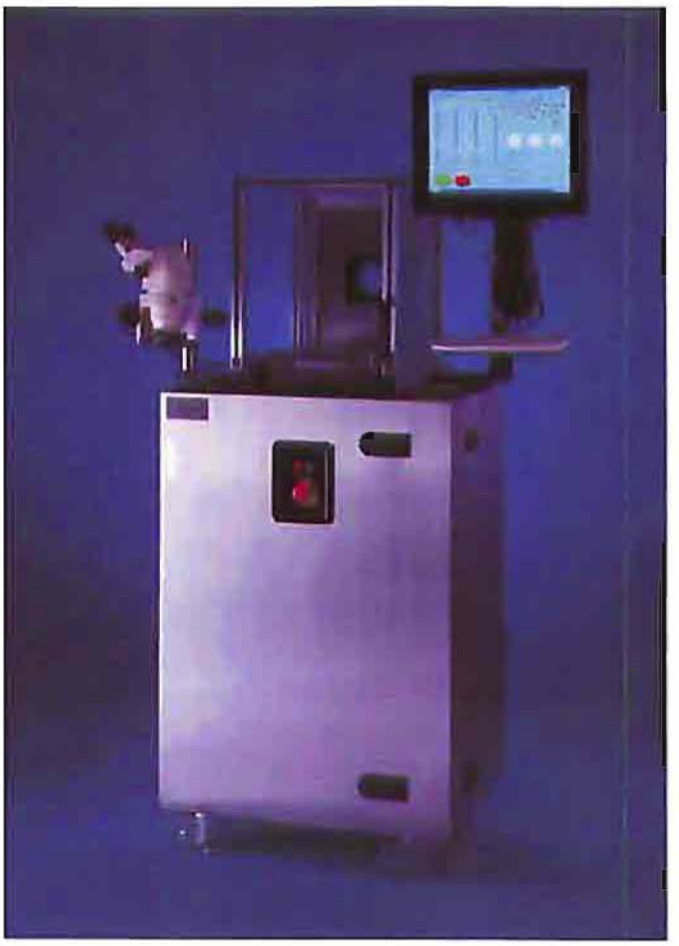
XACTIX

The MEMS Equipment Company™

Xetch® X3 Series System Manual



Manual Version X3-4.1R1.

10/05R0

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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 X3 is the ideal solution for those seeking a cost effective R&D xenon difluoride etch system. Built for high etch uniformity, fast etch rate, simplicity, low cost of ownership, and a small footprint, the Xetch X3 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, system and chamber area fume exhaust, and a pump exhaust 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, top quality components, and experienced workmanship results in a dependable and flexible etching tool for your production and research needs.

The 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
- Electronic image capture of the process chamber
- Remote operating and monitoring software

The major components of the Xetch X3 are:

- XeF_2 source bottle (supplied by customer) 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 (supplied by customer) 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 the etch cycle time is up, gas is pumped out and another etch cycle begins.
- Vacuum pump: this pumps gases out of both the process chamber and the expansion chamber.
- A needle valve for adjusting the flow rate of process N_2 is located on the left side of the Xetch, on the gas panel. This should not have to be adjusted for normal use, and should remain partially open. Additionally, regulators to control the flow of venting N_2 and for additional control of process N_2 are provided. The flows of XeF_2 and nitrogen (N_2) are automatically accomplished through a series of computer controlled valves.
- Temperature control of the expansion chambers, gas box, and the process chamber are controlled electronically and the temperature readouts and setpoints can be adjusted through the Xetch software.
- 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 X3 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.

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.

WARNING

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.

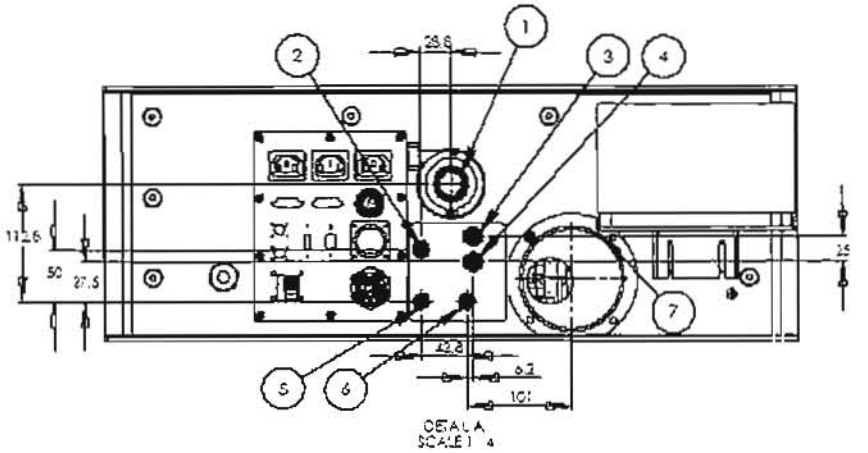
Dimensions and Weights

Crated dimensions (W x D x H): 2 BOXES

Box 1 (Parts): 48"x43"x53" (1220mm x 1093mm x 1347mm)

Box 2 (System): 48"x48"x77" (1220mm x 1220mm x 1956mm)

Total crated weight:	~900 lb (455 kg)
Xetch dimensions:	See Figure 1.
Xetch weight:	~500 lb (227 kg)



CONNECTION NUMBER	STYLE ON MACHINE	SPECIFICATION	PURPOSE
1	NW25	CONNECT TO SUPPLIED PUMP	MAIN VACUUM CONNECTION
2	¼" SWAGELOK TUBING FITTING	70-100 PSI CDA	PNEUMATICS AIR SUPPLY
3	¼" SMC TUBING ONE TOUCH FITTING		PNEUMATICS EXHAUST (OPTIONAL)
4	¼" SMC TUBING ONE TOUCH FITTING	NOT USED	NOT USED
5	¼" MALE VCR FITTING	20 PSI MAX. N_2 HIGH PURITY (99.999%)	NITROGEN USED IN PROCESS
6	¼" MALE VCR FITTING	20 PSI MAX. N_2	NITROGEN USED TO VENT CHAMBER
7	4" OD TUBING	-2.5 mm H_2O STATIC PRESSURE	GAS PANEL VENTILATION
8	4" OD TUBING	-25 mm H_2O STATIC PRESSURE EXHAUST	CHAMBER LID AREA VENTILATION

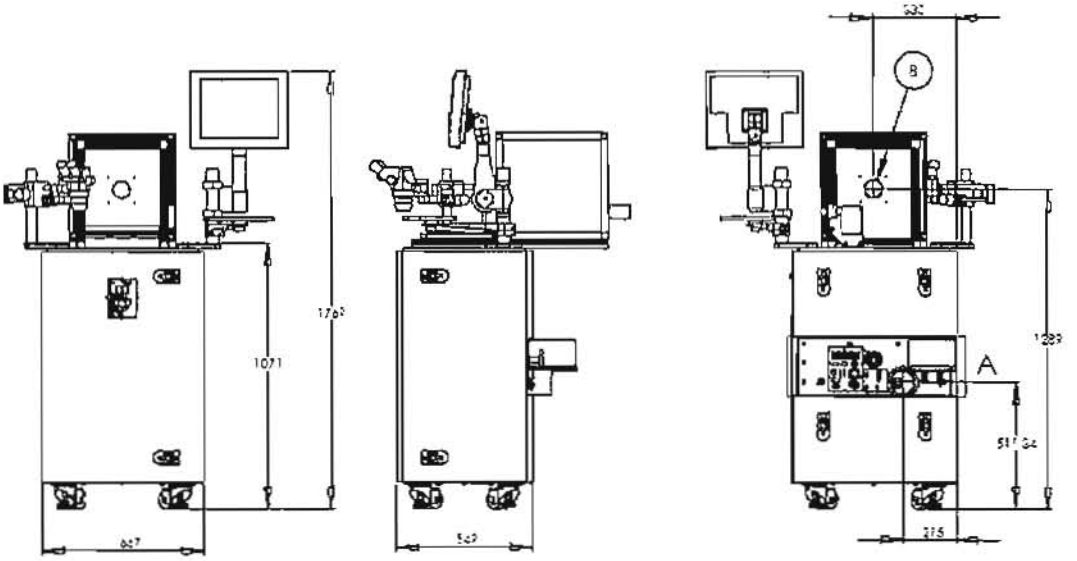


Figure 1. Machine dimensions and locations of utility connections. Contact XACTIX for additional details and to determine if your system varies from this diagram.

Space Requirements

The suggested free floor space for the Xetch in the clean room or laboratory environment is shown in Figure 2. In addition, sufficient space must be provided behind the unit, or in the service chase, for the system's electrical remote box (Figure 3) and vacuum pump (Figure 4).

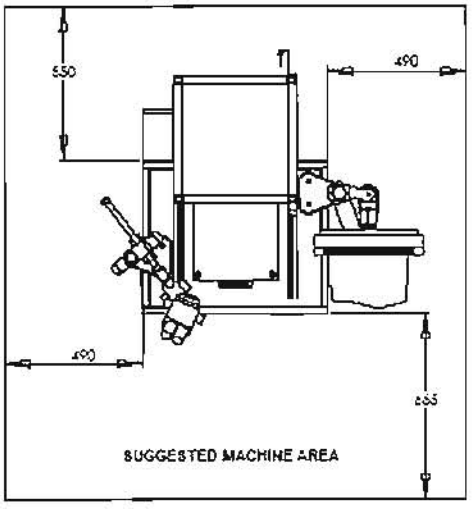


Figure 2. Suggested machine clearance area (in mm).

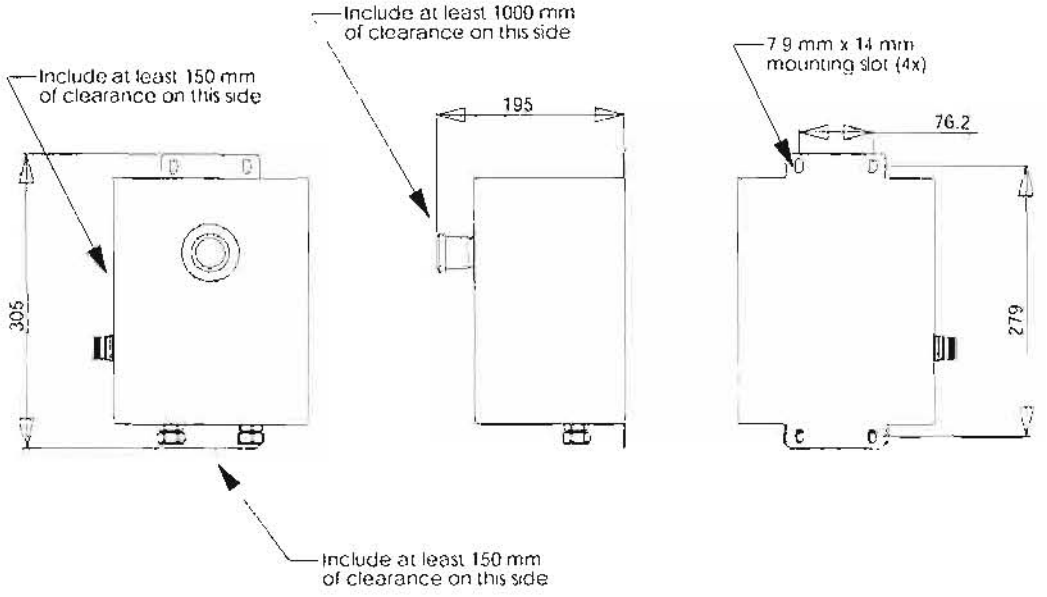


Figure 3. X3 System remote power box to be mounted near X3. This unit is connected to the X3 system via a 5m cable connecting to the left of the remote box. The mass of this box is 6 kg and all dimensions are in mm.

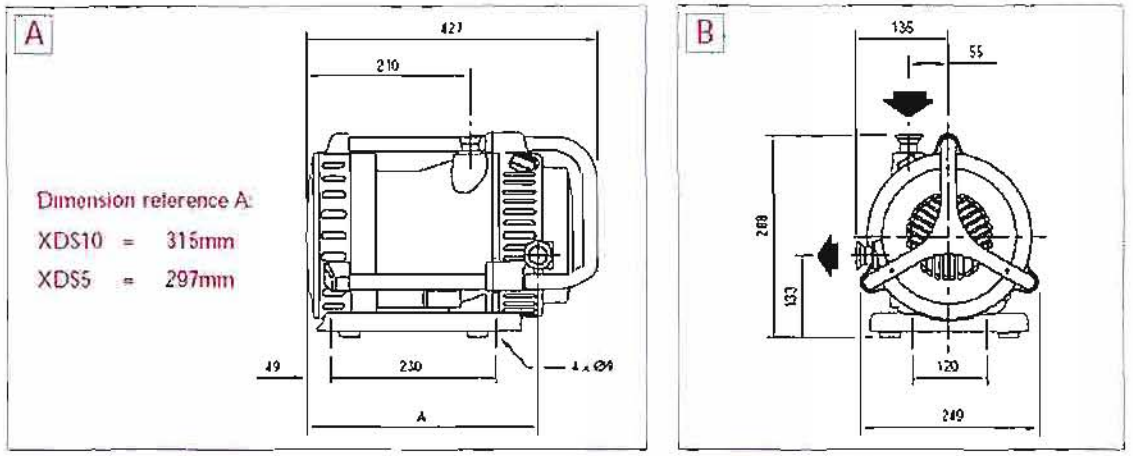


Figure 4. XDS10 pump dimensions in mm. Graphic taken from XDS10 datasheet. See www.bocedwards.com for more details. The pump is to be connected near the system using the supplied 1.2 m long bellows connection. If necessary, longer connections are possible with customer supplied connections. The mass of this pump is 23 kg and all dimensions are in mm.

Electrical Services Required

For North American operations only, the Xetch X3 is supplied with an appropriate 115-volt single-phase power cable and plug. 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. The vacuum pump has separate power requirements and its power is controlled via an external pump controller. It should be noted that since the pump can handle between 100-120 VAC or between 220-240 VAC (set via a selector switch on the pump) and can be thus supplied independently with these voltages.

	Xetch	Vacuum Pump
Mains supply required:	100-120 VAC 50/60Hz Single phase	100-120 VAC or 220-240 VAC 50/60 Hz Single Phase
Mains voltage fluctuations:	±10%	±10%
Power consumption:	1.2kW	0.3kW
External fusing:	20 A at 100-120 V	20 A at 100-120 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) 40-70%

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.

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 can be found on page 14.

Exhaust Requirements

There are three exhaust/ventilation connections to the Xetch:

1. Exhaust connection from the vacuum pump, which is NW25
2. Ventilation connection from the chamber ventilation shroud, which is to be connected to a 3" inside diameter hose
3. Ventilation connection from the gas box, which is to be connected to a 2" inside diameter hose

WARNING

THE EXHAUST GAS FROM THE OUTPUT PORT OF THE XETCH'S VACUUM PUMP MUST BE VENTED INTO A SUITABLE FUME EXHAUST SYSTEM. ANY FITTINGS AND/OR TUBING REQUIRED SHOULD BE OBTAINED LOCALLY. THE CUSTOMER, TO COMPLETELY VENT THE SYSTEM GAS BOX, SHOULD ALSO SUPPLY EXHAUST VENTILATION USING A HOSE TO THE BACK OF THE FRAME.

WARNING

THE CUSTOMER SHOULD SUPPLY EXHAUST VENTILATION TO THE GAS BOX. THIS IS ACCOMPLISHED BY THE CUSTOMER CONNECTING A VENTILATED HOSE TO THE GAS BOX VENTILATION CONNECTION ON THE BACK OF THE FRAME.

WARNING

THE CUSTOMER SHOULD SUPPLY EXHAUST VENTILATION TO THE CHAMBER FUME SHROUD. THIS IS ACCOMPLISHED BY THE CUSTOMER CONNECTING A VENTILATED HOSE TO THE CHAMBER FUME SHROUD VENTILATION CONNECTION ON THE BACK OF THE CHAMBER FUME SHROUD.

WARNING

ALL VENTILATION CONNECTIONS SHOULD BE SUFFICIENTLY INDEPENDENT SUCH THAT A VENTILATION SYSTEM FAILURE DOES NOT ALLOW ANY EFFLUENTS DISCHARGING INTO THE SYSTEM OR TOWARDS THE OPERATOR. ALSO, ALL EXHAUST CONNECTION MUST CONFORM WITH ALL LOCAL REQUIREMENTS.

Installation Material

- Electrical connectors as required for local electrical outlets
- Gas regulators for Nitrogen process and vent gasses (if only process gas is to be used, an appropriate tee assembly must be supplied to tie the process and vent lines together)
- Overpressure relief valves in the Nitrogen process and vent gas lines to prevent the process and vent Nitrogen gasses from exceeding 100 psi at the rear system connections
- Gas regulator for Nitrogen gas box purge gas (if needed – contacted XACTIX for more information)
- Gas cylinder mounting bracket bench mount, or wall mount (if using gas cylinder)
- Gas box exhaust hose
- Chamber shroud exhaust hose
- Vacuum pump exhaust tubing - stainless steel recommended
- Two XeF_2 cylinders for X3 series Xetch with XeF_2

WARNING

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

Pre-Installation Checklist

Subject	Requirement	Yes	No	Comments
Space requirements	See above			
Room temperature	65-75°F (19-24°C)			
Relative humidity	40-70%			
Xetch mains supply	100-120 V ±10%, includes transient fluctuation, 20 A			
	Single phase			
	50/60 Hz			
Pump supply voltage	100-120 VAC or between 220-240 VAC, 0.3 kW			
	Single phase			
	50/60 Hz			
Earthing				Consult local requirements
Process gas	40 cu. ft. min, Nitrogen, 20 psi outlet			
	Provide safety overpressure device for Nitrogen process and vent line			Max. 100 psi
	Two cylinders of xenon difluoride for X3 Xetch			See below for bottle and valve
CDA	Compressed, dry air, 70-100 psi			
Gas box purge gas	Nitrogen, 5 psi			Used to supply diluent gas to gas box to flush possible fumes
System exhausting	Gas box exhaust connection			
	Fume exhaust to vacuum pump outlet			
	100 cfm exhaust to chamber area			

Cylinder and valve for XeF_2

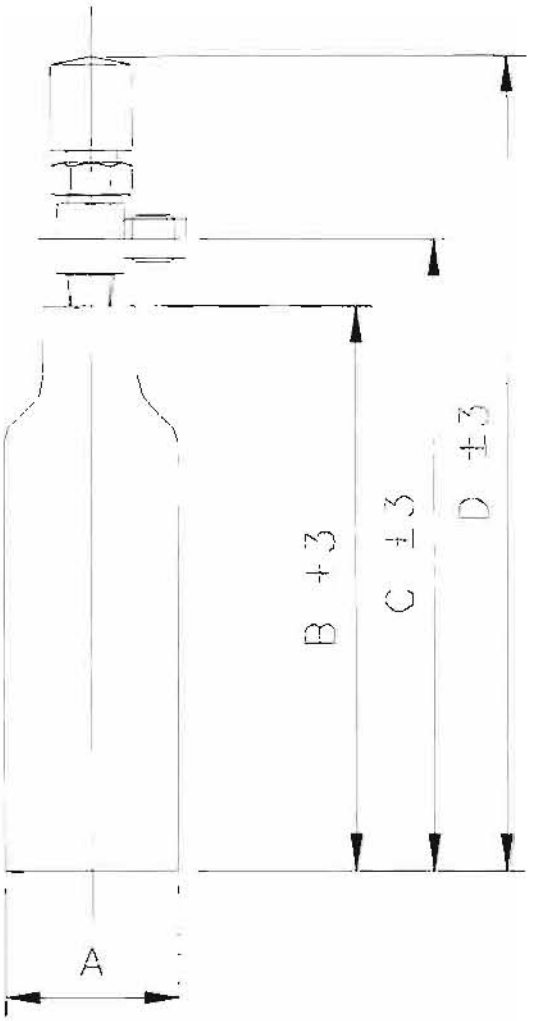


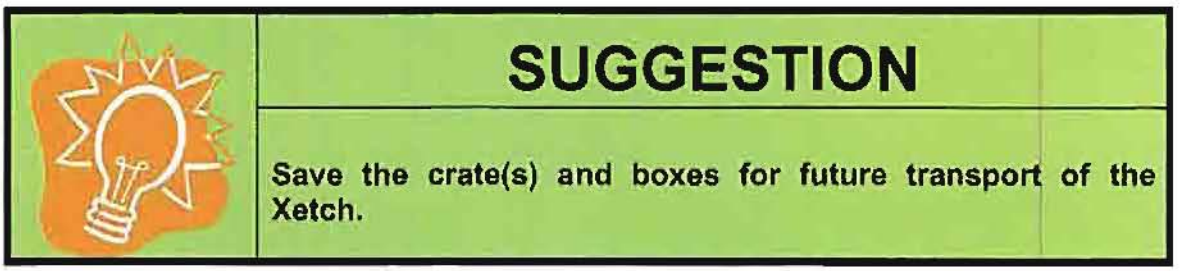
Figure 5: Xenon Difluoride Bottle (drawing not to scale).

Cylinder size	Maximum XeF_2	A	B	C	D
1.0 L	2.0 kg	88 mm	287 mm	307 mm	359 mm

- Cylinder: Seamless Aluminum
- Valve: Stainless steel, Whitey angle pattern valve and ¼" VCR male outlet

Uncrating

Inspect the shipping crate(s) for signs of obvious damage encountered during shipment (dents, scrapes, holes, etc.). Also inspect the "Tip n' tell" and Shockwatch 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.



Setup

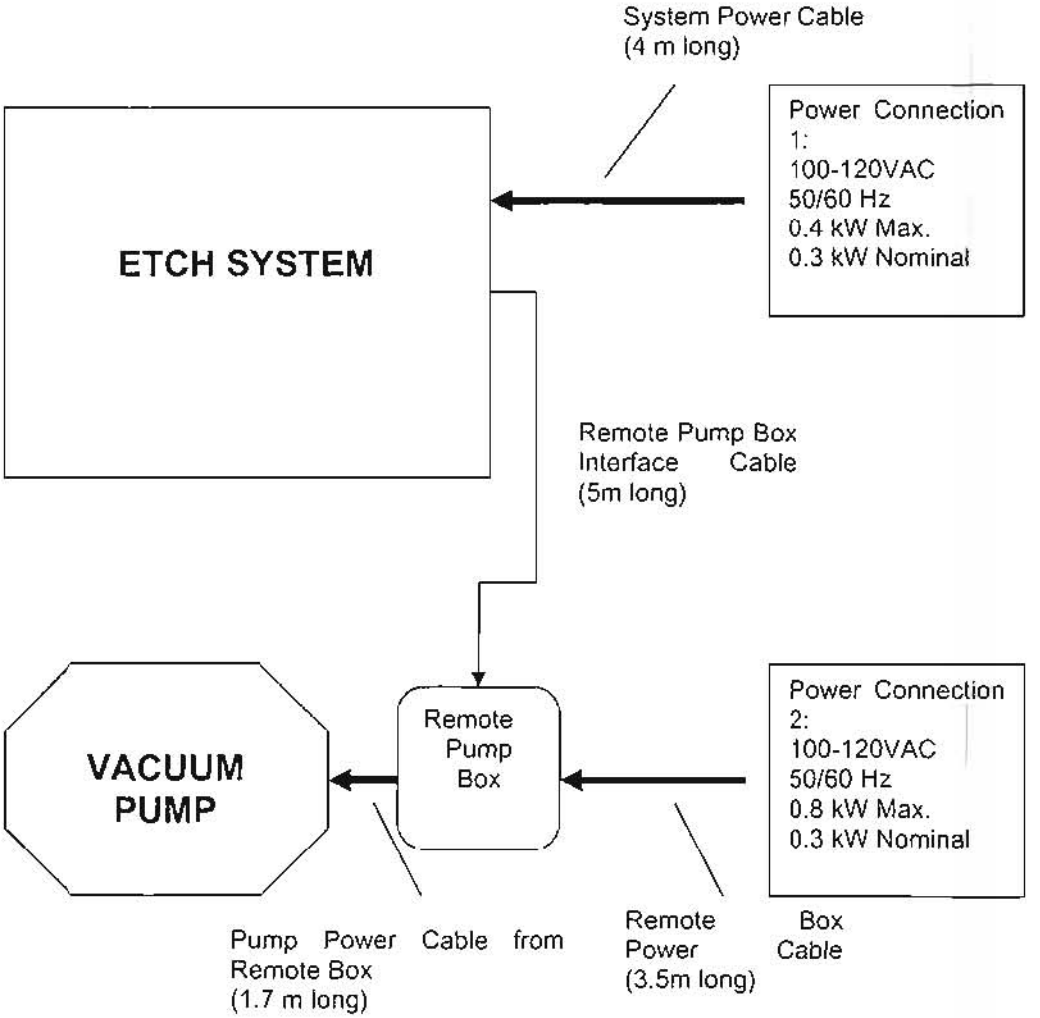
Although these steps will be performed by XACTIX employees or its representatives, a summary of the installation process is described below. Also, for your reference, images of the rear connections of the Xetch is shown in Figure 6, Figure 7, and Figure 8; the pump controller is shown in Figure 9; the rear of the ventilation shroud is shown in Figure 10; and the showerhead stop is shown in Figure 11.

To begin the setup of the Xetch, unpack all items from the boxes, then:

1. Level the Xetch using the leveling feet
2. Install the microscope post
3. Install the display post
4. Install the keyboard arm on the display post
5. Install the microscope illuminator bracket
6. Connect display power supply to acc. outlet
7. Install the display
8. Make display connections
9. Install keyboard and make connections
10. Install the microscope arm and microscope on the microscope post
11. Place the illuminator on the bracket and connect to acc. outlet
12. Install and route the fiber optic cable to the illuminator
13. Install the illuminator remote control and route cable
14. Install the showerhead stop behind the chamber
15. Make the shroud interlock switch connection
16. Install vacuum connection on Xetch to vacuum pump
17. Connect vacuum pump to ***customer supplied exhaust***
18. Connect Xetch to pump controller box
19. Connect pump to pump controller box
20. Connect ***customer supplied pressure relieved nitrogen line*** to process nitrogen connection
21. Connect ***customer supplied pressure relieved nitrogen line*** to vent nitrogen connection
22. Connect ***customer supplied compressed dry air line*** to CDA connection
23. Set internal nitrogen regulators to 10 psi
24. Set internal CDA regulator to 80 psi
25. Connect gas box exhaust to ***customer supplied exhaust***
26. Connect shroud exhaust to ***customer supplied exhaust***
27. Connect ***customer supplied nitrogen*** to gas box ventilation (if needed – contact XACTIX)
28. Plug in pump controller box into ***customer supplied electrical outlet***
29. Plug in Xetch into electrical outlet

Electrical Connections Diagram

The electrical connections diagram is shown below:



Vacuum, Gas, and Exhaust Connections Diagram

The vacuum, gas, and exhaust connections diagram is shown below:

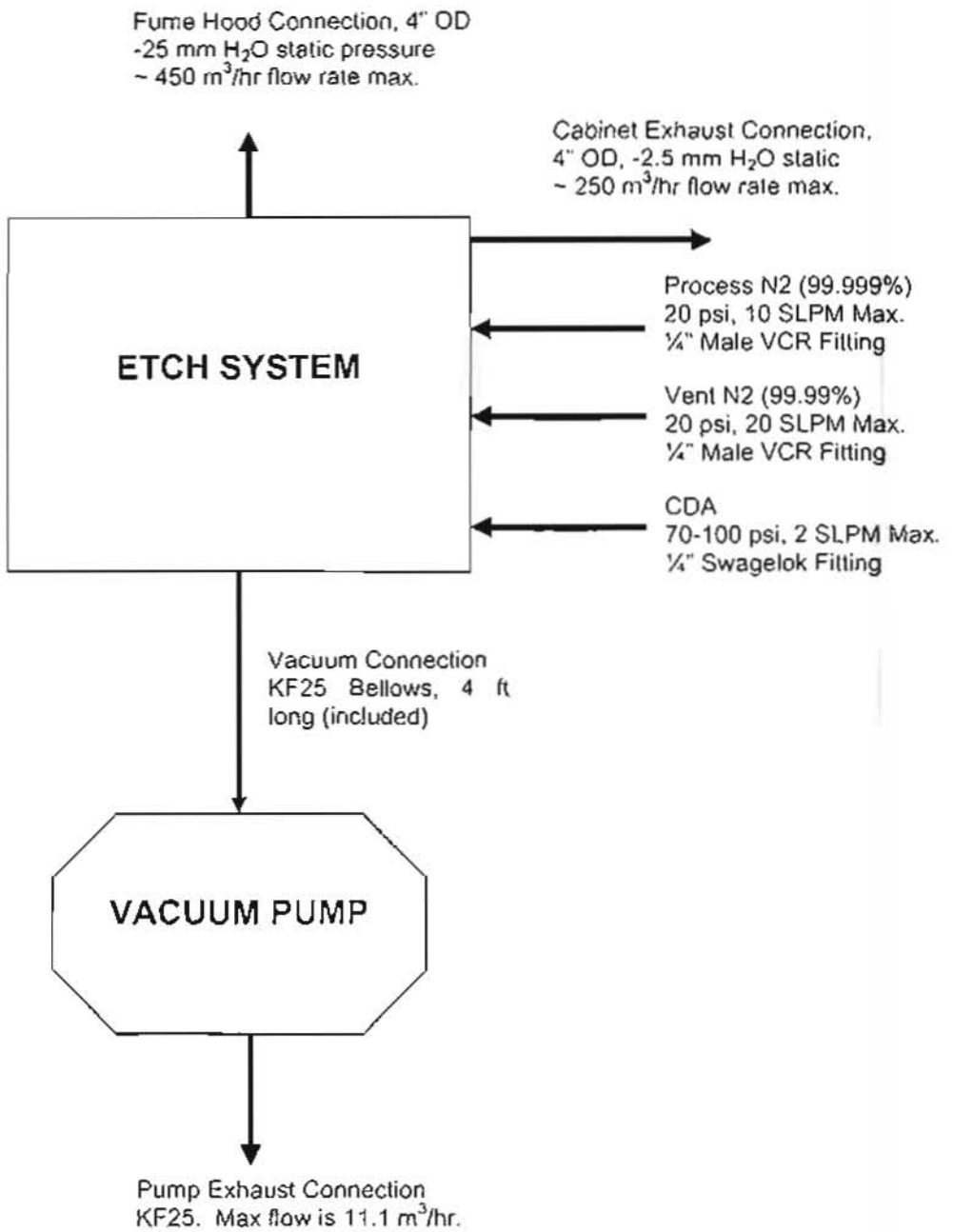


Figure 6. Rear Connections of Xetch. Note, some systems may have different sized exhaust connections. Contact XACTIX for specific information.

Figure 7. Close-up of Electical & Communication Connections.

Figure 8. Close-up of Gas, Vacuum, and Exhaust Connections.

Figure 9. Pump controller box.

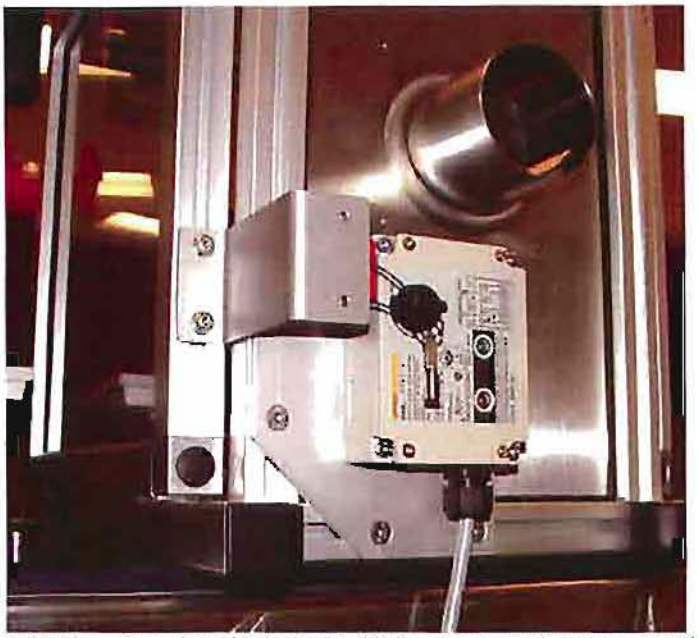


Figure 10. Rear of ventilation shroud and interlock. Note, some systems have different sized exhaust connections. Contact XACTIX for specific information.

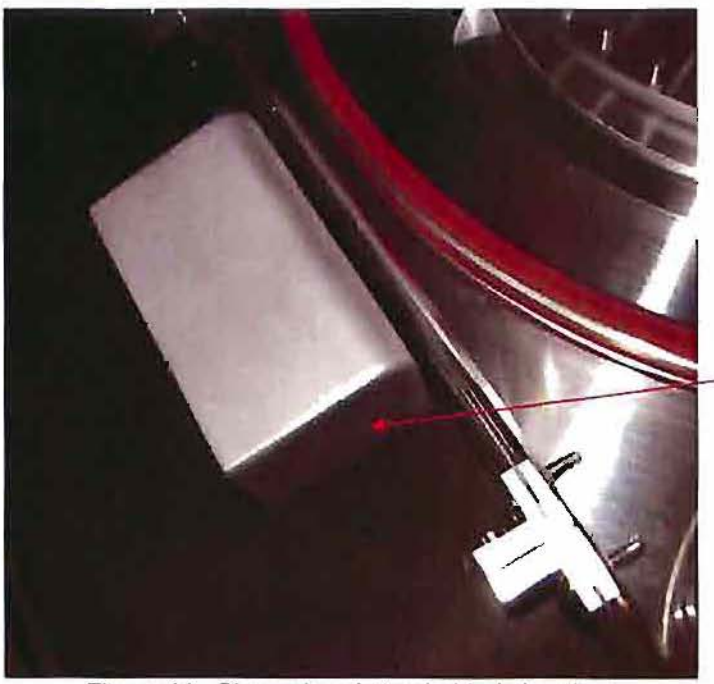


Figure 11. Showerhead stop behind chamber.

Initial Start-up

Safety verification

At this point, verify the following points:

a) Exhaust ventilation is on and all system exhaust including that for the vacuum pump is properly installed.

b) Dry compressed air pressure is between 70 and 100 psi

c) Nitrogen pressure is between 10 and 20 psi for both the vent and the process connections

d) Nitrogen is flowing in through the gas box purge connection

e) Power is available to the system.

f) Emergency Stop button (EMO) is pulled out on both the system and the remote pump (see Figure 9) switch box.

Power Up and EMO reset

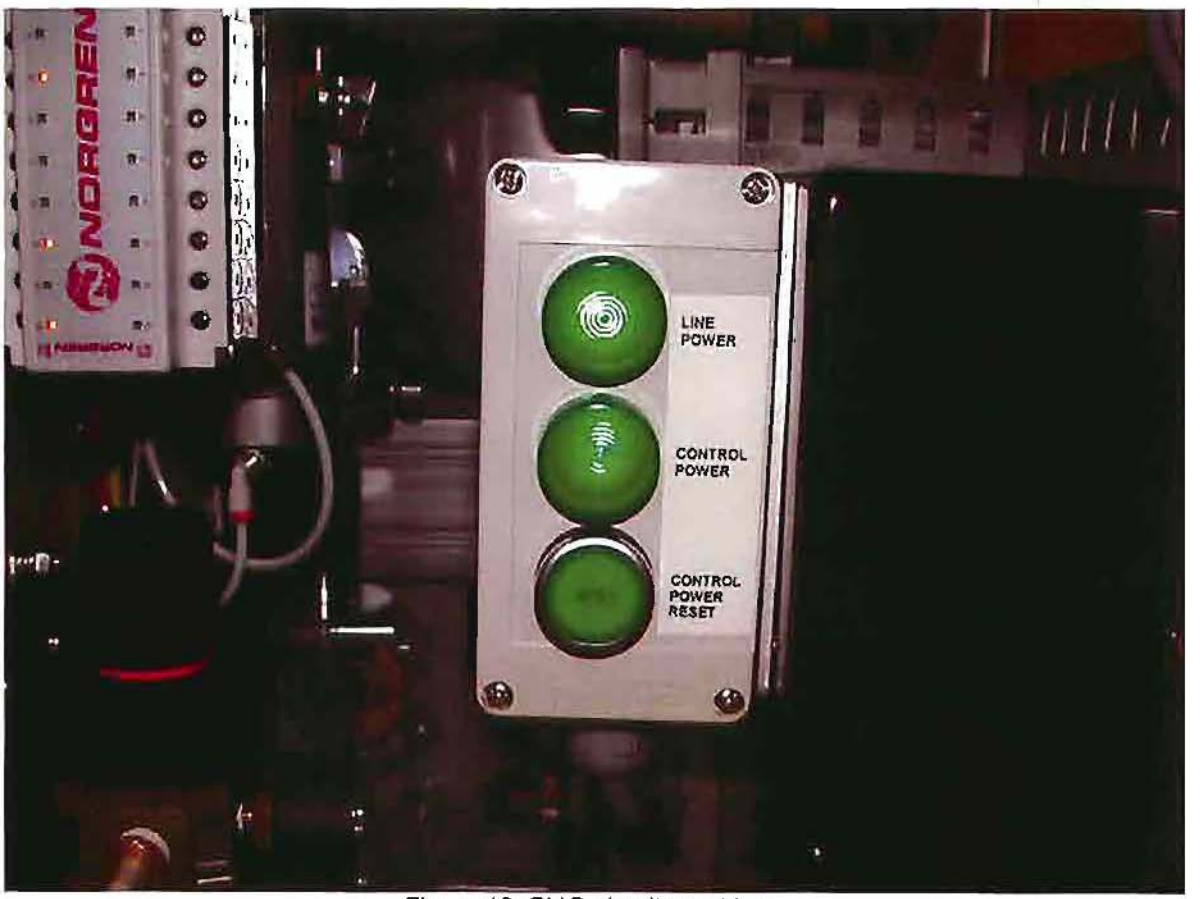


Figure 12. EMO circuit reset box.

First, examine the box shown in Figure 12 which is inside of the front system panel. The top light, LINE POWER, should be lit which indicates there is 100-120 VAC to the system. The lower light, CONTROL POWER, should initially not be on. This light indicates that the power that controls the system

components is on. To turn the CONTROL POWER, press the CONTROL POWER RESET button. CONTROL POWER should remain on except if any of the following situations occur:

- If the Emergency Stop button is pressed (either on the system or on the pump controller box)
- If there is a loss of power to the system

In these situations, resetting the CONTROL POWER as described above will be necessary.

As long as there is CONTROL POWER, the system power can be controlled using the Green (on) and Red (off) buttons on the front of the system as shown in Figure 13.

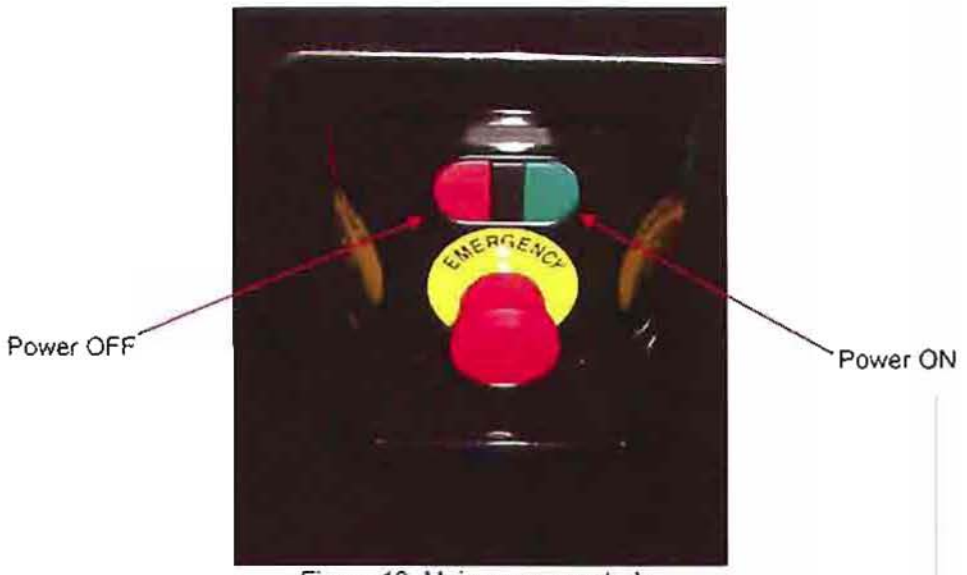
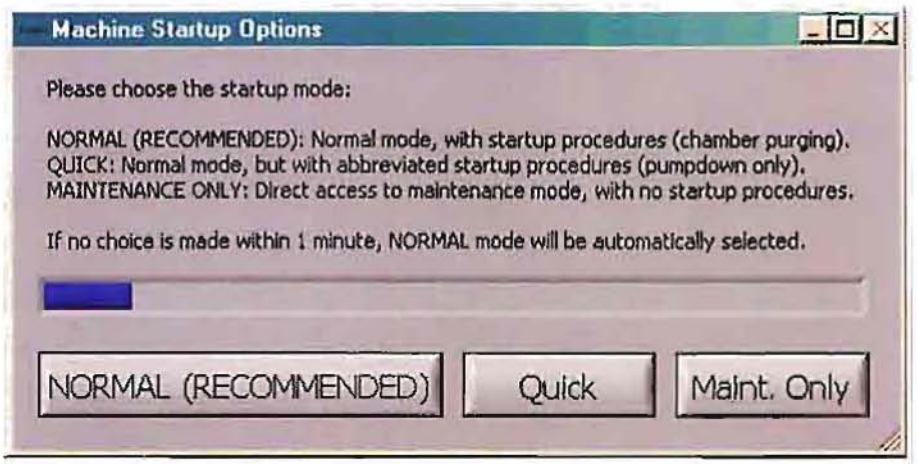


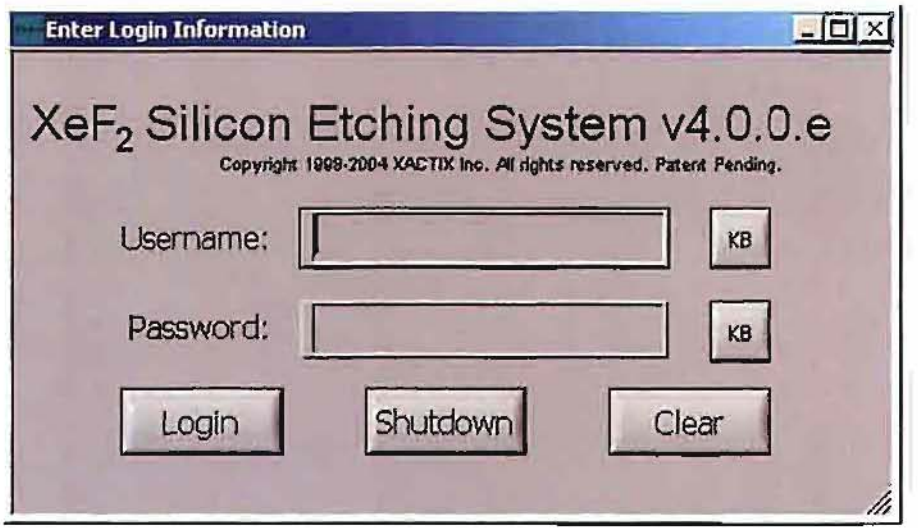
Figure 13. Main power controls.

The computer system will boot up. Then, the Xetch control program, which is located under; Start Button; Programs; Xactix; Xetch, will autostart

After the initialization procedure, a dialog box will appear as below:



Allow the NORMAL startup routine to complete. The control program will run an automatic system purge routine that sequences the various valves making sure that all of the chambers have been purged. This routine will last approximately ten minutes. At the end of this process, the control screen will display a log in menu as shown below:



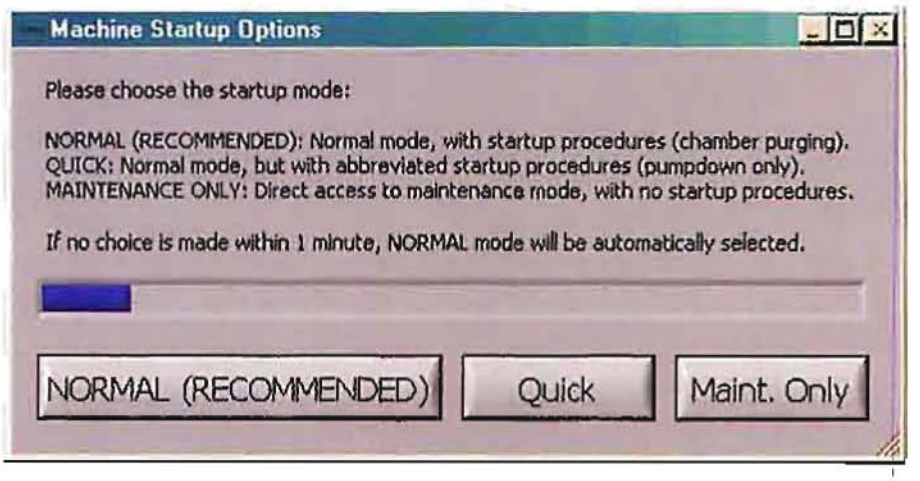
The Xetch is now ready for use.

Software Control

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.

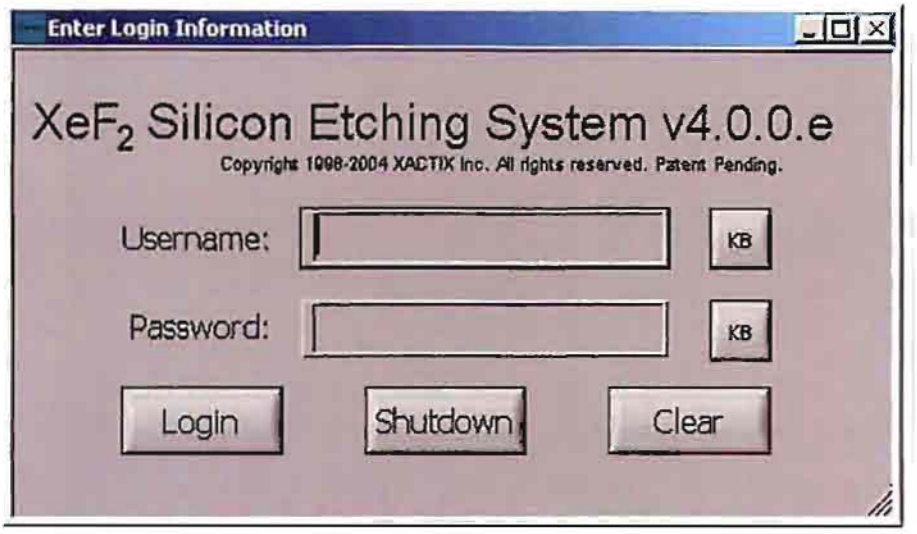
- Normal mode is the recommended method of startup for the Xetch. In this mode, the machine pumps and purges all of the machine chambers, assuring the user that the chambers are purged.
- In Quick mode, the chambers are simply pumped down, with no purging performed. This mode is useful when the state 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.

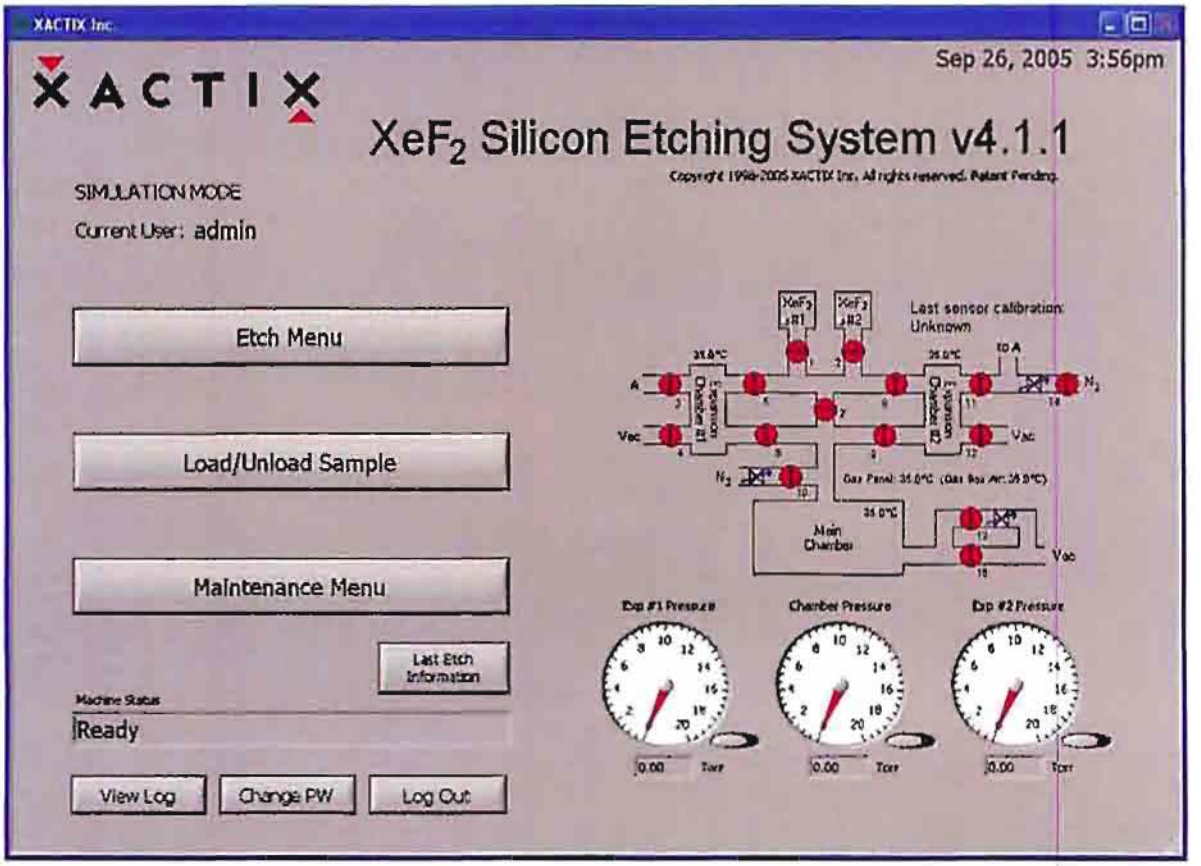
If no choice is made for one minute, Normal mode is selected by default. This allows the system to start up unattended.



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.

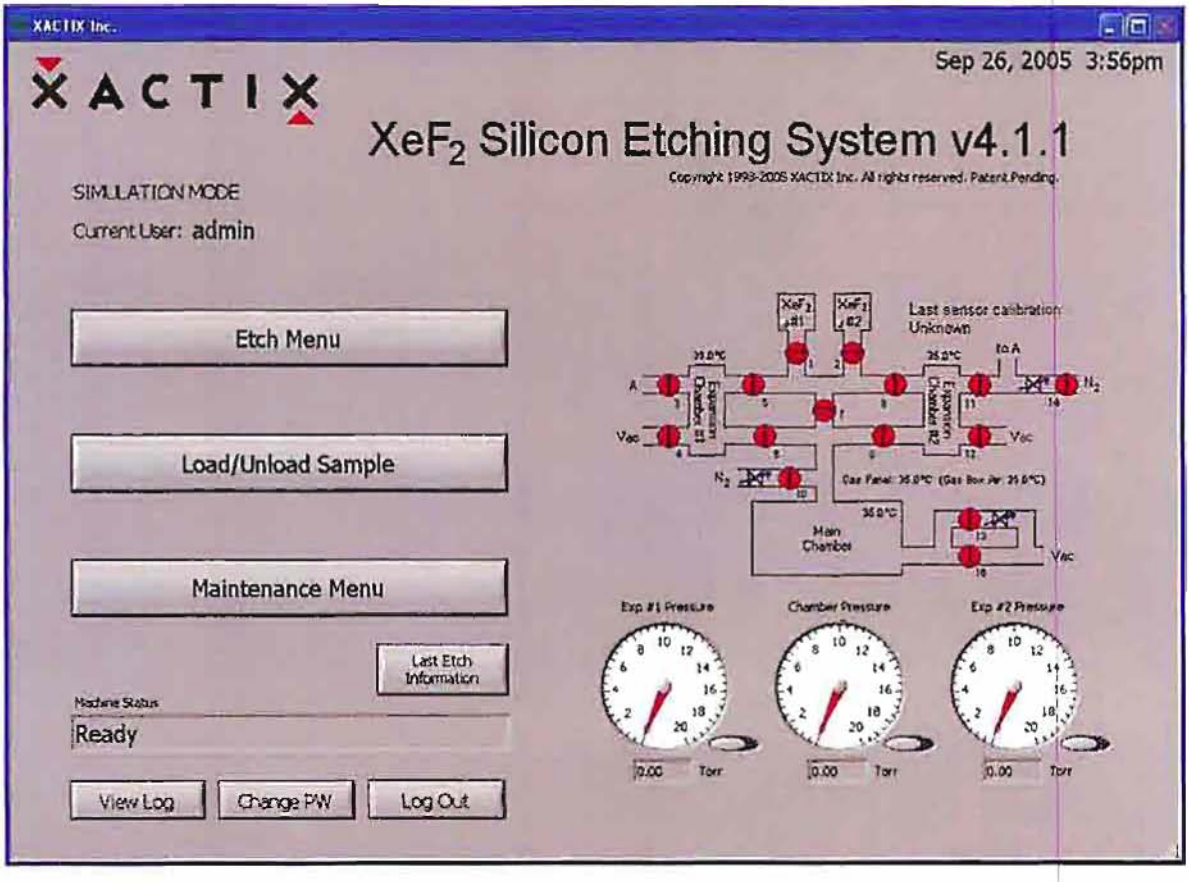




Main menu

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).

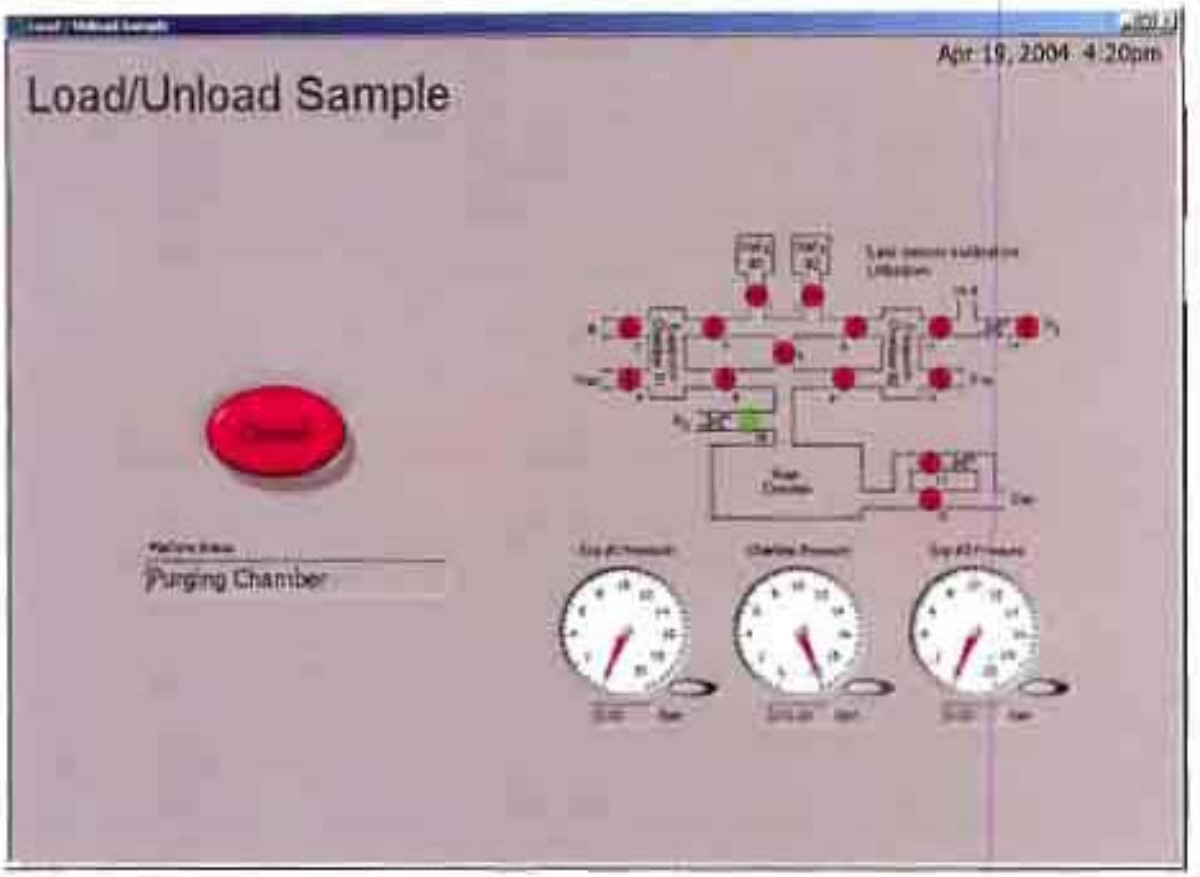
Upon a successful login, the main menu will be displayed as shown below. The machine status is shown in the bottom left corner. When the main menu is displayed, the chamber is under vacuum and ready for use. A schematic for the machine is shown on the right. Red dots next to numbers denote closed valves, 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. In addition, inside of each XeF_2 source bottle, there is a small grey dot which indicates that the quantity of XeF_2 in the bottle is above a the warning level. The dot changes to yellow when the XeF_2 is below the warning level and then changes to red once the system believes that the level is below 0.



Sample Loading

To load/unload a sample:

1. Press "load/unload 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.



2. Swing the microscope out of the way of the chamber.
3. If the chamber ventilation shroud covering the chamber is not pulled fully forward (see Figure 14), a request to close the shroud will be displayed before venting the chamber. Move the shroud forward (see Figure 15) and acknowledge the prompt.
4. 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.

5. If desired, load a sample. If the sample holder and pins have not been placed in the chamber, and you wish to do so, please do so now. See Figure 16 and Figure 17.
6. Close the lid.
7. 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.
8. During the pumping cycle, a "click" sound will be heard that indicates that the ventilation shroud can be moved.

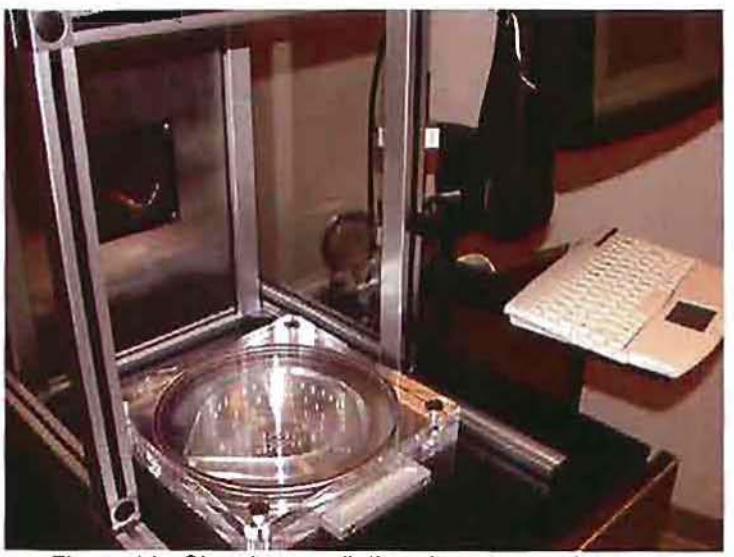


Figure 14. Chamber ventilation shroud moved to back.

Figure 15. Chamber ventilation shroud pulled forward.

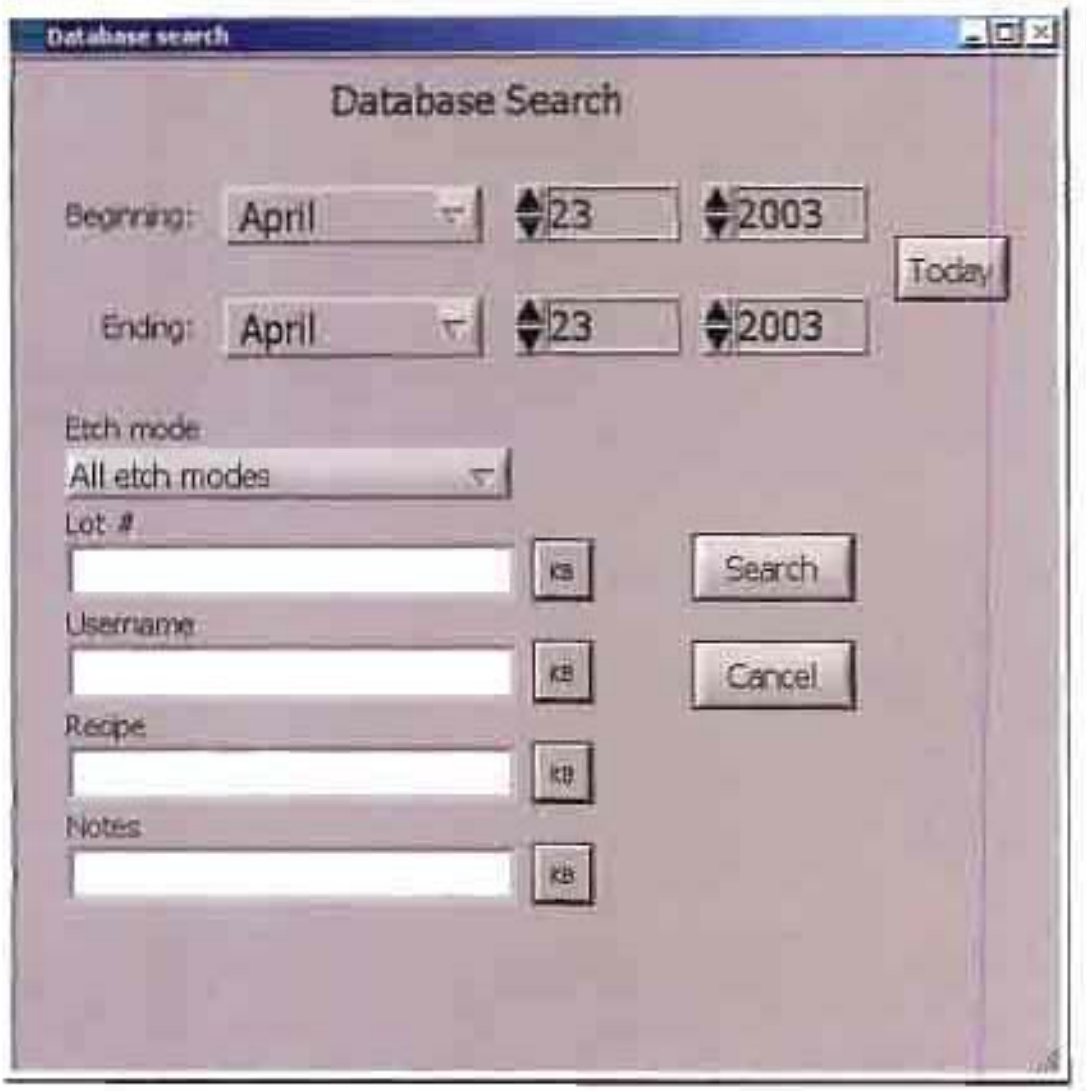
Figure 16. Wafer holding pins in place.

Figure 17. Wafer holder placed on pins.

Viewing the Log

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

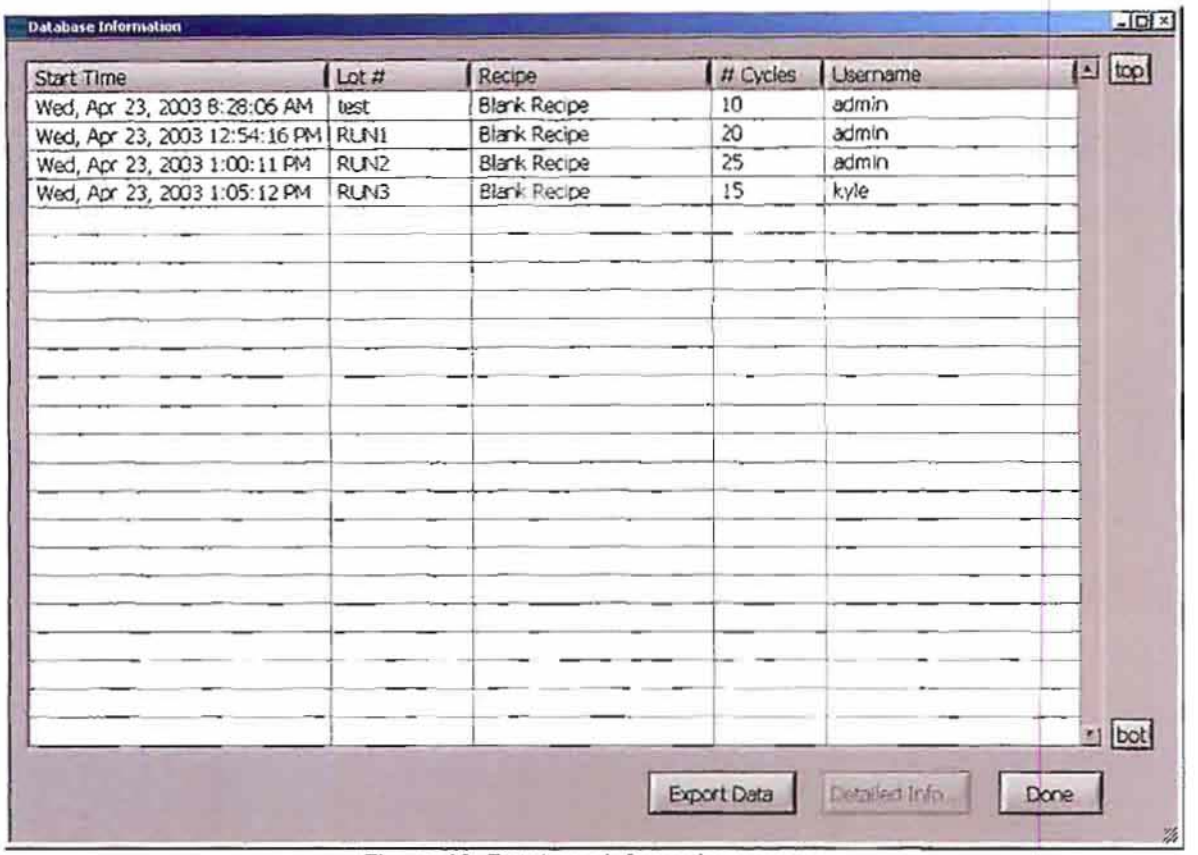
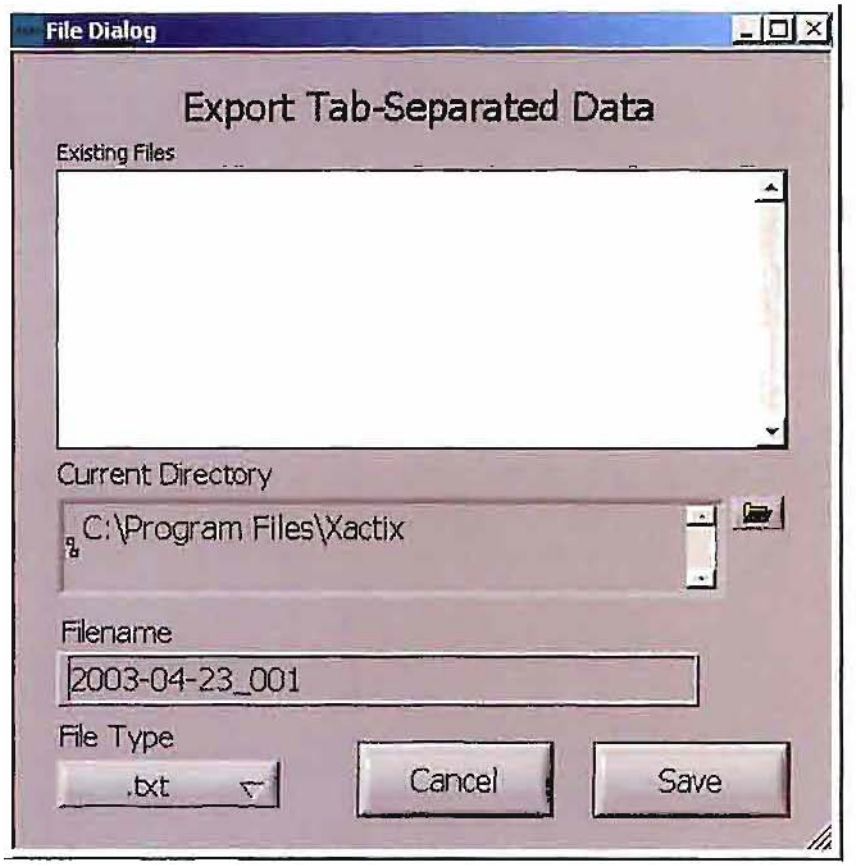
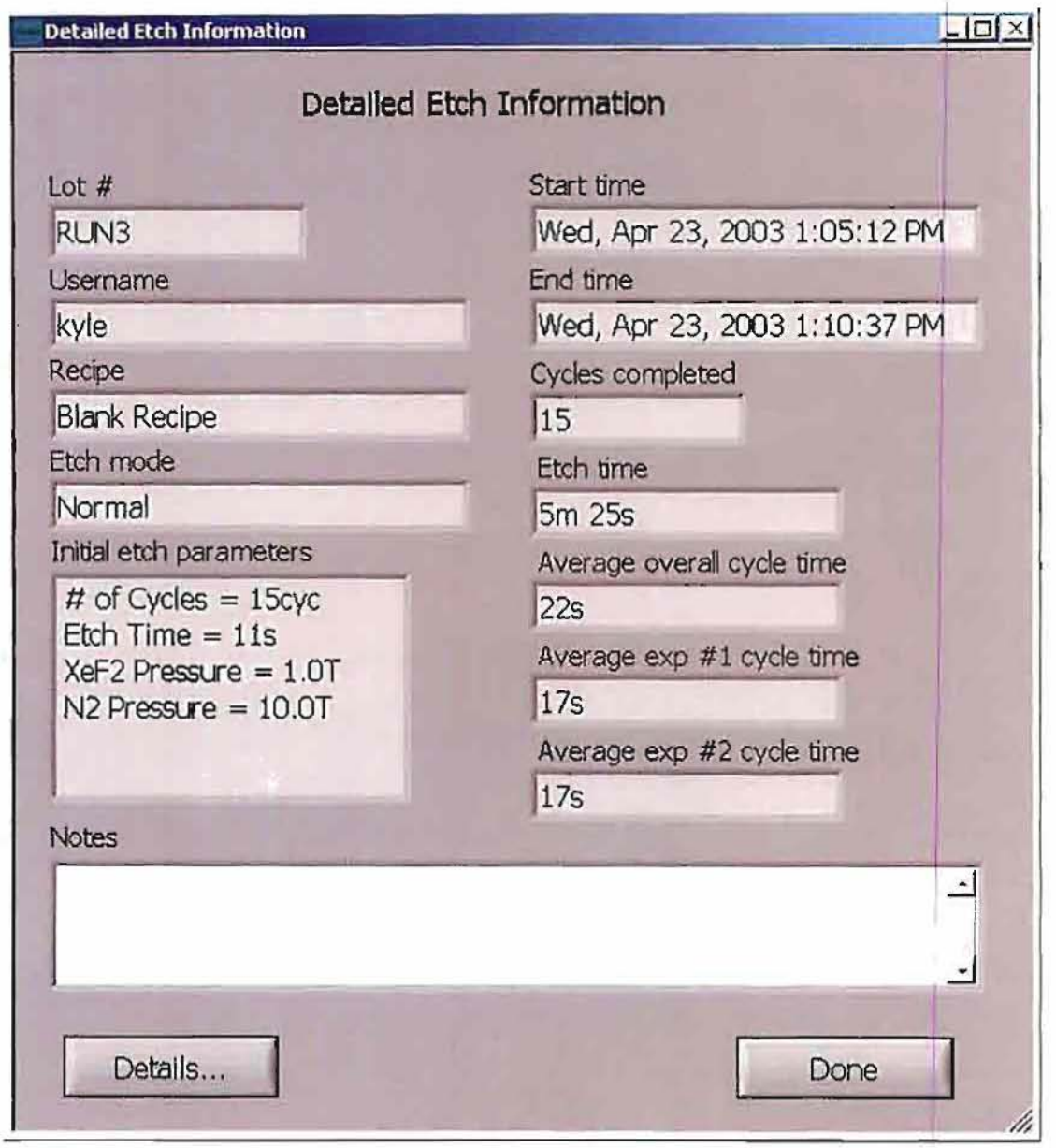


Figure 18. Database Information screen.

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 19), 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.



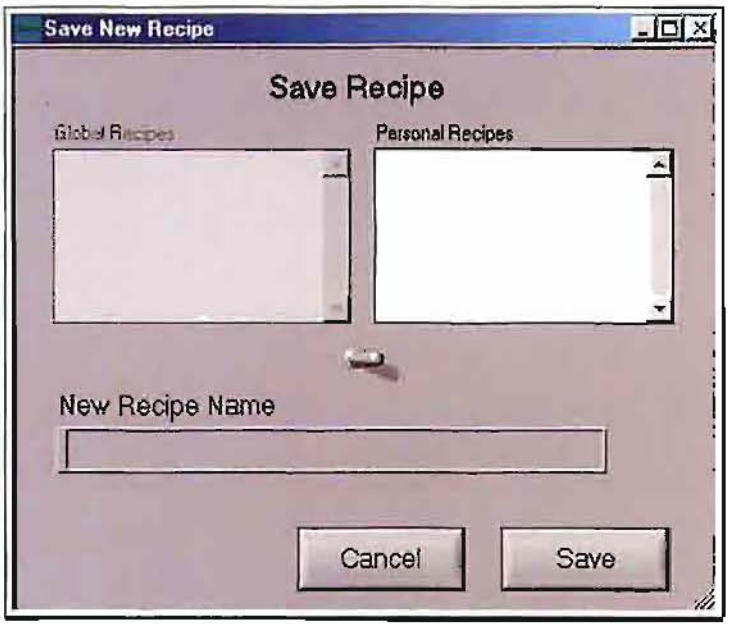
Other Main Menu Items

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

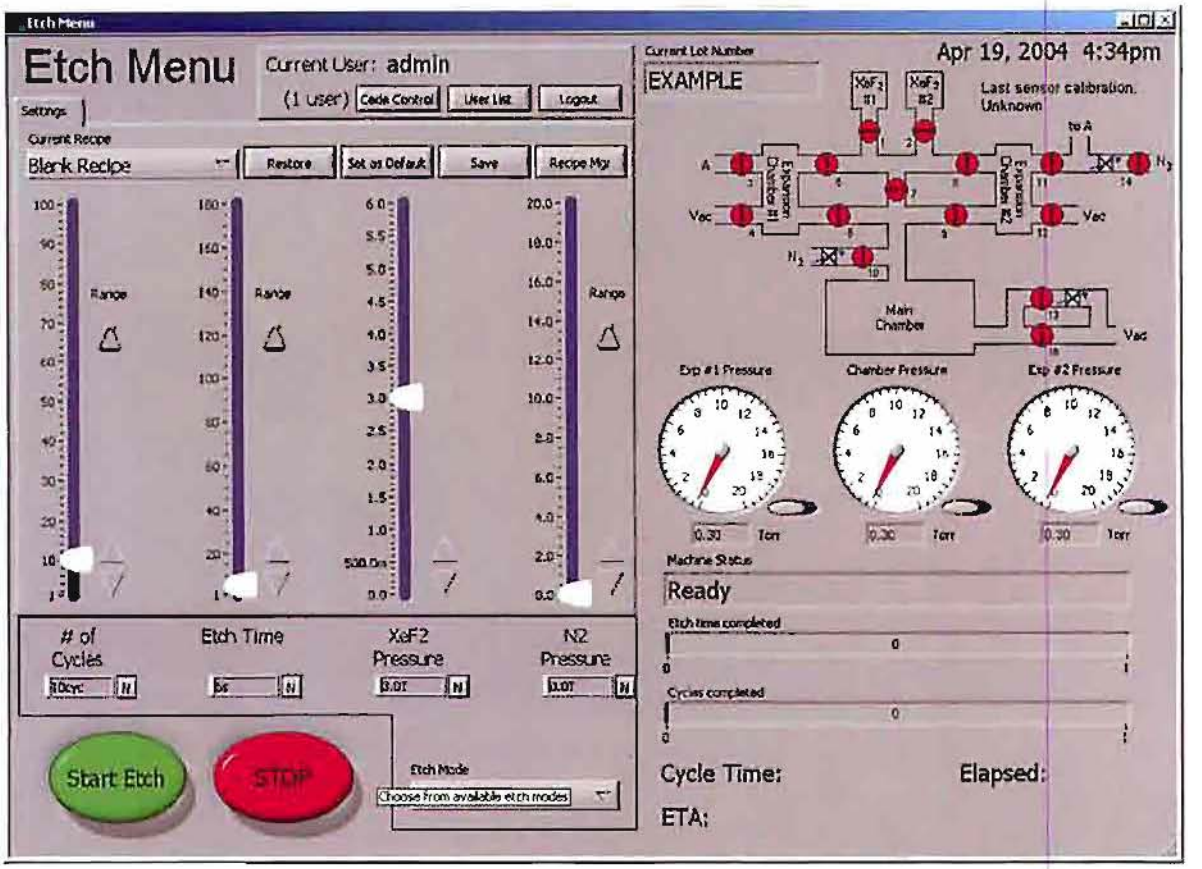
In order to perform an etch, the "perform etch" button in the main menu must be selected. The Xetch will prompt you to enter the lot number of the sample being etched. Press done once number is entered. The "perform etch" screen is shown below with lot number, "EXAMPLE" in this case; the screen pictured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



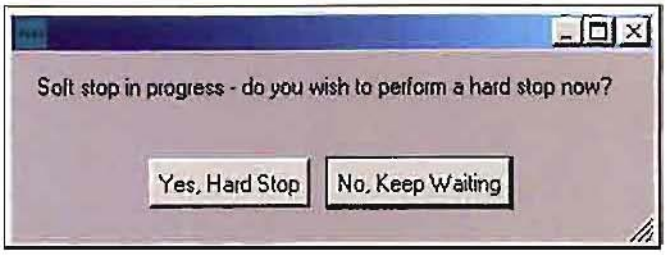
Etch Menu Features

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.

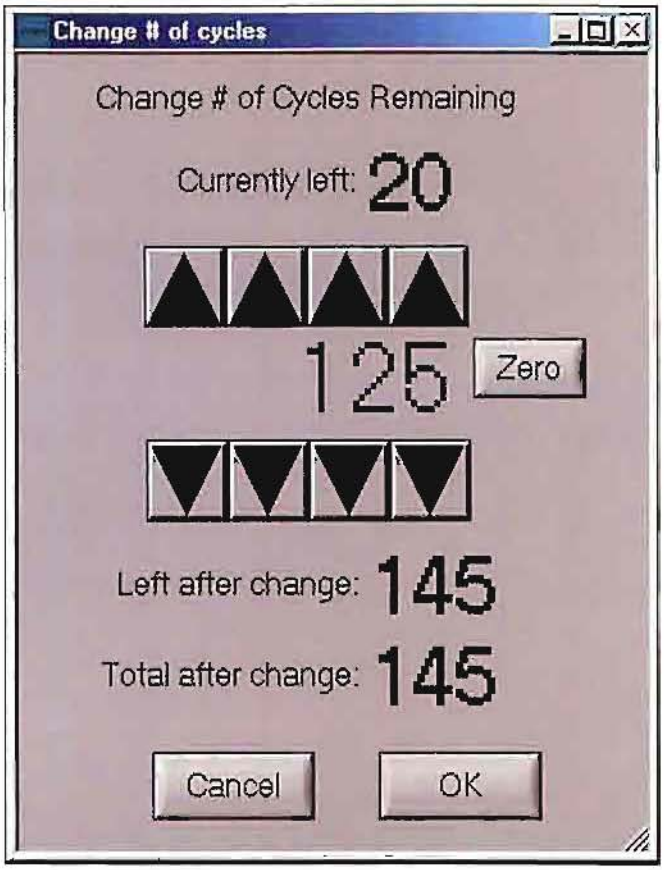
In addition to this, at the bottom of the right side of the screen are two counters. The first counter displays how much time has transpired during the etch portion of the cycle. The second counter shows the number of cycles completed.

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 63). 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.

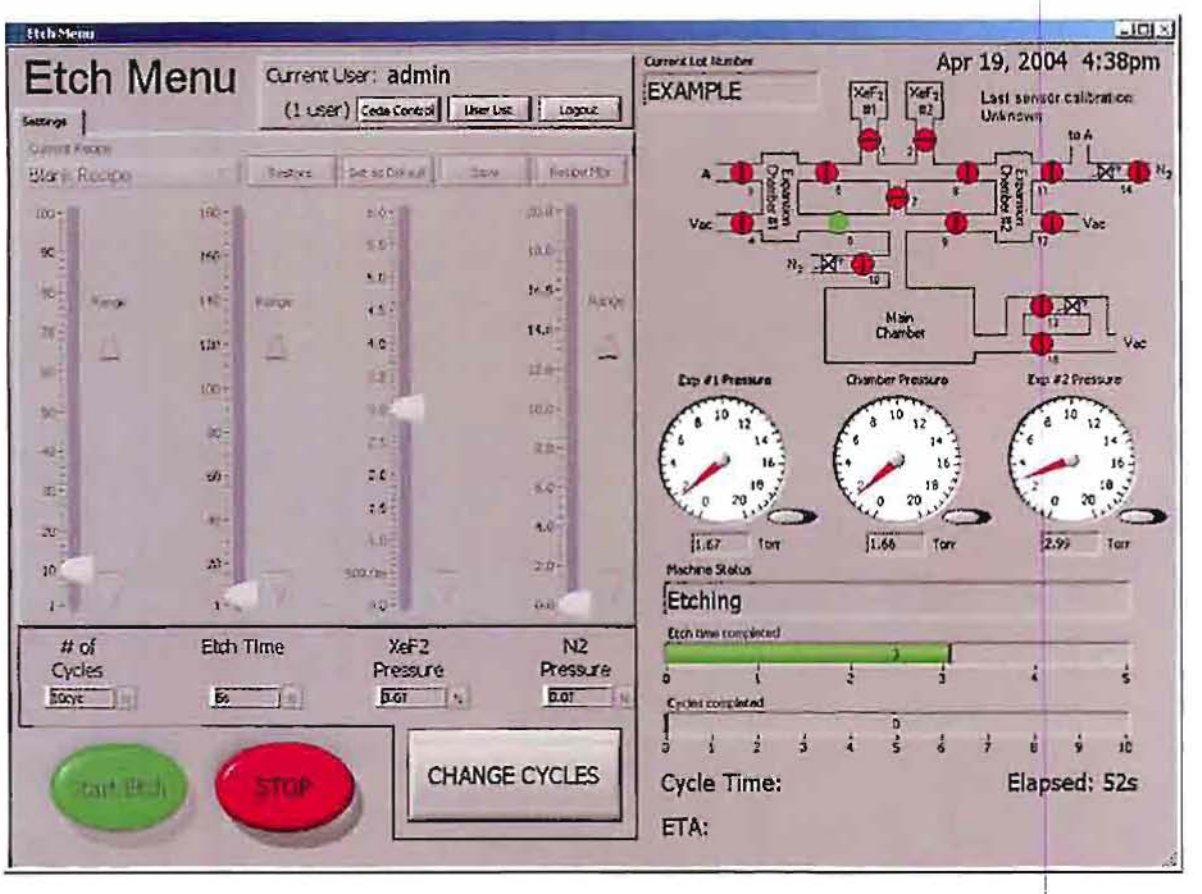
XeF_2 Pressure

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

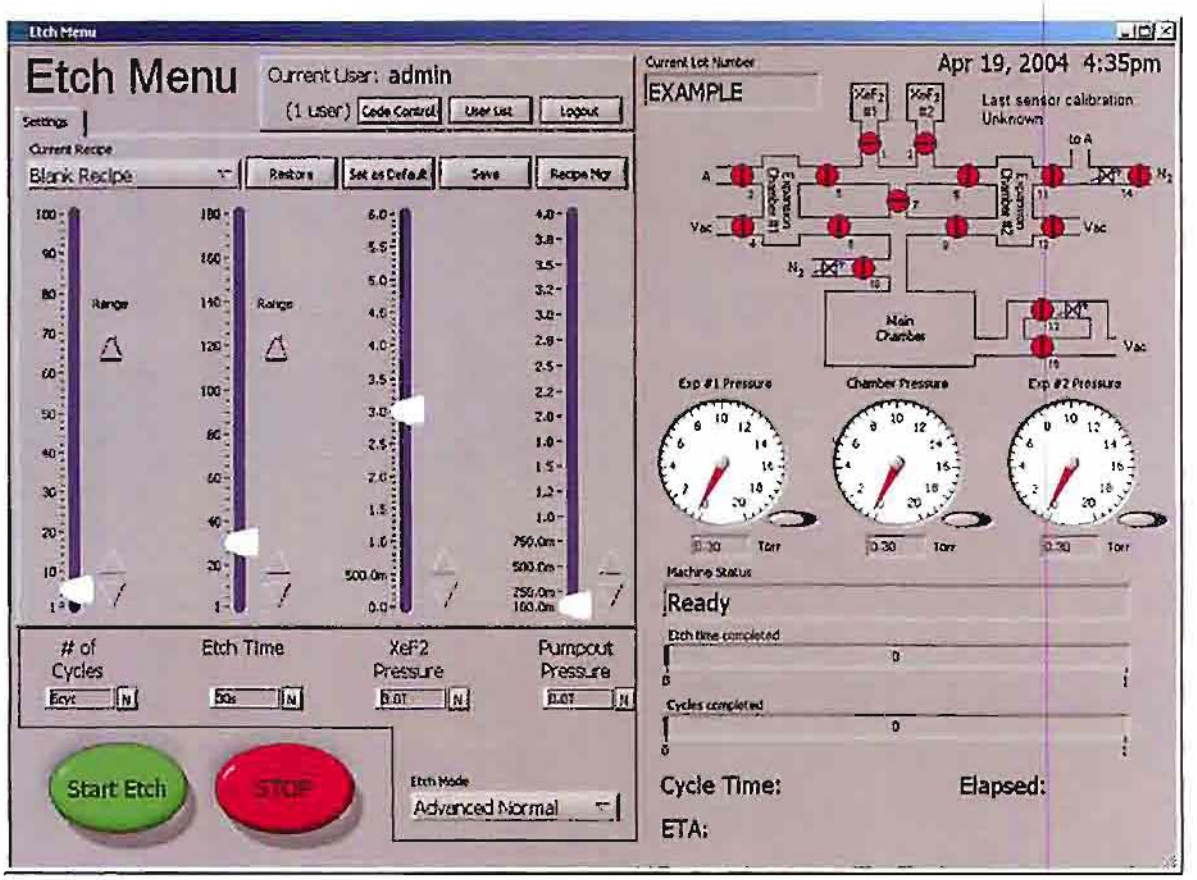
When the valve between the main chamber and expansion chamber is opened the pressure equilibrates and the etching process begins. The etch time is the time between the opening of the valve between the expansion chamber and the process chamber and the opening of the valve between the process chamber and 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

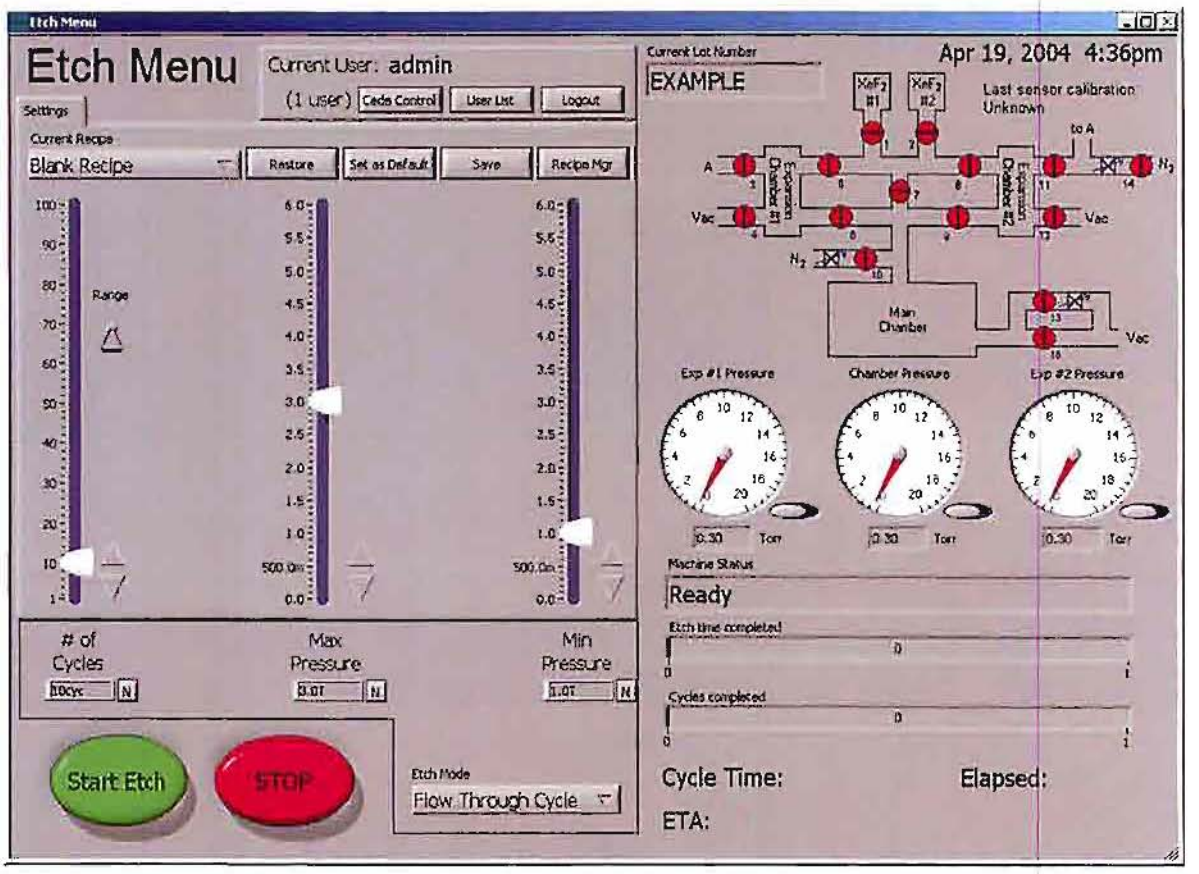
The maximum pressure is the highest pressure of xenon difluoride that is achieved in the process chamber prior to the vacuum valve opening. If the pressure were to reach in excess of 300 T, all valves are closed to prevent over-pressurization leak.

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.

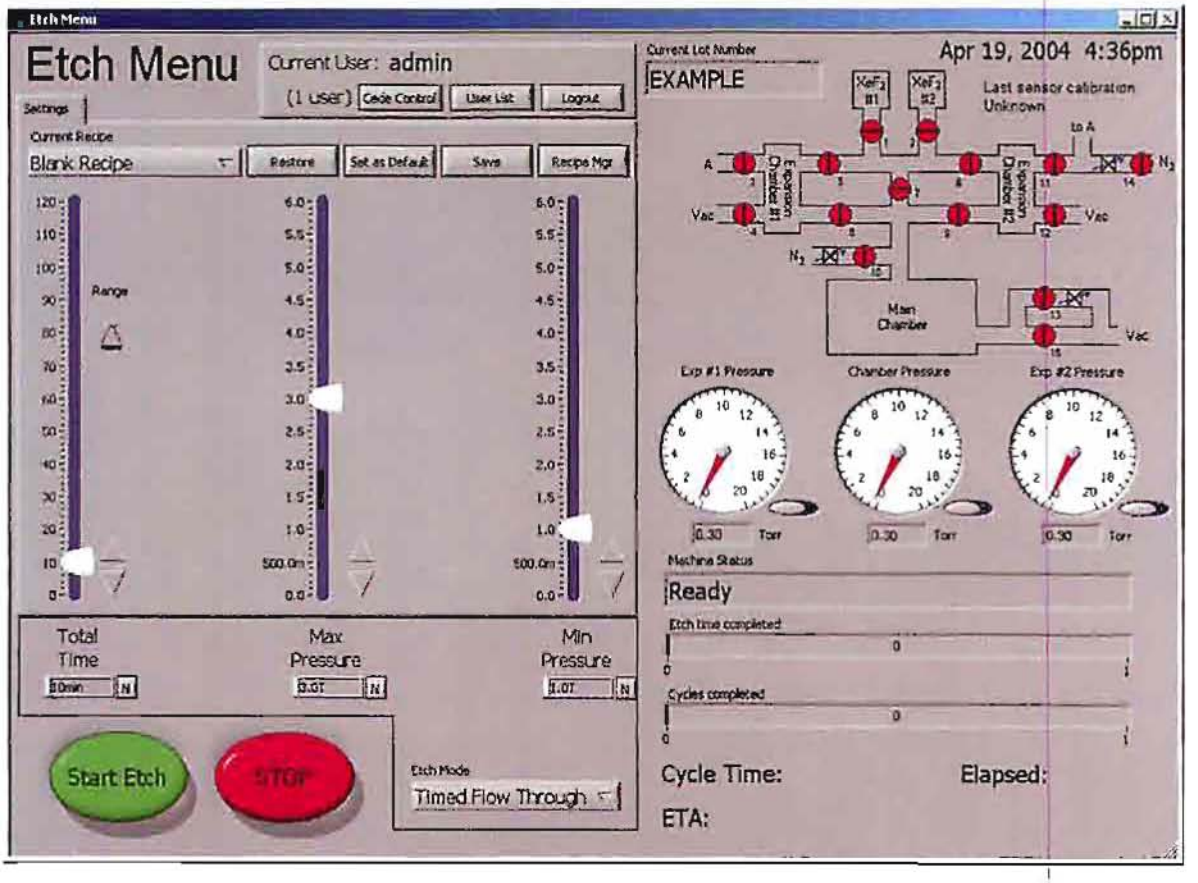
The Flow Through Cycle etch screen is shown below for flow through cycle mode etching.



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.



Performing an Etch in the Normal with Delays Mode

Normal with Delays 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.

Etch Delay

During each cycle, since XeF_2 etching is an exothermic reaction, the wafer temperature will increase. By putting a time delay between each etch cycle, the wafer can cool down to maintain a consistent, reduced temperature.

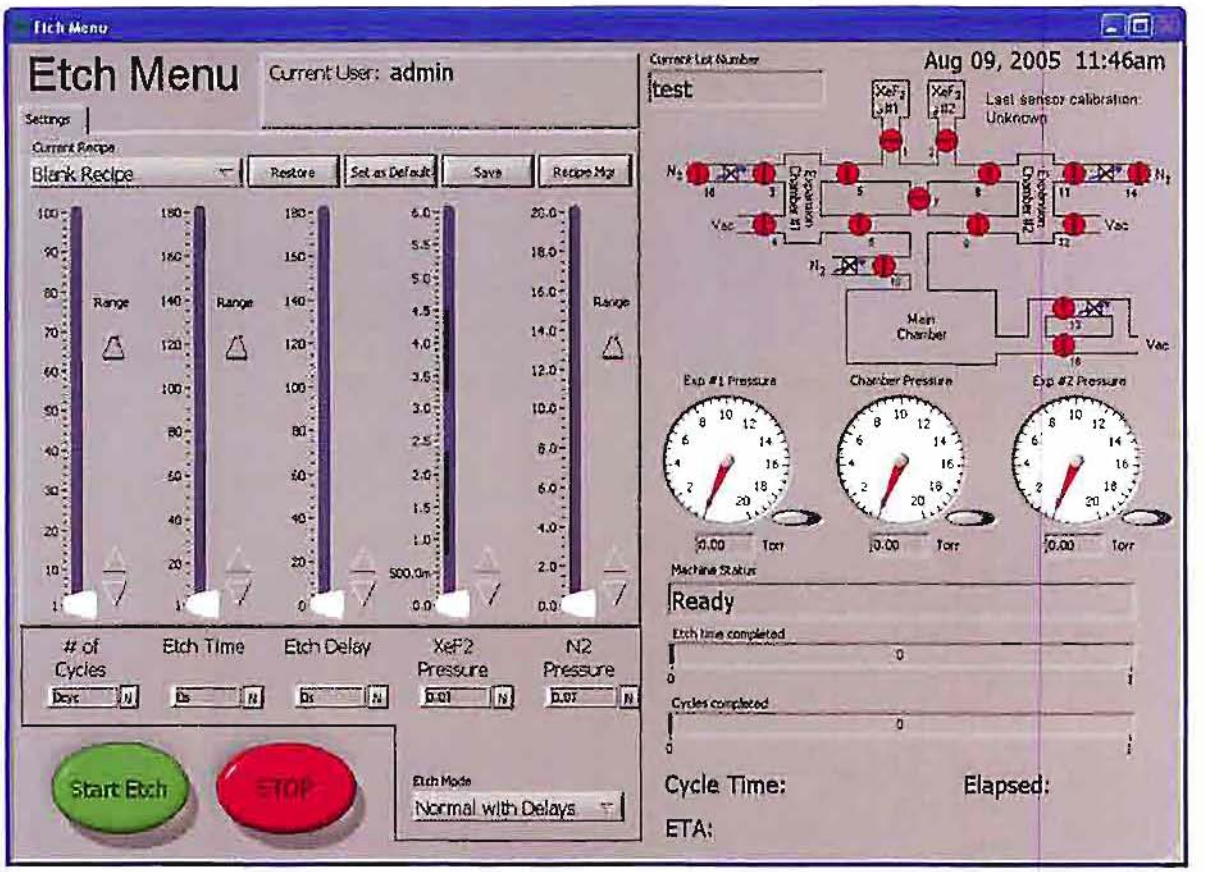
XeF_2 Pressure

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 with delays mode.



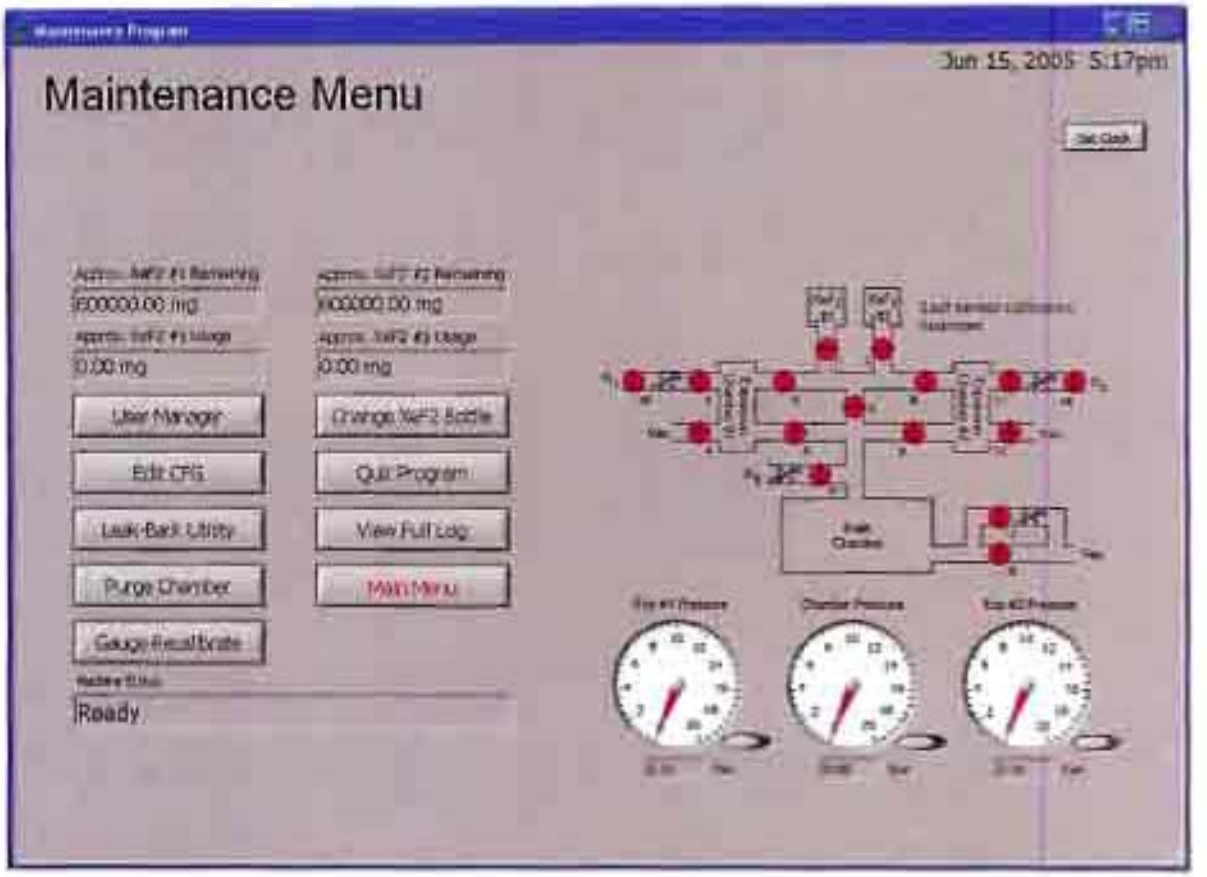
Maintenance Menu

WARNING

MAINTENANCE MODE SHOULD ONLY BE USED BY THOSE INDIVIDUALS WHO UNDERSTAND THE RISKS OF EXPOSURE TO XEF_2 AND ARE FULLY TRAINED IN THE USE OF THE MAINTENANCE ACTIVITIES FOR THE SYSTEM.

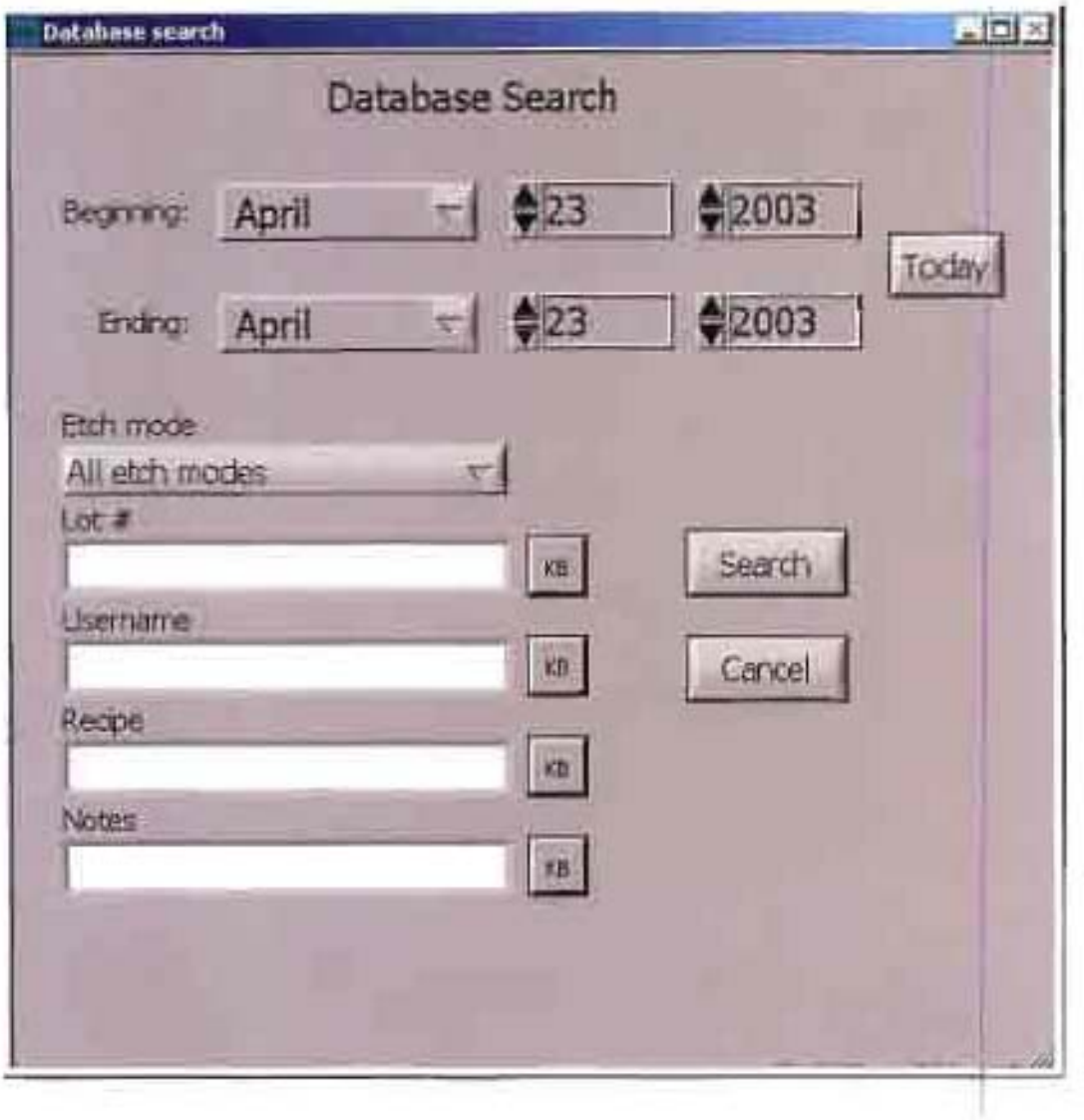
The maintenance menu may be accessed via the "maintenance menu" button found on the main menu screen. For users without maintenance privileges the maintenance menu will not be accessible.

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 80), 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 and remaining for 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.

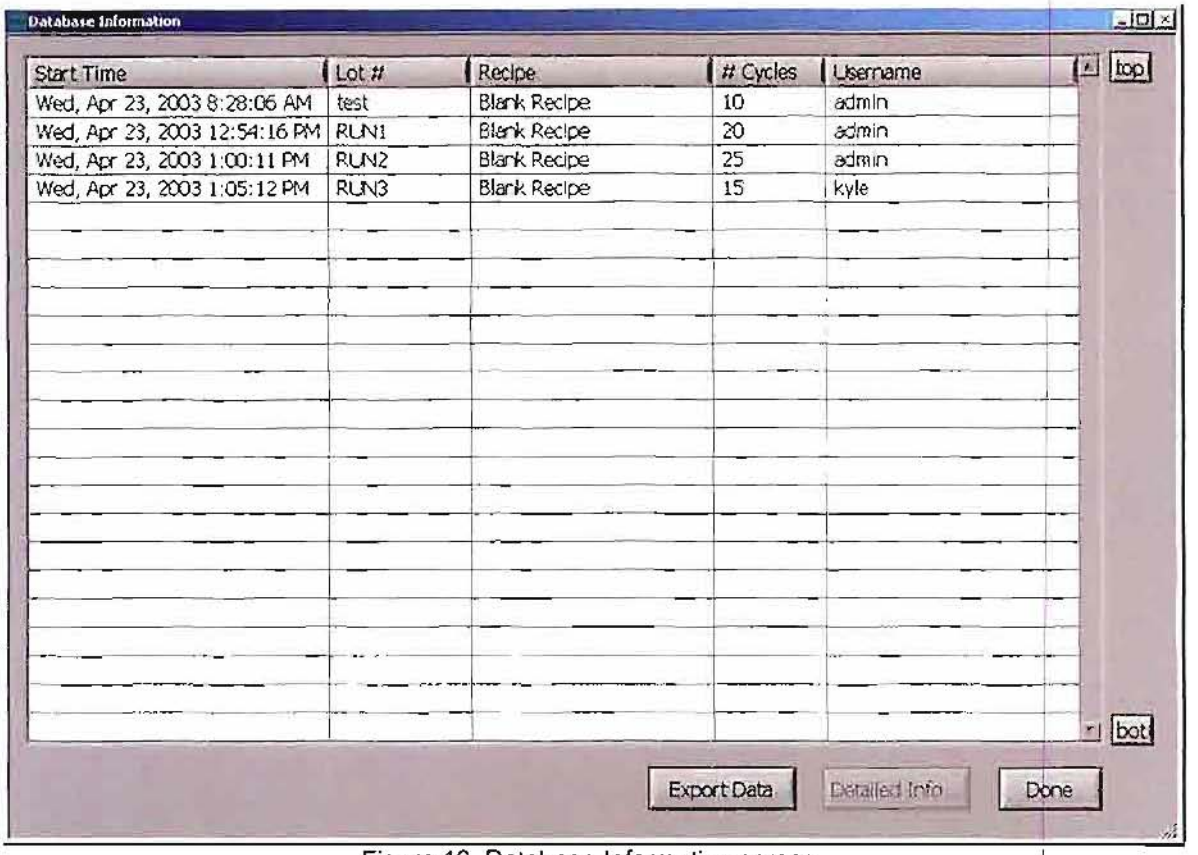
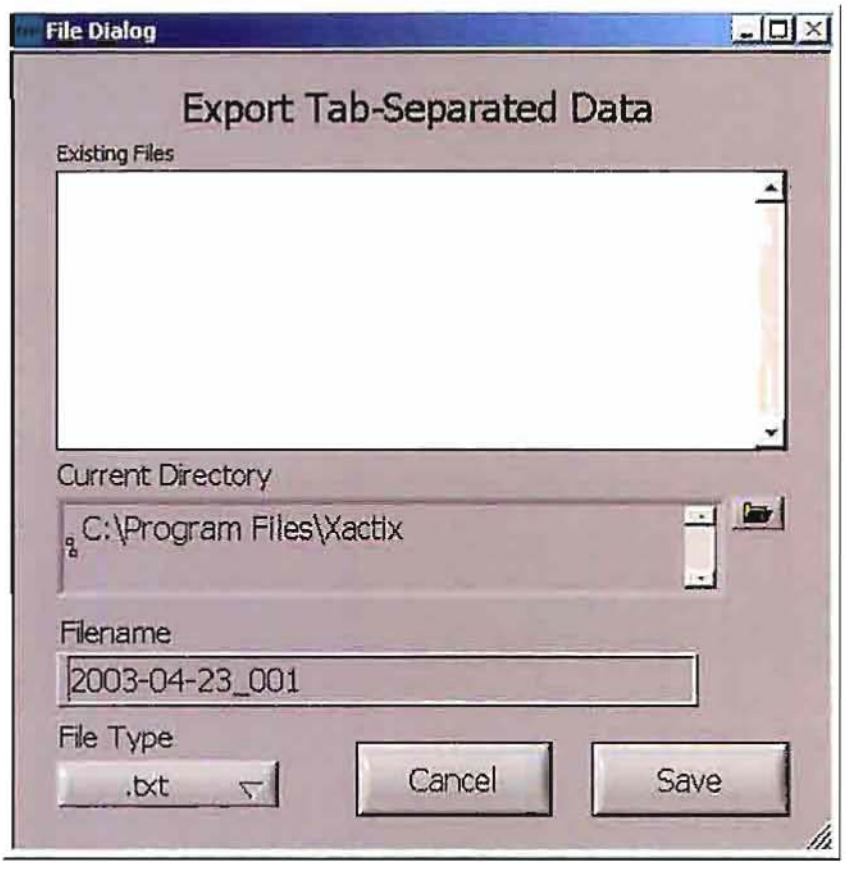
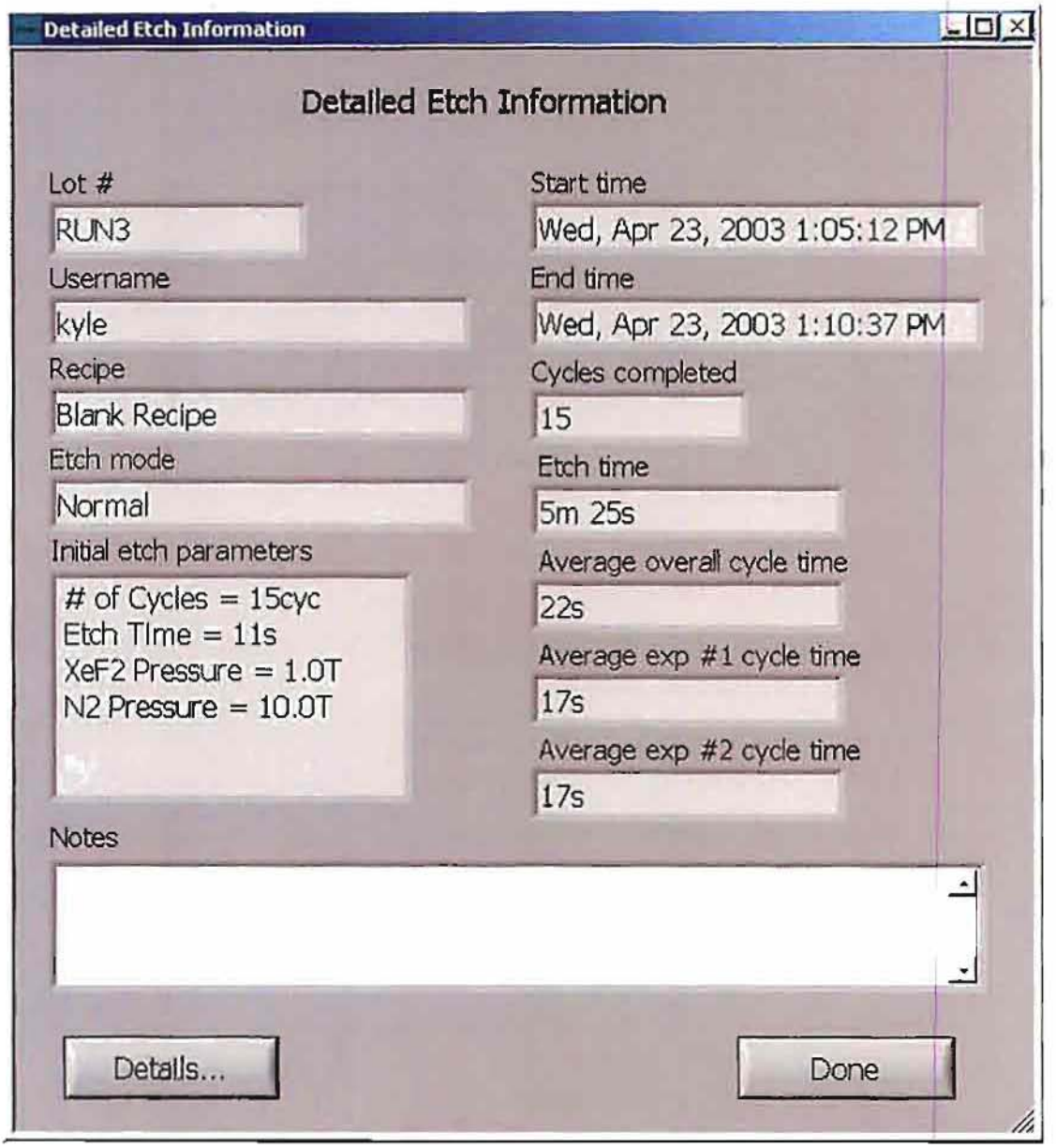


Figure 19. Database Information screen.

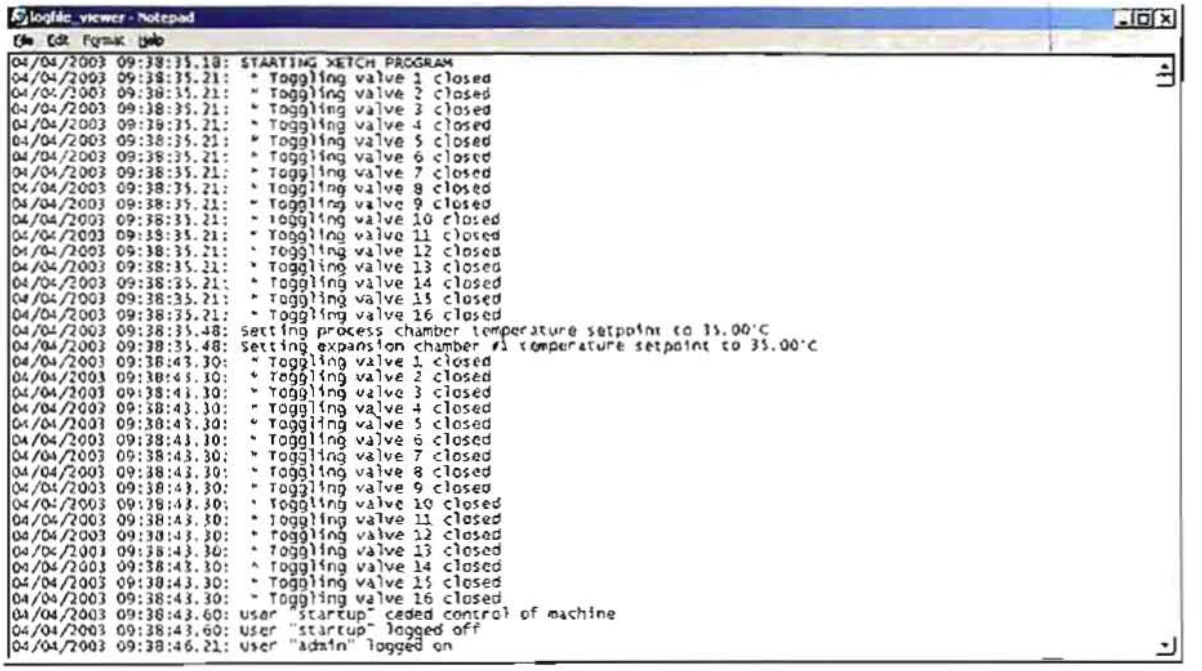
The export data button allows you to export all of the information shown in the table to a tab-separated text file that can be opened in the program of your choice, such as Microsoft Excel, Microsoft Access, and Microsoft Word, as shown below. Choosing a destination folder can be done by clicking on 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 19), 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.



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.

Precedence is used in conjunction with the system remote control operation software (available as an option). Lower numbers give the user higher precedence in running the machine remotely.

Four options (privileges) are available for users.

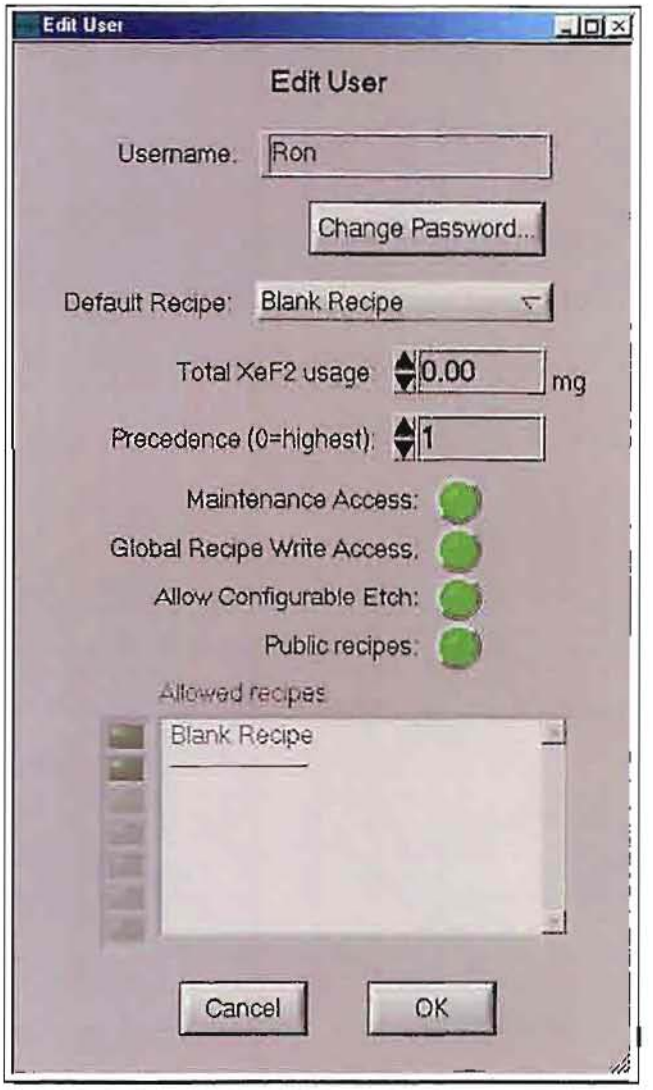
Maintenance Access gives a user permission to access the maintenance menu thus giving them the ability to execute such functions as changing the machine configuration, changing the xenon difluoride bottle, and viewing the full log.

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.

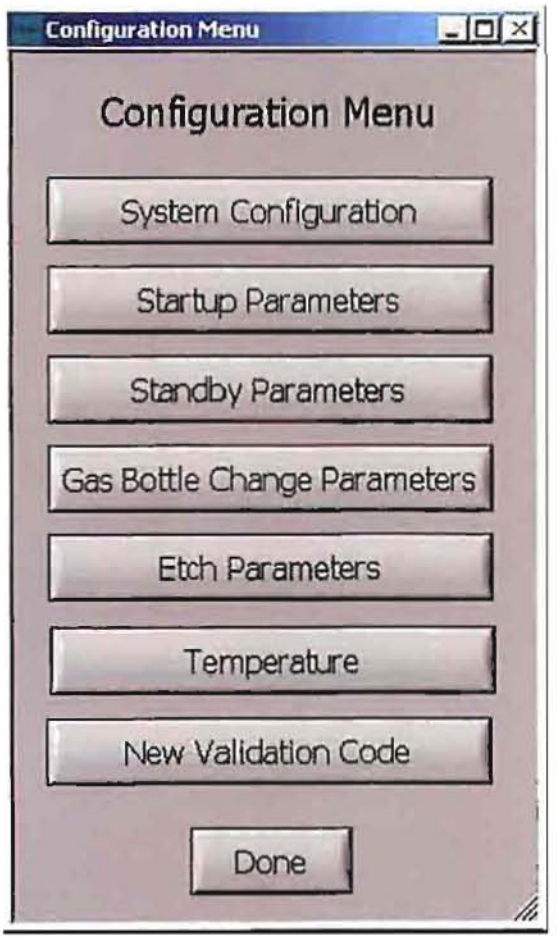
For users with no privileges a default recipe is required. It is recommended that foundry operator accounts be set up with no privileges. A number of allowed recipes can be given to the user and by checking the box next to the recipe name, it can be enabled. For example, a user without the ability to 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

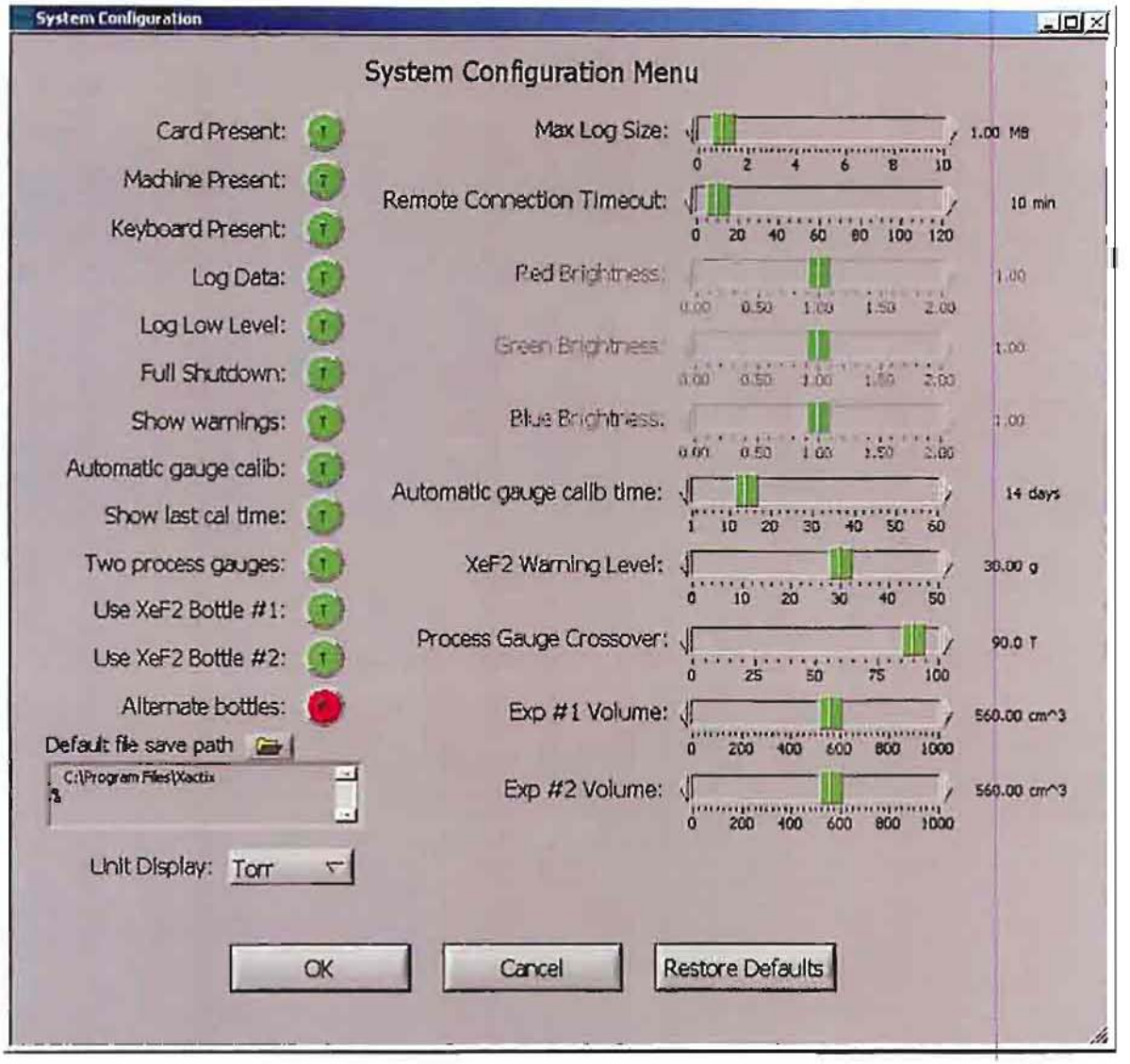
The configuration menu can be edited to change various system operations relating to basic system parameters, startup parameters, standby parameters, maintenance parameters, etch parameters, and validation codes; ***NOTE:*** *The validation code should only be changed by the system administrator.*

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 during the etch (use one bottle for one expansion chamber and the other bottle for the other expansion chamber), or use both bottles simultaneously. Using both bottles simultaneously will have faster cycle times; however, equal usage from each bottle isn't guaranteed since it may favor one bottle more than another. If making certain that the usage from each bottle is equal, then setting Alternate Bottles to true may be advantageous.

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.

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

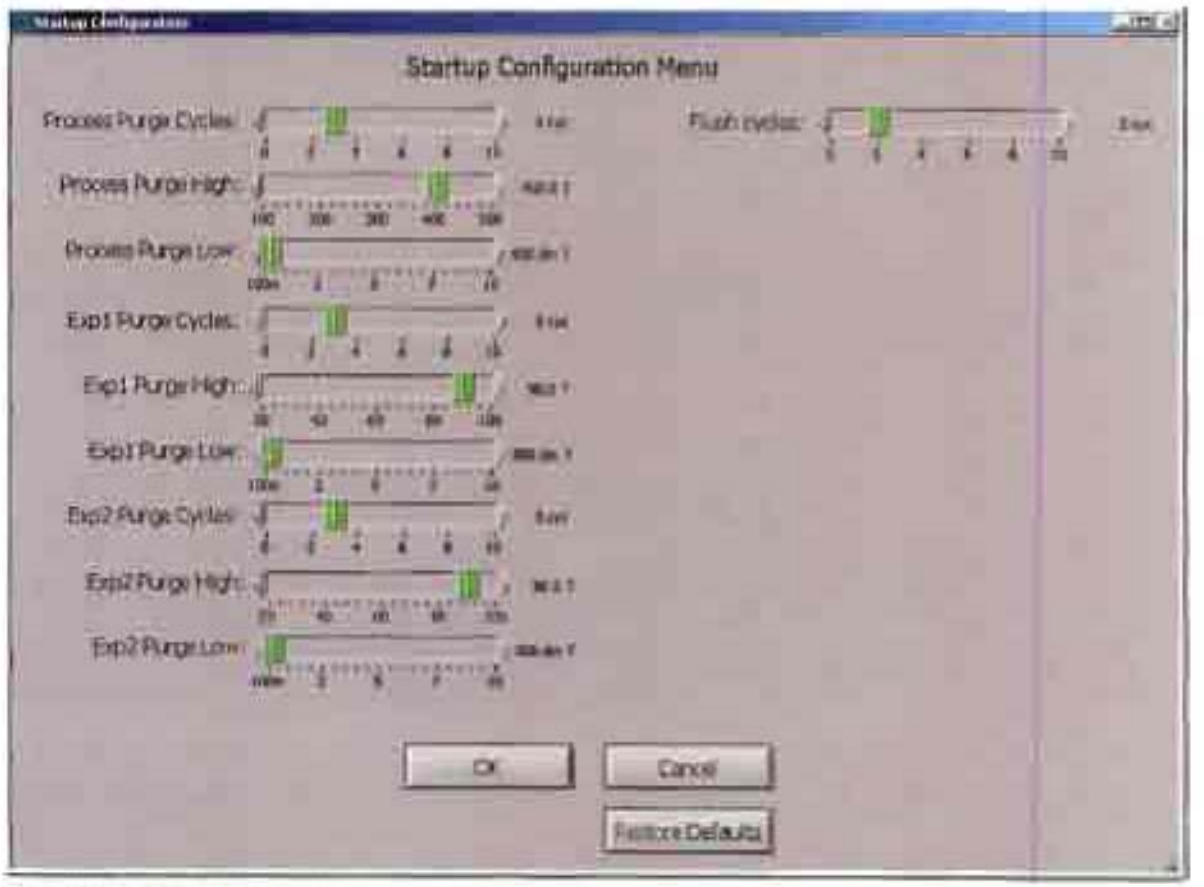
Allows the user to set the nitrogen pressure for expansion chamber #2 purge cycles during the machine startup.

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.



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 is closed and Valve 16 opens when pumping down the main chamber. Valve 13 is a restricted valve that minimizes turbulence in the chamber but does pump the chamber down slower than Valve 16.

Load Purge Cycles

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

Unload Purge Cycles

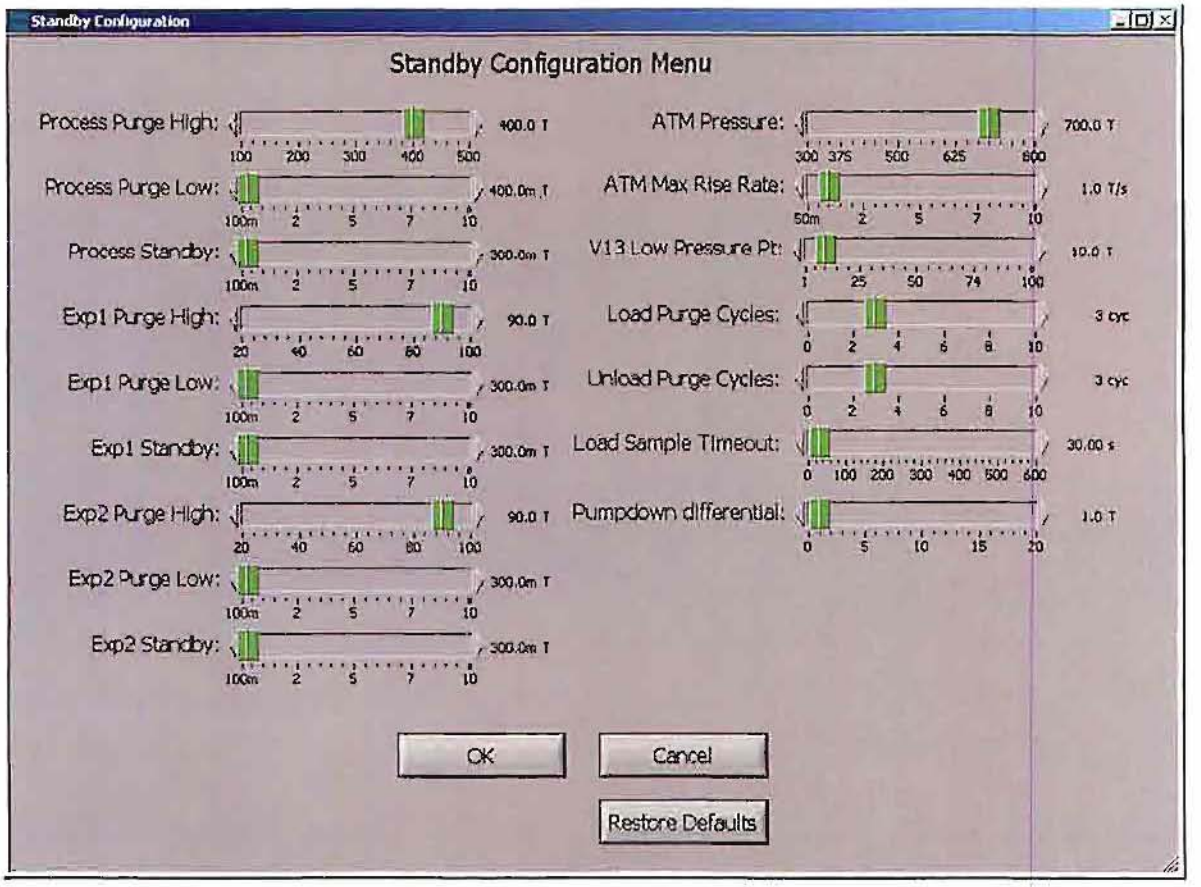
Allows user to set the number of purge cycles for during the unload cycle.

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

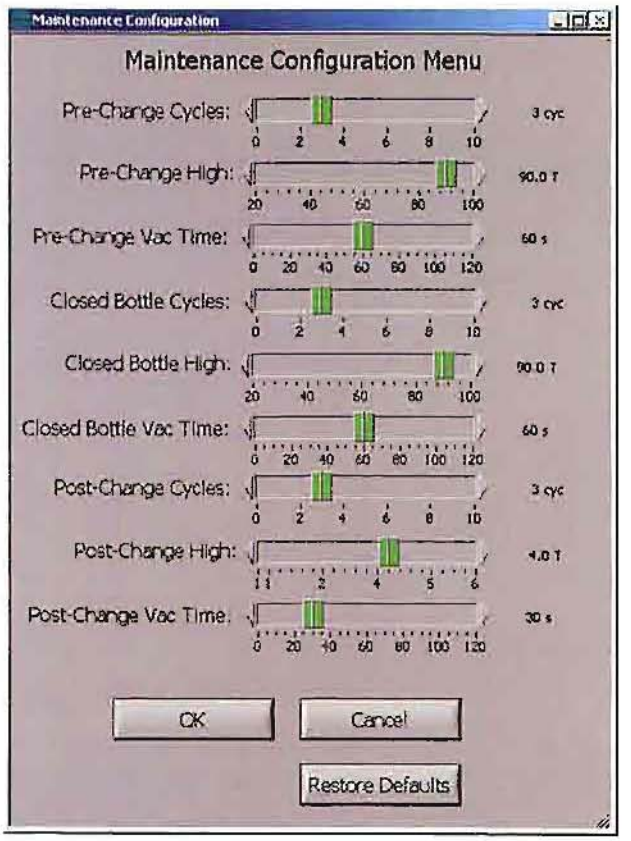
Allows user to set the number of cycles used to ensure that the XeF2 bottle is operating correctly.

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 expansion chamber side nitrogen valve 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.

Wait for pre-etch stability

This feature requires the system to test the expansion chamber fill pressures before exposing the wafers to process gas. The tolerance that the expansion chambers must be filled to is set under the Pre-etch stability threshold below and the number of cycles in a row that must be within the tolerance before starting is under the Pre-etch stability # of cycles. It is recommended that this feature be enabled to ensure maximum run-to-run uniformity. A useful trick is that if you are certain that the pre-cycles are not necessary during a process run, the Stop button can be pressed during the pre-cycle and it will then begin the etch.

Pre-etch stability threshold

This is the tolerance that the Wait for pre-etch stability routine must satisfy before proceeding to etch the wafer.

Pre-etch stability # cycles

If Wait for pre-etch stability is selected, this setting allows the user to set the number of pre-cycles in a row that must be within tolerance before stability is considered to be achieved.

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. This feature only applies to Pressure Estimation Pre-Cycles.

N2 Pressure Estimation # Bins

Allows the user to set the number of pressure overshoot bins for N2 pressure between 0T and 30T. This feature only applies to Pressure Estimation Pre-Cycles.

Max Pressure Estimation Age

Allows the user to predetermine the longest amount of time, between 0 and 120 hours, that Pressure Estimation Pre-Cycles information expires. This feature only applies to Pressure Estimation Pre-Cycles.

Pressure Estimation Pre-Cycles

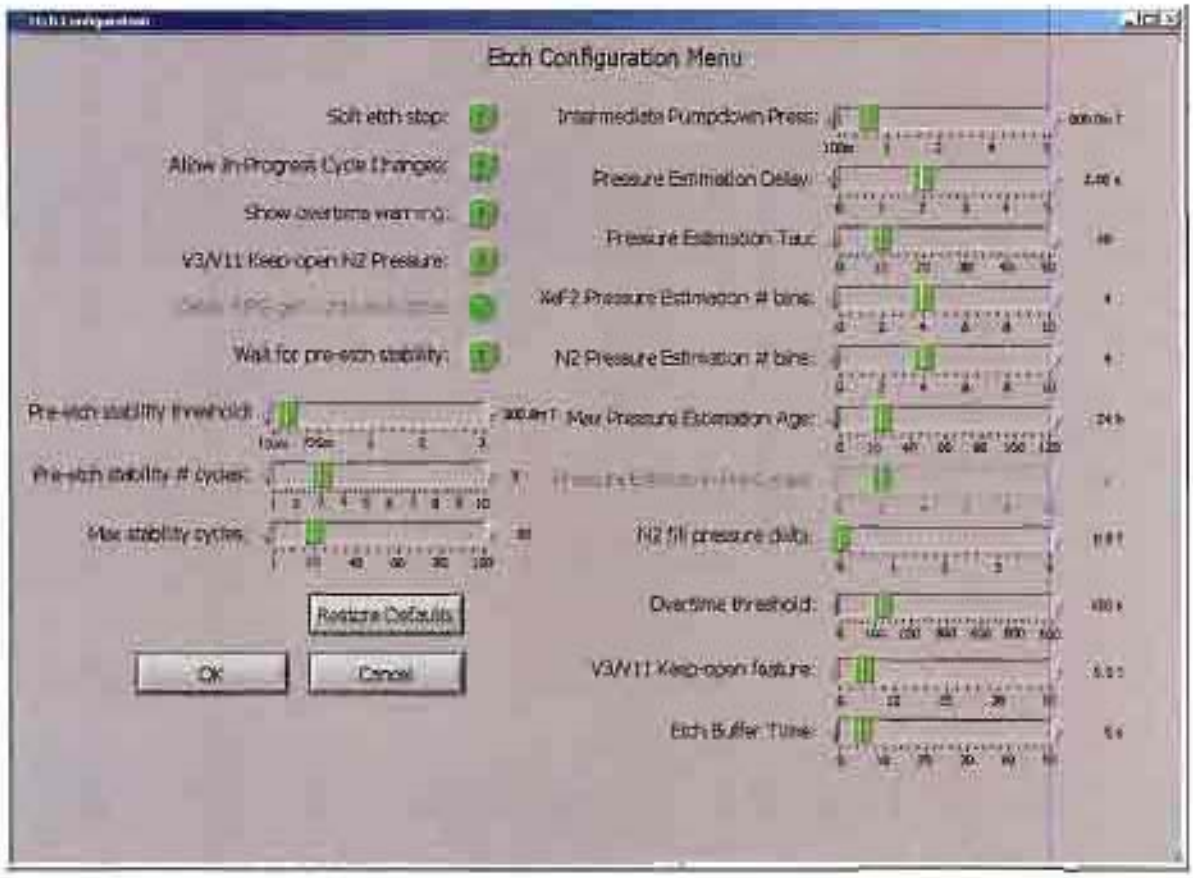
Allows the user to set the number, between 0 and 10, of pre-cycle pressure purging cycles and only applies if Wait for pre-etch stability is not selected. This is the number of pre-cycles that will be run before starting the etch (please note that the XeF2 Pressure Estimation # Bins, N2 Pressure Estimation # Bins, and Pressure Estimation Pre-Cycles are related to this feature).

N2 fill pressure delta

This setting relates to the pressure that the nitrogen inlet valve, V14, to close in advance of reaching the expansion chamber nitrogen fill pressure setpoint to minimize the pressure jump during expansion chamber evacuation.

Etch Buffer Time

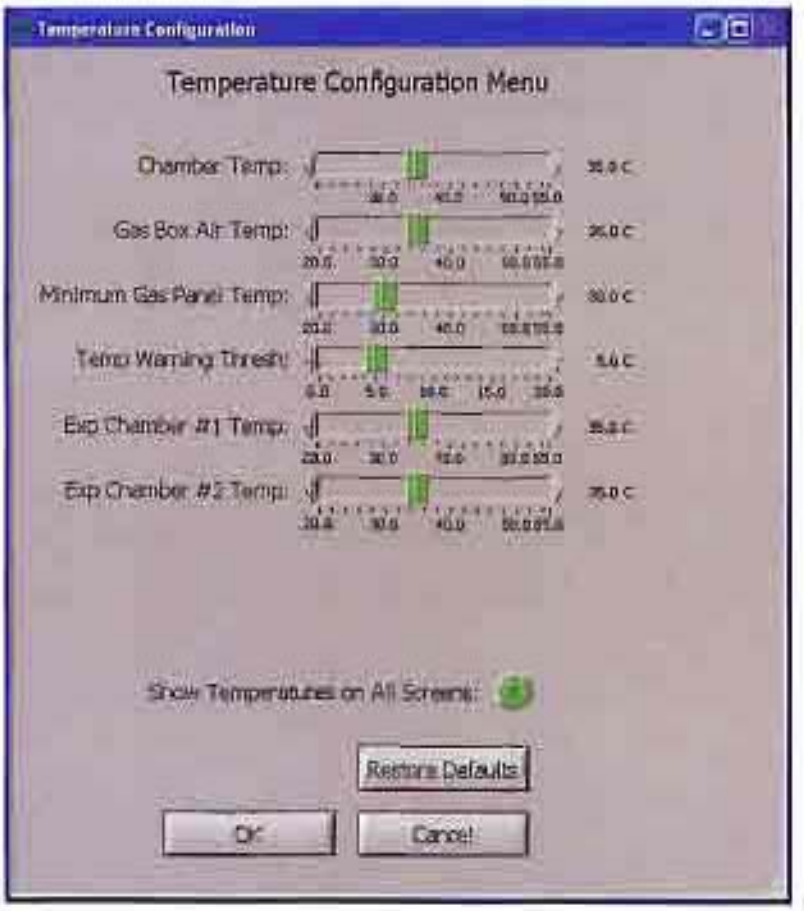
This setting relates to the overlapping pumpout of chambers. Since this is a multiple expansion chamber system, there is the possibility that during the etch, one expansion chamber may be evacuating while the main chamber also needs to be evacuated. This situation could create some variation in the etching performance and is avoided by the software making sure that there is time at least as long as the Etch Buffer Time, between chamber evacuations during the etch, before allowing the system to evacuate an expansion chamber during an etching cycle.



Temperature Configuration Menu

The temperature of the system can be set through the Temperature Configuration Menu. Most of the settings are self-explanatory but a few settings require some additional explanation. Specifically, the Minimum Gas Panel Temperature is the minimum temperature that the gas panel must be above so that the system does not display a warning. The purpose for this is to prevent the user from running XeF_2 in a cold system which could possibly condense in the gas panel.

The temperature warning threshold is the tolerance that all setpoint temperatures must be within before the system displays a warning.

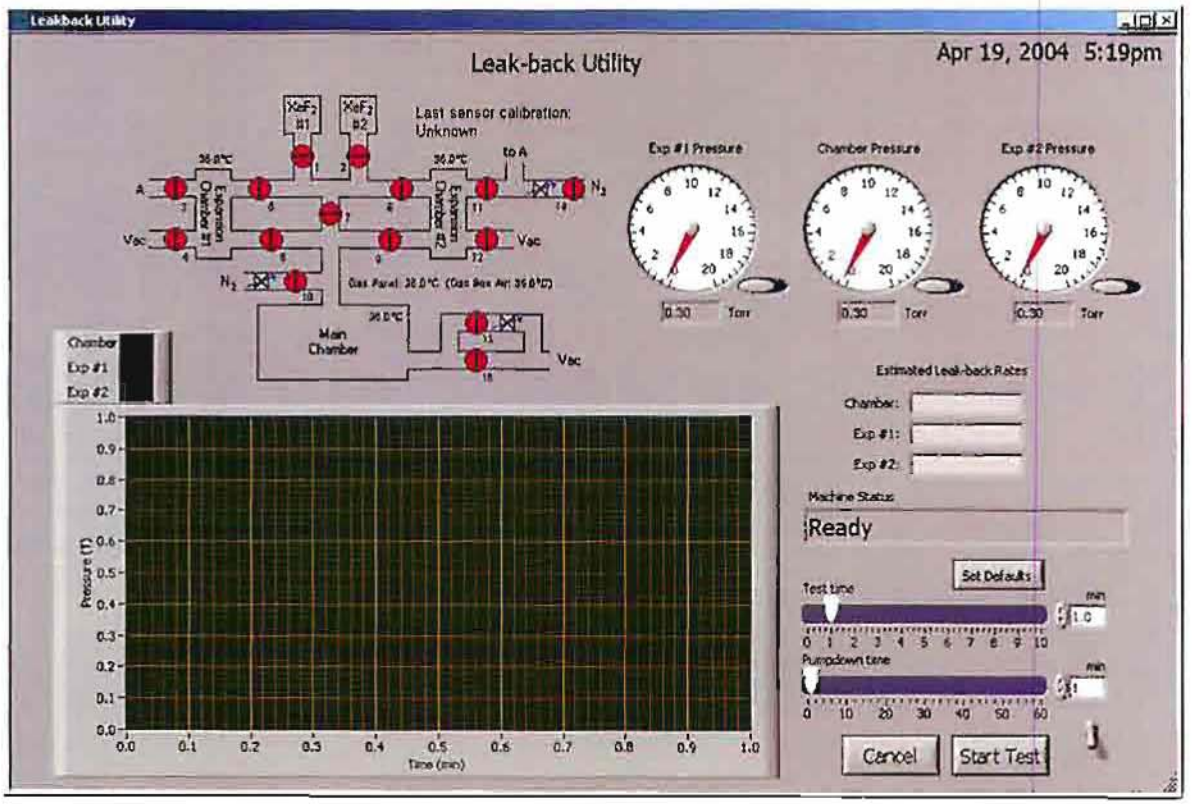


New Validation Code

Additional features and options may be purchased from XACTIX to add additional software functionality. These features are enabled via the entry of different validation codes

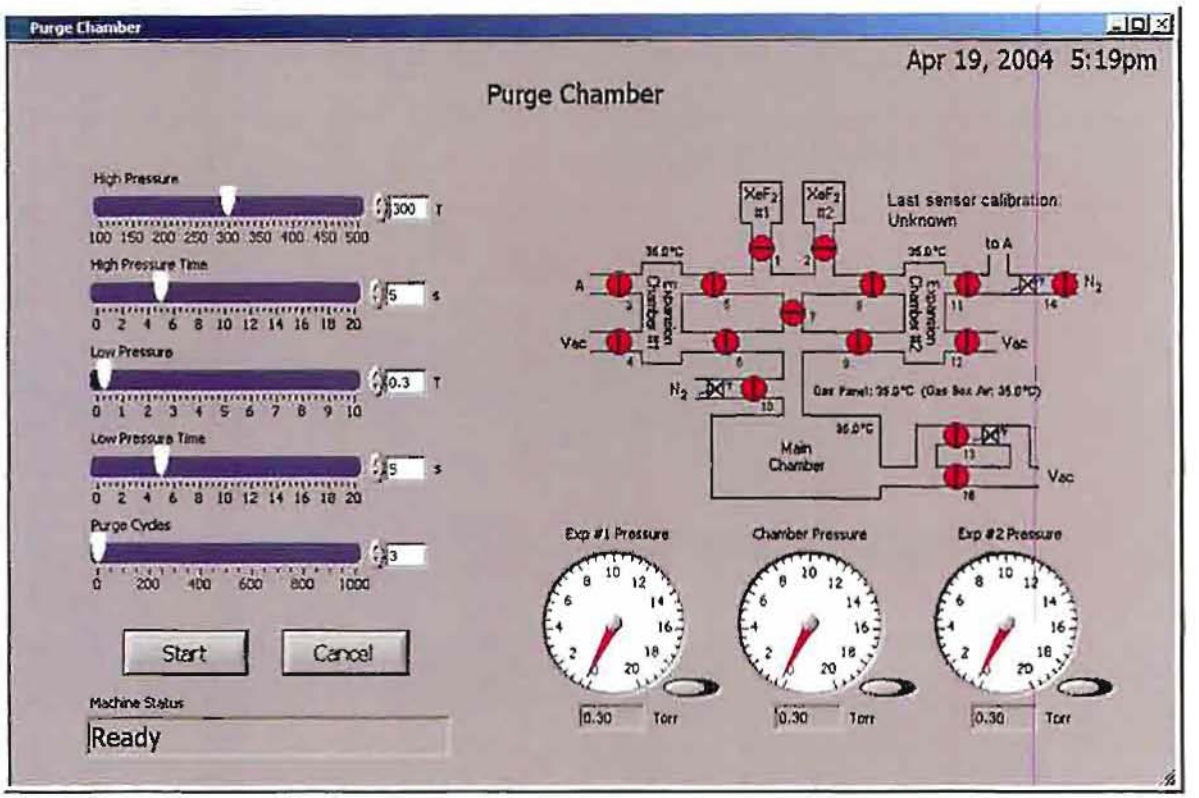
Leak-Back Utility

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.



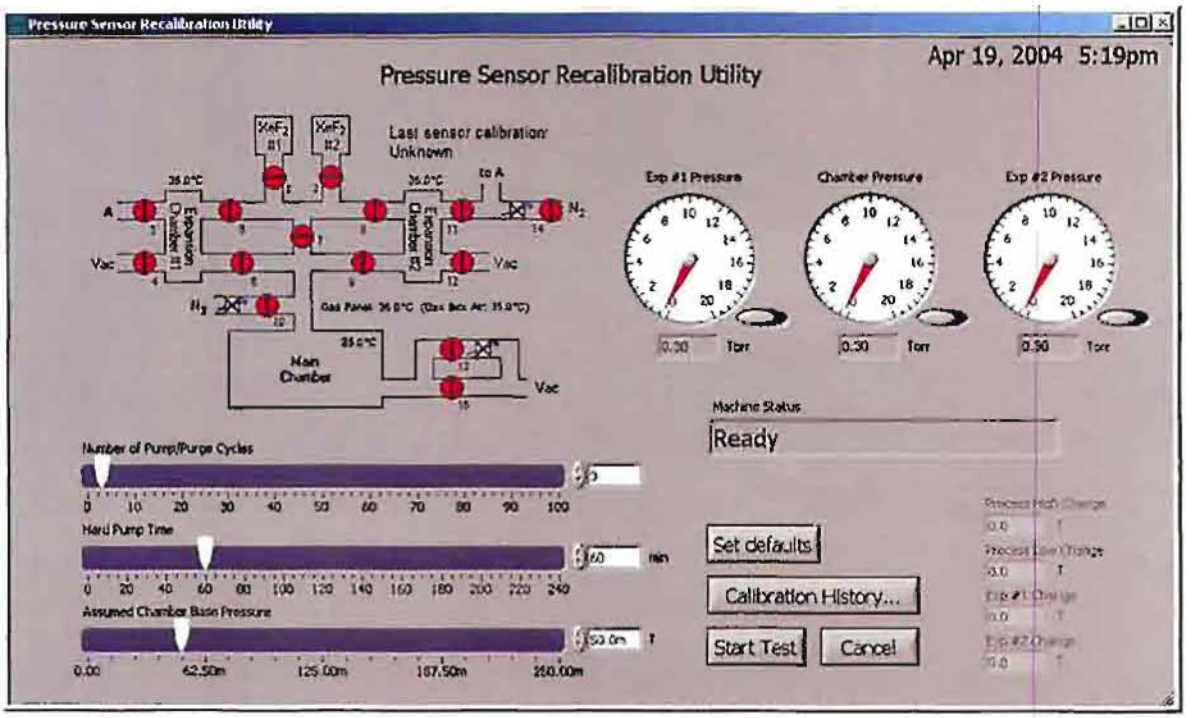
Main Chamber Purge

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.



Video Capture Option

Overview

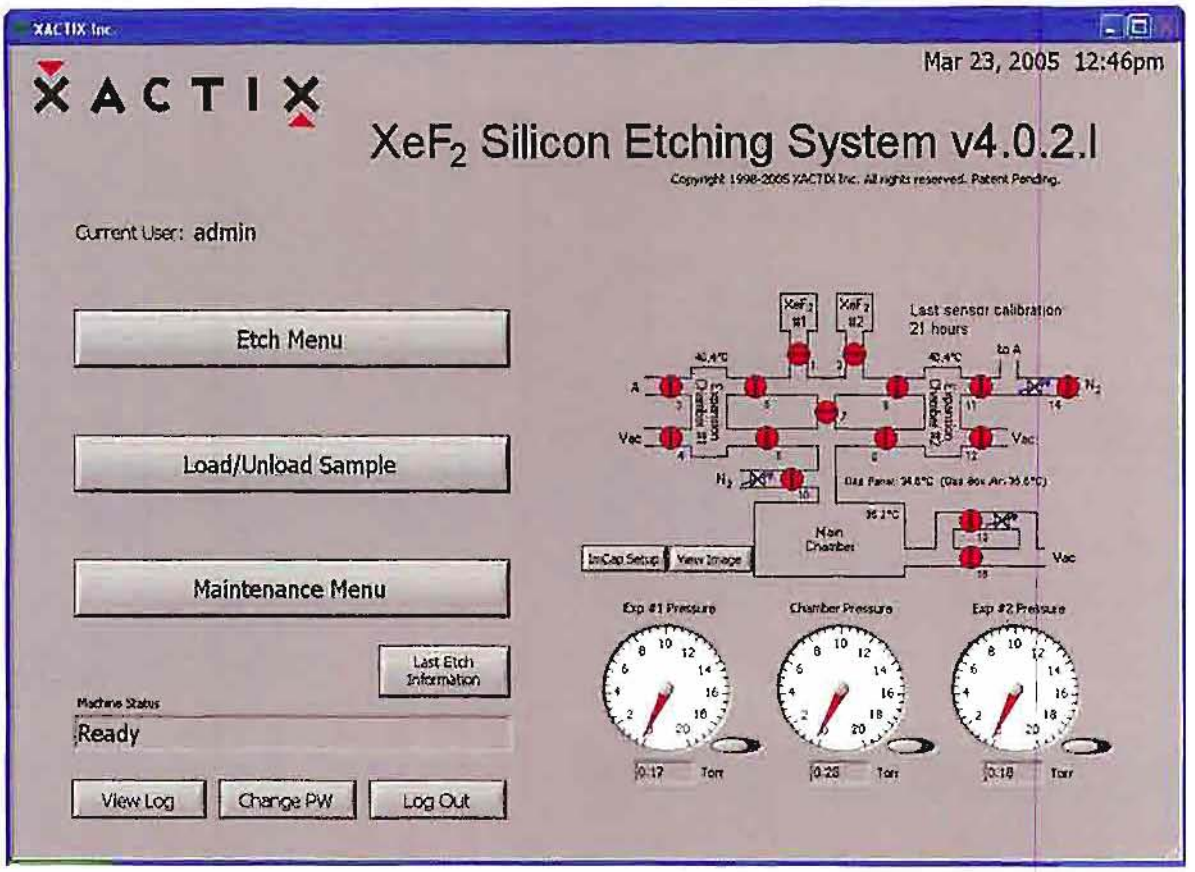
The optional video capture integrates image capturing through a camera attached to the microscope with the Xetch software. Specific features include:

- Snap images at a user settable number of etch cycles
- Snap images at user adjustable time interval
- Images can be saved as either JPG (compressed) or BMP (raw) formats
- Images captured during an etch process are stored in a folder unique to that specific etch run

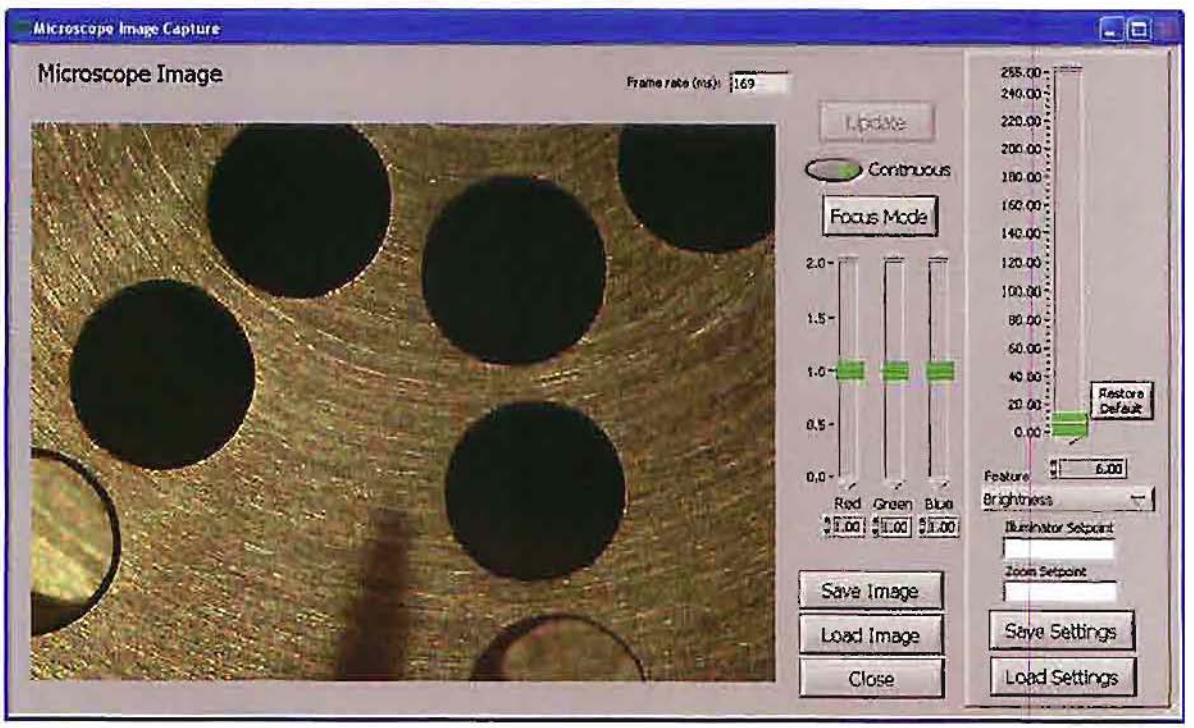
Capturing Images

To capture images through the microscope, the slider near the rear of microscope, must be in the video setting. This causes the image seen through the right eyepiece of the microscope to be routed to the camera. The left eyepiece of the microscope will continue to operate normally.

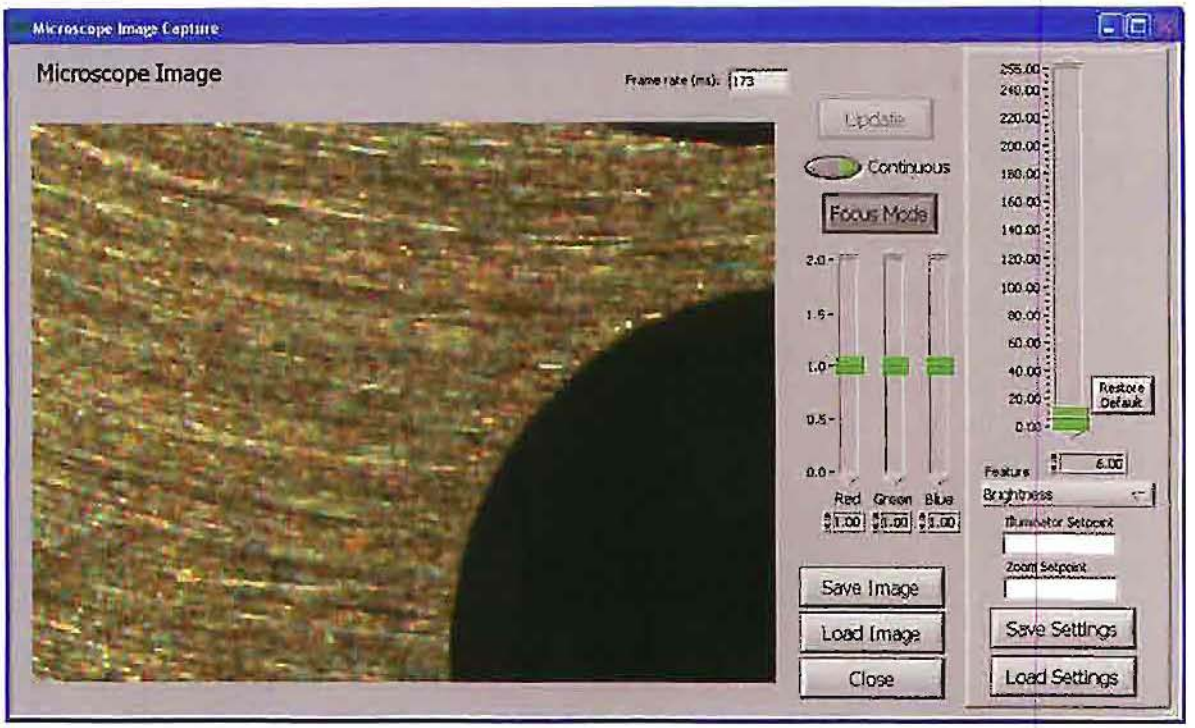
The image capture feature is accessed through either the Main Menu or the Etch Menu via the View Image button shown below:



Pressing the View Image button brings up the following menu:



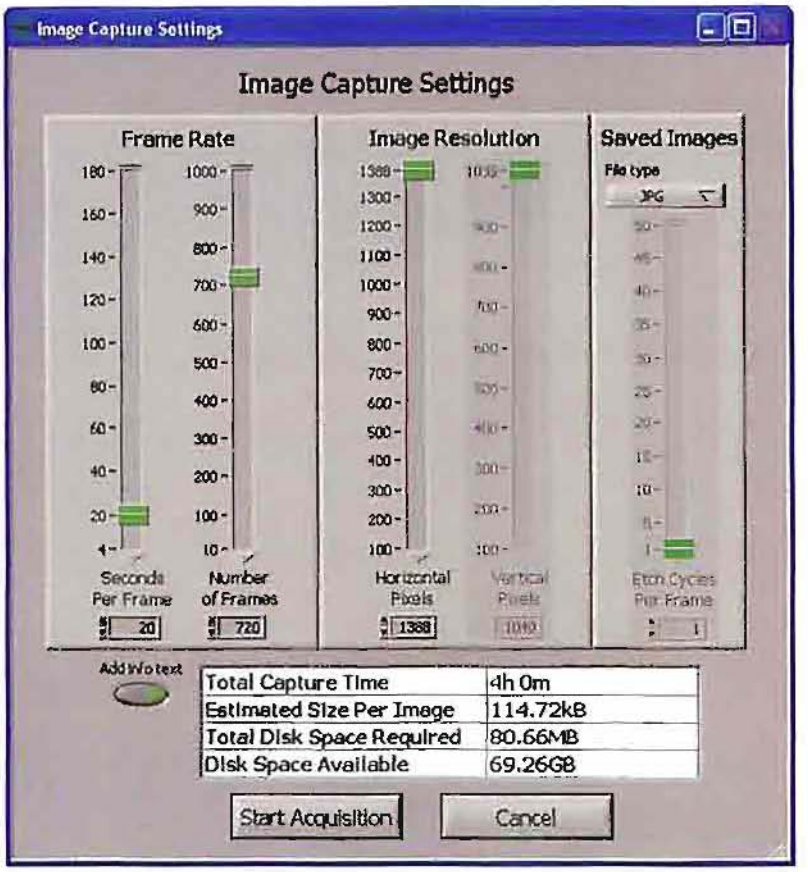
Pressing the Focus Mode button zoom in the center of the image so that the microscope can be accurately focused.



Other features of the above menus is that the images can be continuously updated, as shown, or if the feature is disabled, the image can be updated through the Update button. Colors can be adjusted through the Red, Green, and Blue sliders. Images can also be saved or loaded through this menu. Colors can be adjusted through the Red, Green, and Blue sliders.

On the right hand side, specific features of the camera can be accessed using the pull-down menu and the sliders. Also note that the image settings can be stored and since the illuminator setting (the setting on the illuminator remote control) and the zoom setting of the microscope affect the image, these parameters can be stored for later use. This is useful when trying to capture images with a consistent appearance.

Images can be captured at a certain interval by going through the ImCap Setup menu on the Main Menu:

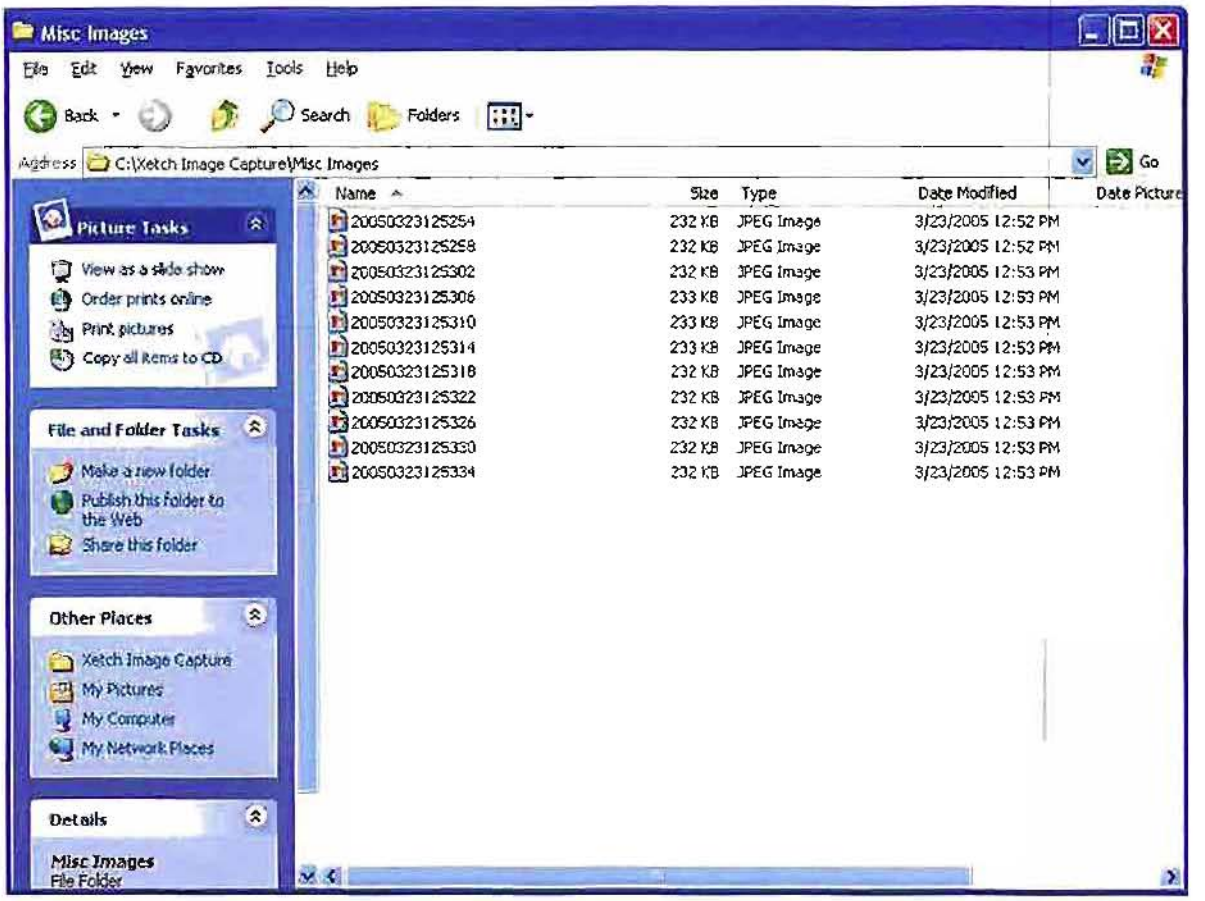


The Seconds Per Frame setting sets the frequency that images are taken after pressing the Start Acquisition button. Number of Frames is the maximum number of images that will be taken. Add info text includes some information about the system's status on the captured image.

The resolution of the stored image is set by the Image Resolution setting. The type of image stored can be either JPG, which is a compressed image, or BMP, which is the raw image (no compression). Note that since the setup of the imaging is being done outside of the Etch Menu, that the Etch Cycles Per Frame slider is not active.

Estimates for the time of image capturing and image size relative to available disk space are also listed.

Images captured in this mode are stored in the Misc Images directory below:



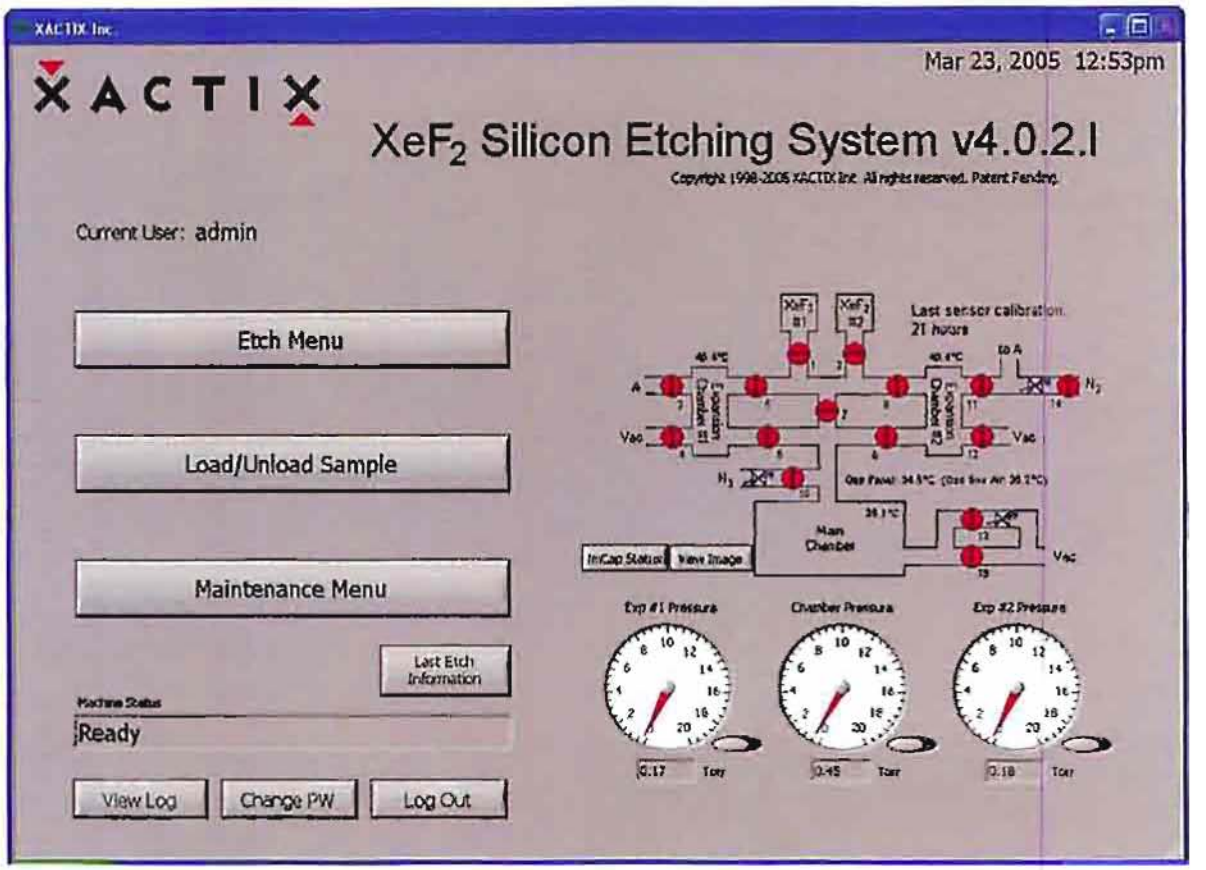
and are sorted by the format:

YYYYMMDDHHMMSS

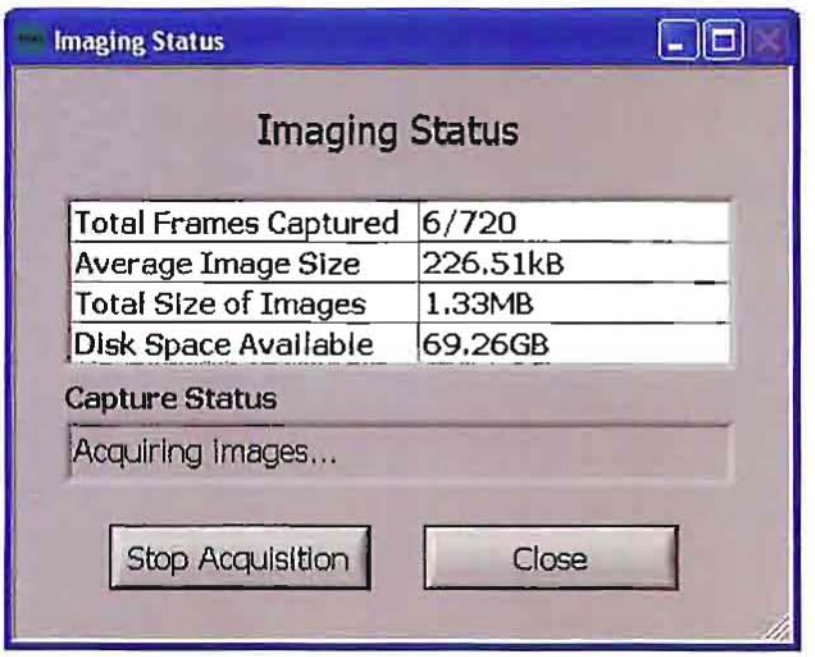
Where YYYY is the year, MM is the month, DD is the date, HH is the hour in 24 hr format, MM is the minute, and SS is the second of the image capture.

Note: it is because of this naming procedure that maintaining accurate time and date for the system is critical.

The status of the image capture can be obtained by pressing the ImCap Status button, which appears when images are being captured.

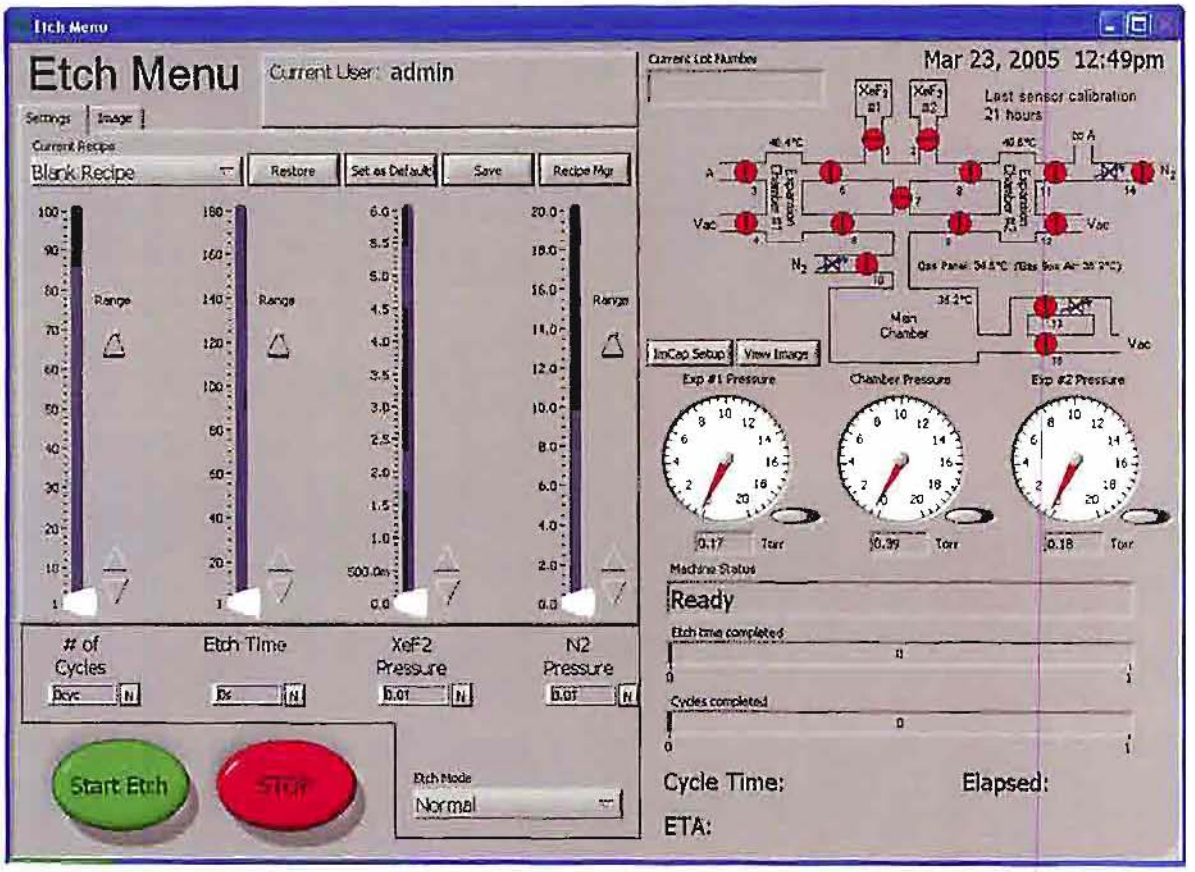


The window that appears when pressing this button is:

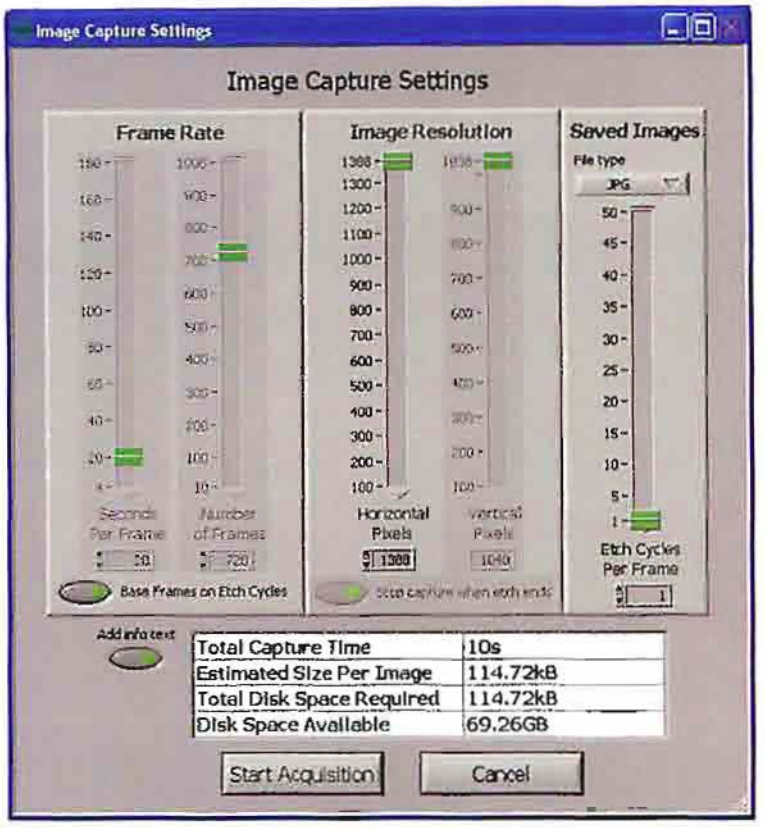


which summarizes the status of the image capturing and also allows the ability to stop the image capture by pressing Stop Acquisition.

Images can also be captured through the Etch Menu:

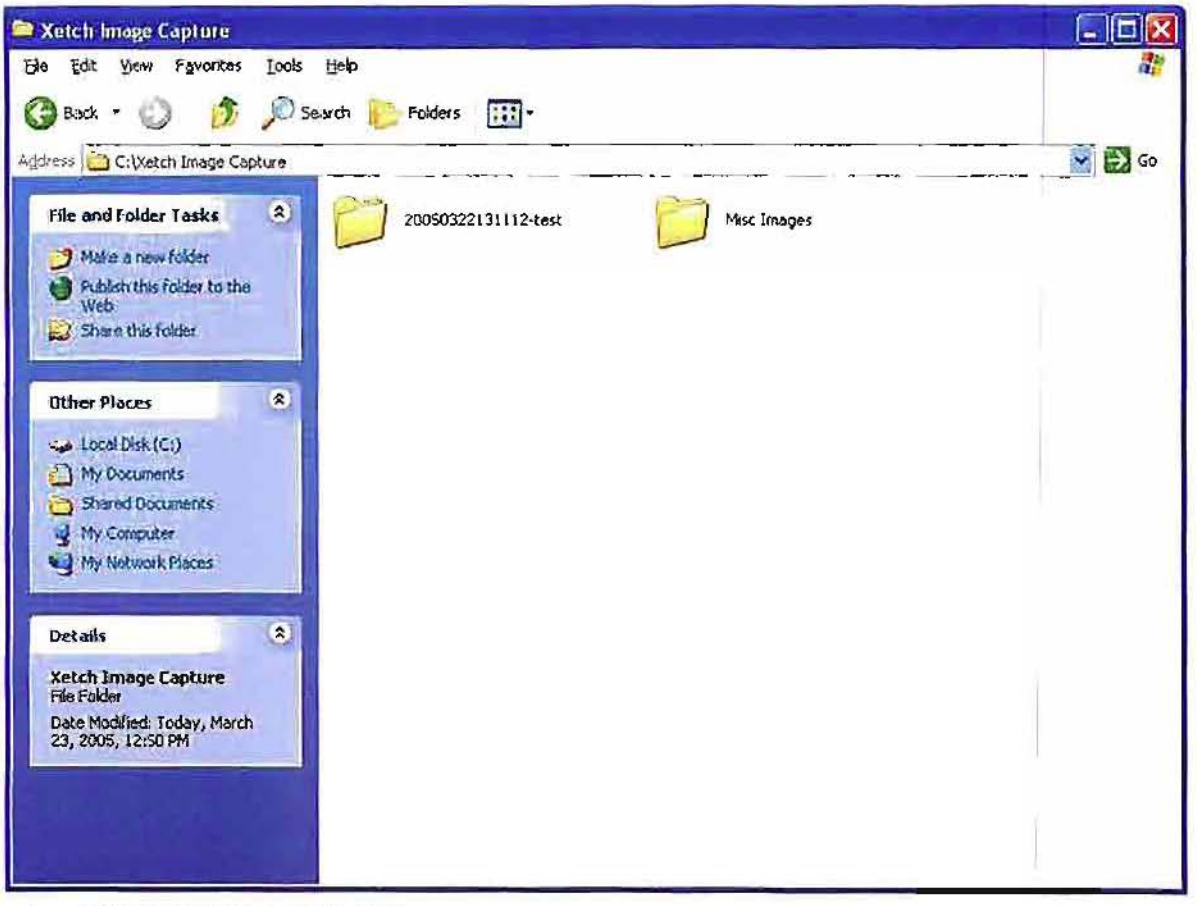


through a similar procedure to that from the Main Menu. The critical difference is that the ImCap Setup screen enables the Etch Cycles per Frame slider as shown below. This feature snaps an image at a specified number of cycles.



Pressing Start Acquisition will enable images to be captured during the etch.

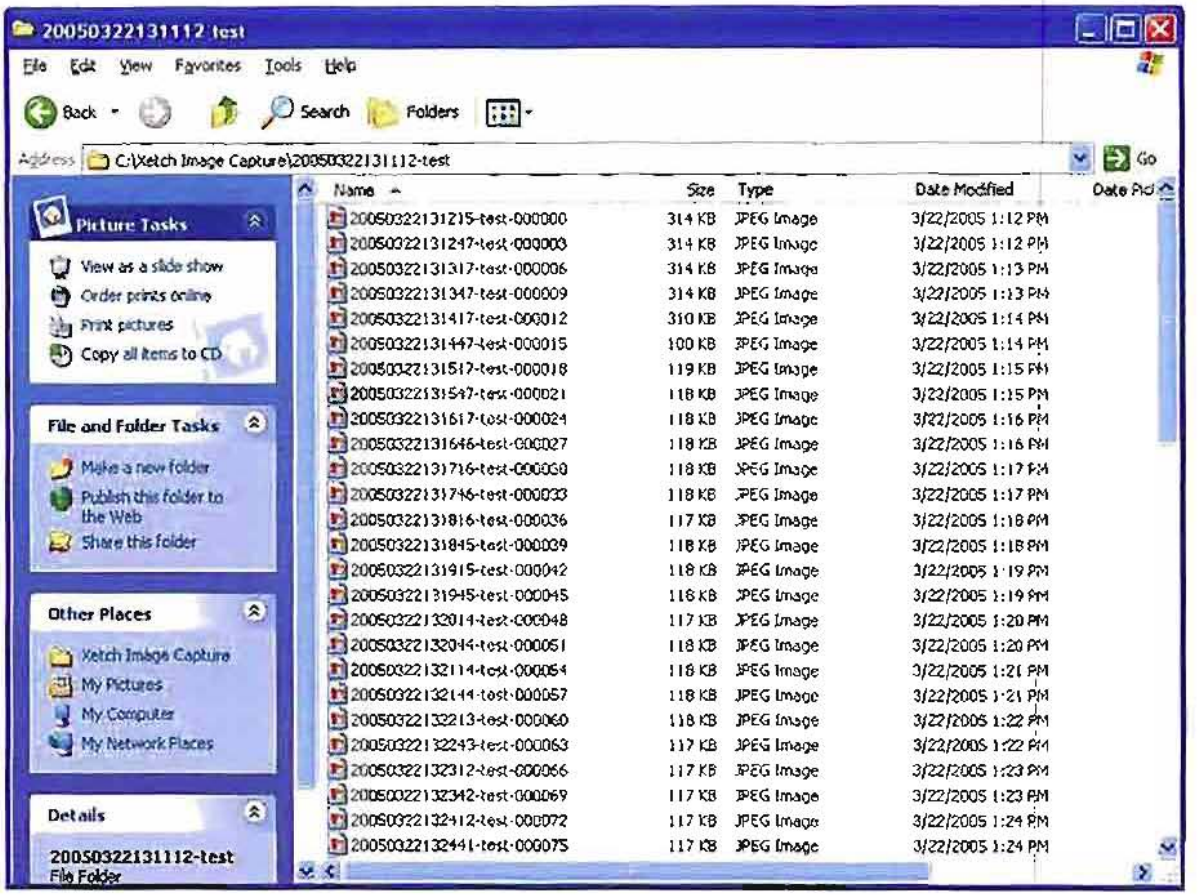
The images are stored in directories such as:



where YYYYMMDDHHMMSS-LOT

Where YYYY is the year, MM is the month, DD is the date, HH is the hour in 24 hr format, MM is the minute, SS is the second of the start of the etch, and LOT is the lot name.

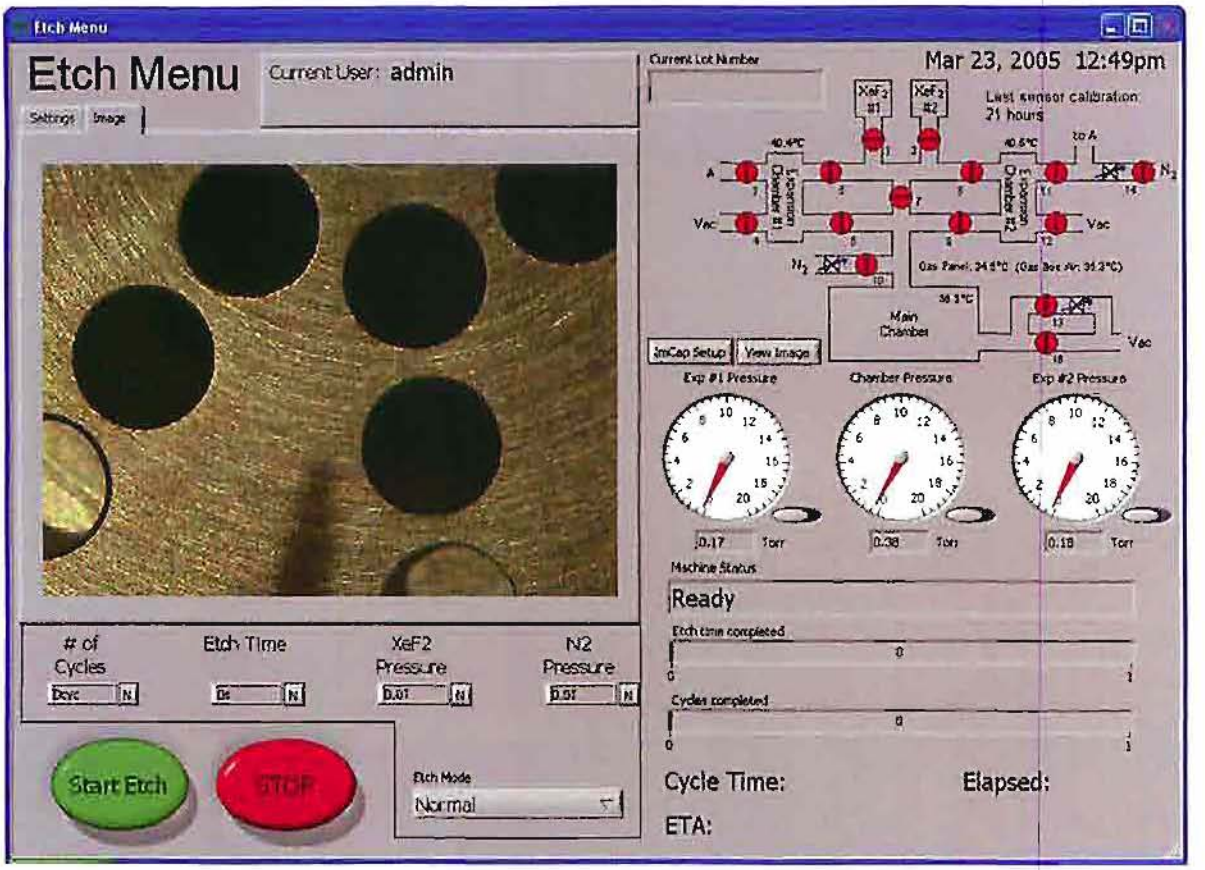
Inside of the directory, the images are stored in the following format:



where YYYYMMDDHHMMSS-LOT-XXXXXX

Where YYYY is the year, MM is the month, DD is the date, HH is the hour in 24 hr format, MM is the minute, SS is the second of the start of the etch, LOT is the lot name, and XXXXXX is the cycle number.

As a side note, the image can be viewed on the Etch Menu by pressing the Image tab.



Another note about viewing and capturing images during etching is that special provisions are made in the software to avoid capturing an image when a critical etch operation is occuring. This is necessary since image capturing is very processor intensive. In addition, critical etch operations are put on hold until an image capture is complete. This avoids deteriorating etch performance; however, you may experience some delays on the image refresh. Generally, when the software is preventing an image refresh when looking at the View Image window, a Wait note is displayed.

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

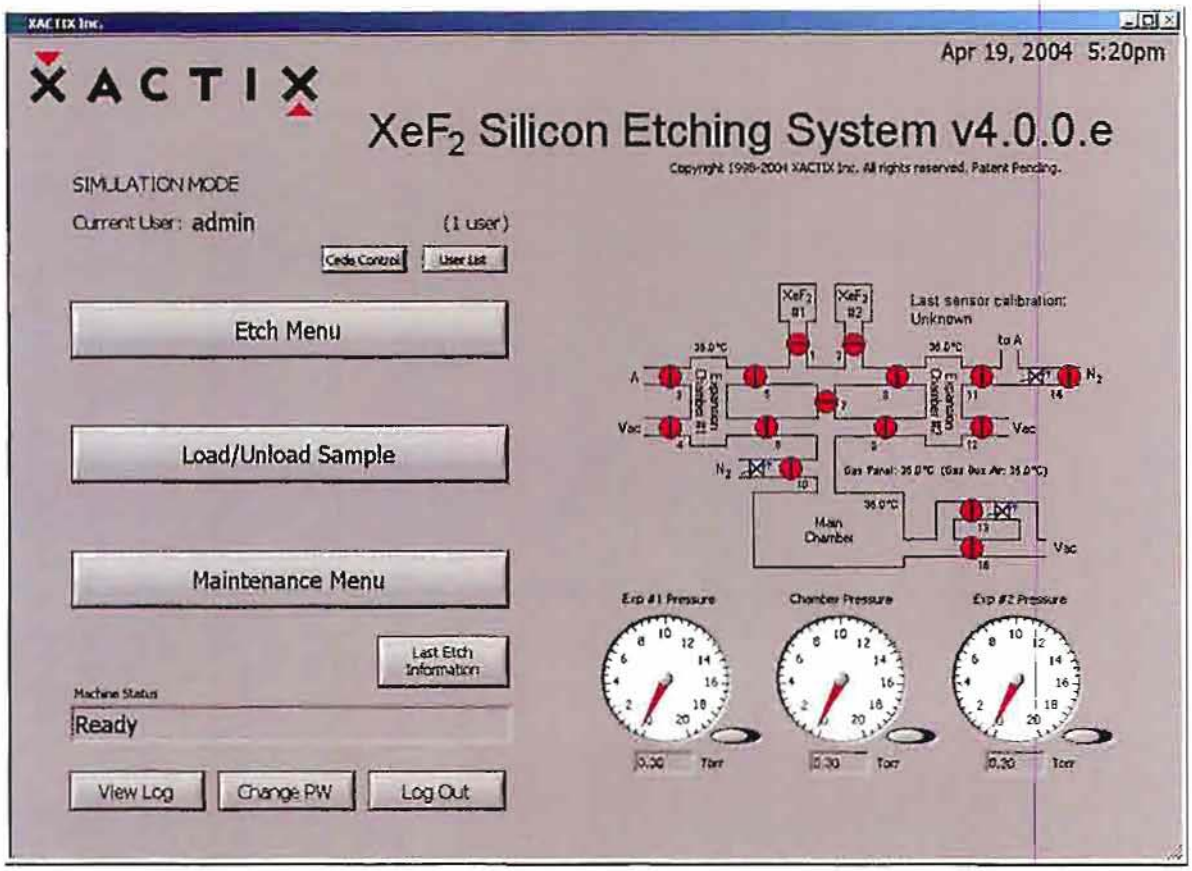
- Swagelok Gaskets (www.swagelok.com)
  NI-4-VCR-2-VS or NI-4-VCR-2-GR-VS
- 5/8" and 3/4" Standard Wrenches
- Latex Gloves

Time allocation

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

Changing XeF_2 Bottles

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



To change the gas bottles click on the top right button, *Change XeF_2 bottle*, shown in Figure 21.

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 20).

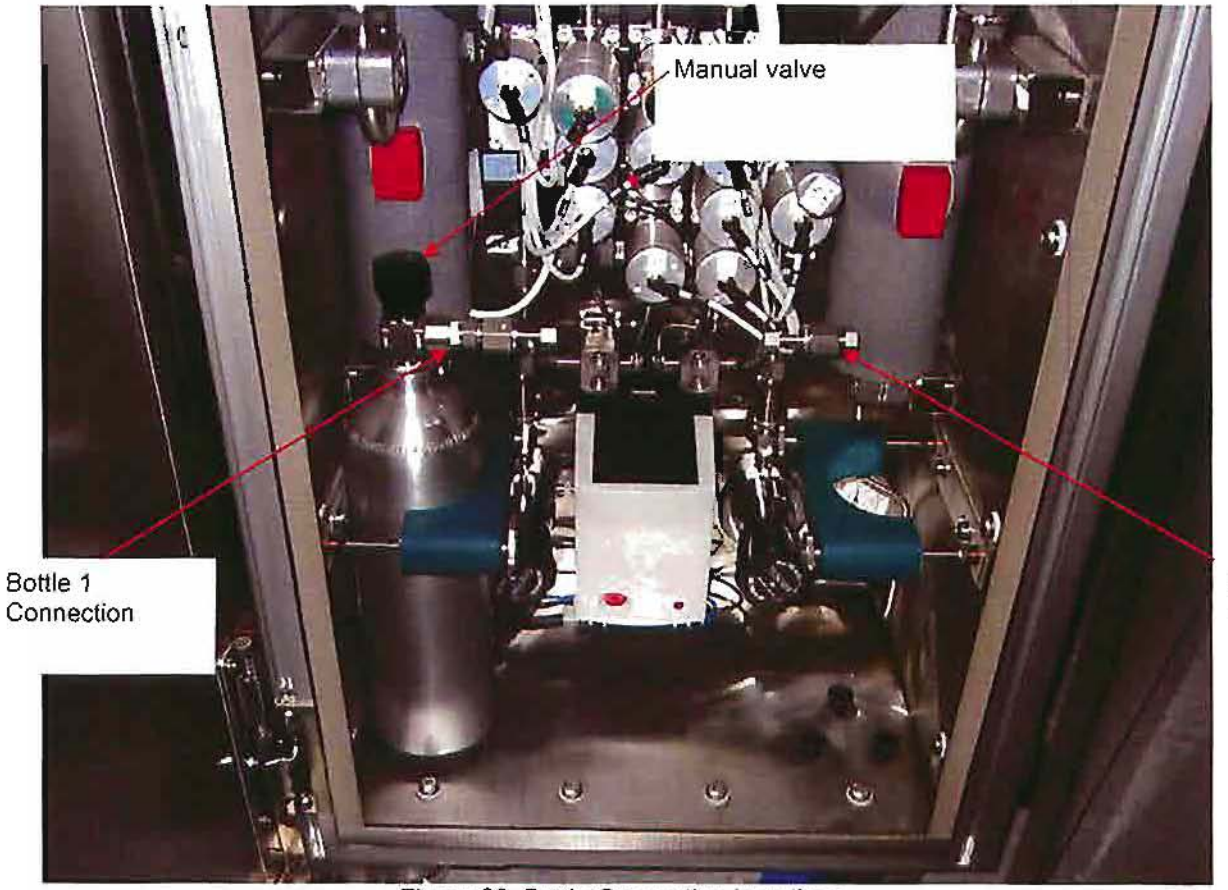


Figure 20. Bottle Connection Locations.

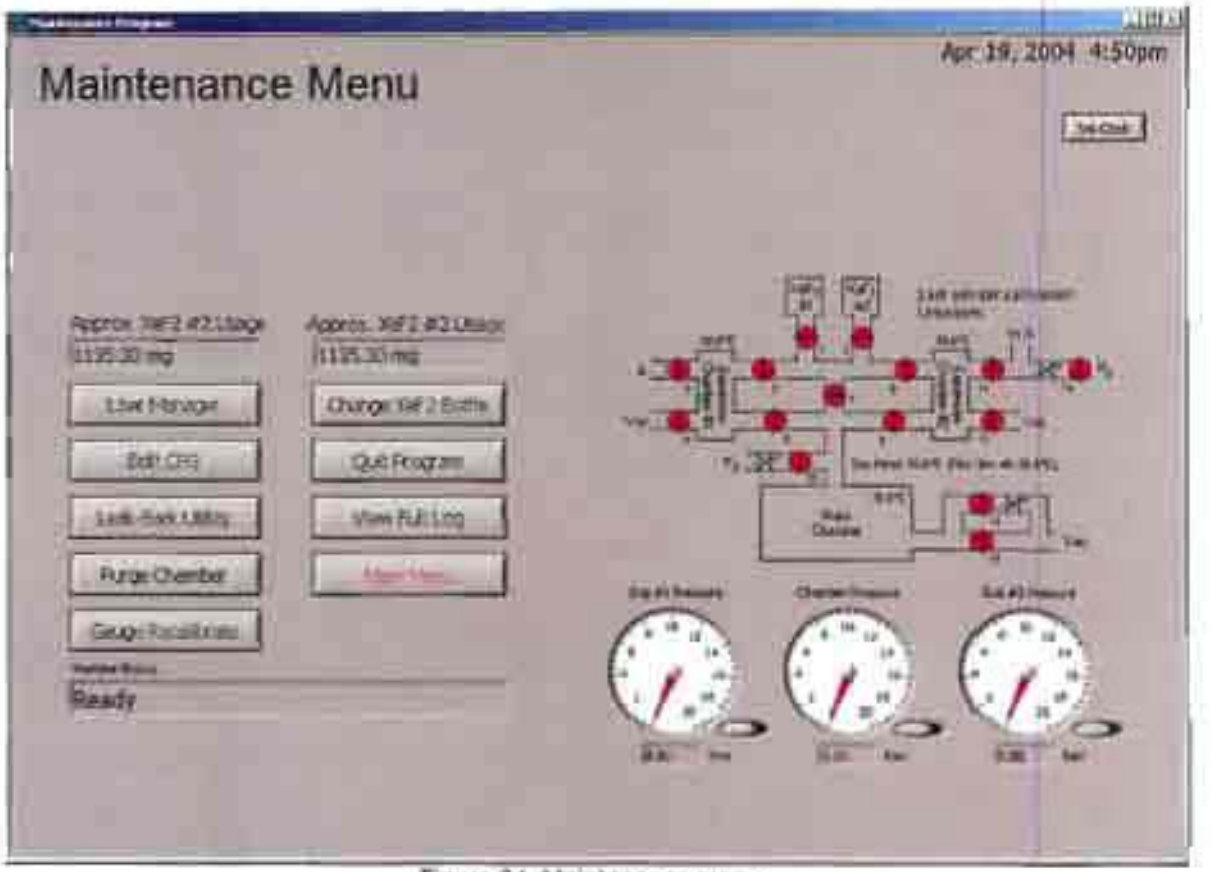
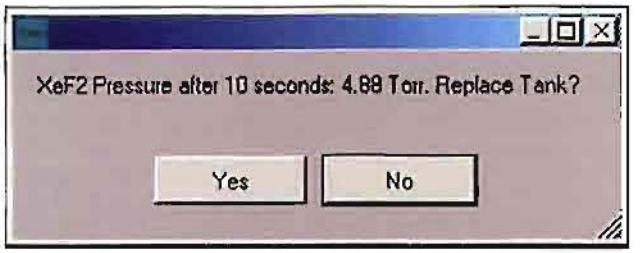


Figure 21 Maintenance menu.

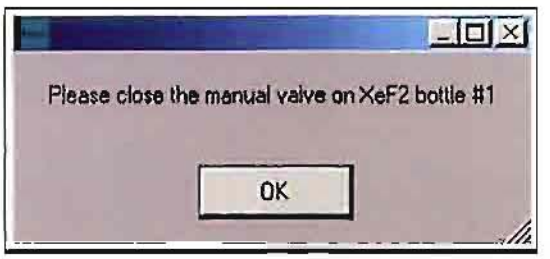
The Xetch will automatically test the pressure of the bottle you've chosen to change, #1 for example. This provides a test method to qualify XeF_2 pressure at any point in time as shown on next page.

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.



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.



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.

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.

The bottle is removed by loosening the two thumb screws, removing the half clamp, and lifting the bottle upwards (see below). Be carefully not to scratch the VCR glands on either the bottle or the system. Replace the bottle by following this procedure in reverse.

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 22). 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 22). Mark the male and female nuts position with a line across each to establish 1/8 turn (see C. in Figure 22). 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 22). 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.

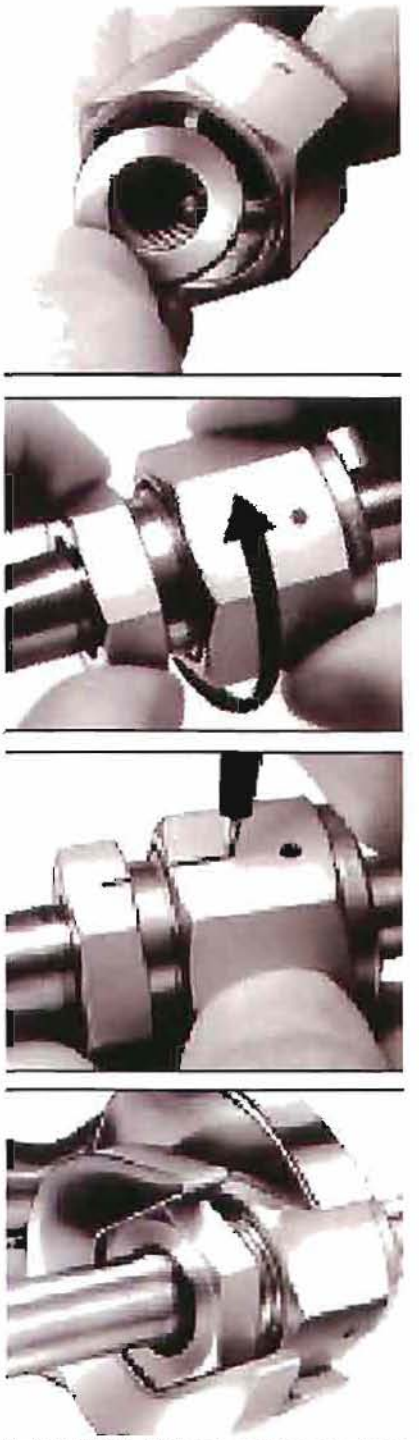
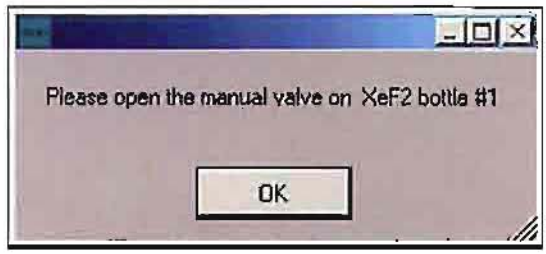


Figure 22. VCR Gasket Assembly Procedure (Image from www.swagelok.com).

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.

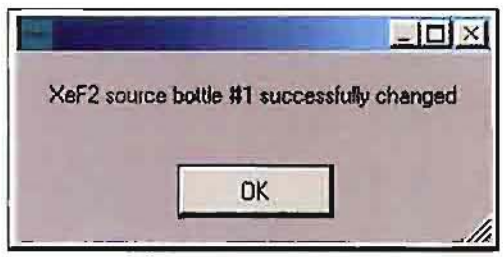
Once again, the Xetch will purge the lines to ensure a clean system before any XeF_2 is present, and leak test fittings to ensure a proper seal. If the seal leaks, a failure prompt will appear. Recommended steps would be to restart the leak-test up to three times by clicking yes, then check that the 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.



Service & Maintenance

WARNING

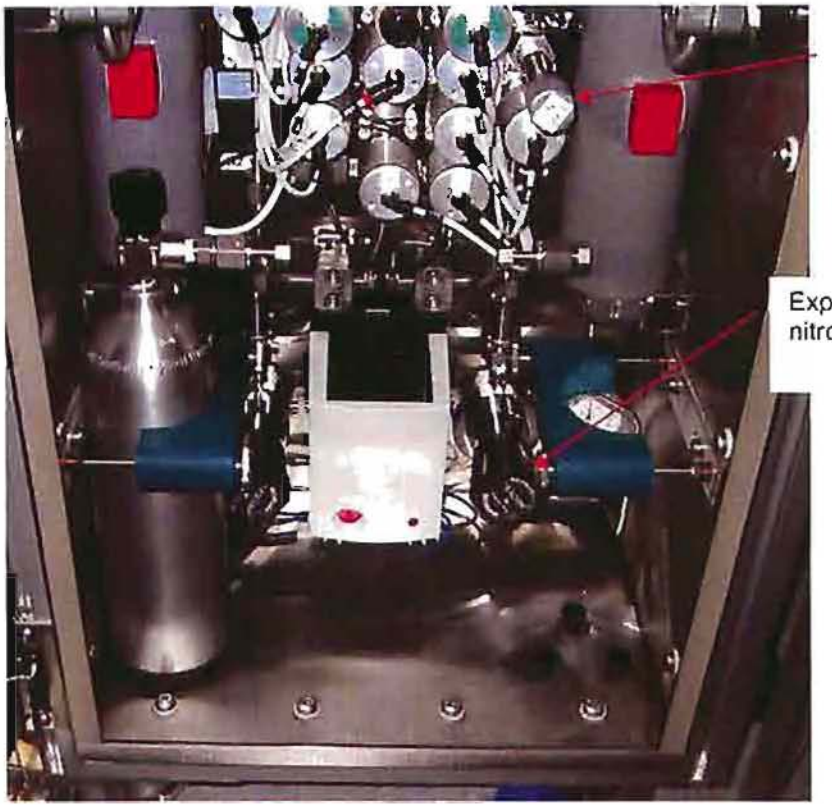
SERVICE AND MAINTENANCE SHOULD ONLY BE PERFORMED TO THOSE INDIVIDUALS WHO UNDERSTAND THE RISKS OF EXPOSURE TO XEF2 AND ARE FULLY TRAINED IN THE MAINTENANCE ACTIVITIES FOR THE SYSTEM.

Adjusting Chamber Venting Rate

The rate that the main chamber vents is controllable through the adjustment of the vent regulator shown below. The setpoint of the regulator should be approximately 10 psi for normal operation but can be increased or decreased to accommodate special applications.

Adjusting Expansion Chamber Nitrogen Fill Rate

The fill rate of the expansion chambers can be adjusted through two methods. The first method is to adjust the expansion chamber N2 needle valve, EXP N2 (see below). It is important that the needle valve is not over tightened which may damage this expensive component. The adjustment of the needle valve should satisfy most applications. An additional method of adjusting the flow rate is to adjust the expansion chamber nitrogen fill regulator (see below). Normally, this should be set to approximately 5 psi, but can be adjusted slightly as necessary



Showerhead hole plugs

For maximum uniformity, the showerhead can be plugged with Teflon plugs. A length of Teflon beading is supplied with the tool and small pieces, approximately 1 cm long should be cut as needed as shown in Figure 23. The cuts should be on a 45 degree angle to aid in the insertion of the plug into the showerhead.

Figure 23. Teflon beading and pieces that have been cut from it using a razor blade.

Insert the plug into the showerhead with pliers as shown in Figure 24. ***Be very careful not to scratch the showerhead.*** The plug should only be inserted far enough to hold the plug in place. The excess of the plug can be trimmed using wire cutters as shown in Figure 24, ***leaving approx. 1-2 mm exposed so that the plug can be easily removed.***

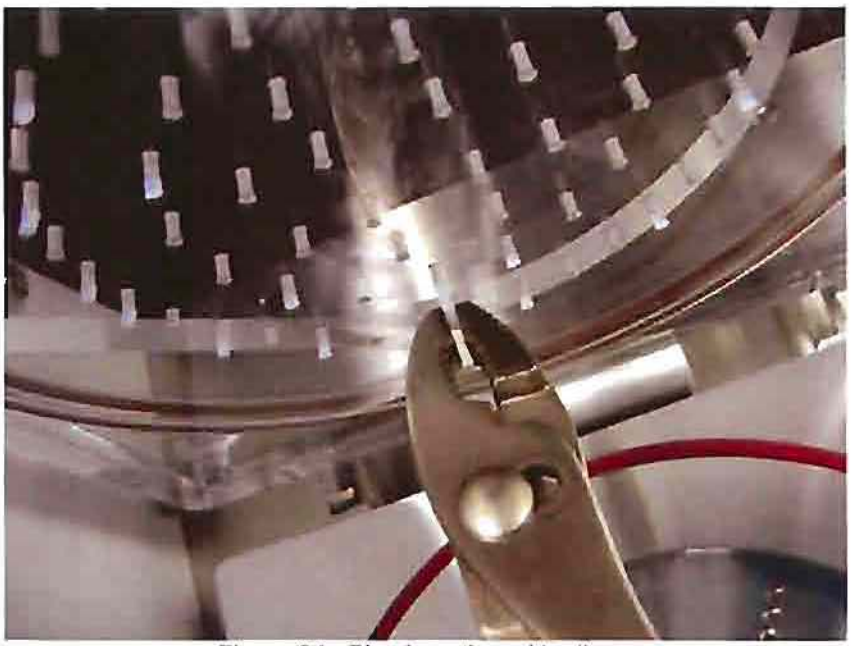


Figure 24. Plug insertion with pliers.

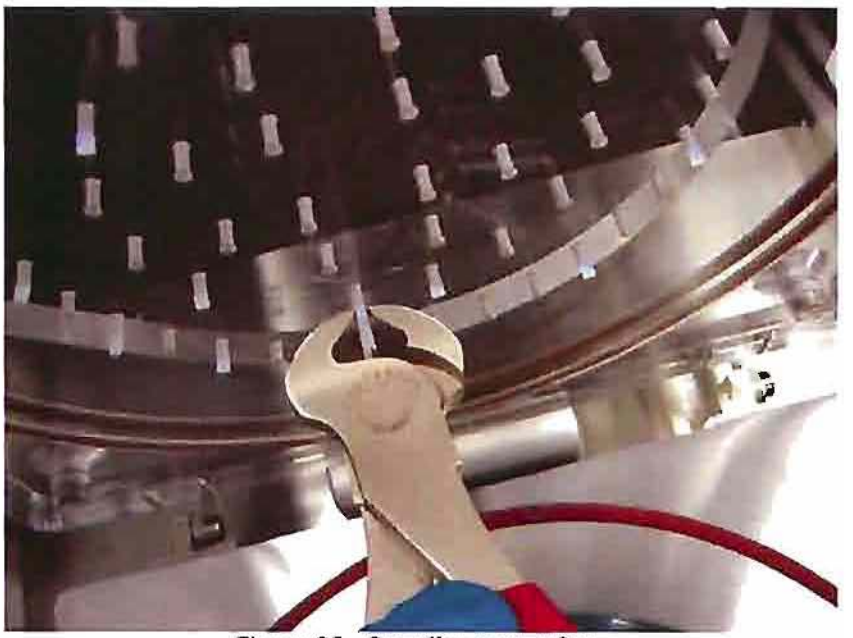


Figure 25. Cut off excess teflon.

Roughing Pump

The Xetch ships with an Edwards XDS10 dry scroll pump. This pump 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.

Chamber interlock

The purpose of the chamber interlock is to make certain that there is not an accidental release of xenon difluoride from the source bottles via the chamber. The operation of the interlock is performed by first detecting if the vacuum pressure is below approximately 400 Torr using the chamber vacuum switch shown in Figure 26. The signal is then fed to the chamber vacuum relay shown in Figure 27. The light on the relay will light if the chamber pressure is below 400 Torr ***AND*** if the main vacuum line is below 400 Torr (see Vacuum interlock below). If this relay is lit, the pneumatic manifold should be receiving power to valves 1 and 2 to ***permit*** them to operate. Otherwise, even if the computer sends a signal via the DeviceNet interface to open either valves 1 or 2, they will not have the power to open. It should be noted that this sensor is tested every time that the chamber is vented. If there is a sensor failure, a warning message will be displayed (note that it is necessary for the Show Warnings setting to be enabled in the System Configuration Menu any warning messages to be displayed). This test is performed by the computer verifying that the chamber vacuum switch trips during venting,

Vacuum interlock

The purpose of the vacuum interlock is to prevent any valve from opening if the vacuum to the system is insufficient. The logic is that if there is not sufficient vacuum to the system, it is not safe to allow the opening of valves. The primary causes of this interlocked situation would be a pump failure or a break in the connection between the system and the pump. The operation of the interlock is performed by first detecting if the vacuum pressure is above or below approximately 400 Torr using the main vacuum switch shown in Figure 26. The signal is then fed to the main vacuum relay shown in Figure 27. The light on the relay will light if the main vacuum pressure is below 400 Torr. If this relay is lit, the pneumatic manifold should be receiving power to all valves, except possibly valves 1 and 2 (see above) to ***permit*** them to operate. Otherwise, even if the computer sends a signal via the DeviceNet interface to open any of the valves, they will not have the power to open. If there is a main vacuum failure, a warning message will be displayed (note that it is necessary for the Show Warnings setting to be enabled in the System Configuration Menu any warning messages to be displayed).

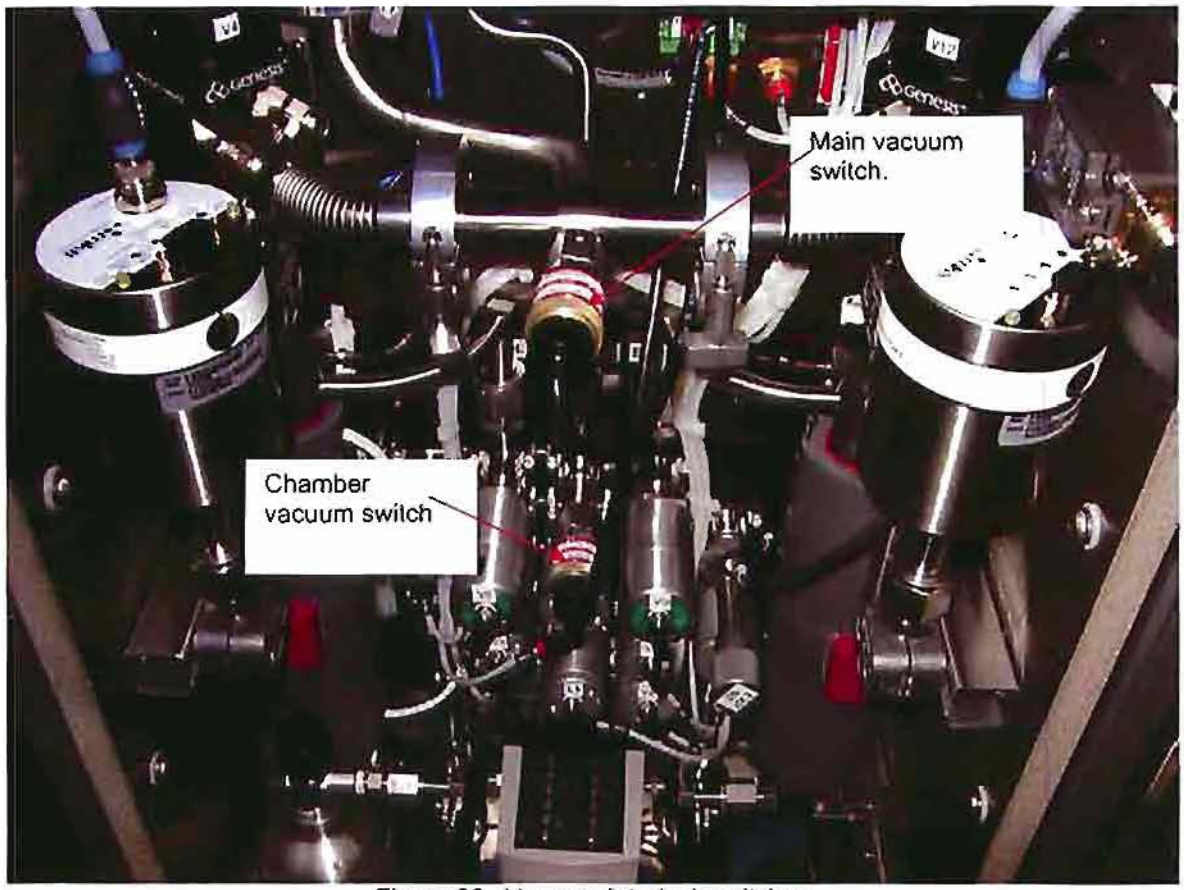


Figure 26. Vacuum interlock switches.

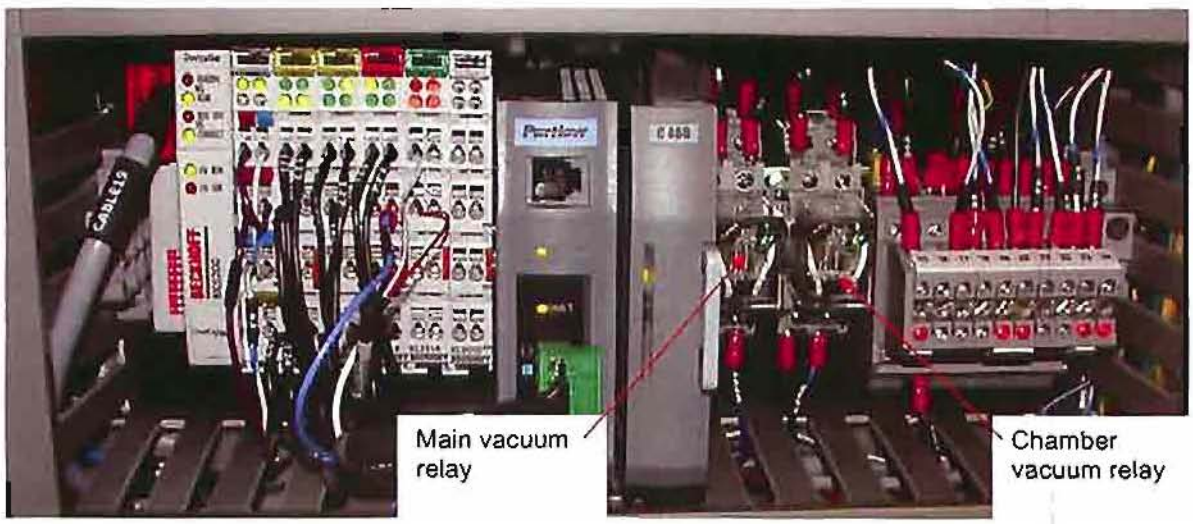


Figure 27. Interlock relays.

Manual valve operation

Figure 28. Valve manifold.

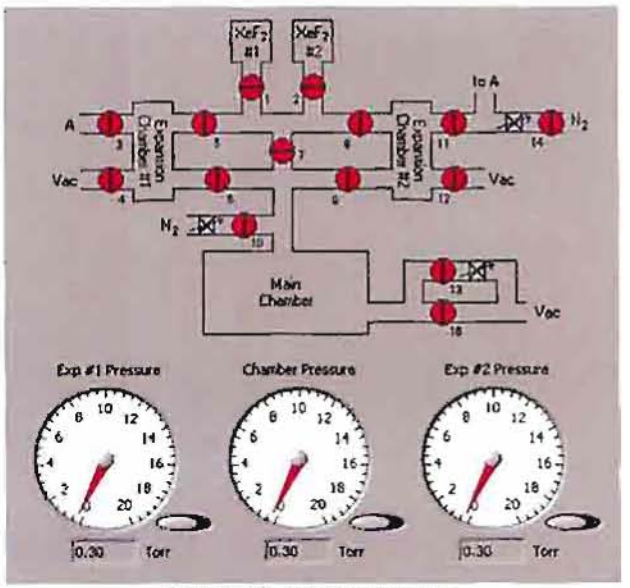


Figure 29. Valve diagram.

WARNING

MANUAL OPERATION OF THE VALVES COULD LEAD TO DAMAGE TO THE EQUIPMENT OR HARM TO PERSONNEL. MANUAL VALVE OPERATION IS INDEPENDENT OF INTERLOCKS AND SHOULD ONLY BE PERFORMED BY TRAINED PERSONNEL.

In service or maintenance circumstances, only to be performed using trained personnel, where manual operation of the valves is necessary, manual valve operation can be accomplished using a pointed object. The valve manifold, see Figure 28, has 16 buttons to manually actuate the valves. For reference, the valve diagram for the system is shown in Figure 29.

Temperature Related Devices

Temperature controller

The temperature controller is shown in Figure 30 (older version – C460) and Figure 31 (new version – Z46XX). Its setpoints are set by the Xetch software through its DeviceNet connection but the controller will still operate even if the PC is off. For diagnostic purposes, the C460 (not the newer Z46XX) controller provides feedback using its LEDs.

The number of the LED relates to the control of the following:

1. The main chamber
2. The gas box air temperature
3. Expansion chamber 1
4. Expansion chamber 2

The flashing or steadiness of the LEDs have significance as follows:

- When an LED is steady green, it indicates that the temperature is within tolerance of the setpoint
- If an LED is on for 1 second and off for 3 seconds, the temperature is below the setpoint
- If an LED is on for 3 seconds and off for 1 second, the temperature is above the setpoint

The Z46XX controller uses green LEDs to only indicate that the control loop is working correctly. If the LEDs are red, there is a problem.

Figure 30. C460 temperature controller module.

Figure 31. Z46XX temperature controller module.

Thermostats

Although the temperature of the gas box and chambers are controlled through the temperature controller, for additional safety, the Xetch has four overtemperature thermostats (shown in Figure 32 to Figure 35) that are set to disconnect heater power to a heater if the surface temperature of the heated device exceeds between 57 and 62 °C. The thermostats reset automatically and will allow power to the heater once the surface temperature of the heated device falls below 46 and 51 °C.

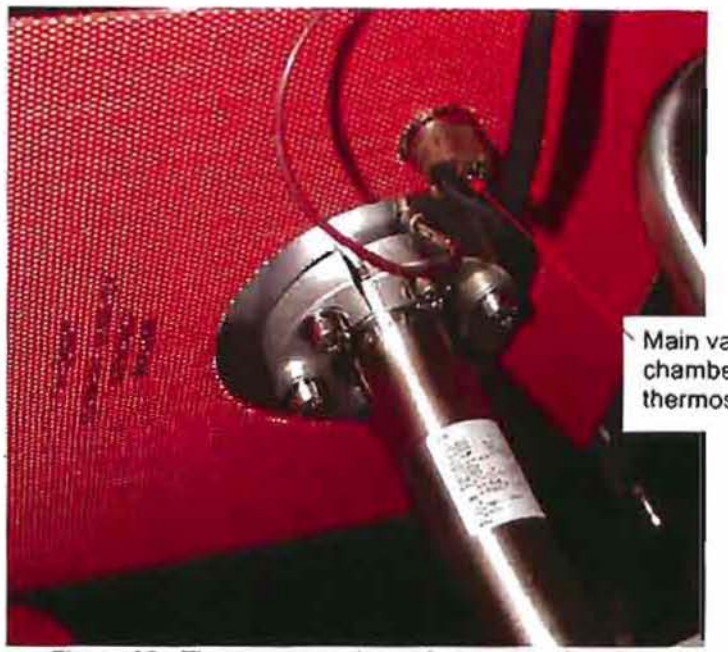


Figure 32. Thermostat under main vacuum chamber.

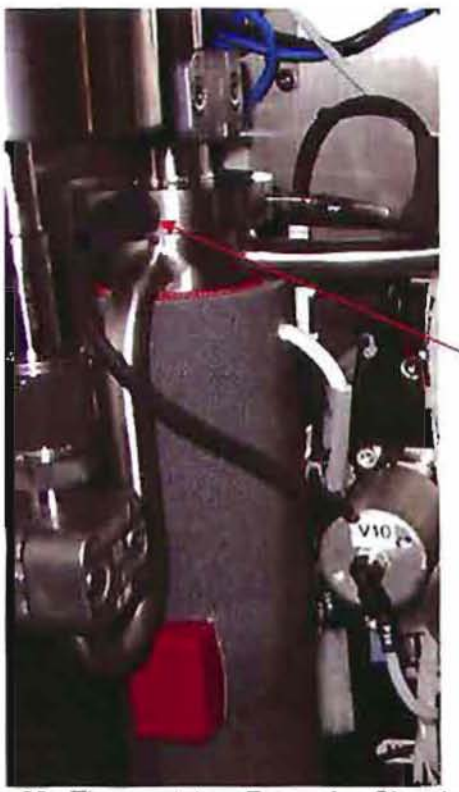


Figure 33. Thermostat on Expansion Chamber 1.

Figure 34. Thermostat on Expansion Chamber 2.

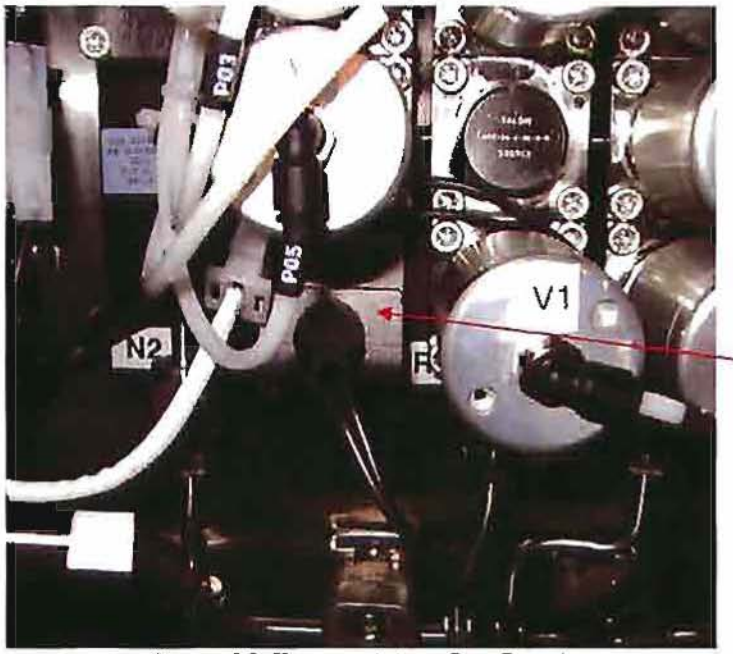


Figure 35. Thermostat on Gas Panel.

Gas box door interlock switch

To prevent hot air from blowing on the operator during maintenance in the gas box, such as during bottle changes, the power to the gas box heater (see Figure 36) is disconnected when the door to the gas box is opened. This is sensed by the switch shown in Figure 37. It should be noted that the expansion chamber heaters still will function, however, when the gas box door is open.

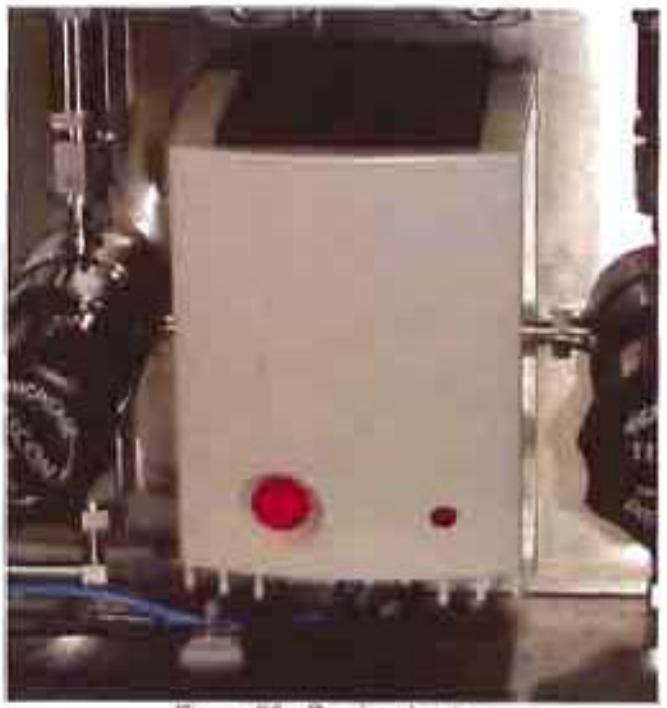


Figure 36. Gas box heater.

Figure 37. Gas box door switch.

Ventilation shroud interlock

The ventilation shroud is interlocked via a safety switch/lock mechanism as shown in Figure 38. This mechanism is controlled via the PC and the input/output signals related to this interlock are communicated through the device shown in Figure 39.

If it is necessary to override the Ventilation shroud interlock, a pair of keys is provided that are used to unlock the shroud.

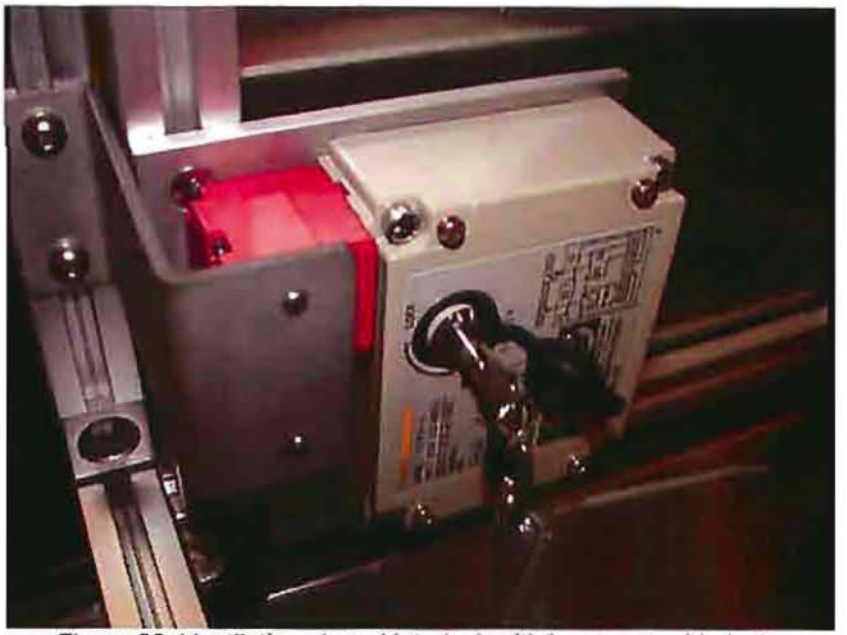


Figure 38. Ventilation shroud interlock with key to override lock.

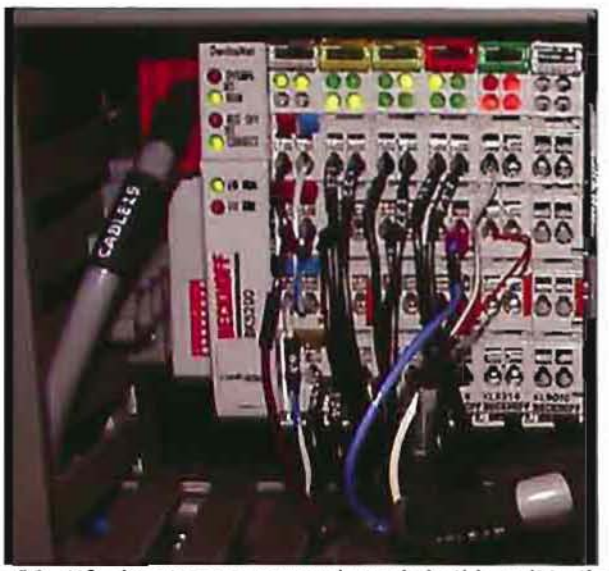


Figure 39. I/O signals are communicated via this unit to the PC.

Contact Info

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

XACTIX

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

XACTIX, Inc.
2403 Sidney Street, Suite 300
Pittsburgh, PA 15203
USA
(412) 381-3195
(412) 381-1136 fax
info@xactix.com
http://www.xactix.com