressure in expansion chamber #2 for purging the system during the load/unload cycle.

Exp. #2 Purge Low

Allows for the user to set the pressure that expansion chamber #2 is pumped down to when purging the system during the load/unload cycle.

Exp. #2 Standby

Allows the user to set the base pressure in expansion chamber #1 for the pump-down process.

ATM Pressure

Allows the user to define the set point for the atmospheric pressure light to come on during the venting process.

V13 Low Pressure Point

Allows user to define the pressure at which Valve 13 opens.

Load Purge Cycles

Allows user to set the number of purge cycles for during the load cycle.

Unload Purge Cycles

Allows user to set the number of purge cycles for during the unload cycle.

Load Sample Timeout

Allows the user to set the amount of time for which the nitrogen vent gas continues to when the chamber is at atmospheric pressure.

Pump-down Differential

When the system chambers are being evacuated, a check is made to see if one of the expansion chambers is higher than the other by this amount. If so, the chamber at the higher pressure is evacuated first, until both chambers reach the same pressure; then both chambers are evacuated together. This is to avoid back streaming of gas from one chamber to the other through the vacuum system.
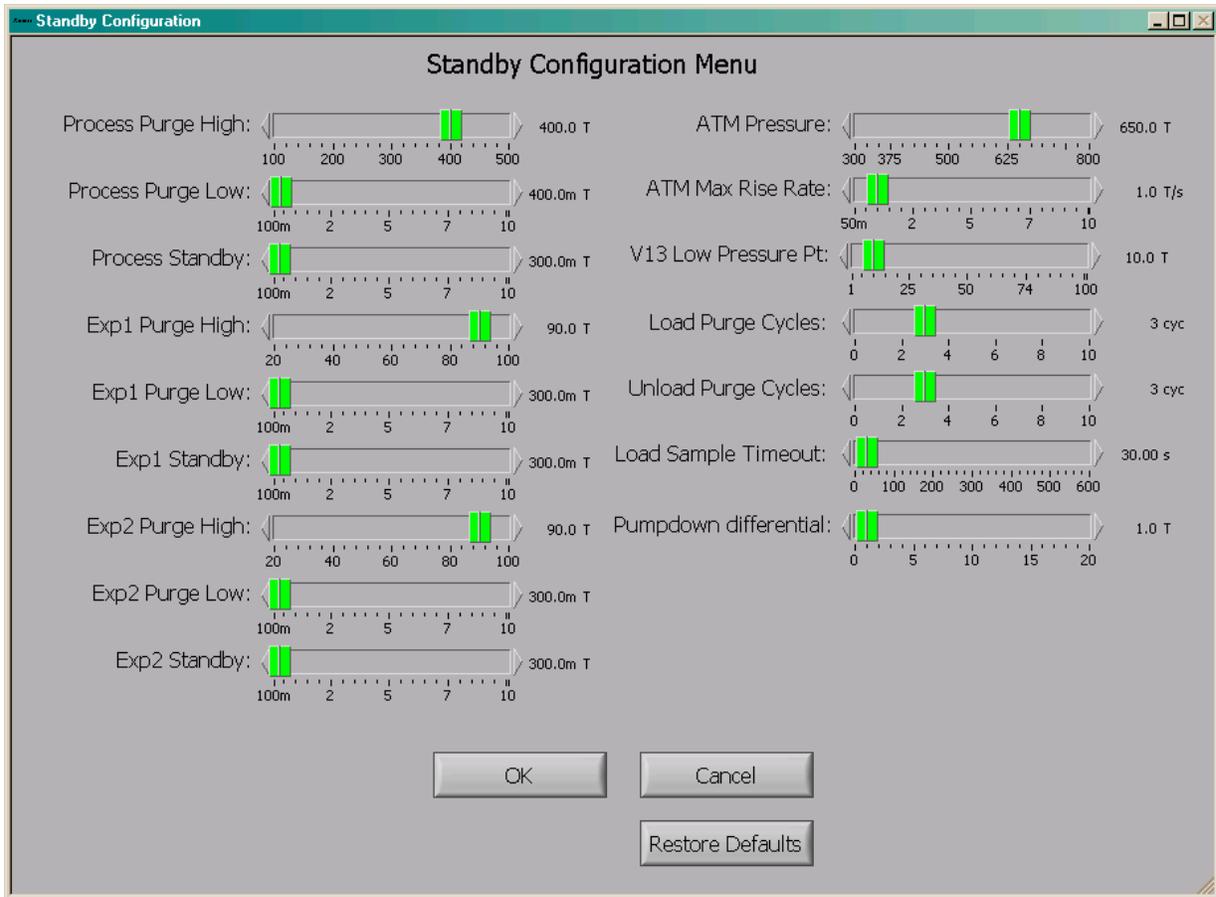
Gas Bottle Change Parameters Menu

The maintenance parameters options screen is displayed on next page. Each of the options is briefly explained

Pre-Change Cycles

Allows user to set the number of purge cycles prior to disconnecting the XeF2 lecture bottles.

Pre-Change High

Allows the user to set the nitrogen pressure for the purge cycles prior to disconnecting the XeF2 bottles.

Pre-Change Vac Time

Allows the user to set the amount of time that the vacuum valve is open prior to disconnecting the XeF2 bottles.

Closed Bottle Cycles

Allows user to set the number of purge cycles to remove atmospheric gas from the lines following a XeF2 bottle change.

Closed Bottle High

Allows user to set the nitrogen pressure for the purge cycles following a XeF2 bottle change.

Closed Bottle Vac Time

Allows user to set vacuum time for the purge cycles following a XeF2 bottle change.
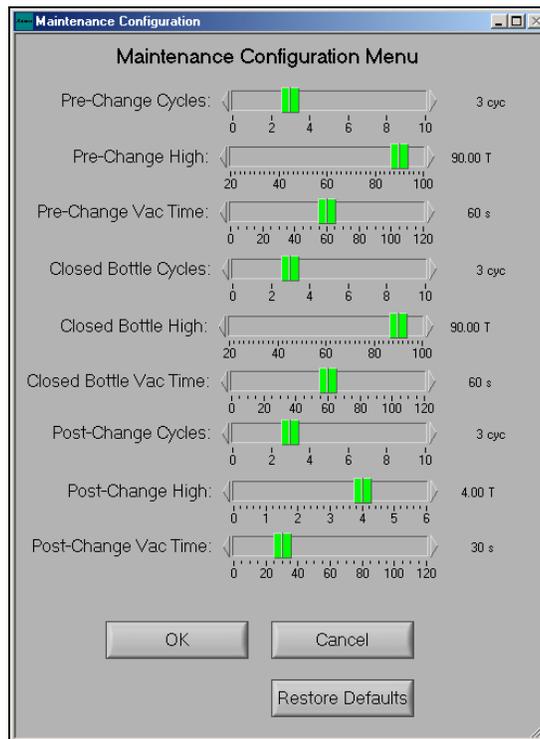
Post-Change Cycles

Allows user to set the number of cycles used to ensure that the XeF2 bottle is operating correctly.

Post-Change High

Allows user to set the XeF2 pressure for the conditioning cycles following a XeF2 bottle change.

Post Change Vac Time

Allows user to set the vacuum time for the conditioning cycles following a XeF2 bottle change.

Etch Configuration Menu

The etch parameters options screen is displayed on the next page. Each of the options is briefly explained:

Soft Etch Stop

Allows the user to stop etching; yet allow the current cycle to finish before exiting. As opposed to a hard etch stop; which can still be performed by touching the "STOP" button twice, which immediately evacuates all chambers closes all valves, and returns to the main menu.

Allow In-Progress Cycle Changes

Allows the user to add additional cycles to an etch while etch is still in progress.

Show overtime warning

If this is enabled, a warning message will be displayed to alert the user that the system is taking a longer time than is expected to complete an etch cycle. The overtime associated with this feature is set via the Overtime threshold. Typically, a long time such as 100 seconds is recommended to avoid an accidental warning.

V3/V11 Keep-open feature

This feature is typically used in conjunction with etches that use nitrogen. Enabling this feature in combination with setting the V3/V11 Keep-open N2 pressure allows the two expansion chamber side nitrogen valves to remain open throughout the etch and can reduce cycle times. However, if V3/V11 are kept open at low nitrogen fill pressures (approximately 5 torr or below), accurate expansion chamber fills may become difficult. Therefore, this feature has a threshold value below which it will not be enabled. This threshold value is set via the V3/V11 Keep-open N2 pressure setting.

Delay .MPG gen. until done

This feature is only related to the systems that have the optional image acquisition system option. Enabling it allows the video file to be created after the etch finishes to minimize the load on the computer processor during the etch.

Intermediate Pump-down Pressure

Allows the user to set the intermediate pressure used for expansion chamber through main chamber pump-downs during an etch cycle.

Pressure Estimation Delay

Allows the user to set the delay after filling of a chamber before the pressure is measured. This is done to keep track of the pressure fill overshoot – the "extra" pressure achieved after a fill valve is closed.

Pressure Estimation Tau

The pressure overshoot is filtered using an exponentially weighted moving average filter. This parameter allows the user to set the time constant for that filter.

XeF2 Pressure Estimation # Bins

The pressure overshoot is also recorded separately for different fill targets. This parameter allows the user to set the number of "bins" that the pressure range between 0T and 8T is divided into.

N2 Pressure Estimation # Bins

Allows the user to set the number of pressure overshoot bins for N2 pressure between 0T and 30T

Max Pressure Estimation Age

Allows the user to predetermine the longest amount of time, between 0 and 120 hours, that the machine will be pumped -on without any processing.

Pressure Estimation Pre-Cycles

Allows the user to set the number, between 0 and 10, of pre-cycle pressure purging cycles.

Etch Buffer Time

During an etch cycle, one expansion chamber can be evacuated while the other expansion chamber is being used for etching. However, it is essential that while the expansion chamber is being evacuated that the main chamber not also be evacuated since it is possible that this could interfere with the etch cycle. To avoid this potential overlap of evacuating an expansion chamber and then simultaneously needing to pump out the main chamber, an Etch Buffer Time is specified. Setting this parameter to 5

seconds requires that there be at least 5 seconds between completion of the evacuation of an expansion chamber and the need to evacuate the main chamber. This time is determined during the first seven cycles of the etch, afterwards, if the expansion chamber is fully evacuated the Etch Buffer Time before the need to evacuate the main chamber, the evacuation of the expansion chamber will occur during the etch cycle.

N2 fill pressure delta

This setting relates to the pressure that the nitrogen inlet valves, V14/V15, close in advance of reaching the expansion chamber nitrogen fill pressure setpoint to minimize the pressure jump during expansion chamber evacuation.
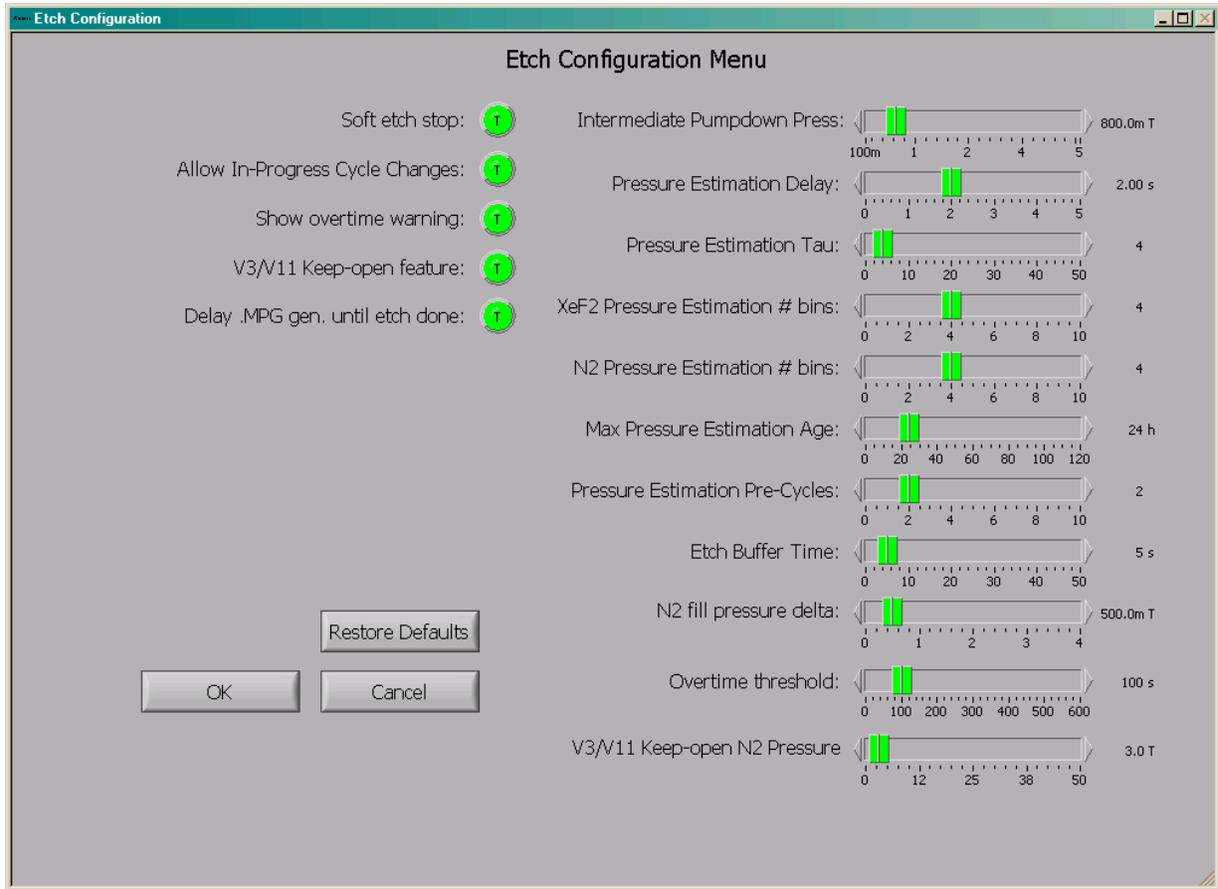
Leak-Back Utility

To test the leak-back rate of each of the chambers, the Leak-back Utility can be used. This program pumps down all chambers, and then closes all valves for a pre-set amount of time. It then estimates the leak-back rates for each chamber and displays them. To use this utility, first choose the duration of the test, the duration of the pumpdown before test, and then press "Start Test". The test will be performed, and the rates will be displayed. When the test is complete and you have observed the rates, press "Done" to return to the Maintenance Menu.
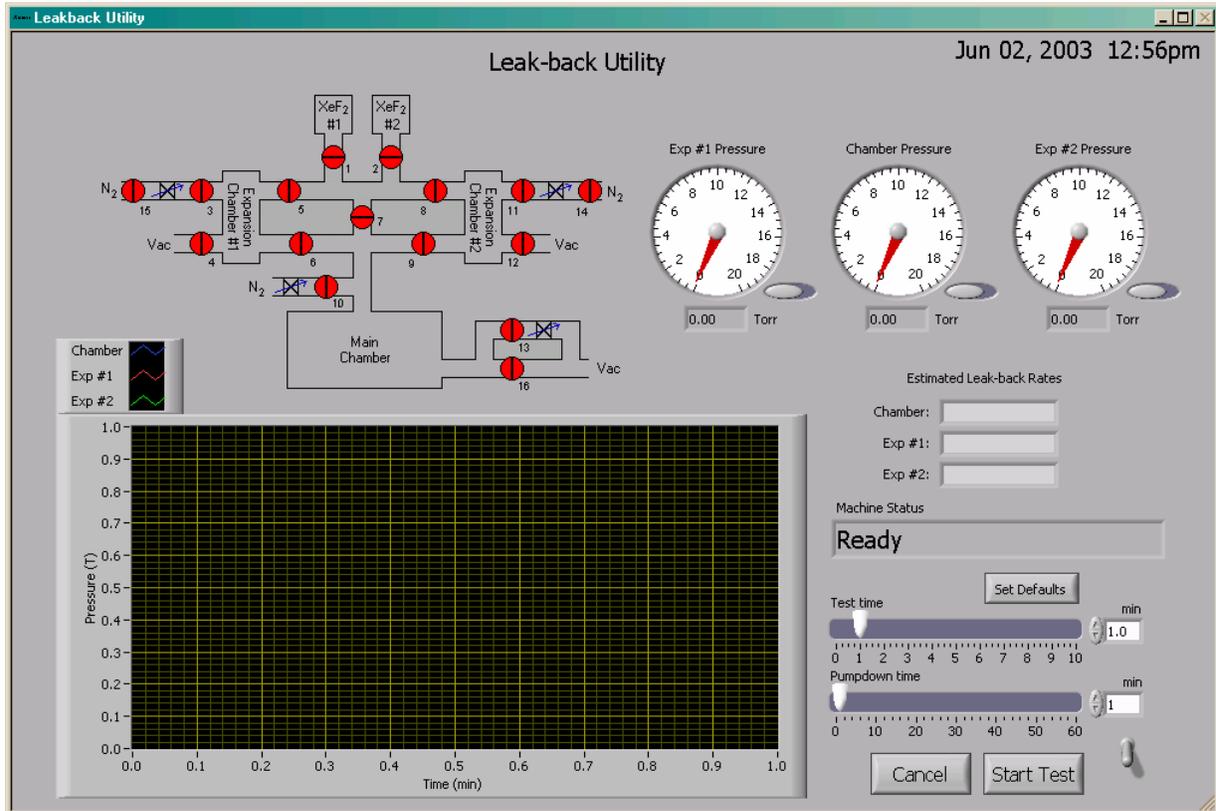
Main Chamber Purge

To repeatedly pump and purge the main chamber to remove residual gas or water vapor, the Chamber Purge Utility can be used. First, set the parameters for the purge routine, including N2 fill high-pressure, high-pressure time, pump-down low pressure, low-pressure time, and number of purge cycles. Then press, "Start" to start the cycle. At any time, the "Cancel" button can be used to end the routine and return to the Maintenance Menu.
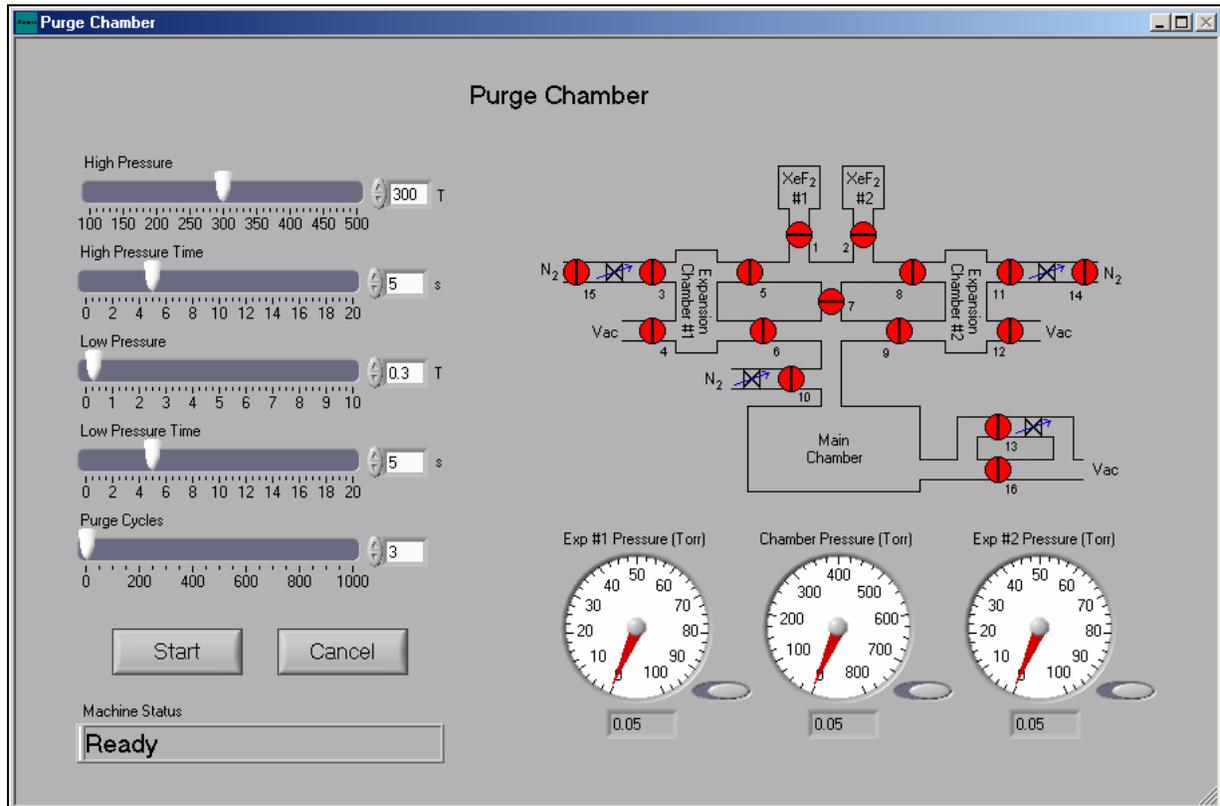
Pressure Sensor Recalibration Utility

Capacitance manometers may "drift" over time indicating less accurate readings. The gauge recalibration utility is a method to periodically recalibrate them. To recalibrate the capacitance Manometers, set the number of purge cycles, length of pump time, and assumed chamber base pressure. The manometers are zero calibrated to .05 T or 50 mT, which is the assumed base pressure of the system. Pressing the "Calibration History" button accesses a log file for the recalibration function. The "Set Defaults" button can be used to save recalibration settings for easy one-touch use. Set the preferred settings and press "Set Defaults", this will allow these parameters to be saved and appear each time calibration is performed unless otherwise set. When desired parameters are set press "Start Test" button and calibration will begin. Occasionally executing the calibration a second time may be needed to achieve calibration. An automatic calibration function may be set to "True" in the configuration menu under "System Configuration". This function will automatically recalibrate the capacitance manometers at a low-usage time, typically at night. The last calibration time is then displayed on the main menu.

*The MEMS Equipment Company*TM

XeF$_2$ Bottle Change

Bottle Change General information

XeF$_2$ Counter Reset

Before proceeding with a bottle change, be aware that the XeF$_2$ usage display will be reset to zero once the bottle is changed. You may wish to record the usage displayed before changing for your records. The usage information can be found by clicking the Maintenance Menu. The information is located at the top left under *Approx. XeF$_2$ Usage*.

Parts List

- Swagelok Gaskets (www.swagelok.com)
  NI-4-VCR-2-VS or NI-4-VCR-2-GR-VS
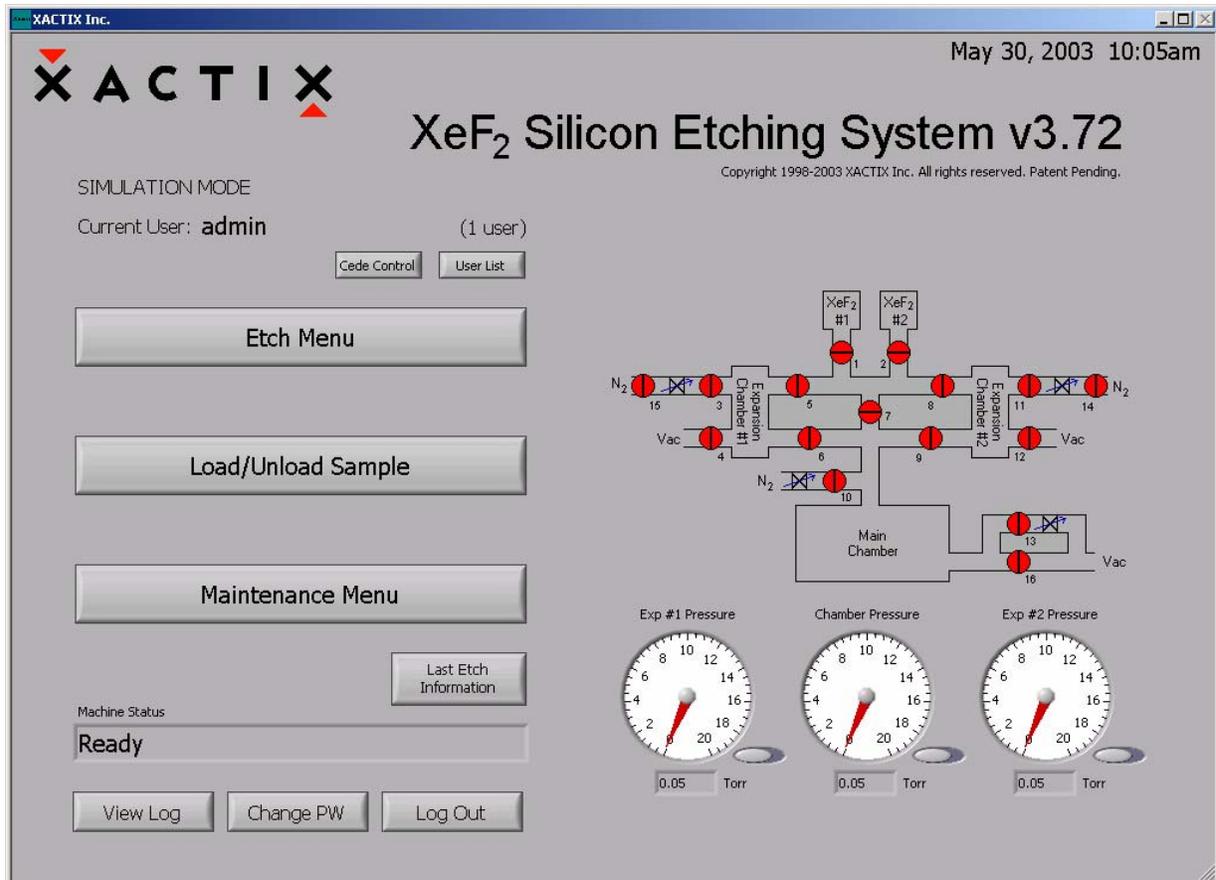
- 5/8" and 3/4" Standard Wrenches

- Latex Gloves

Time allocation

The time to complete the bottle change is typically between 30 to 45 minutes.

Changing XeF$_2$ Bottles

⚠	**WARNING**
	IT IS IMPERATIVE THAT THESE DIRECTIONS BE FOLLOWED EXACTLY TO SAFELY CHANGE THE XENON DIFLUORIDE BOTTLE(S).

Beginning from the Main Menu screen, click on *Maintenance Menu*.

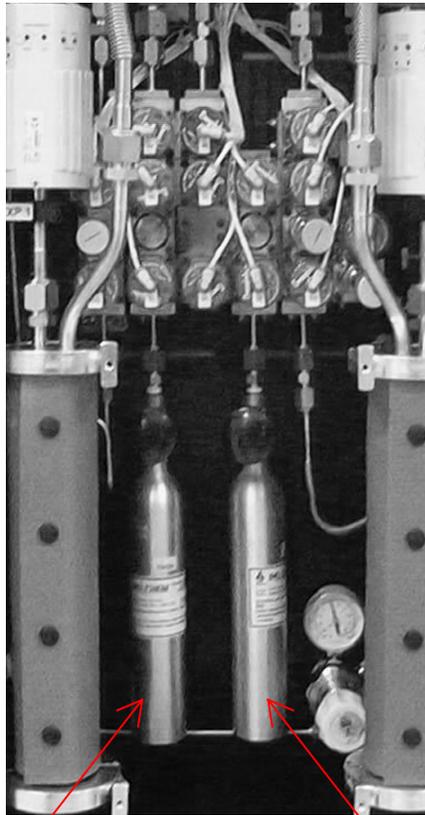To change the gas bottles click on the top right button, *Change XeF₂ bottle*, shown in Figure 4.

You will then be prompted to choose which bottle you would like to change, #1 or #2 (the locations of

the bottle connections is shown in
Figure 3).

XeF$_2$ Bottle # 1   XeF$_2$ Bottle # 2

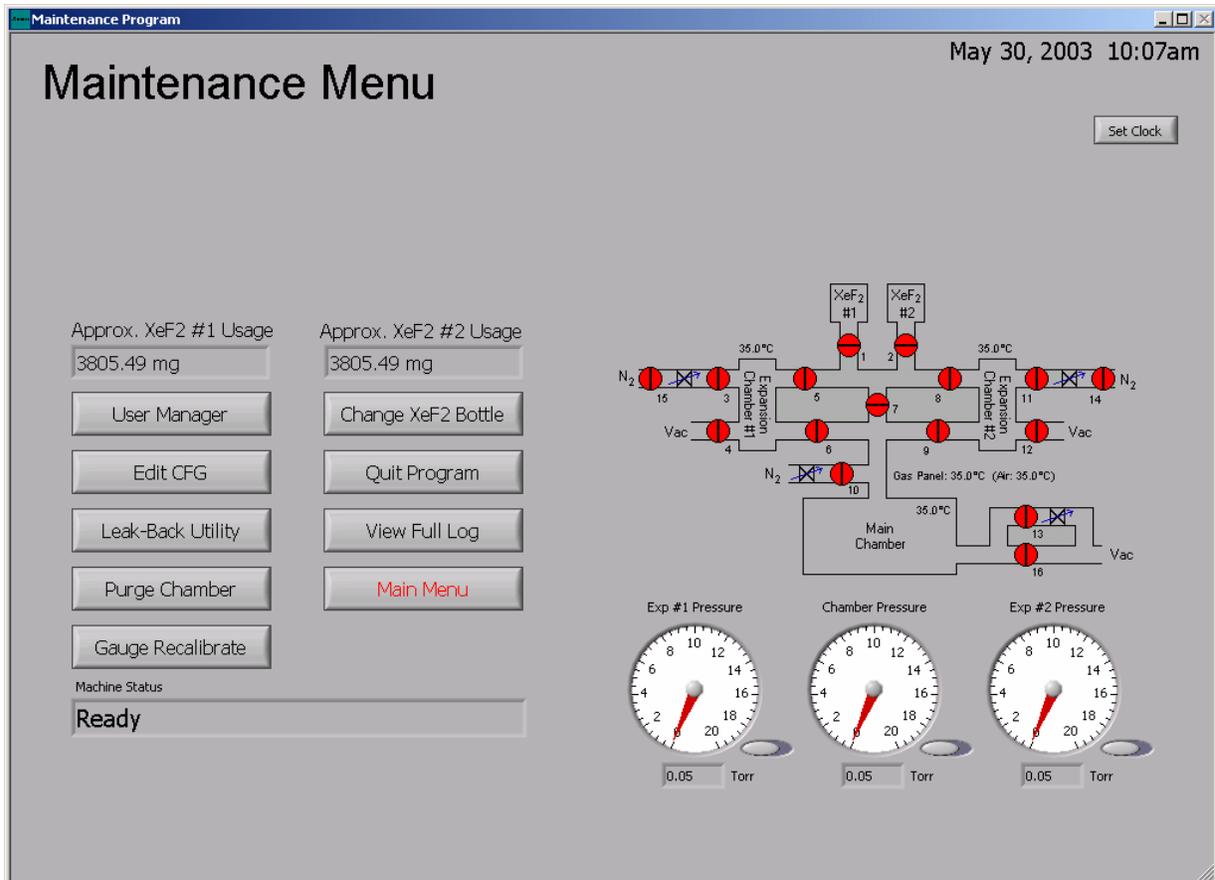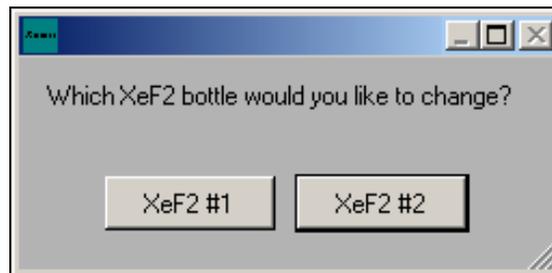Figure 3. Bottle Connection Locations.

Figure 4. Maintenence menu.

The Xetch will automatically test the pressure of the bottle you've chosen to change, #1 for example. This provides a test method to qualify XeF$_2$ pressure at any point in time as shown on next page.

Please note that the 2 Torr value used below is an illustration and your organization may decide to choose another pressure value to make the bottle change determination.

For example, if the pressure displayed is above approximately 2 Torr, click NO and you will be returned to the maintenance menu. If the pressure is below approximately 2 Torr, click YES, and the bottle change will continue.

> XeF2 Pressure after 10 seconds: 4.88 Torr. Replace Tank?
>
> Yes   No

If you have chosen to change the XeF$_2$ bottle, you will be instructed to close the manual valve on the bottle. Once you have closed the proper bottle's valve, click OK as shown below.

> Please close the manual valve on XeF2 bottle #1
>
> OK
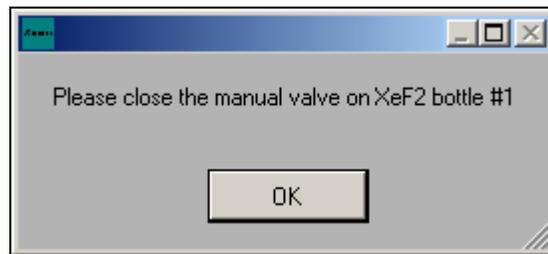
NOTE: Clicking Stop Button At Lower Right Can Stop Process At Any Time

The Xetch will proceed to clear out or purge the lines to assure all XeF$_2$ gas is removed from the system lines. This will take approximately 2 minutes. You will then be instructed as below to remove the gas bottle, refill it, and replace with full bottle. Be sure to leave the manual valve closed.

> Please remove XeF2 bottle #1, refill it, and replace it. Leave the manual valve on the bottle closed.
>
> OK

Removing Gas Bottle

To remove the XeF_2 bottle you have chosen, use a 3/4" standard wrench on the female or larger nut. You will also use a 5/8" standard wrench on the male or smaller nut that is attached to the bottle. The male nut is held firmly, while rotating the wrench on the female nut to loosen the female nut.

⚠	WARNING
	THERE MAY STILL BE RESIDUAL XENON DIFLUORIDE IN THE REMOVED BOTTLE SO BE CERTAIN THAT THE BOTTLE VALVE REMAINS CLOSED.

Replacing Gas Bottle

Before reattaching the gas bottle after verifying the old gasket is removed, a nickel-plated Swagelok gasket (NI-4-VCR-2-VS) must be inserted between the male and female nuts to insure a good seal (see A. in Figure 5). A retainer gasket (NI-4-VCR-2-GR-VS) is also available and acceptable to use on the Xetch, the retainer gasket makes completing the seal less complicated by attaching itself over the VCR fitting gland. The un-retained gaskets require balancing the fittings until finger tight is established but can certainly be used successfully. Use latex gloves when handling the gaskets to prevent dust or grease degrading the seal's performance. If the gasket falls on the floor or is suspected of having scratches, THROW IT AWAY. If not, you could damage the VCR gland or face. Mate the male and female nuts to finger tight by turning female nut clockwise (see B. in Figure 5). Mark the male and female nuts position with a line across each to establish 1/8 turn (see C. in Figure 5). Then holding the lower male nut firmly with the 5/8" wrench, turn the upper female nut with the 3/4" wrench clockwise 1/8 turn (see D. in Figure 5). Note that over tightening may damage the VCR gland and under tightening may result in poor gasket seal.

| ⚠	CAUTION
	The steps on the next page must be followed exactly to ensure proper gasket installation.

(A.)

(B.)

(C.)

(D.)

Figure 5. VCR Gasket Assembly Procedure (Image from www.swagelok.com).

The Xetch will ask you to double check that the manual valve is closed on the bottle. When positive that valve is closed click "YES". If you decide not to change bottle and continue, click "NO". If NO was selected you will be to the previous screen and must click "YES" once bottle is removed, refilled, and replaced.
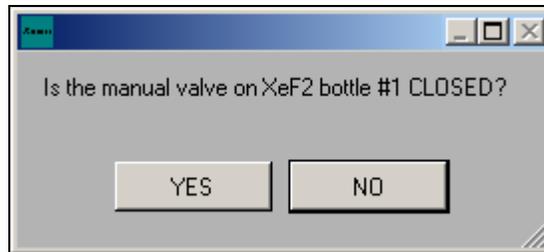
Once again, the Xetch will purge the lines to ensure a clean system before any XeF_2 is present, and leak test fittings to ensure a proper seal. If the seal leaks, a failure prompt will appear. Recommended steps would be to restart the leak-test up to three times by clicking yes, then check that the female nut is sufficiently tight. If leak still exists, replace the gasket.

If leak-test is passed Click "YES", and you will be prompted as shown to open manual valve on bottle. Turn manual valve counter clockwise to open. Click "OK" when task is complete.
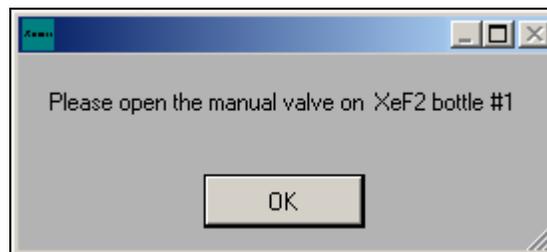
Completing Bottle Change

If the Xetch accepts all parameters the bottle will then have been changed successfully. Click "OK" as illustrated on the prompt screen below. If bottle #2 also needs to be changed repeat these steps from beginning to end.

Maintenance

Roughing Pump

The Xetch ships with an Edwards XDS10 dry scroll pump. This pump is does not use oil and therefore the maintenance is considerably less than a rotary vane pump. The primary maintenance is the replacement of the tip seal, which Edwards typically recommends performing this less than 30 minute operation on an annual basis. Please see the XDS10 manual for more details.

Vacuum Interlocks

The Xetch has two vacuum interlocks, one to make certain that the chamber is below approximately 400 Torr of pressure before permitting the source bottle valves (Valves 1 and 2) on the gas panel to open. The other interlock prevents all valves on the gas panel from opening if the pressure at the main vacuum line is above approximately 400 Torr.

Xenon difluoride

Physical Properties

Density	4.32 g/cm^3
MW	169.290
MP	130-135°C
FP	None
Vapor Pressure	3.9 Torr (at room temperature)

Xenon difluoride is very volatile and should be stored cold to keep it from decomposing.

Safety

XeF_2 does not explode on contact with moisture or air, nor does it form compounds that explode. The "exploding XeF_2" story comes from impurities in the XeF_2, according to Neil Bartlett, discoverer of noble gas chemistry in 1963 (and now professor of chemistry at the University of California at Berkeley). Specifically, XeF_4 is a common impurity. In the presence of moisture XeF_4 turns into XeO_3, which is a contact explosive. Lots of the early noble gas chemists had XeO_3 explosions due to working with XeF_2 that had XeF_4 in it. The XeF_2 that you buy has only trace XeF_4 impurities, so the total mass of explosive that could be generated under any circumstances is probably measured in tens milligrams - enough to cause a pop perhaps, but not dangerous.

For further information refer to the Material Safety Data Sheet (MSDS) from Pelchem, one of the many suppliers of xenon difluoride. This MSDS can be found on the XACTIX website at www.xactix.com.

Selectivity during etching

XeF_2 shows very high selectivity of silicon versus SiO_2, silicon nitride, Al, Cr, photo-resist, and TiN. The Xetch's selectivity to silicon nitride is better than 100:1, and the selectivity to silicon dioxide is considerably higher. More data will be made available on the XACTIX website as performance specifications are compiled.

Xenon difluoride market pricing

Xenon difluoride is available from a number of worldwide suppliers. XACTIX maintains a list of suppliers, pricing and product specifications on its website. Please visit www.xactix.com for more information.

Xetch Specifications

Wafer capacity

The Xetch is designed to be manually loaded for superior substrate geometry flexibility. The Xetch is the ideal solution for those seeking cost effective R&D xenon Difluoride etch system. Built for high etch uniformity, simplicity, low cost of ownership, and a small footprint, the Xetch is well suited for both industrial users and universities.

Wafer size limitations

The unit comes in three versions, a system which is optimized for 4" wafers or smaller parts, a system which is optimized for 6" wafers or smaller parts, and a system which is optimized for 8" wafers or smaller parts.

Gas and Vacuum System Valves

The gas and vacuum system includes the following valves:

V1:	Xenon difluoride source #1 bottle	V9:	Process #2 isolation
V2:	Xenon difluoride source #2 bottle	V10:	Process chamber nitrogen source
V3:	Nitrogen #1 isolation	V11:	Nitrogen #2 isolation
V4:	Expansion chamber #1 vacuum	V12:	Expansion chamber #2 vacuum
V5:	Xenon difluoride expansion #1 isolation	V13:	Variable rough vacuum
V6:	Process #1 isolation	V14:	Expansion #2 nitrogen source
V7:	Xenon difluoride flow through mode isolation	V15:	Expansion #1 nitrogen source
V8:	Xenon difluoride expansion #2 isolation	V16:	Fast rough vacuum
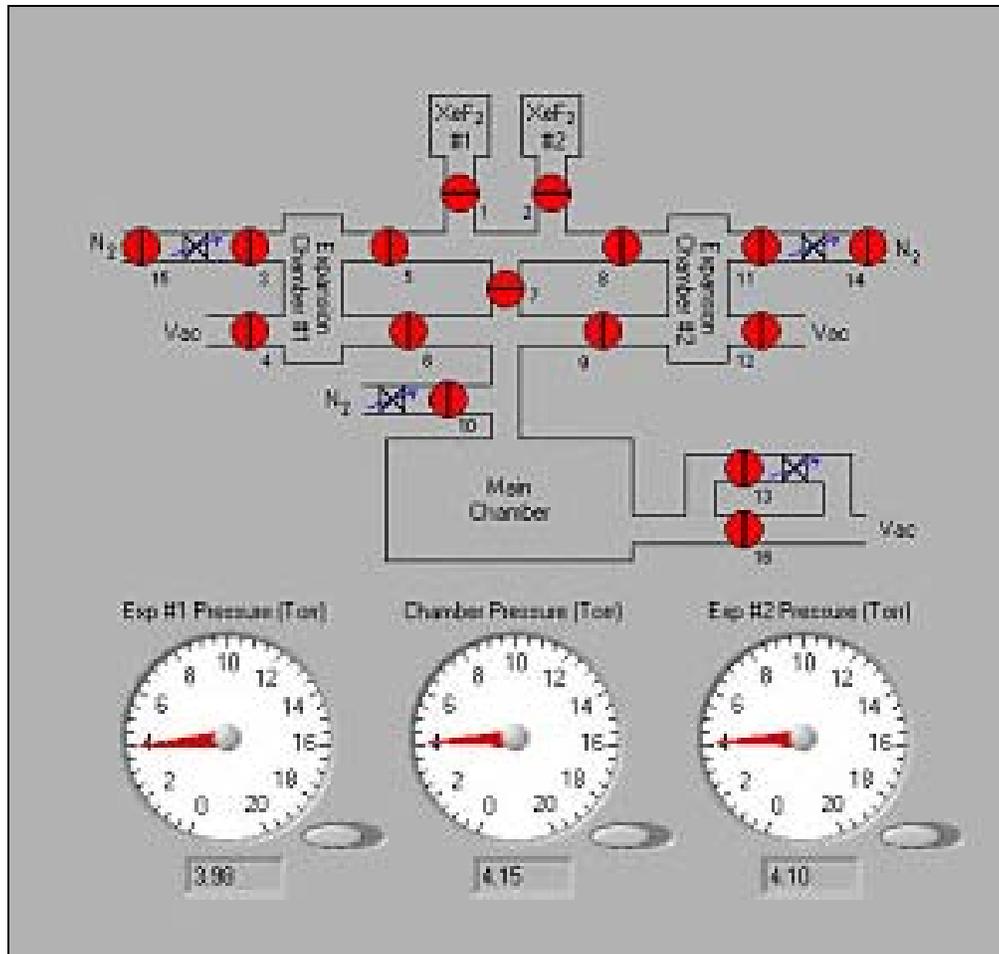
Silicon etch rates

The etch rate is very dependant on the feature size and amount of silicon to be etched. Etch rates as high as 15 um per minute on small parts are achievable, with lower rates on large wafers. (The Xetch is a pulsed etching system, so high rates should be achievable once the process is optimized).

Data obtained from customers shows:

- Uniformity and repeatability on 6" wafers better than +-3%

- On a 6" Si wafer with 90% exposed area, etching 2 microns of Si in 14 minutes

- On a 4" Si wafer with 10% exposed area, etching 1 micron per minute.

Amount of silicon consumed per charge

The amount of silicon consumed per charge depends on the exposed silicon surface area and the utilization of the XeF_2 during the etch process. The utilization is the percentage of XeF_2 which actually reacts with the silicon during an etch. If XeF_2 is brought into a chamber containing a Si wafer, and flushed out before it has completely reacted with the wafer, the utilization would be low. If the XeF_2 is left in the chamber for an extended period of time, the highest utilization of XeF_2 would be obtained.

Following the formula: $2XeF_2 + Si => 2 Xe + SiF_4$

The amount of silicon consumed per gram of XeF_2 is calculated. For a 4-inch wafer, assuming the entire top surface is being etched (usually the majority of the wafer is masked), 1 gram of XeF_2 will etch about 2 μm of silicon. If only 10% of the wafer was being etched, 1 gram of XeF_2 would etch approximately 20 μm of silicon. The Xetch is set up so that one may fit 500 grams of XeF_2 in a bottle. (Bottles are easy to change).

Utility requirements

- 120 Volt AC/ 20 Amps max.
- Nitrogen: 10-20 psi
- Compressed Dry Air: 70-100 psi
- Exhaust to roughing pump outlet
- 100 cfm fume exhaust

Dimensions and Weight

- System Frame. 21" wide X 26" deep X 41" high
- Height to top of LCD monitor 5' 6"
- Approx. 400 lbs

Conclusion

We thank you for your business and value the trust you have placed in our Company.

We always welcome suggestions and comments regarding our products and our services. Please feel free to contact:

Service/Technical:

support@xactix.com

Sales/Marketing:

U.S. Sales: ussales@xactix.com

International Sales: intsales@xactix.com

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