PECS II

Precision Etching and Coating System

Owner's Manual and User's Guide

Part Number 685.82001

Revision 2.0

2014

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Safety Information

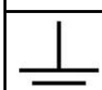
This chapter presents a summary of the safety symbols throughout this manual. Gatan, Inc., recommends following all safety precautions to prevent harm to yourself or the equipment. Please follow all warnings marked on the equipment as well.

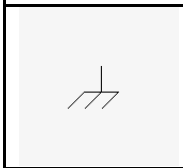
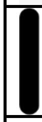
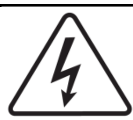
CAUTION - Documentation must be consulted in all cases where this symbol is marked.

IMPORTANT - For Regulatory Compliance and Safety information and instructions please refer to the *<u>Regulatory Pamphlet</u>* provided with this product. Review this document in full before installing and operating this product.

Symbols and Attention Symbols

You must be aware of safety when you install and use this system. This Guide provides various procedures that require careful attention to precautions.

SYMBOL	REFERENCE	DESCRIPTION
	IEC 60417-5031 (2002-10)	Direct current
	IEC 60417-5032 (2002-10)	Alternating current
	IEC 60417-5033 (2002-10)	Both direct and alternating current
	IEC 60417-5017 (2006-08)	Earth (ground) TERMINAL

	IEC 60417-5019 (2006-08)	Protective Conductor Terminal
	IEC 60417-5020 (2002-10)	Frame or chassis TERMINAL
	IEC 60417-5007 (2009-02)	On (Power)
	IEC 60417-5008 (2009-02)	Off (Power)
		Caution, possibility of electric shock
	IEC 60417-5041 (2002-10)	Caution, hot surface
	ISO 7000-0434B (2004-01)	Caution - documentation must be consulted in all cases where this symbol is marked
		Caution, magnetic field.

Product Safety Information

Review the following precautions to avoid injury and prevent damage to this product, or any products to which it is connected. To avoid potential hazards, use the product only as specified. Read all safety information provided in the component product user manuals and understand the precautions associated with safety symbols, written warnings, and cautions before accessing parts or locations within the unit. Save this document for future reference. Follow all warnings and instructions marked on the equipment. Ensure that the voltage and frequency of your power source matches the voltage and frequency inscribed on the equipment's electrical rating label. Never push objects of any kind through the openings in the equipment. Dangerous voltages may be present. Conductive foreign objects could produce a short circuit that could cause fire, electrical shock, or damage your equipment.

Danger: Disconnect power before replacing fuses and only use value specified on the product's rating label.

Do Not Operate Without Covers: To avoid electric shock or fire hazard, do not operate this product with any removed enclosure covers or panels.

To Avoid the Risk of Electric Shock: Do not operate in wet, damp, or condensing conditions. When supplying power to the system, always make connections to a grounded main. Always use a power cable with a grounded plug (third grounding pin).

Do not operate in wet, damp, or condensing conditions.

Disconnect all external power connections before servicing.

Should a leak occur, remove power from PECS. Use paper towels or a Kimwipe to clean up the spill.

Warning: To avoid electrical hazards (heat, shock and/or fire hazard), do not make connections to terminals outside the range specified for that terminal. See the product user manual for correct connections.

Electronic components on printed circuit boards are extremely sensitive to static electricity. Ordinary amounts of static electricity generated by your clothing or work environment can damage the electronic equipment.

When installing the board in a system, you must use anti-static grounding straps and anti-static mats to prevent damage due to electrostatic discharge.

To avoid injury, fire hazard, or explosion, do not operate this product in an explosive atmosphere.

Preface

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Disclaimer

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Support

Gatan, Inc. provides free technical support via phone, fax, and electronic mail. To reach Gatan technical support, contact the facility nearest you, or send electronic mail to help@gatan.com.

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Mobile : 33 6 80 13 51 39
Fax : 33 1 34 87 16 68
Contact: dmonville@gatan.com

Returns

If there is a need to return equipment to the factory, please call Gatan to obtain a Returned Merchandise Authorization Number (RMA #). This RMA number must appear on your shipping document, to help in tracking and to ensure that proper action will be taken to repair or replace your equipment.

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1. Overview

The Model 685 Precision Etching and Coating System (PECS II ™) is a compact, bench-top instrument designed to etch and/or coat samples for electron and light microscopy (see Figure 1-1). It produces exceptionally large, clean, and viewable areas ideal for applications requiring sample polishing/etching immediately followed by coating, where exposure to air is undesirable. The PECS employs intuitive touch-screen controls for easy operation. This manual was written for PECS II software version 1.7.

Figure 1-1 PECS II Pro system, front view

1.1. Features of the Precision Etching Coating System

1.1.1. *Dual Ion Source*

Ion polishing is done by two variable-angle, miniature Penning ion guns (PIGs). The operating angle of each gun, 0° to 18°, is independent of one another and both have the ability to center the beam onto the specimen at any angle within this range. The PIGs incorporate powerful rare-earth magnets and are capable of very high etching rates. Each gun is mounted in a universal joint so that the x- and z-alignment drives can be used to center the beams on the specimen. These features make it possible to etch specimens at very low angles in a reasonably short time. Motorized operation of beam tilt angle is available as an optional feature.

The same guns are used for coating, where the sample is lowered and a coating target is inserted into the beams path.

1.1.2. *Optimum Gun Design*

The gun's ion optics has virtually eliminated cathode-aperture erosion and, as a result, gun maintenance is reduced, specimen contamination from the ion guns is minimized, and gun consumables have been eliminated. The new focus electrodes in each gun have improved the low energy spot size, keeping the spot size approximately constant across all beam energies. This results in dramatically faster milling rates at low energy, such that it is now practical to etch a final clean-up step at energies as low as 100 eV.

1.1.3. *Gas Flow Optimization*

The optimum gas flow for all beam energies is calibrated at the factory, and may be selected by using the automatic gas flow option. The gas flow of each gun may also be set manually.

1.1.4. *Compact Vacuum System*

Specimen contamination is reduced with an oil-free vacuum system consisting of a molecular drag pump (MDP) backed by a 2-stage diaphragm pump (DP). Additionally, a liquid-nitrogen trap is available to further reduce contaminants and water vapor.

1.1.5. *Touch-screen Interface*

Operation of the system is controlled by the user via a touch-screen interface, which is customer selectable between several languages.

1.1.6. *Versatile Sample Mounts*

The maximum sample size is 32 mm diameter by 20 mm tall. Several sample mounts are available. The following mounts are standard with every system: adjustable height mount for 0-10 mm tall samples, adjustable height mount for 10-20 mm tall samples, cross section mount for Ilion^{+} ™ type blades.

1.1.7. *Loading Dock*

A loading dock is provided which facilitates loading sample mounts into and out of the transfer device. The loading dock is also used to adjust the sample height so that it is at the eucentric of the guns. This allows for small changes in gun tilt angle without re-aligning the guns.

1.1.8. *Multiple Coating Targets*

A dual target-exchange mechanism containing two targets permits the user to quickly select either of two target materials without breaking vacuum. The dormant targets are fully shielded from contamination. See Chapter 7, "Consumables," for a list of available target selections.

1.1.9. *Sample Exchange*

Quick specimen exchange (~90 sec) is achieved using a load lock and transfer device. The transfer device picks up the sample mount from the loading dock, and transfers it into the system.

1.2. Optional Features of the PECS II

The PECS II system has several optional features, most of which are available only at the time of purchase.

1.2.1. *Vacuum transfer*

The system may be ordered with vacuum transfer capability. The load lock and vacuum transfer device are configured so that a sample may be transferred into or out of the system without exposure to atmosphere. The transfer device may be pressurized with Ar or evacuated for transfer either to a glove box or to a specially modified SEM load lock.

1.2.2. *Liquid nitrogen cold trap*

A liquid nitrogen cold trap may be installed to improve the chamber vacuum while coating. This is particularly useful when coating with materials such as Chromium which oxidizes readily. This option may be installed at any time. This option is not necessary or available if the system has a cold stage.

1.2.3. *Liquid nitrogen cold stage*

A liquid nitrogen cold stage is a system option at the time of purchase. This cools the sample to approximately -100C. Cooling is important for many samples which are sensitive to the temperature rise associated with ion etching. The cold stage has an integrated heater which can be used to raise the sample temperature prior to transfer out of the PECS II.

1.2.4. *Zoom microscope system*

The Zoom Microscope is a system option. The microscope includes a 6x optical zoom, and a digital camera connected to an external PC. The camera is mounted on the system and allows for in-situ observation of the sample. In addition, the supporting software allows for manual/automated acquisition of images during etching, typically one automated image per rotation. The external PC can also be used for remote control of the PECS II system, via remote desktop type software.

The microscope is typically set to image a sample in the etching position. The microscope must be lowered to image a sample in the coating position. During coating, the sample is obscured by the coating target. The target may be retracted periodically to allow for imaging of the sample.

1.2.5. *Film thickness monitor*

A crystal thickness monitor may be ordered which measures the amount of material deposited onto a crystal next to the sample mount. This may be used to estimate the thickness of the film deposited on the sample. The system may be programmed to stop coating once a designated amount of material is deposited.

1.2.6. *Etch-only system*

The system may be ordered without coating targets or the other associated hardware.

1.2.7. *Motorized guns*

The system may be ordered with motorized gun tilt. This allows for programmed recipes where the gun angle is changed automatically from one step to the next.

1.3. Main Work Chamber

Figure 1-2 is a top view of the PECS II main work chamber. The figure shows the right and left PIGs.

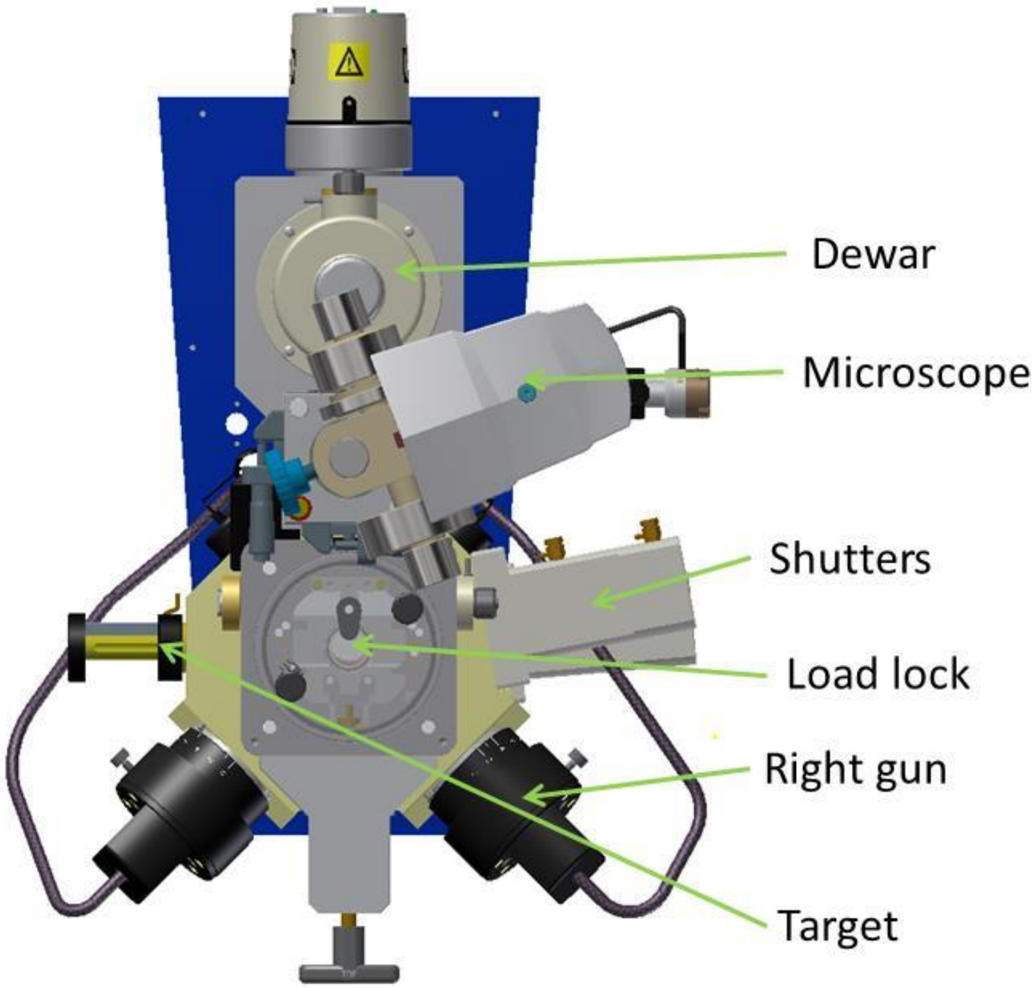


Figure 1-2 Work chamber, top view.

Figure 1-3 is a cross-sectional view through the main Work Chamber of the PECS II. The specimen mount is in the Coat position (lowered) in the Chamber.

Specimens are mounted on sample mounts. One of the PIGs is shown inclined at an angle of 0° to horizontal. By simply grasping the gun knob and rotating it, the gun angle can be increased up to 18° (beam incident to the top surface of sample).

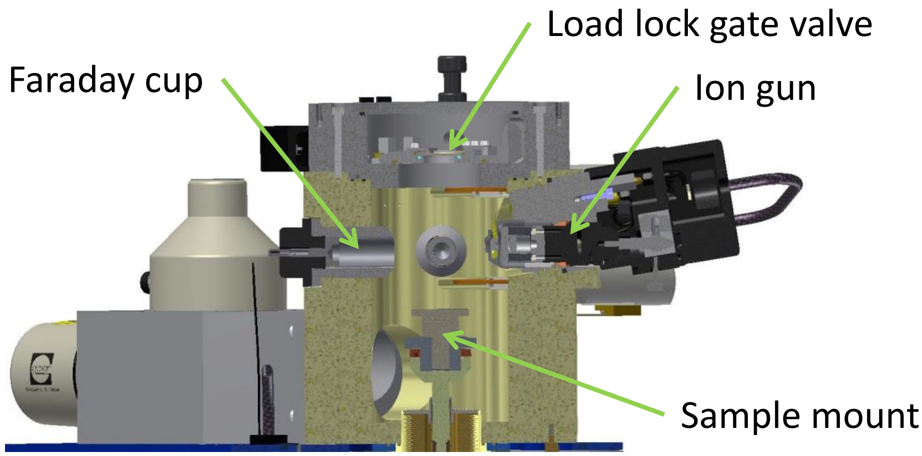


Figure 1-3 Work chamber, cross-section view.

1.4. Vacuum System

PECS II has a compact, oil-free vacuum system consisting of a molecular drag pump (MDP) backed by a 2-stage diaphragm pump (DP). The vacuum system is designed to hold vacuum when the power is turned off. The working vacuum can be reached very quickly when the power is resumed.

1.4.1. *The Pumping system*

The MDP has an argon pumping speed of 80 L/sec. It is in series with a 2-stage diaphragm pump (DP) that maintains a backing pressure for the MDP of less than 10 Torr and a chamber base pressure in the 10^{-6} Torr range. The pumping time from atmosphere to near the base pressure is typically less than 15 min. The console is cooled by a single fan mounted on the rear panel that directs air onto the MDP.

1.4.2. *The Pumping Manifold*

The Pumping Manifold contains the cold-cathode gauge tube and the MDP, which is offset from the Work Chamber to minimize any possibility of debris falling into the pump. Pressure is monitored by the cold-cathode gauge tube, which will not turn on unless the MDP is close to its normal running speed.

1.4.3. *Load lock Vacuum*

The Airlock vacuum is controlled by three solenoid valves (see Figure 1-4). The VAC valve in conjunction with the LL (load lock) valve evacuates the load lock. The Vent valve in conjunction with the LL valve vents the load lock. The bleed valve connects the load lock to the chamber after the load lock is pumped down to roughing vacuum.

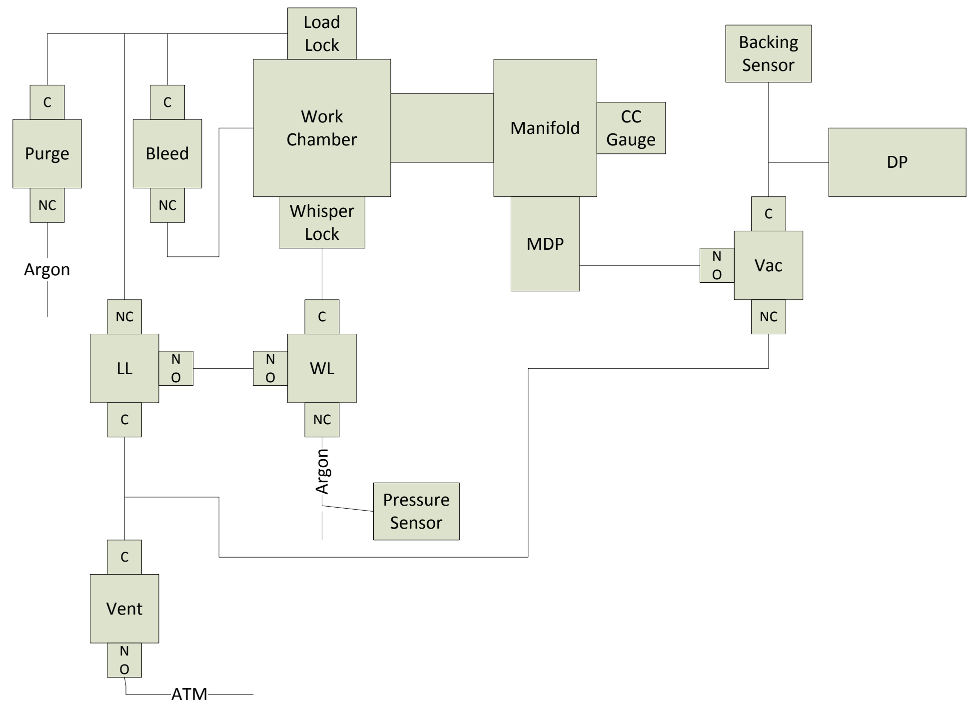


Figure 1-4. Vacuum system.

1.4.4. *Gas and Argon Manifolds*

The gas manifold combines most of the solenoid valves except for the VAC valve onto a single manifold. This includes valves for pneumatic controls as well as airlock vacuum control. All of these valves are of the same type; 3-way normally closed, 15 mm valves from Clippard Minimatic. These valves have an LED which indicates when they are active. The mass flow controllers and a gas regulator are also mounted on the gas manifold.

Fittings with captive o-rings are inserted into tapped holes on the manifold and gas and vacuum tubing is connected to the fittings. It is critical that these fittings are not over-tightened, or the manifold material can be cracked. When tightening a compression fitting, be sure that a second wrench prevents the fitting from turning.

The Gas-Control system controls the Argon gas supply to the ion guns, an alternate gas input for the guns, the Whisperlok piston, and the pneumatic shutter. The Gas-Control System consists of a pressure regulator and four normally closed three-way solenoid valves. Figure 1-5 shows the Gas-control system. The gas supply to the guns is controlled by a regulator.

The alternate gas input for the guns may be used if a different gas is desired for the ion guns than is used for the pneumatic control. For example, Xenon may be used for the guns while Argon is used for pneumatic control. This minimizes the amount of the much more expensive Xenon that is used.

The Argon manifold includes valves for actuating the coating shutter as well as connections for distributing Argon to the gas manifold and pressure sensor. The vacuum transfer version of the Argon manifold also includes a regulator and valve for pressurizing the transfer device with Argon.

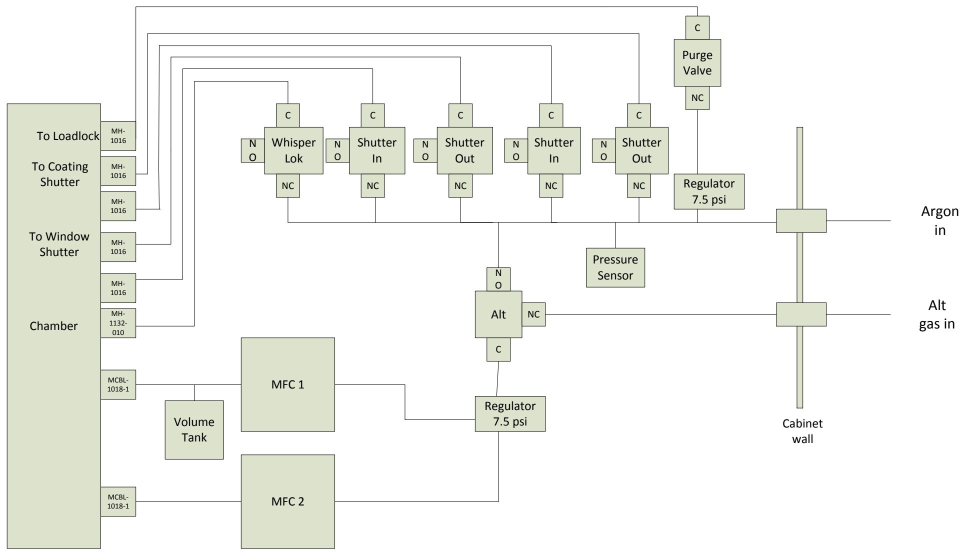


Figure 1-5 Gas-control system.

Gas Supply to the Guns

The PECS requires a clean, high purity (99.998%) Argon supply at 25 psi (1.72 bar). The Argon gas for the ion guns is regulated by a pressure regulator that reduces the incoming gas supply from 25 psi down to about 7.5 psi. Two O-rings form vacuum seals in the gun housing and the ionizing gas is fed into the guns between the O-rings. The Alt valve (AG) when activated connects the alternate gas input to the guns, however, Argon gas must still be supplied to the Ar input to provide pneumatic control.

Gas Supply to the Whisperlock™

The Whisperlok assembly is controlled by a normally closed three-way solenoid valve (WL). When WL valve is energized, Argon pressurizes the Whisperlok assembly and lowers the piston. When the power to WL is switched off, the gas pressure is cut and the piston is raised. This means that in the event of a power failure, the specimen will automatically be raised into the etch position. In addition, the LL and the VAC valves are configured so that the DP evacuates the bellows. This increases the pressure raising the Whisperlok.

Gas Supply to the Pneumatic Shutter

The pneumatically-operated Shutter is designed to minimize sputtered material from depositing on the specimen window and is controlled by the 3-

way valves, SI and SO. When the power to SI is switched off, the shutter piston cylinder is vented. When power to SO is activated, the shutter piston is pneumatically driven outward.

1.5. Electrical system

The total power consumption of the PECS II is relatively small. The beam energy has been limited to 8.0 keV as the best compromise between maximizing the specimen etching rate and minimizing specimen radiation damage and heating effects.

1.5.1. *Energy Isolation*

Prior to servicing the system, remove the AC line cord and attach a suitable lockout/tagout device, such as RS Hughes Co. part number 65674 or similar.

1.5.2. *Air Flow*

The cabinet interior is cooled by a single fan, mounted on the rear panel directing air onto the MDP. The air flow to the fan and the slots on the rear panel should not be blocked since this may cause the MDP to overheat and shut down, possibly damaging other electrical components in the instrument.

1.5.3. *DC Power Supply*

All power to the system is supplied by a 24 VDC power supply connected to the power main input. It accepts universal power input (90-240 VAC, 50-60 Hz).

1.5.4. *HV Power Supply*

The high voltage (HV) power supply provides the ionization voltage, the acceleration voltage, and the focus voltage for the ion guns. The three voltages are programmed with a defined relationship to give the optimum beam parameters for each beam energy. This supply also provides for fast switching of the guns during sector milling.

The HV supply measures the current to each electrode and the output voltages. This can be used to determine if the guns are operating properly.

1.6. The Standard Operating Mode

Gatan recommends the PECS II be left running continuously 24 hr a day, seven days a week. This will insure optimum performance of the vacuum system and the ion guns and purge time will be minimized.

2. Installation

Although the PECS II is a small, bench-top system, it is relatively heavy (38 kg (84 lb)) and should not be lifted by a single person. It can be lifted safely by two people who are experienced in the techniques of lifting heavy objects. Alternatively, proper laboratory lifting equipment should be used. The size of the PECS is 21” (W) x 23” (L) x 30” (H). The size of the vacuum pump is 7” (W) x 9” (L) x 9” (H), and the weight is 7 kg (15 lb).

2.1. Site Requirements

The PECS II requires a sturdy bench top area approximately 1.2 m (48 in.) wide by 60 cm (23.6 in.) deep by 72 cm (28.3 in.) high, located near a power outlet and a source of 99.998% purity argon (Grade 4.8). If the cold stage option is installed, the dewar will often interfere with any cabinet mounted on the wall above the system; therefore, a bench space without a cabinet would be required. A desktop computer will be used with the camera system. A 23” monitor, keyboard, and mouse will occupy desk space next to the PECS II, and a small tower case will likely sit on the floor. A molded power cord is supplied with the PECS II to fit the local standard power socket. If the power cord supplied is not suitable, the plug should be replaced with a suitable one. Before connecting the new plug, make sure the voltage requirement conforms to that specified on the label on the rear panel of the PECS. The wiring color codes should conform as shown:

Live	Black or Brown
Neutral	White or Blue
Ground	Green or Green/Yellow

Electrical Ratings:
100-120/220-240 VAC
50/60 Hz
10 A fuse

A 3 m nylon tubing with compression fittings (1/8 inch Swagelok) is supplied to connect the argon regulator to the gas input of the PECS II, located on the rear panel of the console. The PECS II is air cooled and does not require connection to a water supply.

The system typically uses about 150 Watts when in operation, 130 Watts when idle, and peak power usage is about 300 Watts.

2.2. Unpacking

Be sure to have the necessary personnel or use proper laboratory lifting equipment when unpacking the PECS II.

1. Inspect the exterior and interior of the shipping box for damage.

Note or photograph any external visible damage. There are “tip and tell” sensors on the outside of the box to indicate if the box was mishandled in shipping. Take pictures of these sensors if they have been tripped.

Open the boxes and inspect for any internal damage. If any damage is observed, the Shipper should be informed immediately.

2. Remove the computer (if applicable) and accessory boxes.

If a camera system was purchased with the PECS II, the computer and accessories are packed in a smaller box on top of the main box. Lift the cover off of the top box and remove the computer and accessories.

Lift off the top layer of support foam and unfold the protective plastic cover.

3. Lift the box lid, then the internal box off of the PECS II.

The internal box for the PECS II is designed to lift off of the PECS II, do not cut open the top of this box. Lift off the top layer of support foam and unfold the protective plastic cover.

4. Lift the PECS II off of the support foam and place on a sturdy surface such as a bench top (follow lifting instructions above).

5. Remove the diaphragm pump from the small box, and the camera system (if applicable) from the larger box.

If a camera system was not purchased, the accessories will be in a smaller internal box.

6. Keep all packing material.

Replace all packing material into the shipping box and store in the event the instrument must be returned for factory repair or maintenance.

7. Verify accessory items.

Inspect the contents of the accessory boxes against the items ordered and those listed on the packing list.

If there are any discrepancies, inform your local Gatan Sales Office immediately.

2.3. Installation

Place the PECS II on an appropriate work bench, close to a suitable power outlet and a cylinder of compressed argon. Then proceed with the setup.

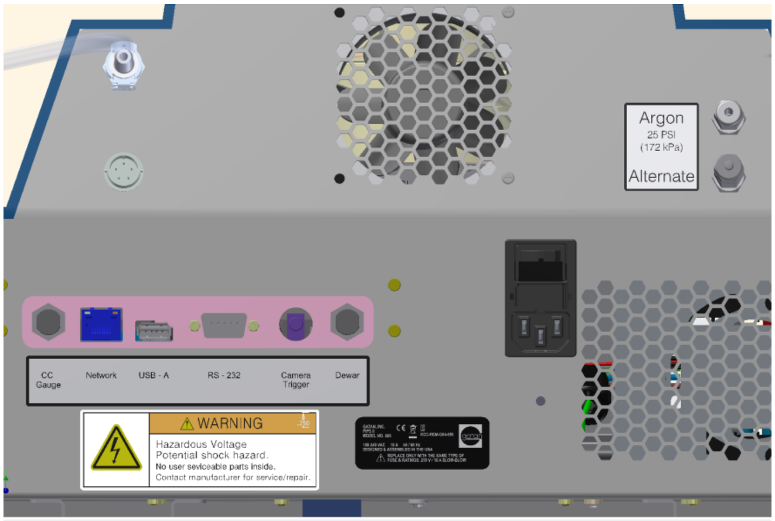


Figure 2-1 View of connections on rear of cabinet.

2.3.1. *Setup of the Diaphragm Pump (DP)*

1. Connect the diaphragm pump cable to the pump connection at the rear of the PECS II and to the two connectors on the diaphragm pump. Tighten the screw on the large connector on the diaphragm pump.

2. Connect the vacuum line between the rear of the PECS II at the Quick Release Fitting and to the fitting on the DP.

3. Place the DP on the floor next to the PECS II. This will isolate the vibrations of the DP from the PECS II.

2.3.2. *Connecting the cables*

1. Connect the Cold Cathode gauge cable (695.04203) from the CC gauge to the connector marked CC Gauge on the back of the instrument.

2. If the cold stage option is installed (selected models only), connect the dewar cable (695.04204) between the dewar and the connector marked Dewar on the back of the instrument.

2.3.3. *Connecting the Argon Source*

NOTE: Be sure the argon supply is properly secured.

1. Adjust your argon tank regulator to 25 psi (1.72 bar).

2. Connect gas-supply hose. Connect one end of the nylon gas-supply hose to the regulator on the cylinder bottle.

3. Purge the gas-supply hose. Crack open the main valve on the cylinder to purge the gas-supply hose.

4. Connect hose to the console. With the argon flowing, connect the hose to the gas-inlet port on the rear panel of the PECS II. Do not over tighten the fitting as this may fracture the hose.

5. Check the pressure. Turn off the main gas valve and check that the pressure reading on the high pressure side of the regulator does not decrease over a 5 min period. This will verify that the gas-inlet line is not leaking.

6. Turn on the main gas valve again to restore the argon supply.

2.3.4. *Setting up the Camera System*

If a camera system is included with the system, it needs to be mounted and connected to the PECS II and the imaging PC.

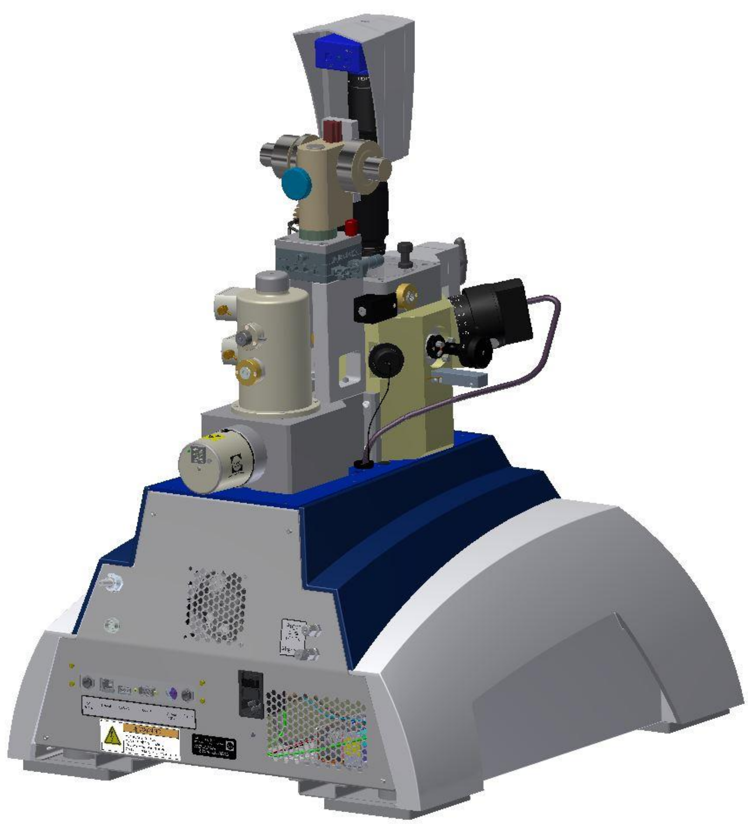


Figure 2-2 Camera system mounted onto the PECS II.

1. **Unpack the camera system.**

2. **Place the plastic washer onto the vertical post on the Manifold.**

3. **Engage the hole in the bottom of the rack and pinion mount into the vertical post on the Manifold.**

4. **Lower the camera system to its working position.** The knob on the back of the focus mechanism can be used to secure the microscope into position. Loosen this to swivel the microscope into/out of the imaging position.

5. **Plug the illuminator cable into the top illuminator connector on the right hand side of the cabinet, and insert the illuminator into the port on the right side of the microscope column.** Gently tighten the knob to secure the illuminator.

6. **Unpack the imaging computer and monitor.** Connect the monitor, keyboard, and mouse to the appropriate port on the back of the PC.

7. **Connect the USB cable from the digital camera to an available USB port on the PC.**

8. **Connect the camera trigger cable from the digital camera to the camera trigger port on the rear panel of the PECS II.**

9. **Connect the crossover Ethernet cable from the second Ethernet port of the PC to the Ethernet port on the rear panel of the PECS II.**

This port should be labeled “To Ion Polisher” on the back of the PC. Note that a standard Ethernet cable will not work, this must be a “crossover” type Ethernet cable (supplied with the system). The second Ethernet port on the PC is on a PCI add-on card. The Ethernet cable must be plugged in to the proper port of the PC in order for the PC to communicate with the PECS II system.

10. **Turn on the PC, wait for Windows to load.**

11. **Start DigitalMicrograph.** The camera system is now ready to use.

2.3.5. *Setting up the Film Thickness Monitor (FTM)*

The FTM has 2 connections, a BNC connector for the RF connection to the Thickness Probe, and a USB connection for communication with the PECS II. The USB port of the PECS II does not provide enough power for the FTM, so an adapter cable is used to provide extra power. This adapter cable is plugged into a USB port on the imaging PC.

1. **Plug the BNC cable into the Film Thickness Monitor.**

2. **Plug the right angle BNC adapter into the BNC cable.**

3. **Plug the right angle BNC adapter into the BNC connector of the FTM probe on the front of the PECS II.**

4. **Plug the B connector (square shaped) of the USB Y-cable into the back of the FTM.**

5. **Plug the black A connector (rectangular shaped) of the USB Y-cable into the USB port on the back of the PECS II.**

6. **Plug the red A connector of the USB Y-cable into the mating connector of the USB A M-F cable.**

7. **Plug the other side of the USB A M-F cable into a spare USB port on the back of the imaging PC.**

Figure 2-3. Film thickness monitor connections

2.3.6. *Replacing the coating targets*

The PECS II system ships with 2 standard targets, C and Cr, installed. Additional targets may be purchased. The PECS II targets are also compatible with targets from an older PECS system. The system must be shut down and vented in order to change targets. After installing the new targets, the UI must be configured for the new target materials.

1. **Shut off main power (switch on rear panel). Wait 10 minutes for turbo pump to spin down.**

2. **Vent the chamber by slowly opening the manual valve on the dewar (cold stage system) or vent valve assembly (non-cold stage system).** Close the valve once the system is fully vented.

3. **Loosen the 3 screws (M2.5x8) in the flange of the target assembly.**

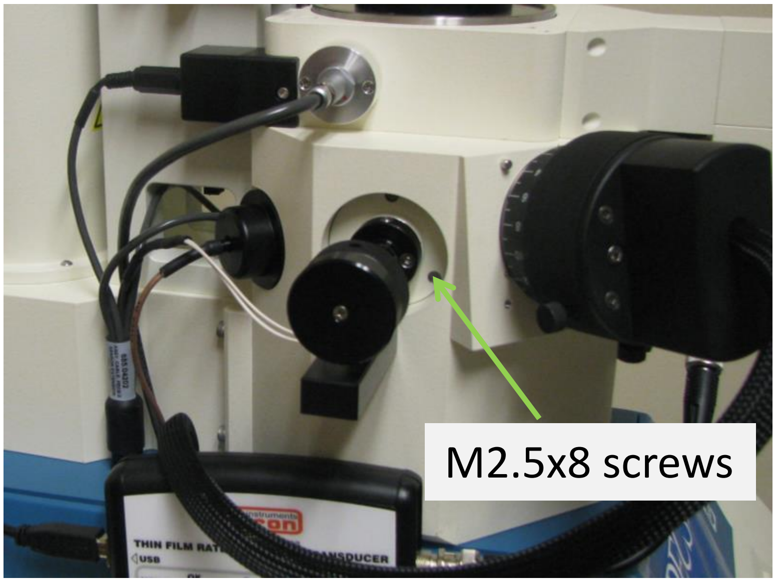


Figure 2-4. Target assembly on chamber

4. **Carefully remove the target assembly from the chamber.**

5. **Slide the knob forward so the targets extend past the end of the cover.**

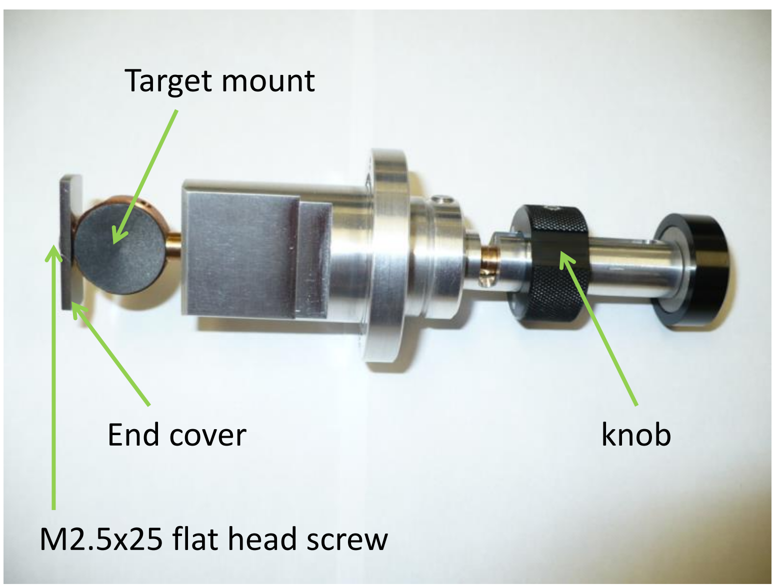


Figure 2-5. Target assembly

6. **Loosen the slotted head screw on the end of the assembly, and remove the end cover and target mount.**

7. **Install the new target mount, and replace the screw and cover.**

8. **Install the target assembly into the chamber and tighten the 3 screws.** Ensure that the o-ring (#2-025) is seated in the o-ring groove.

9. **Ensure the vent valve is closed, and turn on power to the system.**

10. **After the UI in displayed on the screen, press Devices.**

11. **Press Targets.**

12. **Change the material type for targets 1 and 2 to the new materials installed.** Insert the target and observe which target is facing down when the number 1 is visible on the target knob. Set target number 1 as the other target material. For example, if you have installed a target with Carbon and Chromium and you can see the Chromium target through the window in the load lock, then you should set target 2 as Chromium and target 1 as Carbon.

    To change the setting of the target holder: press the button associated with the material you want to change. A pop-up screen will appear, choose the material from this list. If the target material is not shown in the list, contact Gatan service for assistance. The targets list can be edited from the imaging PC with the proper authorization.

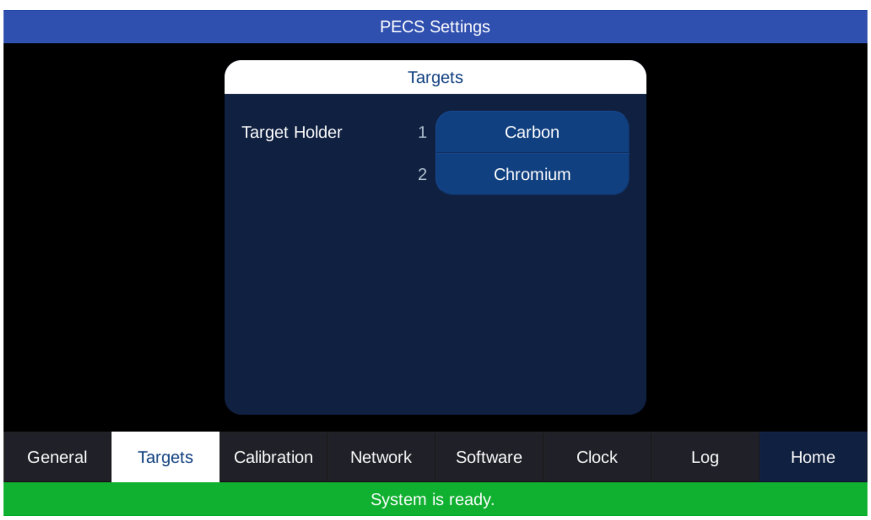


Figure 2-6. Devices / Targets screen

Figure 2-7. Target material selection

3. Operation

The PECS II is relatively simple to operate. The ability of the operator to obtain good specimens depends more on the quality of the starting specimen than on any other factor.

3.1. Graphical User Interface (GUI)

PECS II is mainly operated using the touch screen interface. The main page contains links to the following:

- The Transfer page (initiate loading or unloading of samples)
- The Etching page
- The Coating page
- The Devices page
- The Settings page

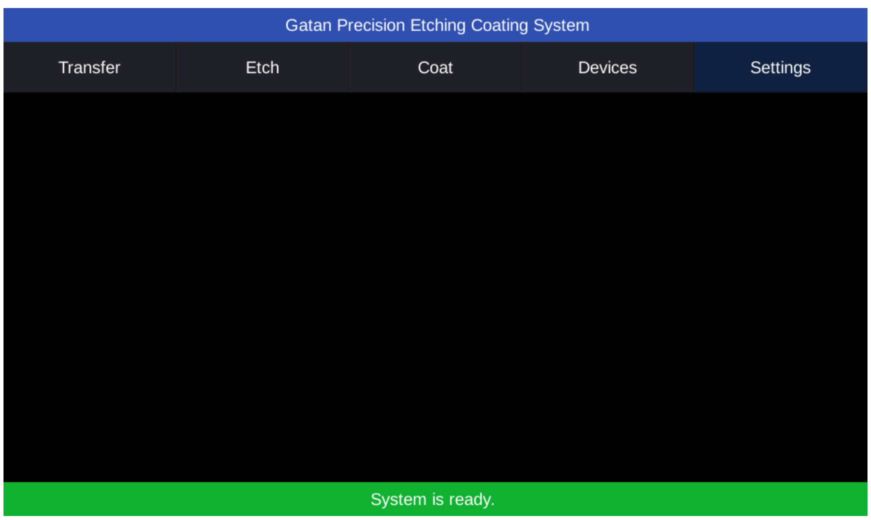


Figure 3-1. Main page

3.1.1. *Transfer Page*

This page is used to transfer samples into or out of the system. After pressing transfer, two options are available: Load Sample and Unload Sample. Load Sample is for inserting a sample into the system, and Unload Sample is for removing a sample from the system. Choose one of these options then follow the prompts on the subsequent pages.

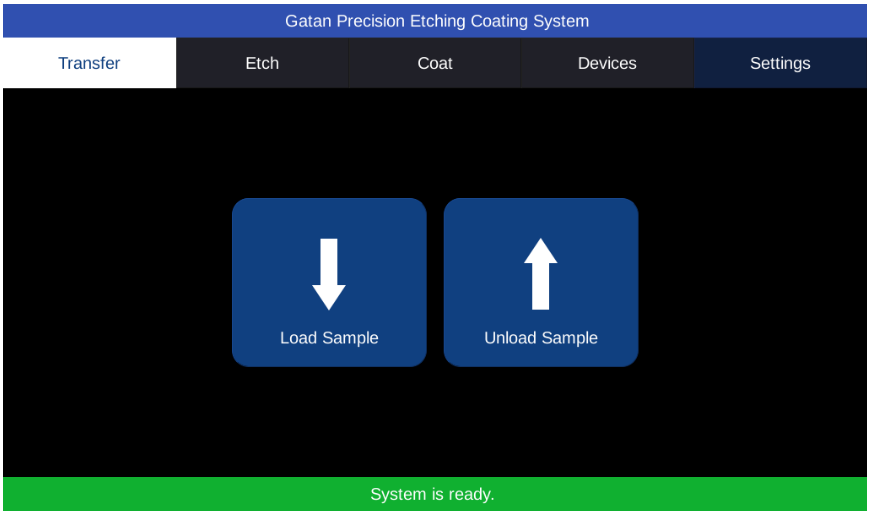


Figure 3-2. Transfer page

3.1.2. *Etch Selection Page*

The etch selection page is displayed when etch is selected. This page allows the user to choose between etching by time and etching by dose. When etching by time, the system will etch for a pre-selected period of time, then stop. When etching by dose, the system will keep track of the beam current from both guns, and stop when a pre-selected amount of dose has been delivered. Because beam current varies between different guns and at different times, etching by dose provides for better reproducibility from one etch process to another.

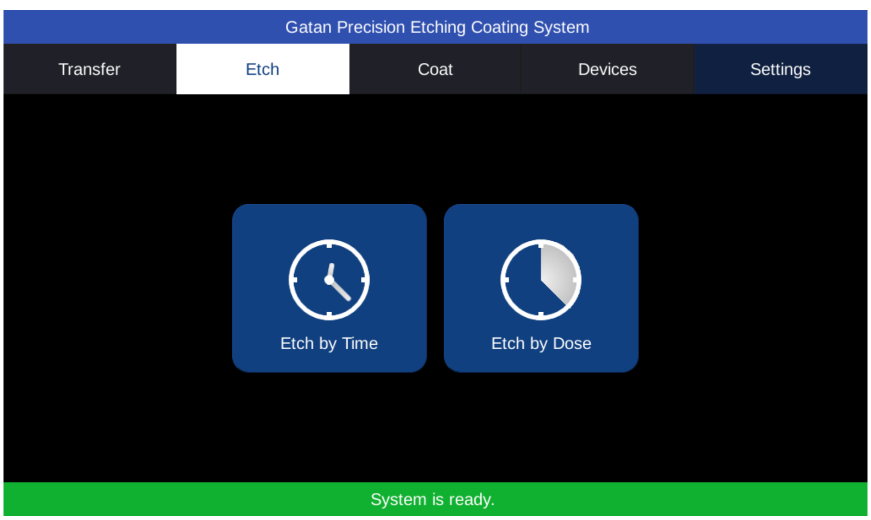


Figure 3-3. Etch selection page

Once either etch by time or etch by dose is selected, the system will raise the stage into the etching position and start stage rotation. This will take a few seconds while the Whisperlok™ bellows is evacuated. Then the Etch page will be displayed.

3.1.3. *Etch Main Page*

The Etch page has several tabs across the bottom, which allow access to advanced functionality. The left-most tab selects the etch main page. Selecting the Done tab exits etch mode and returns to the Main page.

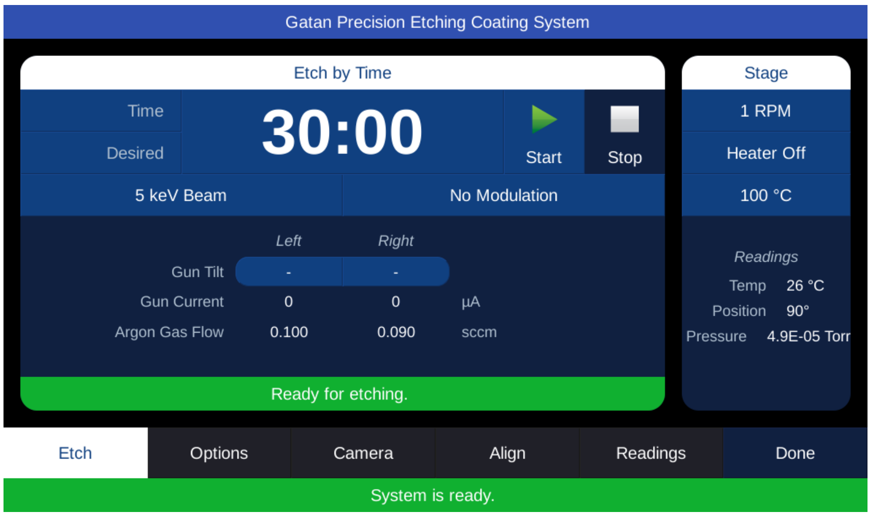


Figure 3-4. Etch by Time page

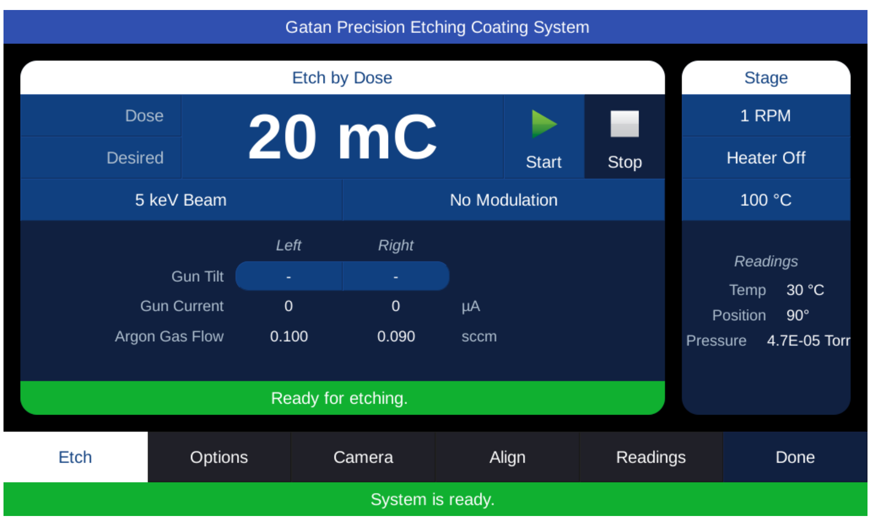


Figure 3-5. Etch by Dose page

Timer: Used to set the etching duration when using Etch by Time. For this, touch the Timer and enter the etching duration in the window shown below (Figure 3-6), then touch Apply.

When the system is etching and the timer times out, the voltage is turned off, the stage rotation stops, the shutter is opened, and the user is notified by a buzzer.

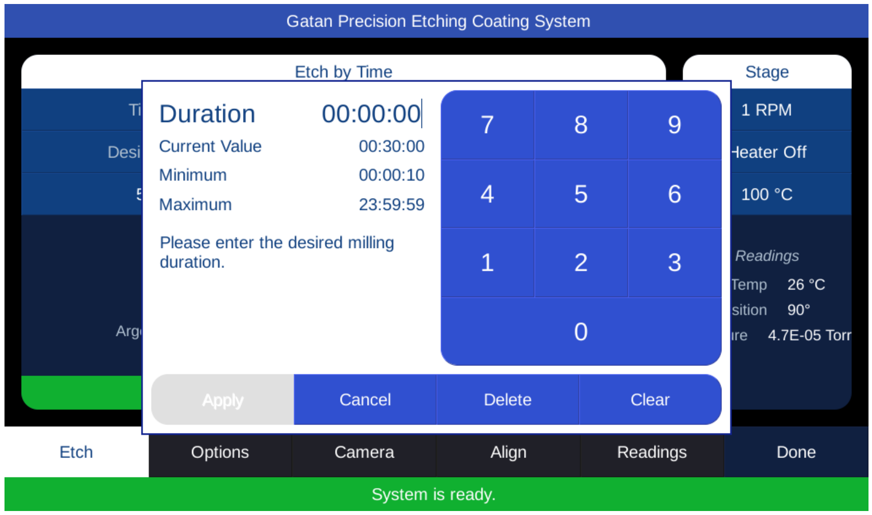


Figure 3-6 Setting etching duration.

Dose: Used to set the desired dose in millicoulombs (mC) when using Etch by Dose. One millicoulomb is one milliamp for one second. For this, touch the Dose display and enter the desired dose, then touch Apply.

Time: Used to switch the display between Time and Dose. After etching by time, it is useful to switch to dose display if you want to note the amount of dose delivered. This can be used for the next sample in etch by dose mode to repeat the same process more reliably than using etch by time.

Desired: Used to switch the display between Desired, Elapsed, and Remaining. Desired is the time you set. Elapsed is the time that has elapsed since etching started. Remaining is the time left until the desired time is reached.

Beam Energy: Used to define the accelerating voltage (0-8.0 keV). Higher beam energy etches/polishes faster, however, it also imparts more energy to the surface of the sample and thus creates more damage to the surface. It is common to start etching at high energy to remove damage caused by mechanical polishing, then lower the energy to improve the surface quality even more.

Modulation control: Used to set the modulation mode during milling process. Modulation controls the action of the guns as the sample is rotated. When modulation is set to No Modulation, both guns are on at all times. When modulation is set to Single Beam Modulation, each gun is turned on only when the front of the sample mount faces that gun. When modulation is set to Dual Beam Modulation, each gun is turned on only when the front or rear of the sample mount faces that gun. When modulation is set to Stationary Left, the left gun is on continuously, the right gun is off, and the sample does not rotate. When modulation is set to Stationary Right, the right gun is on continuously, the left gun is off, and the sample does not rotate. When modulation is set to Custom, operation is similar to Single or Dual Beam Modulation except the user may determine the exact angles that the guns are turned on and off.

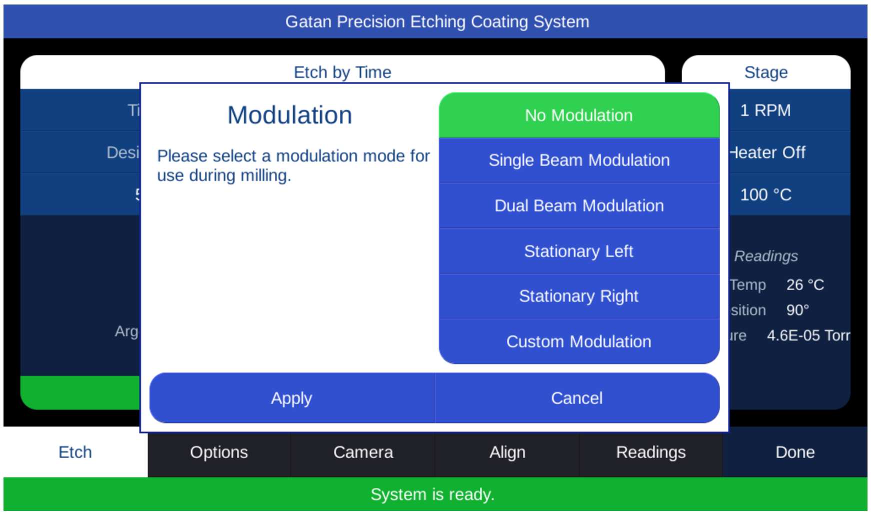


Figure 3-7. Setting Beam Modulation.

Start/Stop: Start turns on the gas flow, starts stage rotation, turns on the beam, closes the top shutter and starts the timer. Stop turns the voltage off, stops the timer, stops stage rotation, and opens the top shutter.

Gun Tilt: Displays a dialog box with number entry to set the Gun Tilt of each gun. This option is only displayed if the system has the motorized guns option.

Gun Current: Displays the current of each gun in µA. This is the current measured by the Faraday cups.

Argon Gas Flow: The amount of gas flow is shown in sccm (standard cubic centimeters per minute) for each gun and can be varied between 0 to 1.0 sccm. Typical values are between 0.05 and 0.25 sccm. Lower beam energy typically requires higher gas flow. The gas flow can be controlled automatically or manually. Note that when the Alternate gas is selected (Etch – Options page), the display will indicate Alt Gas Flow instead of Ar Gas Flow.

Etching status bar: The bar at the bottom of the Etching section shows the status of the etching process (busy, ready, etc.). This bar changes color depending on the status.

Stage RPM control: Used to set the rotation speed (rpm) during the milling process. It can vary between 0.5 and 6 rpm.

Stage Heater on/off: Used to enable or disable the stage heater. The stage heater is typically active only when the dewar is filled with liquid nitrogen (systems with cold stage option only). One use for the stage heater is to keep a sample from reaching too cold of a temperature. This can be useful, for instance, to avoid a phase transition. The primary use of the stage heater is to warm the sample prior to removing it from the system. If the sample is too cold, water will condense on the sample when it is exposed to atmosphere. The sample mount has a large thermal mass, and takes time to warm up. Gatan recommends setting the stage heater control to -30C when etching. This is cold enough that a typical sample will remain below room temperature during etching, and warm enough that the sample and mount can be raised to room temperature within about 30 minutes by using the stage heater set to 100C. The transfer process will automatically detect if the stage is below 0C when removing a sample from the system, and will heat the sample automatically. The duration and stage heater set point can be set by the user.

Stage Heater set point: Used to set the set point of the stage heater. When the temperature of the stage cold finger drops below the set point, the heater will turn on. It will turn off when the temperature rises above the set point. Note that the stage heater can only raise the temperature of the cold finger, not lower it. It is lowered by filling the dewar with liquid nitrogen.

Temperature reading: Shows the temperature at the cold conductor. This is an intermediate block between the dewar and the sample mount. This is not the sample temperature, but is proportional to the sample temperature. There is a time delay between the time the cold conductor reaches a temperature and when the sample mount reaches the same temperature.

Position reading: Shows the stage angle position in degrees. The stage home position is at 0 degrees. This is the position during sample transfer.

Pressure reading: Shows the pressure inside the work chamber and depends on the gas flow settings of the left and right guns. The units may be switched between Torr and Pascal on the Settings-General screen.

System status bar: The bar at the bottom of the etching screen shows the status of the system (busy, ready, etc.). This bar changes color depending on the status of the system.

3.1.4. *Etch Options Page*

This page is used to set options related to etch mode.

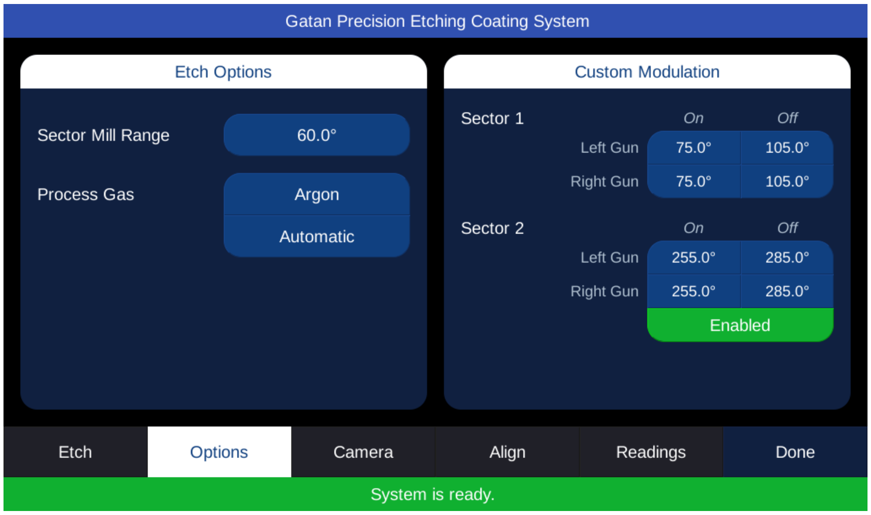


Figure 3-8. Etch options page

Sector mill range: Used to set the angular range of single and dual beam modulation sectors. A sector range of 60 degrees turns the beam on 30 degrees before the home position points directly at each gun, and turns the beam off 30 degrees after the home position points directly at each gun.

Process gas: Used to choose between the Argon gas inlet and the Alt gas inlet for the gas used in the guns. The pneumatics always use the Argon gas. Automatic/Manual is used to choose between automatic gas flow settings and Manual settings. Automatic gas flow settings are optimal values calibrated at the factory. These settings can be re-calibrated (Settings-Calibration-Gas Flow) or individual settings can be overwritten if the factory settings are found to no longer function optimally. If Manual gas flow is selected, the user must enter the gas flow setting for each gun on the Etch Main screen.

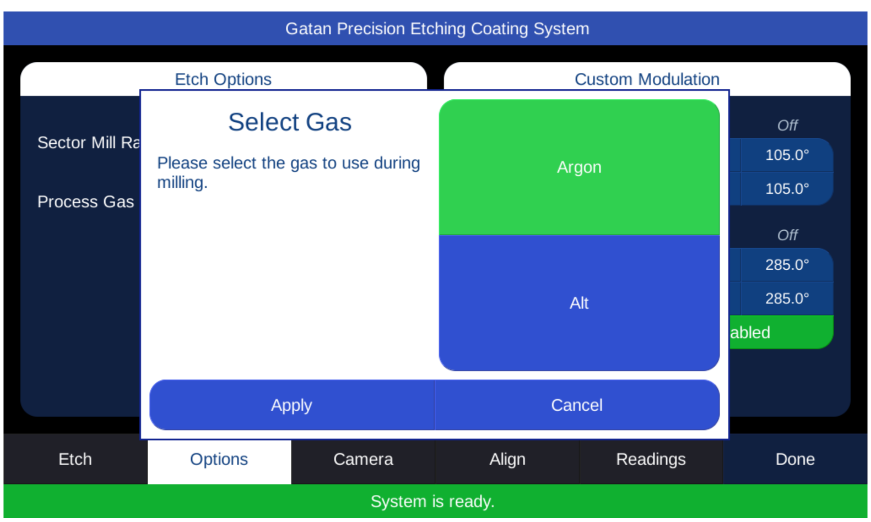


Figure 3-9. Selecting gas input

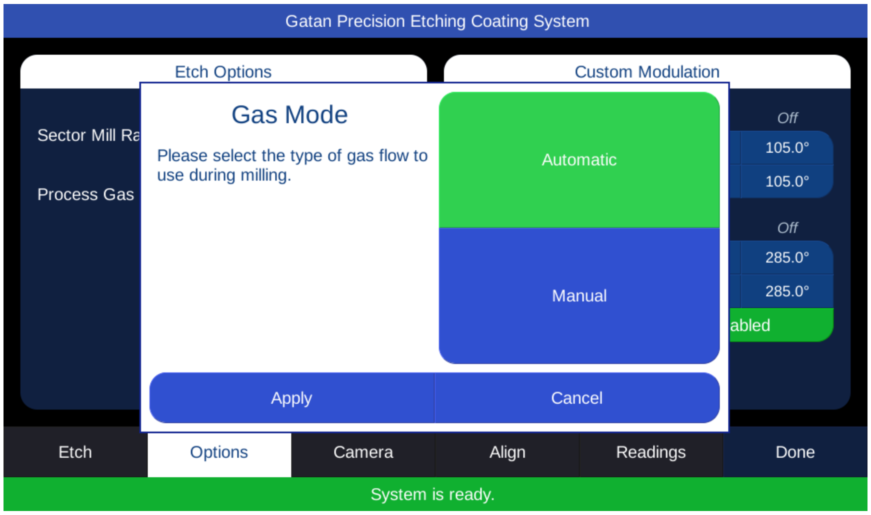


Figure 3-10. Selecting gas mode

Custom Modulation: This feature allows the user to define the start and stop angles for up to two custom defined sectors. The angle entries are the stage angles when the guns should turn on and off. Only positive angle entries are allowed.

For example, the default dual beam modulation settings would be:

Sector 1	On	Off
Left Gun	275	335
Right Gun	25	85
Sector 2	**On**	**Off**
Left Gun	95	155
Right Gun	205	265

3.1.5. *Etch Camera or View Page*

The Camera page is used to control camera acquisition in the systems that have this option and to set the illumination. In systems without a camera, this page is titled View and is used to open/close the shutter and turn on the illuminators.

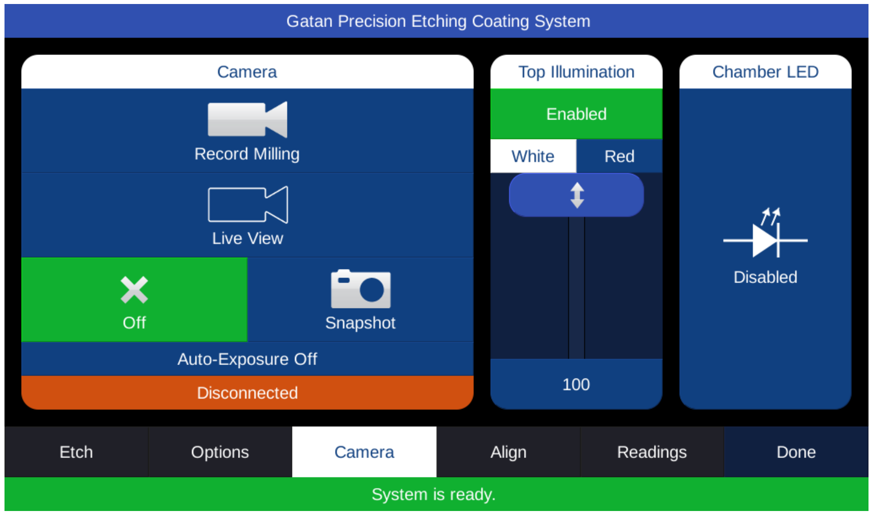


Figure 3-11. Etch Camera page

Camera tab: Is visible when the Digital Zoom Microscope option is installed. It is used to set the imaging mode in Digital Micrograph™ (DM) and to control the illuminators.

Record milling: Acquires an image every rotation. Image saving options can be changed in DM. This is a full resolution image.

Live view: Keeps the camera on at all times and gives the user a live view of the sample. This is a VGA image, either binned by 1x, 2x, or 4x depending on zoom level. This mode also opens the top shutter and turns on the top illuminator if it is enabled.

Off: Stops camera, turns off illuminator, and closes top shutter.

Snapshot: takes a snapshot. This is a full resolution image (5 MPixel). You should be in Live View mode prior to pressing this button so that the illuminators are active.

Auto Exposure: Sets auto exposure mode in DM to on/off. This is a future feature that is not functional in the current version of DM software.

Status bar: The status bar at the bottom of the Camera tab displays the status of the connection to the imaging computer and DM.

Top illumination tab: Is used to enable or disable the reflection lights (red and white) and to change their intensities (use the slider). Pressing Live View opens the shutter and turns on the illuminator according to its setting. Some systems have a two-color illuminator. If you have this option, then the color of the top illuminator may be selected between white and red. The intensity display button at the bottom of the slider may be touched in order to enter a specific intensity level (between 0 and 100%).

Chamber LED: Used to turn on/off the chamber LED so that the sample and inside of the chamber may be observed. This LED is located in the load lock over the window of the gate valve. If etching is active, it is necessary to turn on Live view in order to open the top shutter.

3.1.6. *Etch Alignment Page*

This page controls stage rotation. We define the front of the sample as the part of the sample that faces the front of the instrument when the stage is in the home position. This is the same orientation as when the sample was in the loading dock.

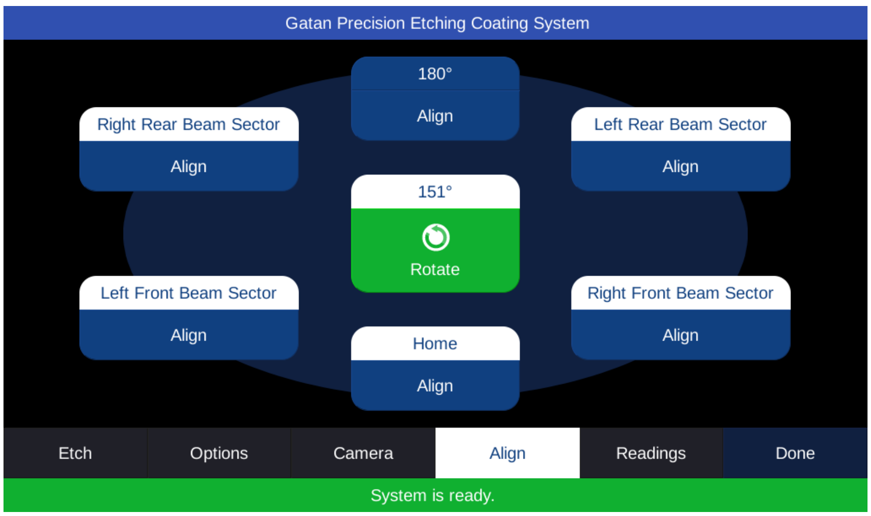


Figure 3-12 Etch alignment page

Rotate: Turns on/off stage rotation. The top of this button displays the current stage rotation angle. The green color on Rotate, shows that rotation is on.

Align Home: Aligns the stage to the home position (0 degrees).

Align Right Front Beam Sector: Aligns the stage so that the front of the sample faces the right gun.

Align Left Front Beam Sector: Aligns the stage so that the front of the sample faces the left gun.

Align Right Rear Beam Sector: Aligns the stage so that the front of the sample faces away from the right gun.

Align Left Rear Beam Sector: Aligns the stage so that the front of the sample faces away from the right gun.

Align Custom: Aligns the stage to the angle displayed at the top of this button. Press the top of this button to enter a custom angle. The default angle is 180 degrees (front of the sample faces the back of the instrument).

3.1.7. *Etch Readings Page*

This page displays high voltage power supply, MFC, and vacuum readings. Adjust Flow buttons are visible when Manual Gas Flow is set. Touching the up or down arrow will increase or decrease the gas flow for the left or right gun.

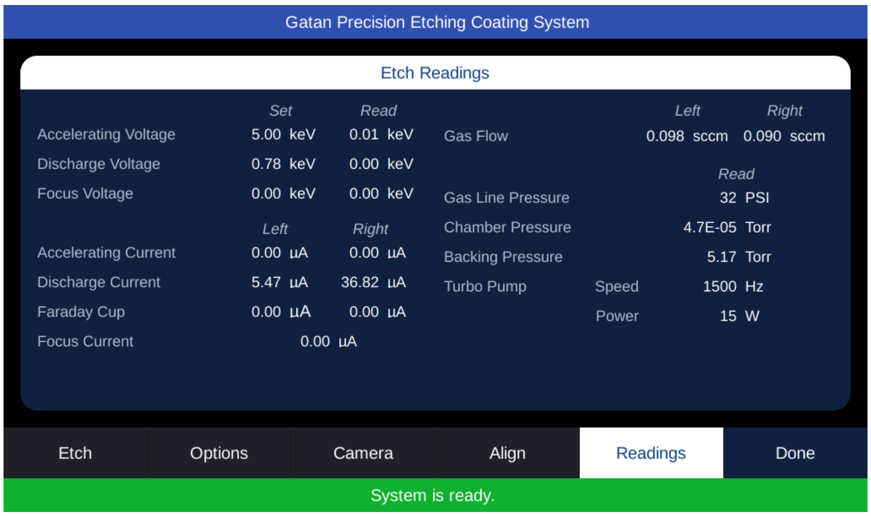


Figure 3-13. Etch readings page

Accelerating Voltage is the voltage on the anode. This is the beam energy. Discharge Voltage is the voltage between the anode and the cathode, this voltage sustains the plasma. The discharge voltage floats on top of the accelerating voltage. Focus voltage is used to focus low energy ions, and is typically only used when the accelerating voltage is lower than 3 kV. Focus current is the sum of the currents on the left and right gun focus electrodes. Accelerating current is proportional to the total beam current. It includes neutral ions in the beam and current lost to the focus electrodes and housings. Discharge current is the current through the plasma. Faraday Cup current is the current measured by the Faraday cups. This current does not include neutral ions or current that misses the Faraday cup. Gas flow is measured by the mass flow controllers. Gas line pressure is the pressure of the Argon gas. Chamber pressure is measured by the cold cathode gauge. Backing pressure is measured at the valve between the turbo pump and backing pump. Turbo pump speed and power is measured by the turbo pump controller.

Accelerating current is a better approximation of the total Argon dose than Faraday cup current because it includes neutrals. The downside to this measurement is that it over-counts because it includes the part of the beam that strikes the housing or misses the sample.

The gun maintenance screen can be used to help determine if a gun is shorted. If the discharge current in microamps is approximately equal to the discharge voltage in volts, and the accelerating current is unusually low; then the gun is likely shorted. For example, when the beam voltage is 6 kV, the discharge voltage is approximately 1100 V. If the discharge current is approximately 1100 uA and the accelerating current is significantly lower than normal for 6 kV beam voltage, then the gun is likely shorted. Note that these same conditions apply during beam modulation when the guns are between milling sectors.

3.1.8. *Coat Selection Page*

The coat selection page is displayed when etch is selected. This page allows the user to choose between coating by thickness, time, and dose. When coating by time, the system will coat for a pre-selected period of time, then stop. When coating by thickness, the crystal thickness monitor probe is monitored until the desired thickness is deposited. The crystal thickness monitor option is required for this feature. When coating by dose, the system will keep track of the beam current from both guns, and stop when a pre-selected amount of dose has been delivered. Because beam current varies between different guns and at different times, coating by dose provides for better reproducibility from one coat process to another.

Figure 3-14. Coat selection page

Once the coating mode is selected, the system will lower the stage into the coating position and start stage rotation. This will take a few seconds. Then the coat main page will be displayed.

3.1.9. *Coat Main Page*

The Coat page has several tabs across the bottom, which allow access to advanced functionality. The left-most tab selects the coat main page. Selecting the Done tab exits coat mode and returns to the Main page.

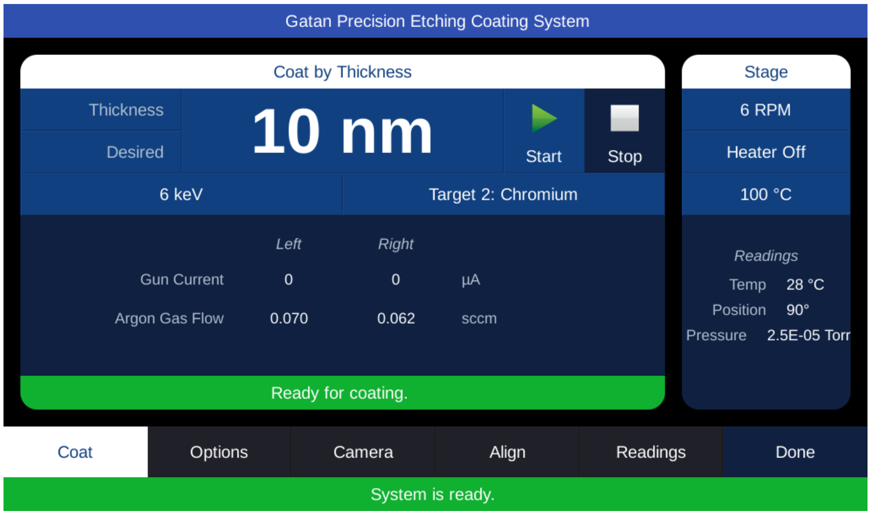


Figure 3-15. Coat by Thickness page

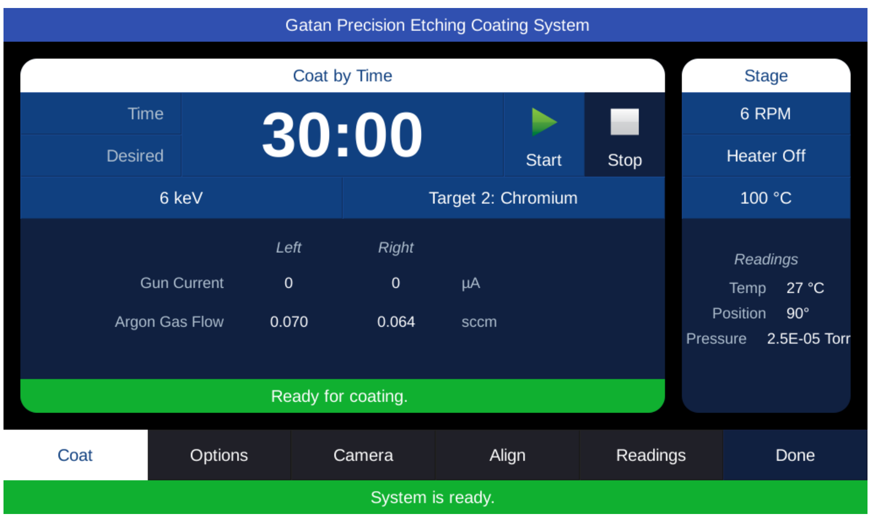


Figure 3-16. Coat by Time page

Figure 3-17. Coat by Dose page

<u>Thickness:</u> Used to set the coating thickness when using Coat by Thickness. Crystal thickness monitor option is required to use this feature.

<u>Timer:</u> Used to set the etching duration when using Coat by Time. For this, touch the Timer and enter the coating duration in the window shown below (Figure 3-18), then touch Apply.

When the system is coating and the timer times out, the voltage is turned off, the stage rotation stops, the shutter is opened, and the user is notified by a buzzer.

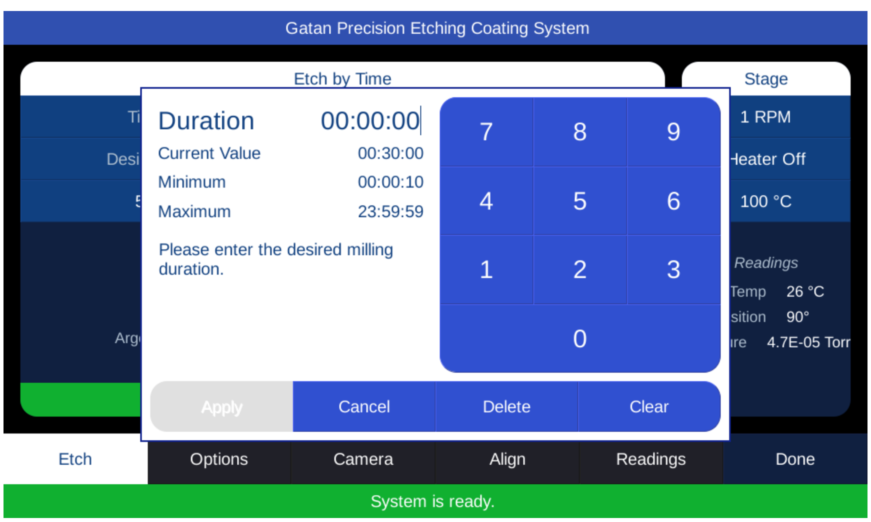


Figure 3-18 Setting etching duration.

<u>Dose:</u> Used to set the desired dose in millicoulombs (mC) when using Coat by Dose. One millicoulomb is one milliamp for one second. For this, touch the Dose display and enter the desired dose, then touch Apply.

Time: Used to switch the display between Thickness, Time and Dose. After coating by time, it is useful to switch to dose display if you want to note the amount of dose delivered. This can be used for the next sample in etch by dose mode to repeat the same process more reliably than using etch by time.

Desired: Used to switch the display between Desired, Elapsed, and Remaining. Desired is the time you set. Elapsed is the time that has elapsed since coating started. Remaining is the time left until the desired time is reached.

Beam Energy: Used to define the accelerating voltage (0-8.0 keV). Higher beam energy coats faster. Thickness of deposited material will be more reproducible if the same beam energy is used to coat all samples.

Target: Used to tell the system which target is inserted (i.e. which material is being coated). Make sure that the number visible on the target actuator matches the number of the film chosen. This is necessary when using Coat by Thickness, so the proper settings of the film thickness monitor are used.

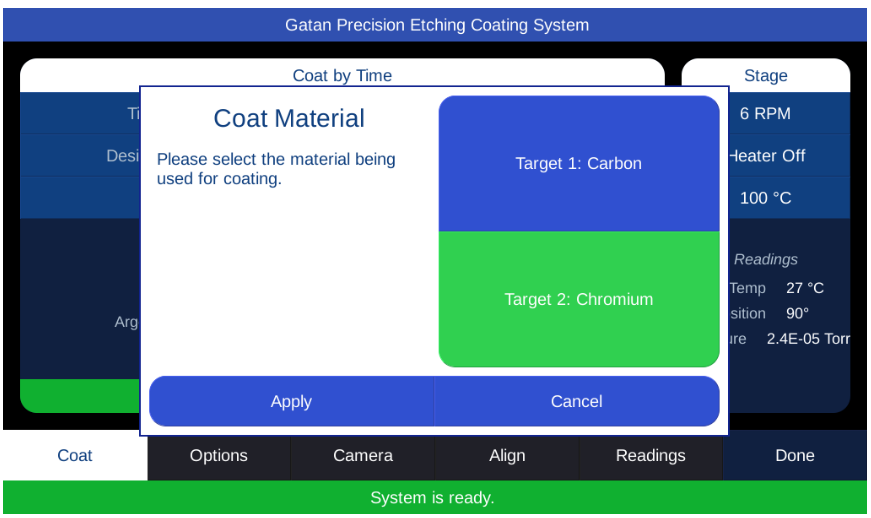


Figure 3-19. Setting the coating target.

Two targets may be installed in the system at any time. The system must be vented in order to change these targets, and the system settings must be set to indicate which two targets are installed. This is done in Settings-Targets.

Start/Stop: Start turns on the gas flow, starts stage rotation, turns on the beam, closes the top shutter and starts the timer. Stop turns the voltage off, stops the timer, stops stage rotation, and opens the top shutter.

Gun Current: Displays the current of each gun in µA. This is the current measured by the HVPS.

Argon Gas Flow: The amount of gas flow is shown in sccm (standard cubic centimeters per minute) for each gun and can be varied between 0 to 1.0 sccm. Typical values are between 0.05 and 0.25 sccm. Lower beam energy typically requires higher gas flow. The gas flow can be controlled automatically or manually. Note that when the Alternate gas is selected (Coat – Options page), the display will indicate Alt Gs Flow instead of Ar Gas Flow.

Coating status bar: The bar at the bottom of the coating section shows the status of the coating process (busy, ready, etc.). This bar changes color depending on the status.

Stage RPM control: Used to set the rotation speed (rpm) during the milling process. It can vary between 0.5 and 6 rpm.

Stage Heater on/off: Used to enable or disable the stage heater. The stage heater is typically active only when the dewar is filled with liquid nitrogen (systems with cold stage option only). One use for the stage heater is to keep a sample from reaching too cold of a temperature. This can be useful, for instance, to avoid a phase transition. The primary use of the stage heater is to warm the sample prior to removing it from the system. If the sample is too cold, water will condense on the sample when it is exposed to atmosphere. The sample mount has a large thermal mass, and takes time to warm up. Gatan recommends setting the stage heater control to -30C when etching. This is cold enough that a typical sample will remain below room temperature during etching, and warm enough that the sample and mount can be raised to room temperature within about 30 minutes by using the stage heater set to 100C. The transfer process will automatically detect if the stage is below 0C when removing a sample from the system, and will heat the sample automatically. The duration and stage heater set point can be set by the user.

Stage Heater set point: Used to set the set point of the stage heater. When the temperature of the stage cold finger drops below the set point, the heater will turn on. It will turn off when the temperature rises above the set point. Note that the stage heater can only raise the temperature of the cold finger, not lower it. It is lowered by filling the dewar with liquid nitrogen.

Temperature reading: Shows the temperature at the cold conductor. This is an intermediate block between the dewar and the sample mount. This is not the sample temperature, but is proportional to the sample temperature. There is a time delay between the time the cold conductor reaches a temperature and when the sample mount reaches the same temperature.

Position reading: Shows the stage angle position in degrees. The stage home position is at 0 degrees. This is the position during sample transfer.

Pressure reading: Shows the pressure inside the work chamber and depends on the gas flow settings of the left and right guns. The units may be switched between Torr and Pascal on the Settings-General screen.

System status bar: The bar at the bottom of the coating screen shows the status of the system (busy, ready, etc.). This bar changes color depending on the status of the system.

3.1.10. *Coat Options Page*

This page is used to set options related to coat mode.

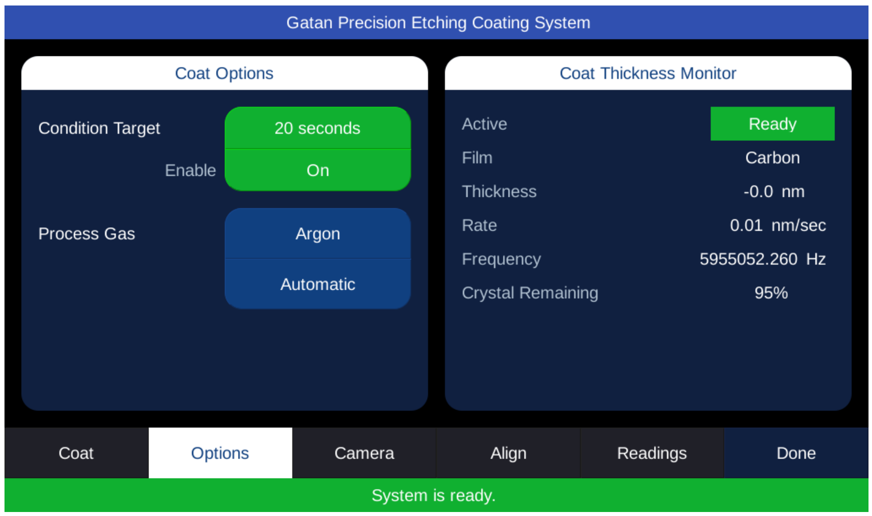


Figure 3-20. Coat > Options page

Condition target: Used to enable/disable conditioning of the target at the start of coating. If enabled, the system will close the coat shutter so that sputtered material does not land on the sample, then coat for the time selected. Conditioning is only performed the first time a new sample is coated. A new sample is implied by a transfer in sequence.

Process gas: Used to choose between the Argon gas inlet and the Alt gas inlet for the gas used in the guns. The pneumatics always use the Argon gas. Automatic/Manual is used to choose between automatic gas flow settings and Manual settings. Automatic gas flow settings are optimal values calibrated at the factory. These settings can be re-calibrated (Settings-Calibration-Gas Flow) or individual settings can be overwritten if the factory settings are found to no longer function optimally. If Manual gas flow is selected, the user must enter the gas flow setting for each gun on the Coat Main screen.

Coat Thickness Monitor: Displays the readings from the film thickness monitor controller.

3.1.11. *Coat Camera Page*

The Camera page is used to control camera acquisition in the systems that have this option and to set the illumination. In systems without a camera, this page is titled View and is used to open/close the shutter and turn on the illuminators. This page is identical to the Etch Camera page and is described in section 3.1.5.

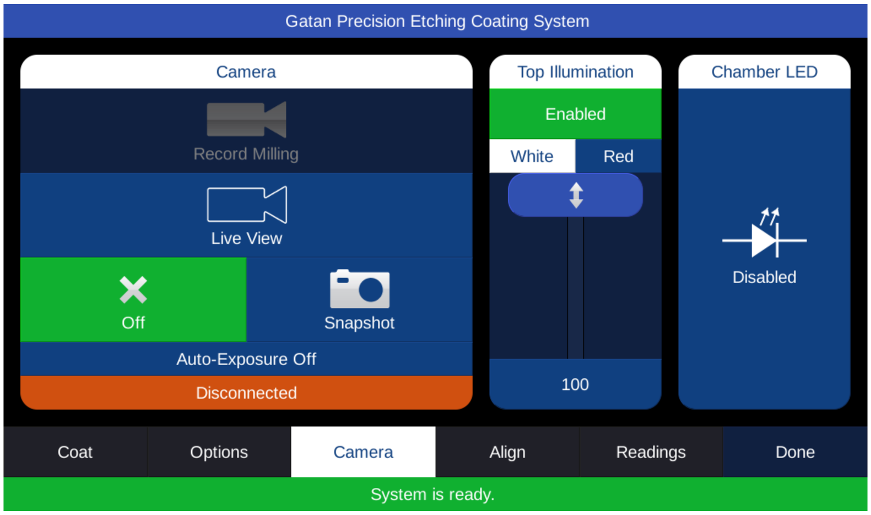


Figure 3-21. Coat > Camera page

3.1.12. *Coat Alignment Page*

This page controls stage rotation. We define the front of the sample as the part of the sample that faces the front of the instrument when the stage is in the home position. This is the same orientation as when the sample was in the loading dock. This page is identical to the Etch Camera page and is described in section 3.1.6.

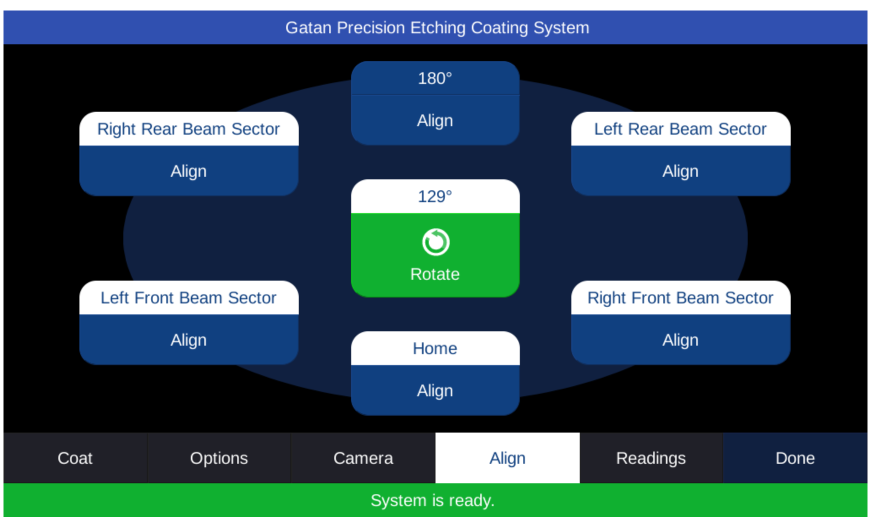


Figure 3-22. Coat > Alignment page

3.1.13. ***Coat Readings Page***

This page displays high voltage power supply, MFC, and vacuum readings. Adjust Flow buttons are visible when Manual Gas Flow is set. Touching the up or down arrow will increase or decrease the gas flow for the left or right gun. This page is identical to the Etch Readings page and is described in section 3.1.7.

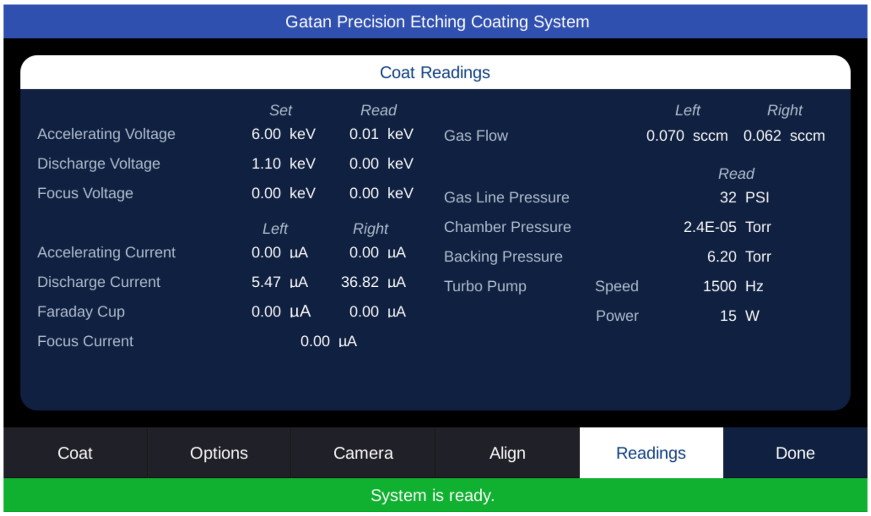


Figure 3-23. Coat > Readings page

3.1.14. ***Devices Page***

The devices page allows control of certain hardware devices, such as the cold stage heaters, the vacuum system, and the chamber LED.

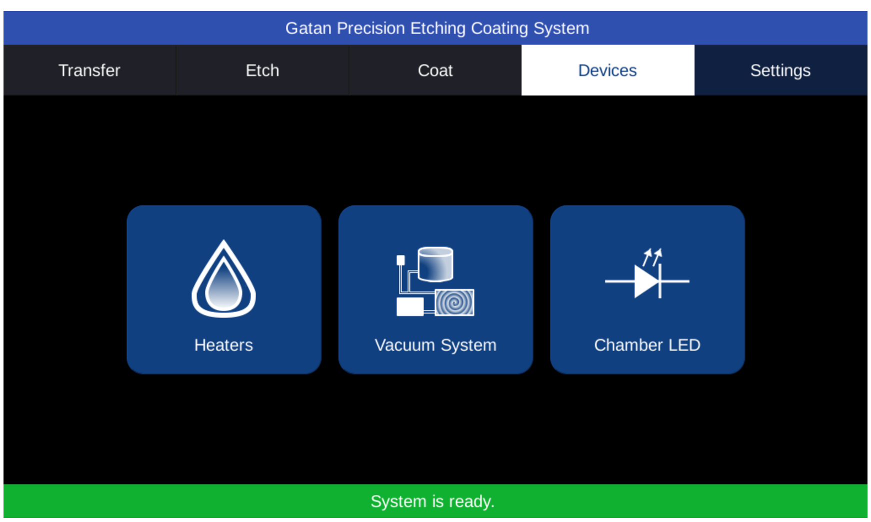


Figure 3-24. Devices Page

3.1.15. ***Devices Heaters Page***

This page controls the cold stage heaters. This option is only functional in systems with a cold stage.

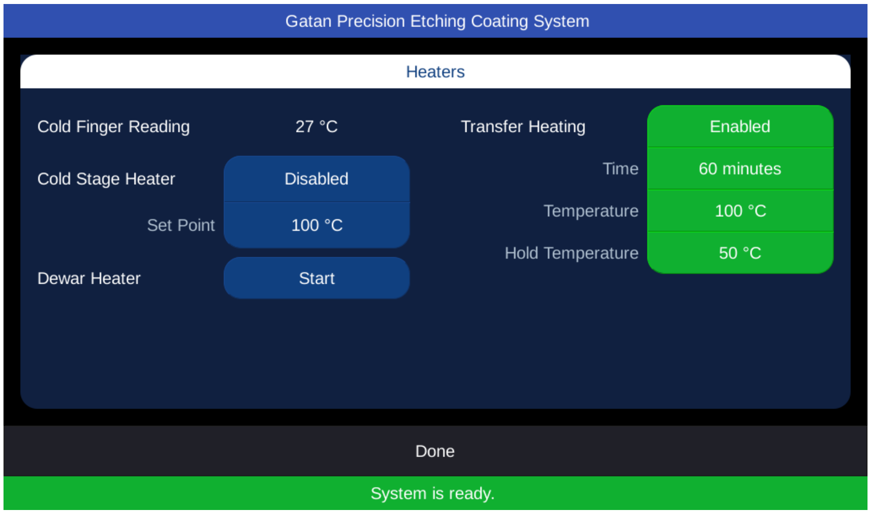


Figure 3-25. Devices > Heaters Page

Cold Finger reading: Displays the temperature of the cold conductor.

Cold stage heater: Turns the heater on and off. If the heater is enabled and the temperature drops below the heater set point, the heater is turned on until the temperature is above the set point, thereafter that temperature is maintained.

Dewar heater: Activates the dewar heater. This heater stays on continuously until the Cold Finger Temp reaches 25° C, then holds the temperature at 25° C for ~15 minutes, then shuts off. The stage heater must be off before starting this heater.

Transfer Heating: Used to automatically warm up a sample when it is transferred out of the system. This is done to minimize the chance of condensation when the sample is exposed to atmosphere. This heating is only performed if the cold conductor temperature is below 0 C at the start of a Transfer Out sequence.

In the example shown in Figure 3-25, the following will execute during a transfer out sequence if the cold conductor temperature is below 0° C: the stage heater will automatically be set to 100° C and held for 60 minutes, then it will be set to 50° C and held at that temperature until the user finishes the transfer sequence.

Gatan recommends the following settings:

- Enabled
- Time = 30 minutes
- Temperature = 100 C
- Hold temperature = 23 C

Transfer Heating Time: The time that the heater is active at the Temperature set point. Transfer Heating must be enabled, and the temperature of the cold conductor must be below 0 C.

Transfer Heating Temperature: The temperature that the heater is set during the Heating Time.

Transfer Heating Hold Temperature: After the programmed time at the Temperature set point, a hold set point is programmed and maintained until the remainder of the transfer sequence is performed. Typically this is set to room temperature.

3.1.16. *Devices Vacuum System Page*

This screen is used to control and monitor the vacuum pumps and gauges.

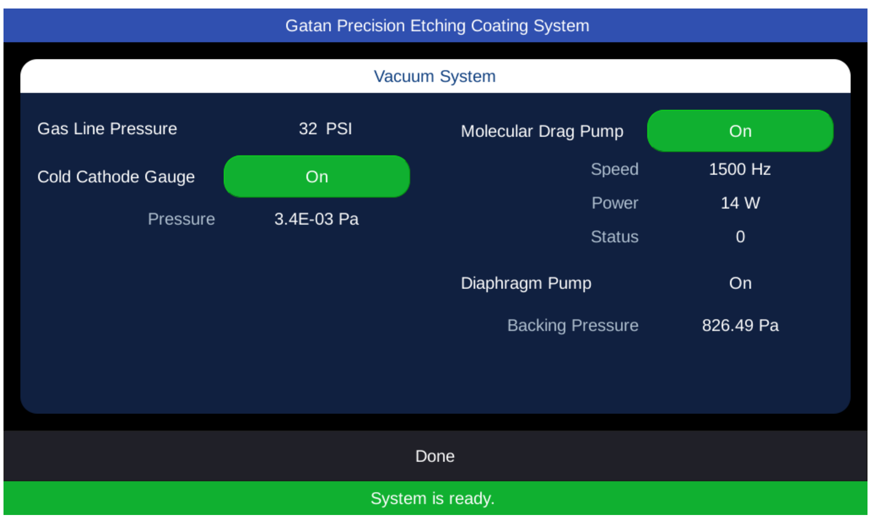


Figure 3-26. Devices > Vacuum System page

Cold Cathode Gauge: On/Off controls the power to the CC gauge. The power is automatically turned off when the MDP speed is less than 1275 Hz. Pressure displays the pressure measured by the gauge.

Molecular Drag Pump: On/Off controls the pump. Speed displays the rotational speed of the pump, where the nominal speed is 1500 Hz. Power displays the power drawn by the MDP. Status shows any errors (0= none).

Diaphragm Pump: On/Off controls power to the pump. This control is disabled when the MDP is on, so the DP cannot be turned off if the MDP is on. Backing Pressure displays the pressure measured in the backing line. When this pressure is higher than 10 Torr, the DP is set to full speed, when it is less than 10 Torr the DP is set to half speed. This reading is used to determine when the airlock is pumped out sufficiently for the stage to be lowered.

Gas Line Pressure: Measures the pressure of the Argon gas inlet line. If the pressure is outside of the acceptable range, an error message will be displayed and the system will not mill.

3.1.17. *Devices Chamber LED*

This button activates the chamber LED.

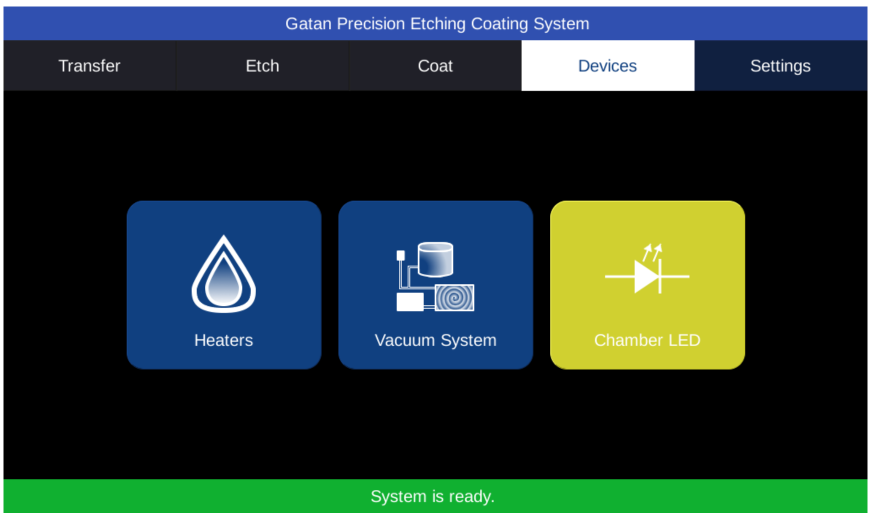


Figure 3-27. Devices chamber LED

3.1.18. *Settings General Page*

This screen is used for general settings. Pressing Home exits the Settings screen and returns to the Main page.

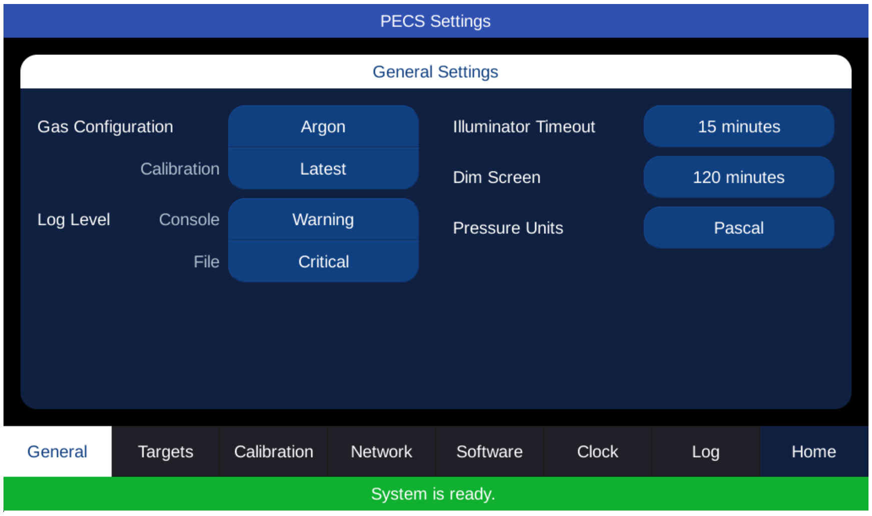


Figure 3-28 General Settings page.

Illuminator timeout: This timer starts when the user touches the View button. When it times out, the shutter closes and the illumination is turned off.

Dim Screen: When the touch screen has not been touched for this time, the screen will be dimmed.

Pressure units: Torr or Pascal.

Gas: allows the user to choose between Ar and Alternate Gas to be used for the guns. The default is Ar. Alternate is chosen by activating the Alternate Gas valve. If Alternate is selected, an alternate gas must be connected to the Alt input on the rear panel of the cabinet.

When Argon is chosen, the button just below is highlighted in blue. You may then choose between 3 calibration modes: Latest, Factory, and Safe. Latest mode uses the latest calibration values. These values are overwritten when the gas flow is calibrated . By selecting Factory mode, the system is returned to the values calibrated at the factory. Selecting Safe mode sets the gas flow to a set of values that will generally work on any gun, but are not optimized for that gun. For instance, if the calibration routine is run when the guns are not fully degassed, then once the guns are degassed they will not operate properly. If the calibrated values are not working well, selecting the Safe mode will set the system to a mode where both guns operate at all voltages.

3.1.19. *Settings Targets Page*

This page is used to define which targets are installed in the system. Any time targets are physically changed, this screen must be updated. This feature is only used with the film thickness monitor option during coating by thickness.

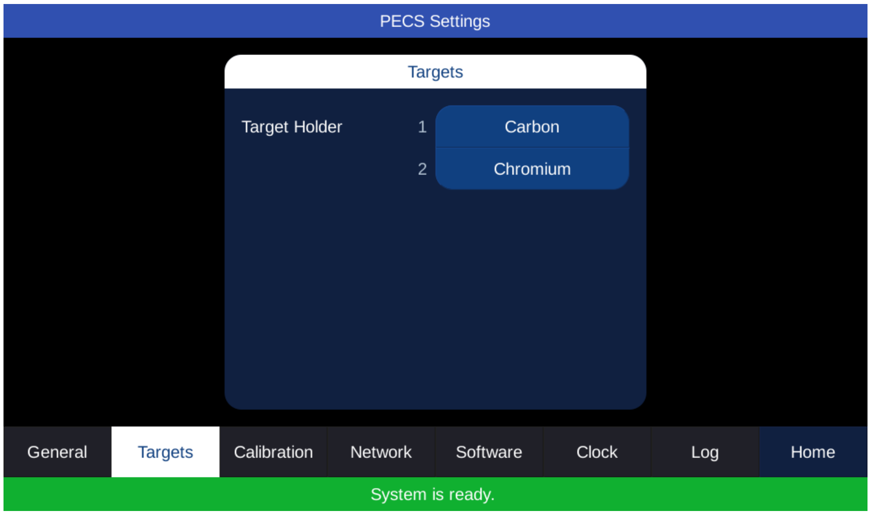


Figure 3-29. Settings > Targets page

To set the material for a target holder, select the button next to the target number. Choose the material from the list of available materials, then touch Apply. Film thickness monitor parameters are stored for that material, so the thickness readings are as accurate as possible.

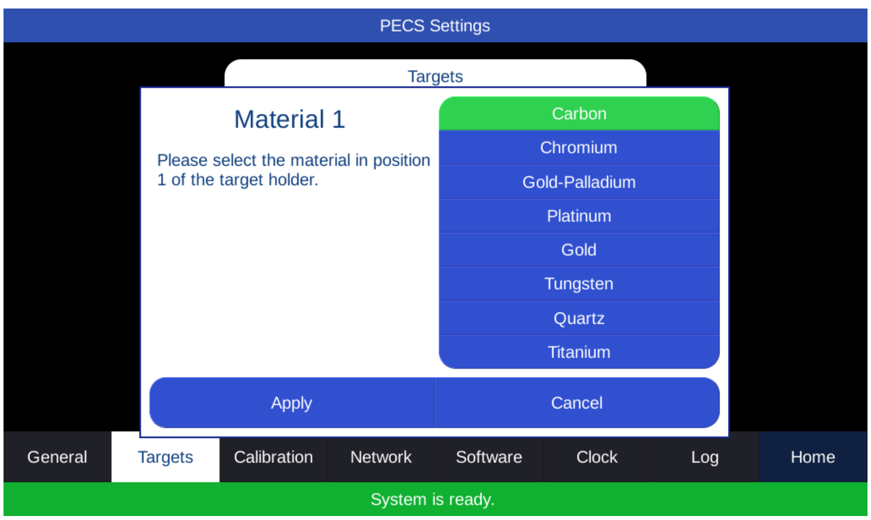


Figure 3-30. Defining a target material

3.1.20. *Settings Calibration Page*

Gas Flow Calibration

Figure 3-31. Gas Flow Calibration Page

This is performed at the factory and is not generally needed unless something changes dramatically in a gun. When Create All is selected, the optimum gas flow for each gun will be measured and saved at different beam energies. (this takes 2-3 hours) These values are used when "Automatic gas flow" control is selected. If the guns have been changed or if it is observed that the automatic gas flow settings do not produce good results, then this calibration may be run.

Individual settings in the calibration table may be set manually using this screen. First choose a Calibration Point: point 1 = 250 eV, point 2 = 500 eV, …, point 10 = 8 keV. Next select the sccm button for the left gun (left sccm button), and set it to the desired value. Then select the sccm button for the right gun, and set it to the desired value. Repeat for all Calibration Points that you would like to change.

An automatic gas flow curve for a single Calibration Point may also be run. First remove any sample posts, and lower the piston. Next select the Calibration Point. Next press Recalibrate.

Zero Controllers is a function to remove offset errors in the mass flow controllers. This is not normally needed unless requested by Gatan service.

Gun angle calibration

This is only available for systems with motorized guns. To calibrate the motorized gun angles:

1. Touch Maintenance – Guns – Gun Tilt

2. Manually set both guns to 18 deg, write down the dac readings displayed.

3. Manually set both guns to 0 deg, write down the dac readings displayed.

4. Touch Calibrations – Guns

5. Enter the dac readings for the appropriate settings.

6. Touch Maintenance – Guns – Gun Tilt

7. Verify that both guns can be set within the full range of 0 to 18deg.

Figure 3-32 Motorized gun calibration.

Stage position

This page is used for calibrating the stage home position.

1. **Lower piston.**

2. **Go to the Alignment page.**

3. **Watch the stage rotate, when it gets to the home position press Rotate. If it does not stop exactly at the home position, repeat.**

4. **Go to the Calibrate -- Stage screen. Note the Current Encoder Position. Press the Index button. Enter the current encoder position noted above.**

5. **Go to Alignment screen, press Rotate, then press Home.**

6. **Verify that the position is correct.**

Figure 3-33 Stage home position calibration.

Temperature

This sensor measures the temperature of the cold conductor. To calibrate, press the blue temperature button and enter the actual temperature of the cold conductor.

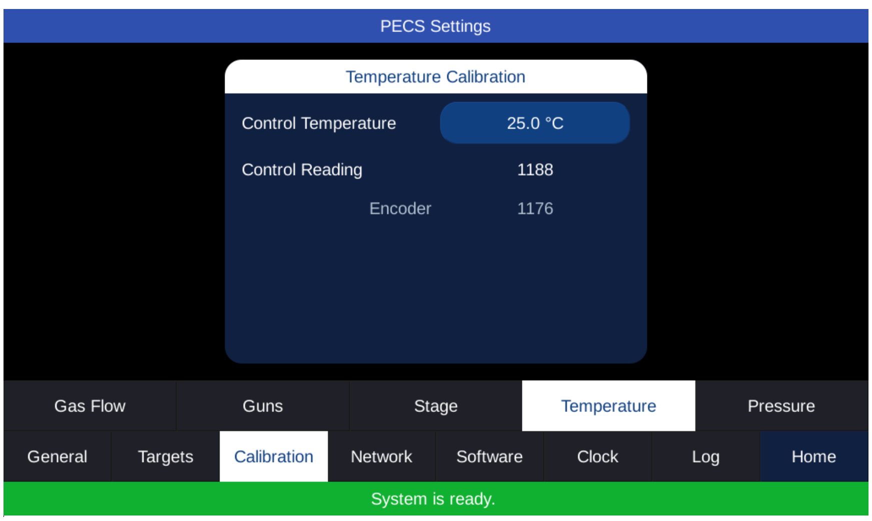


Figure 3-34 Temperature sensor calibration.

Pressure

The gauges in this unit are factory calibrated and ready to use. Calibration is a multi-step procedure requiring the connection of external control equipment and calibration should only be performed at the instruction of Gatan service. If gauges need to be calibrated in the field, it is best to set them to the default calibration.

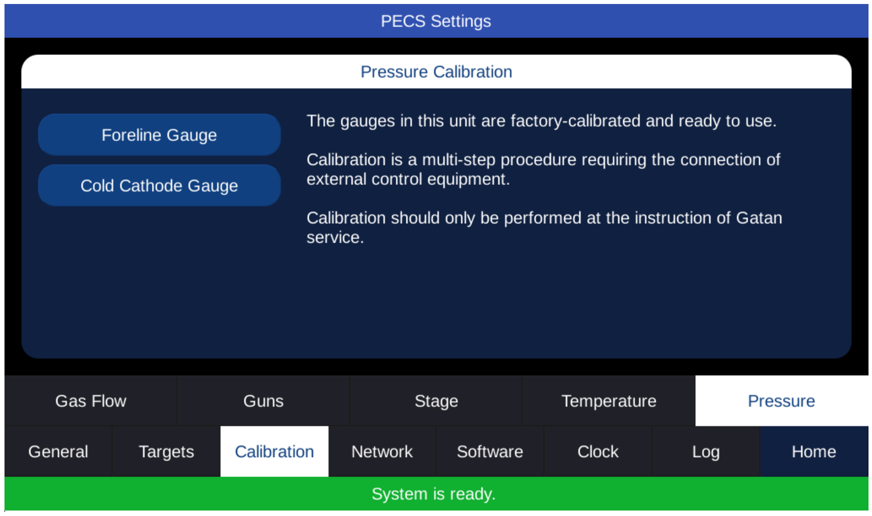


Figure 3-35 Pressure calibration.

Foreline Gauge: This gauge measures the pressure in the line leading to the diaphragm pump. It normally is measuring the backing pressure, but when the airlock is pumped out it measures the airlock pressure. This should not need to be calibrated in the field (Default | Apply).

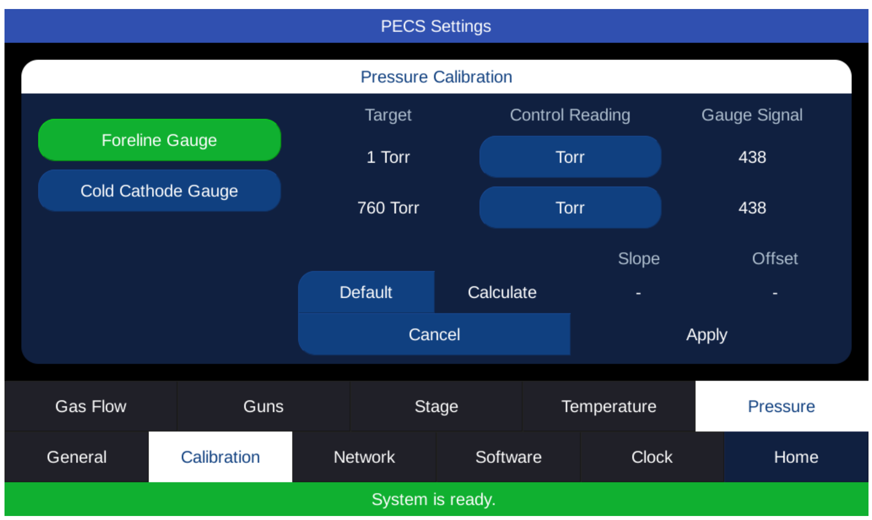


Figure 3-36 Foreline gauge calibration.

Cold cathode gauge: This gauge measures the work chamber pressure. It is turned on when the MDP speed is above 1250 rpm. This should not need to be calibrated in the field.

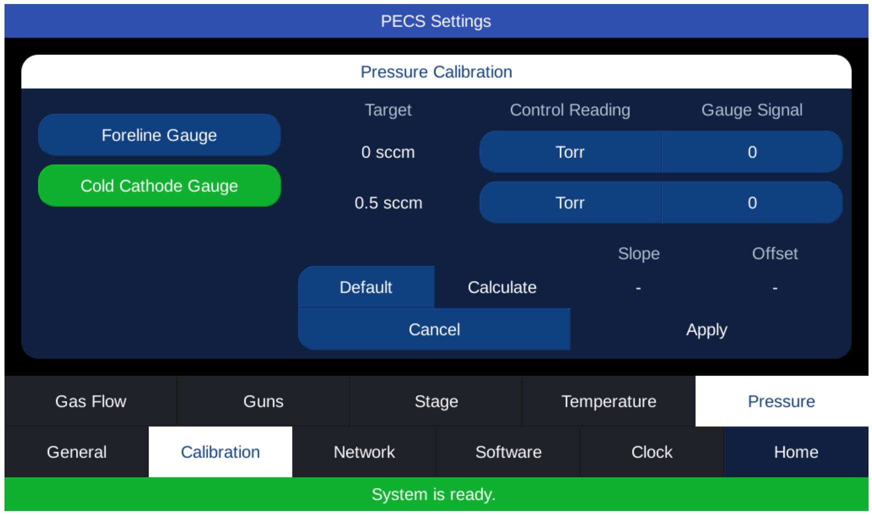


Figure 3-37 Cold Cathode gauge calibration.

3.1.21. *Network Page*

This displays the network settings for the PECS II. These setting are set at the factory and cannot be adjusted.

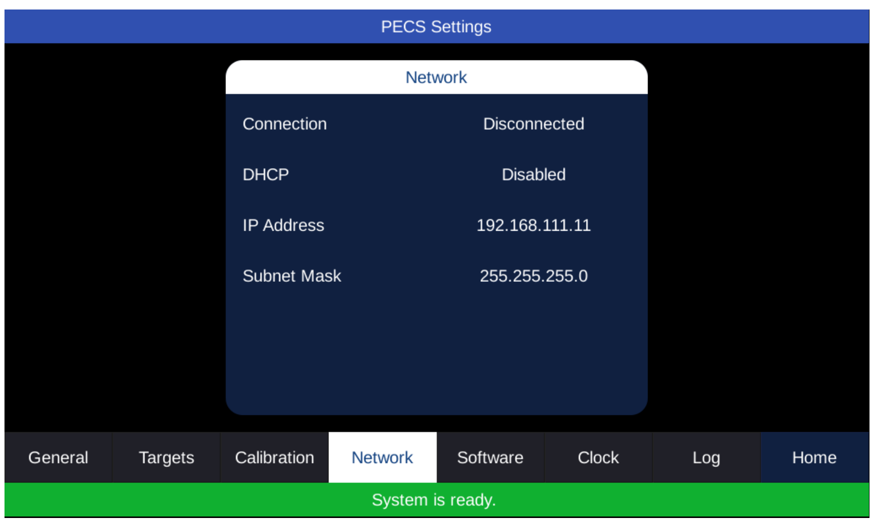


Figure 3-38 Settings > Network page.

3.1.22. *Software Page*

Software Version

This page shows the latest software version and the date it has been last updated.

In order to update the software, plug in a USB flash drive in the back of the PECS II. This drive should have 2 files in its root directory, ending in .swimg and .fwimg. Wait a few moments for it to register and then touch “Update”. After successful installation of the updated version, a message will appear on the screen to notify the user to restart the PECS II. At this time turn the power off, wait a few seconds, then turn the power on. The power switch is located on the back of the instrument.

The latest software and firmware revisions can be found at: ftp.gatan.com\public\software\SpecimenPrep Download the zip file and unzip it to the root of a USB flash drive.

Not all flash drives are supported. It may take some experimentation to find a drive that works. Try pausing and pressing Update more than once, some drives do not always work on the first attempt.

The “Export Support Files” button copies configuration files to a USB flash drive (gatan_export directory) that must first be inserted into the USB port on the back of the system. These files may be useful to service personnel when troubleshooting. A service person can modify these files and restore them to the system using a diagnostic shell command.

Software Configuration

This page configures the software for system options. If the system has any of these options, the button to the right of that option should be set to Included. Certain pages in the user interface change depending on which options are included.

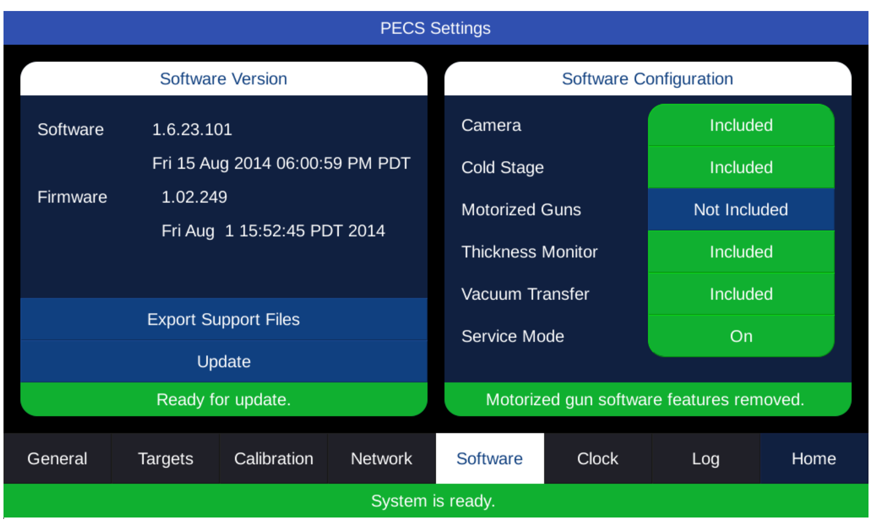


Figure 3-39 Software maintenance page.

3.1.23. *Clock Page*

Set the date and time on this page. Note that the system clock does not automatically adjust for daylight savings time.

Figure 3-40 Clock page.

3.1.24. *Maintenance Log Page*

This page displays the maintenance log. There are two numbers for every entry, a permanent number and a temporary number. The permanent number is a log since the instrument was built, and the temporary number is recorded since it was last reset. For instance, if the diaphragm pump membranes are replaced, the user should reset the temporary log. Similarly the gun hours may be reset if a gun is replaced or cleaned. This log is stored in flash memory on the CPU board, and will be reset if that board is replaced.

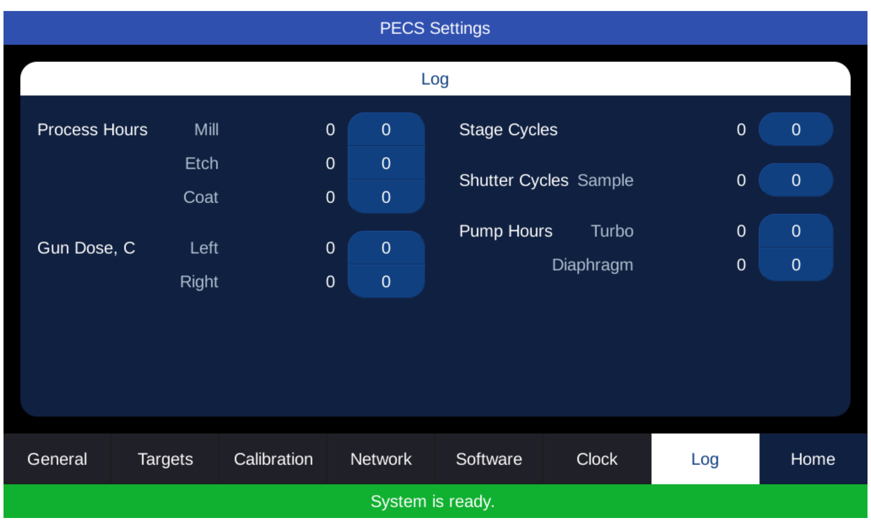


Figure 3-41. Maintenance Log Page

3.2. Start-up Procedure

Turn on the power to the PECS II. The molecular drag pump (MDP) will start immediately and the diaphragm pump (DP) will start after about 30 seconds.

Once the operating system has booted up, the Main page will be displayed. The cold cathode pressure reading will turn on when the MDP is at about 85% of full speed. Wait for the MDP to spin up fully (1500 Hz) before inserting a sample (Devices-Vacuum System).

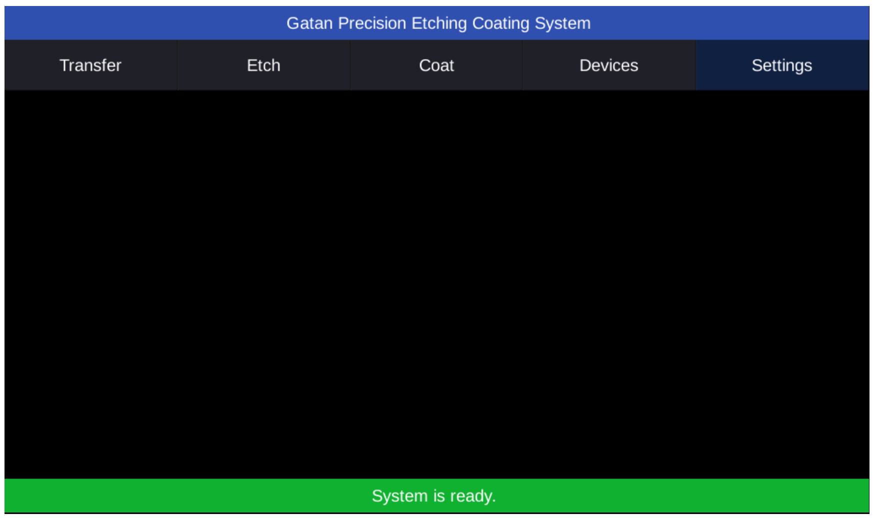


Figure 3-42. Main page

3.2.1. *Ion-gun Purging*

The PIGs are very efficient and operate with an extremely low gas throughput. However, even when the argon gas flow to the guns is turned off, small amounts of out-gassing from materials in the ion guns will produce significant ion currents (discharge current >10 µA). In extreme cases, out-gassing will result in sudden bursts of ionization that make the PIGs unstable in operation. To minimize this effect, the PIGs must be purged with dry argon. Typically, this is necessary whenever the gun components have been exposed to a poor vacuum, i.e., whenever the PECS II has been switched off for more than 4 hours or the chamber has been vented. In addition, the automatic gas flow settings are valid only after the guns have been purged thoroughly.

The gas flow settings are set to 0.3 sccm on start-up in order to facilitate purging. Once the guns have been operated, the gas flow will be reset to their automatic values. If further purging is needed, it is recommended that the gas flow of both guns be set to 1.0 sccm using the Manual mode. Gas flow will not likely be stable above 0.3 sccm, but this is acceptable during purging.

Once purging is complete, manually set the gas flow to 0.1sccm for both guns, and then set the gas flow back to Automatic mode.

To Purge the Guns Manually

Switch the gas flow to manual, and set both guns to 1.0 sccm. Purge for about 15 min if the guns have been under vacuum. Purge for 4 hours minimim if the system has been vented to atmosphere. In any case, purging should be continued until a gun current of <10 µA is obtained with an accelerating voltage of 5.0 keV and the gas flow turned off to both guns (manual gas flow = 0 sccm). For best results, it is recommended that maintenance be performed at the end of the day, and the guns be purged overnight.

Guns may be purged at up to 1.0 sccm, however, gas flow will not likely be stable above 0.3 sccm, but this is acceptable during purging.

3.3. Specimen Mounts

Several types of specimen mount are available. Some, but not all, of these are standard accessories.

3.3.1. *Adjustable height, rotatable mount*

Two versions of this mount are available. One is for samples from 0 to 10 mm tall (Specimen Mount, Tall), and the other is for samples from 10 to 20 mm tall (Specimen Mount, Short). These mounts have a flat surface for attaching a sample with an adhesive, such as double sided tape or Silver paint. There are two lines scribed into the surface as an aid to help mount the sample with the region of interest in the center of the mount. The tall mount has a central hole to ac**ce**pt a 3.2mm pin stub.

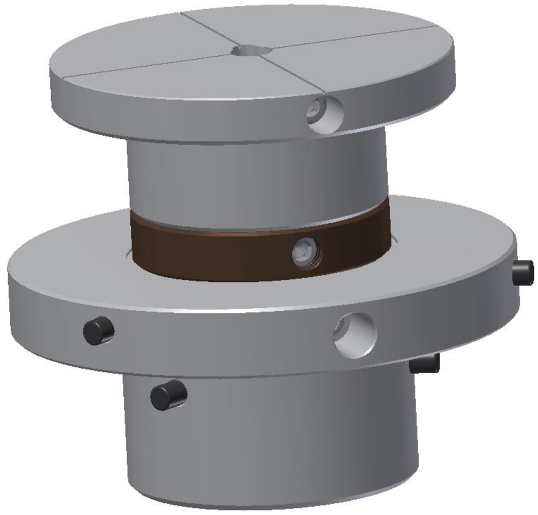


Figure 3-43. 685.08530 Specimen Mount, Tall, Rotatable

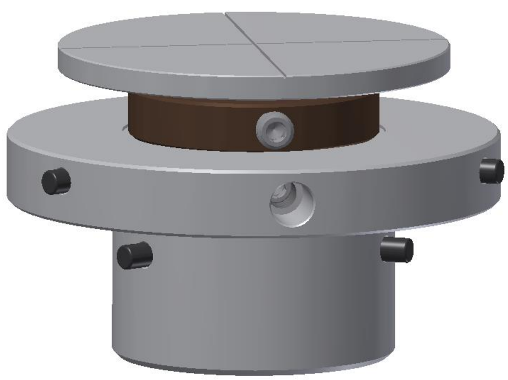


Figure 3-44. 685.08520 Specimen Mount, Short, Rotatable

3.3.2. *Cross-section Ilion$^+$ blade mount*

This mount holds a standard Gatan Ilion$^+$ blade. This is used for preparing cross sectional samples. A set screw fixes the blade to the mount. The blade should be installed so that the sample is mounted on the back side (away from the set screw).

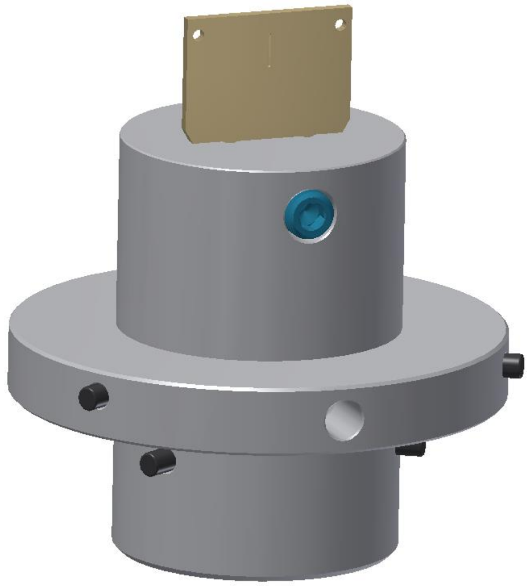


Figure 3-45. 685.08540 Specimen Mount, Ilion

3.3.3. *Vise mount*

This mount has two adjustable plates that can be used to hold a sample in a vertical orientation. For instance, it can be used to hold a Silicon wafer so that the edge can be etched.

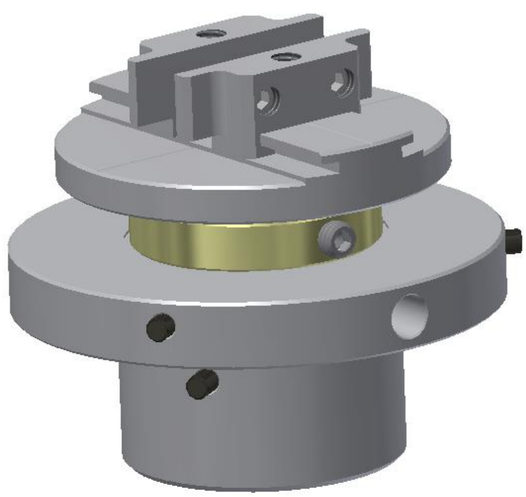


Figure 3-46. 685.08514 Specimen Mount, Vise

3.3.4. *Metallographic mount*

This mount has a recessed round hole for holding a 25.4 mm round metallographic sample. A set screw holds the sample in place.

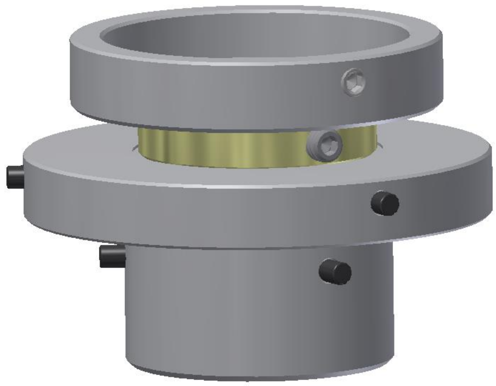


Figure 3-47. 685.08560 Specimen Mount, Metallographic

3.4. Loading Dock

IMPORTANT - The Loading Dock accessory contains a Class II Laser / wavelength 400-700 nm, operating at a maximum emission of 0.6 mW/cm^2. See the Regulatory Pamphlet for more details.

WARNING: LASER RADIATION. DO NOT STARE INTO BEAM.

The loading dock has two purposes. The first is to set the height of the sample to the eucentric height of the guns. The second is to enable the transfer device to pick up and place sample mounts.

It is critical that samples be set to the proper height prior to etching, so that the ion beams strike the center of the sample.

A laser beam is directed across the surface of the sample, and impinges on a photodetector. LEDs indicate the intensity of the laser as measured by the photodetector. When the sample is at the proper height one of the green LEDs in the center of the array will be lit. It is preferable for the center green LED to be lit, but any of the three green LEDs are acceptable.

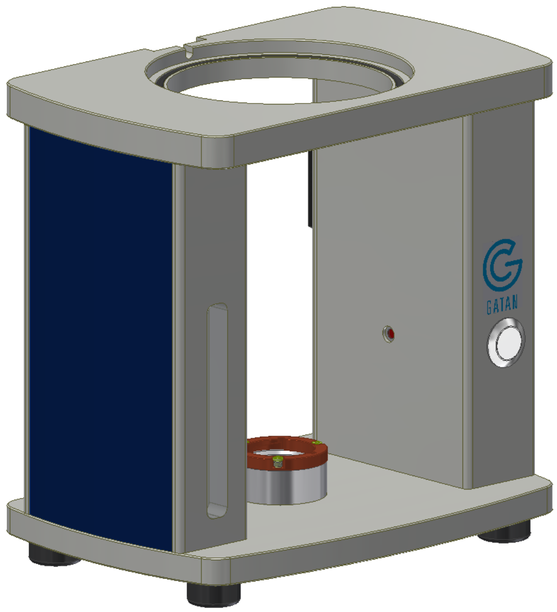


Figure 3-48 Loading dock.

3.4.1. ***Mounting a sample***

- It is best to mount the sample under a stereo microscope.
- Place a removable adhesive, such as double-sided tape or Silver paint on the surface of the mount.
- Place the sample on the mount so that it is in contact with the adhesive and the region of interest is centered in the mount as designated by the cross scribed into the mount.
- If applicable, wait for the adhesive to cure.

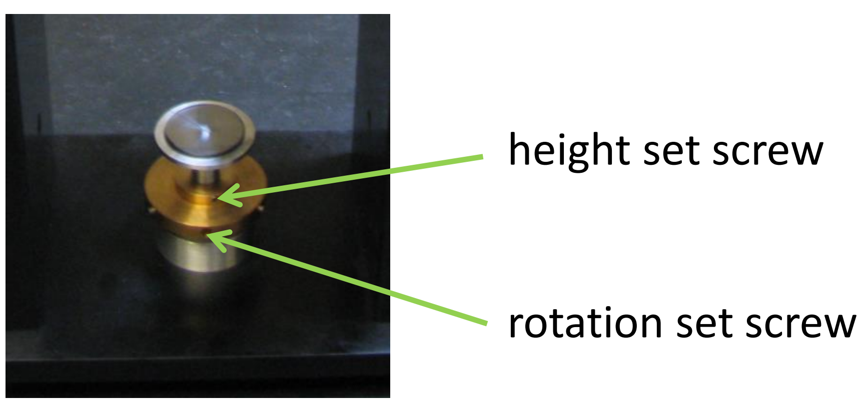


Figure 3-49 Sample mounted with interest area centered.

3.4.2. *Setting the height of a sample*

- Place the sample mount into the loading dock. Rotate the mount counterclockwise until it clicks into place, so that the horizontal hole on the largest diameter is facing forward.
- Press the power button on the loading dock.
- Loosen the set screw to allow the height to be adjusted. (top set screw)
- Rotate the mount surface to adjust the height until one of the center green LEDs is lit (preferably the center one).
- Gently tighten the set screw. If a different LED is now lit, loosen the screw and adjust until the desired LED is lit after tightening.
- Loosen the rotation set screw (bottom set screw) and rotate the sample platform to the desired orientation. This is important when beam modulation is used. Tighten the set screw. Re-check the height setting.
- The loading dock power will turn off automatically after about 3 minutes.

3.4.3. *Picking up a sample mount with the Transfer Device*

- Place the transfer device onto the loading dock, with the Tee aligned to the slot in the back of the loading dock.

Figure 3-50. Transfer device on loading dock

- Loosen the locking knob on the side of the transfer device.
- Place one hand on the transfer device and with the other hand grasp the knob at the end of the transfer shaft and lower the arm.
- Note the pin near the top of the shaft. Rotate the shaft so that this pin enters through the left notch in the top of the housing. Lower the shaft until it stops.

Figure 3-51. Transfer device grasping sample mount

- Rotate the shaft counter clock-wise until it stops. (about 75 degrees)
- Hold the transfer device with on hand, and with the other hand lift the shaft (and the sample mount) until it stops.

Figure 3-52. Transfer device lifting sample mount

- Tighten the locking knob on the side of the transfer device.

3.4.4. *Placing a sample mount with the transfer device*

- Place the transfer device onto the loading dock, with the Tee aligned to the slot in the back of the loading dock.
- Loosen the locking knob on the side of the transfer device.
- Place one hand on the transfer device and with the other hand grasp the knob at the end of the transfer shaft and lower the arm.
- Note the pin near the top of the shaft. Rotate the shaft so that this pin enters through the right notch in the top of the housing. Lower the shaft until it stops.
- Rotate the shaft clock-wise until it stops. (about 75 degrees)
- Lift the shaft until it stops. The sample mount should remain in the loading dock.
- Tighten the locking knob on the side of the transfer device.

3.5. Specimen Loading and Unloading

Specimens are mounted on a Gatan specimen mount. The specimen mount is inserted into the loading dock, then the mount is adjusted until the top of the sample is at the proper height. The transfer device is then used to pick up the sample and transfer it into the PECS II. It is critical that the top of the sample be set to the proper height with the loading dock. The sample will not be milled properly if this height is incorrect.

3.5.1. *To load a specimen:*

1. **On the Main page, select the Transfer tab.**
2. **Select Load Sample (see)**

The stage will be lowered into the transfer position and rotated to home.

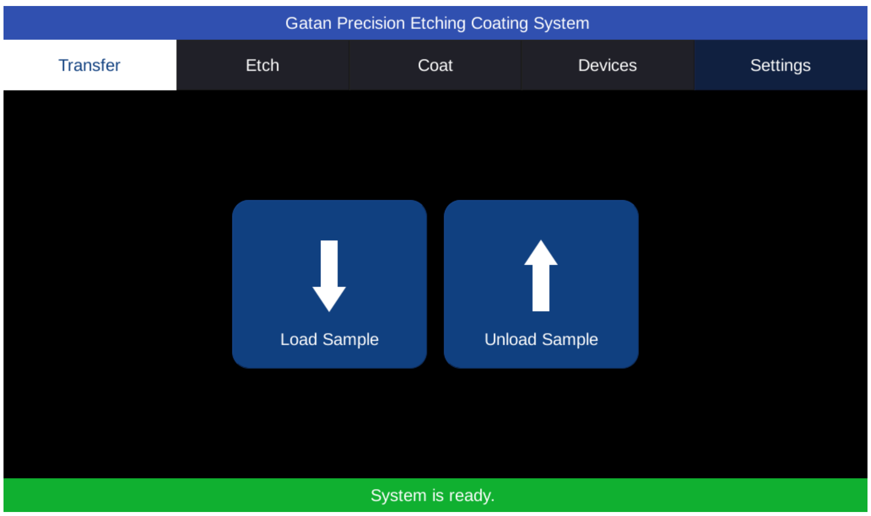


Figure 3-53. Transfer page

3. **Set the Transfer Device onto the load lock of the PECS II.**

Align the tee on the back of the transfer device with the mating slot on the loading dock (see Figure 3-54). Make sure the O-ring is properly seated in the O-ring groove.

Figure 3-54. Transfer device on load lock

4. Press the Next button.

The load lock will be pumped out, then the user will be instructed to open the gate valve.

5. Ensure the Tee handle on the front of the load lock is horizontal. Pull the Tee handle out fully and turn counter-clockwise (see Figure 3-55) until it stops.

The system will recognize this and notify the user to perform the next step.

Figure 3-55. Opening the gate valve

6. Lower the transfer arm into the PECS and release the sample.

- Loosen the locking knob on the side of the transfer device.
- Grasp the knob at the end of the transfer shaft and lower the arm.
- Note the pin near the top of the shaft. Rotate the shaft so that this pin enters through the left notch in the top of the housing. Lower the shaft until it stops. It may help to rotate the shaft slightly back and forth when the mechanism contacts the pins on the sample mount to be sure it engages the pins fully.

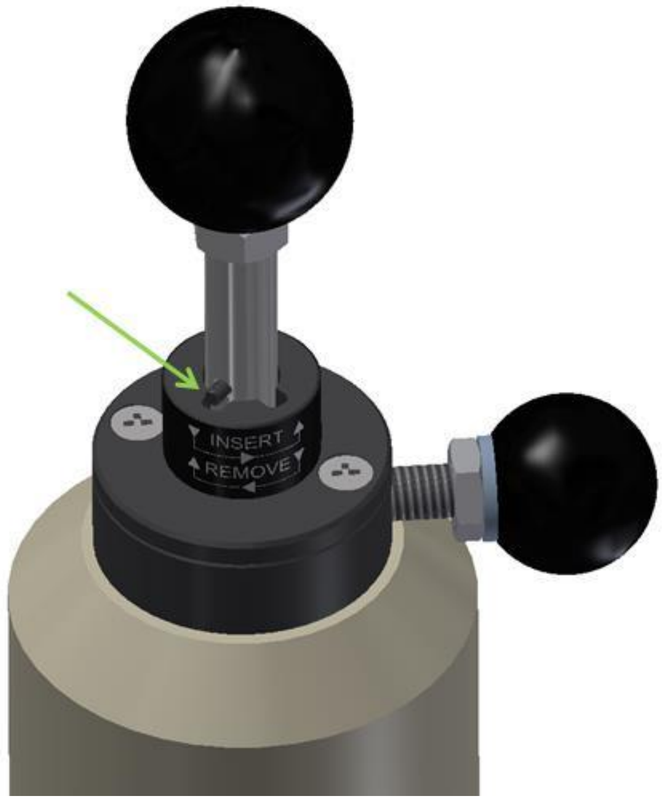


Figure 3-56. Transfer device while loading

- Rotate the shaft counterclock-wise until it stops. (about 75 degrees) If it does not rotate, wiggle it back and forth until it drops the rest of the way down.
- Lift the shaft until it stops. The sample mount should remain in the system.
- Tighten the locking knob on the side of the transfer device.

7. Turn the Tee handle clockwise until horizontal and insert back into the chamber until it stops.

8. Press the Continue button to vent the airlock.

9. Remove the Transfer Device from the load lock and store it on the Loading Dock.

3.5.2. *To Unload a Specimen:*

1. **On the Main page, select the Transfer tab.**
2. **Select Unload Sample**

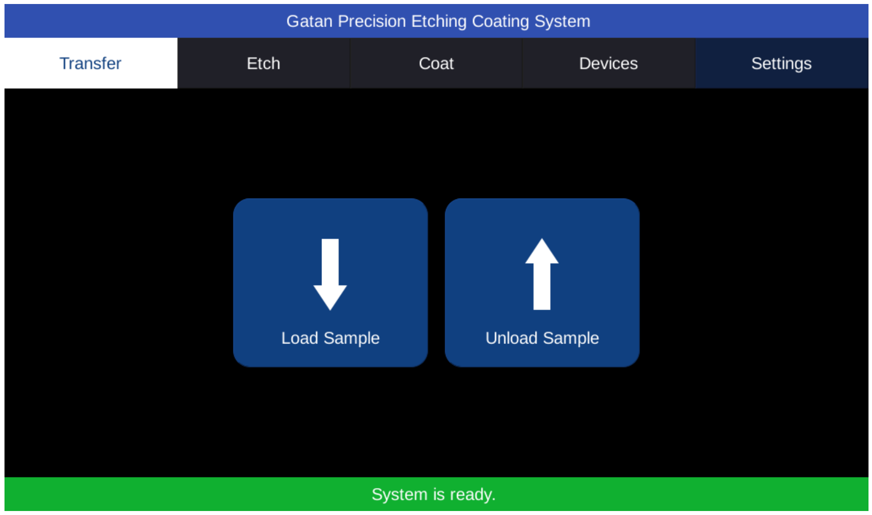


Figure 3-57. Transfer page

3. Set the Transfer Device onto the load lock of the PECS II.

Align the tee on the back of the TD with the mating slot on the loading dock. Make sure the O-ring is properly seated in the O-ring groove.

Figure 3-58. Transfer device on load lock

4. Press the Next button.

5. **Ensure the Tee handle is horizontal, then pull the Tee handle out fully and turn counter-clockwise until it stops.**

Figure 3-59. Opening the gate valve

6. **Lower the transfer arm into the PECS II and release the sample.**

- Loosen the locking knob on the side of the transfer device.
- Place one hand on the transfer device and with the other hand grasp the knob at the end of the transfer shaft and lower the arm.
- Note the pin near the top of the shaft. Rotate the shaft so that this pin enters through the right notch in the top of the housing. Lower the shaft until it stops. It may help to rotate the shaft slightly back and forth when the mechanism contacts the pins on the sample mount to be sure it engages the pins fully.

Figure 3-60. Transfer device while unloading

- Rotate the shaft clock-wise until it stops. (about 75 degrees) If it does not rotate, wiggle it back and forth until it drops the rest of the way down.
- Lift the shaft until it stops. The sample mount should be in the transfer device.
- Tighten the locking knob on the side of the transfer device.

7. **Turn the Tee handle clockwise and insert back into the chamber.**
8. **Press the Continue button to vent the airlock.**
9. **Remove the Transfer Device from the airlock and store it on the Loading Dock.**

3.6. Etching

Insert the sample by following the sample loading procedure (section 3.5.1) and moving the stage to the etching location. This will move the sample to the correct location for etching, cross sectioning or planar polishing. Heat sensitive samples can be cooled with liquid nitrogen to counter the increased temperature from the beam (cold stage option).

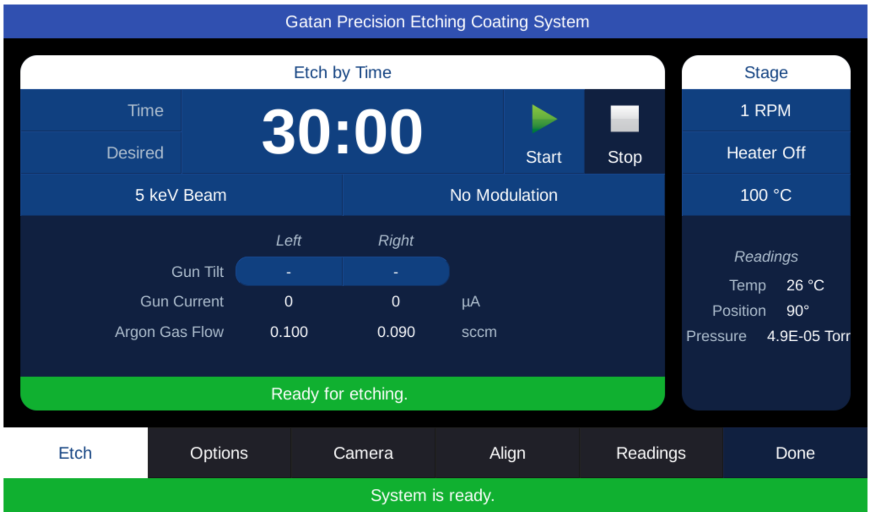


Figure 3-61. Etch main page

3.6.1. *Etching a planar sample:*

Etching a planar sample is used to remove damaged material from the sample surface and polish features of interest. It is commonly used to improve the quality of EBSD (electron backscatter diffraction) patterns.

1. **Ensure that the ion guns are aligned properly.** Ideally they will have been aligned at the same angle the sample is milled.

2. **If the sample is sensitive to increased temperature and the system has a cold stage, fill the dewar with liquid nitrogen.** Top it off over the next several minutes to compensate for N2 that has boiled off.

3. **Start etching mode.** Press Etch, then Etch by Time or Etch by Dose. Etch by Dose is useful because gun currents can vary from one etch to the next. This option measures the beam current (dose) and terminates etching when the specified dose is delivered to the sample. This creates a more reproducible etch depth.

4. **Set the Time desired or Dose desired.**

5. **Set the gun angles.**

If motorized guns are installed, this is done by touching the Angle buttons and entering the desired angles. If motorized guns are not installed, rotate the gun knobs until the desired angle is aligned with the notch in the chamber just above the guns. Higher gun angles result in faster milling, while lower angles typically result in more planar surfaces.

6. **Set the beam energy.**

   Higher beam energy etches/polishes faster, however, it also imparts more energy to the surface of the sample and thus creates more damage to the surface. It is common to start etching at high energy to remove damage caused by mechanical polishing, then lower the energy to improve the surface quality even more.

7. **Set beam modulation.**

   Planar samples are typically milled with No Modulation. There are circumstances where beam modulation can be advantageous. If a sample has scratches from mechanical polishing in one direction only, then better results are often obtained by aligning the scratches parallel to the front of the instrument and using Dual Beam Modulation. This prevents the beam from accentuating the scratches.

8. **Set the stage rotation speed.** This is typically 1 – 3 RPM.

9. **If the system has a cold stage, then set the temperature of the cold stage heater and set enable on.**

   If the system has a cold stage and the dewar is filled, set the temperature of the cold stage heater. Gatan recommends a setting of -30 C. This is low enough that the sample will typically stay below room temperature. This setting allows a reasonable warm-up time (~30 minutes) when unloading the sample from the system.

10. **Set Imaging mode, if desired.**

    If the system has a camera system, you may record an image once per rotation by selecting Record Milling in the Camera tab. First set Live View and focus the microscope and set illumination.

11. **Press Start.**

12. **The system will stop when the desired time or dose is reached.**

3.6.2. *Cross sectioning a sample:*

Cross sectioning is good for removing large amounts of material, in the $600um^2$ range. The samples are mounted to a Ti blade and that blade is then inserted vertically into a custom PECS II mount. This polishing is typically done at a high voltage and a low angle, usually 0 degrees for both guns. This removes material above the edge of the blade, thereby creating a cross section.

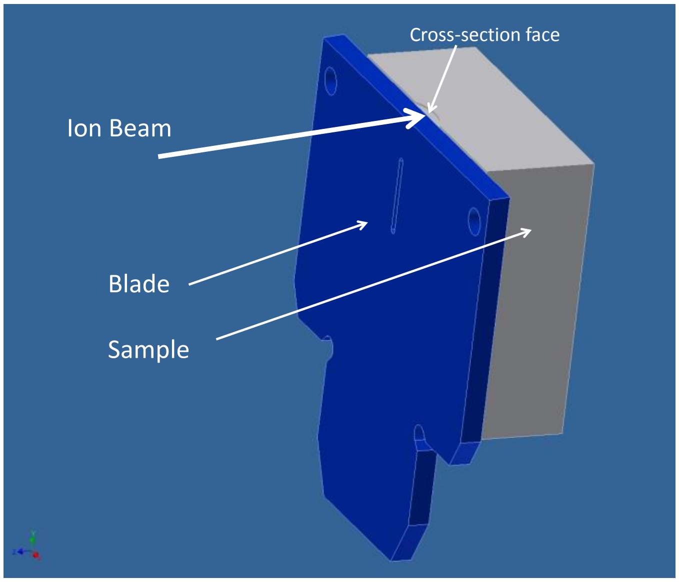


Figure 3-62. Cross section schematic

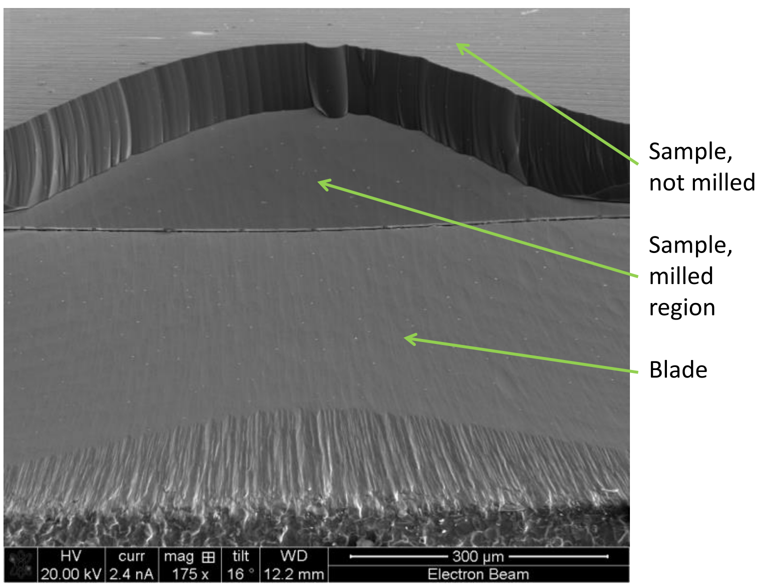


Figure 3-63. Example of cross-sectioned sample mounted to blade

Due to the location of the sample relative to the blade it is mounted on, the sample will be milled using single beam modulation. This will cause the guns to fire during a specified sector while remaining off during the rest of the rotation.

Cross section milling time is based on observation and the sample can be stopped once the beam has milled roughly 40um past the area of interest to ensure that redeposition has been cleared. If a large area is desired, mill until enough surface is exposed for analysis and stop milling at that point.

For detailed instructions on how to prepare and mount cross section samples, please see section 4 of this user manual.

1. **Ensure that the ion guns are aligned properly.** Ideally they will have been aligned at the same angle the sample is milled (0 deg).

2. **If the sample is sensitive to increased temperature and the system has a cold stage, fill the dewar with liquid nitrogen.** Top it off over the next several minutes to compensate for N2 that has boiled off.

3. **Start etching mode.** Press Etch, then Etch by Time or Etch by Dose.

4. **Set the Time desired or Dose desired.**

   A typical cross section time is 2 hours.

5. **Set the gun angles.**

   If motorized guns are installed, this is done by touching the Angle buttons and entering the desired angles. If motorized guns are not installed, rotate the gun knobs until the desired angle is aligned with the notch in the chamber just above the guns. Cross section samples are typically milled at 0 degrees and high energy (8kV). Once the final desired depth is reached, The gun angle can be increased and the beam energy decreased in order to remove surface damage (i.e. clean up).

6. **Set the beam energy.**

   Cross section samples are typically milled at 6-8 keV.

7. **Set beam modulation to Single Beam Modulation.**

   Cross section samples are milled with Single Beam Modulation.

8. **Set the stage rotation speed.** This is typically 0.5-1 RPM.

9. **Set the temperature of the cold stage heater and set enable on.**

   If the system has a cold stage and the dewar is filled, set the temperature of the cold stage heater. Gatan recommends letting the sample cool for 30 minutes with the heater disabled, then enable the heater with a setting of -30 C. This is low enough that the sample will stay below room temperature, even for beam energy of 8 keV. This setting allows a reasonable warm-up time (~30 minutes) when unloading the sample from the system.

10. Set Imaging mode, if desired.

If the system has a camera system, you may record an image once per rotation by selecting Record Milling in the Camera tab. First set Live View and focus the microscope and set illumination.

11. Press Start.

12. The system will stop when the desired time or dose is reached.

3.6.3. *To Etch a sample for decoration*

Etching at high angle (e.g. normal incidence) can be used to accentuate grain structure of some samples. A SEM pin stub may be used to mount the sample vertically or at intermediate angles. This pin stub may be installed on the Tall Sample Mount. Alternatively, the sample may be mounted flat and the gun angles set to 18 deg.

1. **Load the sample mount into the system.**

2. **Press Etch>Etch by time.**

3. **Select time, modulation, kV, and rpm.**

4. **If using the camera to record images, focus on the sample and select the folder to save the captured images into.**

5. **Select the gun angle based on your etching procedure.**

6. **Press Start.**

3.7. Coating

Place the sample to be coated on a PECS II mount and insert into the PECS II using the sample loading procedure. Select to coat by thickness, coat by dose, or coat by time. When coating to eliminate charging on the sample surface, deposit the least amount of material needed to achieve the desired effect.

The PECS II can hold 2 different coating targets at one time. The target is conditioned prior to coating each time a new sample is loaded into the system. This feature may be disabled via the Options tab.

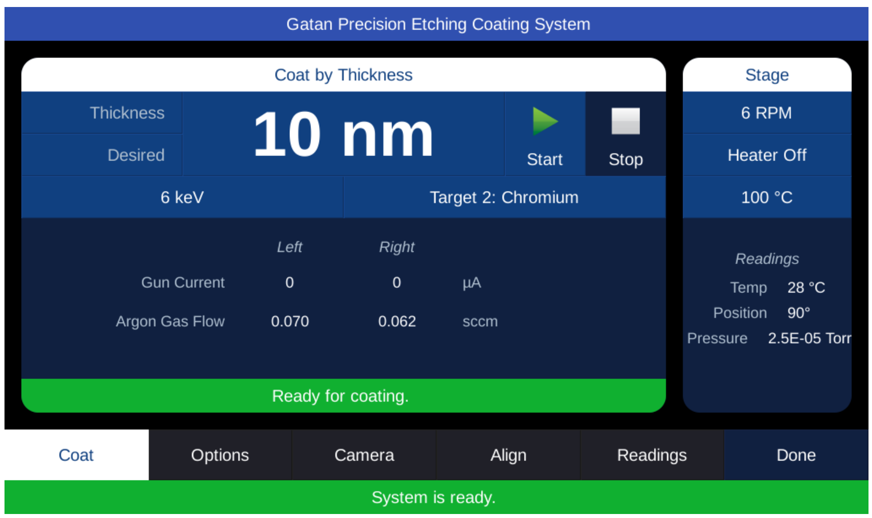


Figure 3-64. Coating main page

3.7.1. *Coating a sample by time:*

1. **Select coat.**

2. **Select Coat by Time.** Wait for the stage to move.

3. **Set both guns to 0 degrees.** The system will prompt this, unless the system has motorized guns, in which case the guns angles will be set automatically.

4. **Set the film thickness monitor probe to the shield position.** If the system does not have a FTM, skip this step. The probe may be set in Crystal position in order to monitor the amount of coated material.

5. **Set the coating time, voltage, and target on the coat main page.**

Gatan recommends that the same voltage be used each time a particular material is coated. This will maximize repeatability. Higher voltages will coat faster.

6. Insert the desired target.

Push the target knob inward to the stop, then rotate clockwise or counterclockwise to the stop, so either the number 1 or 2 is visible at the top of the knob. Be sure the number of the target matches the number of the target set on the Coat page above.

7. Press Start. Coating will stop when the timer stops.

3.7.2. *Coating a sample by thickness:*

1. Select coat.

2. Select Coat by Thickness. Wait for the stage to move.

3. Set both guns to 0 degrees. The system will prompt this, unless the system has motorized guns, in which case the guns angles will be set automatically.

4. Set the film thickness monitor probe to the Crystal position.

5. Set the coating thickness (in nm), voltage, and target on the coat main page.

6. Insert the desired target.

Push the target knob inward to the stop, then rotate clockwise or counterclockwise to the stop, so either the number 1 or 2 is visible at the top of the knob. Be sure the number of the target matches the number of the target set on the Coat page above.

7. Press Start. Coating will stop when the timer stops.

3.7.3. *Coating a sample by dose*

1. Select coat.

2. Select Coat by Dose. Wait for the stage to move.

3. Set both guns to 0 degrees. The system will prompt this, unless the system has motorized guns, in which case the guns angles will be set automatically.

4. Set the film thickness monitor probe to the Shield position.

5. Set the coating dose (in mC), voltage, and target on the coat main page.

6. Insert the desired target.

Push the target knob inward to the stop, then rotate clockwise or counterclockwise to the stop, so either the number 1 or 2 is visible at the top of the knob. Be sure the number of the target matches the number of the target set on the Coat page above.

7. Press Start. Coating will stop when the timer stops.

3.8. Specimen Viewing

The PECS II has been designed so that the specimen is visible either with the naked eye or with the digital zoom microscope either in the raised (etching) or in the lowered (coating) position. The wide-angle view with the naked eye is helpful when aligning the PIGs using the Beam Alignment Screen. The microscope/camera view is essential when looking at surface roughness or for buried features during delayering.

The top shutter closes automatically when the system is milling or coating. To open the top shutter, go to the Camera page, and activate Live View.

There are two illuminators which are controlled by the UI.

3.8.1. *Chamber Illuminator*

The chamber illuminator is located in the load lock. It is used to view the inside of the chamber. This illuminator can be controlled from the Devices screen or the Camera screen in either etch or coat mode. The intensity of this illuminator cannot be varied.

3.8.2. *Microscope Illuminator (optional)*

The microscope illuminator is controlled from the Camera or View screen of the Etch or Coat Screen. It is enabled or disabled using the button at the top of the slider. Turn the illuminator on/off by touching the Live View button. If the system is Etching or Coating, then Live View or View also opens the shutter. The color of the illumination can be changed from white to red by pressing the appropriate button. Increase/decrease the intensity of the light by lowering/raising the slider. Finer control over the intensity may be achieved by touching the numerical display tab below the slider, then entering a number between 0 and 100%. The illumination intensity is intentionally non-linear over the range of 0 to 100%. Note that the Camera page will be active if the system has a microscope, and the Viewing page will be active if it does not have a microscope.

3.8.3. *Microscope zoom (optional)*

The microscope includes a 6x optical zoom, as well as digital zoom. The optical field of view can be varied from approximately 1.3x0.95 mm to 8.4x6.3 mm. The microscope option is described in more detail in section 8.4.

3.9. Shutter Control

The top Shutter protects the specimen Viewing Port from sputter deposits, operates automatically, and is keyed to the Start button in the Etching and Coating tabs and the Live View button in the Camera tab. It closes when milling starts and retracts when milling stops. The Shutter retracts when Live View or View is turned on and it closes when View is turned off. When the camera is in Record Milling mode, the shutter will open once per rotation so that an image may be acquired. The system must be shut down and vented to clean the viewing port. This shutter is not spring loaded, and does not retract automatically when the system is powered down.

The bottom shutter shields the sample from sputtered material while the target is conditioned. This shutter is controller automatically by the coating process. This shutter is spring loaded to retract automatically when the system is powered down.

3.10. Specimen Rotation

The specimen is rotated in a CCW direction by a variable-speed DC motor. The rotation speed can be varied from 0.5 through 6 rpm using the Rotation Speed control on the GUI. Rotation can be stopped by the Rotate button on the Alignment page. The motor drives a timing belt mounted to the Whisperlok piston.

An optical encoder is mounted to the drive shaft which allows for recognizing the home position as well as sector milling angles. The home position is calibrated in the Maintenance section of the GUI. The stage advances to the home position at the start of a transfer sequence.

The Align screen is used to control rotation.

Rotate: Turns on/off stage rotation. The top of this button displays the current stage rotation angle. The green color on Rotate, shows that rotation is on.

Align Home: Aligns the stage to the home position (0 degrees).

Align Right Front Beam Sector: Aligns the stage so that the front of the sample faces the right gun.

Align Left Front Beam Sector: Aligns the stage so that the front of the sample faces the left gun.

Align Right Rear Beam Sector: Aligns the stage so that the front of the sample faces away from the right gun.

Align Left Rear Beam Sector: Aligns the stage so that the front of the sample faces away from the right gun.

Align Custom: Aligns the stage to the angle displayed at the top of this button. Press the top of this button to enter a custom angle. The default angle is 180 degrees (front of the sample faces the back of the instrument).

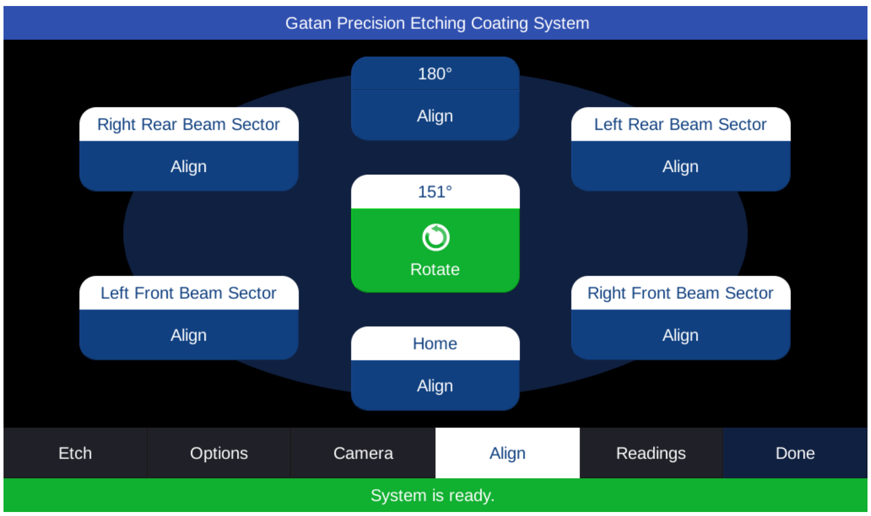


Figure 3-65. Align screen

3.11. Gun Gas-flow Adjustment

The Automatic gas flow mode is designed to set the gas flow to an optimized value. Gatan recommends using this mode.

NOTE: The optimum operating gas flow must be obtained once the guns have been thoroughly purged. If performing manual gas flow adjustment, adjust the flow one gun at a time.

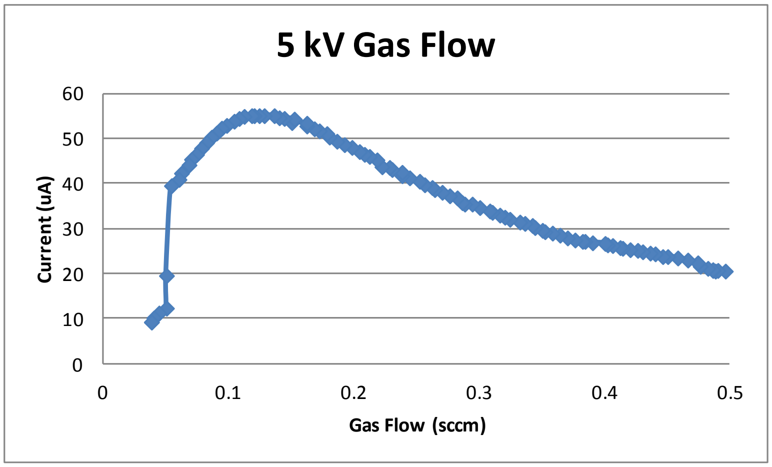


Figure 3-66 Operating characteristics of the PIG.

The gas flow can be adjusted either automatically or manually.

3.11.1. *To Automatically adjust the gas flow*

1. On the Etch or Coat Options page, select Automatic for the Gas Mode.

2. Set the milling energy.

3. Start milling.

3.11.2. *To Manually adjust the gas flow*

Note that as guns warm up, the beam current can drift. The guns should be warmed up for 10-20 minutes before setting the gas flow manually. The optimum gas flow changes with accelerating voltage, and it is necessary to adjust the gas flow whenever the accelerating voltage is changed. The curve in Figure 3-66 shifts to the right and increases in height as a gun warms up. If the curve shifts so that the operating point is far to the left of the peak, then it can be in an unstable region of the curve or the current may drop to an unusable level.

1. Remove any sample or alignment screen that is in the chamber.

2. On the Etch/Coat Options page, select Manual for the Gas Mode (see Figure 3-66**).**

3. Be sure Beam Modulation is turned off.

4. Adjust the Ion Gun voltage to the desired energy.

5. Set the timer to 30 min and touch start.

6. Go to the Readings page. The gas flow is displayed on the top right side of the screen. When Manual gas flow mode is enable, Adjust Flow buttons are displayed just below the readings. Use the + and – buttons to increase/decrease the gas flow.

7. Adjust the gas flow to each gun individually. Find the gas flow corresponding to the peak Faraday cup current. A typical curve relating gas flow to ion current is shown in Figure 3-66. The operating point indicated has been chosen because it gives the most focused beam and the highest milling rate.

NOTE: Variations of ±20% in the performance of the two ion guns are typical and are caused by small differences in the properties of the rare-earth magnets used to enhance the gas-ionization rate.

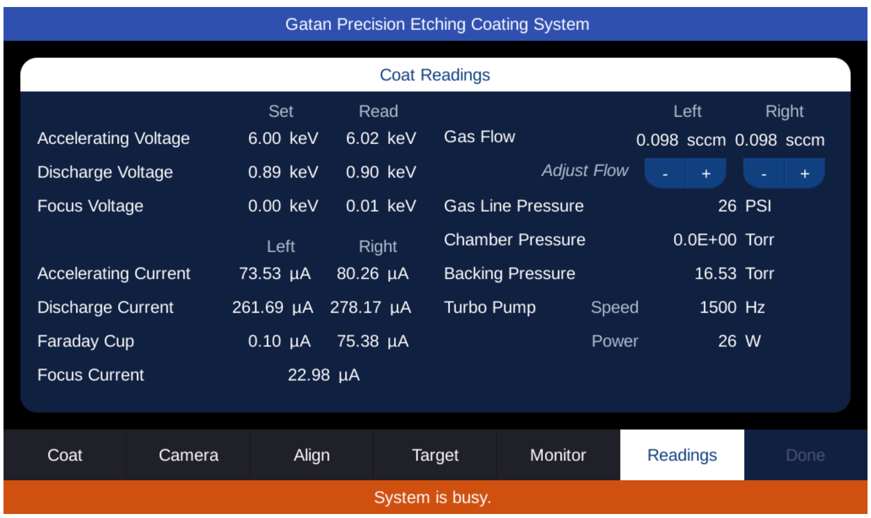


Figure 3-67. Manually adjusting gas flow

3.12. Aligning the Beam

The ion beams produced by the PIGs contain both ions and fast neutrals. Electrostatic beam alignment does not work with the fast neutrals and the ion guns in the PECS II must be aligned mechanically. This is done with the aid of the Beam Alignment Screen installed on the cross section sample mount.

This Screen inserts into the cross section specimen mount and is precisely positioned at the standard specimen height. It consists of a 7 mm fluorescent screen with a 0.5 mm diameter hole at its center. After lowering the Screen to its standard working position, start milling. The beams are bluish in color on the fluourescent alignment screen.

NOTE: Although the guns are designed to maintain alignment during all angles of rotation, the guns should be aligned at the angle they will be used.

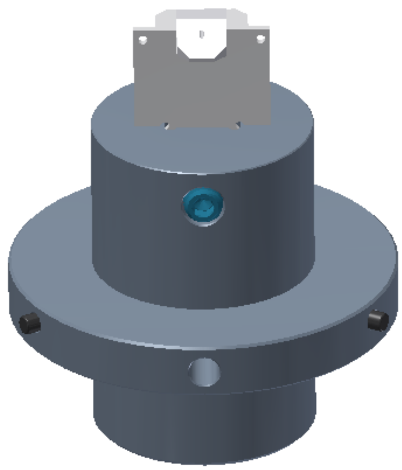


Figure 3-68. Cross section sample mount with beam alignment screen

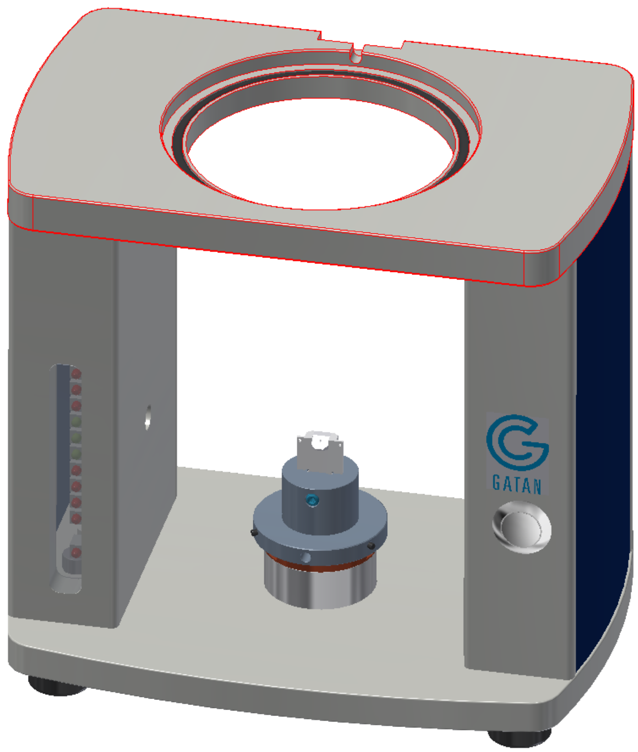


Figure 3-69. Beam alignment screen in loading dock

3.12.1. *Align the PIGs*

1. Load the alignment screen/ cross section sample mount into the system . The front of the alignment screen (angled surface with oval hole) must be aligned with the hole in the front of the sample mount, see Figure 3-68. The front of the sample mount is shown in this figure, and should face the front of the loading dock when the sample mount is picked up with the transfer device, see Figure 3-69.

2. Start Etch mode.

3. Set the gun angles to the angle they will be used.

4. Set the gun voltage to 5 KeV. Higher voltage will create a brighter spot on the alignment screen, but also wear out the alignment screen faster.

5. Set the gas flow control to Automatic.

6. Set the modulation to Single Beam Modulation.

7. Set the timer to 30 min.

8. Start milling.

9. On the align page, select Right Front Beam Sector.

10. Use the alignment knobs on the plastic gun shell to move the beam to the center of hole of the alignment screen. Note: the microscope may be used to set alignment. Set Live View. Set the optical zoom to 0.7. Change the dwell time to 1-2 sec. Then maximize the contrast of the image.

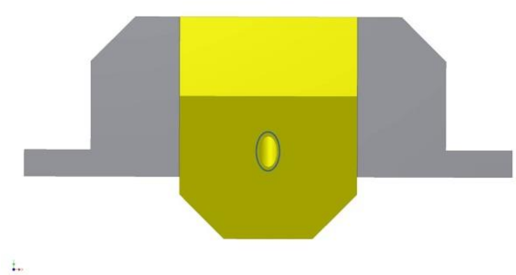


Figure 3-70. Alignment ellipse observed (blue) on beam alignment screen

11. Rotate the gun knob to 18 deg, then 0 deg, then back to the angle set above. Verify that the alignment has not changed. If it has changed redo the alignment.

12. On the alignment page, select Left Front Beam Sector and repeat for the left gun.

3.12.2. *Alternate Alignment Mode*

When using the guns at high angles, a viewing window may be used to align the beams. Install a loadlock viewing window onto the tall specimen mount using a couple of very small dabs of Silver paint. Set the height using the loading dock. Install the sample mount into the system. With the beams on, the glass will fluoresce and the beams may be aligned to the cross in the middle of the sample mount under the glass.

3.13. Ion-beam Modulation

Ion-beam modulation is used primarily for cross-sectional samples (Ilion+ samples). Beam modulation consists of fast on/off electronic switching of the guns with variable specimen-rotation speeds within polishing sectors to minimize differential thinning rates of specimens. Variable rotation speeds within the sector of up to 6 rpm are achieved while outside the polishing sector, the speed is fixed at 12 rpm to reduce total specimen preparation time.

NOTE: When loading a cross-sectional specimen, it is important to insert the specimen such that the blade is parallel to the front panel (home position) and the sample is behind the blade. This procedure ensures that the polishing sectors will be ±30° normal to the blade face during operation of beam modulation. Single beam modulation must be selected when milling cross-sectional samples.

The default sector mill range is 60° (±30°). This can be changed for all samples on the Options tab.

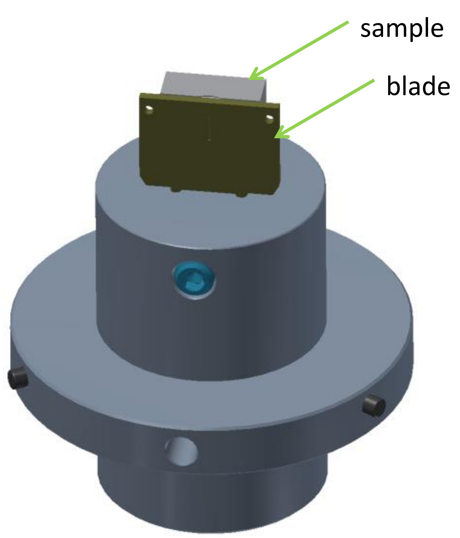


Figure 3-71. Cross-section sample on sample mount

Ion-beam modulation can also be used for planar samples that have a directional bias. For instance, if a sample was straight grain mechanically polished, a better result is often obtained by using dual beam modulation. In this mode, the beams are primarily striking the sample perpendicular to the scratches. The scratches are then flattened instead of accentuated. The sector mill range can be adjusted to optimize the milling. A smaller sector mill range (e.g. 30 degrees) results in the beam striking more perpendicular to the scratches, however, this results in longer milling times because the duty cycle is smaller.

An important planar example is delayering of semiconductor devices. In this case there are sample features largely perpendicular to each other. The best result (flattest surface) is often obtained when the beams are oriented 45 degrees with respect to the sample features. Either dual-beam or single-beam modulation can be used. A sector range of 30 degrees is recommended. A custom sector has also proven effective, such that the beams strike the sample from all four sides but always 45 degrees from the device axes.

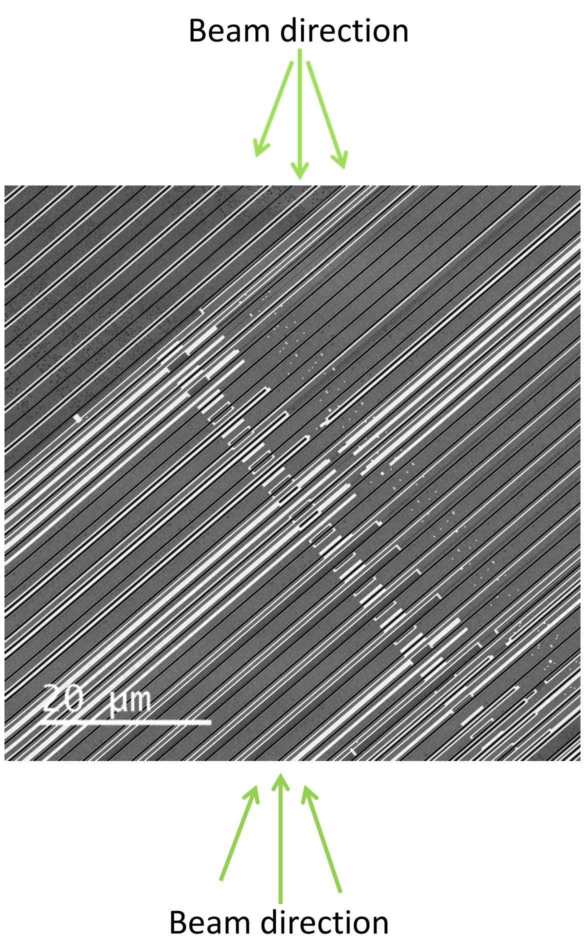


Figure 3-72. Semiconductor sample with dual beam modulation

To achieve this result, align the sample as in Figure 3-72 with the bottom of the figure facing the front of the sample mount. Then set the system for dual beam modulation with 30 degree sectors at 0.5 or 1.0 RPM. Good results are typically obtained with gun angles of 3-5 degrees. Higher angles will result in much faster milling.

Custom modulation can be useful when you want the beams to impinge on the sample from 4 different directions, all at 45 degrees from the device axes. This can be obtained with the custom modulation table shown in Figure 3-73 and the sample device axes aligned as shown in Figure 3-74. The green arrows show the direction of the beams with respect to the device axes. This orientation is useful in the images captured with the Record Milling feature show the device features parallel to the image edges.

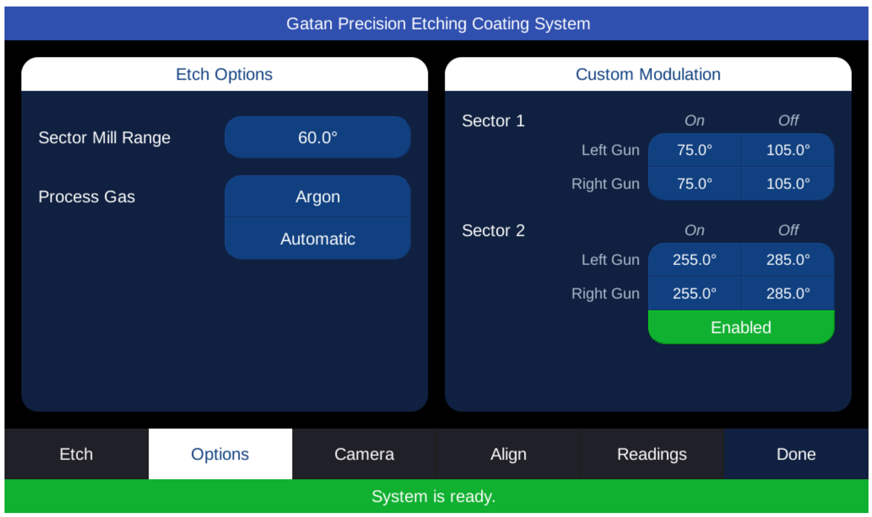


Figure 3-73. Custom modulation table for delayering

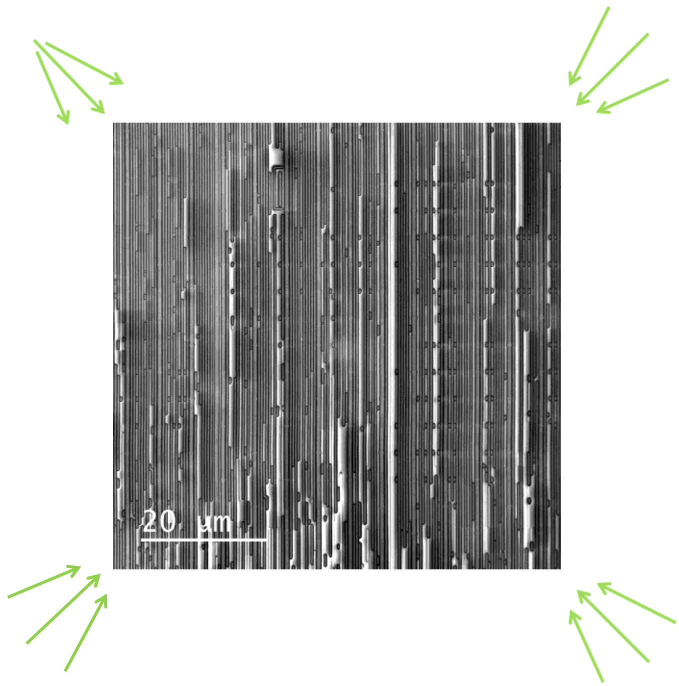


Figure 3-74. Semiconductor sample with custom modulation

3.13.1. *Ion-Beam Modulation Selection*

This panel enables selection of single- or double-sector mode:

Single Beam Modulation: The system is operating in the single-sector mode. This activates each gun during the polishing sector when the front of the specimen blade is facing that gun. The stage rotates at the milling speed during the polishing sectors and at 12 rpm between the polishing sectors to reduce total specimen-preparation time. Single beam modulation must be selected when milling cross-sectional samples.

Dual Beam Modulation: The system is operating in the double-sector mode. This activates each gun during the polishing sector when the front and rear of the specimen blade is facing the gun. The stage rotates at the milling speed during the polishing sectors, and at 12 rpm between sectors.

No Modulation: Beam modulation is disabled and there is continuous milling. This is used for most planar samples.

Stationary Left: The stage does not rotate, and the left gun is on continuously. The right gun is off. The desired stage rotation position must be set prior to pressing Start.

Stationary Right: The stage does not rotate, and the right gun is on continuously. The left gun is off. The desired stage rotation position must be set prior to pressing Start.

Custom Modulation: This feature allows the user to define the start and stop angles for up to two custom defined sectors per gun. This can be useful when you want front and rear sectors that are asymmetric. The angle entries are the stage angles when the guns should turn on and off. Positive angle entries must be used.

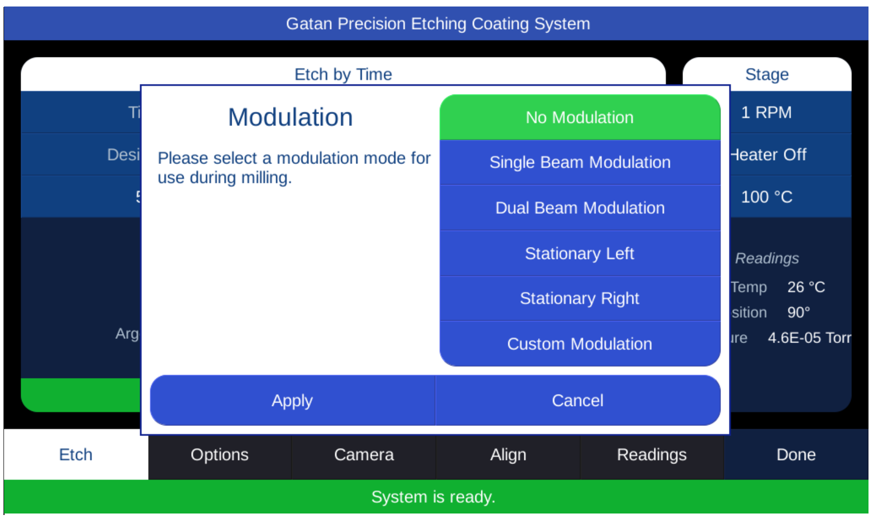


Figure 3-75. Setting modulation modes

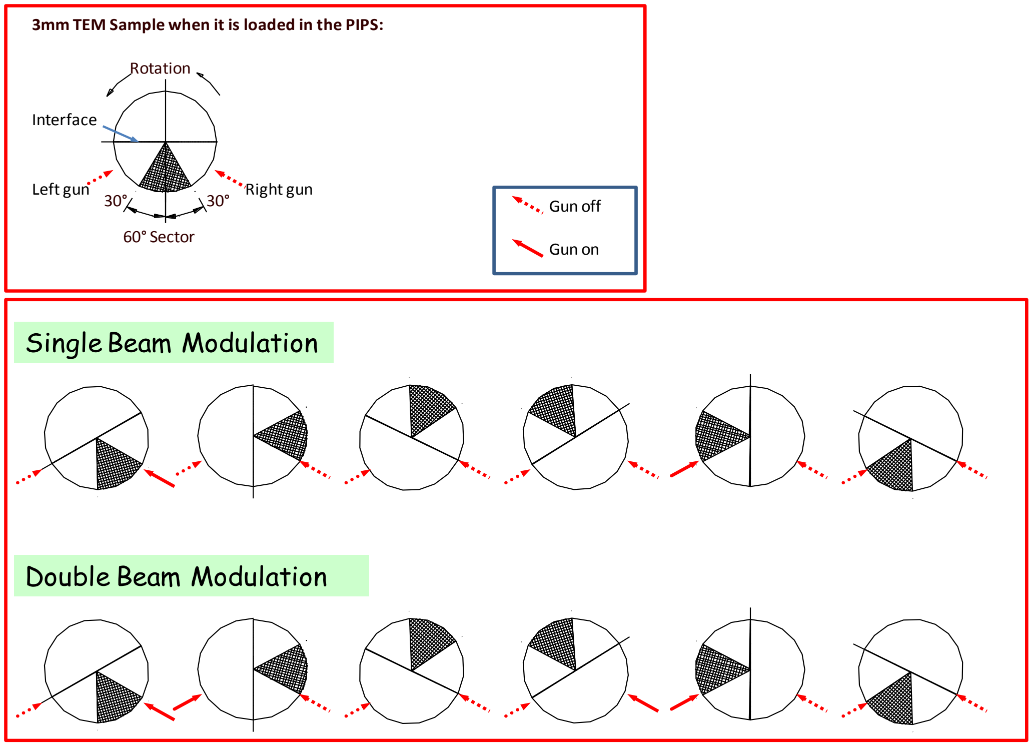


Figure 3-76 Beam modulation

3.14. Manual Shutdown Procedure

Main power to the PECS II (power consumption of less than 100 W) should be left on at all times to provide for more efficient trouble-free operation. The vacuum will be continuously maintained resulting in a cleaner system with shorter pump downs and minimum purging requirements of the PIGs.

Prior to shutting down the system the target must be retracted and any sample should be removed. If the target is not retracted, the stage will raise and run into the target assy. If this happens, turn on the power to the system and set it in coat mode, which will lower the stage. Then the target can be retracted and inspected for damage.

Caution: If the target is not retracted when power is shut off, the stage will raise and run into the target assy. If this happens, turn on the power to the system and set it in coat mode, which will lower the stage. Then the target can be retracted and inspected for damage.

To shut down, simply turn off the power switch on the rear panel of the instrument.

4. Cross-Section Specimen Preparation

4.1. Sample Blade Basics

Identify the blade surfaces:

- **Notch-side surface**: Notch identifies the center of the blade, the point at which the beam intersects the blade
- **Blade-specimen surface**: The face of the blade where the sample is mounted
- **Blade face**: Angled surface used to direct the ions to the sample
- **Blade edge**: The intersection edge where the blade-specimen surface and the blade face edge meet
- **Blade shoulders**: Features used to seat the sample onto the stage and SEM analysis strip
- **Blade eyelets**: Machined holes for handling with provided tweezers
- **Tabbed edge**: Edge opposite the blade face

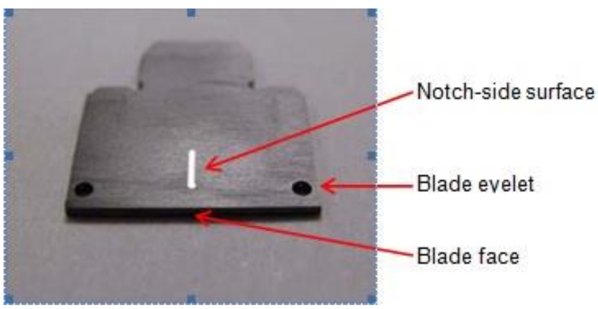


Figure 4-1 Sample blade notch-side and sample blade face

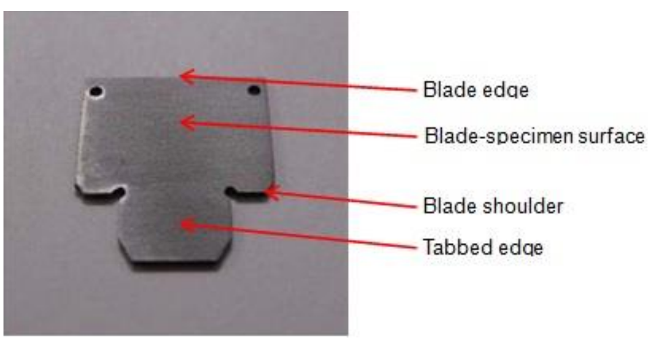


Figure 4-2 Sample blade-specimen surface

4.2. Sample Blade Handling and Cleaning

4.2.1. *Sample Blade Handling*

The sample blade material is prone to scratching and chipping. Always handle the blade with the provided tweezers, as shown in Figure 4-3. In instances when the blade has to be handled otherwise, use the lower edge, opposite the blade face where damage caused by contact will not impact the quality of the cross-section cut (refer to Figure 4-4).

> **CAUTION:** Do not touch or contact the sample blade face or the sample blade edge!

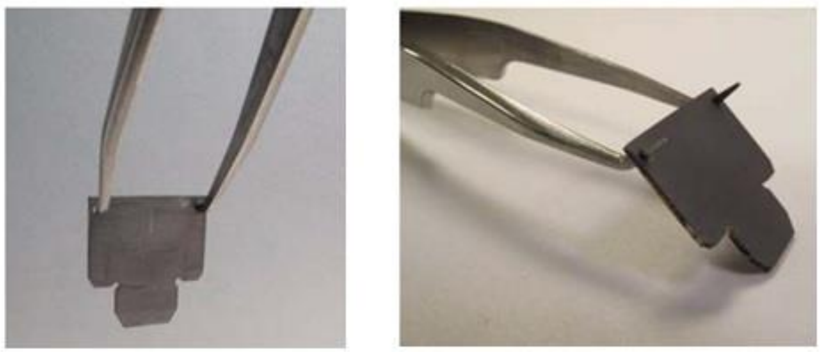


Figure 4-3 Sample blade handling with tweezers

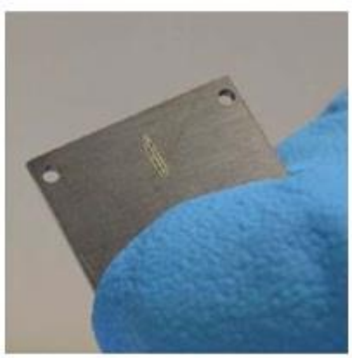


Figure 4-4 Sample blade handling without tweezers

4.2.2. *Sample Blade Cleaning*

Whenever possible, use compressed air to remove loose debris and avoid physical contact to the blade. For more thorough cleaning, use acetone and a Q-tip to remove Ag paint or contamination from blade surfaces. Sample blades should be inspected and cleaned between each completed specimen. Whenever possible, inspect the cleaned blade with a light microscope to verify the next specimen will be free of artifacts caused by a contaminated blade or debris on the specimen surface. Refer to Figure 4-6 or 4-33 for an example of Ag paint on the sample blade and specimen surface.

To Properly Clean a Sample Blade

1. **Insert the sample blade into one of the two styles of Scanning Electron Microscope (SEM) stubs provided with the Ilion+**

   Before proceeding refer to Section 4-3 for specific instructions on how to use the SEM stubs

2. **Add acetone to a cotton tipped applicator or Q-tip and gently brush the cotton swab across the sample blade face and blade-specimen surface (Figure 4-5)**

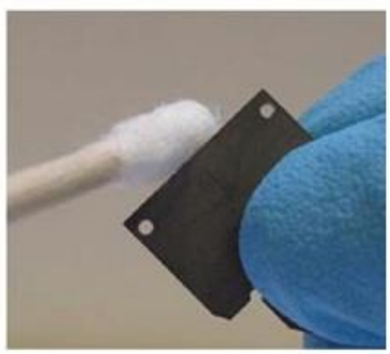


Figure 4-5 Cleaning the sample blade face

3. **Rotate the cotton swab and repeat until all visible Ag paint is removed from the blade surfaces**

   If possible, work under a low magnification light microscope for increased efficiency. Dust off with compressed air to remove any particles left behind by the cotton swab

4. **Inspect with a Light Microscope**

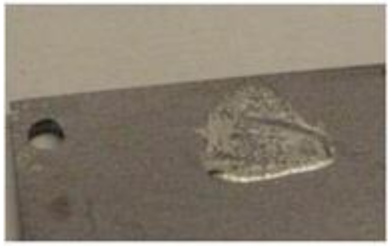


Figure 4-6 Ag paint residue on a sample blade-specimen surface

4.3. Sample Blade Storage and SEM Stubs

Preferably, new blades should be stored in the packaging provide for shipping. Blades in use should either be store in the SEM stubs provided with the instrument or store flat on a post-it note, blade-specimen surface side up, and kept in a clean secure location for protection against accidental damage.

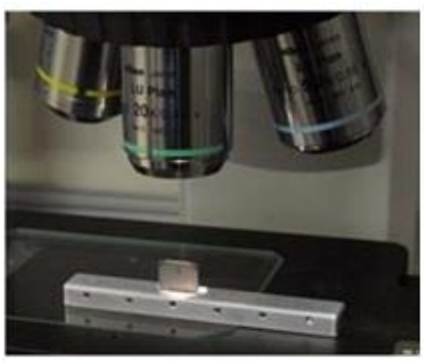


Figure 4-7 Multi-sample SEM Stub on Light Microscope stage

Note: Both sample SEM stubs are designed with set screws to fix the sample blade. An M1.5 hex key (provided with the instrument) will drive the set screws

Note: The multi-sample SEM stub storage slots are numbered for convenience

Two types of SEM stubs are provided with the Ilion^{+}, an individual SEM stub with removable pin stub (shown in Figure 4-11 and 4-12) and a multiple sample SEM stub, also equipped with a removable pin to mount (shown in

Figure 4-8 and 4-9). The SEM stubs are capable of blade storage once the pin mount has been removed.

Figure 4-8 Multi-sample Blade SEM stub

Figure 4-9 Bottom of Multi-sample blade SEM stub with pin stub

Figure 4-10 Post-it note sample blade storage

Figure 4-11 Single Blade SEM stub

Figure 4-12 Pin Stub of single sample SEM stub

4.4. Mounting Adhesives

Several epoxies, glues, paints, and waxes may be used to mount the specimen to the sample blade. Be mindful of the electrical conductivity of the specimen; if it is conductive, use a conductive adhesive for electrical contact between the blade and specimen. Ag paint is an ideal choice for electrical and thermal conductivity, quick setting time, easy removal, and behavior at cryogenic temperatures. Please refer to the following sections for instructions on the application and removal of Ag paint.

Gatan recommends the following adhesive:

-Ted Pella Fast Drying Silver Paint, Product No. 16040-30 (Electrodag 1415M)

Note: Different silver paint products have different binders and particle sizes. Some will not work well for this adhesion application. Always compare results to these listed products when qualifying a new adhesive.

Note: Although one bottle of silver paint is supplied with each new system, Gatan does not sell these adhesives. Please purchase them from your local supplier.

4.4.1. *Application and Removal of Adhesive*

A small amount of any adhesive is required to bond the specimen to the sample blade. Judge the viscosity of the medium to gauge the interaction between the specimen and the substance. The use of a very low viscosity adhesive will increase the likelihood of unwanted spread and wicking onto areas exposed to the beam (i.e., blade face and specimen surface of intended cut). In comparison, the use of a medium with high viscosity requires careful placement between the specimen and blade to guarantee the specimen is securely set.

Note: Follow the manufacturer's recommendations for basic use, precautions, curing time, and removal procedures.

4.4.2. *Ag paint Application*

Gather Ag paint and shake well. Use either a toothpick or other fine ended tool to extract the adhesive from the Ag paint container (Figure 4-13). Toothpicks and small wooden dowels are easy to obtain, use, and carve into shapes that extract small amounts of paint that can be concisely and controllably applied to the sample blade or specimen. For use with the standard loading dock, apply a small amount of Ag paint to the sample blade where the lower half of the specimen will contact the sample blade or to the back edge of the specimen itself. Applying the paint away from the blade face will allow the spread of the adhesive under the sample and limit the likelihood of the adhesive wicking onto the blade or exposed surface of the specimen.

Figure 4-13 Gathering Ag paint from the jar lid

4.4.3. *Ag Paint Removal*

Use a toothpick or wooden dowel suggested above. Firmly hold the back tabbed edge of the sample blade against a sturdy surface. Apply force to the specimen side, perpendicular to the sample blade face, and in the direction parallel to the blade edge (refer to Figure 4-14). This technique protects the blade edge from damage during the removal of the specimen.

Some specimens will be more difficult to remove than others when using Ag paint for an adhesive. If the above removal technique does not work, use a razor blade (refer to Figure 4-15) to score the Ag paint around the specimen, with careful precaution to avoid scratching the sample blade edge and repeat the removal procedure.

Figure 4-14 Scoring the Ag paint for specimen removal

Figure 4-15 Removing the specimen from the sample blade

Note: Exercise caution for safe removal of the sample from the sample blade

4.5. Basic Specimen Preparation

Specimen preparation is important for repetitively successful cross-sections with the Ilion+. In the following sections, the aim is to identify terms, accessories, features, techniques, and parameters that are integral for achieving a high-quality specimen.

4.5.1. *Specimen Dimensions*

Samples must not exceed dimensions of 10 mm x 10 mm x 4 mm (L x W x H). If a sample is mounted off-center on the blade, then it must be accordingly smaller in that dimension. For instance, if a sample is mounted 1 mm off center, then it cannot be larger than 9 mm in width. In other words, the sample must fit within the envelope shown in Figure 4-16.

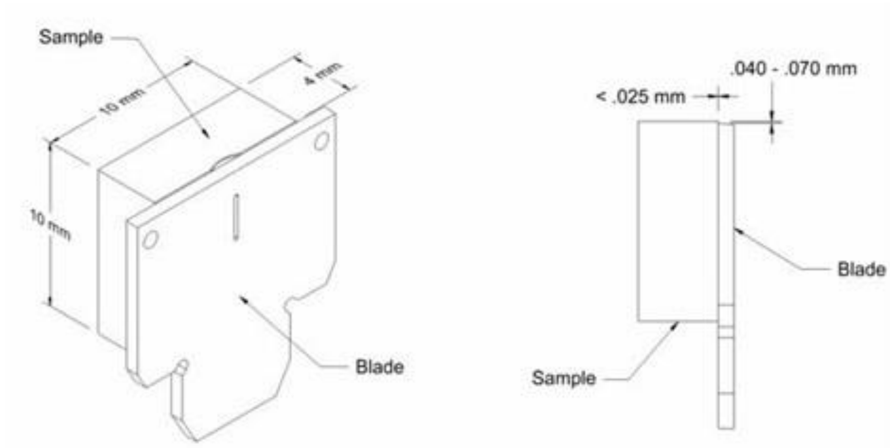


Figure 4-16 Maximum Sample Envelope

4.5.2. *Define the Area of Interest*

The area of interest should not exceed 70 µm from the edge of the blade. This limit is imposed to restrict the area of the specimen exposed to the beam, minimizing total cutting time and reduces the occurrence of material redeposition artifact. To ensure an adequate amount of specimen is exposed to the ion beam and maximize the efficiency of the instrument, keep your area of interest at least 40 µm from the specimen edge.

If necessary, the area of interest may extend more than 70 µm from the edge of the specimen; however, it will be necessary to mill longer to obtain the same depth and quality of cross-section as obtained at 70 µm.

4.5.3. *Specimen Surface Characteristics*

Specimen topography causes curtaining artifact on the ion milled cut face. Specimens with little to no topography can be mounted to the sample blade as is. The surface that contacts the blade may be damaged during removal, therefore, it might be advantageous to encapsulate or add a sacrificial layer to the material which will protect the specimen during the removal from the blade. Specimens with extreme topographical features should be embedded in an epoxy, set to cure under vacuum to remove trapped air in the potting mixture and polished flat to provide a planar surface to avoid curtaining artifact across the ion milled cut face. A relatively smooth surface also assists specimen adhesion to the sample blade and creates a uniformly flat platform, important for controlling the distance between the blade-specimen surface and specimen; this distance should not exceed 25 µm.

The edge of the specimen that contacts the specimen stop on the loading dock should also be planar to provide the user a flat edge used to aid the mounting process to the sample blade. Recommended abrasives for the final polish should be 30 µm (US and European grit ratings) or less. As a rule, the better the surface finish, the better the cut quality.

Specimens should be free of loose debris before mounting to the sample blade. Inspection of the critical surfaces should be performed before and after mounting. Follow typical cleaning hygiene required for good microscopy analysis work for the specific specimen. If after the specimen is mounted to the sample blade and debris is identified on the specimen, first use compressed air to displace the contaminants after the mounting medium is set.

4.6. Advanced Specimen Preparation

This section is intended to give users from multiple disciplines suggestions for specimens that require more advanced specimen preparation.

Note: Ultimately: the final preparation protocol is decided by the user and an informed decision about the use of the suggestions below is the sole responsibility of the user.

4.6.1. *Embedment of Specimens*

Embed specimens that are irregularly shaped, particles, porous, easily damaged by mechanical preparation such as cleaving, cutting, or grinding, require additional support for handling and mounting purposes, or for specimens prone to delaminating.

For micron-sized particle preparation, mix the particles with an epoxy in a ratio of 3 parts specimen to 1 part epoxy. The higher the particle content, the less work will have to be performed prior to mounting the polymerized epoxy. To embed larger particles, use just enough epoxy to encapsulate the material for easy post- cast preparation, handling and mounting onto the sample blade. Depending on the size of the particle and the location in the cast, removing a small section of the epoxy or epoxy and specimen from the cast, might be necessary to ensure that 1) no more than 70 µm of the material is exposed to the ion beam and 2) the area of interest is exposed to the beam for ion milling.

There are two techniques for embedding particles, these are described in the following sections.

Note: Gatan recommends the following potting medium

- Gatan G-2 Epoxy (Part No. 601.07270)

- Loctite® Professional Heavy Duty Epoxy (Part No. 01.06824-01) with a set time of 5 minutes

- Loctite® Professional Extra Time Epoxy (Part No. 1147735) with a set time of 1 hour

Embedding Samples with Silicone Rubber Mold

Silicone rubber molds can be obtained in a variety of shapes and sizes. The molds most readily available are designed for biological tissue preparation and are easily purchased through a lab supply vendor. However, the dimensions of the molds are typically 11 to 14 mm in length, which exceeds the maximum length value of 10 mm for the maximum length of a specimen. At least 1-4 mm will have to be removed by the user when employing this technique, but the recommended epoxies are durable enough to sand or cut away any excess material. In addition, the process below also describes a second technique for obtaining the proper length without removing bulk material (mm).

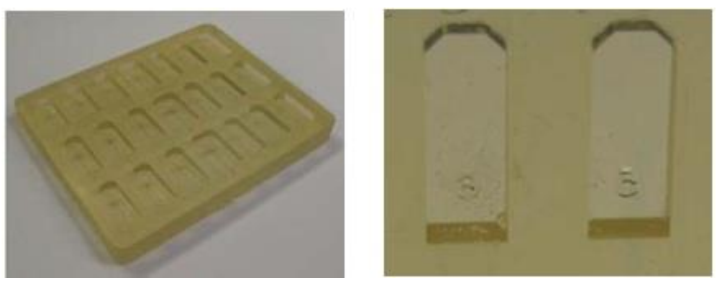


Figure 4-17 Silicone Mold

1. **Mix the epoxy according to the manufacturer's instructions and add the specimen to the mixture.** Combining the particles and epoxy can be done in a mixing dish or in the individual molds. After the end of either method, the mixture should end up in the mold(s) to set.

Figure 4-18 Particle Specimen and Epoxy

2. **Cleave a glass slide or something similar to the width of the individual molds and wrap with Teflon tape.** Insert this into the individual mold(s) to crop the dimension to 10 mm or less. Mix the epoxy according to the manufacturer's instructions and add the specimen to the mixture.

Combining the particles and epoxy can be performed in a mixing dish or in the molds. After the end of either method, the mixture should end up in the mold(s) to set. When the polymerization occurs, the Teflon-coated shim can be removed from the individual mold(s) and specimen cast.

Figure 4-19 Casts removed from the Silicone Mold

Note: Peel the hardened cast off of the Teflon tape-coated shim. Remove as much of the tape from the embedded specimen as possible. For tape that can't be peeled away, lightly sand off any remaining material.

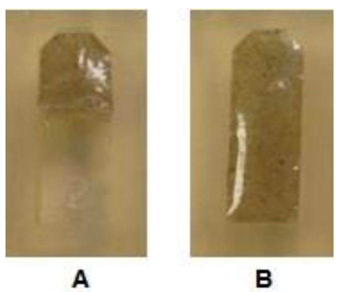


Figure 4-20 Mixture in the mold with (A) and without (B) the shim

Image A exhibits the top-down view of particle mixture in a Silicone mold created with a Teflon-coated piece of Si used as a shim. In image B, the mold is completely filled with the particle mixture.

Note: The silicon rubber mold with the mixture can be inserted to a chamber connected to a vacuum pump to remove air bubbles for a more thorough embedment of the specimen. A low pressure environment is all that is required for this to function. It is the users responsibility to research and test this technique for pressure and time settings conducive to this application.

3. **Allow the epoxy time to set (follow the manufacturer's instructions).**

4. **Remove the cast from the mold and prepare the sample to the recommended dimensions of 10 mm x 10 mm x 4 mm (L x W x H).**

You can combine this action with that of polishing 40-70 µm to your area of interest. The flat embedding mold also ensures the intended cut surface of the cast is planar for even adhesion and minimal topography, an ideal surface for creating a gap of less than 25 µm from the blade edge and the surface of the specimen.

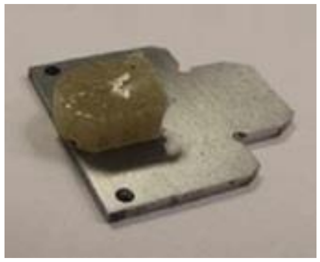


Figure 4-21 Embedded mixture mounted on sample blade

Embedding specimens on a flat surface

Specimens can be embedded without a mold, with the use of Teflon tape and a glass slide or something similar. The following describes the technique for preparing an embedded specimen without a pre-formed mold.

1. **Gather glass slide, Teflon tape, epoxy, and specimen**

   Wrap the glass slide with the Teflon tape. Pull the tape taught over the slide to create a flat, wrinkle-free surface. This creates a feature-free specimen-to-blade interface and will minimize the occurrence of curtaining throughout the ion milled cut area.

Figure 4-22 Glass slide wrapped with Teflon tape

2. **Mix the epoxy according to the manufacturer's instructions and add specimen to the mixture**

   Extract a small amount of the mixture with a toothpick or something similar and place on the Teflon tape. Continue to add to the deposit on the tape until the desired amount is present. Try to keep the shape of the deposit at or below the maximum dimensions of 10 mm x 10 mm x 4 mm (L x W x H).

3. **Allow the epoxy time to set (refer to the manufacturer's instructions)**

4. **Peel the hardened cast off of the Teflon tape-coated glass slide**

   Remove as much of the tape from the embedded specimen as possible. For tape that can't be peeled away, lightly sand off any remaining material. Refer to Figure 2-37 for an example of Teflon tape left on the epoxy.

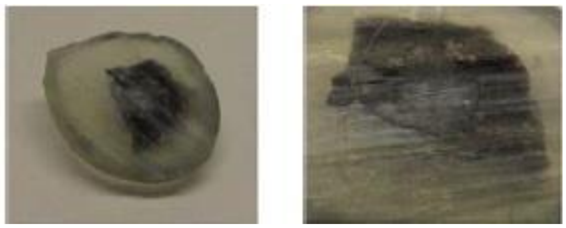


Figure 4-23 Remnant strands of Teflon tape on embedded specimen

5. **Presuming the cast is at or below the recommended sample dimensions, judge if any epoxy or epoxy and material needs to be removed to polished within 40-70um of your interest area.**
   Gatan also recommends the cut surface edge that contacts the sample stop of the loading docks is flat for ease of alignment and mounting to sample blade. This edge of the specimen can be squared off with a precision cut-off saw or created with a hand polishing jig and an abrasive polishing paper.

4.6.2. *Preparing Specimens*

The following process is recommended for materials that require cover glass slips to protect the top layer of the specimen, a dummy Si support or protective layer, and specimens that are more easily prepared using the existing back-side substrate. Such specimens include metal thin films or foils, soft polymers, some semiconductor devices and other materials that may be damaged during the preparation process or prone to delaminating. The advantage of using a cover glass slip, dummy Si or the technique of approaching the area of interest from the existing substrate is that the feature-free specimen-to-blade interface will minimize the occurrence of curtaining throughout the ion milled cut area.

NOTE: Ultimately, the final preparation protocol is decided by the user and an informed decision about the use of the suggestions below is the sole responsibility of the user.

Specimens with cover glass slips or dummy silicon

If the site-specific loading dock is required for the identification and mounting of the specimen, use a cover glass slip which will enable the user to view the area of interest during the process. If dummy Si layer is selected, measure the distance from the edge of the specimen, where it meets the sample stop of the loading dock, to the area of interest and use this measurement to determine where to place the blade onto the specimen.

1. **After the need is determined that a specimen would benefit from the use of a cover glass slip or dummy Si protective layer, apply material to specimen with and adhesive that will not damage the specimen surface.**

2. **Material from the sacrificial layer (the cover glass slip or the dummy Si piece) can be removed to minimize the amount material the ion beams will have to sputter away in order to reach the area of interest.**

   Gatan recommends a final polish with an abrasive of 30 µm or less. As a rule, the better the surface finish, the better the cut quality.

NOTE: The above assumes the dimensions of the cover glass or dummy Si piece will be sized in accordance to the dimensions of the specimen and both the sacrificial layer and the sample are suitable for use in the loading docks.

Backside Thinned-specimens

If there is a pre-existing substrate that is easily thinned, the cut can be set up from the substrate side of the specimen. Thinning the substrate reduces the total preparation and ion milling time. The quality of the cut is dependent on the surface finish of the substrate. As a rule, the better the surface finish, the better the cross-section quality.

4.7. Mounting a Specimen with a Standard Loading Dock

The standard loading dock is provided with the instrument. The specimen is applied face down, so the area of interest is out of view during the mounting process, therefore, it is important to follow the parameters and suggestions offered in Section 4.5**Error! Reference source not found.**. If the area of interest is a known distance from the specimen cut edge, use that measurement to define the placement of the sample blade, preferably with the use of a light microscope, and adjust the micrometer. The standard loading dock is recommended for use in applications for mounting specimens that do not require highly accurate alignments (i.e., samples with large or repetitive areas of interests).

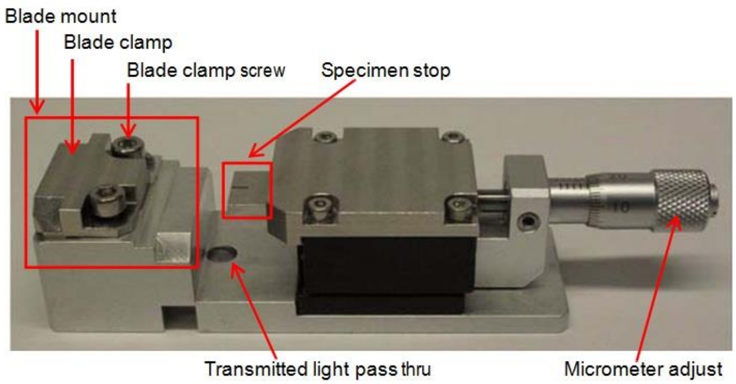


Figure 4-24 Standard Loading Dock

The machined groove in the stop marks the center of the blade and the specimen stop.

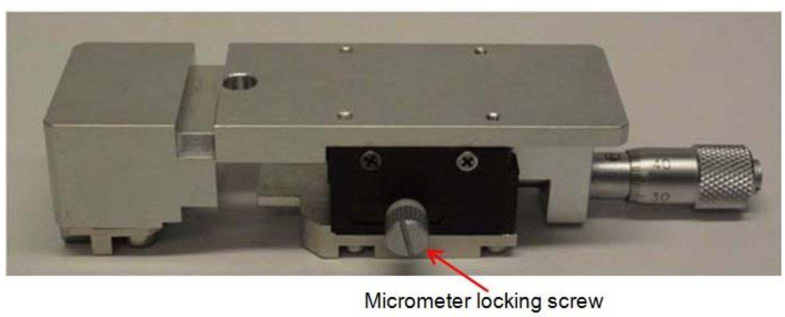


Figure 4-25 Standard Loading Dock

The micrometer locking screw must be loose to drive the micrometer adjust. Gatan recommends the locking screw remain loose throughout the use of the loading dock.

The following describes two methods on how to mount a specimen to the sample blade using the standard loading dock. In method 1, adhesive is applied to the blade, then the specimen is positioned in the adhesive on the blade. In method 2, the specimen is first positioned on the blade, then adhesive is added to three locations at specimen and blade intersections. Although silver paint is referenced as the adhesive in each method, another adhesive may be substituted if suitable.

4.7.1. Method 1

To start, measure distance from the area of interest to location of intended cross-section with a light microscope. Note the rough dimensions of the entire sample. Clean the specimen stop edge to remove material that may hinder proper alignment of the specimen.

1. **Move the specimen stop to the farthest distance from the blade mount.**

   Loosen the blade clamp screws with the M2.5 hex key (provided with the instrument) and move the clamp away from the blade mount. Seat the sample blade, notch-side down, and use the tweezers to maintain that the shoulders of the blade are flush against the blade mount of the loading dock. Move the blade clamp over the sample blade and tighten the clamp screws.

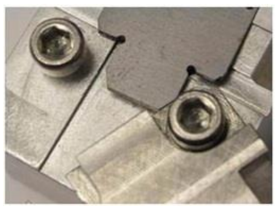


Figure 4-26 Blade Clamp

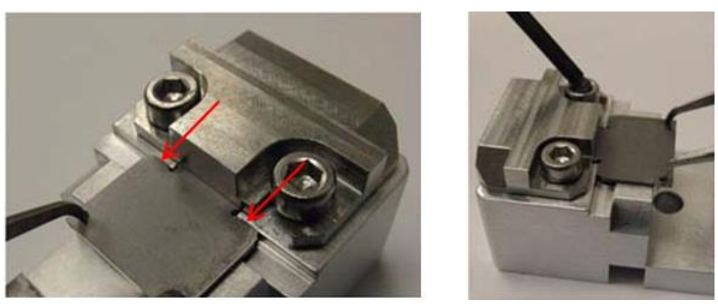


Figure 4-27 Loading the sample blade into the blade mount

Verify the sample blade shoulders are flush against the metal step in the blade mount.

2. **Transport standard loading dock to LM stage**

   Verify the blade shoulders are flush against the blade mount. Drive the stop, controlled by the micrometer, until it is present in the field of view. Use the highest objective possible, dictated by the specific LM lens working distance, to measure and set the distance between the blade edge and the stop. The bot- tom of the groove in the specimen stop is approximately in the same focal plane as the sample blade edge. Image both surfaces when measuring the distance between the blade edge and the stop. Next, make a note of the micrometer reading. If at Step 7, for example, the total distance exposed past the sample blade is 100 µm (30 µm too far), adjust the micrometer 30 µm before the sample is remounted.

Note: One may also use transmitted light mode to measure the illuminated gap between the specimen stop and sample blade edge.

3. **Remove the loading dock from the LM stage**

   Verify the mount and sample blade are clean. Set the specimen face down on the blade mount, cut edge toward the blade edge.

   Note: If there is sufficient clearance, steps 3 and 4 may be done while the loading dock is on the LM stage.

4. **Mix Ag paint, extract a small amount, and apply in an area on the blade where the back edge of the specimen (farthest from the back edge) will contact the sample blade.**

   The machined groove in the stop marks the center of the blade and the specimen stop.

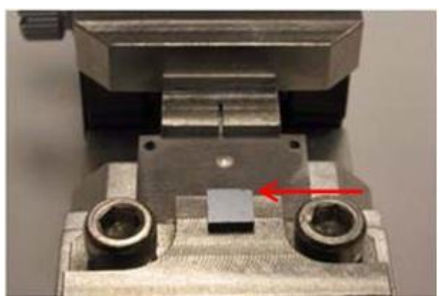


Figure 4-28 Specimen on sample blade mount of standard loading dock

The cut edge of the Si specimen is indicated by the arrow. The machined groove in the stop marks the center of the blade and the specimen stop. The base of the groove is at the approximate same focal plane as the sample blade edge.

5. **Set the middle of the specimen down onto the Ag paint deposit and use tweezers, toothpick or something similar, to apply pressure to the back of the specimen while advancing it towards the stop.**

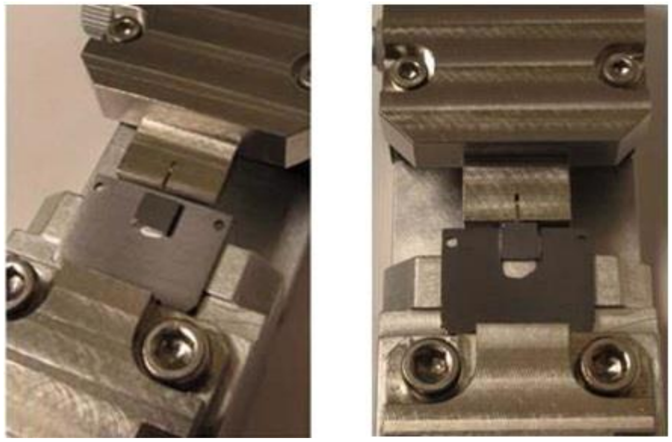


Figure 4-29 Before and after images of advancing the specimen to the specimen stop

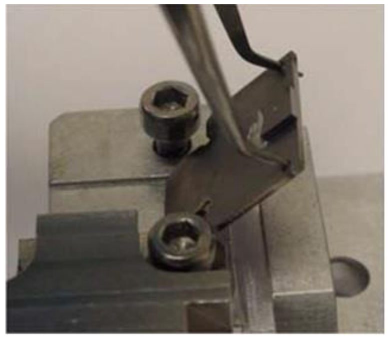
6. **Use the same tool, used to move the specimen into the stop, to apply force to the back surface of the specimen.**

   This will help to minimize the gap distance between the blade edge and specimen surface. Remember, the distance between the blade edge and the specimen should not exceed 25 µm. Allow paint to dry (2-5 minutes or until paint is thoroughly dry).

7. **Retract the stop away from the specimen mounted blade.**

8. **While the blade clamping screws are loosened, move the blade clamp and remove the sample blade by securing it with tweezers through the eyelets.**

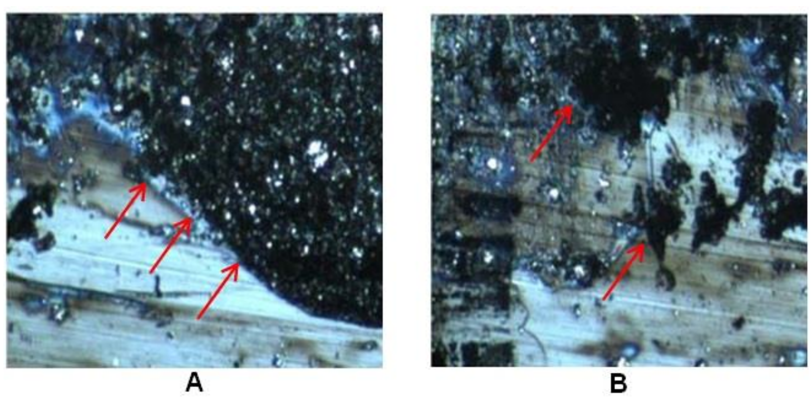
   Use the LM to measure 1) the distance between the specimen and blade edge and 2) amount of specimen exposed to the ion beam. If either measurement is outside of the specified range listed in Section 4.5.2., remove and remount the specimen. Verify that adhesive is not on the area of the specimen exposed to the ion beam or on the blade face.



4-30 Removing Sample blade from standard loading dock

4-31 Ag paint on Si specimen

The red arrows indicate where the Ag paint is located on a polished Si specimen.



4-32 Light micrograph of Ag paint on the specimen cut edge at low magnification

Ag paint on the cut edge that contacts the specimen stop of the loading dock will disrupt alignment of the specimen to the sample blade. In image A, a large deposit of paint has dried on the cut edge of the Si specimen. The red arrows in image B point out large clusters of Ag paint.

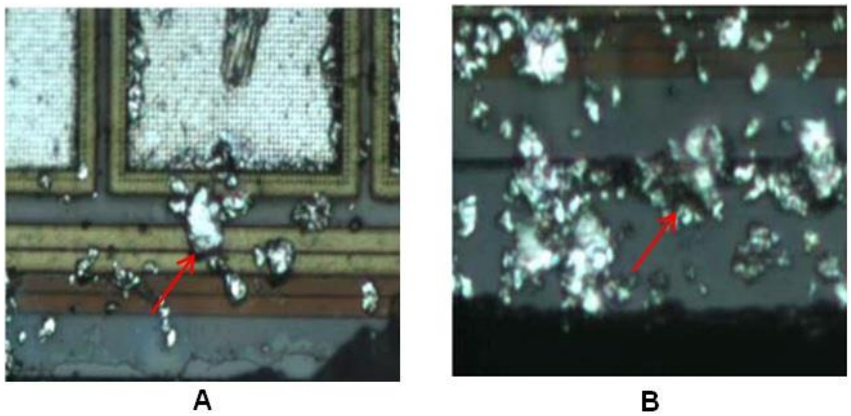


Figure 4-33 Ag paint on the specimen cut surface

Ag paint may be removed from the cut surface of the specimen with compressed air or with acetone and a cotton-tipped applicator. Do not use a sharp object to remove debris to avoid damaging the sample blade edge. In images A and B, the bright clusters are Ag paint particles.

4.7.2. *Method 2*

To start, measure distance from blade edge to area of intended ion sputter cut with a light microscope. Note the rough dimensions of the entire specimen. Clean the specimen stop to remove material that may hinder the alignment and mounting process.

1. **Move the stop to the farthest distance from the blade mount.**

   Loosen the blade clamp screws with the M2.5 hex key (provided with the instrument) and move the clamp away from the blade mount. Seat the sample blade, notch-side down, and use the tweezers to maintain that the shoulders of the blade are flush against the blade mount of the loading dock. Move the blade clamp over the sample blade and tighten the clamp screws.

2. **Transport loading dock to LM stage.**

   Verify the blade shoulders are flush against the blade mount. Drive the stop, controlled by the micrometer, until it is present in the field of view. Use the highest objective possible, dictated by the specific LM lens working distance, to measure and set the distance between the blade edge and the stop. The bot- tom of the groove in the specimen stop is approximately in the same focal plane as the sample blade edge. Image both surfaces when measuring the distance between the blade edge and the stop. Next, make a note of the micrometer reading. If at Step 7, for example, the total distance exposed past the sample blade is 100 µm (30 µm too far), adjust the micrometer 30 µm before the sample is remounted.

Note: One may also use transmitted light mode to measure the illuminated gap between the sample stop and sample blade edge.

3. **Remove the loading dock from the LM stage.**

   Verify the sample and sample blade are clean. Set the specimen face down on the sample blade, cut face toward the blade edge. The machined groove in the stop marks the center of the sample blade and the stop.

   Note: If there is sufficient clearance, steps 3 and 4 may be done while the loading dock is on the LM stage.

4. **Use tweezers, toothpick, or something similar to apply slight pressure to the top of the specimen and prevent the specimen from moving.**

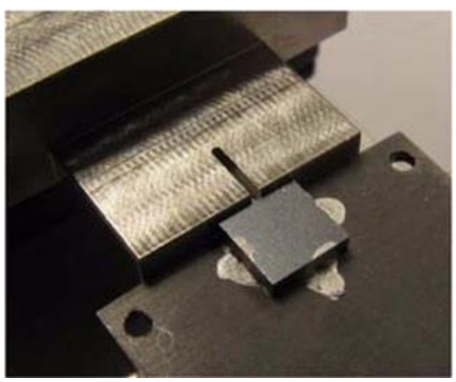


Figure 4-34 Ag paint applied to back edges of specimen

5. **Retract the stop away from the specimen mounted blade.**

6. **While the blade clamping screws are loosened, move the blade clamp and remove the sample blade by securing it with tweezers through the eyelets.**

Use the LM to measure 1) the distance between the specimen and blade edge and 2) amount of specimen exposed to the ion beam. If either measurement is outside of the specified range listed in Section 2.12.2, remove and remount the specimen. Verify the adhesive is not on the area of the specimen exposed to the ion beam, on the sample blade face or on the specimen edge that contacts the specimen stop.

4.8. Mounting a Specimen with the Site-Specific Loading Dock

4.8.1. *Introduction of the Site-Specific Loading Dock*

The site-specific loading dock is an optional purchase and is not provided with the Ilion+ II. The site-specific loading dock is designed to provide the user with a more controlled specimen alignment process. This loading dock will fit on the stages of most light microscopes. In most instances the specimen area of interest is visible during the mounting process and adjustments are executed without removing it from the microscope stage. The following information describes the site-specific loading dock features and proper use of the mounting and alignment jig.

Note: Contact a Gatan Sales Representative for purchasing information of the site-specific loading dock, part number 693.14200.

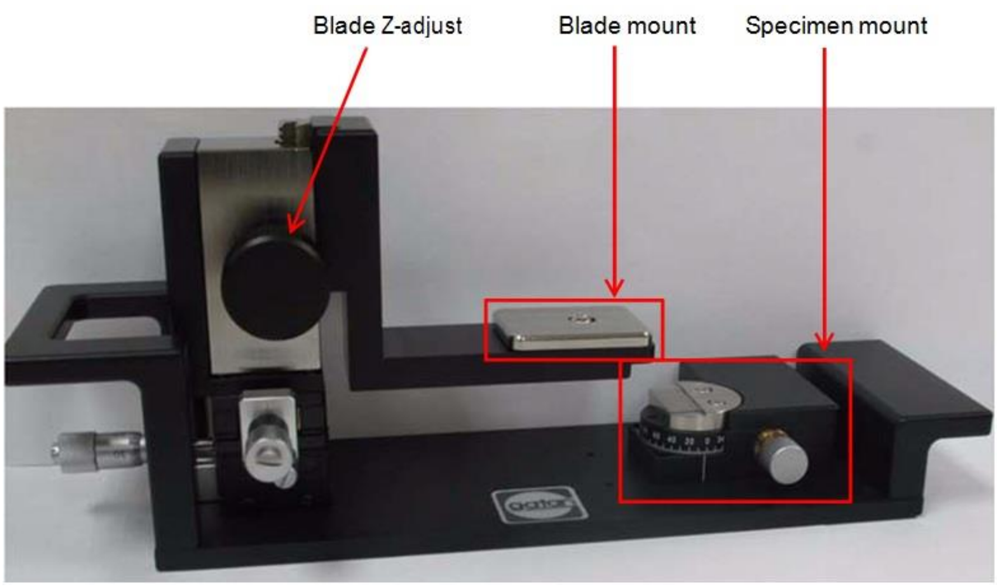


Figure 4-35 **Site-Specific loading dock**

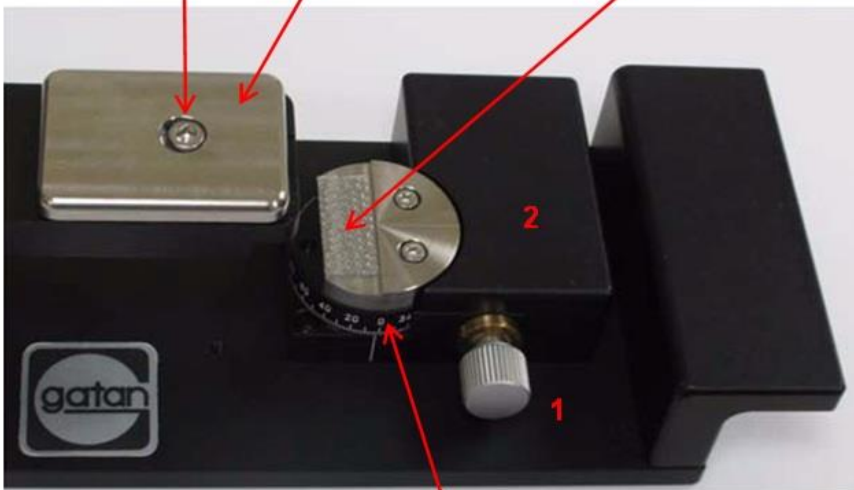


Figure 4-36 Site-specific loading dock sample blade mount and rotatable specimen mount

The adjustment knob (1) is used to rotate the stage by +/- 5 degrees. The cover (2) may be removed by two screws under the base of the unit to expose a tension adjustment and rotation locking knob. These adjustments should not have to be adjusted under normal use.

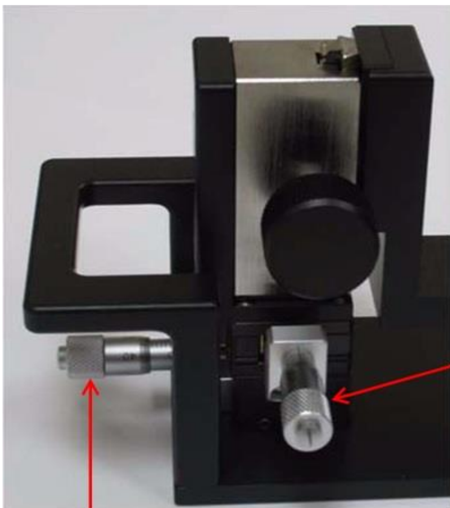


Figure 4-37 Site-specific loading dock blade mount X, Y, and Z micrometer adjusts

4.8.2. *Mounting a Specimen with the Site-specific Loading Dock*

To start, clean the sample to remove any debris that may hinder accurate mounting and alignment of the specimen.

1. **Move the blade mount up, with the black blade z-adjust knobs, and away from the specimen platform, with the x-micrometer adjustment, located at the end opposite the specimen platform.**

   Verify the surface of the non-slip pad on the specimen platform is clean. 3M Scotch tape will remove large particles from this surface and alcohol will renew the non-slip surface.

2. **Apply the specimen, feature-side up, on the non-slip pad of the specimen platform.**

   Position the specimen against the specimen stop. Center the area of interest to the machined groove in the stop, which marks the center of the sample blade and the stop. This step may be performed with the use of a light microscope. Lightly press the sample into the non-slip pad with tweezers, toothpick, or something similar, in a region that will not harm the specimen

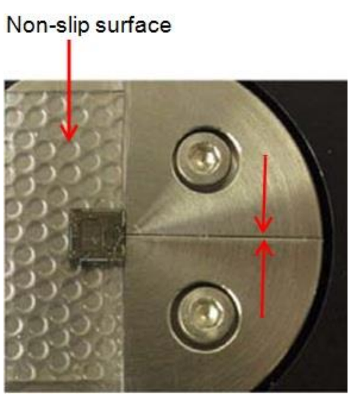


Figure 4-38 Specimen on non-slip surface

   Machined groove on the specimen rotation mount is used to center notch-side of the sample blade to the area of interest of the Si specimen.

3. **Loosen the blade clamp screw with the M2.5 hex key (provided with the Ilion+ II).**

   Seat sample blade, notch-side up, and use the provided tweezers to maintain that the shoulders of the sample blade are flush against the blade mount.

Tighten the clamp screw to fix the sample blade. Drive the blade mount with the y-adjust to position the blade within a few millimeters from the stop. Next, lower the blade mount, with the z-adjust knobs, until it is suspended a few millimeters above the specimen. Lastly, move the y-adjust to align the machined notch in the blade and the machined groove in the stop.

Figure 4-39 Blade mount clamp

Figure 4-40 Verify the sample blade shoulders are fixed into position

The image demonstrates the sample blade shoulder positioned correctly against the blade mount.

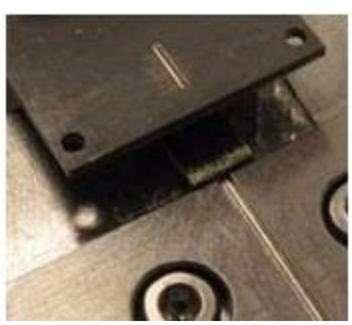


Figure 4-41 Aligning the specimen mount to the sample blade

4. **Transport the site-specific loading dock to the LM stage and drive the sample blade, controlled by the x-adjust, until it is present in the field of view.**

   Use the highest objective possible, dictated by the specific LM lens working distance, to set the blade edge to the desired cut location, which must not defy the parameters listed in Section 4.5. Next, use the rotation adjustment knob to alter the angle of the specimen to the desired setting.

   Note: As the blade wears, the position of the edge can move a few microns. You may want the blade edge to overlap the desired cut position slightly in order to compensate for this effect.

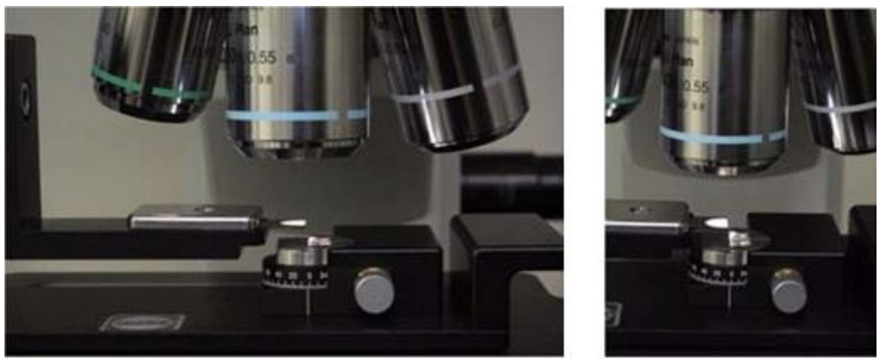


Figure 4-42 Site-specific loading dock on Light Microscope stage

5. **Raise the sample blade z-adjust knobs to allow room for adhesive application (read note below).**

   Mix Ag paint and extract a small amount using the tool and technique suggested in Section 4.7.1. Apply on the back edge of the specimen and lower the blade, with the z-adjust knobs, onto the specimen until it is flat against the sample blade and the non-slip pad is slightly compressed. If necessary, make the final alignment adjustments while the Ag paint is drying; the specimen may have moved when the sample blade was pressed against it. Remember, the distance between the sample blade surface and specimen should not exceed 25 µm.

   Note: One may also remove the loading dock from the LM stage to raise the sample blade z-adjust knobs to allow room for adhesive application. Quickly return the loading dock to the LM stage to lower the blade onto the specimen and make the final alignment adjustments.

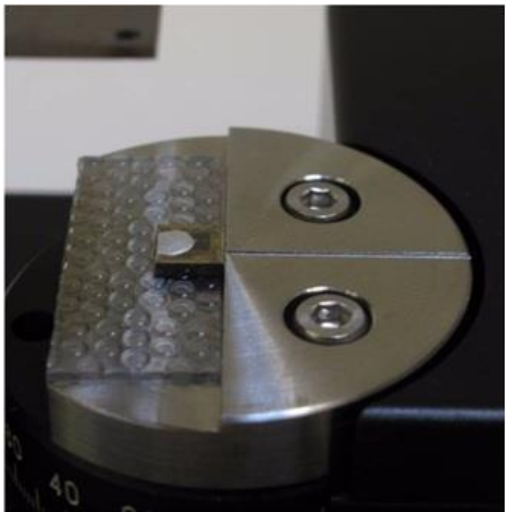


Figure 4-43 Ag paint on specimen

6. **Remove loading dock from LM stage and allow paint to dry (2-5 minutes or until paint is thoroughly dry).**

   Raise the blade and sample using the z-adjust knob until the sample is well clear of the non-slip surface. While the blade clamping screws are loosened, move the blade clamp and remove the sample blade by securing it with tweezers through the eyelets. Use the LM to measure the distance between the specimen and blade edge. If the measurement exceeds the specified amount (listed in Section 4.5.), remove and remount the specimen.

5. Routine Maintenance and Servicing

The maintenance operations listed in Table below should be carried out on a routine basis.

Table 1 Maintenance Operations

Operation	Frequency	Symptom
Clean Viewing Port.	As required	Specimen viewing becomes difficult.
Clean Airlock vacuum seals.	Monthly	Airlock pumps down slowly or not at all.
Clean Cold-Cathode gauge tube.	As required	Erratic reading or out of range reading.
Clean Shutter.	Every 3 months	Sputtered material falling onto specimen.
Dry clean the PIGs.	As required	Gun shorted.
MDP maintenance.	Once a year	Required servicing.
Diaphragm Pump maintenance.	Every 4000 hr	Backing pressure above 12 Torr.
Argon leak detection	As required	Excessive argon usage or poor vacuum.
Clean Work Chamber.	Once a year	Excessive flaking of sputtered material.
Replace stage motor.	As required	Stage piston does not turn.
Replace stage encoder.	As required	Angle position does not register.
Replace bellows assembly.	As required	Chamber vents or pressure increases dramatically when stage is lowered.
Replace gas manifold.	As required	Ar or vacuum leak or valve malfunction.

Caution: Do not use acetone as a cleaning agent. It can cause irreparable damage to instrument parts.

5.1. Replacing the Loading Dock Battery

The loading dock is powered by a 9 Volt battery. It is activated by pressing the button on the front panel. It turns off automatically after about 2-3 minutes. Do not use a rechargeable battery. Either an alkaline or a Lithium battery may be used. An alkaline battery will typically last for about 200 activations. A Lithium battery will typically last for about 500 activations.

- Locate the battery holder on the back side of the loading dock. The holder is labeled "Battery."
- Press the face of the holder to the side, as indicated by the marking "Lift to withdraw" then slide the battery drawer out.
- Remove the old battery and replace with a new 9V battery.
- Replace the battery drawer in the battery holder.

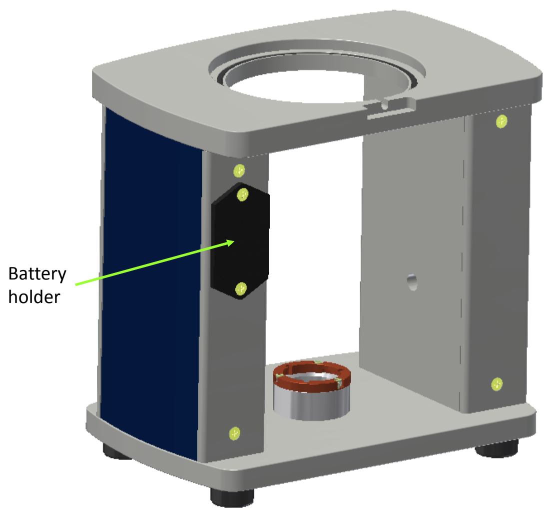


Figure 5-1. Battery holder location

5.2. Cleaning the Viewing Window

The Viewing Window should be cleaned when it becomes difficult to view the sample.

NOTE: This operation requires the PECS II to be shut down and vented.

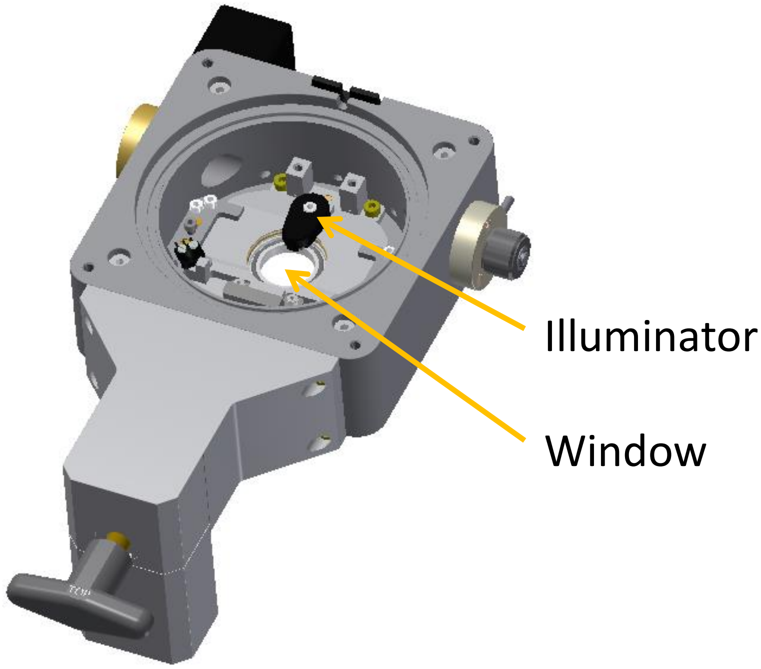


Figure 5-2. Load lock viewing window

1. **Shut off main power (switch on rear panel). Wait 10 minutes for turbo pump to spin down.**

2. **Vent the chamber by slowly opening the manual valve on the dewar (cold stage system) or vent valve assembly (non-cold stage system).** Close the valve once the system is fully vented.

3. **Loosen the screw that holds the illuminator in place.** Rotate illuminator out of the way of the window. Be careful not to damage the wires.

4. **Use a small suction cup to remove the window from the gate.** If the window does not come out easily, remove the load lock from the chamber and push upward on the window from below.

5. **Check the window O-rings. Clean them. If necessary, replace.**

6. **Clean the window.** Use a nonabrasive cleaner or a 2-4 µm diamond polishing compound. Replace the window if deposits are too difficult to remove.

7. **Replace the window into the gate O-rings.**

8. **Turn on the system power.**

5.3. Cleaning the Load Lock Vacuum Seals

The transfer device O-ring should be cleaned monthly with regular use. The system does not need to be vented to clean this O -ring. It can be cleaned without removing it by simply wiping the shaft with a lint-free cloth, then re-lubricating with Krytox. If more thorough cleaning or replacement is necessary, disassemble the transfer device and remove the O-ring with a plastic O-ring removal tool or toothpick. Do not remove the O-ring with a metal tool such as tweezers.

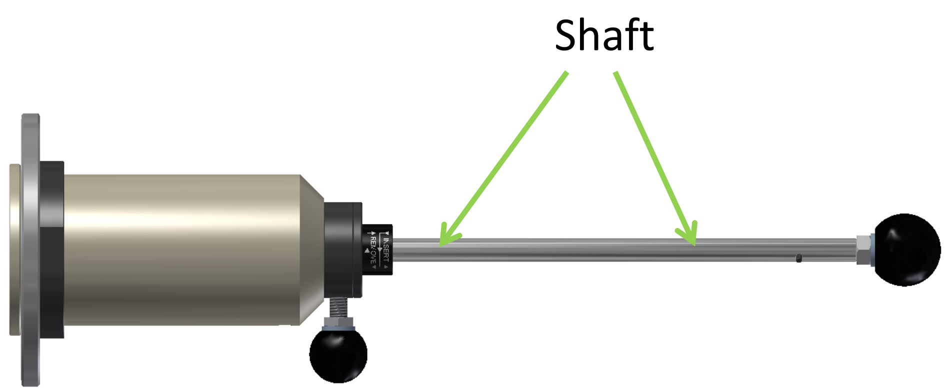


Figure 5-3. Transfer device

Caution: Do not use a metal tool to remove an O-ring. This will cause irreparable damage to the O-ring groove.

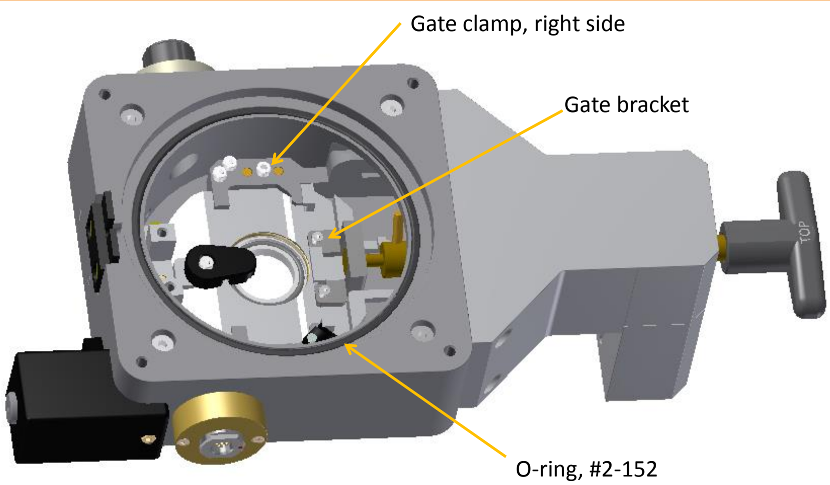


Figure 5-4. Load lock

The gate valve vacuum seals should be cleaned on a quarterly basis with regular use. Clean gloves should be worn at all times when handling these parts.

1. **Shut down the power to the PECS II.** Wait at least 10 min to allow the MDP to come to a complete stop. Then vent the work chamber by opening the Vent valve.

2. **Remove the illuminator from the gate.** Loosen the M2.5 socket head screw and remove the assembly from the gate. Be careful not to damage the wires.

3. **Remove the right hand side gate clamp.** Three M2.5 socket head screws hold this down. Loosen these screws and remove the guide. Lift straight up until the pins clear the base.

4. **Remove the gate bracket from the gate.** 2 M2 socket head screws hold this down.

5. **Remove the gate.** Slide the gate to the right so that it clears the left hand side clamp. Lift out the gate.

6. **Consider cleaning the vacuum window while the system is vented and disassembled. See Section 5.2.**

7. **Clean the O-ring (#2-134) on the bottom side of the gate.** Wipe the o-ring on the bottom of the gate. Krytox GPL-206 may be used as a solvent. If necessary, use a wooden toothpick or O-ring removal tool to remove the O-ring. Never use a metal tool to remove an O-ring.

8. **Clean the underside of the gate and the O-ring grooves with a grease solvent.**

9. **If necessary, replace the O-ring. Lubricate with Krytox GPL-206 vacuum grease (supplied with the system).**

10. **Replace the gate bracket, gate clamp, and close the Vent valve.**

11. **Consider cleaning the guns, if they have not been cleaned lately.** Venting the system can cause particles to flake off the inner walls of the anode cup and create a gun short.

12. **Turn on the power.** Pump down to keep the system free of moisture and minimize oxidation of sputtered materials around the guns. The guns will need to be purged before use.

5.4. Cleaning the Cold-cathode Gauge Tube

Caution: The cold cathode gauge contains a very powerful permanent magnet. Pacemaker wearers should not clean this gauge.

Contamination of the measuring chamber within the tube will affect the pressure reading and generally produce an indication that the pressure is poor. If contamination becomes severe, instability may occur resulting in shorts that may cause pressure bursts. If this occurs, the gauge tube must be dismantled and cleaned.

Tools required: Hex wrenches (1.5 mm & 3.0 mm), open-end wrench (7.0 mm), and locking-ring or snap-ring pliers.

5.4.1. *To Disassemble the Gauge Tube*

1. **Shut down the power to the PECS II.** Wait at least 10 min to allow the MDP to come to a complete stop. Then vent the Work Chamber by opening the Vent valve. Unplug the power cable from the back of the system.

2. **Unplug the connector from the gauge tube.** Unscrew the retaining screw at the center of the connector.

3. **Remove the gauge tube. Pull it straight out from the Manifold.**

4. **Remove the electronic module.** Use the 1.5 mm hex wrench to loosen the set screw on the side of the module and slide it from the gauge tube.

5. **Remove the retainer.** Use the 3.0 mm hex wrench to remove the two socket-head screws at the back of the tube and remove the retainer.

6. **Carefully remove the anode, support ring, and Viton O-ring.** These parts can be individually cleaned or replaced if necessary. Use compressed air to blow out loose particles from within the gauge tube. If the inside of the gauge tube must be cleaned with an abrasive, continue with Steps 7 and 8.

7. **Separate the anode assembly from the magnet.** Use the 7.0 mm wrench to remove the hex-head screw from the magnet and slide off the anode assembly from the magnet.

8. Remove the locking ring and the pole insert from the front of the measuring chamber of the anode assembly.

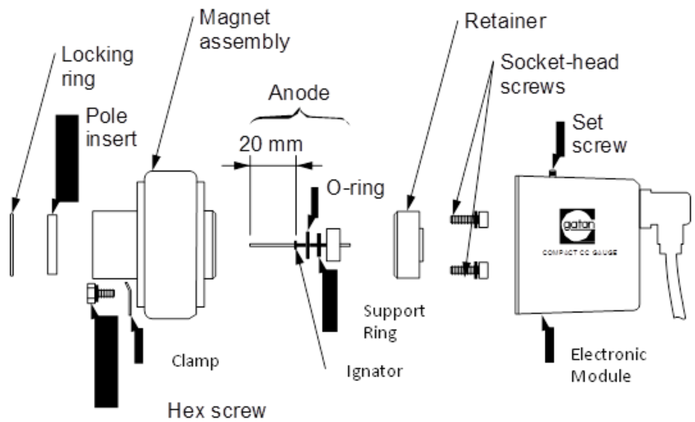


Figure 5-5 Cold-cathode gauge tube.

5.4.2. *To Clean Gauge Tube Parts*

1. Clean the inside of the tube and the front pole insert. Use a "Scotccbrite" pad or polishing cloth (500 grain).

2. Rinse both parts with methanol. Dry with compressed air or nitrogen gas.

3. Carefully clean the anode and ignitor with a polishing cloth.

The ignitor can be moved on the anode by sliding it up or down. The ignitor is fragile and can easily be damaged, use extreme care when moving or cleaning it. Do not bend the anode pin or damage the ceramic part since it forms the vacuum seal.

5.4.3. *To Reassemble the Gauge Tube*

1. Position the ignitor 20 mm from the end of the anode pin.

2. Insert the O-ring and support ring into the tube. The sealing surface, O-ring, and ceramic part must be clean.

3. Carefully insert the anode and ignitor into the tube.

4. Replace the retainer and tighten the screws uniformly until the stop position is reached.

5. Slide the pole insert into the front of the tube and mount the snap ring against the pole insert.

NOTE: Visually check that the anode pin is centered within the hole of the pole insert.

6. **Mount the magnet onto the anode assembly.** Lock it with the hex-head screw and clamp.

7. **Carefully push on the electronics module until it stops.**

8. **Position the connector rotated 180º from the magnet retaining screw.** Secure the module snugly in place with the socket-set screw.

⚠ **Caution:** Do not tighten down hard on the set screw.

9. **Replace the gauge tube into the manifold.** Locate the magnet retaining screw into the notch on the manifold.

10. **Plug the connector into the gauge tube. Secure the retaining screw.**

11. **Close the Vent valve, restart the PECS II, and pump down the system.**

⚠ **Caution:** Do not allow the PECS II to run for more than 1 hr with the cold-cathode gauge at pressures above 10^{-3} Torr since a glow discharge will occur in the tube causing it to become contaminated.

5.5. Cleaning the Shutters

The pneumatically operated Shutter is designed to operate for an extended period of time with only a minimal amount of maintenance. The top Shutter reduces buildup of sputtered material on the viewing window and instead accumulates material on its underside. The bottom shutter shields the sample from coating while the target is conditioned. Material builds up on the top side of this shutter.

Over a period of time, the accumulated material may crack, peel, and flake off onto the specimen. Venting to atmosphere also may cause the sputtered material to lose adhesion and to peel and flake. For these reasons, the Shutters should be examined and cleaned periodically, at least every 3 months or so with regular use.

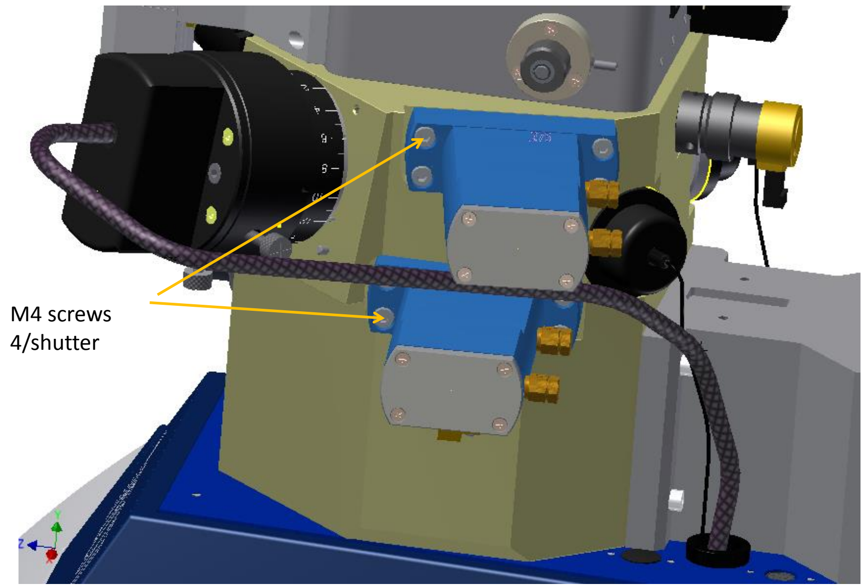


Figure 5-6. Shutter removal

1. Shut down the power to the PECS II. Wait at least 10 min to allow the MDP to come to a complete stop. Then vent the Work Chamber by opening the Vent valve.

2. Remove the 2 screws that hold the sensor to the bottom of the bottom shutter.

3. Remove the tubing from the back of both shutters. Remember which tube is installed on which fitting so it can be replaced properly. The green tubing is closer to the chamber and the red tubing is farther from the chamber. The tubing to the top shutter is typically longer than the tubing to the bottom shutter. This tubing is very tight on the barbed fittings, pliers may be required to remove it.

4. Loosen the 4 screws that hold each shutter to the work chamber. Carefully pull the shutter straight out until the shutter clears the work chamber.

5. Clean the sputtered material off the top and bottom of the shutters. If the shutter is relatively clean, it may only require manual wiping with a lint-free cloth and alcohol. If the material is difficult to remove, clean using fine grain Scotch-Brite 7447B or similar pad. Clean with alcohol and dry with compressed air.

6. Pull the shutter rod outward from the shutter assembly so the rod is fully exposed. The bottom shutter is spring-loaded and will want to remain closed. Clean the rod with alcohol and thoroughly dried. Inspect the O-ring leading into the shutter assembly.

7. **Inspect the movement of the shutter.** The interior O-rings should be cleaned every 250,000 cycles (~2.5 years with heavy use), or if movement becomes extremely difficult.

8. **Clean the O-rings on the face of the shutters.**.

9. **Install both shutter assemblies onto the work chamber.** Replace the 4 screws each. Replace the tubing. Replace the sensor assembly on the bottom of the bottom shutter. Be sure the top and bottom shutter assemblies are installed in the proper place, see the labels on the bottom of the assemblies.

10. **Close the vent valve and turn on system power.**

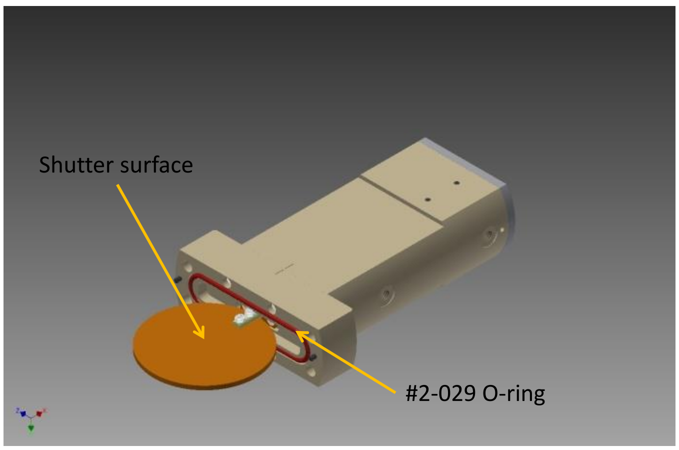


Figure 5-7. Cleaning the shutters

⚠ **Caution:** The Shutter will not operate if the blade or shaft is bent by improper handling during cleaning.

5.6. Care of Penning Ion Guns

⚠ **Caution:** The Penning guns contain very powerful permanent magnets. Pacemaker wearers should not clean these guns.

Good care and maintenance of the PIGs are absolutely essential to obtaining good specimen thinning. There are two ways to clean the guns: dry method and wet method.

The gun maintenance screen can be used to help determine if a gun is shorted. If the discharge current in microamps is approximately equal to the discharge voltage in volts, and the accelerating current is unusually low; then the gun is likely shorted. For example, when the beam voltage is 6 kV, the discharge voltage is approximately 890 V. If the discharge current is approximately 890 uA and the accelerating current is significantly lower than normal for 6 kV beam voltage, then the gun is likely shorted. Note that these same conditions apply during beam modulation when the guns are between milling sectors, because the guns are shorted in the HVPS. Similarly, if the accelerating voltage read is significantly lower than the accelerating voltage set, then the gun is also likely shorted.

⚠ **Caution:** any time the work chamber is vented, the guns must be purged for 4-5 hours at 1 sccm before milling samples (overnight is better). This ensures that the gas flow settings are correct and that the beams will be focused properly.

5.6.1. *Dry Cleaning the Penning Ion Guns*

The dry method of cleaning involves wiping the parts with a clean dry tissue, then using dry nitrogen or clean compressed air to remove any dust, lint, or metallic whiskers that are the primary cause of shorts in the guns. This method is preferred because the cleaning time and the actual time the gun parts are out of the vacuum is reduced to a minimum. Additionally, since no solvents are used, the required argon purging time for the guns after start-up is greatly reduced.

<u>To Remove the Gun:</u>

1. **Shut down the power to the PECS II.** Wait at least 10 min to allow the MDP to come to a complete stop. Unplug the power cable from the back of the system.

Then vent the Work Chamber by opening the Vent valve. There is no need to unplug the HV cables nor remove any of the side covers from the PECS II.

2. **Remove the gun assembly from the work chamber.** Pull straight outward to remove the gun from the chamber.

3. **Remove the gun knob from the gun housing.** Use the 3.0mm hex wrench to remove the two screws from the gun knob and pull the knob from the gun housing.

4. **Withdraw the ion source from the gun housing.** Use the 3.0 mm hex wrench to remove the single screw from the molded connector assembly. Slowly pull on the toggle stick to withdraw the ion source from the gun housing.

5. **Wipe off sputtered material from the exterior of the gun housing.**

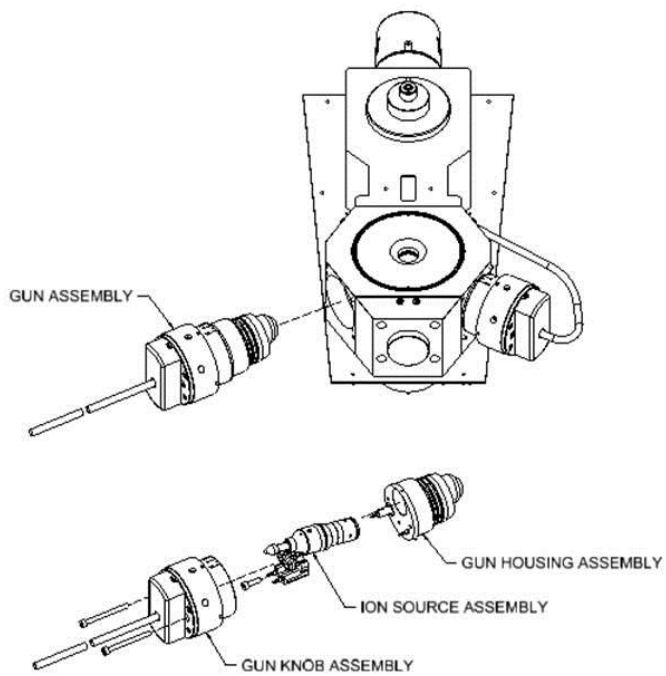


Figure 5-8. Removal and disassembly of ion guns.

NOTE: From this point, use nylon or latex gloves to handle all parts. Special attention must be paid to the cleanliness of all the parts, especially the magnet assembly. The disassembly and subsequent assembly should be done with the aid of a x10 stereo microscope.

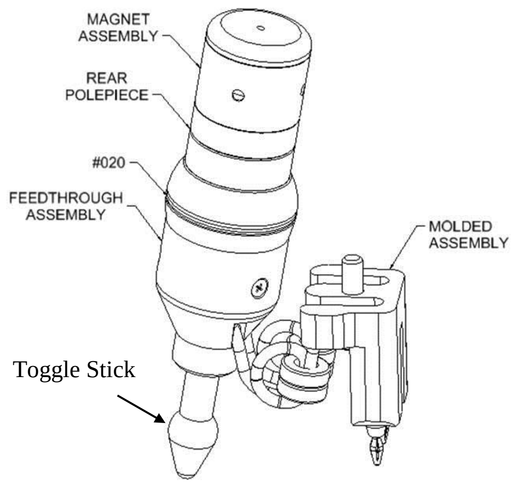


Figure 5-9 Ion source assembly.

To Disassemble the Ion Source:

1. Lift the magnet assembly off the rear polepiece.

Hold the ion source with one hand and grasp the magnet assembly with the other hand. Lift the magnet assembly off the rear polepiece by tilting it to one side.

NOTE: The rear polepiece can be cleaned directly on the HV connector (without disassembly) by dusting it off using dry nitrogen or clean compressed air. If any particles remain, use a tissue or Scotch-Brite to remove them and dust again with compressed air.

2. Remove the anode cup assembly from the magnet.

Lightly tap the assembly on its edge until enough of the anode protrudes to be pulled out of the magnet.

3. Remove the anode cup insulator with the eraser end of a pencil.

4. Separate magnet from the front polepiece.

Holding the magnet in one hand, place the eraser end of a pencil into the magnet and push against the front polepiece to separate it from the magnet. Warning: The magnet is extremely powerful and requires careful handling to prevent it from attracting metallic whiskers and from being attracted to any other magnetic material that may shatter it.

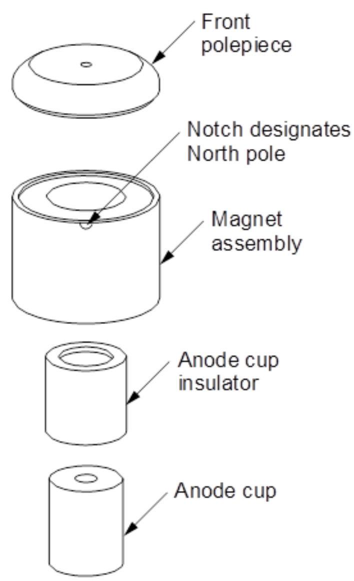


Figure 5-10 Removal of anode assembly and anode cup insulator.

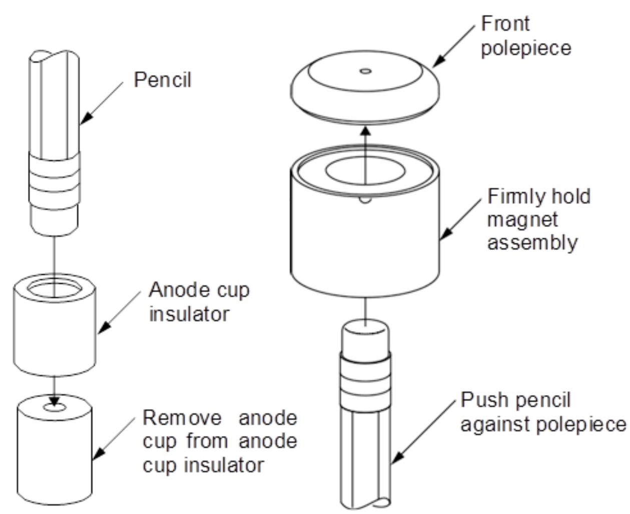


Figure 5-11 Removing anode cup assembly/front pole piece.

To Inspect and Clean the Gun:

1. Carefully examine the inside face of the front polepiece and the top of the anode cup.

Look for black or burnt spots that would indicate a short. Burn marks on the front polepiece may easily be removed using 600-grit emery paper or Scotch-Brite. Depending upon the severity, burn marks on the anode cup insulator may also be removed with 600-grit paper. However, if burn marks are deep, replace the anode cup insulator.

2. Clean the anode cup.

Clean the anode cup by wiping with a clean dry tissue and dusting it with dry nitrogen or clean compressed air. Clean all the loose sputtered material on the inside surface and the face of the cup using an abrasive pad such as Scotchbrite 7447. Wipe clean with a dry tissue and dust with dry nitrogen or compressed air.

3. Clean any particles or whiskers off of the magnet assembly. Use a lint-free cloth and clean compressed air. If there are stubborn particles that are difficult to remove, touch the surface with scotch tape to remove the particles.

4. Remove the O-ring from the ion source, if necessary.

Squeeze and push up from both sides with thumb and index finger to remove the O-ring from the ion source. Clean, apply vacuum grease (Krytox), and replace. Apply vacuum grease to the curved Rulon bearing that captures the o-ring. If this surface and the o-ring are not lubricated, then the beam alignment will not move freely. Also apply vacuum grease to the curved surface of the toggle stick, which mates with the drive screws in the gun knob. This helps the toggle stick slide freely against the drive screws.

5. Dust inside the gun housing and the inside face of the front polepiece.

Be sure the curved face on the inside of the gun housing that meets the o-ring is clean. This face should be lubricated with Krytox grease provided.

To Reassemble the Gun:

1. Insert the anode cup into the anode cup insulator (sliding fit).

2. Insert the anode assembly into the magnet assembly (loose sliding fit).

3. Carefully place the magnet assembly against the edge of the rear polepiece.

Slowly lower the magnet assembly in place until the rear polepiece is within the magnet shield. The parts will be concentric to one another.

4. Slip the ion source into the gun housing.

Pay particular attention that the O-ring is not damaged in the process. Carefully align the white reference dot at the back of the gun to the mating groove machined into the outside diameter of the gun housing.

5. Insert the screw into the molded connector assembly and tighten.

This assembly should be aligned relatively square with the chamber. Guide the knob over the toggle stick until it is firmly in place and screw in the two retaining screws.

Repeat this procedure on the second gun if necessary.

5.6.2. *Wet Cleaning the Penning Ion Guns*

As stated earlier, the dry method of cleaning the guns is preferred. However, once the guns have been used extensively, a more thorough cleaning may be required. The wet method of cleaning involves the use of solvents such as freon or methanol with an abrasive material. A Scotchbrite pad or 600-grit emery paper can be used to remove all sputtered material. Once complete and assembled, the time required to pump down the chamber and to argon purge the guns is significantly longer when compared to the dry method of cleaning. If it is necessary to use this method, then this is a good time to also clean the Shutter and the inside of the Work Chamber to reduce overall down time.

To Remove the Gun

1. Shut down the power to the PECS II.

Wait at least 10 min to allow the MDP to come to a complete stop. Then vent the Work Chamber by opening the Vent valve. Since the HV cables are not unplugged, there is no need to remove any of the side covers from the PECS II. Unplug the power cable from the back of the system.

2. Remove the gun knob from the gun housing.

Rotate the gun knob to the 10° Top position. Use the 3.0mm hex wrench to remove the two screws from the gun knob and pull the knob from the gun housing.

3. Lift off the Viewing Port and the top cover plate from the chamber.

Place one hand at the back of the gun and with the other hand push on the gun housing from inside the chamber. Remove the gun.

To Disassemble the Gun

1. Withdraw the ion source from the gun housing.

Use the 3.0mm hex wrench to remove the single screw from the molded connector assembly then slowly pull on the toggle stick to withdraw the ion source from the gun housing.

2. Lift the magnet assembly off the rear polepiece.

Hold the ion source with one hand and grasp the magnet assembly with the other hand. Lift the magnet assembly off the rear polepiece by tilting it to one side.

NOTE: The rear polepiece can be cleaned directly on the HV connector by dusting it off with dry nitrogen or clean compressed air. If any particles remain, use a tissue to remove them and dust again with the compressed air. Special attention must be paid to the cleanliness of all the parts, especially the magnet assembly.

3. Remove the anode cup assembly from the magnet.

Lightly tap the assembly on its edge until enough of the anode cup protrudes to be pulled out of the magnet.

4. Remove the anode cup insulator with the eraser end of a pencil.

5. Separate magnet from the front polepiece.

Holding the magnet in one hand, place the eraser end of a pencil into the magnet and push against the front polepiece to separate it from the magnet.

Warning: The magnet is extremely powerful and requires careful handling to prevent it from attracting metallic whiskers and from being attracted to any other magnetic material that may shatter it.

To Inspect and Clean the Gun

1. With a low-power microscope, carefully examine the inside face of the front polepiece and the top of the anode cup.

Look for black or burnt spots that would indicate a short. Burn marks on the front polepiece may easily be removed using 600-grit emery paper. Depending upon the severity, burn marks on the anode cup insulator may also be removed with 600-grit paper. However, if burn marks are deep, replace the anode cup insulator.

NOTE: From this point, use nylon gloves to handle all clean parts. Special attention must be paid to the cleanliness of all the parts, especially the magnet assembly. The subsequent assembly should be done with the aid of a ×10 stereo microscope.

2. Clean the anode cup using freon or methanol.

Clean all the sputtered material on the inside surface of the cup using a Scotchbrite pad.

3. Wipe off the magnet and the rear polepiece with freon or methanol.

4. Clean and lubricate the O-ring and the bearing surface on the outside of the ion-source assembly.

Dust parts off using clean compressed air or nitrogen gas to remove any dust, lint or metallic whiskers that are the primary cause of shorting in the gun.

Squeeze and push up from both sides with thumb and index finger to remove the O-ring from the ion source. Clean, apply vacuum grease (Krytox), and replace. Apply vacuum grease to the curved Rulon bearing that captures the o-ring. If this surface and the o-ring are not lubricated, then the beam alignment will not move freely. Also apply vacuum grease to the curved surface of the toggle stick, which mates with the drive screws in the gun knob. This helps the toggle stick slide freely against the drive screws.

5. Clean the gun housing O-rings.

Remove the two O-rings from the gun housing and thoroughly clean all surfaces with freon or methanol, including the O-ring grooves.

Replace O-rings, if necessary.

Dry off all surfaces and parts with compressed air or freon gas.

To Reassemble the Gun

1. Insert the anode cup into the anode cup insulator.

2. Insert the anode assembly into the magnet.

Be sure the top of the anode is at the north face of the magnet.

3. Replace the front pole piece.

4. Carefully place the magnet assembly against the edge of the rear polepiece.

Slowly lower the magnet assembly in place until the rear polepiece is within the magnet shield. Properly assembled, the parts will be perfectly concentric to one another.

5. Place a light film of vacuum grease around the inside surface (first one centimeter) of the port for the ion source.

6. Slip the ion source into the gun housing.

Pay particular attention that the O-ring is not damaged in the process.

7. Align ion source in the housing.

Align ion source so that the moulded assembly is aligned to the screw hole in the housing.

8. Insert the screw into the molded connector assembly and tighten.

This assembly should be aligned squarely with the Chamber.

9. Test the gun before inserting into the Work Chamber.

Use an ohmmeter and test the gun to ensure that a short does not exist across the HV contacts. A direct short usually indicates the gun was not assembled properly. A higher resistance short up to 2MΩ indicates the presence of small conductive whiskers within the gun. If this is the case, the cleaning steps described above should be repeated.

10. Place a light film of vacuum grease around the Work Chamber gun port.

11. Insert the complete assembly into the Work Chamber.

Align the reference mark on the diameter of the gun housing to the mating mark on the Chamber.

12. Replace the gun knob in the gun housing.

Guide the gun knob over the toggle stick until it is firmly in place and screw in the two retaining screws.

Repeat this procedure on the second gun.

5.6.3. *Servicing the Focus Electrode*

The focus electrode should not normally require maintenance. Sputtered material may build up on the electrode or insulator and need to be removed.

1. Shut down the power to the PECS II.

Wait at least 10 min to allow the MDP to come to a complete stop. Then vent the Work Chamber by opening the Vent valve.

2. Remove the gun knob from the gun housing.

Rotate the gun knob to the 10° Top position. Use the 3.0mm hex wrench to remove the two screws from the gun knob and pull the knob from the gun housing.

3. Remove the gun housing from the work chamber.

4. Remove the upper front housing electrode from the gun housing.

Rotate the electrode counter clock-wise using a spanner wrench.

5. **Clean the ground electrode if necessary.**

6. **Remove the focus electrode insulator from the housing.**

Gently pry the insulator from the housing. Be careful not to damage the flex cable or the gasket material.

7. **Clean the focus electrode.**

Clean the focus electrode cup by wiping with a clean dry tissue and dusting it with dry nitrogen or clean compressed air. Clean all the loose sputtered material on the inside and outside faces of the cup using an abrasive pad such as Scotchbrite. Wipe clean with a dry tissue and dust with dry nitrogen or compressed air.

8. **Reassemble the gun housing.**

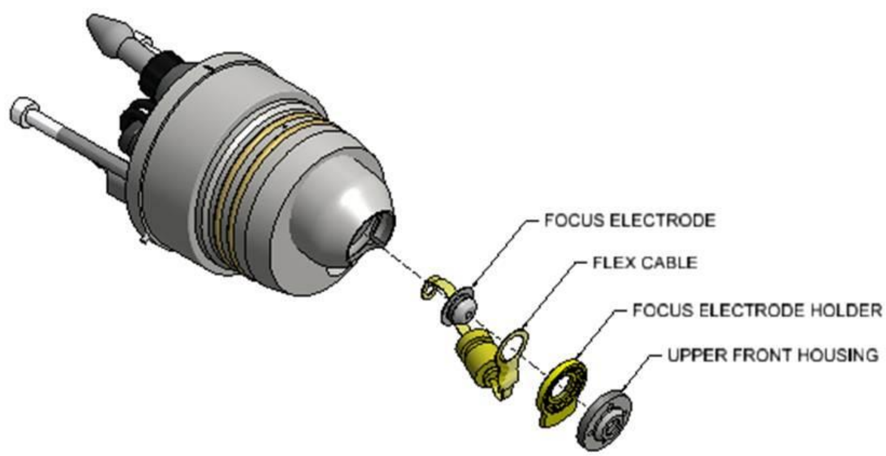


Figure 5-12 Focus electrode assembly.

5.7. Removing the Cover

To remove the cover:

1. Shut down the power to the PECS II.

Unplug the power cable from the power entry module.

2. Remove the 4 M3 screws from the outside edges of the rear panel.

3. Pull the cover forward until the latches release from the frame.

4. Bend the sides of the cover slightly outward so that the cover may be completely removed.

Be careful not to bend the cover too far.

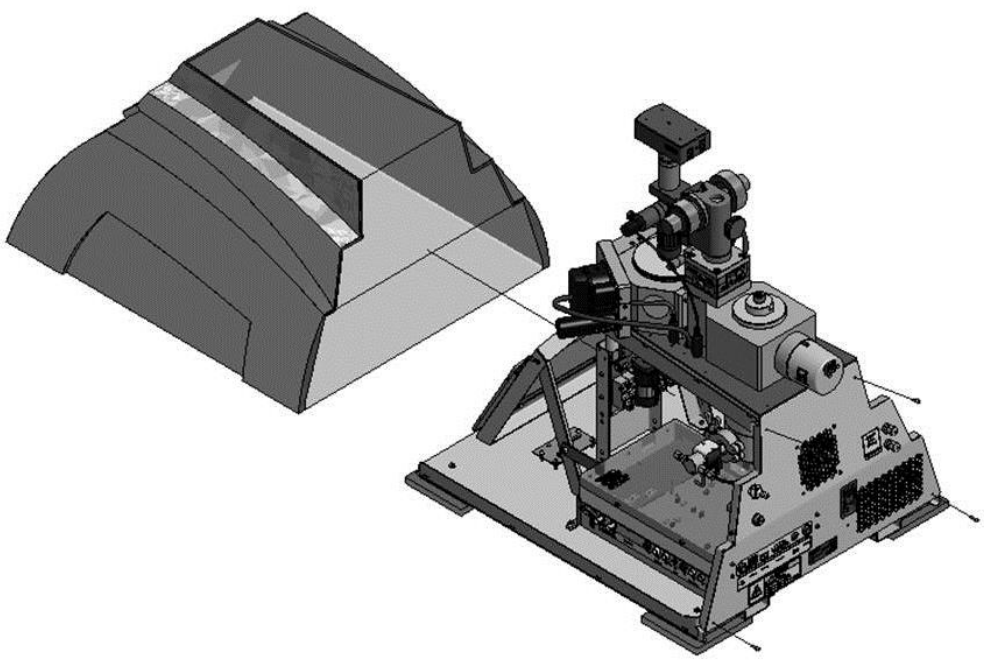


Figure 5-13 Cover removal.

5.8. Replacing the MDP Oil Cartridge

The MDP requires the oil cartridge to be changed at least once a year. However, if a high- pitched squeal begins, the oil cartridge should be changed immediately.

The oil cartridge consists of a stack of felt discs saturated with oil and is replaced as a unit. Changing the cartridge requires the Chamber to be vented to atmosphere and the MDP to be completely removed from the PECS II. This provides an opportunity to service other parts of the vacuum system.

NOTE: The oil in the MDP is for lubrication of the bearings only, and does not come in contact with the vacuum chamber hence eliminating any concern for hydrocarbon contamination.

5.8.1. *To Remove the MDP*

1. **Shut down the power to the PECS II.**

   Wait at least 10 min to allow the MDP to come to a complete stop. Then vent the Work Chamber by opening the Vent valve. Unplug the power cable from the power entry module.

2. **Remove the control cable from the MDP.**

   Loosen the 2 screws in the D-sub connector and unplug the cable.

3. **Remove the Vac-valve assembly.**

   Loosen and remove the compression fitting on the back of the Vac-valve assembly, this will separate the Vac-valve assembly from the tubing that connect the DP. Loosen and remove the KF clamp and centering ring from the exhaust port in order to remove the Vac-valve assembly. Carefully place the Vac-valve assembly on the electronics enclosure, being careful not to kink the nylon tubing.

4. **Loosen the 4 MDP mounting screws on the support plate.**

   These screws retain the flange clamps used to lock the MDP to the manifold. Remove two of the screws and clamps completely; then support the MDP from the underside with one hand while removing the other two screws and clamps.

5. **Lower the MDP and remove it from inside the cabinet.**

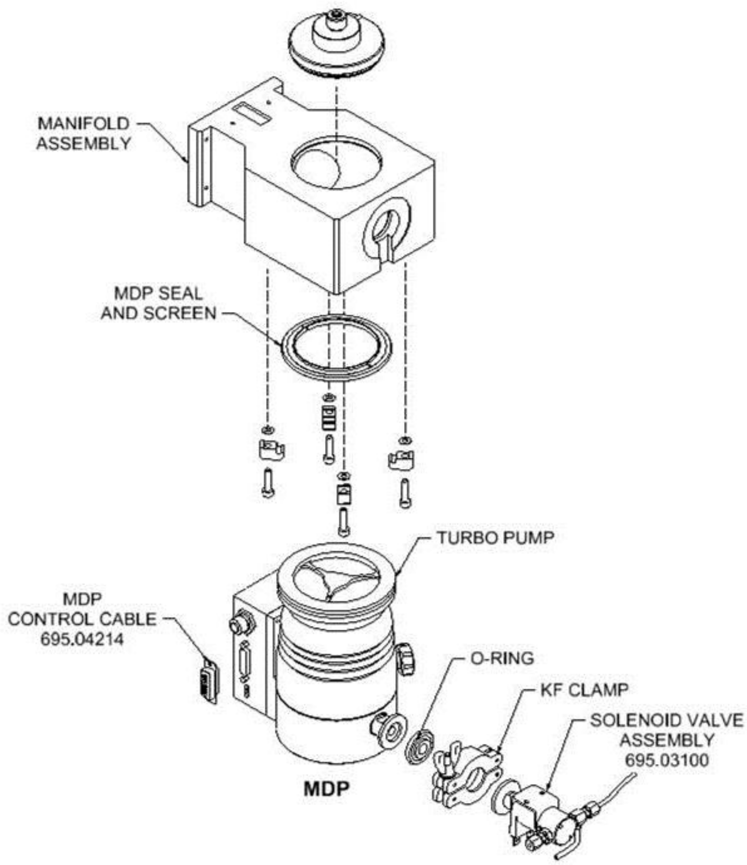


Figure 5-14 Molecular drag pump removal.

The oil cartridge can be replaced upon removal of the MDP from the cabinet.

5.8.2. *To Replace the Oil Cartridge*

Follow the directions in the Pfeiffer HiPace 80 TurboDrag Pump Operating Instructions manual (shipped with PECS II).

After the MDP is reconnected to the PECS, and the system is powered on, the guns must be purged for 4-5 hours before milling samples.

5.9. Diaphragm Pump Maintenance

Both diaphragms should be replaced after 4000 h of use. If either of them fails after 2000 h, replace both of them.

5.9.1. *To Disconnect the Diaphragm Pump*

1. Shut down the power to the PECS II.

Wait at least 10 min to allow the MDP to come to a complete stop. Then vent the Work Chamber by opening the Vent valve.

2. Unplug the power cord from the power entry module (rear panel).

3. Unplug the two electrical connectors on the DP.

4. Disconnect the vacuum hose running from the pump to the back of the PECS cabinet.

Press the latch of the quick disconnect fitting and remove the hose.

5.9.2. *To Replace Diaphragm*

Follow the directions in the Pfeiffer MVP 020-3 Diaphragm Pump Operating Instructions manual (shipped with PECS).

After the DP is reconnected to the PECS, and the system is powered on, the guns must be purged for 4-5 hours before milling samples.

5.10. Cleaning the Work Chamber

Clean the Work Chamber when you have vented the system for other maintenance to reduce overall down time.

1. Shut down the power to the PECS II.

Wait at least 10 min to allow the MDP to come to a complete stop. Then vent the Work Chamber by opening the Vent valve. Unplug the power cable from the back of the system.

2. Unplug the 2 cables connected to the outside of the load lock chamber. See Figure 5-15.

3. Remove the 4 screws that hold the load lock chamber to the work chamber. See Figure 5-16. Lift off the load lock assembly from the work chamber.

4. Clean the Chamber. There is no need to polish the chamber. Just remove flakes of sputtered materials with a simple vacuuming and/or wiping with a lint-free cloth. Methanol can be used but it will increase pump down time. Stubborn material can be removed with a Scotch-Brite pad such as is used to clean the guns.

5. Replace the load lock assembly.

6. Power on the PECS II.

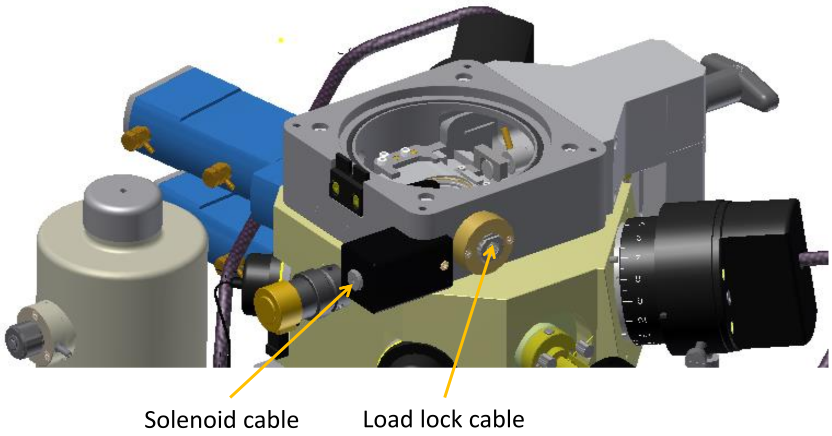


Figure 5-15. Load lock cable connections

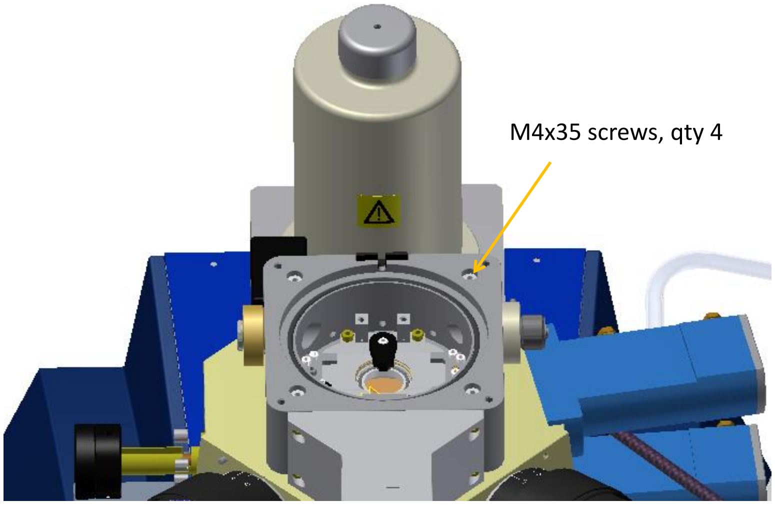


Figure 5-16. Removing the load lock

5.11. Cleaning the Shutter Pistons

The shutter piston is controlled by two valves, SI and SO. The SI valve is on and the SO valve is off when the shutter is closed (covering the window). The SI valve is off and the SO valve is on when the shutter is open. Sputtered material can build up on the shutter piston shaft, and need to be cleaned off. If the speed of the shutter decreases significantly over time, or if the shutter no longer moves as far, it may need to be cleaned and inspected.

The interior O-rings should be cleaned every 250,000 cycles (~2.5 years with heavy use), or if movement becomes extremely difficult.

1. Shut down the power to the PECS II. Wait at least 10 min to allow the MDP to come to a complete stop. Then vent the Work Chamber by opening the Vent valve.

2. Remove the 2 screws that hold the sensor to the bottom of the bottom shutter.

3. Remove the tubing from the back of both shutters. Remember which tube is installed on which fitting so it can be replaced properly. The green tubing is closer to the chamber and the red tubing is farther from the chamber. The tubing to the top shutter is typically longer than the tubing to the bottom shutter. This tubing is very tight on the barbed fittings, pliers may be required to remove it.

4. Loosen the 4 screws that hold each shutter to the work chamber. Carefully pull the shutter straight out until the shutter clears the work chamber.

5. Clean the sputtered material off the top and bottom of the shutters. If the shutter is relatively clean, it may only require manual wiping with a lint-free cloth and alcohol. If the material is difficult to remove, clean using fine grain Scotch-Brite 7447B or similar pad. Clean with alcohol and dry with compressed air.

6. Disassemble the shutters and clean the internal O-rings. The bottom shutter is spring-loaded and the top shutter is not. Clean the rod with alcohol and re-lubricate with Krytox. Clean the O-rings that contact the shaft. Inspect and clean the O-ring on the back of the piston (oval piece).

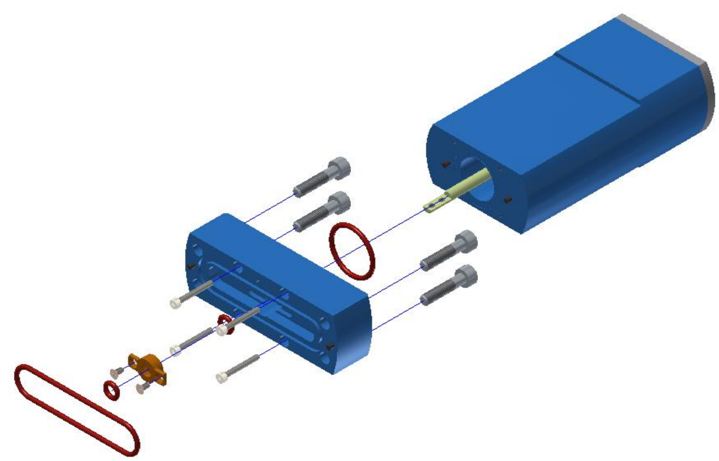


Figure 5-17. Front side of shutter assembly

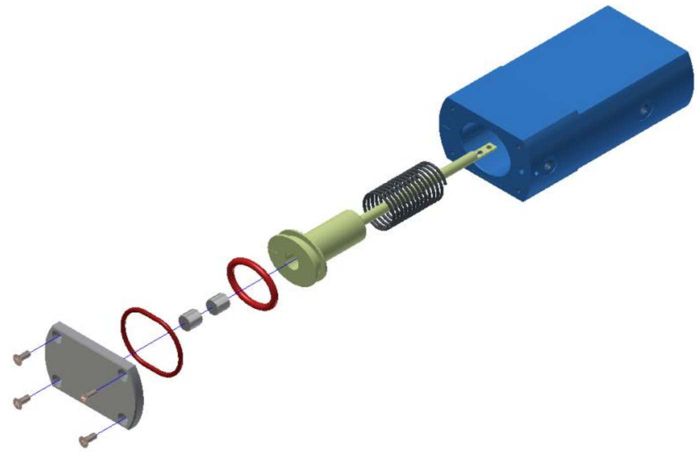


Figure 5-18. Back side of shutter assembly

7. Reassemble the shutters.

8. Install both shutter assemblies onto the work chamber. Replace the 4 screws each. Replace the tubing. Replace the sensor assembly on the bottom of the bottom shutter. Be sure the top and bottom shutter assemblies are installed in the proper place, see the labels on the bottom of the assemblies.

9. Close the vent valve and turn on system power.

5.12. Motor Drive Replacement

The specimen motor drive is located under the specimen chamber. It does not need to be replaced unless it fails, which typically does not happen during the lifetime of the instrument.

It can usually be replaced without removing the stage assembly, but if this proves too difficult the Whisperlok assembly can be removed from the work chamber prior to motor replacement.

1. Shut down the power to the PECS II. Unplug the power cable from the back of the system.

2. Remove the cover.

3. Unplug the motor from the motor cable.

4. Loosen the set screws that hold the timing pulley to the motor.

5. Remove the four M2 socket head screws that hold the motor to the bracket. The motor has specific characteristics for the PECS II and should only be replaced with the same type.

6. **Remove and replace the motor.** Insert the motor drive shaft into the timing pulley as the motor is installed.

7. **Tighten the set screws to the timing pulley.**

8. **Plug the motor into the motor drive cable.**

9. **Install the cover.**

10. **Turn on power to the PECS II.**

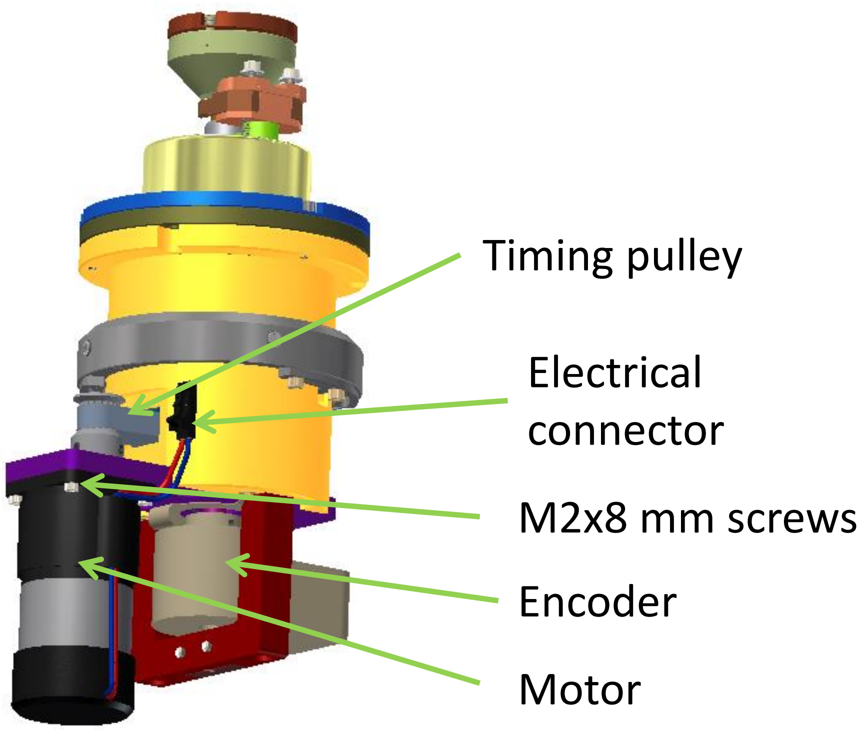


Figure 5-19 Motor Drive Removal.

5.13. Replacing the Stage Encoder

The stage encoder is located under the specimen chamber. It does not need to be replaced unless it fails, which typically does not happen during the lifetime of the instrument.

The stage encoder can be replaced without removing the stage assembly from the chamber, but it may be easier to remove the stage assembly first and then change the encoder on a bench.

1. **Remove the cover.**

2. Shut down power to the PECS II. Unplug the power cable from the back of the system.

3. Remove the cover.

4. Loosen the 2 set screws that connect the encoder to the drive shaft.

5. Remove the 2 screws that secure the U-shaped clamp at the bottom of the stage assembly, and remove the clamp and the encoder.

6. Install the new encoder, securing it with the U-shaped clamp. Tighten the 2 set screws.

7. Re-install the cover. Turn the power on.

8. Calibrate the stage home position.

a) Press Etch then Align.
b) Watch the stage rotate, and stop rotation when the alignment mark is at the top.
c) Press Done. Press Settings > Calibration > Stage
d) Note the Current Encoder Position.
e) Touch Home Position button and enter the Current encoder position.
f) Press Home > Etch > Align > Home. Verify that this is the proper home position.
g) Load the Cross-section sample mount with a beam alignment screen. (this may be difficult if the alignment is not quite right)
h) Press Home > Etch > Align > Home. Verify that this is the proper home position. The beam alignment screen should be perfectly aligned to the front of the instrument.
i) If not, adjust the home position until it is.

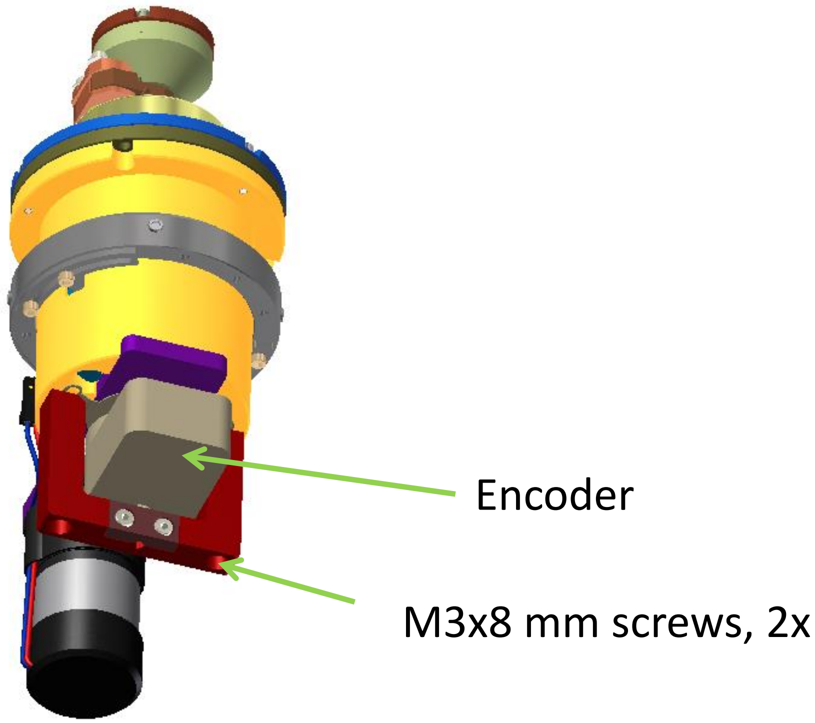


Figure 5-20 Replacing the encoder.

5.14. Replacing the Whisperlok assembly

1. Shut down the power to the PECS II. Wait at least 10 min to allow the MDP to come to a complete stop. Then vent the work chamber by opening the Vent valve. Unplug the power cable from the back of the system.

2. Remove the system cover.

3. Remove the load lock.

4. If the system has a cold stage, do the following: (see section 8.1.4)

   a. **Remove the load lock.** Unplug the cables from the load lock. Loosen the 4 M4x35mm screws in the top of the unit. Lift off the load lock from the chamber.

   b. **Loosen the two M2.5 screws and washers on the top of the cold conductor assembly.**

   c. **Move the heater and braid assemblies out of the way.**

5. Remove the Whisperlok™ assembly.

a. **Unplug the motor drive cable and the encoder cable.**
b. **Remove the 3 M3 screws that secure the Whisperlok™ assembly to the work chamber.**
c. **Gently lower the Whisperlok™ assembly and remove it, being careful not to disturb the vacuum and pneumatic tubing.** In some cases it may be more convenient to disconnect some of the tubing from the chamber bottom.

6. **Install the new Whisperlok™ assembly.**

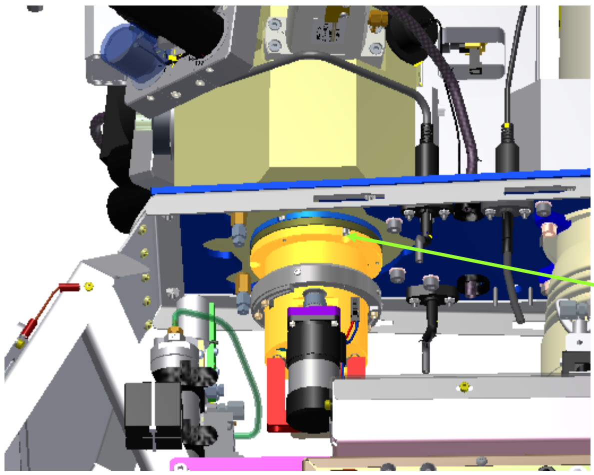


Figure 5-21. Whisperlok removal

5.15. Servicing the Sample Mount Receiver

The Sample Mount Receiver is located at the top of the rotate shaft. It does not need to be replaced unless it fails or is damaged.

There are 3 screws and associated springs that hold down the clamping plate. Inspect these screws through the gate window with the chamber light on. If one or more of these screws become loose, it will become impossible to load and unload samples.

To tighten a screw in the Sample Mount Receiver

1. **Shut down the power to the PECS II.**

Wait at least 10 min to allow the MDP to come to a complete stop. Then vent the Work Chamber by opening the Vent valve. Unplug the power cable from the back of the system.

2. **Unplug the 2 cables connected to the outside of the load lock chamber. See Figure 5-15.**

3. Remove the 4 screws that hold the load lock chamber to the work chamber. See Figure 5-16. Lift off the load lock assembly from the work chamber.

4. Tighten the loose screws. Use a slotted head screwdriver.

5. Replace the load lock assembly.

6. Power on the PECS II.

To replace the Sample Mount Receiver

1. Shut down the power to the PECS II. Wait at least 10 min to allow the MDP to come to a complete stop. Then vent the work chamber by opening the Vent valve. Unplug the power cable from the back of the system.

2. If the system has a cold stage, do the following:

- **a. Remove the load lock.** Unplug the cables from the load lock. Loosen the 4 M4x35mm screws in the top of the unit. Lift off the load lock from the chamber.

- **b. Loosen the two M2.5 screws and washers on the top of the cold conductor assembly.**

- **c. Move the heater and braid assemblies out of the way.**

3. Remove the Whisperlock assembly (see section 5.11).

4. Remove the Sample Mount Receiver. Remove the M2.5x5 mm screw from the top of the sample mount receiver. Remove the M1.6x4 mm screw from the side of the sample mount receiver. Lift the sample mount receiver off of the spindle**.**

5. Install the new sample mount receiver.

6. Install the Whisperlock assembly (see section 5.14).

7. Close the Vent valve and turn on the power.

8. Verify that the stage home position is correct. If the stage home position is not correct, calibrate it as described below.

- a) Lower the stage and set the home position. Alignment > Home.
- b) Observe the actual rotational position of the stage. It will not be at the home position. Note how many degrees in rotation it is from the proper home position.
- c) Adjust the home calibration setting to compensate. Maintenance > Calibration > Stage. The calibration setting is in 10ths of a degree,

so that if the position is 10 degrees away from the proper position adjust the calibration setting by 100.

d) Repeat this process until the home position is correct.

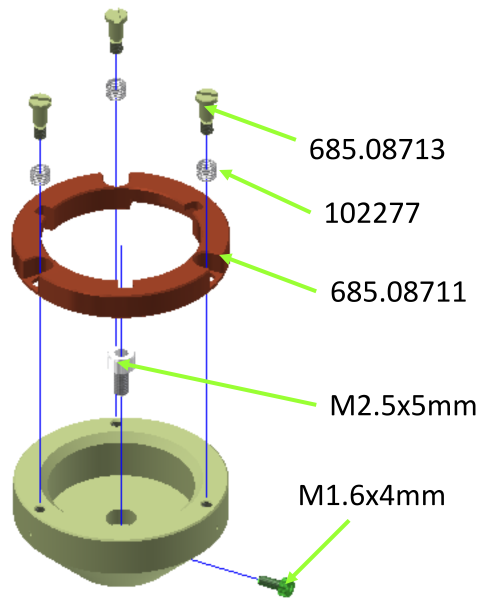


Figure 5-22 Sample mount receiver

5.16. Replacing the Bellows Assembly

The Bellows Assembly is part of the Whisperlok™ assembly. It does not need to be replaced unless it fails.

5.16.1. *To Remove the Whisperlok™ Assembly*

7. Shut down the power to the PECS II. Wait at least 10 min to allow the MDP to come to a complete stop. Then vent the work chamber by opening the Vent valve. Unplug the power cable from the back of the system.

8. Remove the system cover.

9. Lift off the Viewing Port. Press the Airlock piston down into the Work Chamber if it hasn't already lowered itself.

10. Remove load lock.

11. If the system has a cold stage, do the following: (see section 8.1.4)

a. **Remove the load lock.** Unplug the cables from the load lock. Loosen the 4 M4x35mm screws in the top of the unit. Lift off the load lock from the chamber.

b. **Loosen the two M2.5 screws and washers on the top of the cold conductor assembly.**

c. **Move the heater and braid assemblies out of the way.**

12. Remove the Whisperlok^{TM} assembly.

a) Unplug the motor drive cable.
b) Remove the 3 M3 screws that secure the Whisperlok^{TM} assembly to the work chamber.
c) Gently lower the Whisperlok^{TM} assembly and remove it, being careful not to disturb the vacuum and pneumatic tubing.

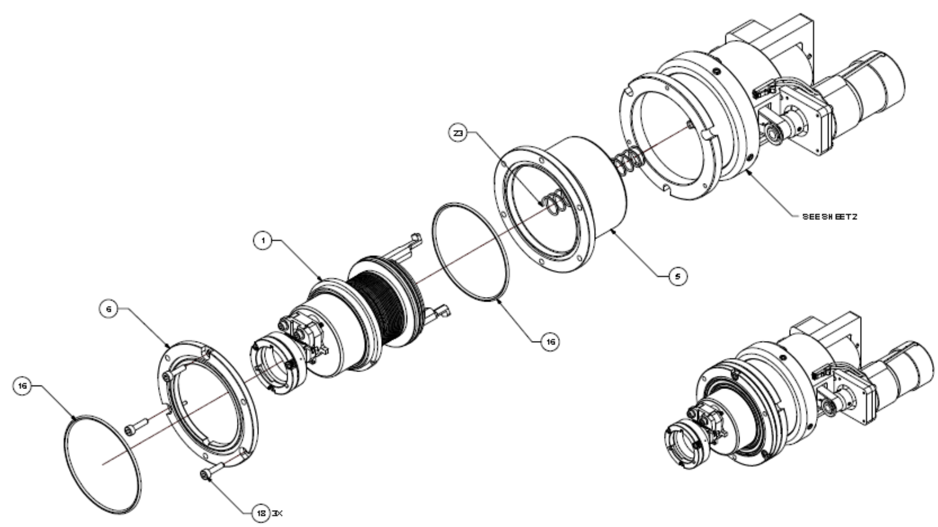


Figure 5-23 Whisperlok assembly.

5.16.2. *To Dis-assemble the Whisperlok^{TM} Assembly*

1. **Remove the 3 screws in the top of the assembly.**

2. **Remove the top clamp ring.**

3. **Remove the bellows assembly from the cylinder body.** It will be necessary to rotate the bellows assembly slightly to clear the height adjust stops. Check the inside of the housing where the o-ring at the bottom of the bellows assembly slides up and down. If necessary clean and lubricate with Krytox GPL-206.

4. If the system has a cold stage, remove the brush arms by first removing the spring that clamps them to the hinged conductor assembly.

5. Remove the Specimen Mount. While holding the rotate shaft, rotate the Specimen Mount counter-clockwise until it is completely free of the rotate shaft.

6. Remove the window shield from the rotate shaft, if it did not remain with the specimen Mount.

7. Remove the 4 screws and the clamping plate at the bottom of the Whisperlok™ assembly.

8. Remove the rotate shaft from the bellows assembly. This can be accomplished by pulling on the large bearing at the bottom of the assembly, or by pushing slightly on the top of the rotate shaft.

9. Clean and lubricate the rotate shaft quad-seal. This seal should always be cleaned and lubricated when the Whisperlok is disassembled.

10. Remove the 2 o-rings from the bellows assembly.

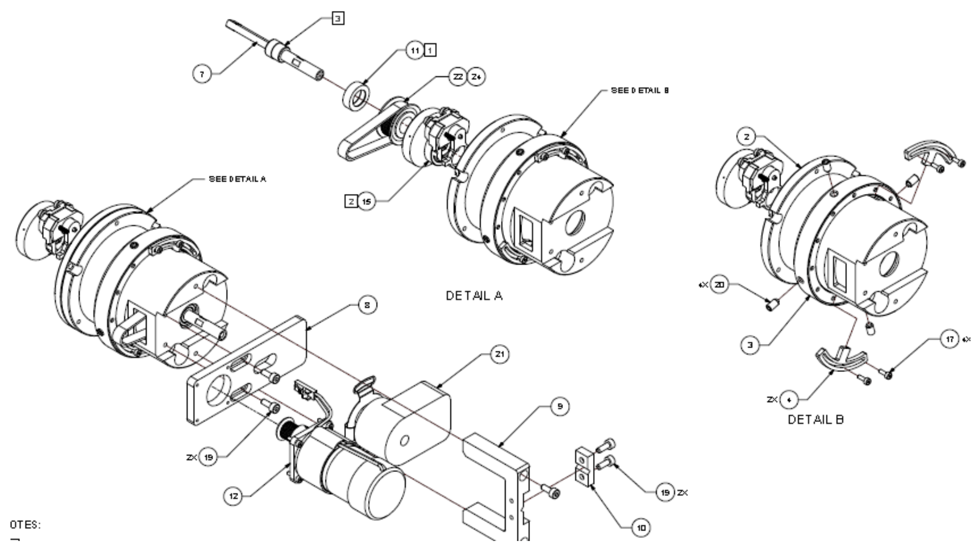


Figure 5-24. Whisperlok disassembly

5.16.3. *To Assemble the Whisperkok™ Assembly*

Assemble the Whisperlok™ assembly with the new bellows assembly.

1. Install the 2 o-rings on the new bellows assembly.

2. Clean and lubricate the o-ring at the bottom of the bellows assembly with Krytox GPL-206.

3. Clean and lubricate the quad-seal on the rotate shaft with Krytox GPL-206.

4. Clean the o-rings in the cylinder body and clamp ring.

5. Lubricate the inside of the bellows assembly where the quad-seal contacts with Krytox GPL-206.

6. Install the piston assembly into the bellows assembly.

7. Install the Specimen Mount onto the piston assembly.

8. If applicable, install the brush arms and the clamping spring.

9. Lubricate the inside of the cylinder body with Krytox GPL-206.

10. Install the bellows assembly into the cylinder body. The center notch in the outside top flange of the bellows assembly must be oriented toward the front of the system. The motor must be on the right hand side of the Whisperlok™ assembly when viewed from the front of the system. Compress the bellows fully.

11. Install the clamp ring. The 2 pins in the bottom of the clamp ring align to the 2 outside notches in the top flange of the bellows assembly. Install the 3 screws.

12. Install the Whisperlok™ assembly onto the work chamber. The motor assembly must be to the right when viewed from the front of the system.

13. Replace the Top Cover plate and Viewing Port.

14. Close the Vent valve and turn on the power.

15. Verify that the stage home position is correct. If the stage home position is not correct, calibrate it as described below.

a) Go to Etch and set the home position. Alignment > Home.
b) Observe the actual rotational position of the stage. It will not be at the home position. Note how many degrees in rotation it is from the proper home position.
c) Adjust the home calibration setting to compensate. Maintenance > Calibration > Stage. The calibration setting is in 10ths of a degree, so that if the position is 10 degrees away from the proper position adjust the calibration setting by 100.
d) Repeat this process until the home position is correct.

16. Purge the guns at least 4-5 hours at 1 sccm before milling samples.

5.17. Checking the Specimen Height

The specimen height is pre-set at the factory, and should not need adjustment. The height can be checked by aligning the beams to the center of the beam alignment screen, then changing the gun tilt from 0 to 18 degrees. It is helpful to increase the gas flow so as to decrease the length of the ellipse illuminated on the screen. As the gun tilt is changed, the beams should stay in the same relative location on the alignment screen.

If the Whisperlok™ bellows or the specimen mount is replaced, it may be necessary to re-set the specimen height.

If the specimen is not held at the eucentric height of the guns, the ellipses will move toward or away from the guns as the tilt is adjusted. If the center of the ellipse moves by more than about 1 mm, then you should consider adjusting the specimen height as described below. Note that a slight adjustment change in gun alignment can make it seem as though the height is wrong. This can be caused by insufficient lubrication of the o-ring in the Ion Source assembly, if so then lubricate per Section 5.6. Before changing the stage height, be sure that both guns exhibit behavior as described above. Try adjusting the direction perpendicular to the long axis of the ellipse slightly, then re-testing.

5.18. Replacing the Gas Manifold

The gas manifold is made of acrylic and must be replaced if a crack develops which creates a leak. A crack can be created if a fitting or screw in the gas manifold is over-tightened. A field replacement gas manifold assembly includes the gas manifold, valves, fittings, and tubing. It does not include the mass flow controllers.

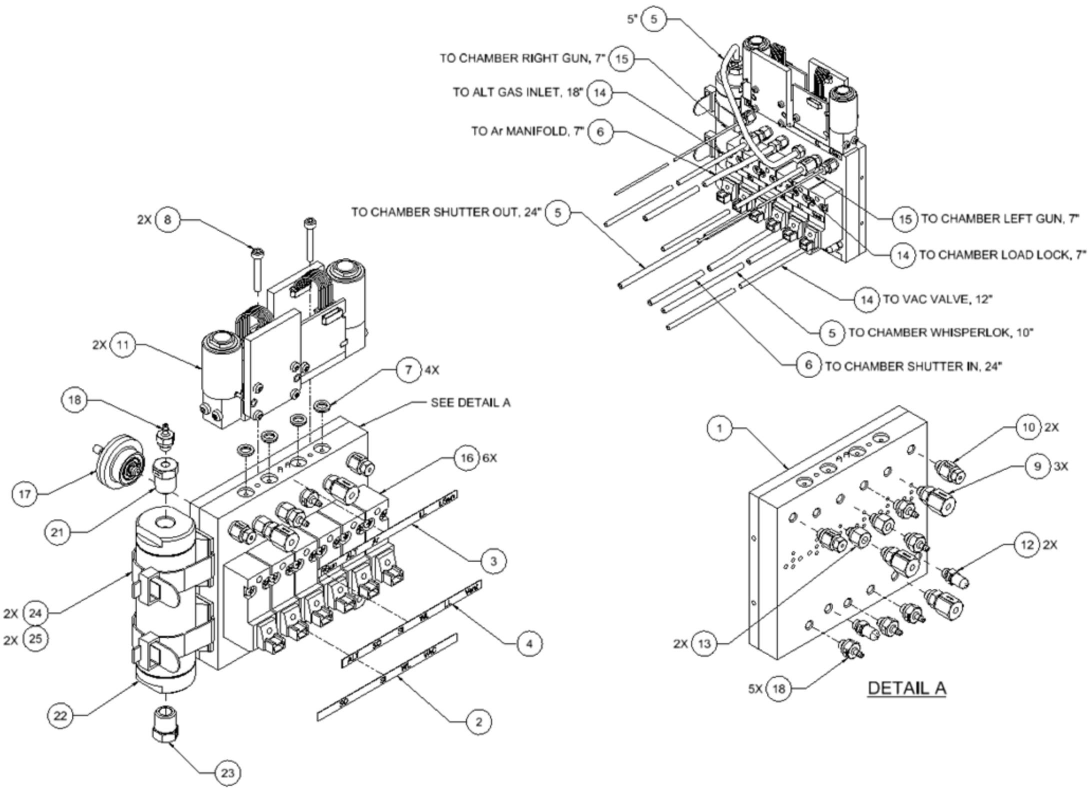


Figure 5-25 Gas manifold assembly.

Table 2. Gas Manifold Assembly

Part Number	Name	Qty	Item #
695.03011	ASSY,MANIFOLD	1	1
695.03061	LABEL,MANIFOLD,BOTTOM	1	2
695.03062	LABEL,MANIFOLD,TOP	1	3
695.03063	LABEL,MANIFOLD,VALVES	1	4
05631	HOSE POLY 5/32OD 5/64ID TR GRN	2.8	5
05632	HOSE POLY 5/32OD 5/64ID TR RED	2.6	6
06424	ORNG,VITON,#008	4	7
06753	SCR,SCH,CAP,M3X20MM,SST	2	8
101287	FTG,CMPRSSIN,1/8" TBNG,10-32,BRASS	3	9
101288	FTG,CMPRSSIN,1/16"OD,10-32 THRD,BRS	2	10
101482	MASS FLOW CONTROLLER	2	11
101483	MUFFLER,10-32-1/4 NPT-MMPA	2	12
101485	FILTER,20 MICRON,10-32THD M-F	2	13
101492	TUBING,.093" ID,.016" WALL,NYLON	3	14
101493	TUBING,.03 ID X 1/16" OD,PEEK	1.2	15
101632	VALVE,90 DEGREE CONN. W/LED	6	16
102073	Regulator,Pressure,Manifold Mount	1	17
102289	FTG,10-32 THREAD TO BARB ,BRASS	4	18
101498	FTG,1/8" NTP STRAIGHT ADAPTOR	1	21
102469	AIR VOLUME TANK	1	22
102470	FTG,1/8" NPT PLUG	1	23
102471	STRAP,ADJUSTABLE ,NYLON	2	24
06763	SCR,SCH,CAP,M3X6MM,SST	2	25

5.18.1. *Removing the Gas Manifold*

1. Shut down the power to the PECS II. Wait at least 10 min to allow the MDP to come to a complete stop. Then vent the work chamber by opening the Vent valve. Unplug the power cable from the back of the system.

2. Remove the system cover.

3. Turn off the Ar pressure at the regulator which supplies Ar to the system.

4. Unplug the electrical connectors for each of the 6 valves.

5. Unplug the electrical connectors for each of the 2 mass flow controllers.

6. Disconnect the tubing from all of the connectors on the bottom of the work chamber. Remember where each tube was connected.

7. Disconnect the tubing between the gas manifold and the Ar manfold and Alt inputs.

8. Disconnect the tubing between the gas manifold and Vac-valve assembly. This should be done at the Vac-valve assembly side.

9. Remove the gas manifold. Unscrew the 4 screws that secure the gas manifold to the sheet metal bracket. Gently remove the gas manifold. Inspect the gas manifold assembly. The o-ring seals may be observed from the back side through the Acrylic manifold with an optical microscope. Cracks in the Acrylic or other issues may be observed.

10. Remove the Mass Flow Controllers. Remove the screws attaching the MFCs to the gas manifold. Lift the MFCs off the gas manifold. Remove the o-rings from the gas manifold and save for re-use.

5.18.2. *Installing the Gas Manifold*

The new gas manifold field replacement kit includes a full set of tubing, which should be connected to the gas manifold before installing the manifold in the system.

1. Attach the Ar and Alt tubing to the gas manifold. This is 1/8 inch (~3.2 mm) nylon tubing with a Swagelock fitting at one end and a Beswick fitting at the other end. Connect the Beswick fitting to the Ar and Alt fitting of the gas manifold.

Caution: be sure to use 2 wrenches when installing compression fittings. One wrench is to insure that the fitting is not tightened with respect to the Acrylic manifold, which could create a crack in the manifold. Tighten the compression fittings finger tight plus 1/4 turn.

2. **Attach the gun tubing to the LG and RG fittings of the gas manifold.** This is 1/16 inch (~1.6 mm) green PEEK tubing with a Beswick compression fitting at each end.

3. **Attach the LL and Vac tubing to the gas manifold.** This is 1/8" nylon tubing with a Beswick compression fitting at both ends. The shorter tubing is connected to the LL fitting.

4. **Attach the tubing to the SO, SI, and WL fittings.** This is polyurethane tubing with no fittings attached. Press it on to the barbed fittings on the gas manifold. The Vac tubing is the longer of the three.

5. **Install the MFCs.** Place the o-rings in the o-ring depressions in the top of the gas manifold. Place the MFCs on the gas manifold, with the pins aligned to the appropriate holes. Install and tighten one screw per MFC until the MFC is flush with the face of the gas manifold. Do not overtighten.

6. **Install the Gas Manifold.** Using the 4 screws, secure the gas manifold in the sheet metal bracket.

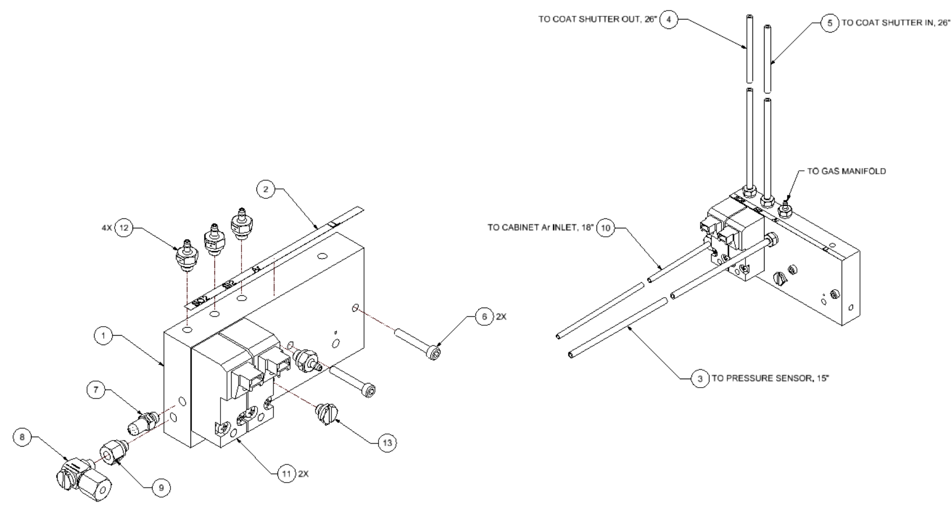
7. **Attach the tubing.** Attach the tubing to the work chamber, gas inlet fittings, and Vac-valve assembly. Use 2 wrenches to insure the fittings are not over-tightened.

8. **Close the Vent valve and turn on the power.** The MDP speed and backing pressure may be monitored in the Maintenance > Vacuum screen.

9. **Turn on the Ar pressure at the regulator.**

10. **Purge the guns for 4-5 hours before milling samples.**

5.19. Replacing the Argon Manifold



ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	685.03021	MANIFOLD,PECS II
2	1	685.03061	LABEL,MANIFOLD
3	1	05629	HOSE POLY 5/32OD,5/64ID TR BLU
4	1	05631	HOSE POLY 5/32OD 5/64ID TR GRN
5	1	05632	HOSE POLY 5/32OD 5/64ID TR RED
6	2	06753	SCR, SCH, CAP, M3x20MM, SST
7	1	101287	FTG,CMPRSSIN,1/8" TBNG,10-32,BRASS
8	1	101483	MUFFLER,10-32-1/4 NPT-MMPA
9	1	101484	FTG,ELBOW,10-32 THD,1/8" OD TUBING
10	1	101485	FILTER,20 MICRON,10-32THD M-F
11	1	101492	TUBING,.093" ID,.016" WALL,NYLON
12	1	102073	REGULATOR,PRESSURE,MANIFOLD MOUNT
13	2	101632	VALVE,90 DEGREE CONN. W/LED
14	4	102289	FTG,10-32 THREAD TO BARB ,BRASS
15	1	102323	VALVE,2-WAY,24 VDC,MANIFOLD MOUNT
16	1	102324	PLUG,10-32 THD SCREW

1. **Shut down the power to the PECS II.** Wait at least 10 min to allow the MDP to come to a complete stop. Then vent the work chamber by opening the Vent valve. Unplug the power cable from the back of the system.

2. **Remove the system cover.**

3. **Turn off the Ar pressure at the regulator which supplies Ar to the system.**

4. **Unplug the electrical connectors for the valves.**

5. **Unplug the tubing from the fittings.** Use 2 wrenches for compression fittings. Be careful not to break any fittings.

6. **Remove the 2 screws holding the Ar manfold to the gas manifold.** Remove the Ar manifold.

7. **Install the new manifold.**

8. **Connect the electrical connectors to the valves.**

9. **Connect the tubing.**

5.20. Replacing a Mass Flow Controller (MFC)

This is a difficult operation due to space limitations. Gatan recommends that the MFC be replaced without removing the Gas Manifold, because this method is less likely to cause a problem with any of the tubing or fittings. If this cannot be accomplished, then remove the Gas Manifold prior to replacing the MFC.

1. **Raise the Stage and vent the airlock chamber.** This allows the airlock cover to be removed after system power is off.

2. **Shut down the power to the PECS II.** Wait at least 10 min to allow the MDP to come to a complete stop. Then vent the work chamber by opening the Vent valve. Unplug the power cable from the back of the system.

3. **Remove the system cover.**

4. **Install a ground strap on your wrist.** The MFC contains static sensitive components.

5. **Turn off the Ar pressure at the regulator which supplies Ar to the system.**

6. **Unplug the power/signal cable from the MFC.**

7. **Loosen the M3x20 screw which secures the MFC to the Gas Manifold.** Note that you will need a hex tool that is shorter than the tool provided with the instrument. It should be between 38 mm long and about 70 mm long. Note the orientation (the two MFCs have opposite orientation). Carefully remove the MFC.

8. **Clean and inspect the 2 O-rings.** Replace the O-rings in the pockets in the Gas Manifold.

9. Install the replacement MFC. Note that there is a pin in the top of the Gas Manifold that mates to a hole in the MFC.

10. Carefully plug the power/signal cable into the MFC. The connector and wires are delicate.

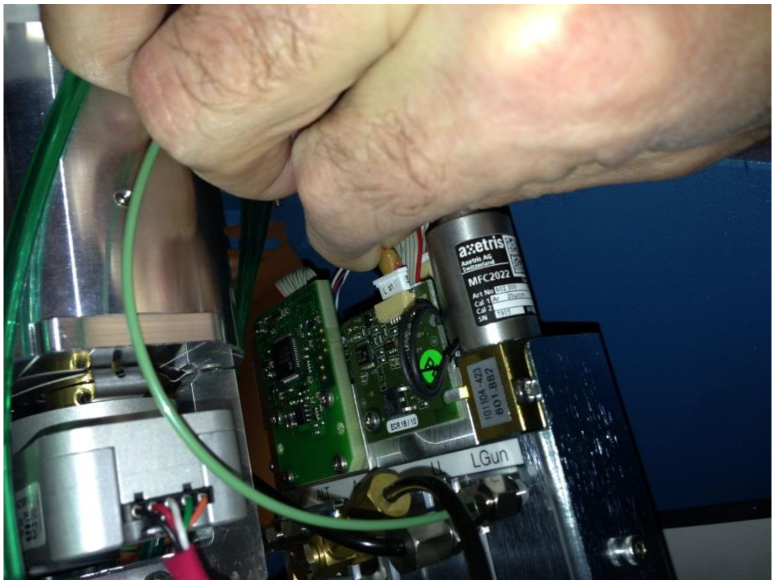


Figure 5-26 MFC removal. Unplugging the power/signal cable from the MFC.

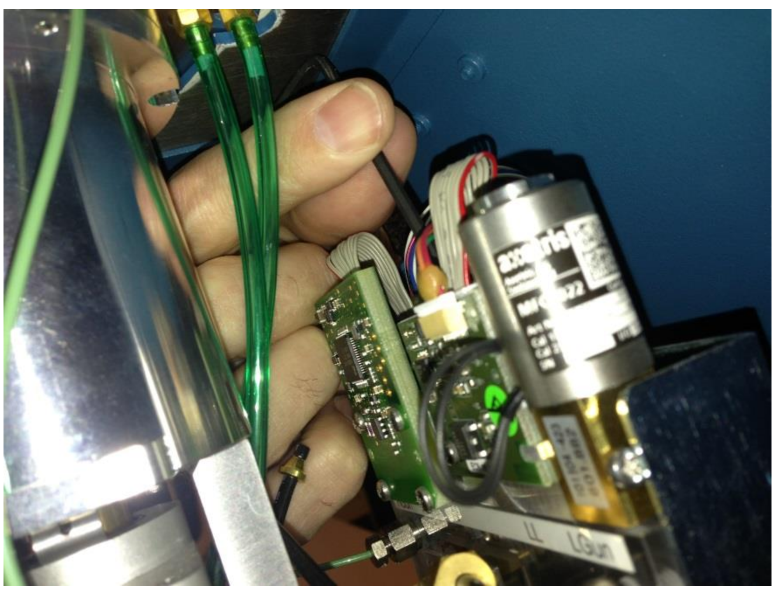


Figure 5-27 MFC removal. Loosening the M3 screw that secures the MFC.

5.21. Replacing the Touchscreen

1. **Shut down the power to the PECS II.** Unplug the power cable from the back of the system.

2. **Remove the system cover.**

3. **Unplug the touchscreen flex cable from the touchscreen adapter PCA.** Using a small screwdriver, lift the back of the black hinged clamp up and toward the front of the system. Gently remove the flex cable.

4. **Unplug the coax flex cable from the touchscreen adapter PCA.**

5. **Remove the 4 M2x20 screws that secure the touch display to the touchscreen adapter plate.**

6. **Remove the touch display with the coax flex cable attached.** The coax flex cable is glued to the touchscreen.

7. **Install the new touch display and coax flex cable.** Install the 4 screws.

8. **Connect the coax flex cable and touchscreen flex cable to the touchscreen adapter PCA.**

9. **Install the cover.**

10. **Power on the PECS II.** First plug the power cable into the power entry module.

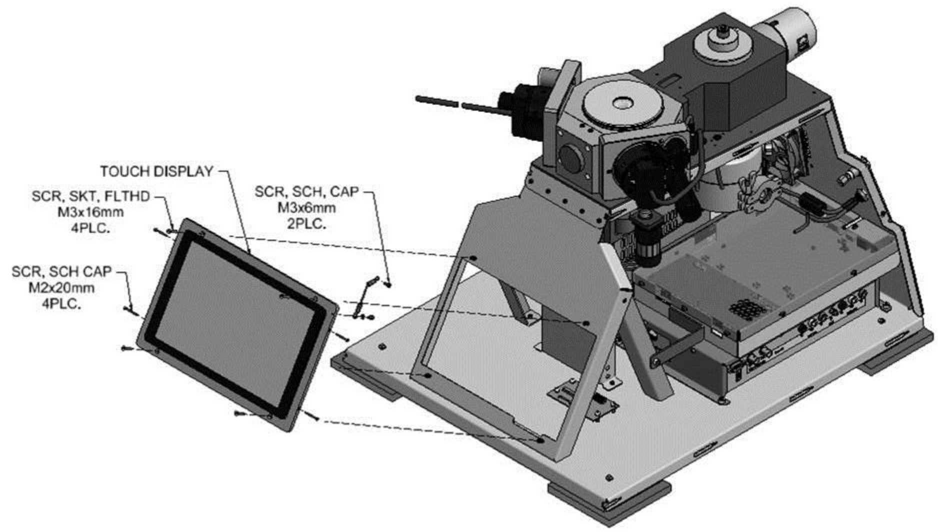


Figure 5-28 Touch display assembly.

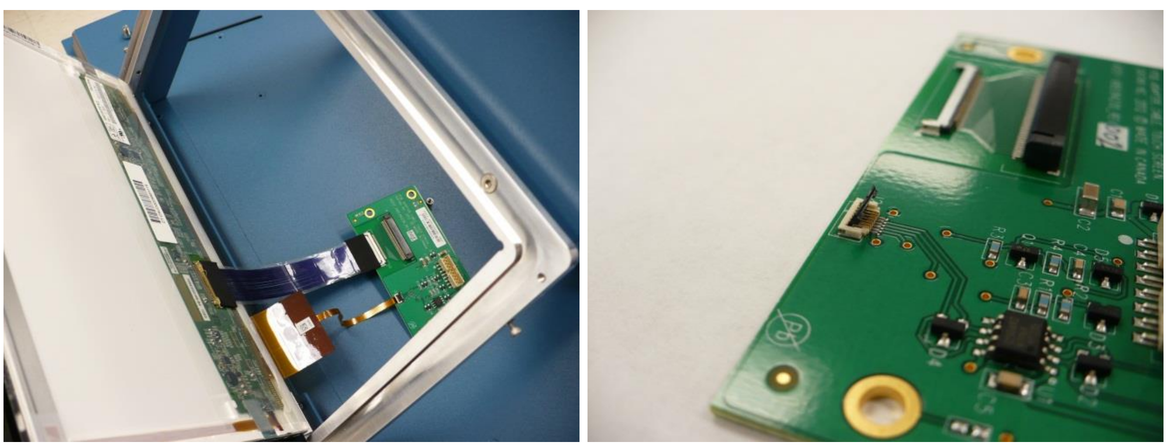


Figure 5-29 Connections for touch display.

Left image shows cable connections made prior to attaching the touch display. Right image shows the clamp for the touchscreen cable in the open position. After the touchscreen cable is inserted into this connector, press down on this clamp. Note that this is a delicate connection.

5.22. Replacing the High Voltage Power Supply

1. **Shut down the power to the PECS II.** Unplug the power cable from the back of the system.

2. **Remove the system cover.**

3. **Unplug the gun high voltage cables from the high voltage power supply.** Remove the ground wires from the ground lug in-between the two sets of high voltage connectors.

4. **Unplug the power and control cables from the high voltage power supply.**

5. **Remove the three easily accessible screws that attach the HVPS to the frame.** Loosen the fourth screw but do not remove it, the HVPS is slotted in this location.

6. **Remove the HVPS from the cabinet.**

7. **Install the replacement HVPS.** Install screws.

8. **Reconnect all the cables to the replacement HVPS.**

9. **Replace the cover**.

10. **Power on the system.** First replace the power cable.

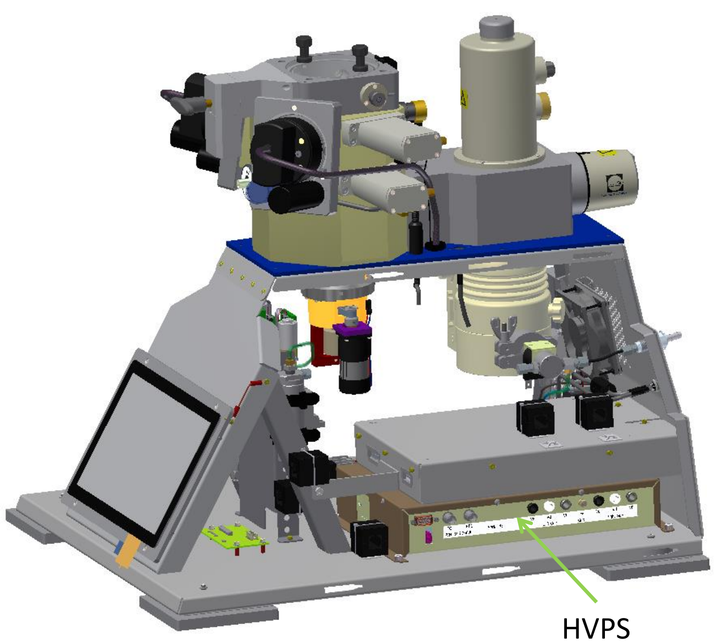


Figure 5-30 HVPS location.

5.23. Replacing the Control PCAs (CPU, I/O)

1. **Shut down the power to the PECS II.** Unplug the power cable from the back of the system.

2. **Remove the system cover.**

3. **Remove the cover of the electronics enclosure.**

4. **Unplug the gun high voltage cables, if necessary, from the high voltage power supply.** This may be helpful to allow access.

5. Unplug the CC Gauge cable, Dewar cable, Ethernet cable, and camera trigger cable from the back of the system.

6. **Clamp the tubing between the vacuum valve assembly and the backing sensor on the I/O PCA.** A tubing clamp or forceps may be used.

7. Remove the tubing from the backing sensor on the I/O Printed Circuit Assembly (PCA). Be sure the tubing remains clamped and holds vacuum.

8. Clamp the tubing between the Gas Manifold and the Ar pressure sensor. Remove the tubing from the Ar pressure sensor on the I/O PCA.

9. Disconnect the cable connectors from the PCAs. Insert tweezers between the clamping arms and the connector, to release the connector from the clamping arms. Pull the connector out of the socket. Be very careful not to pull on the wires, or they may break.

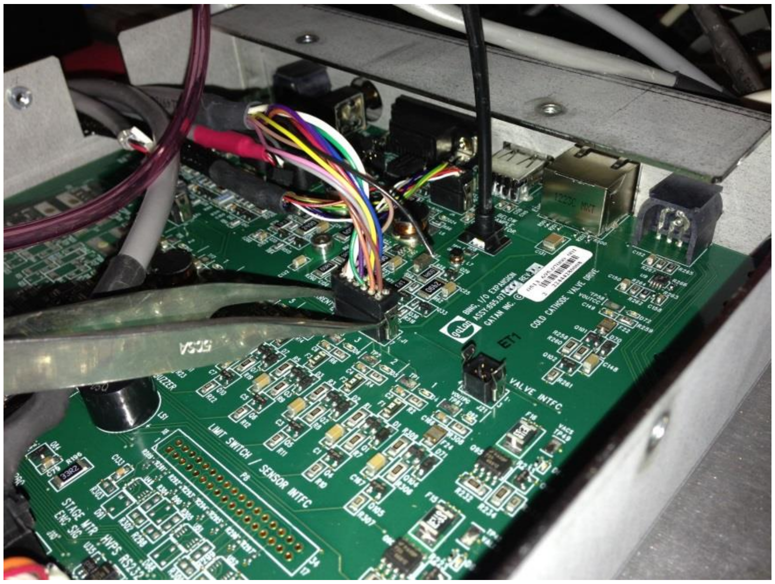


Figure 5-31 Removing cables from the I/O PCA.

10. Remove the 4 screws that secure the I/O PCA.

11. Remove the nuts from the CC Gauge and Dewar connectors on the back of the system.

12. Remove the jack screws from the RS-232 connector on the back of the system.

13. Remove the PCAs from the PCA enclosure.

14. Install the new PCAs. Replace the 4 screws, the 2 nuts, and the 2 jack screws. Note that 685.04103 is fixed to the I/O board with nylon stand-offs and hot-melt adhesive. This adhesive may be re-used.

15. Connect the cables to the same sockets they were removed from. The captive connectors have an orientation defined by a chamfer on two corners. The image below shows the location of the sockets, and each cable should be labeled with the connector. In addition, the List of Cables shows the associated connector for each cable.

16. Replace the electronics enclosure cover.

17. Replace the system cover.

18. Power on the system. First replace the power cable.

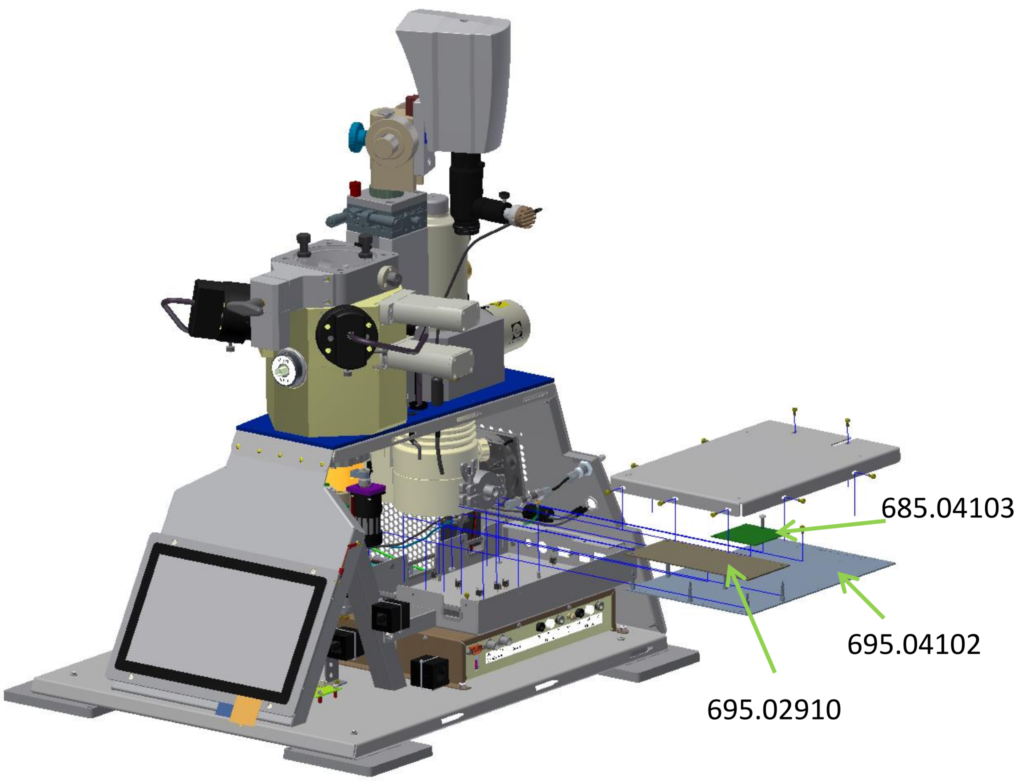


Figure 5-32 PCA assembly.

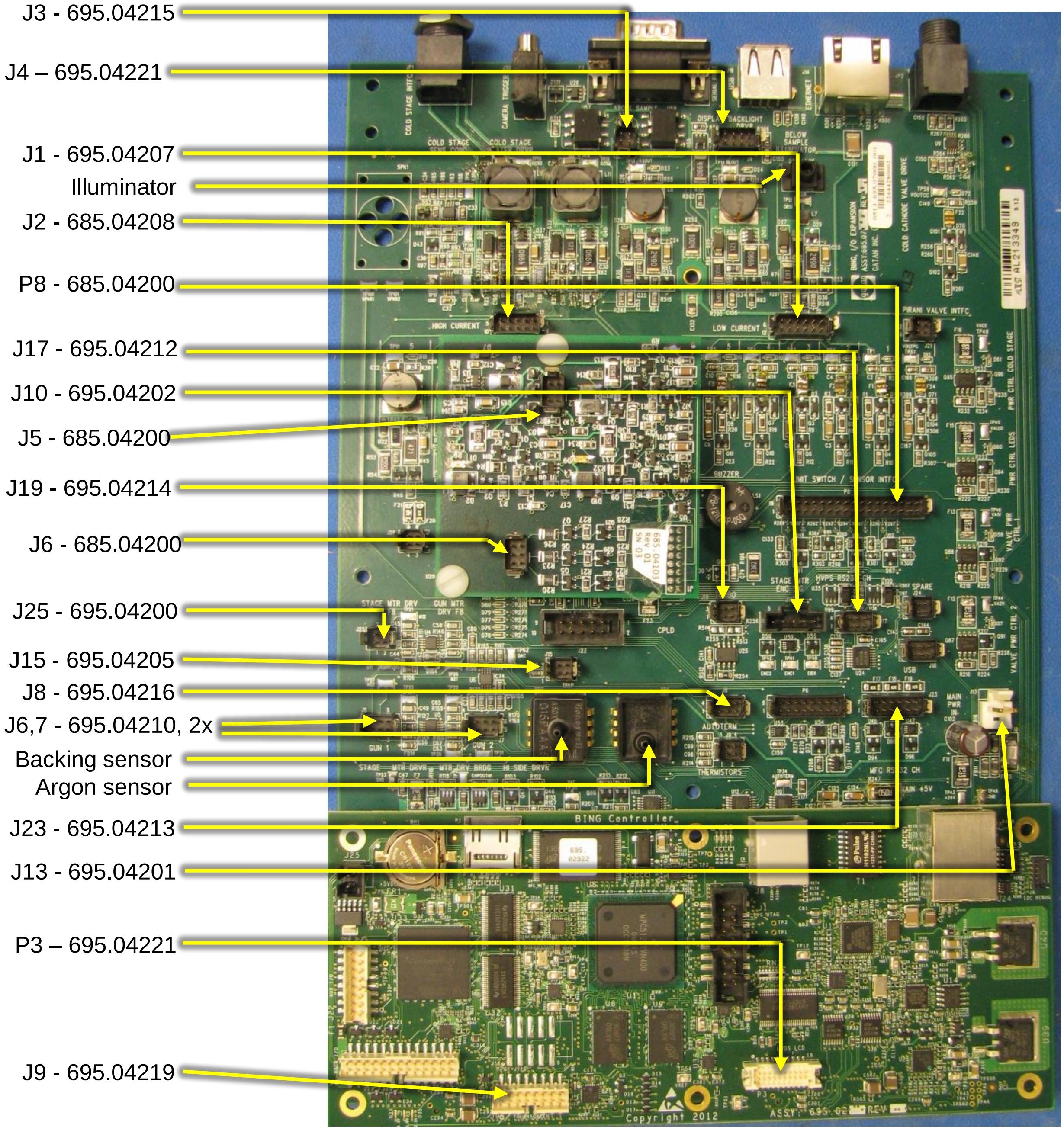


Figure 5-33 PCA connector locations and associated cable part numbers.

5.24. List of O-Rings

Table 3. List of O-rings

Description	Size		Quantity	Location
Diaphragm Pump Assembly	012		1	DP fitting
	M4.5x1.4mm		1	DP fitting
Chamber Assembly	044		2	Airlock/chamber top
	042		1	Chamber top
Film Thickness Probe	006		1	Connector
	018		1	Housing
	028		1	Chamber
Whisperlok Assembly	035		2	Chamber
	031		1	Chamber
	Q4111		1	Rotate shaft
	135		1	Bellows
Ion Gun Assembly	003		1	Focus electrode
	010		2	Focus electrode
	020		1	Housing
	031		2	Chamber
Manifold Assembly	141		1	Manifold-chamber
	123		1	CC gauge
	039		1	Dewar port
Vent Valve	012		1	Vent valve
	010		1	Vent valve
	039		1	Dewar port
Cold Stage Dewar	039		1	Dewar port
	014		1	Electrical feedthru
	112		1	Vent valve
	010		1	Vent valve
	012		1	Vent valve
Gas Manifold	008		4	MFC
Faraday Cup	022		1	Chamber
	015		1	Housing
Target Assembly	010		2	Cover, shaft
	025		1	Chamber
Shutter Assembly	115		1	Piston
	022		1	Back plate
	007		2	Shaft
	017		1	Front plate
	029		1	Chamber
Load Lock	014		1	Electrical Feedthru
	134		1	Gate seal
	019		1	Gate window
	037		1	Gate cavity

	109		1	Shaft
	012		1	Vent valve
	010		1	Vent valve
	112		1	Vent valve
	152		1	Transfer device
	022		1	Gate window
Transfer Device	011		1	Shaft
	033		1	Window
Vacuum transfer device	011		1	Shaft
	033		1	Window
	134		1	Gate
Load lock cover	108		2	Knobs
Loading Dock	152		1	Transfer device

5.25. List of Cables

Table 4. List of Cables

Description	Part #	Qty	Connector #
Whisperlok motor	695.04200	1	J25
Power	695.04201	1	J13
Whisperlok encoder	695.04202	1	J10
Cold Cathode gauge	695.04203	1	JP2
Cold Stage dewar	695.04204	1	JP1
DP, internal	695.04205	1	J15
DP, external	695.04206	1	Back panel
Valves, manifold	695.04207	1	J1
Gun motor, internal	695.04210	2	J6(left), J7(right)
HVPS, communications	695.04212	1	J17
MFCs	695.04213	1	J23
MDP	695.04214	1	J19
Illuminator, above	695.04215	1	J3
Autoterminator, internal	695.04216	1	J8
Gun motor, external	685.04217	2	Top panel
Camera trigger	685.04218	1	J20
Touchscreen	695.04219	1	J9 (CPU)
Video/backlight	101451	1	J4 (I/O),P3(CPU)
Video, coax flex	101462	1	J2(TS Adapter)
Sensor internal	685.04200	1	J5,J6,J8, etc.
Sensor external	685.04202	1	Top panel & load lock
Load lock	685.04203	1	Load lock
Heavy valves	685.04208	1	J2
Faraday cup	695.06204	2	HVPS

6. Trouble Shooting

Table 5. Troubleshooting Guide

Symptom	Problem cause	Solution
Beam currents low when system is first installed, or if it has been turned off for an extended period.	Guns are not degased.	Set gas flow to Manual, 1 sccm. Let purge overnight. Set back to Automatic and test. It can take up to 3-4 days of purging before the guns function optimally.
Chamber pressure display 0 on Etch or Coat screen.	MDP not up to speed. Manual vent valve open. Vacuum leak. MDP failure. DP failure. Gauge tube contaminated.	Turn off gas flow. Verify MDP speed (Devices > Vacuum). Service/clean gauge tube.
Cannot load or unload samples.	Home position wrong.	Check home position, scribe line on specimen mount receiver should be vertical and toward back of instrument. If wrong, recalibrate home position (see Section 5.13).
Argon pressure low warning. System will not mill.	Argon supply interrupted. Ar tubing loose from Ar pressure sensor.	Check argon pressure 25 psi (1.72 bar) or main valve closed. Check tubing between Ar manifold and Ar pressure sensor on I/O PCA.
Specimen difficult to see in working position	Sputtered material obscuring viewing window.	Clean or replace window. See Section 5.2.
Poor vacuum when specimen mount rotation is operated, typically observe periodic pressure burst during each rotation.	Dirty or dry quad-ring in Whisperlok piston.	Clean and lubricate piston quad-ring. See Section 5.16.
Shutter will not close or closes only part way	Argon supply interrupted or HV timer may be off. SI or SO valve failure. Shutter piston may be clogged or have failed.	Check argon pressure 25 psi (1.72 bar) or main valve closed. Check SI valve LED is on and SO valve LED is off when shutter is in. Check SI valve LED is off and SO valve LED is on when shutter is out. Check SI and SO valve cable/control. Clean and inspect the shutter piston.
Excessive Argon use	Argon leak	Check for leaks.
Cold-cathode gauge reading fluctuates or reads excessively high.	Gauge tube contaminated.	Service/clean gauge tube.
Ion gun has no output. Current=0, voltage on, gas on.	Gun shorted (Anode cup to magnet)	Clean guns. See section 5.6.
Gun output is extremely erratic.	Guns are not purged sufficiently	Purge guns.
Chamber pressure very high when stage is lowered.	Leak in bellows.	Replace bellows assembly.
Files not saved in Record Milling mode.	Path length of file name too long.	Store files in a different location, which has a shorter total path length name. For instance c:\data\.
DM will not operate camera. Message on Camera screen says “disconnected.”	PECS was rebooted and lost communication with DM.	Restart DM.

Crystal thickness monitor not working	PECS was rebooted and lost communication with thickness monitor.	Restart PECS with the crystal thickness monitor connected and powered up. This may require the USB power connection to the PC and the PC is powered on.

6.1. Troubleshooting Gun Issues

A small amount of material is sputtered from the rear pole piece during normal operation. This material coats the inside of the anode cup. Over time this material can flake off and cause a gun short. This is especially likely to happen when the system is vented, so it is a good idea to clean the guns when the system is vented. A new gun is more likely to experience gun shorts during the first 2-3 months of use, after which the gun becomes more stable and should last many months between cleanings.

We will describe two methods for recognizing a shorted gun. See section 5.6.1 for instructions on cleaning guns.

6.1.1. *Using the Readings screen*

The Etch Readings screen can be used to help determine if a gun is shorted. If the discharge current in microamps is approximately equal to the discharge voltage in volts, and the accelerating current is unusually low; then the gun is likely shorted. For example, when the beam voltage is 6 kV, the discharge voltage is approximately 1100 V. If the discharge current is approximately 1100 uA and the accelerating current is significantly lower than normal for 6 kV beam voltage, then the gun is likely shorted. Note that these same conditions apply during beam modulation when the guns are between milling sectors.

To check for a shorted gun:

1. **Start Milling.** Remove any sample. Set beam energy to 6 keV. Set modulation to No Modulation.

2. **Let run for > 2 minutes.** The focus voltage will be set to 0 after 2 minutes. If the guns do not ignite (low discharge current), try setting to manual gas mode and 0.1 sccm for each gun.

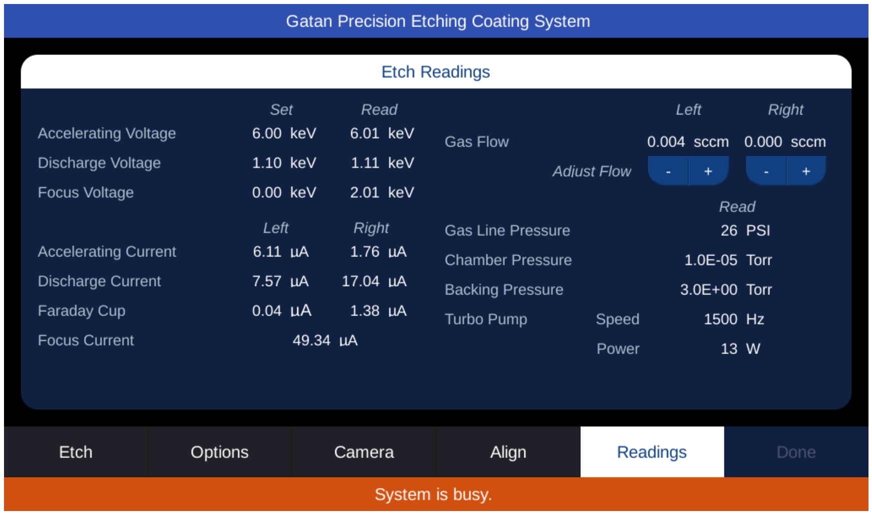


Figure 6-1. Guns that have not ignited a plasma

3. **Observe the gun readings.** The figure below shows readings from guns that are operating normally.

First note that the Accelerating Voltage Read value is approximately equal to the Set value (6.00 keV). A read value significantly lower than the set value indicates a short between the inner gun and the housing.

Note that the Discharge voltage Read value is approximately equal to the Set value (1.10 keV). A read value significantly lower than the set value typically indicates a short between the inner gun and the housing.

Note that the discharge current in uA (240.27 uA/340.79 uA) is significantly lower than the discharge voltage in V (1.11 keV ~ 1110 V). This indicates a gun that is operating normally.

Note that the Faraday cup current is within the typical range (~35-80 uA). Note that the Accelerating cup current is higher than the Faraday cup current, this is normal.

The Focus Current is typical for 6 keV. If either gun were misaligned, this current will increase.

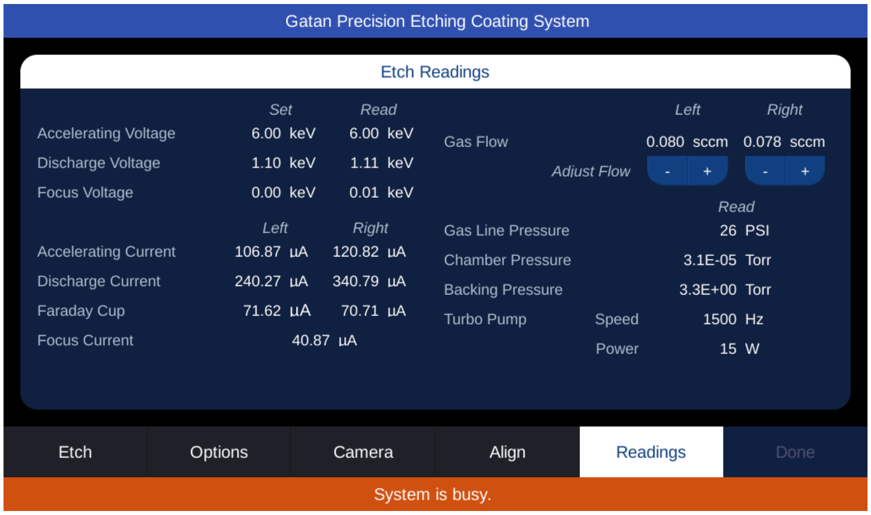


Figure 6-2. Normal gun operation

4. **Set mode to Single beam modulation.** Go to align page, press Align Left. Go to Readings page. This will turn off the right gun by connecting the accelerating voltage to the discharge voltage through a 1 megaohm resistor inside the HVPS. Discharge current will still be measured for the right gun because of internal resistance of the HVPS, but accelerating and Faraday cup currents should be near zero.

It can be useful to observe this mode in order to distinguish which gun has a problem.

Note that the right gun discharge current in uA (1101 uA) is about the same as the discharge voltage in V (1.11 keV ~ 1110 V). This indicates a gun that is turned off by beam modulation. If the left gun looked the same as the right, this could indicate a gun that is shorted between the anode cup and the rear pole piece or the anode cup and the front pole piece.

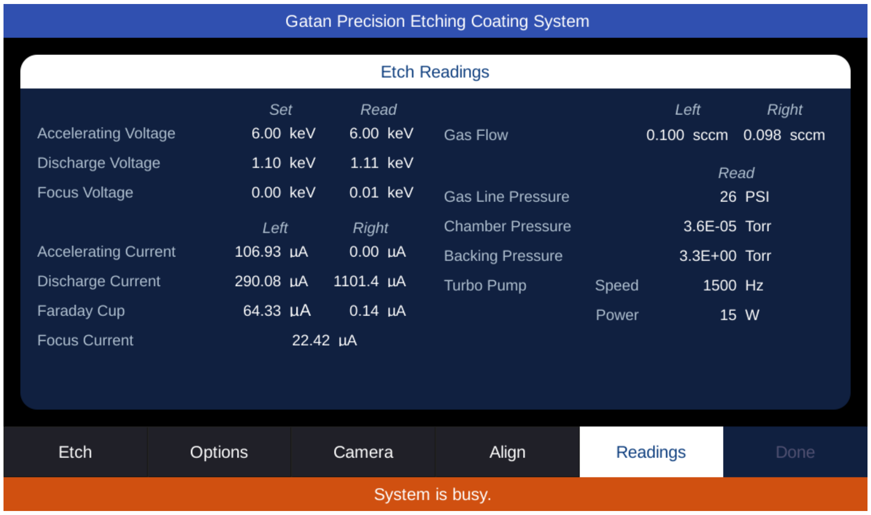


Figure 6-3. Beam modulation with left gun on and right gun off

5. **Go to align page, press Align Right.** Go to Readings page. This will turn off the left gun and turn on the right gun.

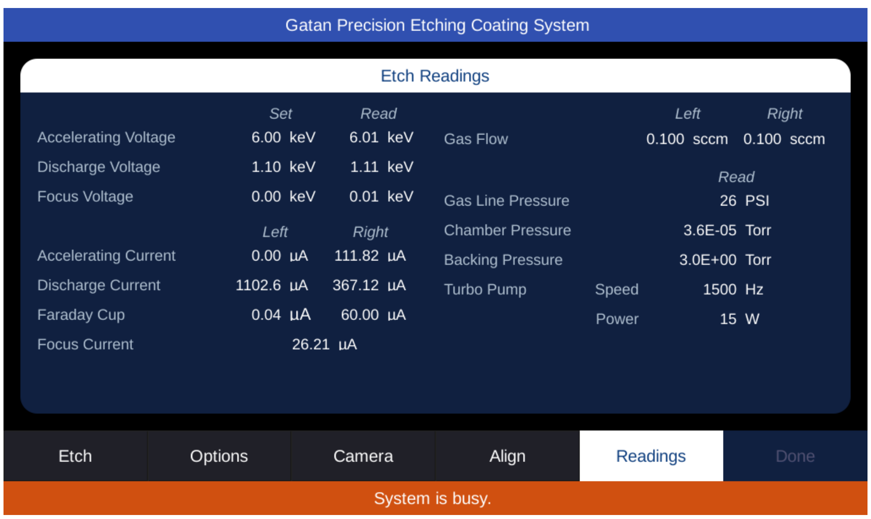


Figure 6-4. Beam modulation with right gun on and left gun off

Note that the left gun discharge current in uA (1103 uA) is about the same as the discharge voltage in V (1.11 keV ~ 1110 V). This indicates a gun that is turned off by beam modulation. If the right gun looked the same as the left, this could indicate a gun that is shorted between the anode cup and the rear pole piece or the anode cup and the front pole piece.

In the following figure, the right gun has a short between the anode cup and the rear pole piece. This gun needs to be cleaned. Note that the accelerating current and Faraday cup currents are both abnormally low. Note that the discharge current is approximately twice as high as normal. In this case there is not a dead (low resistance) short between the anode cup and the rear pole piece because the discharge current is less than ~1100 uA.

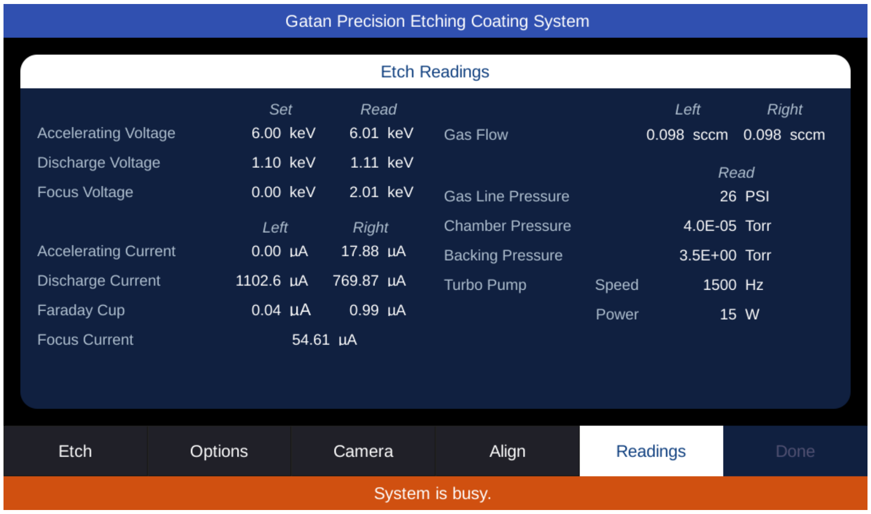


Figure 6-5. Shorted right gun

6. If you cannot solve the problem, take pictures of the above screens in these modes and forward the pictures to Gatan service along with a detailed description of what you have tried and what the results were.

In the example below, the right gun is shorted between the inner gun and the housing. Note that the Accelerating Voltage Read value is significantly less than the Set value. This indicates a short to ground (housing). Note also that the right gun accelerating current is very high. This tells you that the problem is with the right gun, because current is flowing directly from the right gun to ground. The amount of voltage drop and current increase will vary depending on the type of short.

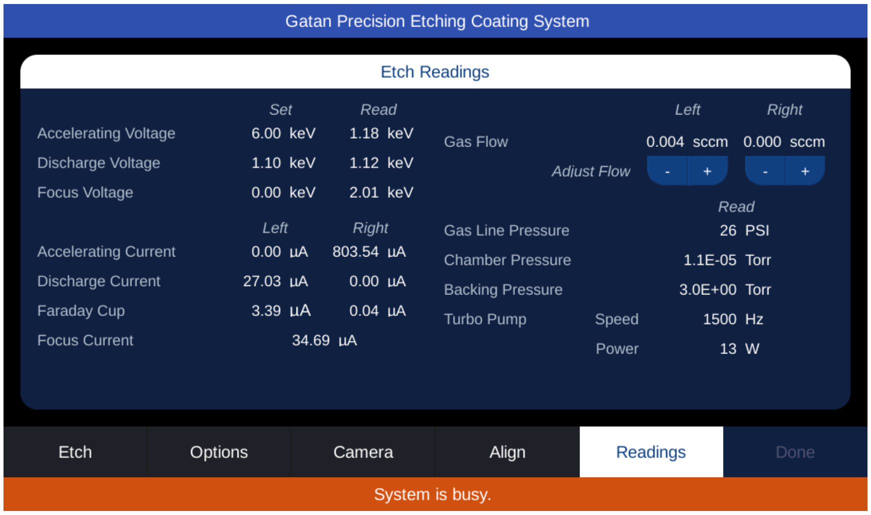


Figure 6-6. Right inner gun shorted to the housing

6.1.2. *Using resistance measurements*

Another way to recognize a gun short is to use a DVM (digital volt meter) measure the resistance between the terminals of the gun. The advantage of this method is that the system does not need to be vented. The cable from the gun to the HVPS has 4 wires. The black terminal is the accelerating voltage, the white terminal is the discharge voltage, the grey terminal is the focus voltage, and the ring/spade lug is the ground.

<u>**To check for a short by measuring the resistance:**</u>

1. **Shut down the power to the PECS II.** Unplug the power cable from the back of the system.

2. **Remove the system cover.**

3. **Unplug the gun high voltage cables from the high voltage power supply.** It is not necessary to remove the ground cable from the ground lug on the HVPS.

4. **Measure the resistance between the white and black terminals of the gun cables.** This should measure open, or infinity. Any other measurement indicates a shorted gun. This is typically caused by a flake of material between the anode cup and the rear pole piece.

Figure 6-7. Resistance measurement showing open (good)

5. **Measure the resistance between the white and grey terminals of the gun cables.** This should measure open, or infinity. Any other measurement indicates a shorted gun. This is typically caused by a flake of material between the focus electrode and the front pole piece.

6. **Measure the resistance between the grey and black terminals of the gun cables.** This should measure open, or infinity. Any other measurement indicates a shorted gun. This is typically caused by a flake of material between the focus electrode and the front pole piece.

7. **Measure the resistance between the white, black, and grey terminals and the ground terminal (still connected to the ground lug on the HVPS).** These should all measure open, or infinity. Any other measurement indicates a shorted gun. This is typically caused by a flake of material between the front pole piece and the housing.

8. **Clean the guns per section 5.6.1.** Test for shorts again using this procedure.

9. **Reconnect all the cables to the HVPS.**

10. **Replace the cover**.

11. **Power on the system.** First replace the power cable.

7. Consumables

Targets

682.1001C	Target gluing kit (customer installed)
682.1001F	Target gluing kit (factory installed)
681.10040	Blank Target Mount (holds 2 targets)
681.10050	Standard dual target set, C/Cr (Includes mount 10040)
681.10061	Carbon target
681.10062	Chromium target
681.10063	Gold/Palladium target (50% Au/50% Pd)
681.10064	Iridium target
681.10065	Platinum target
681.10066	Tantalum target
681.10067	Titanium target
681.10068	Tungsten target
681.10069	Tin target
681.10070	Quartz target
681.10071	Gold target
681.10072	Aluminum oxide (Al2O3) target
681.10074	Nickel
681.10075	Platinum/Iridium (90% Pt/20% Ir)
681.10076	Silver
681.10077	Palladium
681.10078	Aluminum
681.10079	Molybdenum
681.10080	Niobium
681.10083	Nickel Oxide
681.10084	Platinum/Palladium (80% Pt/20% Pd)
681.10085	Cobalt
681.10086	Copper
681.10087	Zinc

Film Thickness Monitor

03173	Thickness Probe Crystal (pack of 5)

Cross-Section Milling

693.08500	Sample blades, pack of 10
693.08510	Sample blades, pack of 100
693.14400	Single Sample Blade SEM Stub
693.14500	Multi Sample Blade SEM Stub
693.14300	Beam alignment screen

Miscellaneous

07874	Gate valve window (25.4 mm diameter x 3.2 mm thick)
09680	Krytox GPL-206 grease
101797	MDP fluid reservoir
10546	Repair kit, MVP-020

8. PECS II Options

8.1. Cold Stage Option

Certain PECS II models include a cold stage. This option must be installed at the factory on a new PECS II.

The PECS II Cold Stage components replace existing PECS II components as follows:

- The dewar assembly replaces the PECS II vent-valve assembly or liquid nitrogen trap.
- The cold stage Whisperlok assembly replaces the warm stage Whisperlok assembly.
- The PECS II I/O PCA connects to the dewar via a cable, and provides a readout of the cold conductor temperature as well as control of two heaters.

The first heater controls the temperature of the cold conductor (cold finger), and the second is used to boil-off the liquid nitrogen in the dewar. For instance, if a sample has a phase-transition temperature at -100 °C that you would like to avoid, the conductor temperature can be set to -50 °C prior to inserting the sample. In addition, if the stage is cold and you would like to mill at room temperature, you can set the conductor temperature to 23 °C.

When the dewar is filled with liquid nitrogen, it cools a copper plate that extends into the specimen chamber. Copper braids connect that plate to a cold conductor that sits next to the cold stage spindle. Brushes thermally connect the cold conductor to the cold stage spindle. See Figure 8-2. Because the Whisperlok stage rotates through a full 360°, this necessitates a thermal path which also rotates. As a result there is a significant delay from the time the dewar is filled to when the sample temperature decreases. Likewise, there is a delay from the time the cold conductor is heated to when the sample temperature rises.

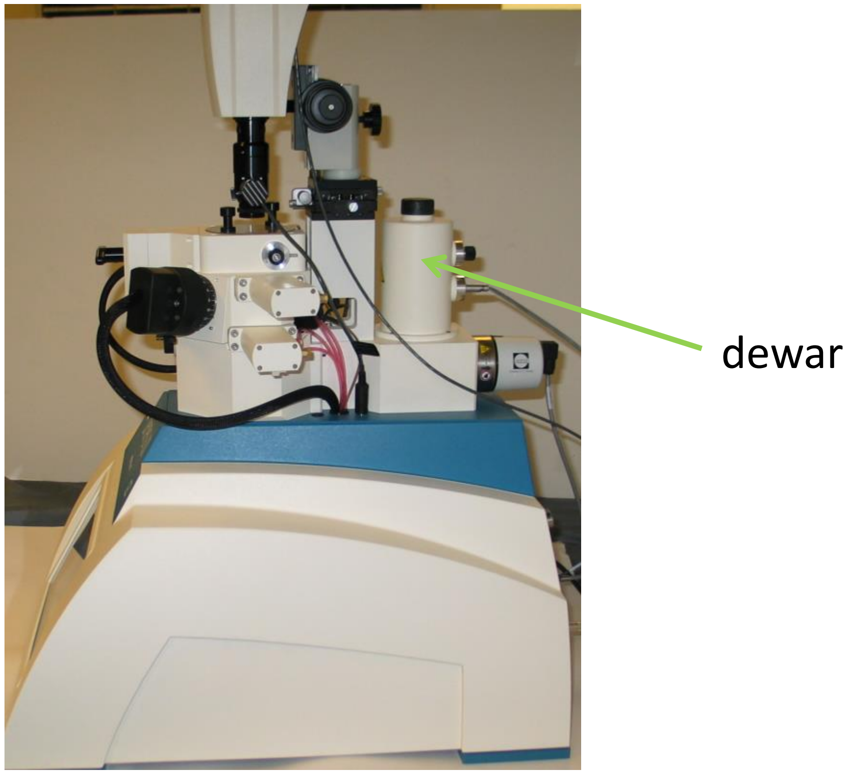


Figure 8-1 System with Cold Stage installed

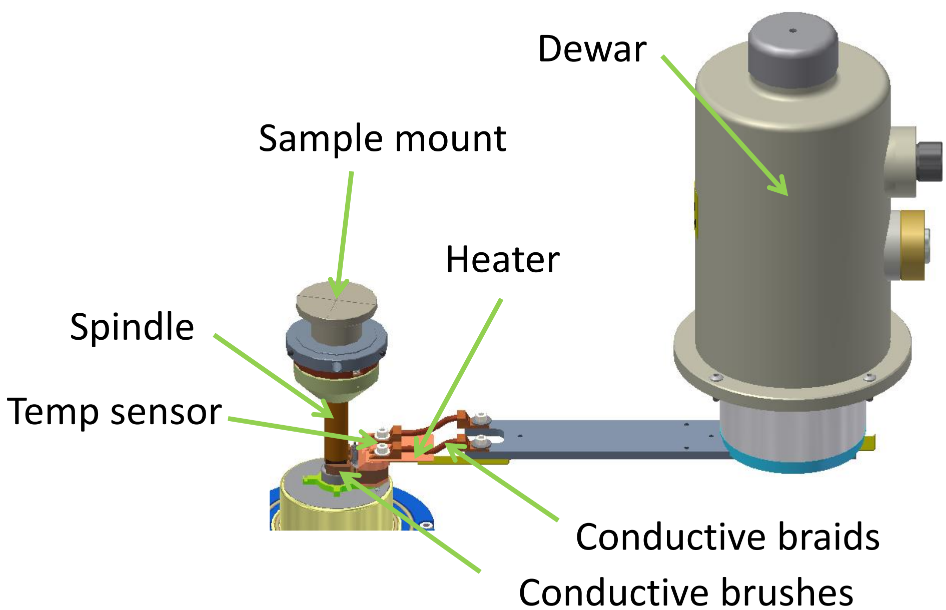


Figure 8-2. Schematic of cold stage system

8.1.1. *Operation*

Fill the dewar with liquid nitrogen prior to loading a sample into the PECS II. You may insert and remove samples from the airlock as required.

It is important when removing a cold sample that you allow enough time (at least 30 minutes) for the sample to warm up before removing the sample. The system can be programmed to automatically warm up the sample as part of the transfer sequence. Gatan recommends using this setting. This will prevent water from condensing on a cold sample. In some regions with low dew point, it may be necessary to wait longer before venting in order to prevent condensation. The stage heater is controlled on the Etch or Coat pages, in the Stage tab on the right hand side, see Figure 3-4 or Figure 3-16.

NOTE: Do not overfill the dewar; the starting level should be just below the bottom of the dewar neck. After about 10 minutes, boiling in the dewar will cease and more liquid nitrogen may be added. The dewar will typically last about 6-8 hours between refills. After the liquid nitrogen has boiled off, it typically takes about 4 hours for the cold conductor to warm up to room temperature. If the cold stage heater is active, the LN in the dewar will not last as long.

Filling the Dewar

1. **Fill the dewar with liquid nitrogen.**

Do not overfill; the starting level should be just below the bottom of the dewar neck.

2. **The liquid nitrogen will boil off in a few minutes.**

Continue refilling the dewar for about ten minutes to replenish the liquid nitrogen.

NOTE: It may take more than one “top off” to initially cool down the dewar.

3. **After about ten minutes the boil-off rate will have slowed dramatically.**

Top off the dewar.

4. Place the supplied lid on the dewar.

5. Set the cold stage heater to -30° C and enable the heater. See Figure 8-3. This is the recommended temperature for most samples and sample mounts. If desired, the heater may be set to a lower temperature, or left disabled. If disabled, the sample mount will eventually reach approximately -100° C or lower, but will take a long time to warm up prior to removal.

The automatic warm-up function is set in Devices -> Heaters. Gatan recommends setting this to 100° C for 30 minutes. This will typically warm a sample from -30° C to close to room temperature. Results will vary with different samples and sample mounts.

6. **The system is ready for a sample to be installed**.

The liquid nitrogen in the dewar should last 6-8 hours if the heater is not being used, and ~4 hours if the heater is set to -30° C. These times will be shorter if the ion beams are on.

Loading a Sample

No special precautions are required when loading a sample. Follow the instructions in section 3.5.1.

Planar samples can typically be etched immediately after loading the sample. Cross section samples typically attain higher temperature due to the thermal conductivity of the blade, therefore, it may be advantageous to wait 30 minutes or more after loading a cross-section sample before etching.

Unloading a Sample

It is important to warm a sample above about 15°-23° C before removing it from the system, or it may experience condensation. Because of the large thermal mass of the sample mount, it can take some time for a sample to warm up above this temperature. The system can be set to automatically warm up the stage when unloading a sample. This is defined in the Devices Heaters page, see section 3.1.15.

If Transfer Heating is *enabled*:

1. **Unload the sample from the system, see section 3.5.2.** Sample warm-up will be handled automatically. Note that the default warm-up time is designed to heat up a planar sample that has been held at -30° C. If the sample was significantly colder than this, it is recommended to warm the stage up according to the directions below prior to unloading the sample.

If Transfer Heating is *disabled*, and sample is cold:

1. **Set cold stage heater to 100° C.** This can be done from the Etch or Coat main pages, or from the Devices Heaters page.

2. **Enable cold stage heater.**

3. **Wait 30 minutes for sample to reach room temperature.** 100° C for 30 minutes will warm a sample mount up from -30° C to approximately 15°-23°

C. If the sample is substantially colder than -30 C, this will take longer. Do not run the heater longer than necessary or the sample will reach temperatures higher than room temperature. This may require some experimentation. If you are not sure how long it will take to warm the sample, run the heater for 30-45 minutes, then set it to 23 C, then wait for about 1 hour.

4. **Set the cold sage heater to 23° C.** This will maintain the sample mount at room temperature and help ensure that the sample temperature does not reach an elevated level.

5. **Unload the sample from the system, see section 3.5.2.**

Note: if you experience condensation on the sample, try waiting longer during step 3 or step 4.

Boiling off the LN Dewar

Use this control prior to venting the system.

1. **Remove the sample.**
2. **Go to Devices > heaters page.**
3. **Start the Dewar Heater.** This heater stays on continuously until the Cold Finger Temp reaches 25° C, then it shuts off. This typically takes less than one hour.

Temperature Control

The cold stage is controlled in two places by the GUI. The first is Devices> Heaters.

Figure 8-3 Heaters Page.

Cold Finger reading: Displays the temperature of the cold finger

Cold stage heater: Turns the heater on and off. If the heater is on and the temperature drops below the heater set point, the heater is turned on until the temperature is 1 deg above the set point.

Set Point: Used to enter the set point of the heater.

Dewar heater: Activates the dewar heater. This heater stays on continuously until the Cold Finger Temperature reaches 25° C, then it shuts off. This feature can only be used when the cold stage heater is disabled.

The second place in the GUI to control temperature is the Etch and Coat pages, in the Stage tab on the right hand side.

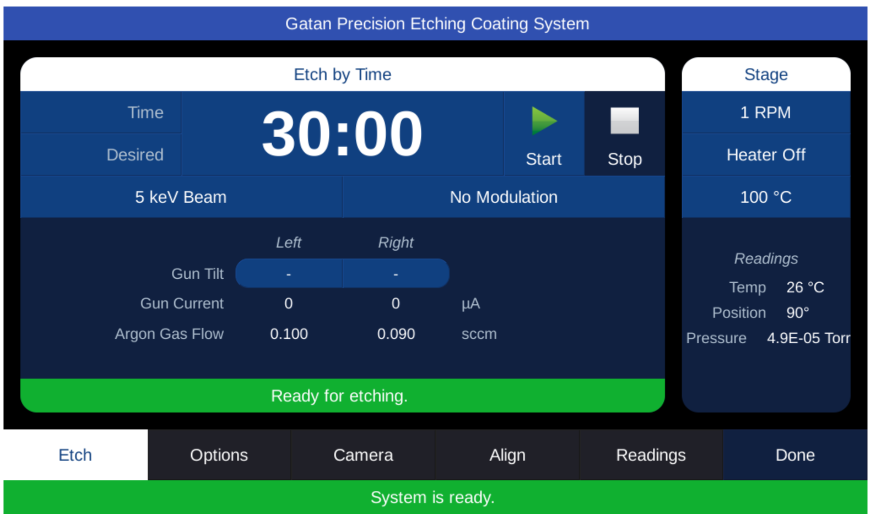


Figure 8-4. Etch page with heater control

Heater On/Off: This button enables or disables the cold stage heater. If the heater is on and the temperature drops below the heater set point, the heater is turned on until the temperature is 1 deg above the set point

Temperature Setting: Used to enter the set point of the heater.

Caution: The cold stage heater will stay active until it is disabled. Do not forget to disable it when it is no longer needed.

8.1.2. ***Recommendations***

Cross section (Ilion$^+$) samples that are temperature-sensitive should be milled with the stage temperature set to -30 C, and the beam voltage no higher than 6 kV. This will typically insure that the blade temperature does not rise above room temperature and the sample can be warmed up in 30 minutes without creating condensation upon removal.

Planar samples should also be milled with the stage temperature set to -30 C. The beam voltage can be set as high as 8 kV in this case, however, some experimentation may be required with different types of samples.

For best results, consider these additional factors:

- Lower ion beam density results in lower sample temperature. Using the gas flow to defocus the beam will result in lower sample temperatures. Likewise, milling at lower beam energy results in lower sample temperature. If you are using beam modulation, increasing the rotation speed will result in a lower sample temperature.
- Recommendations described in this section are approximate and based on experiments performed at Gatan on a limited number of systems. Results may vary. Gatan recommends testing these processes on non-critical samples to determine adequate heating temperature and time settings prior to preparing critical samples.

8.1.3. ***Performance***

A sample will reach a temperature of approximately -100 °C +/- 25 °C. The sample will typically cool to approximately 0 °C in thirty minutes. It will reach its lowest temperature in 4-6 hours. The sample will typically reach the same temperature as the cold finger; how long this takes depends upon the thermal conductivity of the sample and its thickness.

The temperature measured at the cold finger is typically about 50-75 °C cooler than the temperature at the sample. In addition, there is a time delay of at least 30 minutes between a change in cold conductor temperature and the corresponding change in sample temperature.

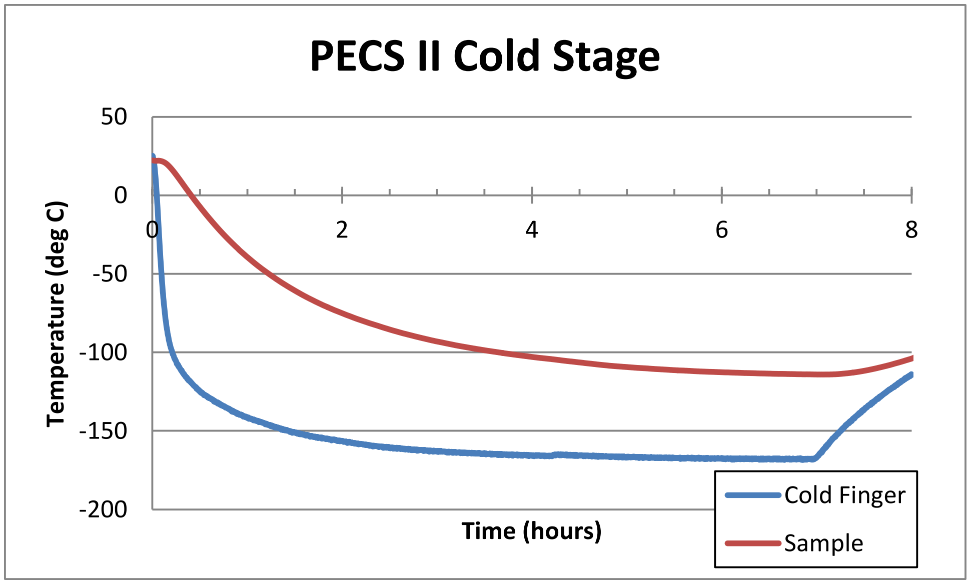


Figure 8-5 Cold stage initial cool down

In Figure 8-5 the dewar was filled at the start. The sample and cold finger temperatures were measured as a function of time. The cold finger temperature began to increase after about 7 hours when the liquid Nitrogen in the dewar was gone. Note that if the cold stage sample heater is turned on, the liquid Nitrogen will not last as long. If the cold stage heater is set to -30 (the recommended setting) the dewar will need to be filled about every 2 hours.

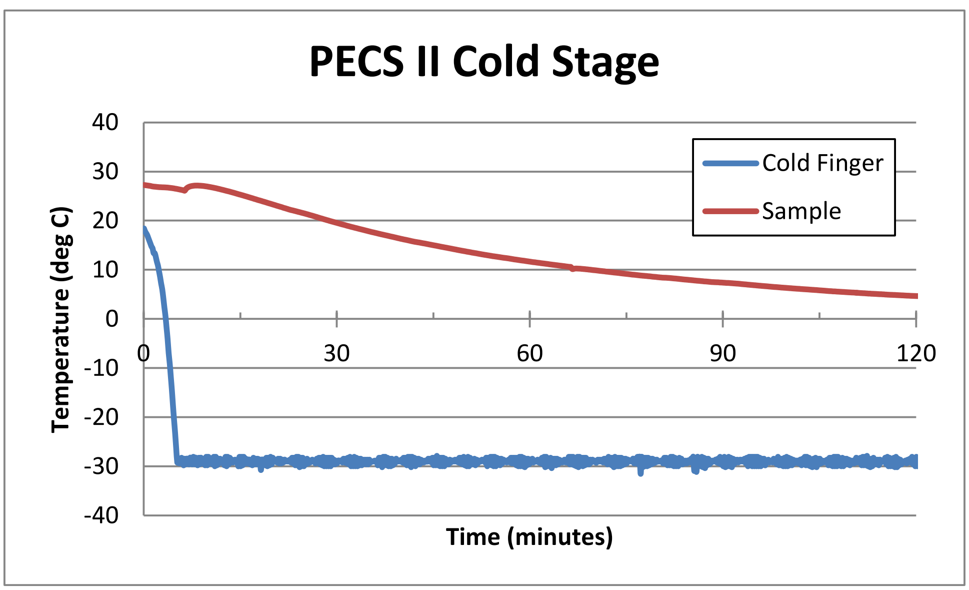


Figure 8-6. Temperature of planar sample with 8kV beams

In Figure 8-6 the dewar was filled, the cold stage heater was set to -30° C, and the beams were turned on at 8 keV 18 degrees at the start of the experiment. The sample temperature did not rise above room temperature, which was the goal. This indicates that many planar samples can be etched immediately upon filling the dewar.

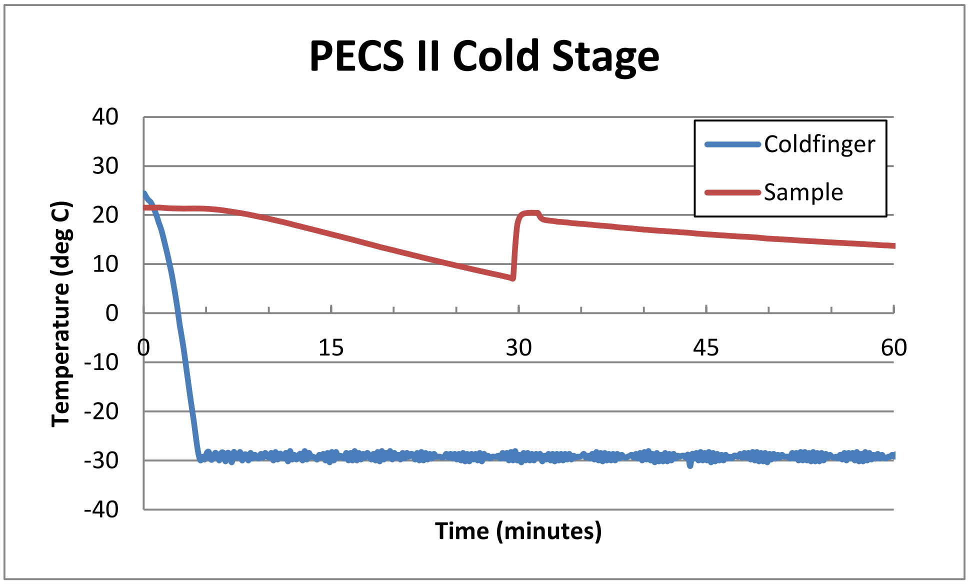


Figure 8-7. Temperature of Ilion blade with 6kV beam

In Figure 8-7 the dewar was filled and the cold stage heater was set to -30° C at the start of the experiment. After 30 minutes the beam was turned on at 6 kV and directed fully on the blade (typically part of the beam misses the sample so this is a worse than normal case). Note that the sample temperature did not rise above room temperature.

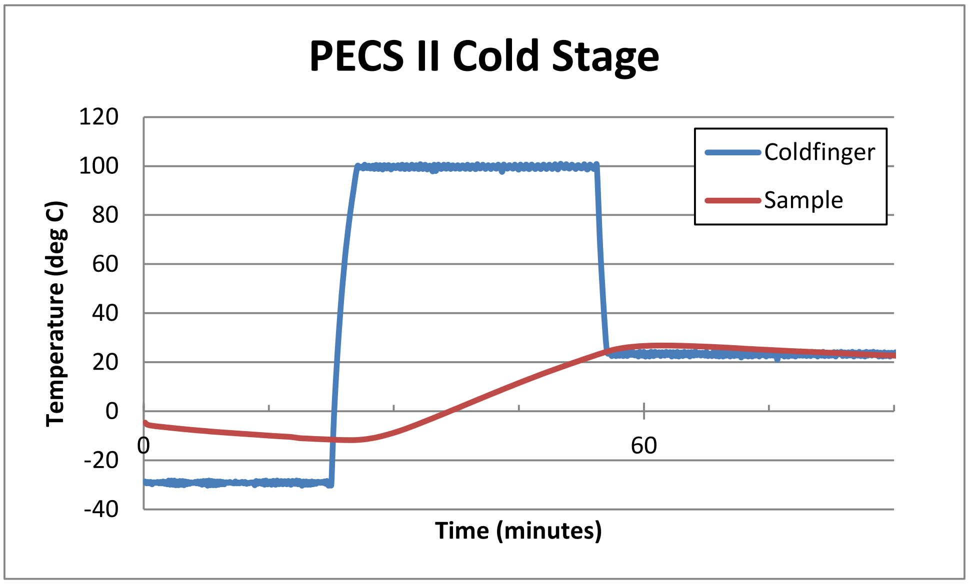


Figure 8-8. Preparing Ilion mount for sample transfer

Figure 8-8 shows a continuation of the experiment from Figure 8-7 designed to simulate sample warm-up prior to transferring the sample out of the system. At 22 minutes the cold stage heater (Cold finger) was turned on with a set point of 100° C. After 30 minutes the heater was turned down to a set point of 23° C. At this time the sample was approximately at room temperature and ready to be transferred out of the system. Note that if the cold stage heater were not active and set to -30° C, then it would have taken longer to warm the sample up to room temperature. From -100° C, it can take 1 – 1.5 hours to warm up to room temperature.

8.1.4. *Maintenance*

Checking the Cold Conductor Brush Wear

The brushes that make contact between the cold conductor and the spindle exhibit wear. They are expected to last several years, but should be inspected every year. The Cold Conductor Assembly brushes can be replaced only with Gatan provided parts, which are designed to meet specific requirements of thermal conductivity, electrical conductivity, and lubricity in vacuum.

1. **Turn off the power to the system.**

2. **Wait ten minutes for the MDP to spin down, then slowly vent the system.**

3. **Remove the load lock.**

4. **Loosen the two M2.5 screws and washers on the top of the cold conductor assembly.**

5. **Move the heater and braid assemblies out of the way.**

6. **Remove the Whisperlok assembly (see section 5.11).**

7. **Visually inspect the brushes for wear.**

    a. **The thinnest part of the brushes are 0.050" (1.27 mm) thick when they are new. When the brushes reach a thickness of about 0.015" (.38 mm), they should be replaced.**

    b. **Note that there is a mechanical stop which prevents the brushes from wearing too thin.**

    c. **If the two sides of the mechanical stop are in contact with each other, then the cold conductor assembly must be replaced.**

8. **Vacuum out any powder or flakes of brush material that has fallen to the region below the brushes.**

This material is a normal part of the wear process of the brushes. If an excessive amount of material is built up on the brushes, you may want to remove the cold conductor assembly and clean the material from the brushes with a dry applicator or similar soft material.

⚠ **Caution:** Do not use any liquid or solvent on the brushes, this will destroy them.

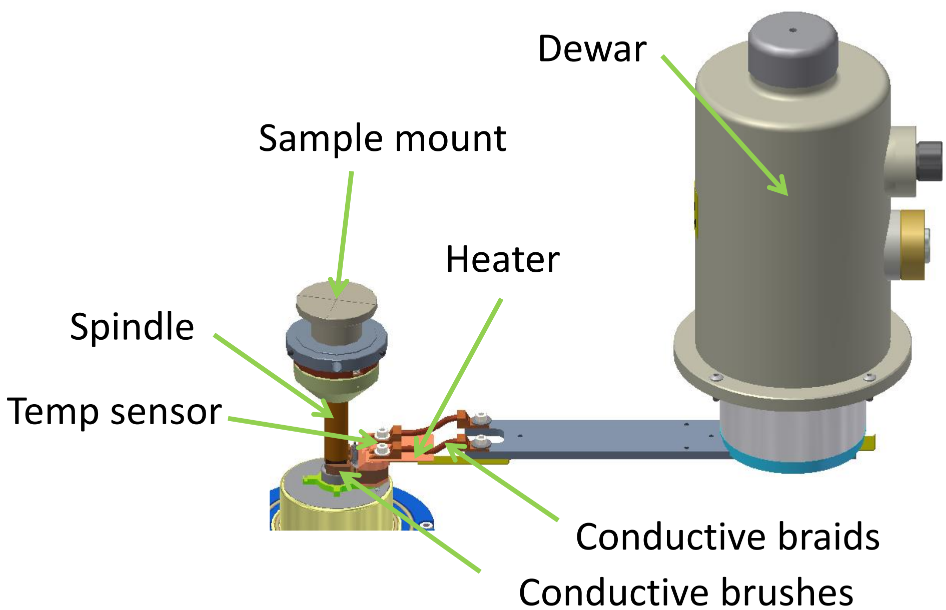


Figure 8-9 Schematic showing the cold conductor brushes

Replacing the Hinged Conductor Assembly

Note: A long bladed (>120 mm) M2 Allen wrench is required for this task.

1. Turn off the power to the system.

2. Wait ten minutes for the MDP to spin down, then slowly vent the system.

3. Remove the load lock. Unplug the cables from the load lock. Loosen the 4 M4x35mm screws in the top of the unit. Lift off the load lock from the chamber.

4. Loosen the two M2.5 screws and washers on the top of the cold conductor assembly.

5. Move the heater and braid assemblies out of the way.

6. Remove the Whisperlok assembly (see section 5.11).

7. Remove the Sample Mount Receiver. Remove the M2.5x5 mm screw from the top of the sample mount receiver. Remove the M1.6x4 mm screw from the side of the sample mount receiver. Lift the sample mount receiver off of the spindle.

8. Loosen the M2 screw that holds the cold conductor assembly to the bellows assembly.

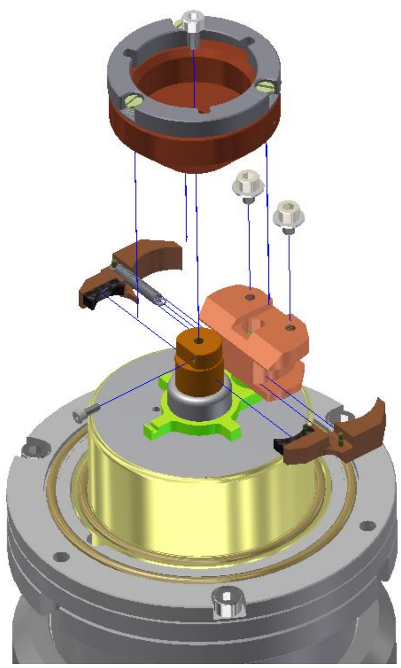


Figure 8-10. Removing the cold conductor assembly

9. **Carefully lift the cold conductor assembly off of the spindle, making sure not to damage the brushes.**

10. **Insert the new brush arms into the new cold conductor base.** Do not install the spring yet. Note that in addition to the spring that clamps the brush arms together, there is a spring threaded into a bottom hole of the cold conductor base. This spring makes electrical contact between the sample stub and the chassis, and is needed for proper operation.

⚠ **Caution:** Do not use any liquid or solvent on the brushes, this will destroy them.

11. **Install the cold conductor base into the system. Be careful not to damage or drop the brushes.** Be sure the spring between the cold conductor base and the top of the bellows assembly is perpendicular to the bellows assembly (not kinked).

12. **Tighten the M2 screw.**

13. **Install the spring onto the two posts on the brush arms.**

    i. **Place one side over the first post, then use tweezers to stretch the spring over the second post. There is an indent in the posts to capture the spring.**

    ii. **Make sure the brushes are aligned to the spindle (i.e. there is not a gap between them).**

14. **Install the Sample Mount Receiver.**

15. **Install the Whisperlok into the chamber.** Feed the heater slots into the space under the two screw heads as the Whisperlok is raised into the chamber using a long Allen wrench.

16. **Install the Braids into the cold conductor screws.** Tighten the screws that clamp the braids and the heater. Make sure the heater and braids are inserted fully against the screws.

17. **Replace the load lock.**

18. **Turn on the power.**

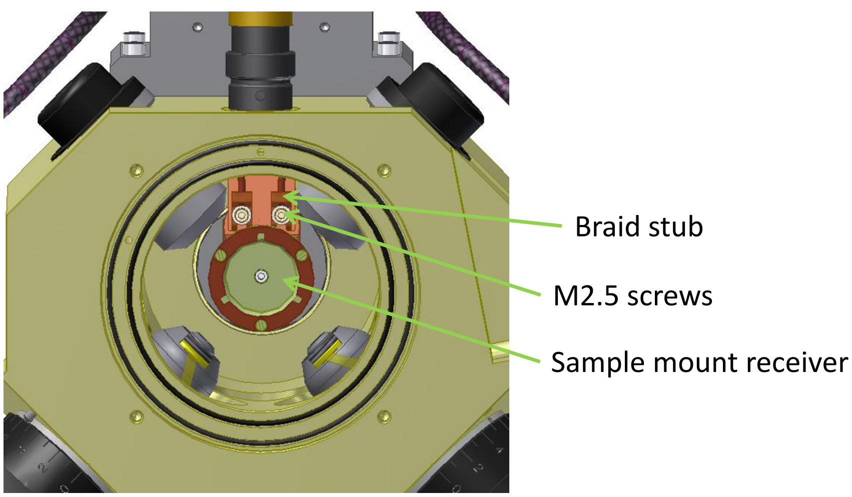


Figure 8-11. Open chamber showing access to cold stage

Replacing the Dewar Assembly

1. **Shut down the power to the PECS II.** Wait at least 10 min to allow the MDP to come to a complete stop. Then vent the work chamber by opening the Vent valve. Unplug the power cable from the back of the system.

2. Remove the load lock assembly. Unplug the cables from the load lock. Loosen the 4 M4x35 mm screws in the top of the unit. Lift off the load lock from the chamber.

3. Slightly loosen the two M2.5 screws and washers on the top of the cold conductor assembly. Be careful not to loosen these so far that they are completely removed. See Figure 8-11.

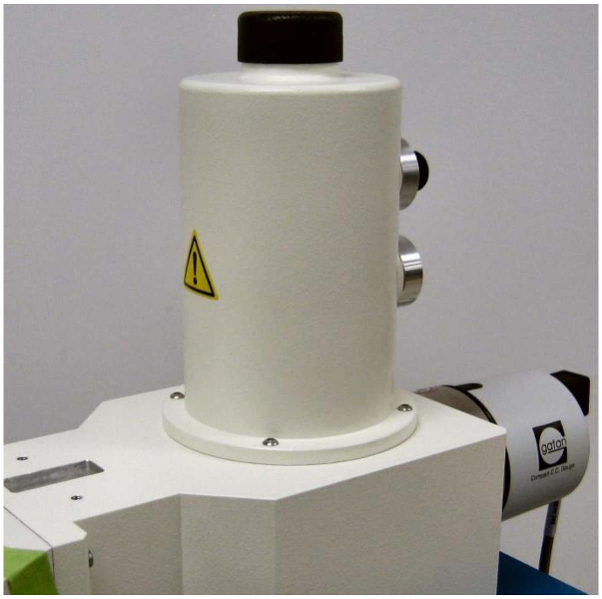


Figure 8-12 Dewar Assembly installed in manifold

4. Remove the Dewar assembly.

a) Unplug the cable from the back of the dewar.
b) Remove the 4 M3 screws that secure the dewar to the manifold. See Figure 8-12.
c) Lift the dewar assembly upward until it is free from the manifold. Then tilt the top of the dewar forward and move the dewar backward so that the Copper bar clears the manifold. It may be necessary to tilt the dewar sideways to clear a microscope assembly, or even to remove the microscope prior to this work.

5. Install the new Dewar assembly.

a) Insert the dewar assembly into the manifold. Press down firmly to seat the o-ring in the manifold.
b) Install the 4 M3 screws that secure the dewar to the manifold. See Figure 8-12.
c) Connect the cold stage to the hinged conductor assembly. Insert the heater and braid clamps against the M2.5 screws in the cold conductor assembly. Tighten the two M2.5 screws and washers

that connect the cold stage heater to the hinged conductor assembly. See Figure 8-11.

6. **Install the load lock assembly.**

7. **Turn on power to the system.**

8.2. Film Thickness Monitor

The Film Thickness Monitor permits improved control of the film-deposition process by providing a direct display of the film thickness and deposition rate during coating. The UI includes a list of the most common materials used, including density and Z-factor settings.

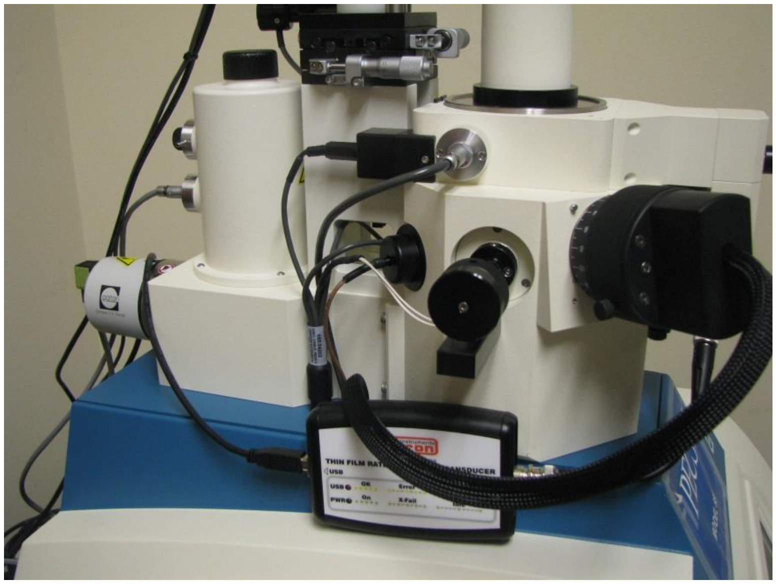


Figure 8-13. Film thickness monitor connected to PECS II

8.2.1. *Thickness monitor settings*

The Monitor requires three parameters to provide the thickness readout directly in nanometers (nm):

- Tooling Factor
- Density of the target material
- Z-Factor of the target material

These settings are stored in the UI for a pre-selected list of target materials. The user cannot change these settings in software version 1.7. Gatan service (or an applications specialist) can edit the list of target materials to include any target materials purchased for the system.

Tooling Factor

This parameter allows the Monitor to compensate for deposition-geometry effects such as target to sensor and target to sample distances that result in proportional but not equal film thicknesses at the sensor and the sample.

Utilizing the Tooling Factor, the Monitor calculates and displays the Thickness and the Rate calculated at the sample rather than measured at the sensor.

The tooling factor varies with beam energy and with material. The system maintains a table with tooling factors that have been empirically measured by Gatan. These tooling factors have not been measured for all materials. A default value of 250 is set for all tooling factors that have not been calibrated. The customer may change this value, based upon customer calibration measurements. In this case it is recommended to use the same beam energy for coating as was used for the calibration.

Density

The density parameter provides the Monitor with the density of the target material being deposited so that the Monitor can calculate and display the physical thickness of the coated film.

Acoustic Impedance Correction

If the target material has an acoustic impedance significantly different from that of the sensor crystal, the Monitor can correct for the acoustic impedance mismatch between the two by using the operator-supplied acoustic impedance for the target material. Without this correction, errors would result as the film thick- ness builds up on the crystal for the sensitivity of the crystal varies with the amount of material buildup. Depending upon the materials, lack of correction could lead to differences between indicated and actual thickness of up to 20%.

8.2.2. *Thickness Monitor Operation*

See section 3.7.2 for instructions.

8.2.3. *Replacing the Coating Targets*

See section 2.3.6 for instructions.

8.2.4. *Crystal Testing*

As materials build up on the crystal face, a point will be reached when the crystal will no longer support oscillation and must be replaced.
A new crystal will produce a crystal health value of 98–99%, which will decrease as material is coated onto the face of the crystal. Crystal health decreases from this value to 0% at a total deposited areal mass of 25 mg/cm2, which corresponds to a frequency shift of about 1.50 MHz or an aluminum thickness of 925 kÅ. Since very few target materials can be deposited to this thickness without causing crystal failure, a crystal health of 0% will never occur. In fact, for most materials, a crystal health below 90% will never be achieved.

The Coat Options page will flash an error message with crystal failure when the crystal must be replaced.

Note: Crystal removal and replacement should be performed in a clean environment and, to prevent contamination, use gloves and plastic tweezers when handling. It is also recommended the unused crystals be kept in the plastic case provided.

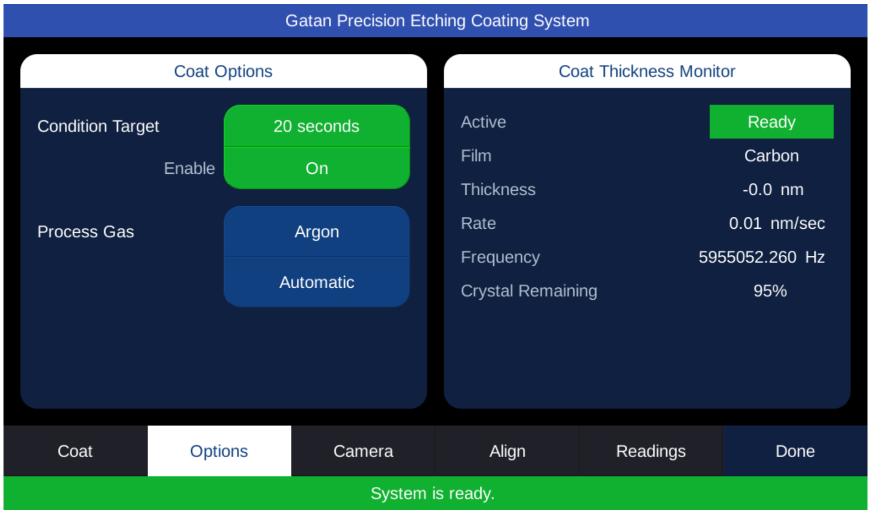


Figure 8-14. Thickness monitor readings on the UI

8.2.5. *Crystal replacement*

The Chamber must be vented to atmosphere to remove this probe and replace the crystal.

1. Shut down the power to the unit.
Wait at least 10 minutes to allow the MDP to come to a complete stop; then vent the Chamber by opening the Vent valve.

2. Remove the probe from the Chamber.
Pull it straight out of the flange adapter.

3. Remove the crystal.
Remove the clamping screw, lift off the clamping plate, and tap or rotate the probe to allow the used crystal to fall out of the recess.

4. Dust off the recess.
Use compressed air to remove any loose coated material that would cause the crystal to short. The recess is designed to be electrically isolated from the probe body.

5. Place the new crystal, patterned side down, into the recess.
Replace the clamping plate and its screw, but do not tighten until carefully examining the crystal to insure it is properly seated in the recess.

6. Test crystal circuit.

Place an ohm meter across the center pin and the housing of the BNC connector to get a reading of infinity. A low resistance or a short indicates the crystal is not properly installed (bottom surface of crystal must be electrically isolated from the top surface).

7. Connect the probe to the Monitor.

8. Replace the probe into the flange adapter and pump down the Chamber.

9. Turn the power on to the system.

10. Select Coat Options. Verify that the FTM is working properly (no error message).

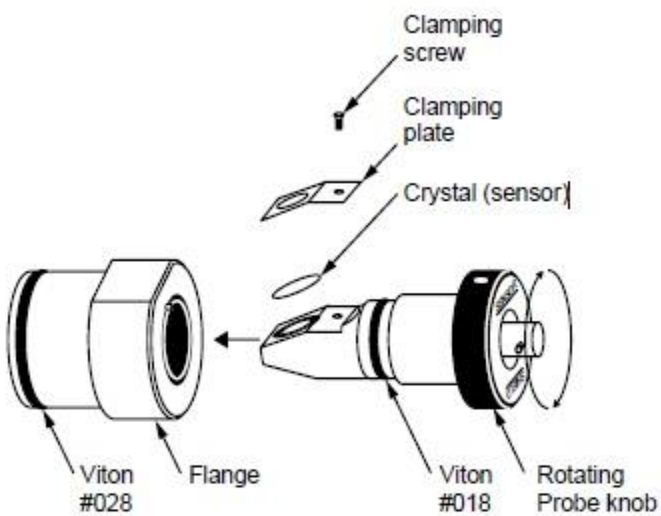


Figure 8-15. Film thickness probe

8.3. Vacuum Transfer Option

Certain PECS II models include a vacuum transfer option. This option must be installed at the factory on a new PECS II.

This system option allows samples to be loaded and unloaded under continuous vacuum or pressurized Argon. A Vacuum Transfer Device (VTD) replaces the Transfer Device. A new version of the Load Lock replaces the standard Load Lock. A new version of the Argon Manifold replaces the standard version. The system must be configured for this option on the Settings / Software page.

The Transfer feature functions differently in the case of Vacuum or Argon transfer. The user may choose between Vacuum or Argon transfer, and extra steps are added to pump out and/or pressurize the VTD during the process.

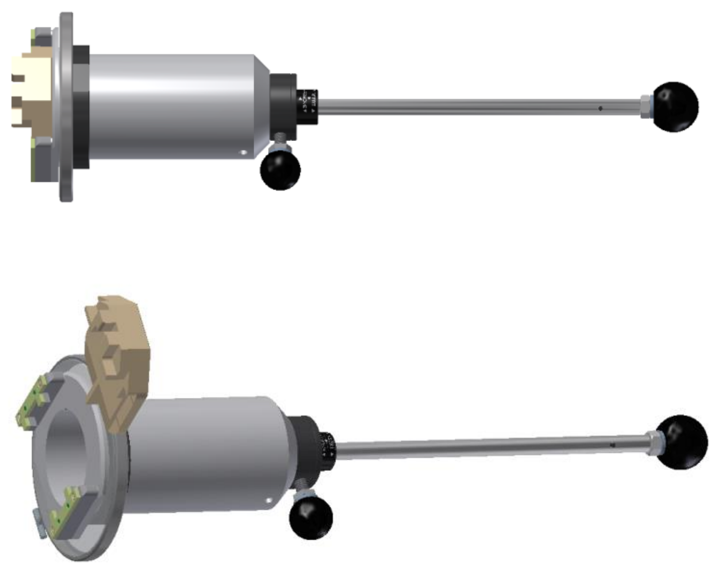


Figure 8-16. Vacuum Transfer Device (VDT)

The vacuum transfer option requires a different version of Argon manifold. A schematic and list of materials used is listed below.

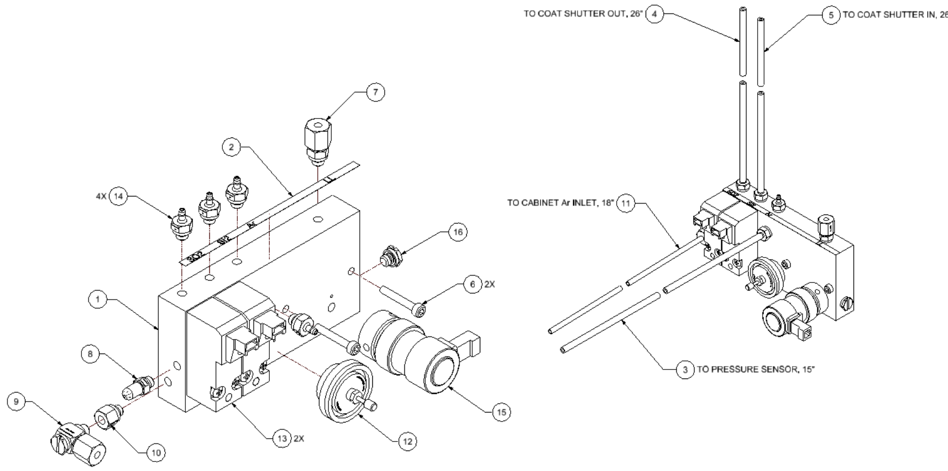


Figure 8-17. Argon manifold, vacuum transfer version

Table 6. Argon Manifold Parts List

ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	685.03021	MANIFOLD,PECS II
2	1	685.03061	LABEL,MANIFOLD
3	1	05629	HOSE POLY 5/32OD,5/64ID TR BLU
4	1	05631	HOSE POLY 5/32OD 5/64ID TR GRN
5	1	05632	HOSE POLY 5/32OD 5/64ID TR RED
6	2	06753	SCR, SCH, CAP, M3x20MM, SST
7	1	101483	MUFFLER,10-32-1/4 NPT-MMPA
8	1	101484	FTG,ELBOW,10-32 THD,1/8" OD TUBING
9	1	101485	FILTER,20 MICRON,10-32THD M-F
10	1	101492	TUBING,.093" ID,.016" WALL,NYLON
11	2	101632	VALVE,90 DEGREE CONN. W/LED
12	4	102289	FTG,10-32 THREAD TO BARB ,BRASS
13	1	102324	PLUG,10-32 THD SCREW

8.3.1. *To load a specimen:*

1. **On the Main page, select the Transfer tab.**

2. **Select Argon Pressurized or Under Vacuum.**

3. **Select Load Sample (see Figure 8-18)**

The stage will be lowered into the transfer position and rotated to home.

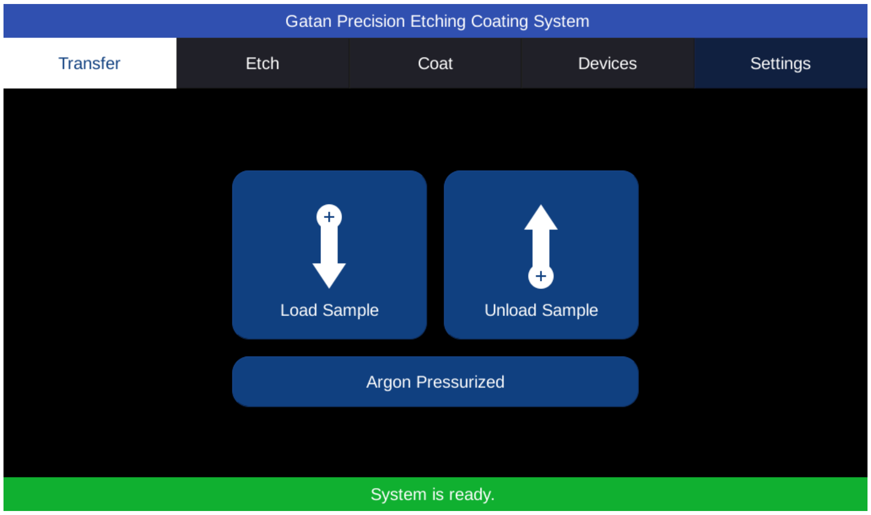


Figure 8-18 Transfer page

4. Set the Vacuum Transfer Device onto the load lock of the PECS II.

Align the tee on the back of the transfer device with the mating slot on the loading dock (see Figure 3-54). Make sure the O-ring is properly seated in the O-ring groove.

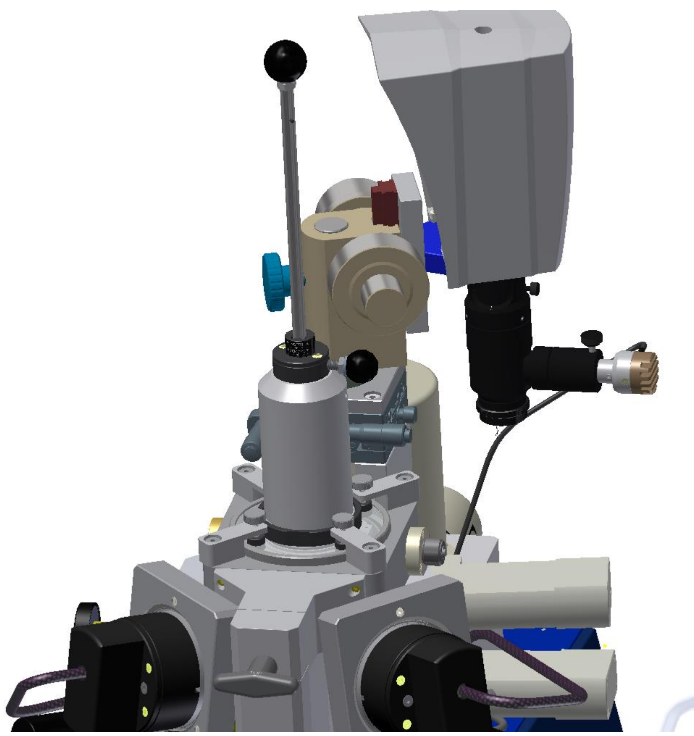
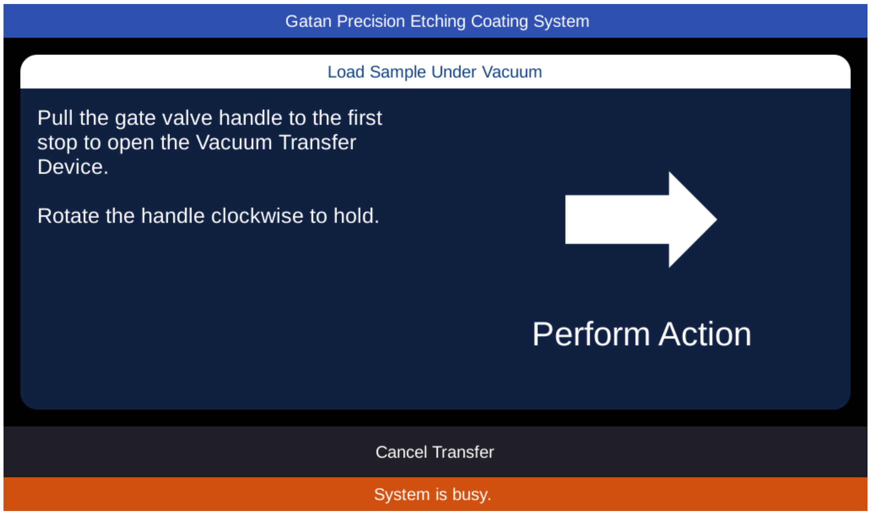


Figure 8-19. Transfer device on load lock with clamps attached

5. If this is an Argon Pressurized transfer, then install the clamps onto the VTD as shown above.

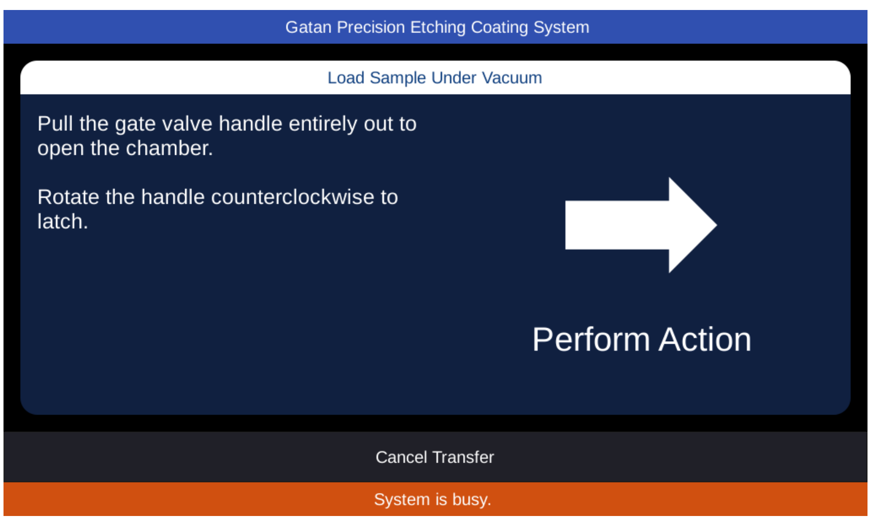
6. Press the Next button.

The load lock will be pumped out, then the user will be instructed to open the gate valve to the first stop and rotate the handle clockwise.



7. Ensure the Tee handle on the front of the load lock is horizontal. Pull the Tee handle out to the first stop (about 6.5 mm) and turn clockwise until it stops.

A catch will stop the handle from being pulled in by the vacuum. The VTD will be pumped out, then the user will be instructed to open the gate valve the rest of the way.



8. Rotate the Tee handle on the front of the load lock counter-clockwise until horizontal. Pull the Tee handle out fully and turn counter-clockwise until it stops.

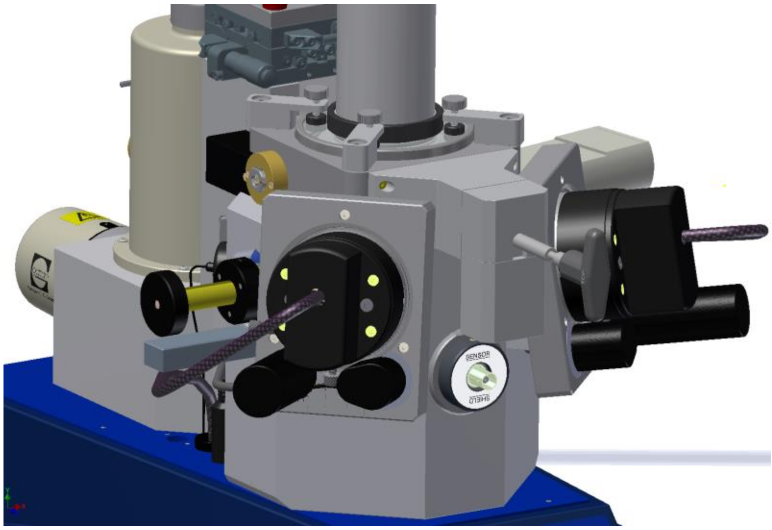
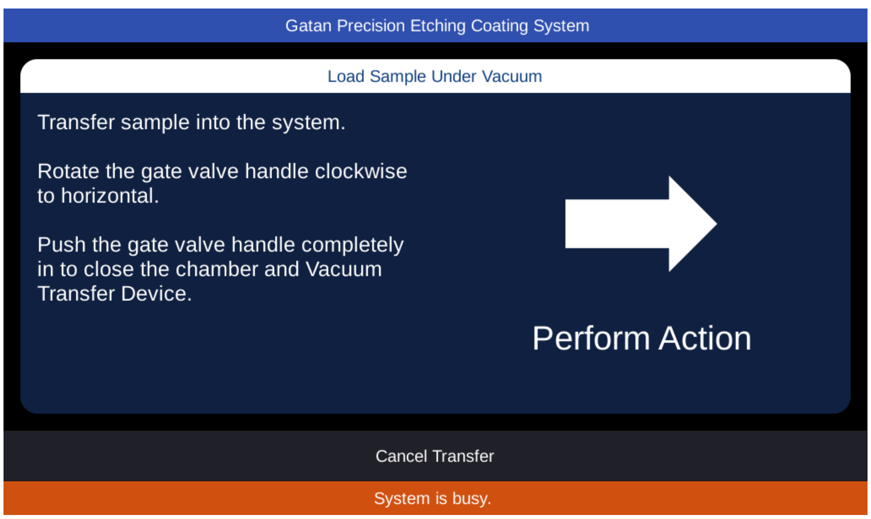


Figure 8-20. Tee handle out fully and rotated counter-clockwise

The system will recognize this and notify the user to perform the next step.



9. **Lower the transfer arm into the PECS and release the sample.**

- Loosen the locking knob on the side of the transfer device.
- Grasp the knob at the end of the transfer shaft and lower the arm.
- Note the pin near the top of the shaft. Rotate the shaft so that this pin enters through the left notch in the top of the housing. Lower the shaft until it stops. It may help to rotate the shaft slightly back and forth when the mechanism contacts the pins on the sample mount to be sure it engages the pins fully.

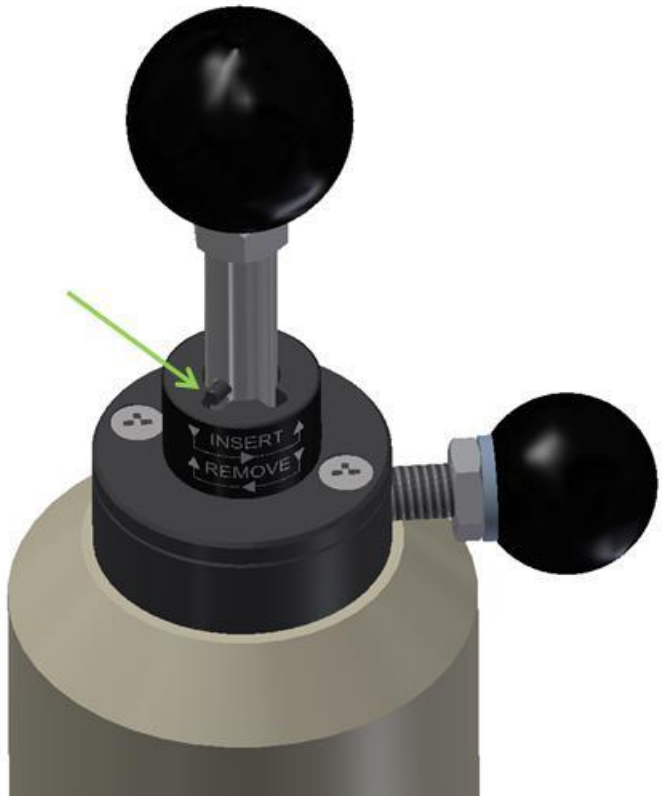
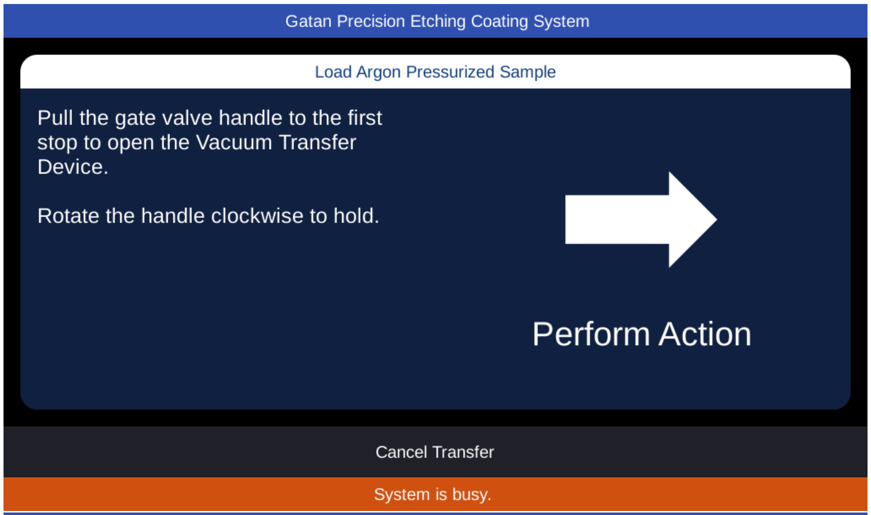


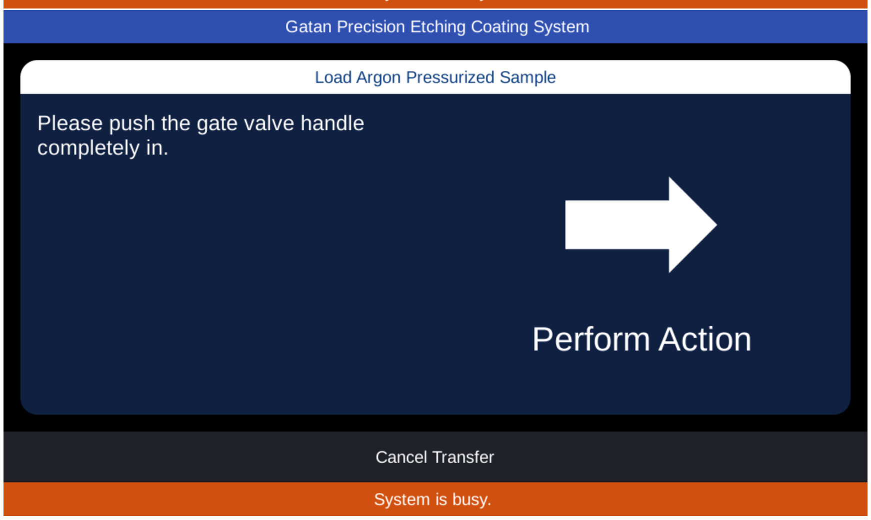
Figure 8-21. Transfer device while loading

- Rotate the shaft counterclock-wise until it stops. (about 75 degrees) If it does not rotate, wiggle it back and forth until it drops the rest of the way down.
- Lift the shaft until it stops. The sample mount should remain in the system.
- Tighten the locking knob on the side of the transfer device.

10. Turn the Tee handle clockwise until horizontal and insert back into the chamber until it stops.

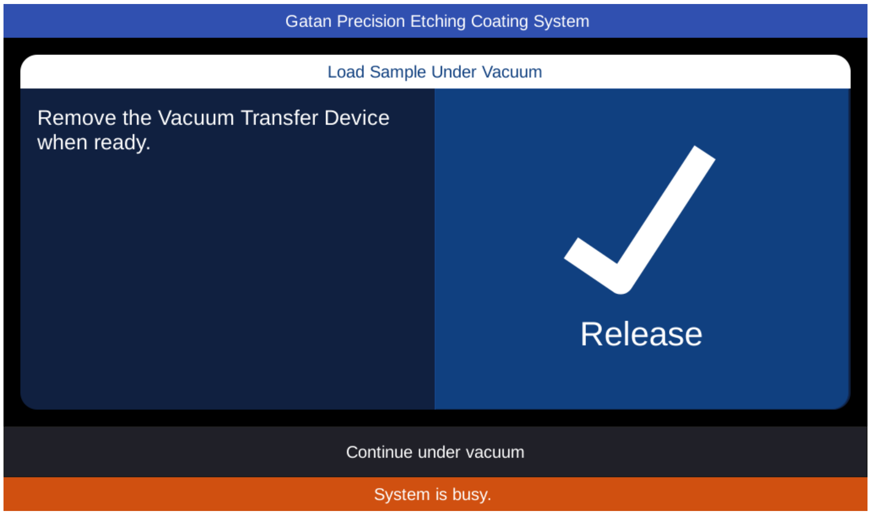
11. If this is an Argon Pressurized transfer, then the user will be instructed to pull the handle out to the first stop and rotate clockwise to hold. Once the VTD is pressurized, the user will be instructed to push the handle all the way in.





12. Press the Continue button to vent the airlock.

If Continue Under Vacuum is pressed instead of the Release button, the load lock will remain under vacuum and the VTD cannot be removed.



13. **Remove the Transfer Device from the load lock and store it on the Loading Dock.**

8.3.2. *To Unload a Specimen:*

1. **On the Main page, select the Transfer tab.**

2. **Select Argon Pressurized or Under Vacuum.**

3. **Select Unload Sample**

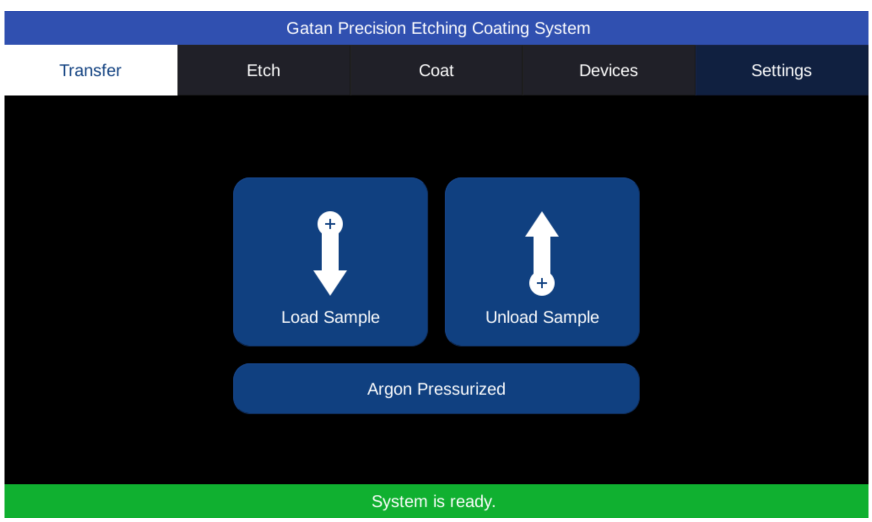


Figure 8-22. Transfer page

4. **Set the Transfer Device onto the load lock of the PECS II.**

Align the tee on the back of the TD with the mating slot on the loading dock. Make sure the O-ring is properly seated in the O-ring groove.

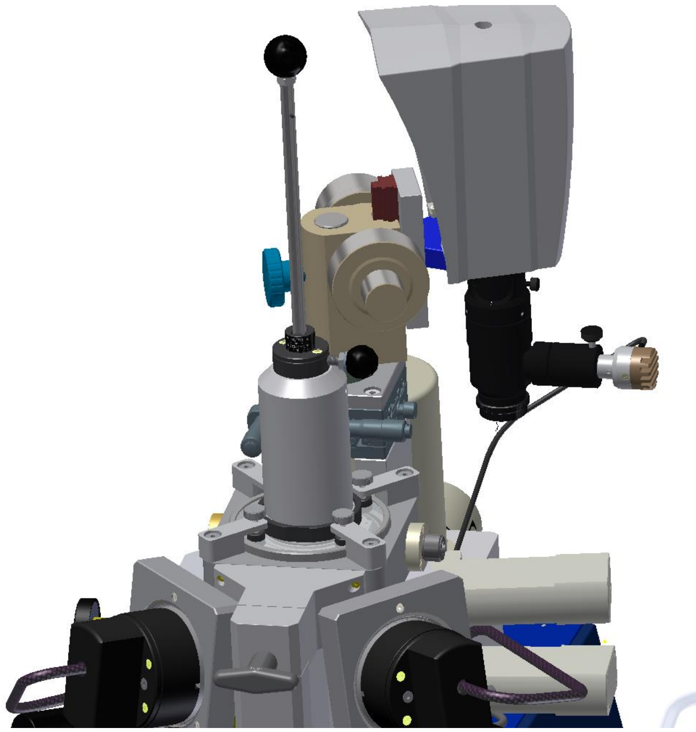
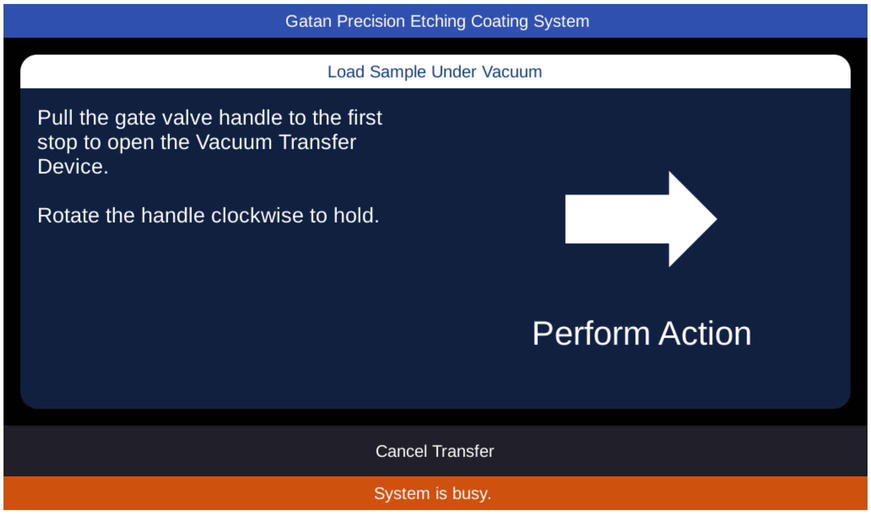


Figure 8-23. Transfer device on load lock

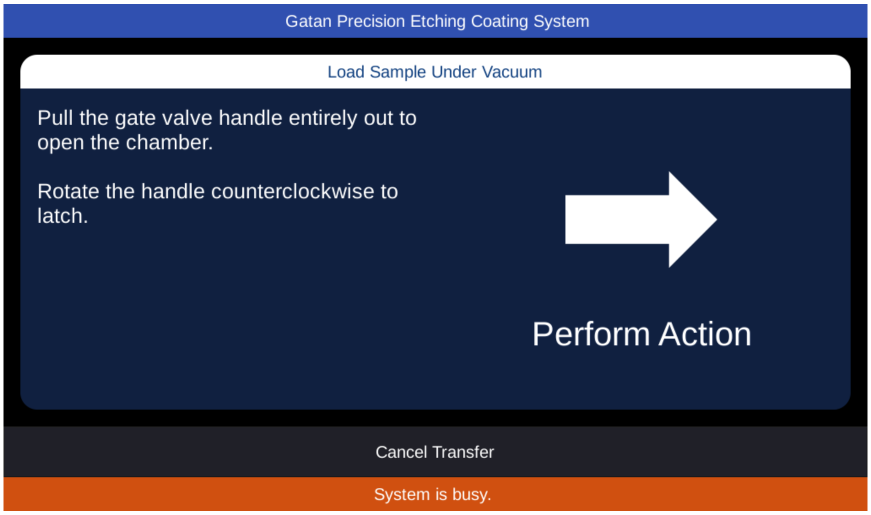
5. If this is an Argon Pressurized transfer, then install the clamps onto the VTD as shown above.

6. Press the Next button.



7. Ensure the Tee handle on the front of the load lock is horizontal. Pull the Tee handle out to the first stop (about 6.5 mm) and turn clockwise until it stops.

A catch will stop the handle from being pulled in by the vacuum. The VTD will be pumped out, then the user will be instructed to open the gate valve the rest of the way.



8. Ensure the Tee handle is horizontal, then pull the Tee handle out fully and turn counter-clockwise until it stops.

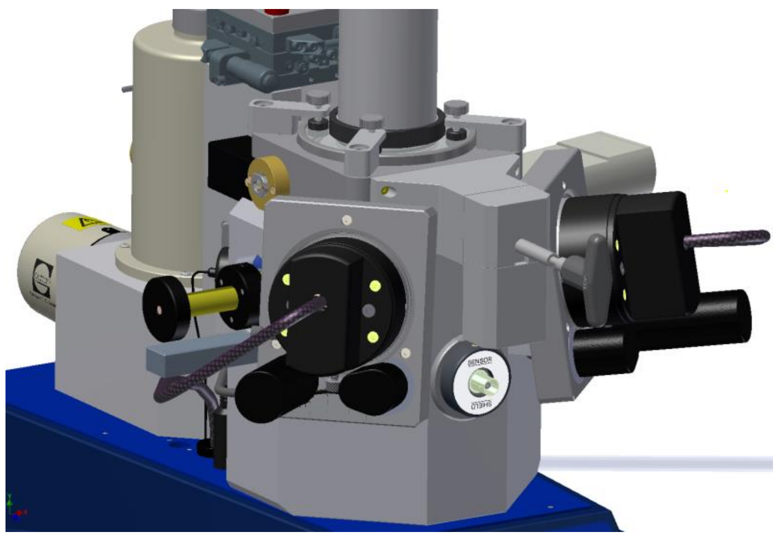
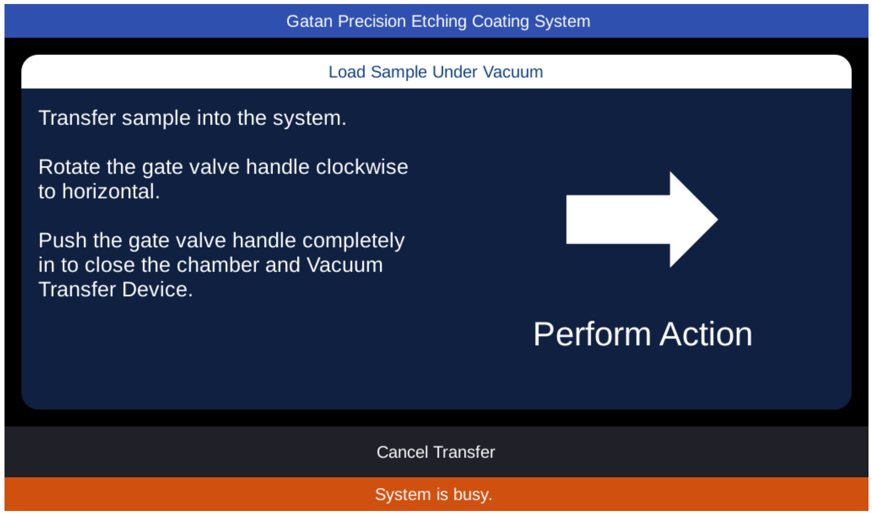


Figure 8-24. Gate valve open and latched

The system will recognize this and notify the user to perform the next step.



9. Lower the transfer arm into the PECS II and release the sample.

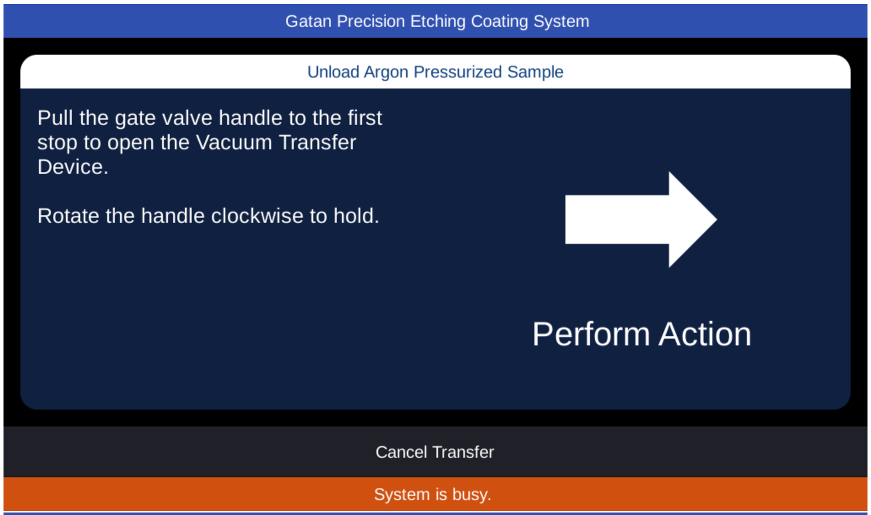
- Loosen the locking knob on the side of the transfer device.
- Place one hand on the transfer device and with the other hand grasp the knob at the end of the transfer shaft and lower the arm.
- Note the pin near the top of the shaft. Rotate the shaft so that this pin enters through the right notch in the top of the housing. Lower the shaft until it stops. It may help to rotate the shaft slightly back and forth when the mechanism contacts the pins on the sample mount to be sure it engages the pins fully.

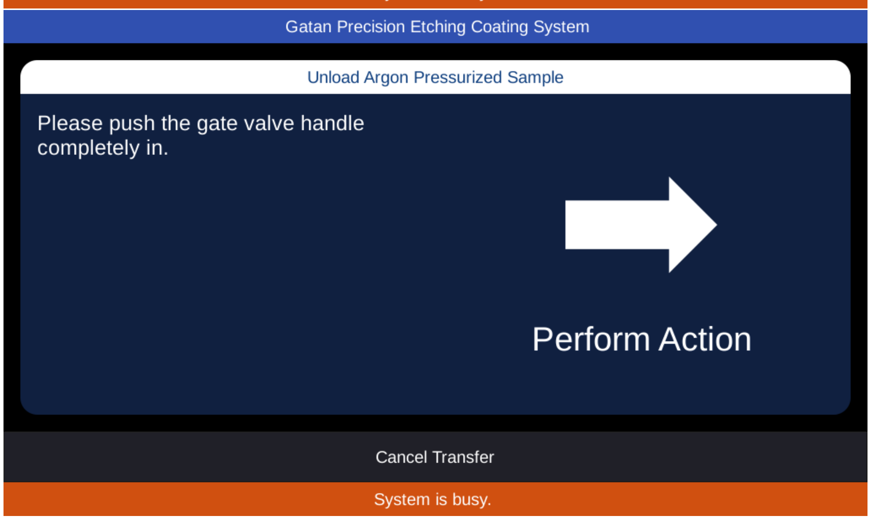
Figure 8-25. Transfer device while unloading

- Rotate the shaft clock-wise until it stops. (about 75 degrees) If it does not rotate, wiggle it back and forth until it drops the rest of the way down.
- Lift the shaft until it stops. The sample mount should be in the transfer device.
- Tighten the locking knob on the side of the transfer device.

10. Turn the Tee handle clockwise and insert back into the chamber.

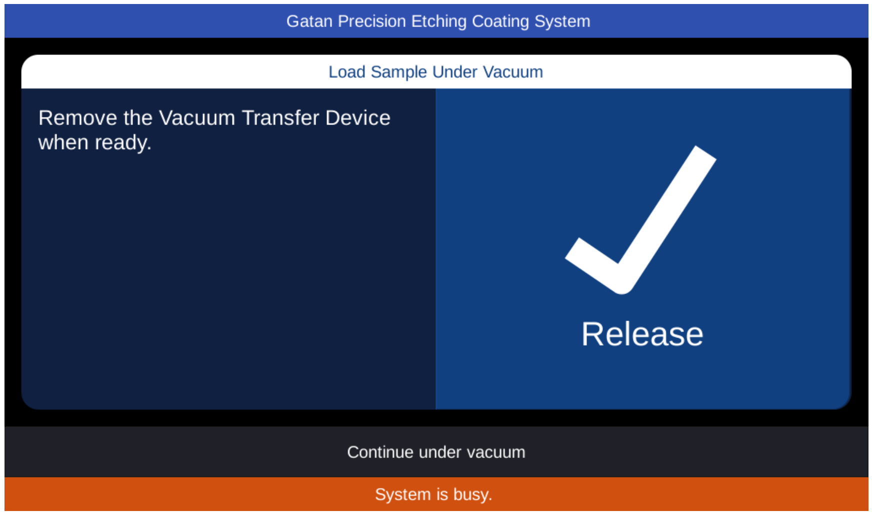
11. If this is an Argon Pressurized transfer, then the user will be instructed to pull the handle out to the first stop and rotate clockwise to hold. Once the VTD is pressurized, the user will be instructed to push the handle all the way in.





12. Press the Continue button to vent the airlock.

If Continue Under Vacuum is pressed instead of the Release button, the load lock will remain under vacuum and the VTD cannot be removed.



13. Remove the Transfer Device from the airlock and store it on the Loading Dock.

8.4. Zoom Microscope Option

Certain PECS II models include a zoom microscope option. This option must be installed at the factory on a new PECS II.

The PECS II zoom microscope option consists of the following components:

- XY stage mount holds the microscope assembly and allows the microscope to be positioned in X and Y.
- Microscope assembly with 6x optical zoom.
- Digital camera, with USB cable to the imaging PC and trigger cable to the PECS II.
- Imaging PC. This PC has an Ethernet cable connected to the PECS II, and a USB cable connected to the camera.
- DigitalMicrograph™ software installed on the imaging PC which controls the camera and certain functions in PECS II.

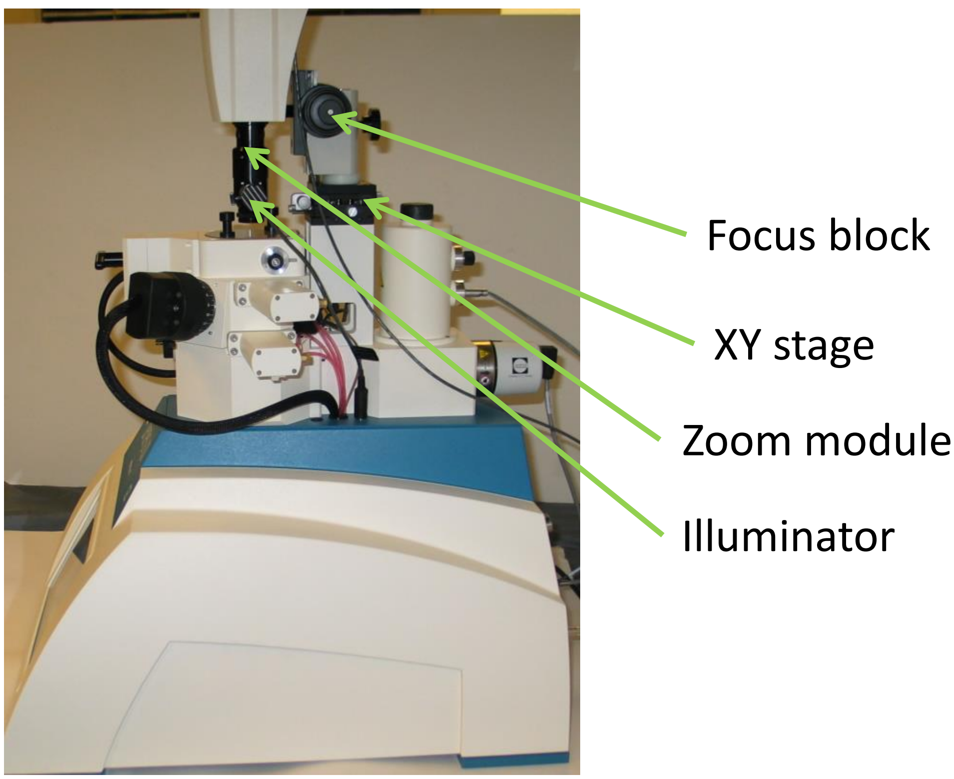


Figure 8-26 System with digital zoom microscope.

8.4.1. *Camera Software Operation (DigitalMicrograph™)*

DigitalMicrograph™ is an application used for acquiring, visualizing, analyzing, and processing digital image data. DigitalMicrograph supports all of the top industry standards for storing files. You can open and store TIFF, GIF, PICT, BMP, and other formats using DigitalMicrograph.

8.4.2. *Basic Concepts*

DigitalMicrograph presents all of its information through the use of windows. Each window contains a set of related information.

Image document windows contain a visible representation of a page of paper. Images can be placed on this page. Other objects such as lines, boxes, and text can also be placed on this page. You can open, save, and print image document windows.

Many aspects of images and objects placed on pages can be controlled through the use of palettes. Palettes "float" above image document and text document windows. You cannot open, save, or print palettes. Palettes can be recognized by their small title bar.

Text document windows contain text. Text document windows do not hold any other graphical objects. You can open, save, and print text document windows.

DigitalMicrograph can be extended to support acquisition devices through the use of plug-ins. Plug-ins are placed in a folder named "PlugIns".

DigitalMicrograph can also run simple programs (called scripts) which carry out automated tasks.

8.4.3. *The DigitalMicrograph Environment*

Before you can use DigitalMicrograph, you must install it on your computer according to the instructions contained in the Installing DigitalMicrograph manual.

To start DigitalMicrograph

You launch DigitalMicrograph as you would any other application; select DigitalMicrograph from the Start menu, or double click the DigitalMicrograph icon on the desktop.

By choosing commands from the menu bar, you can now create a new image window, open an existing one, or acquire one from an acquisition device.

When opening DigitalMicrograph (DM) you will see the following window

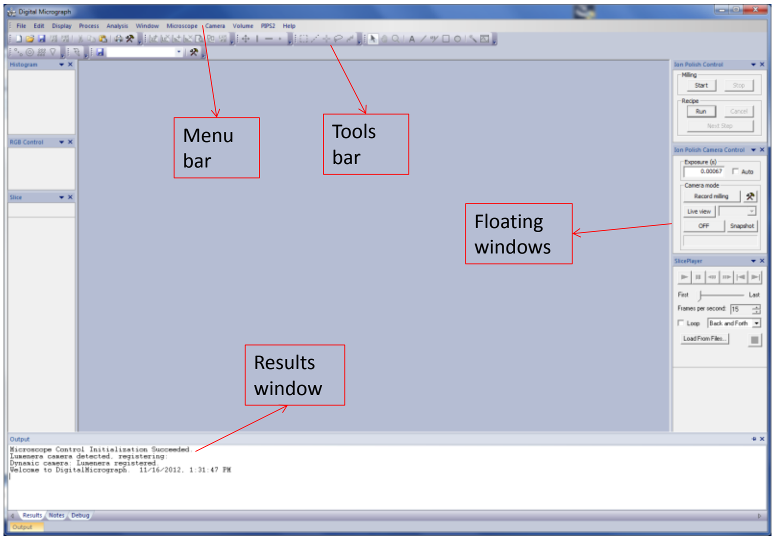


Figure 8-27 DM environment.

This screenshot shows DigitalMicrograph with only its basic plug-ins displayed.

Key areas

Menu bar

At the top is the menu bar containing the File, Edit, Display, Process, Analysis, Window, Microscope and Help menus. In these menus are all the controls for operating the application.

Tool bar

Under the menu bar is a toolbar.

Floating Windows

On the left hand side several Floating Windows are displayed. Floating Windows can also appear on the right hand side of the screen.

Result Window

At the bottom is the Results Window. This window is used to report results and updates of operations performed by DigitalMicrograph. This window may be hidden to increase the area available for image windows.

Image Windows

All images are displayed in Image Windows. They can be displayed anywhere in the application, and many images can be open at the same time.

To Exit DigitalMicrograph

You can exit DigitalMicrograph when you're finished with it. Choose Exit from the File menu, or hold down the Alt key and touch F4 to exit.

If any modified documents are open and haven't been saved, DigitalMicrograph asks whether you want to save the documents.

You can exit without saving any of the files by holding down Control and Alt keys and touch F4 to exit.

Opening an Image

You can either open a single frame image or a series of images (3-dimensional image or a stack).

Single image file: Go to File: Open… and brows to the location the file is saved, then select the file and touch open.

Series of images (stack): Go to File: Open Series… and brows to the location the files are saved, then select the first file in the series, and touch open. The dialog box shown below will appear. Here you can define the number of slices you want to open (Output images, Size). This option is very useful for viewing all the images taken during a Record Milling session. The images may be conveniently viewed in series with the slice player.

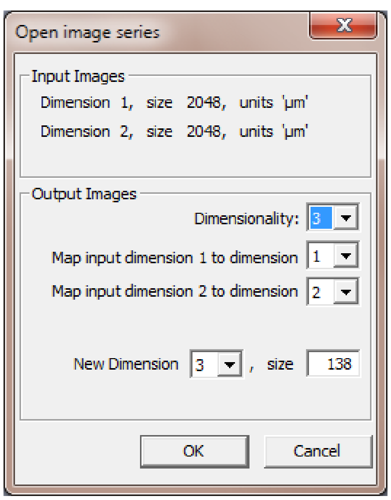


Figure 8-28 DM open image series.

Using Image Windows

DigitalMicrograph provides several ways to customize an image window. Among other things, you can magnify your view of the document, change the page size, and move the image and page around within the window.

To resize the window

Resize the window as you would resize any window on your operating system. To resize manually, click and drag an edge of the window.

If the image document is currently in image mode, its image will change from one integer multiple of its true size to another as you drag the window border. If you hold down the Alt key as you drag the window border then the image will resize to the largest size that fits in the window. If you hold down the Control key as you drag the window border then the image will not resize.

If the image document is currently being viewed in page mode, the page will always be sized to fit as large as possible within the window.

To resize around either the image or the page, click in the maximize box.

Re-sizing around an image or page will size the window so that the image or page fits exactly within the window at its current resolution.

To change printed page size or orientation

You can change the size or orientation of the page. Select Page Setup from the File menu. Enter the desired size and orientation in the dialog that is presented.

To change the magnification of the image document

You can change the size at which DigitalMicrograph displays the image or the page within the window. Click in the image window with the Zoom tool from the Standard Tools. The Zoom tool will display a "+" inside the magnifying glass to indicate you will be magnifying around the point at which you click. Hold down the Alt key to demagnify. The Magnify Page tool will display a "-" inside the magnifying glass to indicate you will be demagnifying.

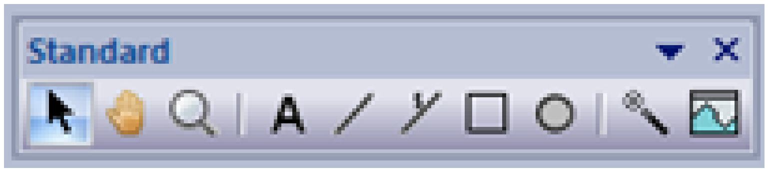


Figure 8-29 DM standard tools.

You can also use the mouse wheel to zoom in and out around the location of the image where the mouse is located.

To move the image around within the window (page mode only)

You can move the image within the window. Click and drag the image within the image document with the Pointer tool.

To move the page around within the window

You can move the page within the window. Click and drag the page within the image document with the Move Page tool

Saving an Image Document

As you work, save early and often; don't wait until you finish working or until "later." This will prevent you from losing images due to power failures and other unexpected circumstances.

The File menu contains 4 items related to saving images: Save, Save As..., Save Numbered, and Save Display As... With the Save and the Save As items you can save the image data; with the Save Display As item you can save the screen rendering of your image document, and with Save Numbered you can do either depending on the preferences you have supplied. The same functions can also be accessed from the FileTools toolbar.

Figure 8-30 DM main menu.

The different image formats supported in DigitalMicrograph have different capabilities. This means that at some times you may be presented with more format choices than at other times. And sometimes the system has to ask for clarification on how to deal with limitations of a particular format.

The Gatan file format is the only format that can save all information properly at all times, and is the only choice when you are saving an image document that is displayed in page mode.

To save an image document in the Gatan file format

Choose Save from the File menu to save current image or click the Save button in the File Tools.

If this is the first time you've saved the file, DigitalMicrograph displays the Save As dialog box. Type in name for the file, choose the desired directory, choose "Gatan Format (*.dm4)", and click Save.

If the image document has already been saved once or was loaded from a file, DigitalMicrograph saves it to the same file, overwriting the previous version.

Choose Save As from the File menu to save to a new file. DigitalMicrograph displays the Save As dialog box. Type a name for the file, choose the desired directory, and click Save.

To save an image in TIFF format

If your image is not displayed in page mode you can save your image in other formats than Gatan Format. The most important of those formats is TIFF. However TIFF has certain limitations, and other applications implement different levels of TIFF format. For example Adobe PhotoShop does not cope well with negative values stored in images stored as signed 2-byte integer format - it assumes that they are large and positive. This is the format generated by Gatan's MSC cameras. When trying to save an MSC image with scale marker to TIFF the following will happen:

- Choose Save from the File menu to save current image or click the Save button in the File Tools.
- Choose TIFF from the "Save as type" drop list. At this time a warning dialog will appear. This dialog appears because your image contains an annotation (the scale marker) and TIFF cannot handle annotations as separate objects. So you are given a choice to burn the annotation into the image data, or to ignore the annotation. Touch the OK button.
- Now DigitalMicrograph gives you a choice to convert to 16 bit unsigned so that you can more readily interpret the data in Adobe PhotoShop. Converting to 16 bit unsigned is done by adding 32768 to all image values. Touch the OK button.

The image will now be saved using the preferences you supplied. Note that you can lock in your choices on the warning dialogs by checking the appropriate check boxes, so that you do not have to go through this whole procedure each time.

To maintain compatibility with the largest number of other applications use the Save Display As function in DigitalMicrograph.

If you have problems with other applications, note that you can always load the TIFF image back into DigitalMicrograph and you will get all image data and meta data back. Then try to save in some other format to make the data appear properly in the other application

To save an image in TIFF format using Save Display As...

- Select the image you want to save and select Save Display As... from the file menu or click the Save Display button in the File Tools. The standard Save As dialog will be displayed and you can now choose from another list of file formats, including GIF and JPEG. In this example choose TIFF and pick a name and location for the image.
- Touch the Save button.
- Here you choose whether to save the image in the size displayed on the screen, or in its full resolution. And you can choose to include the annotations. Once again you can lock in on your choices so that you do not have to see this dialog each time you save an image.
- Touch the OK button.

The image will now be saved.

When you open this image in Adobe PhotoShop, you will see exactly the same thing as in DigitalMicrograph.

To save a series of images

DigitalMicrograph can save image documents in a series of files so that each time you save, the image document gets a new filename. Choose Save Numbered from the File menu or click the Save Numbered button in the File Tools.

You can set the directory in which to save the image documents, the name of the series, and the number in the series that you want to begin with. For example, the first time you do this the image document will be saved with the name "Image Series.1." The next time you do it, the image will be saved with the name "Image Series.2."

Batch Convert

Using the Batch Convert... menu item images saved in Gatan Format can be converted to different data formats. This procedure will always save the data or display at the resolution of the source data, and it will include the annotations in the result. If the Gatan file contained an image document with more than one image, only one of the images is exported and a message to this effect is printed to the results window.

This feature can be useful for saving disk space by converting images to jpg.

- Choose Batch Convert from the File menu.
- A dialog with appear where you can enter the folder name by either typing it or using the Browse... button. If you want to convert all files

in sub-folders of the selected folder as well, then check the Convert sub-folders button.

- Next choose to either save the image data in "Data Only" or MRC format, or save the image display in BMP, JPEG or TIFF format. MRC format does not support all data formats and if an image is encountered that cannot be converted to MRC a message will be printed to the results window.
- Touch the OK button. The procedure will now start converting all files in the selected folder and the following progress window is shown.
- Touch the Cancel button to abort the procedure.

Closing Image Documents

When you're finished using an image document, you can close it to remove the image from your computer's memory. When you're finished using DigitalMicrograph, you can exit it to end the current session. When you close image documents or exit DigitalMicrograph, you will be asked if you want to save any of the changes.

To close an image document

You can close image documents when you're finished with them to save on memory.

Choose Close from the File menu or click in the Close box.

Hold down the Alt key while closing the window to tell DigitalMicrograph not to present the dialog asking whether to save the file or not.

Hold down the Shift and Alt keys to close all windows and avoid being prompted to save each one.

Using Floating Windows

Floating windows are used to display information about and directly manipulate images and other objects within image documents.

You can arrange floating windows in a configuration that most suits your requirements. You can group sets of the floating windows together and you can "roll-up" a particular floating window in order to reduce the space it takes on the screen.

Some of the older DigitalMicrograph acquisition plug-ins will present a floating window that cannot be grouped with other floating windows.

DigitalMicrograph will remember the positions and groupings of all of your floating windows from session to session. If you exit DigitalMicrograph and launch it again later, the floating windows and groups will return to the same configuration.

To open a new floating window

DigitalMicrograph lists all of the floating windows in the Floating Windows menu. Select the desired floating window from the Floating Windows submenu under the Window menu.

DigitalMicrograph will add the new floating window to the group at the top-left of the main screen. If no group exists there, DigitalMicrograph will create a new group.

To move floating windows

Floating windows can be moved in the following ways:

Move an entire group of floating windows. Grab the group title bar and drag it to a new location.

Move a floating window above another within a group. Grab the title bar of a floating window and drag and drop it on the title bar of another to place it above the existing window.

Move a floating window below another within a group. Grab the title bar of a floating window and drag and drop it on the contents of another to place it below the existing window.

Move a floating window to another group. Grab the title bar of a floating window and drag it to the new group.

Move a floating window to a new group. Grab the title bar of a floating window and drop it somewhere where there is no other floating window.

To roll up or roll down a floating window

DigitalMicrograph allows you to roll up and roll down floating windows to save screen space and get unused controls out of your way. Click on the Twist Down control to roll up or roll down a floating window.

To close a floating window

You can close floating palettes completely.

Close an entire group of floating windows by clicking in the Close box of the group palette.

Close a specific floating window by dragging the floating window to a new group and close the new group.

Floating Windows Layout Manager

In many cases there are too many floating windows that you want to display simultaneously, and you are forced to open and close the relevant ones. To alleviate this problem there is a "Floating Windows Layout Manager". With this feature, you can easily save and retrieve different configurations of Floating Windows.

For example you can set up a layout called "Acquisition" that includes all panels you need during acquisition, and a layout called "Analysis" that includes post-processing and analysis related panels. All this functionality is located in the Windows menu under the "Layout Manager" sub-menu.

The "Save Layout As…" item allows you to save your current layout and give it a name.

When choosing "Manage Layouts…" a dialog is displayed that allows you to rename and delete existing layouts.

The items under the separator are the actual layouts you have saved. Choosing one of those items forces all floating windows to be redrawn as defined by that layout.

Image Displays

In order to display an image using Raster or Surface Plot display types, DigitalMicrograph must first map the image's data to the values 0 through 255. To display in gray-scale, the values 0 to 255 are then associated with different gray-scale values, e.g. 0 corresponds to black and 255 corresponds to white. To display in color, each value from 0 to 255 is associated with a color. In the rest of this section, gray-scale values are considered to be just a specific case of a color transformation. The section below describes these transformations.

DigitalMicrograph maps an image's original data values to a color or gray-scale value through a sequence of steps.

1. Determine the contrast limits of the image's data

DigitalMicrograph uses two parameters, the low- and high-contrast limits, to map the image's original data into a range suitable for display of the image. Pixels in the original image below the low-contrast limit are treated as if they were at the low-contrast limit and those above the high-contrast limit are treated as it they were at the high-contrast limit.

DigitalMicrograph can determine these contrast limits "automatically" by surveying the image, or "manually" using values entered by the user.

2. Transform each mapped data value into a color index.

The mapped image values are then transformed into a color index that indicates which color in the color table to use for displaying a particular pixel. The Contrast Transform lines in the Histogram depict how this transformation is performed. DigitalMicrograph supplies a number of standard contrast transform methods and allows you to build a custom one if you desire.

3. Display the pixel using the color table of the image.

DigitalMicrograph uses the color index to correlate each color in the color table with pixels with specific intensities in the image. DigitalMicrograph supplies a number of standard color tables, such as the gray-scale table, for use in images and allows you to build a custom one if you desire.

Histograms

DigitalMicrograph will automatically calculate the histogram of an image displayed using Raster or Surface Plot display types, and display it in the Histogram palette. The Histogram palette also displays the Contrast Transform lines and the color table in the Color Bar on the left of the palette.

The horizontal axis of the histogram represents data values with the left-most side corresponding to the low contrast limit and the right-most side corresponding to the high contrast limit. The vertical axis of the histogram represents the number of pixels with a particular data value.

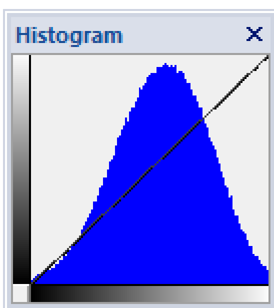


Figure 8-31 DM Histogram Window.

Using Image Regions of Interest

Many times, in order to process or analyze an image, you will need to select a region of interest (ROI) on an image. The region of interest indicates the part of the image you are interested in processing or analyzing.

Figure 8-32 DM ROI menu.

Methods of selecting regions of interest are specific to the type of image display the image is displayed as. The ROI Tools provides a set of tools for indicating regions of interest.

Rectangular ROI

You can make a rectangular region of interest on an image displayed with the Raster or RGB image display type. Use the Rectangle ROI tool to make a region of interest.

Making a region of interest will erase all previous regions of interest. To extend an existing set of regions of interest, hold down the Shift key while making the new region of interest.

Hold down the Shift key while making a rectangular region of interest to restrict it to be a square.

Hold down the Alt key while making a rectangular region of interest to restrict it to be a rectangle with a side that is a power of two (useful when performing FFTs).

The region of interest will appear as a red-dashed rectangle.

Line of interest

You can make a line of interest on an image displayed with the Raster or RGB image display type using the Line ROI tool to make a line of interest.

Making a line of interest will erase all previous regions of interests. To extend an existing set of regions of interest, hold down the Shift key while making the new region of interest.

Hold down the Shift key while drawing a line of interest to restrict it to 45° or 90°.

The region of interest will appear as a red-dashed line.

To specify a point of interest on an image with a Raster or RGB display

Point of interest

You can specify a point of interest on an image displayed with the Raster or RGB image display type using the Point ROI tool to make a point of interest.

Making a point of interest will erase all previous regions of interest. To extend an existing set of regions of interest, hold down the Shift key while making the new region of interest.

The region of interest will appear as a red cross-hair.

To specify a closed-loop region of interest on image with a Raster or RGB display

Closed-loop ROI

You can specify a closed-loop region of interest on an image displayed with the Raster or RGB image display type using the Closed-Loop tool to make a closed-loop region of interest.

Making a closed-loop region of interest will erase all previous regions of interest. To extend an existing set of regions of interest, hold down the Shift key while making the new region of interest.

The region of interest will appear as a red-dashed region.

Open-line ROI

To specify an open-line region of interest on an image with a Raster or RGB display use the Open-Line tool to make an open-line region of interest.

Making an open-line region of interest will erase all previous regions of interest. To extend an existing set of regions of interest, hold down the Shift key while making the new region of interest.

The region of interest will appear as a red-dashed line.

To adjust a region of interest on an image with a Raster or RGB display

Regions of interest are just additional objects attached to images. You can move them around as desired. You can also select, deselect, copy, drag, and delete them.

Rectangular and line regions of interest

Edit rectangle and line regions of interest by dragging their handles.

Hold down the Shift key while changing a rectangular region of interest to restrict it to be a square.

Hold down the Alt key while changing a rectangular region of interest to restrict it to be a rectangle with a side that is a power of two (useful when performing FFTs).

Hold down the Shift key while changing a line of interest to restrict it to 45° or 90°.

Using Line Profiles

You can use a line profile to sample an image along a line and display the sampled data in a line plot. The line plot will represent the data in the source image even if the source data changes or the line-profile position changes in the source image.

You can only create line profiles on images with a Raster display.

Use the Line Profile tool to create a line profile. A new Line Plot window will be created that represents data sampled from the source image beneath the line profile.

Adjusting the endpoints of a line profile

Adjust the endpoints by dragging the handles on the line profile or by double-clicking on the line profile, The Change Profile Info dialog will appear. Enter the desired coordinates in this dialog. The coordinates should be specified in uncalibrated units (i.e. pixels).

Adjusting the integration width of a line profile

You can adjust the integration width of a line profile by two methods: by selecting the line profile and pressing the '+' and '-' keys or by double-clicking on the line profile. The Change Profile Info dialog will appear. Enter the desired integration width in this dialog. The line profile will change to reflect the integration width.

Using the Slice Tool

Some applications, require the use of a three-dimensional image, rather than the standard two-dimensional image. DigitalMicrograph gives you a control to choose which layer (slice) of the three-dimensional dataset to display as the image.

- Select Floating Windows:Slice under the Window menu. This will open the Slice floating window.
- Select the three-dimensional image for which you want to change the slice. The Slice window will be disabled if the data is not three dimensional.
- Drag the top slider to adjust the slices displayed.
- Drag the bottom slider to adjust the number of slices to be integrated and displayed simultaneously.
- Check the Display Center check box to show all coordinates with respect to the center.
-

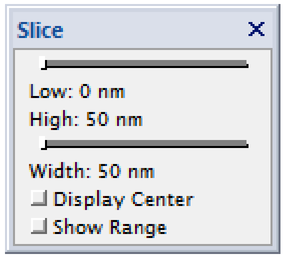


Figure 8-33 DM Slice tool.

Using the Slice Player

Use the slice player to automatically go through (first to last or back and forth) a 3-dimensional image (a stack) or a set of images saved by the Record Milling mode. To view images saved by Record Milling, they must first be opened using the Open Series option.

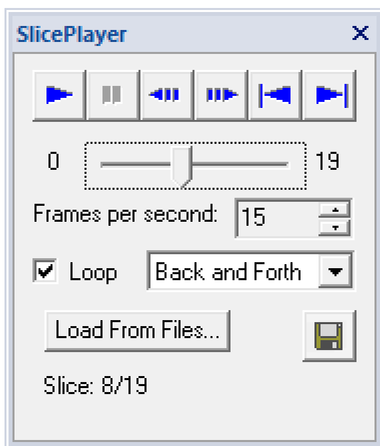


Figure 8-34 DM Slice player.

It is also possible to save a .avi file, by depressing the Disk button on this window. Brows to the location you like to save this file and touch Save, a dialog box will show up as shown below. Select Full frame (uncompressed) and touch ok.

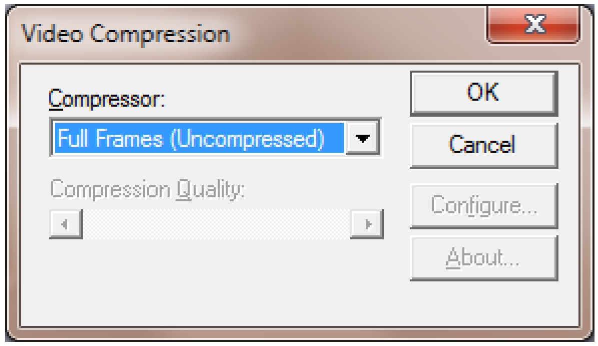


Figure 8-35 DM video compression.

PECS II Milling Control

Milling can be started/paused/stopped at any time using this option on DM. This is specifically useful in cases where the PECS computer is remotely accessed and the user is watching the milling process from outside the lab.

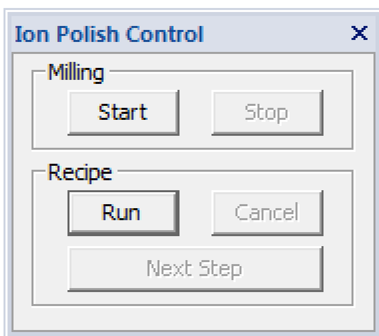


Figure 8-36 DM Ion Polish Control window.

To stop milling, select Stop. This is equivalent to selecting Stop on the PECS II Milling page.

To start milling, select Start. This is equivalent to selecting Start on the PECS II Milling page.

PECS II Camera Control

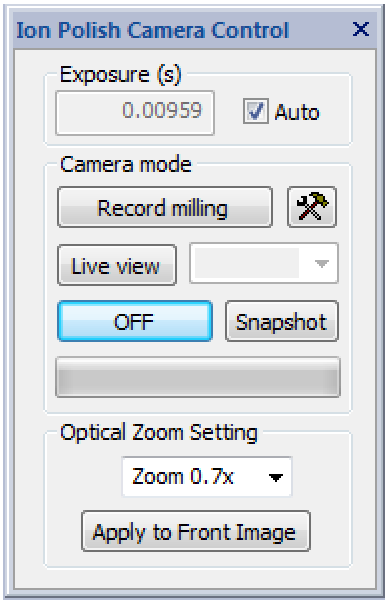


Figure 8-37 DM Ion Polish Camera Control window.

Exposure

Exposure time can be changed in two ways, either type in the exposure time in seconds and touch return or click in the exposure box and change the time by clicking on up and down arrow keys on the keyboard.

Alternatively, the Auto Exposure box may be checked and DM will determine the exposure level automatically. Auto-exposure may also be activated by pressing the Auto-Exposure button on the Camera page of PECS II.

NOTE: Auto exposure mode will cause the live view to be somewhat less smooth. It is recommended to turn off Auto exposure once the exposure level has been found.

Camera mode

This part of the window is used to view the sample in live mode, take a snapshot or record images as the sample is being milled.

Record milling

Use this option for capturing a series of images during the milling process. When selected and the system starts polishing, the software automatically acquires images once every rotation. These images will be retained either in memory or on disk for examination or further processing. The shutter will be opened and the illuminators turned on just prior to image capture.

Gatan recommends using this mode during milling, and using Live View for setting exposure levels.

The frequency at which you want these images to be saved can be set using the toolbox menu. Clicking the toolbox brings up the PECS Record Options window:

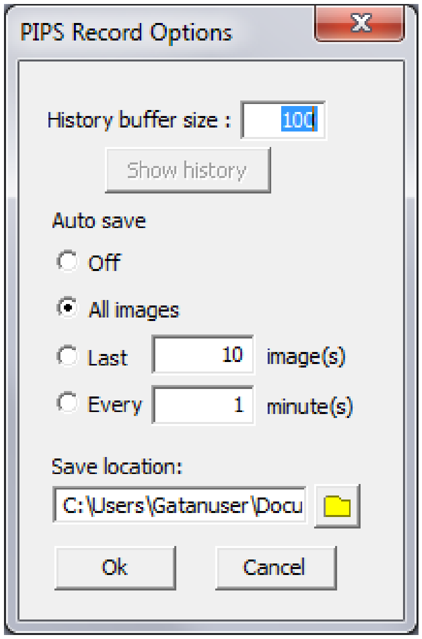


Figure 8-38 DM PECS II record options window.

History buffer size: Defines the size of the stack that is displayed. This is limited by the amount of available memory on the computer. It is recommended that this be set to 19 or less images. Note that if the memory used by images is larger than the available memory, DM will stop acquiring images.

Auto save: Is used for saving the images that are acquired by the camera on the disk. The user has the option to i. turn the auto save **Off**, ii. to save **All images**, iii. to save the **Last X-images**, or iv. to save the images **Every X-minutes**.

Save location: Use this option to define where the images are saved. Files will automatically be named with a sample number and an image number embedded in the file name. If the stage is raised into the airlock, then a new sample number will be used the next time that the Record Milling mode is used. If milling is interrupted by using the Pause or Stop selection on the Milling page of the PECS II, then the sample number remains the same when milling is restarted.

NOTE: The exposure time can be adjusted before the milling process is started and/or anytime during the process. In record milling mode it can take up to a full stage rotation before a change is observed, therefore, it may be preferable to switch to Live View, change the exposure time, then switch back to Record Milling mode.

NOTE: Recording can be stopped at any time by selecting Off.

Live View

This is used to watch the milling process live. The shutter is opened and the illuminators are turned on when this mode is selected. Viewing can be stopped at any time by selecting Off. Live View images are always acquired at VGA size (640x480).

Exposure time: can be changed in two ways, either type in the exposure time in seconds and touch return or click in the exposure box and change the time by clicking on up and down arrow keys on the keyboard.

Zoom: three zoom levels are available in the preview mode:

- Zoom 1x: shows the full camera frame, binned by 4
- Zoom 2x: shows the ½ center camera frame, binned by 2
- Zoom 3x: shows the ¼ center camera frame, binned by 1

In addition to the digital zoom accessible in DM, a manual optical zoom is available on the microscope body.

Snap Shot

This is used to acquire a single full-frame image. Set the exposure time and touch Snapshot.

NOTE: Images in Record and Snap Shot mode will always be in Full frame mode, binned by 1.

NOTE: As shown in figure below, these options are also available on the PECS Etch and Coat Camera Page.

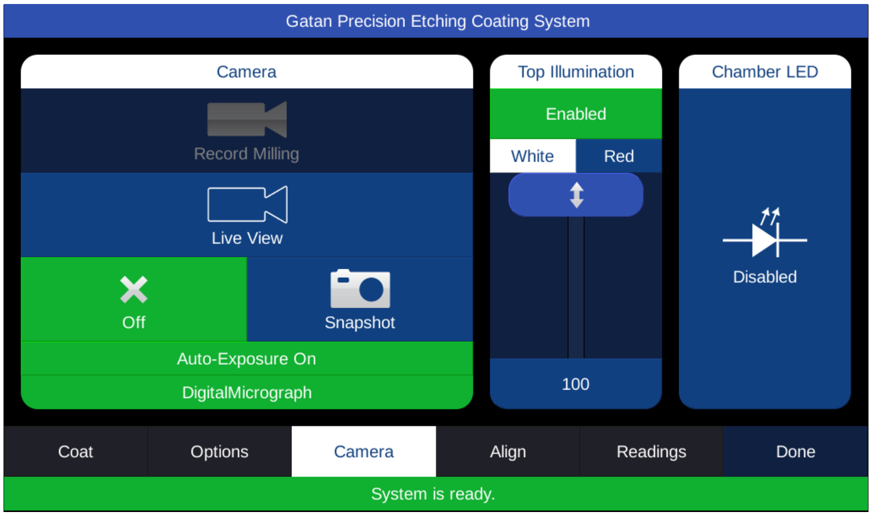


Figure 8-39 Camera page

Optical Zoom Setting

The manual zoom setting on the microscope is not connected to DM, therefore, DM is not updated when the zoom is changed. You must set DM to match the manual optical zoom seting if you want the calibration of the image to be correct.

The manual optical zoom may be set to any value between 0.7 and 4.7, however, DM only has calibrations for the following settings: 0.7, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, and 4.7. Gatan recommends that you use one of these settings when adjusting the manual zoom so that the calibration can be matched.

To set the Optical Zoom Setting:

1. **Click the arrow on the right hand side of the optical zoom setting selection button. A list of available settings will be displayed.**

2. **Drag the mouse to the setting which matches the manual setting on the microscope.**

3. **If you would like this setting to apply to an image that is already displayed (and the active image), click Apply to Front Image. If you do not select this, then the setting will apply to the next image acquired, or the next time Live View is selected.**

Figure 8-40. Manual optical zoom setting of microscope and DM

8.5. Motorized Gun Tilt

Certain PECS II models include motorized guns. In these models, the gun tilt angles are set by the GUI or by a recipe. This option must be installed at the factory on a new PECS II.

Figure 8-41 PECS II with motorized gun tilt

8.5.1. *Operation*

The gun angles may be set on the Milling page at any time by selecting the left and right tilt angle selections just above the gun current readout. The gun tilt angles may be varied between 0 and 18 degrees. Press the gun tilt button then enter the desired angle.

Gun tilt settings are grayed out on the Coat page because the tilt is automatically set to 0 degrees and cannot be changed.

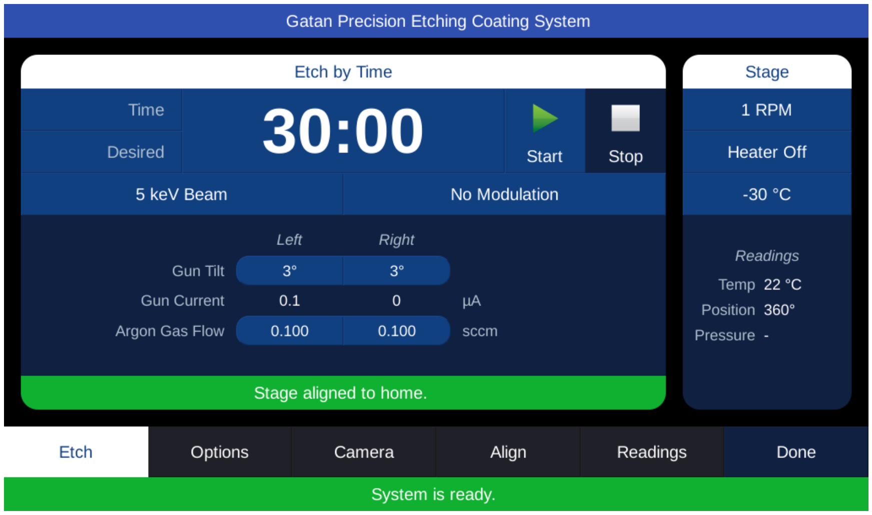


Figure 8-42 Gun tilt settings on the Etch page

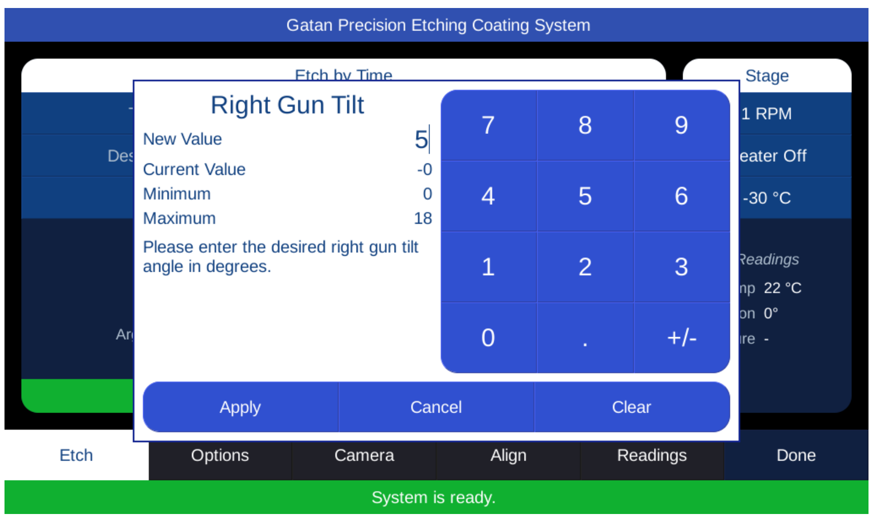


Figure 8-43. Setting gun tilt

8.5.2. *Maintenance*

Each motorized gun assembly includes the following: large gear connected to the gun knob by 3 pins, motor connected to a small gear, potentiometer connected to a small gear, cable assembly. The motorized gun assemblies may be replaced if they fail. The left and right motorized gun assemblies are different, and must be replaced with the proper assembly.

Replacing the Motorized Gun Assemblies

1. **Shut down power to the PECS II.** Unplug the power cable from the back of the system.

2. **Unplug the motorized gun assembly cable from the PECS II.** This is a mini-din connector on the top of the system just behind the chamber.

3. **Remove the gun knob assembly.** Rotate the gun knob to the 18° position. Use a 3.0mm hex wrench to release the two screws from the gun knob and pull the knob from the gun housing.

4. **Remove the 3 screws from the front of the motorized gun assembly.**

5. **Carefully remove the motorized gun assembly from the chamber.** The motorized gun assembly should clear the gun housing assembly without need to vent the chamber and remove the gun housings. The backing plate may be removed and replaced, or simply reused. To replace, remove the 2 screws securing the backing plate to the chamber, remove the backing plate.

6. **Install the new motorized gun assembly.**

7. **Plug the cable into the connector on the chamber.**

8. **Turn on power to the system.** First replace the power cable.

9. **Calibrate the motorized gun assembly.**

Calibrating the Motorized Gun Assembly

Motorized gun assemblies are calibrated at the factory and normally do not require re-calibration. In the event that a motorized gun assembly is replaced, it will need to be calibrated.

1. **Touch Settings > Calibration > Guns**

2. **Unplug the cable of the motorized gun assembly to be calibrated.**

3. **Manually rotate the knob to 18 deg.**

4. **Plug the cable back in.**

5. **Write down the dac reading displayed for that gun.** This is displayed as Position on the calibration screen.

6. **Unplug the cable, manually set the gun to 0 deg, plug in the cable.**

7. **Write down the dac reading displayed.**

8. **Enter the dac readings for the appropriate settings.** These must be entered under Low Calibration and High Calibration, where the angle for low calibration is 0 and the angle for high calibration is 18. The angles for low and high calibration are used to set the limits of the gun angles, so these must be set to 0 and 18!

9. **Verify that both guns can be set within the full range of 0 to 18 deg.**

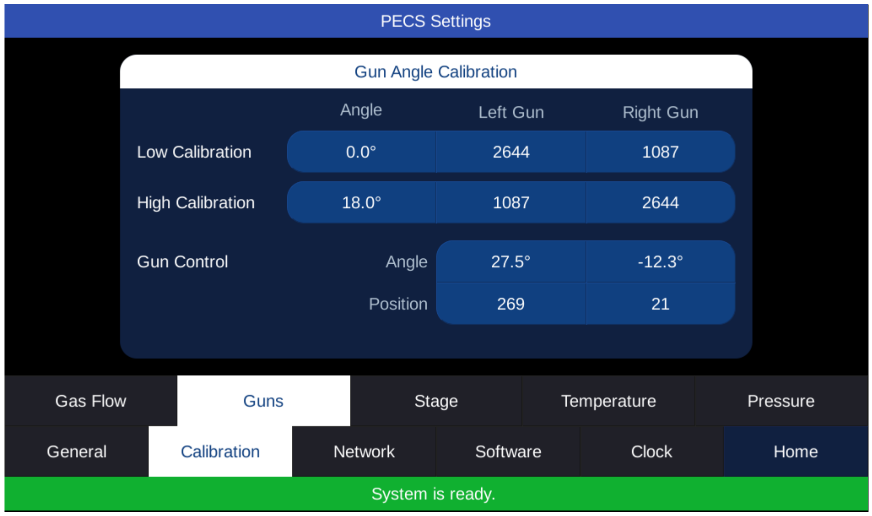


Figure 8-44 Gun angle calibration screen.

1. WARRANTY. Gatan, Inc. (“Gatan”) warrants to the purchaser (“Customer”) that products and components manufactured by Gatan (collectively, “Products”) shall be free of defects in materials and workmanship for one (1) year (“Warranty”) commencing on the date of shipment from Gatan’s factory (“Warranty Period”). Gatan warrants that the Products meet Gatan’s published specifications at the time of shipment from its factory.

2. REPAIR OR REPLACEMENT.

2.1 During the Warranty Period, Gatan will, at its option, either repair or replace defective Products with conforming goods. Gatan will provide the parts (excluding all consumables, wear, and maintenance parts) and labor necessary to effectuate such repair or replacement of the defective Products. For imaging and analytical Products under warranty, travel of up to 100 miles from a Gatan authorized repair center (Pleasanton, CA; Warrendale, PA; Munich, Germany; Corby, UK; and Tokyo, Japan) will be free of charge. Travel expenses for warranty service beyond 100 miles will be charged for. Warranty repair of specimen holder and specimen preparation products will be done on a return to factory basis, with the shipping party responsible for its shipping costs. Gatan’s liability under this Warranty shall be limited to repair or replacement of the defective Products. In no event shall Gatan be liable for the cost of procuring substitute goods.

2.2 Repair or replacement of Products or parts under this Warranty does not extend the original Warranty Period.

2.3 Items not manufactured by Gatan will be warranted by Gatan in accordance with the terms and conditions of the warranty received by Gatan from the original equipment manufacturer (“OEM”). Gatan makes no other warranty whatsoever concerning products or accessories manufactured by an OEM.

3. RETURNED GOODS AUTHORIZATION. The return of any Product, part, or assembly to Gatan for examination or repair shall have Gatan’s prior approval, with the Customer requesting from Gatan a returned goods authorization (“RGA”) approval. This RGA and the associated RGA number may be obtained through Gatan service or directly from Gatan’s Warrendale facility at 724-776-5260 or by Fax at 724-776-3360. (1) If the Product is not under Warranty, to obtain an RGA, the Customer must provide a purchase order (“PO”) agreeing to cover all charges associated with the repair. (2) If the item is under Warranty and the Customer is requesting an expedited exchange, as may be the case for a printed circuit board, a PO will also be required. A credit against this PO will be issued by Gatan upon receipt of the Product returned in accordance with the RGA instructions. The returned item should be shipped prepaid by the Customer with the RGA number clearly marked on the exterior of the shipping container and on the enclosed shipping documents. If the returned Product is under Warranty, the return transportation will be prepaid by Gatan. If the returned item is not under Warranty, return transportation will be charged to the Customer.

4. CUSTOMER RESPONSIBILITIES. The Customer bears the following responsibilities with regard to maintaining the Warranty. The Customer shall:

4.1 Perform the routine maintenance and cleaning procedures at the required intervals as specified in Gatan’s operating manuals.

4.2 Use only Gatan replacement parts.

4.3 Use Gatan or Gatan-approved consumables.

4.4 Provide Gatan’s authorized service representatives with access to the Products during normal Gatan working hours during the Warranty Period to perform service.

4.5 Provide adequate and safe working space around the Products for servicing by Gatan’s authorized service representatives.

4.6 Provide access to, and use of, all information and facilities determined necessary by Gatan to service and/or maintain the Products. (Insofar as the information required for Gatan to service and/or maintain the Product may contain confidential or proprietary information, the Customer shall assume full responsibility for safe-guarding and protecting such information from wrongful use.)

4.7 Failure to comply with any of these Customer responsibilities will automatically void the Warranty provided herein.

5. WARRANTY LIMITATIONS. This Warranty does not cover:

5.1 Parts and accessories which are expendable or consumable in the normal operation of the Product.

5.2 Any loss, damage, and/or malfunction resulting from shipping, storage, accident (fire, flood, or similar catastrophes normally covered by insurance), abuse, alteration, misuse, neglect, breakage, or abuse by Customer or Customer's employees or representatives.

5.3 Operation other than in accordance with correct operational procedures and environmental and electrical specifications.

5.4 Performance to specifications or safety of use (including X-ray emissions) if the Product is physically installed on, used in conjunction with, or used as part of a third party's equipment.

5.5 Performance to specifications or safety of use (including X-ray emissions) due to the design, operation, or fault of the third party's equipment in those special cases where Gatan specifically authorizes in writing the installation and/or use of Products with a third party's equipment.

5.6 Performance to specifications or safety of use (including X-ray emissions) if the Gatan Product is not installed by a Gatan service engineer or Gatan authorized service representative.

5.7 Modification of, or tampering with the Products or components.

5.8 Improper or inadequate care, maintenance, adjustment, or calibration of Products by the Customer or Customer's employees or representatives.

5.9 Contamination or leaks induced by actions of Customer or Customer's employees or representatives.

5.10 Any loss, damage, and/or malfunction resulting from use of software, hardware, or interfaces supplied by Customer or Customer's employees or representatives or consumables other than those specified by Gatan.

6. WARRANTY EXCLUSIONS. In the course of normal use and maintenance, certain parts have finite lifetimes. For this reason, the consumables, wear, and maintenance parts as specified in Gatan's operating manuals carry a ninety (90) day Warranty unless otherwise specified.

7. POST-WARRANTY PERIOD SUPPORT AND PRODUCT OBSOLESCENCE. Upon expiration of the Warranty Period, Gatan will provide service support for Gatan manufactured Products at Gatan's service labor rates and parts pricing in effect at the time of the service support. Gatan will continue to provide billable service support for a period of three (3) years after discontinuance of a Product by Gatan. After this three (3) year period, service support will be offered at the sole discretion of Gatan. Gatan warrants, for a period of ninety (90) days, that the replacement parts or Products used by Gatan during such post-warranty services will be free of defects in materials and workmanship.

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