Ilion^{+} II

Owner's Manual and User's Guide

Part Number: 697.82001

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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.

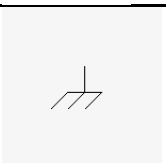
 **CAUTION - Documentation must be consulted in all cases where this symbol is marked.**

IMPORTANT - For Regulatory Compliance and Safety information and instructions please refer to the *Regulatory Pamphlet* 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

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 PIPS. Use paper towels or a Kim wipe 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

Copyright and Trademarks

The product names AutoFilter, BioScan, Clipring, DigiPEELS, DigiScan, DigitalMicrograph, DigitalMontage, Duo Mill, DuoPost, Gatan LowDose, GIF, Hexlok, Hexring, HotHinge, MSC, PECS, PIPS, Toggle Tilt, and Whisperlok are trademarks belonging to Gatan, Inc.

The Ilion^{+} II is protected by US Patent 8,283,642. Other patents are pending.

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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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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 697 Ilion+ II is a self-contained, compact, bench-top system designed to produce high-quality cross section SEM specimens with exceptionally large, clean areas. It can also be used to polish planar samples, by removing material damaged by mechanical polishing or high energy ion milling.

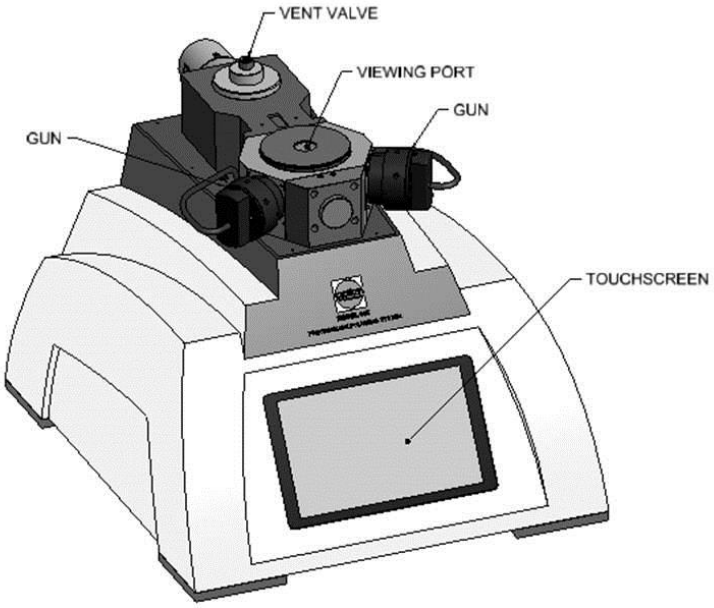


Figure 1-1 Ilion+ II front view.

1.1. Features of the Ilion+ II

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, 0-10°, is independent of one another and both have the ability to accurately 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 milling 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. Motorized operation of beam tilt angle is available as an optional feature.

Normal milling is performed at 0°. Gun operating angles between 0 and 10° allow a surface to be etched following cross section milling. This can be used to enhance surface features or move the cut face slightly deeper into the sample.

1.1.2. *Optimum Gun Design*

The gun's ion optics has virtually eliminated cathode-aperture erosion. 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.

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 Holders*

Samples are affixed to sample blades with adhesive using a loading dock. The blade may then be moved between the Ilion+™, an optical microscope, and an SEM without losing the alignment between the blade edge and the sample. This allows repeated milling of the sample until the desired result is achieved. The standard loading dock allows simple and reliable mounting of samples to blades. When viewed under a customer provided optical microscope, an optional site-specific loading dock allows the blade edge to be aligned with specific microscopic features on a sample.

Optional Planar Holder allows planar polishing of flat samples.

1.1.7. *Stereo Microscope*

An optional optical stereo microscope is used to inspect the specimen in its working position at any time during the milling process to achieve control over the termination point of milling.

1.1.8. *Digital Zoom Microscope System*

Digital Zoom Microscope is a system option. This system uses 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, typically one automated image per rotation. The external PC can also be used for remote control of the Ilion+ II system, via remote desktop type software.

1.1.9. *Whisperlok™ Stage*

Quick specimen exchange (<30 sec) is achieved using a miniaturized version of Gatan's pneumatically controlled Whisperlok™. The specimen can be easily removed from the tool, coated, imaged in an SEM or optical microscope and put back in the Ilion+ II for further milling.

1.2. Main Work Chamber

Figure 1-2 is a top view of the Ilion+ II main Work Chamber. The figure shows the right and left PIGs. The Airlock cover is removed to reveal the main Airlock O-ring and a top view of the specimen mount.

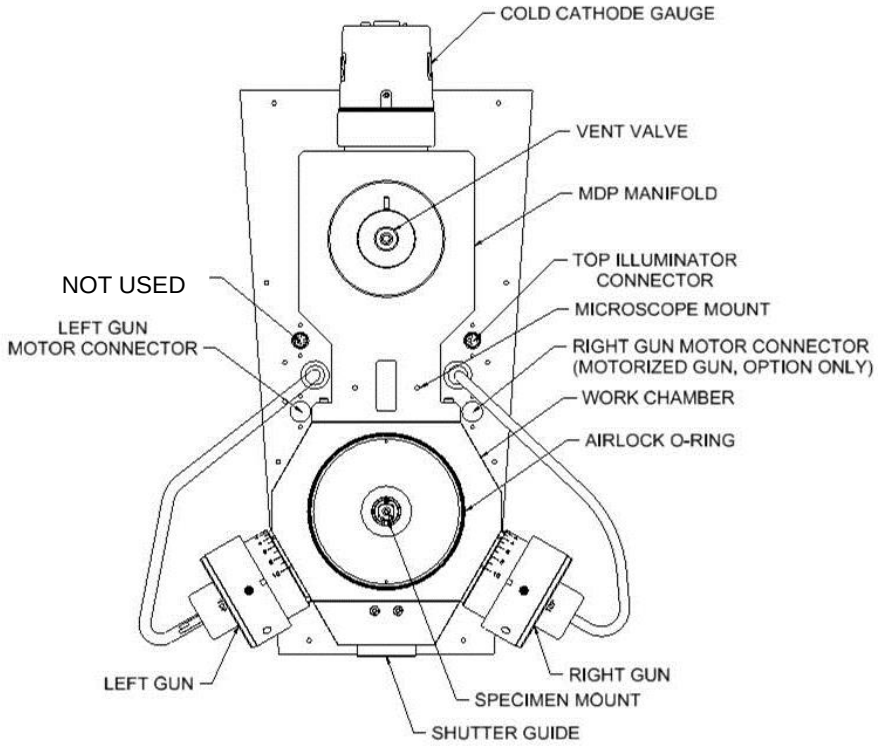


Figure 1-2 Work chamber, top view

Figure 1-3 is a cross-sectional view through the main Work Chamber of the Ilion+ II. The Airlock cover is in place with the specimen in its working position at the center of the Chamber.

Specimens are mounted on blades that insert into the specimen mount. During normal operation, the specimen mount rotates continuously through 360°. Each gun fires once each rotation when the blade faces the gun. The gun fires between -30° and +30° with respect to the blade face. This minimizes curtaining caused by differential sputter rates of sample regions. It is possible to alter the size of the sector from the default 60° if desired.

The Shutter is shown in its inserted position, which prevents sputtered material from depositing on the specimen Viewing Port.

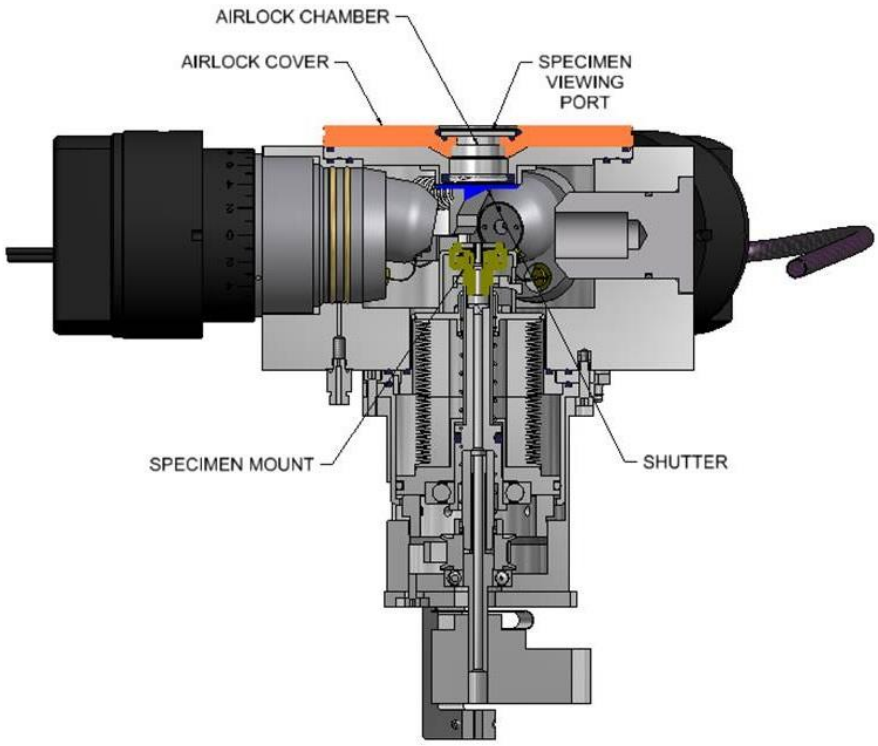


Figure 1-3 work chamber, cross-section view

1.3. Vacuum System

Ilion+ 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.

1.3.1. *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.

1.3.2. *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.

1.3.3. *Airlock Vacuum*

The Airlock vacuum is controlled by three solenoid valves (see Figure 1-4). The VAC valve in conjunction with the LL (loadlock) valve evacuates the Airlock. The Vent valve in conjunction with the LL valve vents the Airlock.

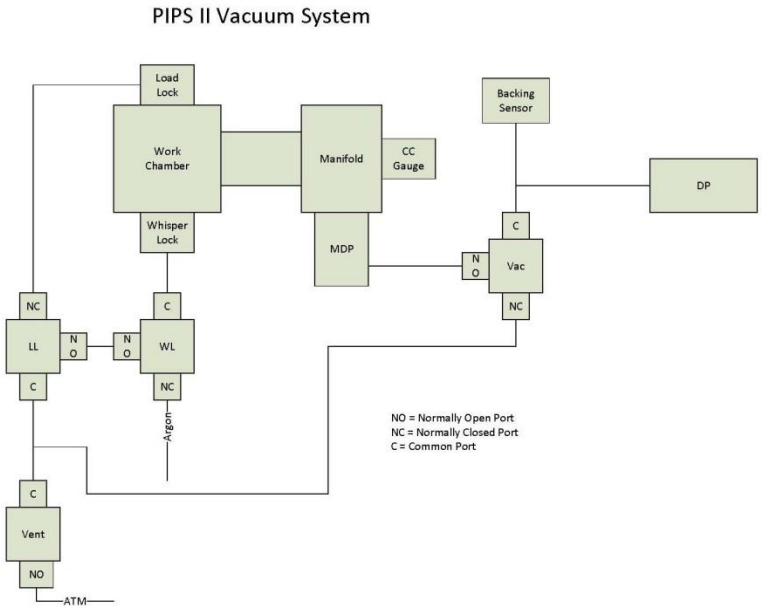


Figure 1-4 Vacuum system

1.3.4. *Gas Manifold*

The gas manifold combines all 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.

Energy Isolation

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

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 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 the 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.

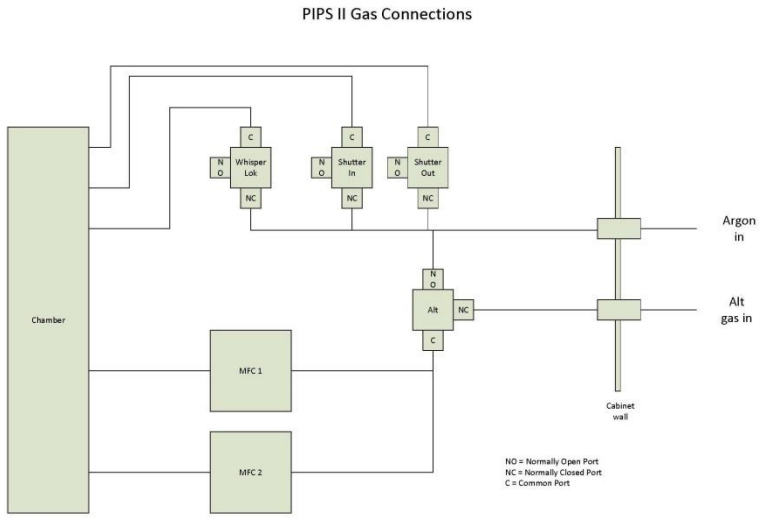


Figure 1-5 Gas-control system

Gas Supply to the Guns

The Ilion+ II 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 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 Airlock. 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 Viewing Port 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 and the Shutter is opened by the action of a coil spring mounted behind the Shutter piston. This means that in the event of a power failure the Shutter will automatically retract and allow the specimen to rise into the Airlock. When power to SO is activated, the shutter piston is pneumatically driven outward, in addition to the action of the spring.

1.4. Electrical system

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

1.4.1. *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.

1.4.2. *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). This supply has an internal fan that is activated when the internal temperature exceeds its set point.

1.4.3. *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 also measures the current to each electrode and the output voltages. This can be used to determine if the guns are operating properly.

1.5. The Standard Operating Mode

Gatan recommends the Ilion$^+$ II be left running continuously 24 hours 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 Ilion+ II is a small, bench-top system, it is relatively heavy (38 kg) 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 Ilion+ II is 20" (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 15 lb.

2.1. Site Requirements

The Ilion+ 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). A desktop computer will be used with the camera system, and a 23" monitor, keyboard, and mouse will occupy desk space next to the PIPS II, and a small tower case will sit on the floor. A molded power cord is supplied with the Ilion+ 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 PIPS. 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
0.5/0.25 A

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

2.2. Unpacking

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

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

Note or photograph any external visible damage.

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

2. **Remove the accessory boxes.**

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

3. **Lift the Ilion+ II out of the box (see lifting precautions above).**

4. **Keep all packaging material.**

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

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

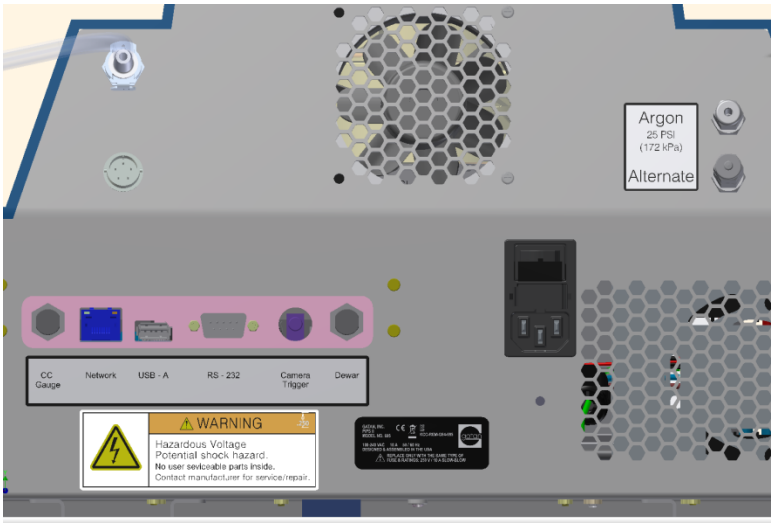


Figure 2-1 View of connections on rear of cabinet.

2.3.1. *Setup of the Diaphragm Pump*

Connect the diaphragm pump cable to the pump connection at the rear of the Ilion+ II and to the two connectors on the diaphragm pump. Also connect the

vacuum line between the rear of the Ilion^{+} II at the Quick Release Fitting and to the fitting on the DP.

2.3.2. *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 Ilion^{+} 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 minute 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.**

2.3.3. *Setting up the Camera System*

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

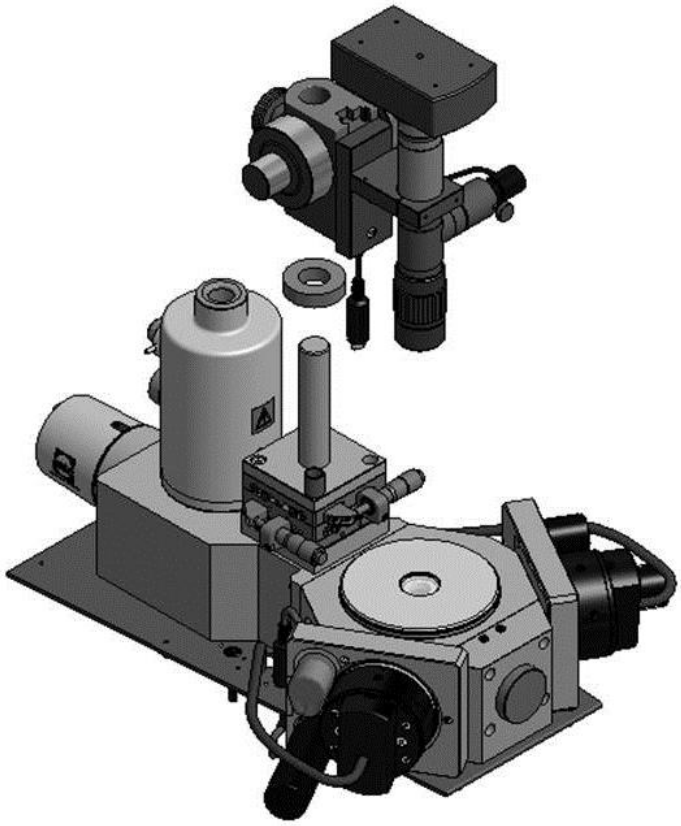


Figure 2-2 Camera system going onto the Ilion$^+$ II

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.

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 Ilion$^+$ 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 Ilion$^+$ II.

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 Ilion$^+$ II system.

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

11. Start DigitalMicrograph.

The camera system is now ready to use.

2.3.4. *Mounting the Stereo Microscope*

If a microscope was purchased with the system, it needs to be mounted and centered.

1. Properly engage the microscope slide into the pivoting slide on the Manifold.

2. Lower the microscope to its working position.

Rotate the focus knob CCW to lower the microscope to its working position where it can pivot to the left or right rest position.

3. Plug the microscope illuminator into the Reflection Illuminator power jack.

4. Plug the Ilion$^+$ II into the main power socket. Do not load a specimen post just yet.

5. Rotate the microscope objective turret to the 2x position.

Adjust the focus knob to clearly view the hex shape at the top of the piston.

2.3.5. *Aligning the Stereo Microscope*

The microscope is shipped pre-aligned so the hex shape at the top of the piston should appear concentric with the microscope field-of-view. Keep in mind the field-of-view is a true image such that if a gap exists between the post and the field-of-view at the 6 o-clock position, the microscope must be shifted toward the rear of the Ilion$^+$ II for centering.

NOTE: Alignment should be performed only when the Ilion$^+$ II is under vacuum and the piston can be lowered into the chamber.

If alignment is necessary, the tools required are a 1.5 mm and a 3.0 mm hex wrench and the small spanner wrench all supplied in the accessory kit.

1. **Insert a blade into the specimen mount to use as a target.**
2. **Lower the stage, and touch the View button on the Milling page. This should turn on the illuminator, if not verify that it is enabled and the intensity set on the Camera page.**
3. **Note the center of rotation of the blade. You will want to center the field of view of the microscope on the center of rotation of the blade.**

Front-to-back alignment

1. **Loosen sufficiently the two socket-head screws on the pivoting slide.**

Use the 3.0 mm hex wrench to loosen the two screws. This will permit the microscope to slide back and forth with minimal side motion.

2. **Center the specimen post; tighten the two screws.**

Be sure the two socket-head screws are tight before proceeding.

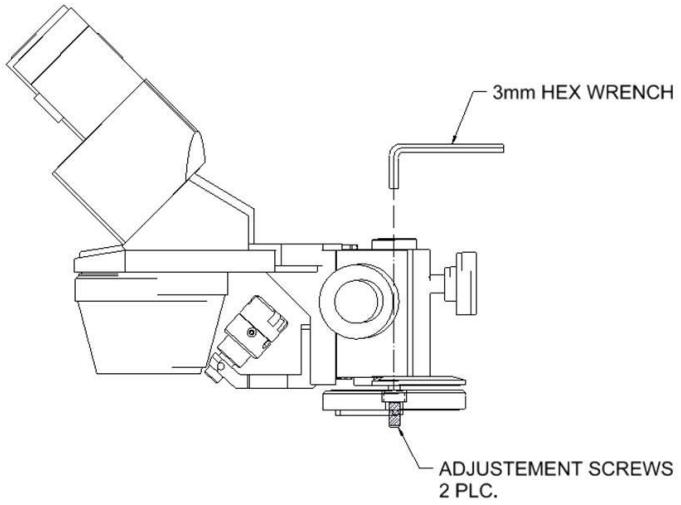


Figure 2-3 Microscope front to back alignment

Left-to-right alignment

1. Loosen the socket-set screw on the pivoting slide.

Use the 1.5 mm hex wrench to loosen the socket-set screw (facing the rear on the pivoting slide itself).

2. Position the microscope.

Look between the microscope slide and the pivoting slide to find a brass cam. Engage the spanner wrench in the cam and rotate left or right in small increments to position the microscope. Rotate CW to move the microscope to the right. Rotate CCW to move the microscope to the left.

3. Once centered, tighten the set screw.

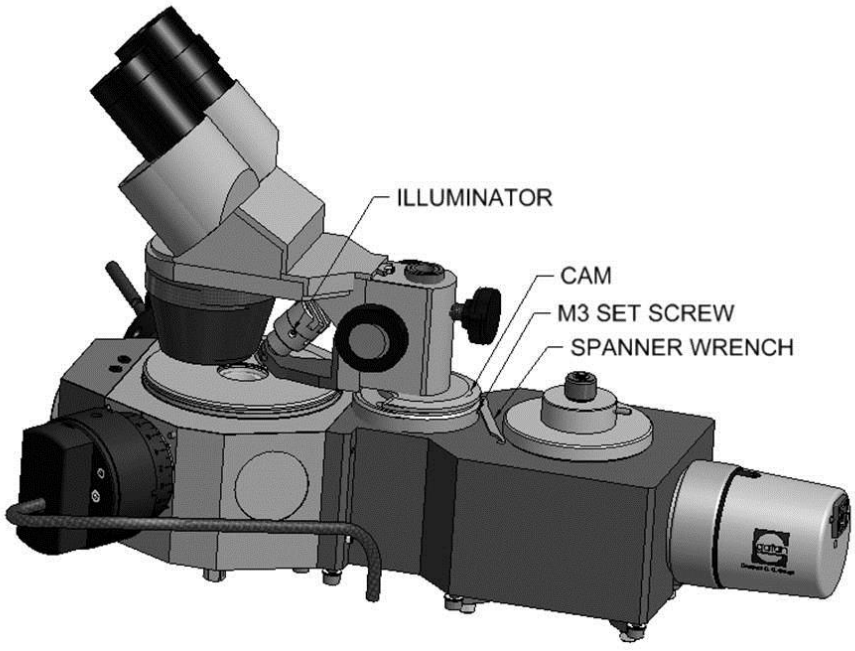


Figure 2-4 Microscope left to right alignment

3. Operation

The Ilion+ II is relatively simple to operate. The ability of the operator to obtain good X/S specimens depends primarily on proper mounting of samples and beam alignment.

3.1. Graphical User Interface (GUI)

Ilion+ II is mainly operated using the touch screen interface. This interface contains:

- The Milling page
- The Recipes page
- The Alignment page
- The Camera page
- The Settings Page
- The Maintenance page

3.1.1. *The Milling Page*

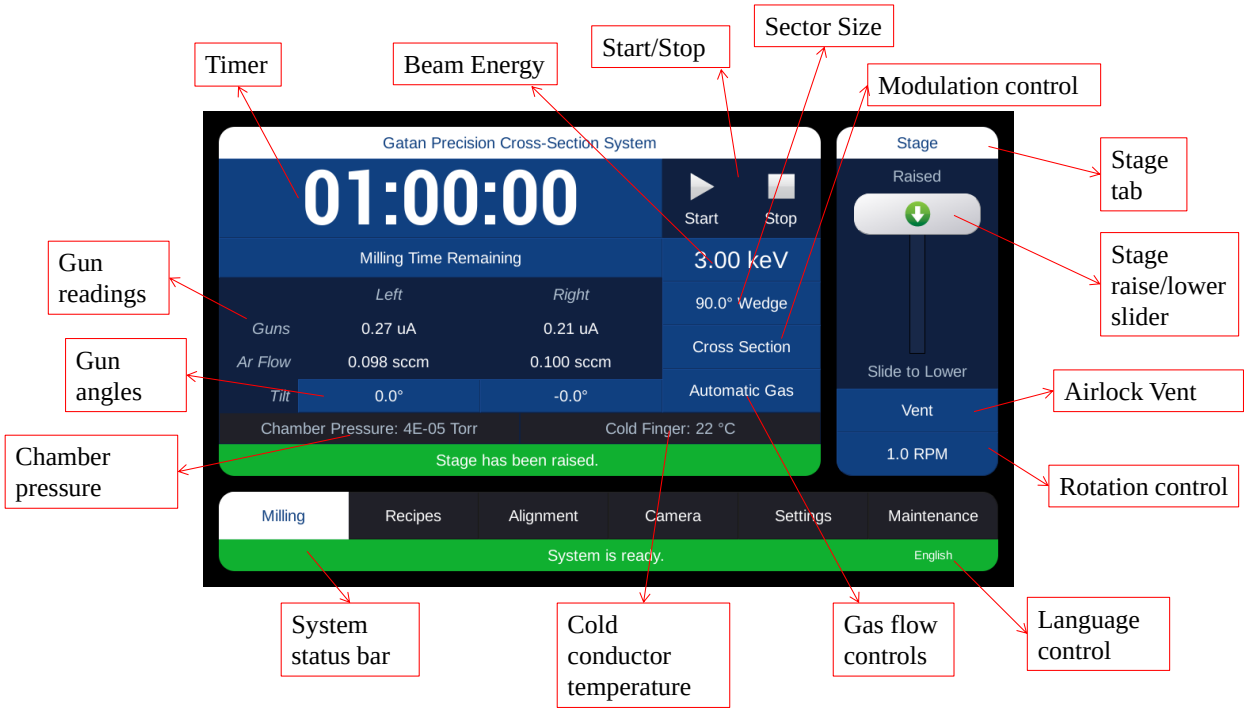


Figure 3-1 Milling page on the GUI

Timer: Use to define the milling duration. For this, touch the Timer and enter the milling duration in the window shown below (Figure 3-2), then touch Apply.

When the system is milling and the timer times out, the voltage is turned off, the stage rotates to home position, the shutter is opened and the user is notified by a buzzer.

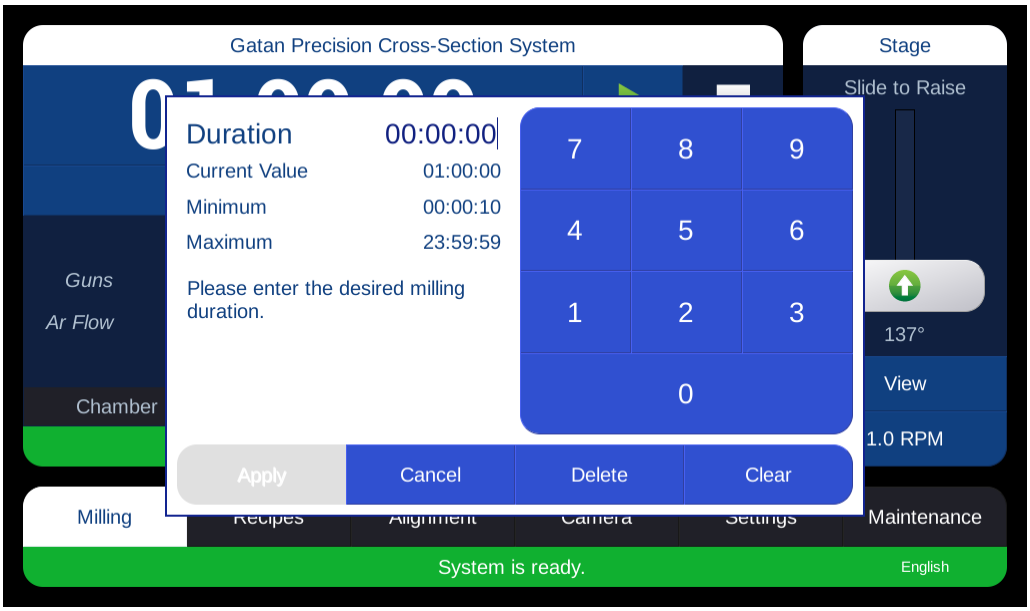


Figure 3-2 Setting the milling duration

Gun controls: These are used to define the accelerating voltage (0.1-8.0 KeV), and to read the left and right gun currents.

Gas flow controls: The amount of gas flow is shown in sccm (standard cubic centimeter per minute) for each gun and can be varied between 0 to 1 sccm. The gas flow can be controlled automatically or manually.

Automatic: The system adjusts the gas flow for each accelerating voltage to determine where the peak is, then sets the flow to a preselected percentage of that peak. This value is stored in a table, then used when that voltage is selected.

Manual: Each gas flow can be entered manually.

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.

Cold conductor temperature: 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 of approximately 15 minutes between the time the cold conductor reaches its minimum temperature and when the sample mount reaches its minimum temperature.

System status bar: Shows the status of the system (busy, ready, etc.)

Chamber pressure: Shows the pressure inside the work chamber and depends on the gas flow settings of the left and right guns. If you touch this display, the Maintenance / Vacuum screen will be displayed.

Rotation control: Used to set the rotation speed (rpm) during the milling process. It can be set between 0.5 to 6 rpm.

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 Planar (No Modulation), both guns are on at all times. When modulation is set to Cross Section (Single Modulation), each gun is turned on only when the front of the sample mount faces that gun. When modulation is set to Dual 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.

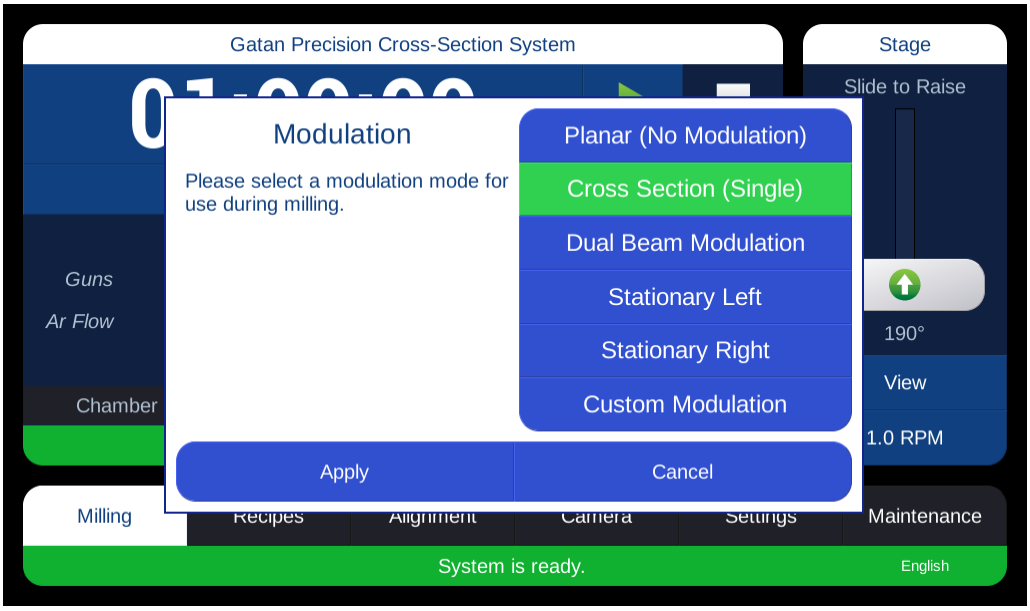


Figure 3-3 Setting the modulation mode

Stage tab: Used for raising/lowering the stage and for venting the airlock when the sample is in raised position

NOTE: The airlock is automatically pumped down when the sample is lowered.

Start/Stop: Start turns on the gas flow, starts stage rotation, turns on the beam, closes the shutter and starts the timer. Stop turns the voltage off, stops the time, rotates the stage to the home position and opens the shutter.

Language Control: Press this text to set the language of the user interface.

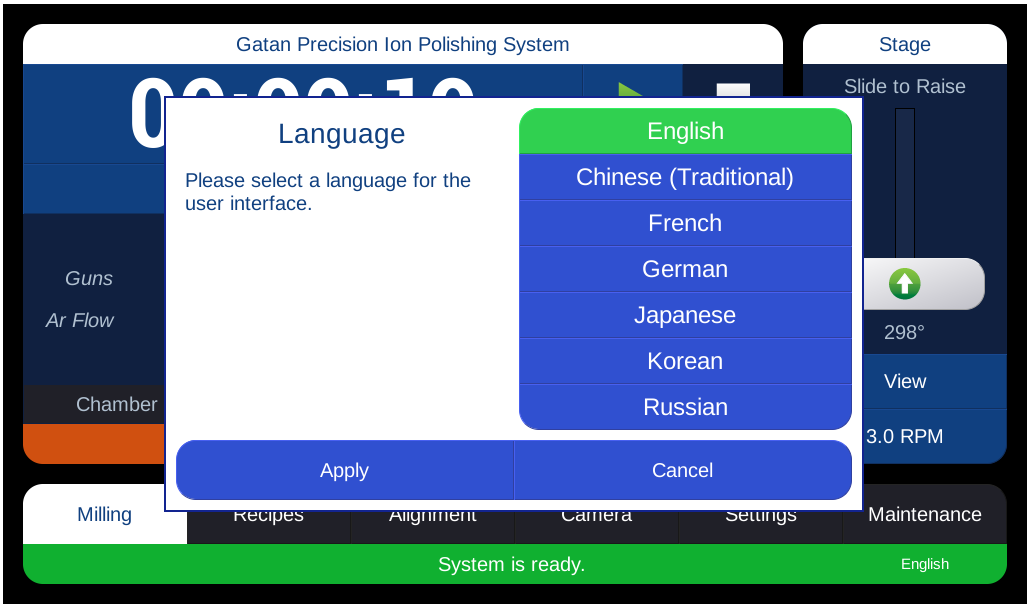


Figure 3-4 Setting the language.

3.1.2. *The Recipes Page*

Use this page to create, store, edit and run milling recipes. Milling parameters like voltage, duration, gun angle (if motorized guns are provided), rotation speed, beam modulation, illumination, camera mode, and cold stage can be varied for each step in a recipe.

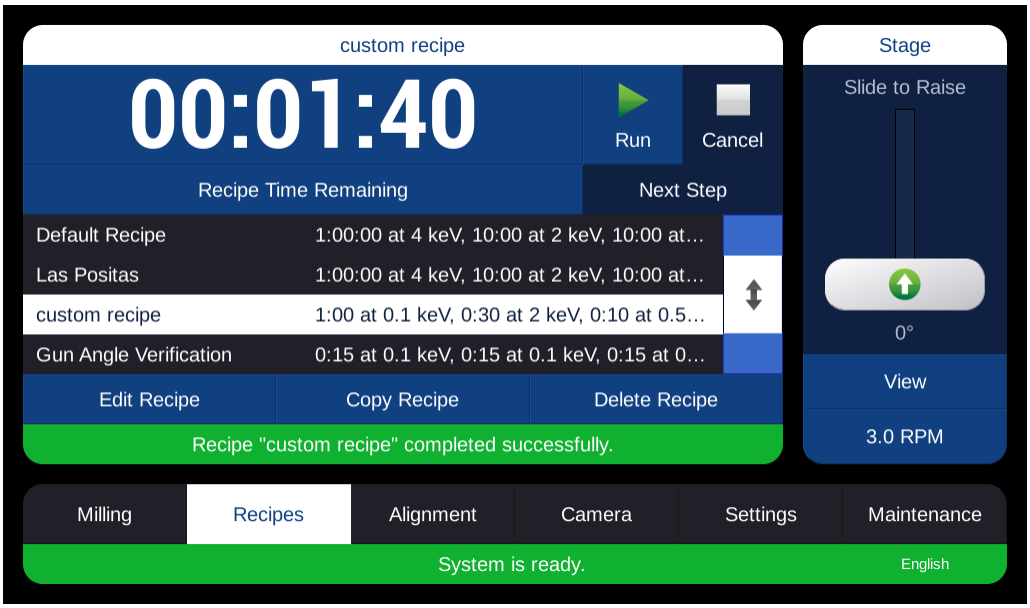


Figure 3-5 Recipes page

Running a recipe: To run an existing recipe, select the recipe you want and touch Run. As a recipe runs, the remaining time and the current step number are shown on the top left corner of the page. Status bar will show the user that the system is busy running a recipe.

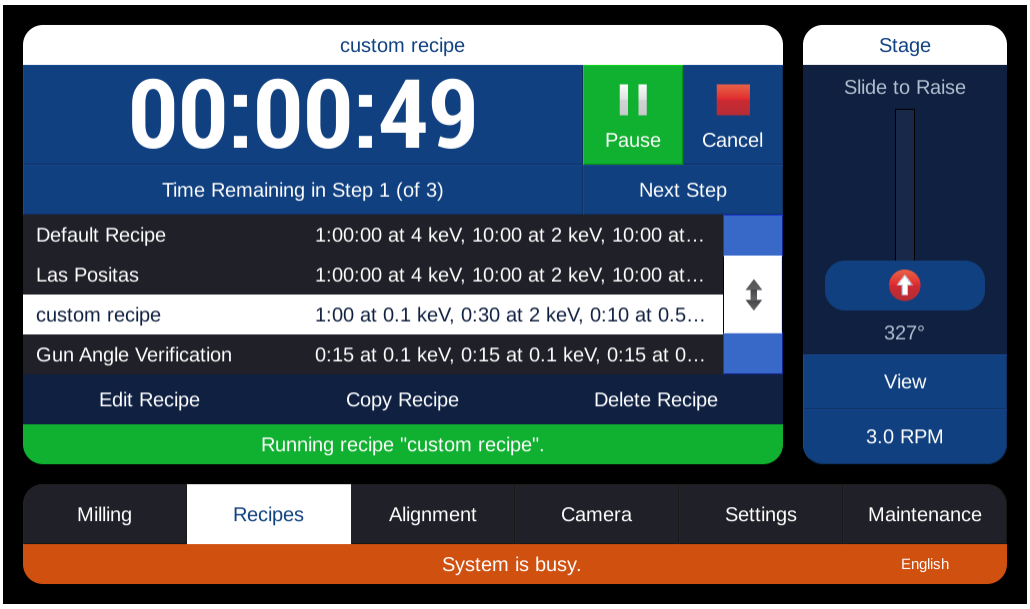


Figure 3-6 Status bar, showing a recipe is running

Milling can be stopped or paused anytime during this process. In order to skip from one step to the next, touch Next Step. After all the steps are complete, the status bar will show the user that the recipe has been completed successfully.

Editing a recipe: To edit a recipe, select the recipe and touch Edit Recipe. This opens the Recipe Edit page, where you can edit the parameters in each step, add/delete a step, rename the recipe, revert (bring all parameters to what they were set to before editing started) and save. The horizontal slider allows more options to be viewed or edited. The vertical slider allows more steps to be viewed or edited.

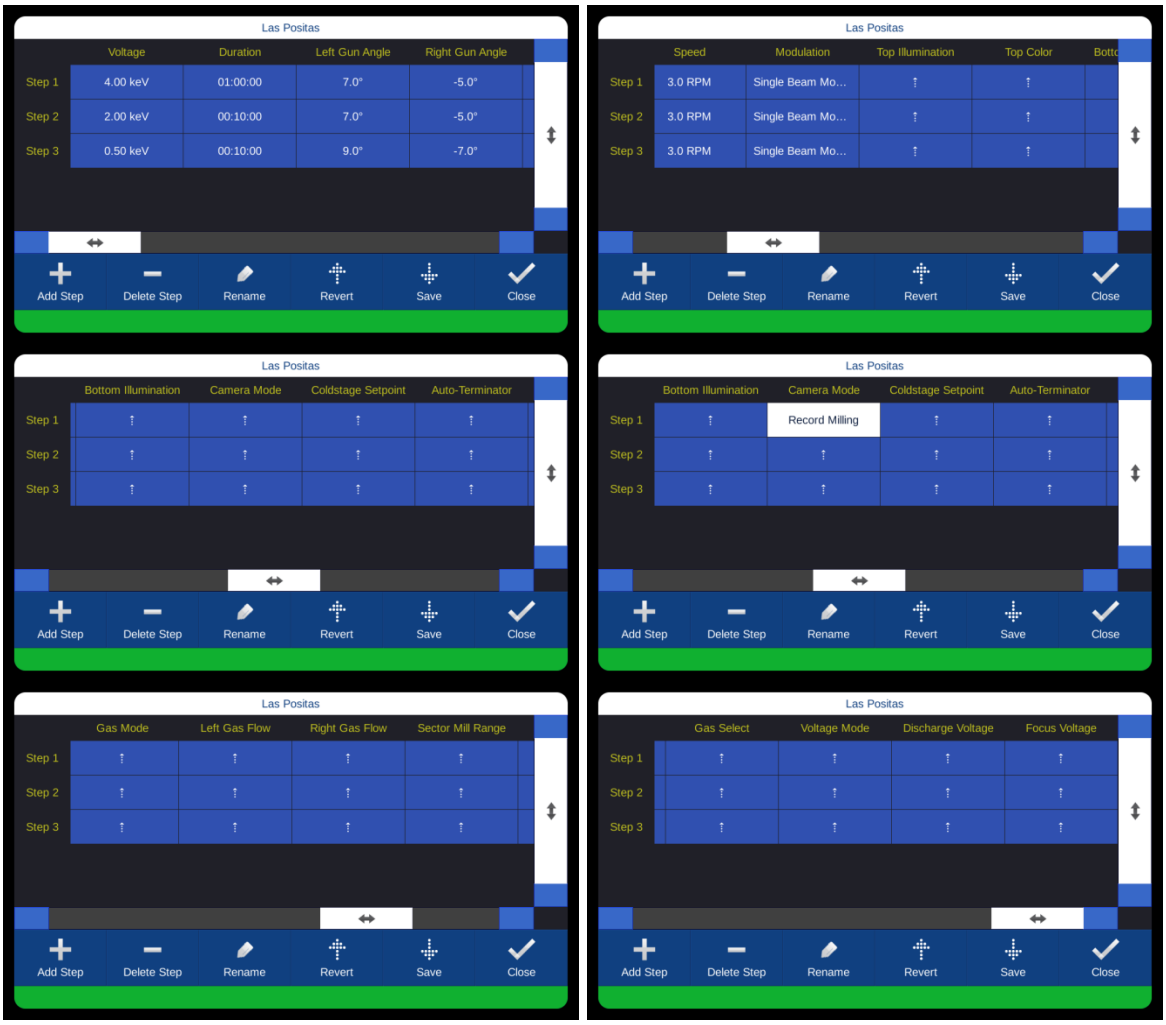


Figure 3-7 Edit recipe page.

In order to change each parameter in recipe steps, touch it. A window opens where you can enter the new value/setting and apply. An up arrow entry means that the value will not change from its previous setting. For instance, if you want to manually set the gas flow before starting a recipe, use the up arrow selection. Then when the recipe is started, the gas flow value will stay the same as it was set prior to starting the recipe.

To add a step, touch the Add Step button, enter the step number, and touch Apply.

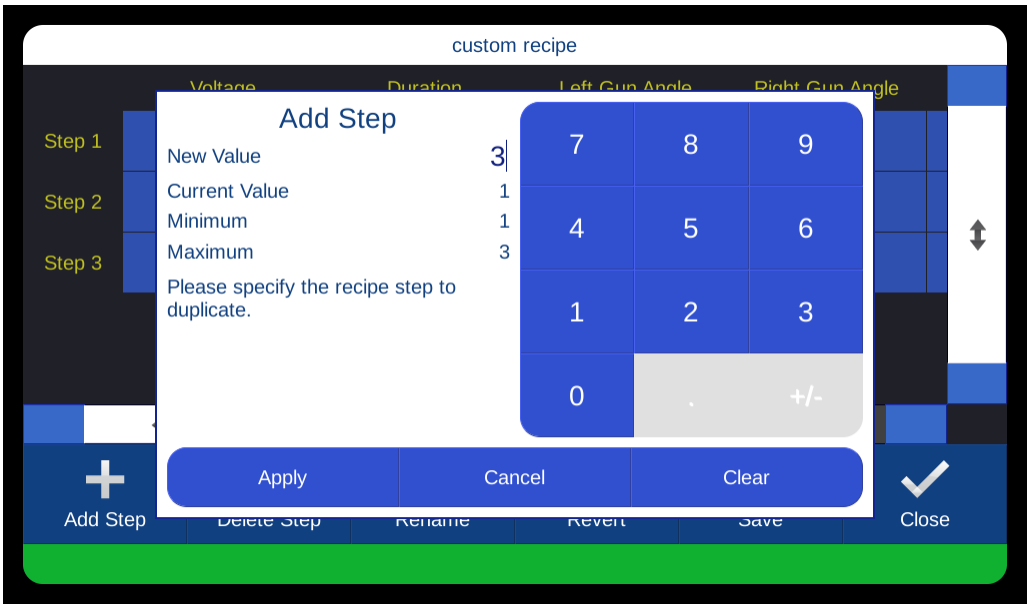


Figure 3-8 Adding a recipe step.

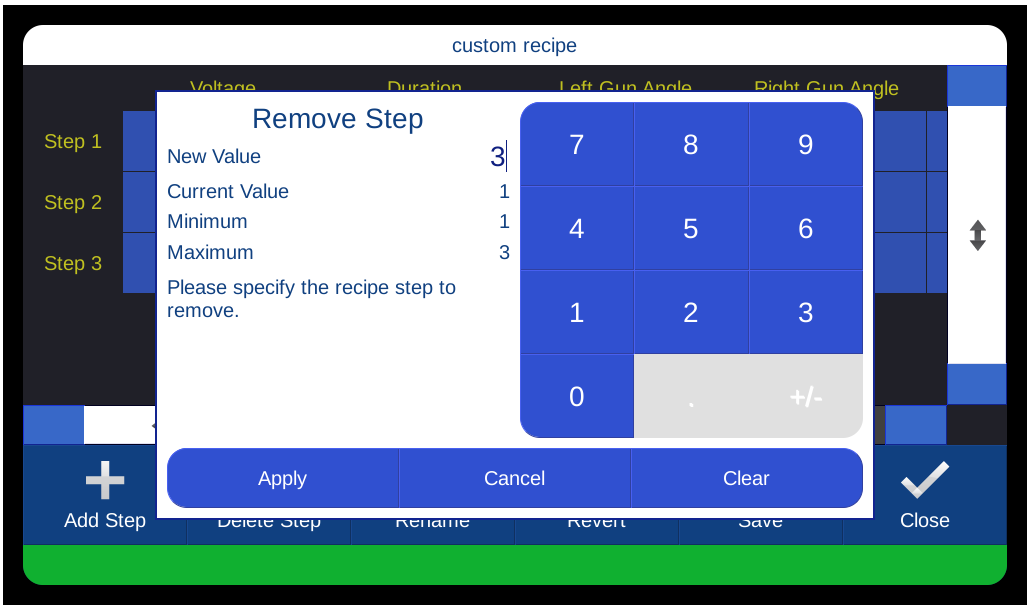


Figure 3-9 Deleting a recipe step.

After done editing, touch Save and then Close to go back to the recipes page.

Creating a new recipe: This is done by copying an existing recipe and then editing it. To create a new recipe, select the recipe you want to copy, then touch Copy Recipe. The user will then be asked to enter the name for the new recipe. Enter the name and touch Apply. After the new recipe is created, select it and go to Edit Recipe page to modify/delete the existing steps or to add more steps.

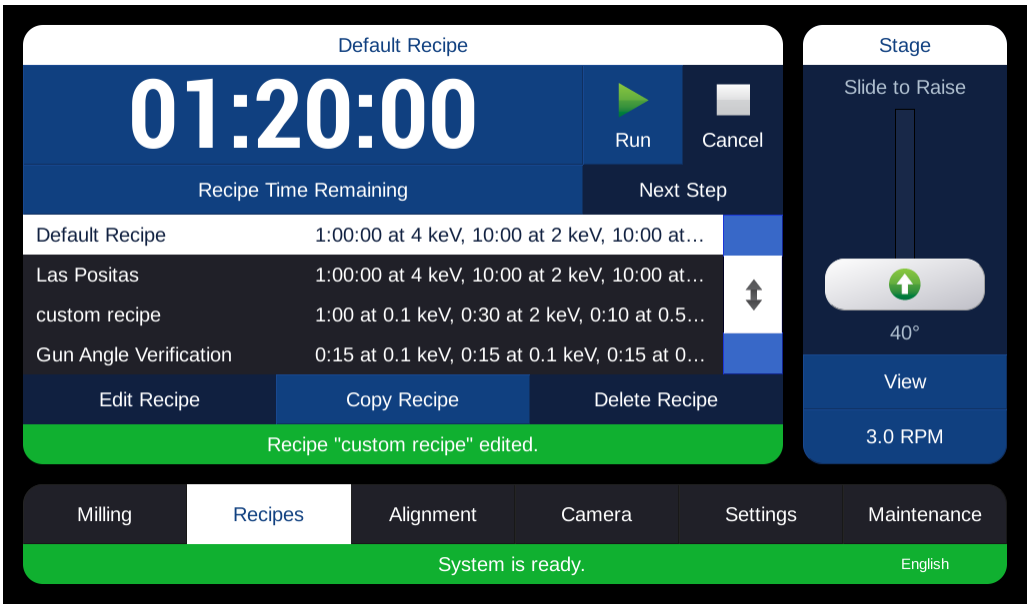


Figure 3-10 Copying a recipe.

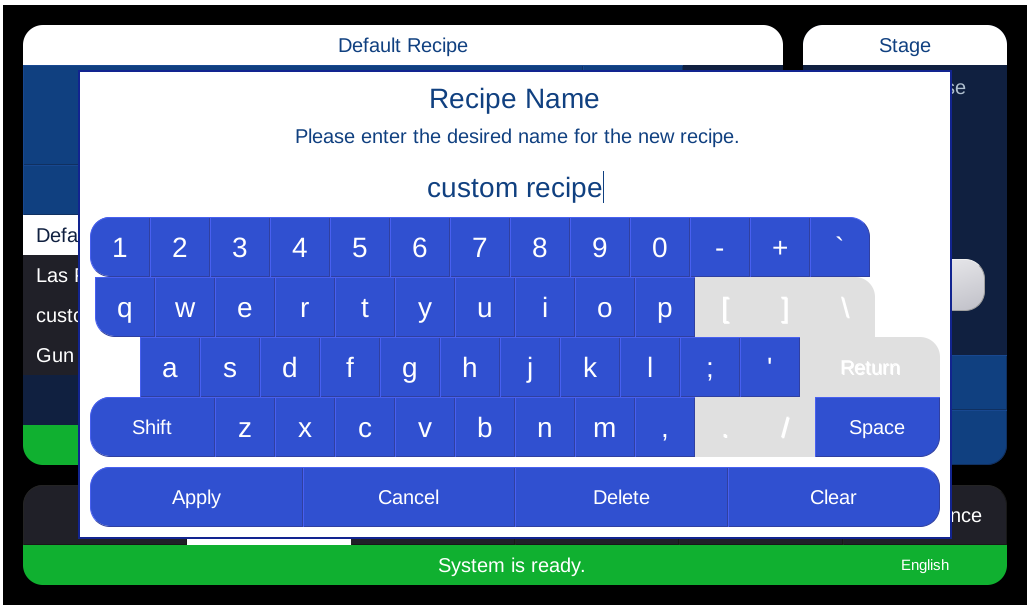


Figure 3-11 Creating a new recipe: enter the name

3.1.3. *The Alignment Page*

Use this page to perform beam alignment.

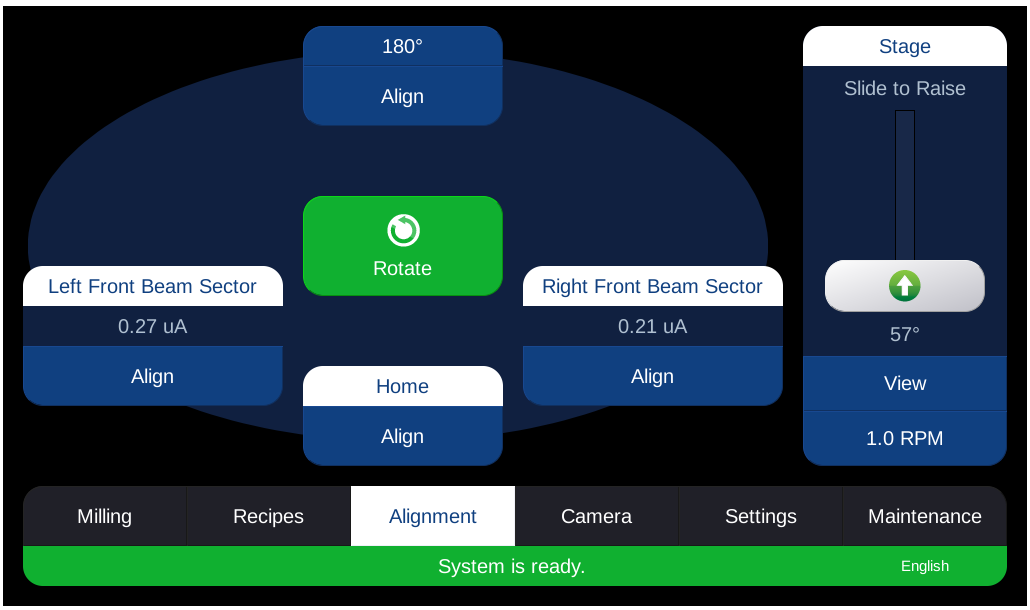


Figure 3-12 Alignment page

Whenever "Align" is touched in this page, the stage will rotate to the specified position and will stay there until "Rotate" is touched again. The green color on Rotate, shows that rotation is on. Left Front Beam Sector causes the blade face to face the left gun. Right Front Beam Sector causes the blade face to face the right gun. Home causes the blade face to face the front of the instrument. The Align button with an angle displayed causes the stage to rotate to that specific angle. The angle may be set manually between 0 and 360 degrees.

The Angle display on the stage tab shows the current rotation angle. The stage tab can be used similarly to the milling page to lower/raise the sample and change the rotation speed.

The Faraday cup current for the left gun is shown below the Left Front Beam Sector display, and the Faraday cup current for the right gun is shown below the Right Front Beam Sector display.

3.1.4. *The Camera or Viewing 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 set the illumination.

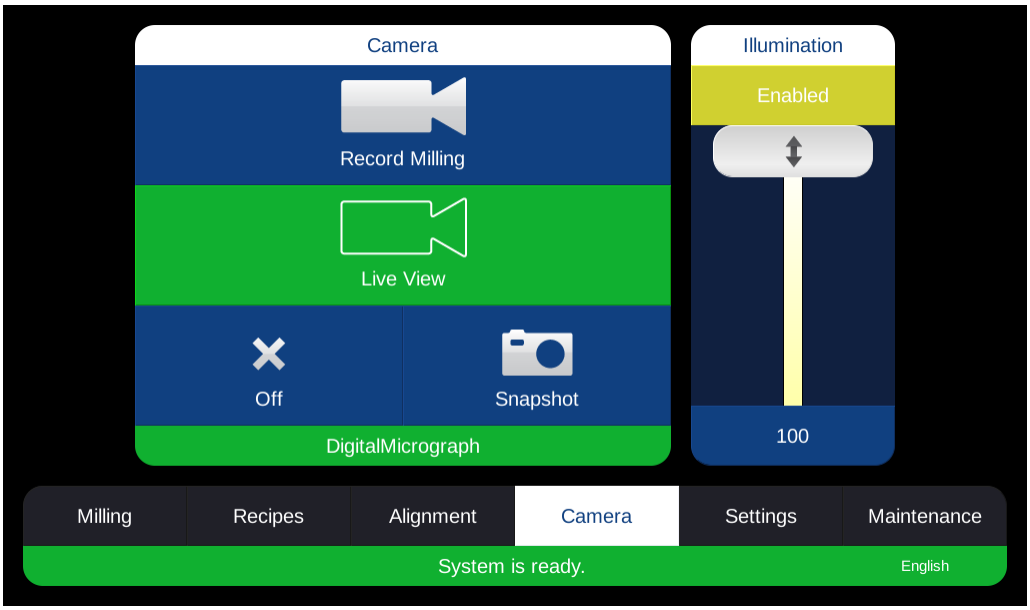


Figure 3-13 Camera page

Camera page: Is used to set the imaging parameters in DM. It can be

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.
Off: stops camera.
Snapshot: takes a snapshot. This is a full resolution image.

Top illuminator tab: Is used to enable or disable the reflection illuminator and to change its intensity (use the slider). Pressing View or Live View opens the shutter and turns on the illuminator according to its setting. 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%).

Viewing page: Is visible when the Digital Zoom Microscope option is not installed. It is used to control the illuminators and open the shutter.

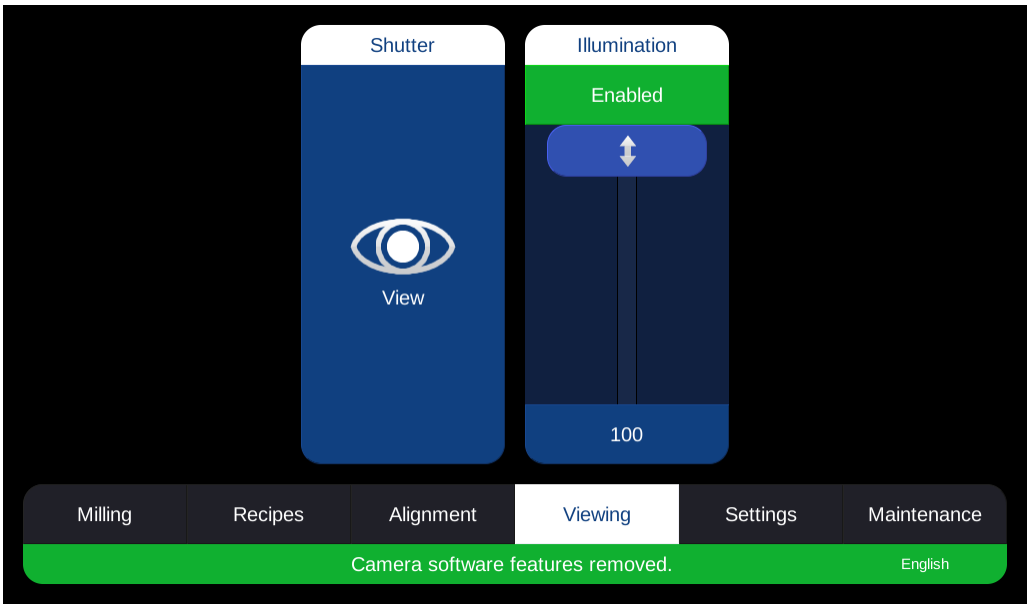


Figure 3-14. Viewing page.

Shutter tab: The View button is used to open the shutter and turn on the enabled illuminators.

Top illuminator tab: Is used to enable or disable the reflection light and to change its intensity (use the slider) independently. Pressing View or Live View opens the shutter and turns on the illuminator according to the settings. 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%).

Bottom illuminator tab: Is used to enable or disable the transmission light and to change its intensity (use the sliders). Pressing View or Live View opens the shutter and turns on the illuminators according to their settings. 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%).

3.1.5. *The Settings Page*

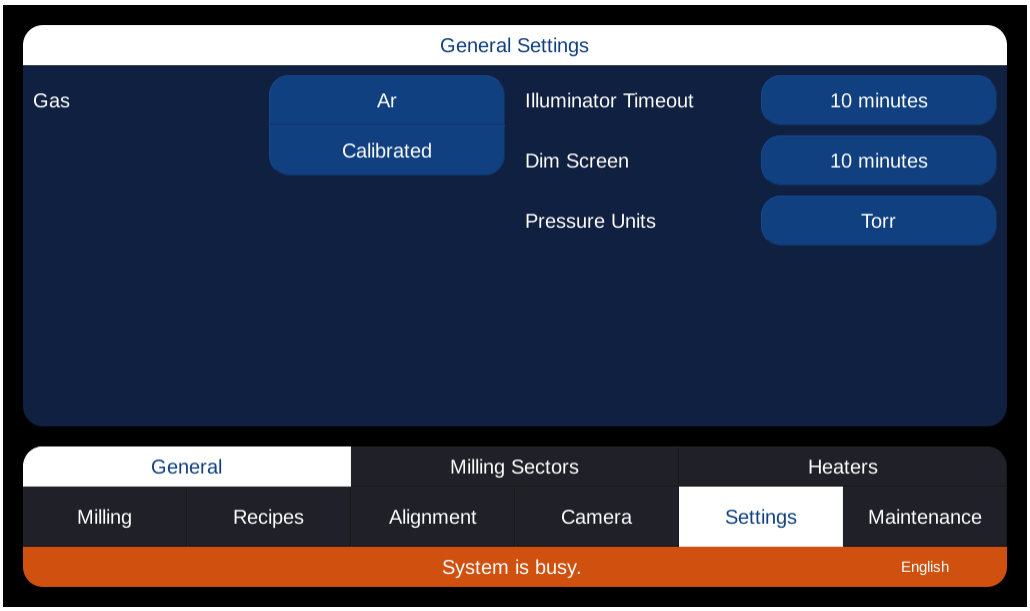


Figure 3-15 General Settings

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.

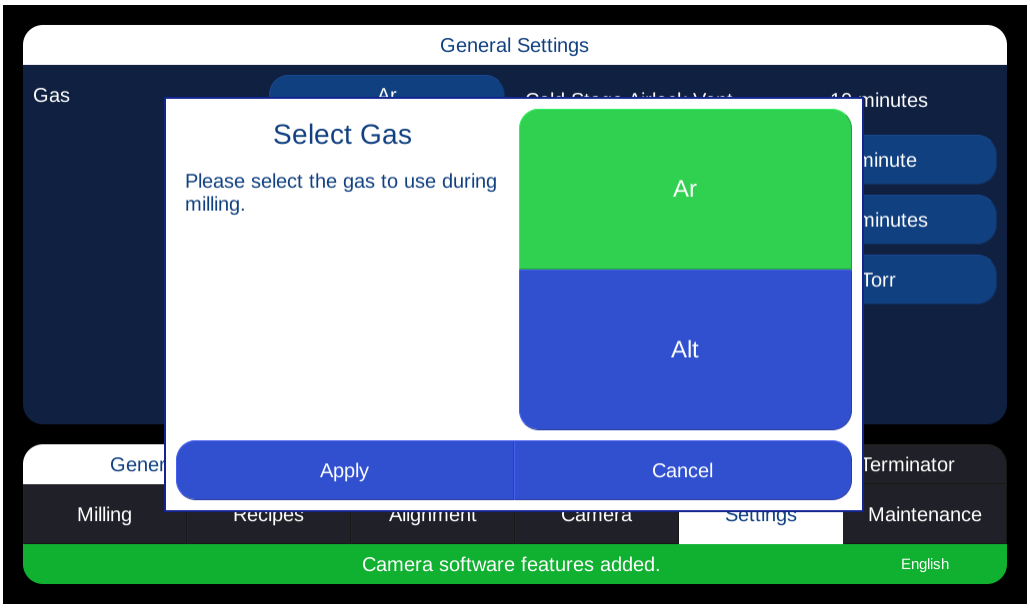


Figure 3-16. Setting the gas inlet used for the guns.

When Argon is chosen, the button just below is highlighted in blue. You may then choose between 3 calibration modes: Calibrated, Factory, and Safe. Calibrated mode uses the latest calibration values. These values are overwritten when the gas flow is calibrated (see section). 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 properly, selecting the Safe mode will set the system to a mode where both guns operate at all voltages.

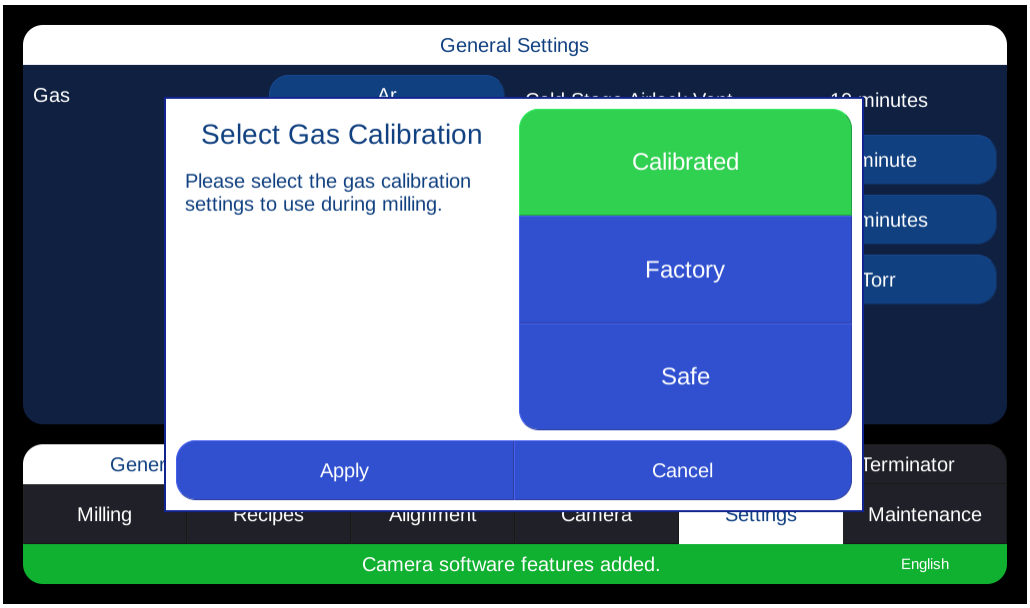


Figure 3-17. Choosing the calibration table used for the Argon gas inlet.

Milling Sectors:

Figure 3-18. Milling sectors.

Sector milling range: Sector Mill Range sets the angle through which the sector milling is on. Default is 60 degrees. Values can be changed from 90 to 10 degrees. This option may also be set in individual recipes.

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 standard 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

Heaters:

This option is only functional in systems with a cold stage.

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 above the set point.

Dewar heater: Activates the dewar heater. This heater stays on continuously until the Cold Finger Temp reaches 25° C, then it shuts off. The stage heater must be off before starting this heater.

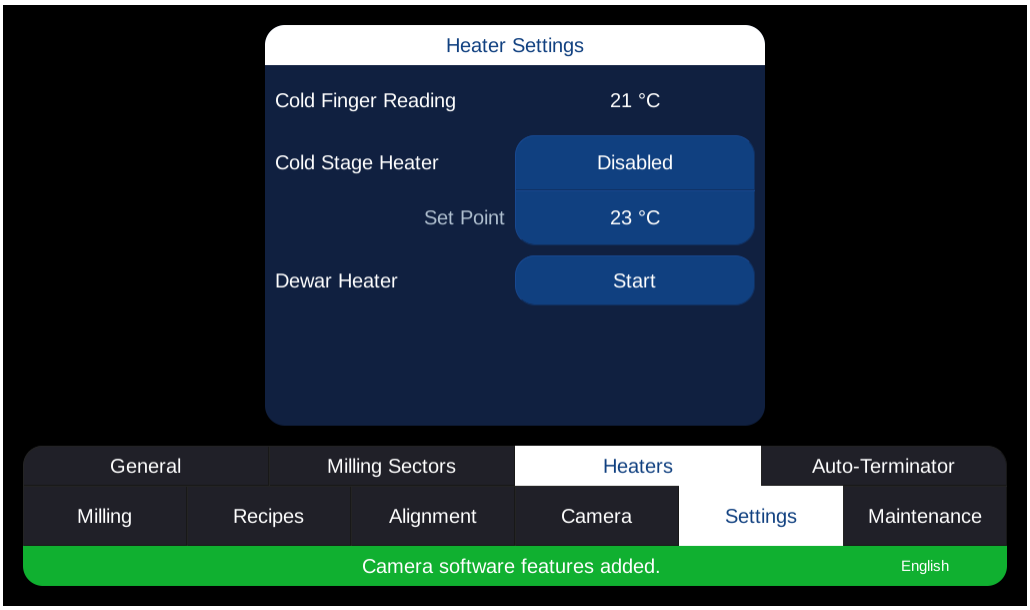


Figure 3-19 Heaters settings page.

3.1.6. *The Maintenance Page*

Calibration

Gas flow: This is performed at the factory and is not generally needed. When start is selected, the optimum gas flow for each gun will be measured and saved at different beam energies. 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.

The bar at the top indicates if **Ar**gon or **Alt**ernate gas has been selected.

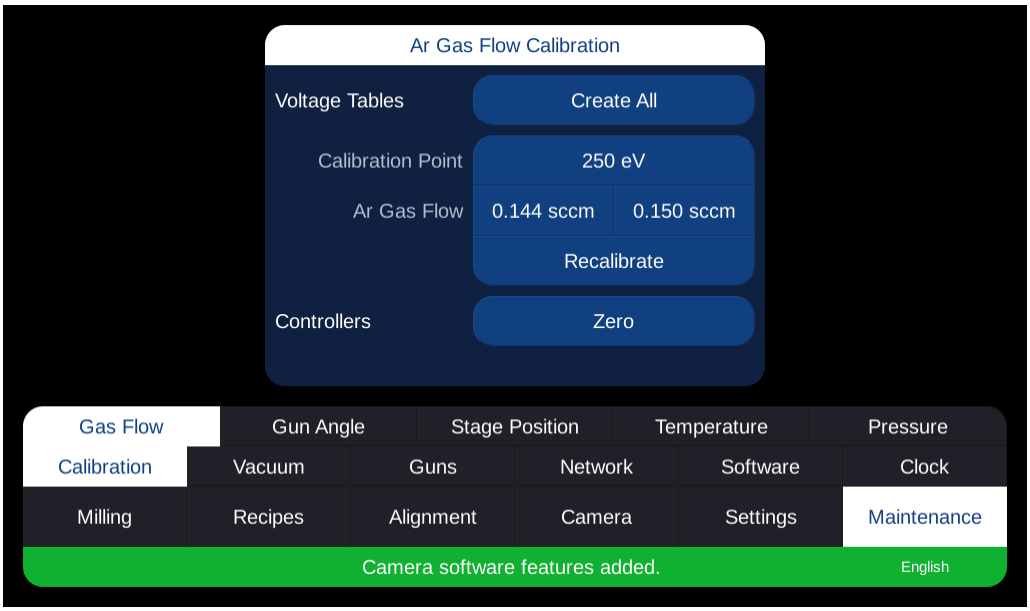


Figure 3-20 Gas flow calibration

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 angles:

This is only available for systems with motorized guns:

1. **Touch Maintenance – Guns – Gun Tilt**
2. **Manually set both guns to +10 deg, write down the dac readings displayed.**
3. **Manually set both guns to -10 deg, write down the dac readings displayed.**
4. **Touch Maintenance – Calibrations – Gun angle**

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 -10 to +10 deg.**

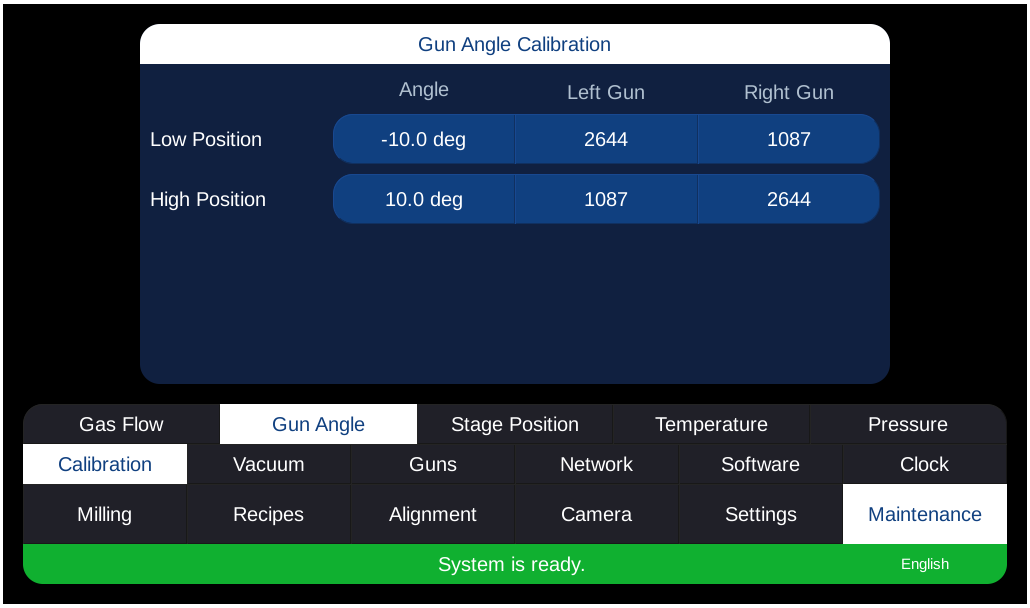


Figure 3-21 Motorized guns calibration

Stage position: This window is used for calibrating the stage home position.

1. **Lower piston.**

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

3. **Press Home, wait for the stage to stop moving. Note the number of degrees between the desired home position and the actual stage position.**

4. **Go to the Maintenance | Calibrate | Stage screen. Press the Index button. Enter the number of degrees noted above times 10 (max 3600).** That is, if the stage is 15 degrees from home in the CW direction, enter 150. If the stage is 15 degrees from home in the CCW direction, enter 3450.

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

6. **Repeat above steps until a blade is parallel to the front of the system and the sample mounts toward the back.**

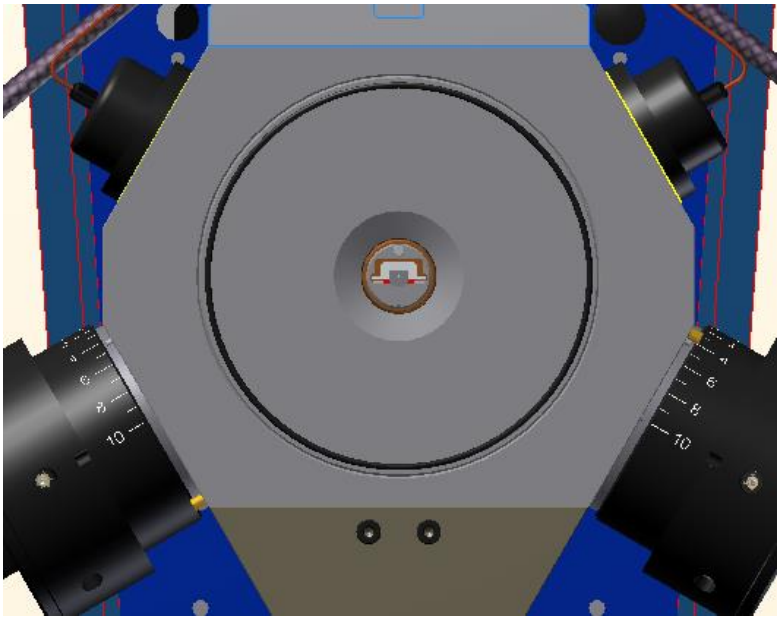


Figure 3-22 Properly aligned stage in the Home position

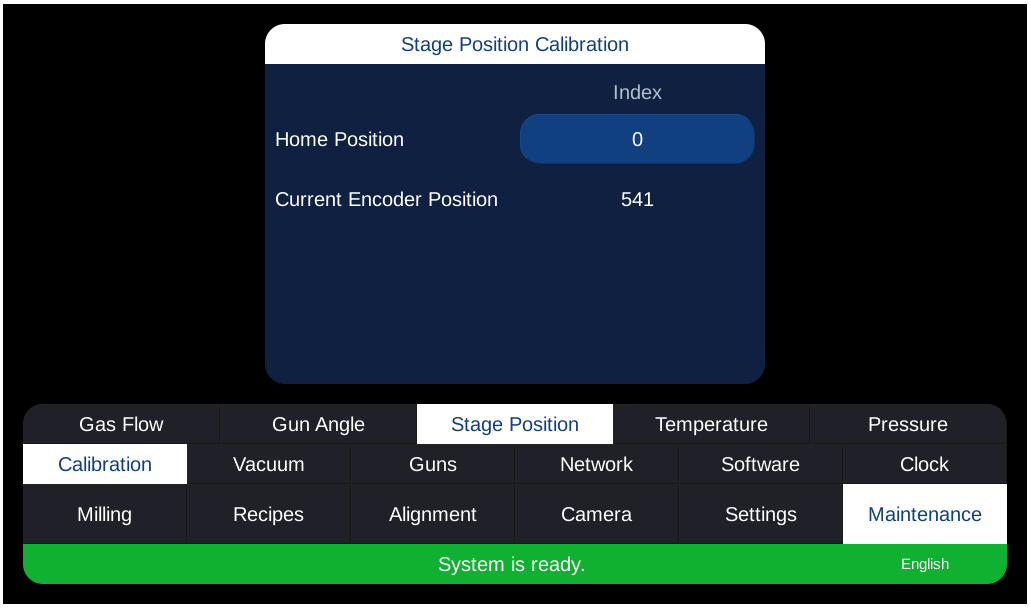


Figure 3-23 Stage home position calibration

Temperature Gauge: This sensor measures the temperature of the cold conductor.

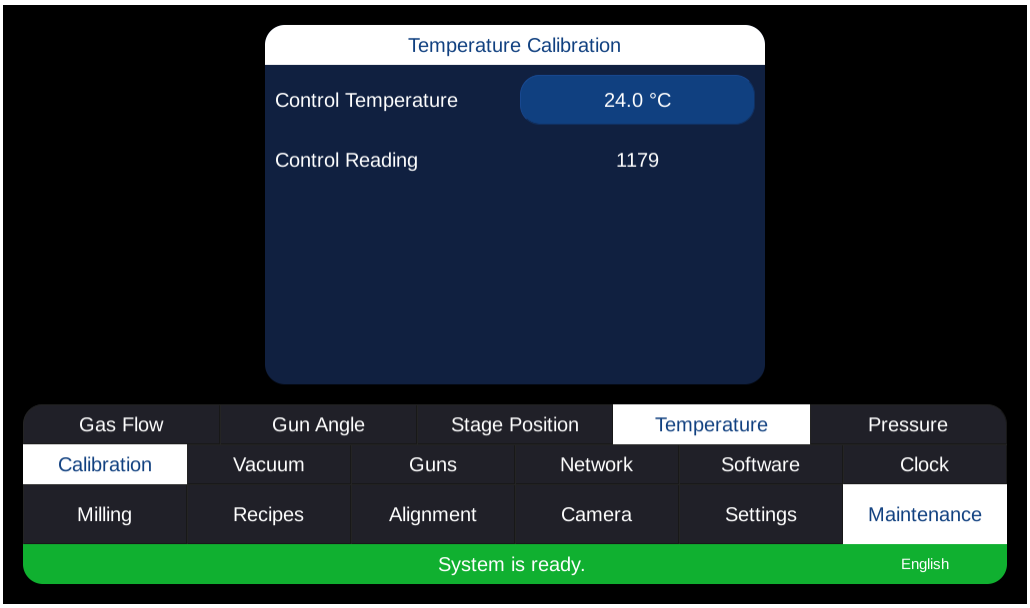


Figure 3-24. Temperature sensor calibration.

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.

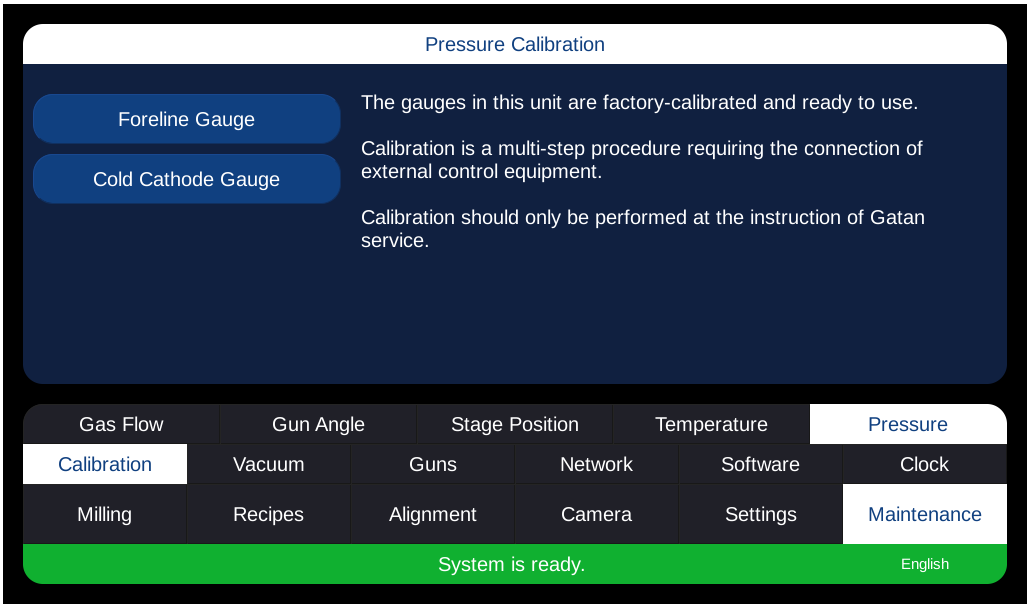


Figure 3-25 Pressure calibration.

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.

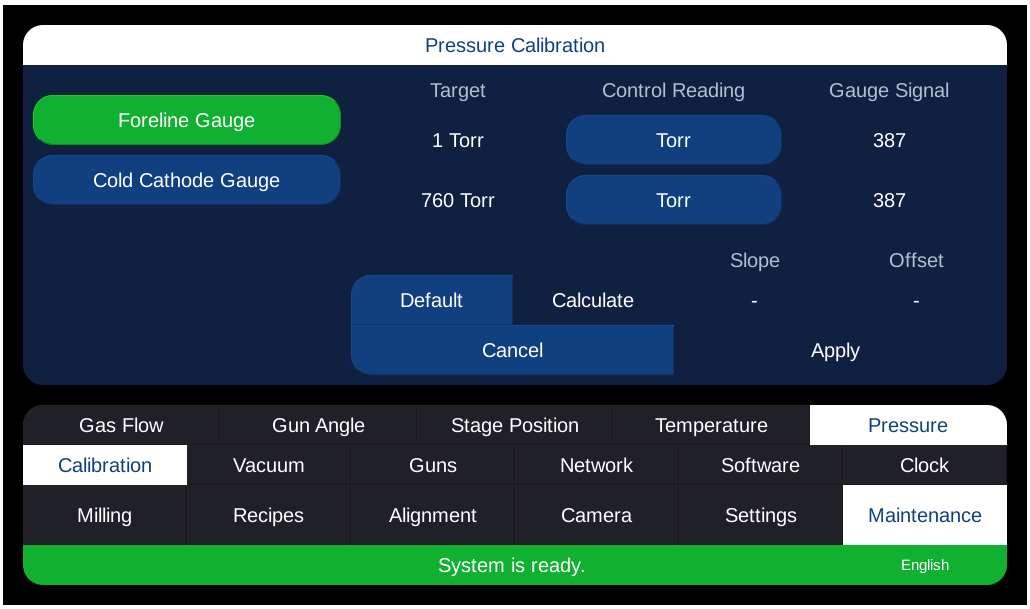


Figure 3-26 Foreline gauge calibration

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.

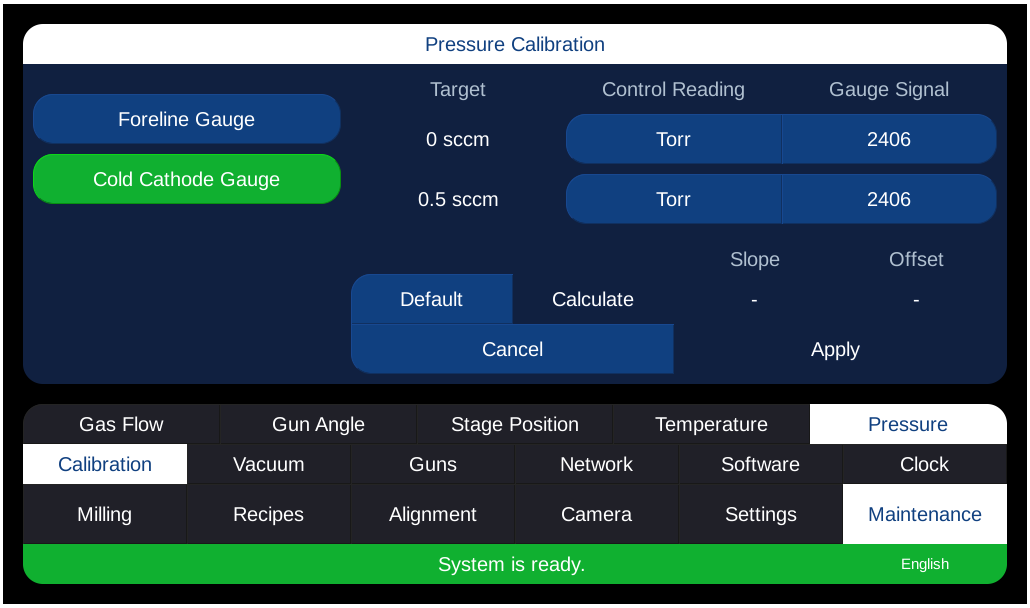


Figure 3-27. Cold cathode gauge calibration.

Vacuum

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

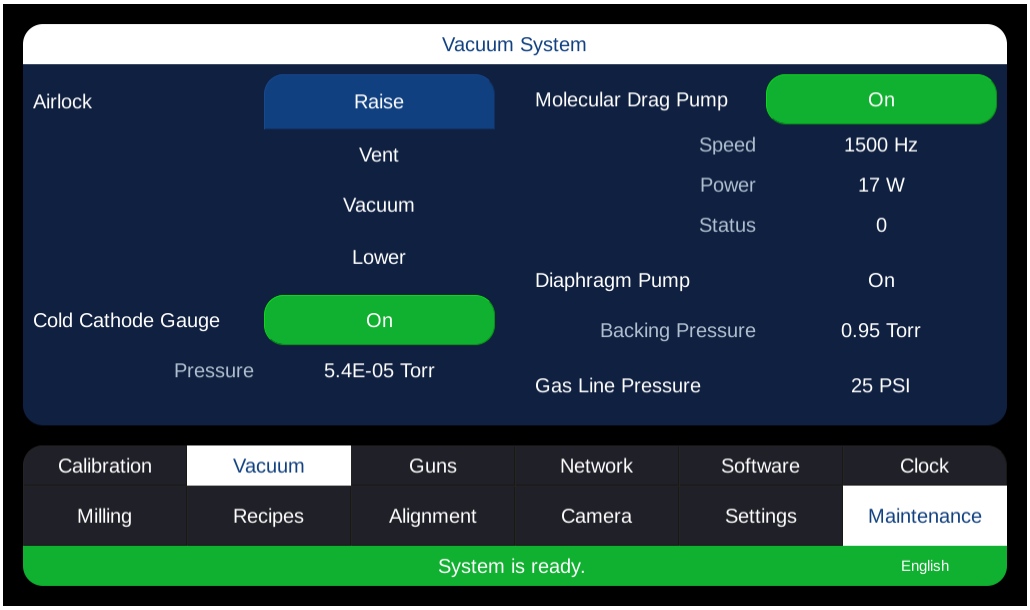


Figure 3-28 Vacuum System

Airlock: Raise is used to raise the stage into the airlock. Vent is used to vent the airlock.Vacuum is used to pump out the airlock without lowering the stage. Lower is used to lower the stage.

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.

Guns

Gun readings: This page displays the high voltage power supply readings. The 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. 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 only used when the accelerating voltage is lower than 2.5 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.

Accelerating current is a better approximation of the total Argon dose 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. Faraday cup current is useful because all of this current would likely strike the sample, however, most of this current is blocked by the sample during milling. Faraday cup current does not include neutrals.

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.

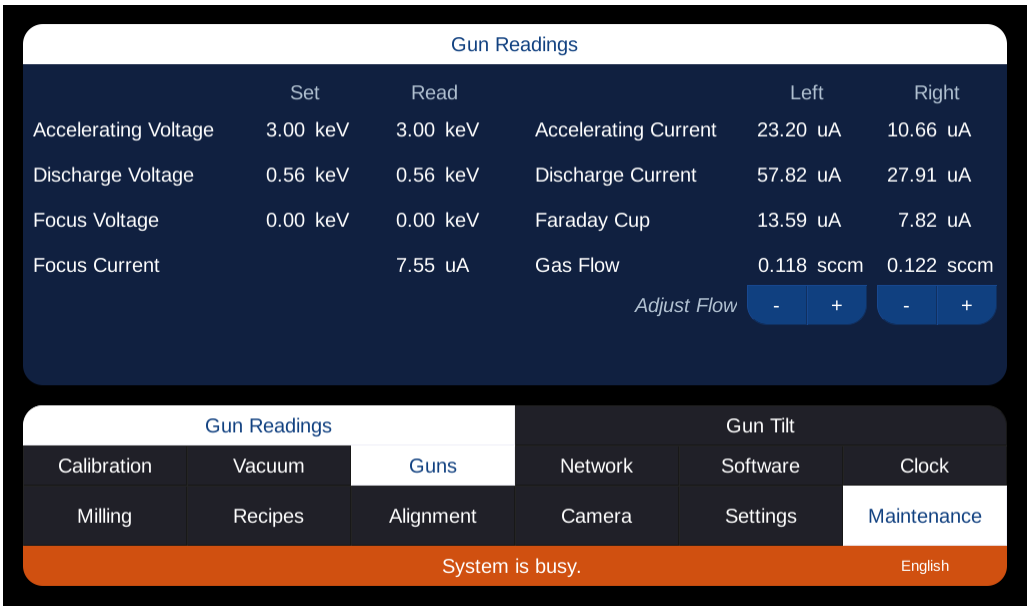


Figure 3-29 Gun Readings

Gun tilt: This option is only available for systems that have motorized guns. Left/Right Gun Angles set the tilt angle the left/right guns should be set to, respectively. The position reads the current gun angle position in degrees and dac values. The remainder of the readings are for service personnel diagnostic purposes.

Figure 3-30 Gun Tilt

Network

This sets the network settings for the Ilion+ II. These setting are set at the factory and should not be adjusted.

Figure 3-31 Network

Software

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

In order to update the software, plug in the USB drive that is provided for this purpose in the back of the Ilion+ II. This drive should have 2 files in its root directory, ending in .swimg and .fwimg. Wait a few moments for it to load 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 Ilion+ II. At this time turn the power off, wait a few seconds, then turn the power on.

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.

The "Export Support Files" button copies configuration files to a USB flash drive that must first be installed into the USB port on the back of the system. These files may be useful to service personnel when troubleshooting.

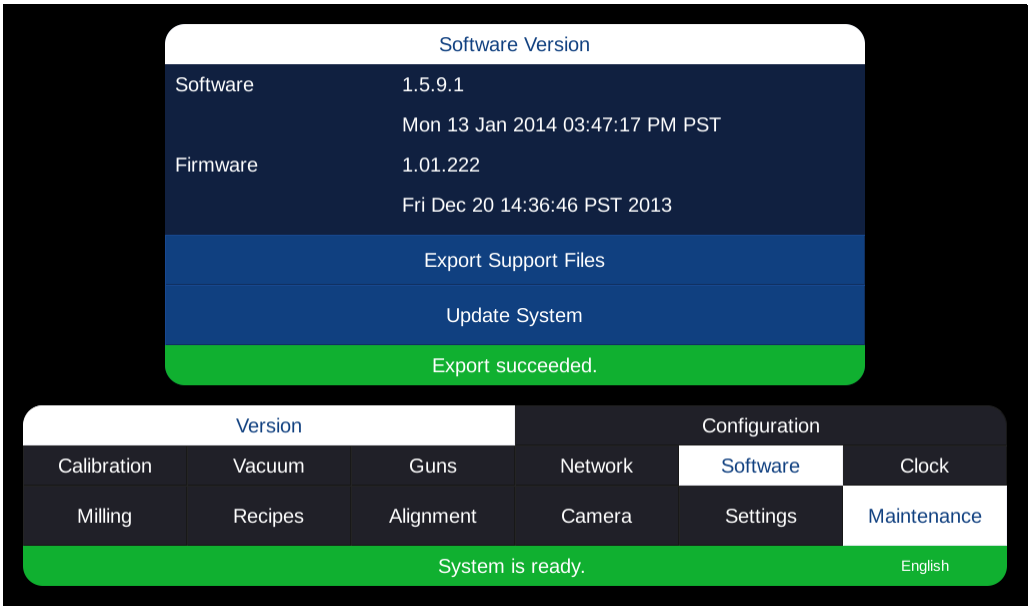


Figure 3-32 Software maintenance

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.

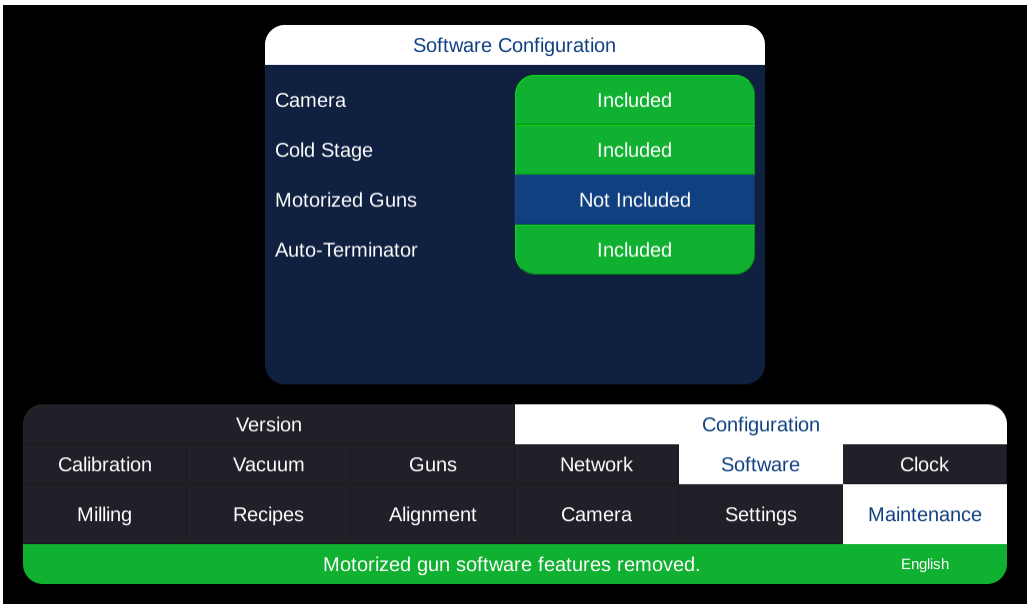


Figure 3-33. Software configuration page.

Clock

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

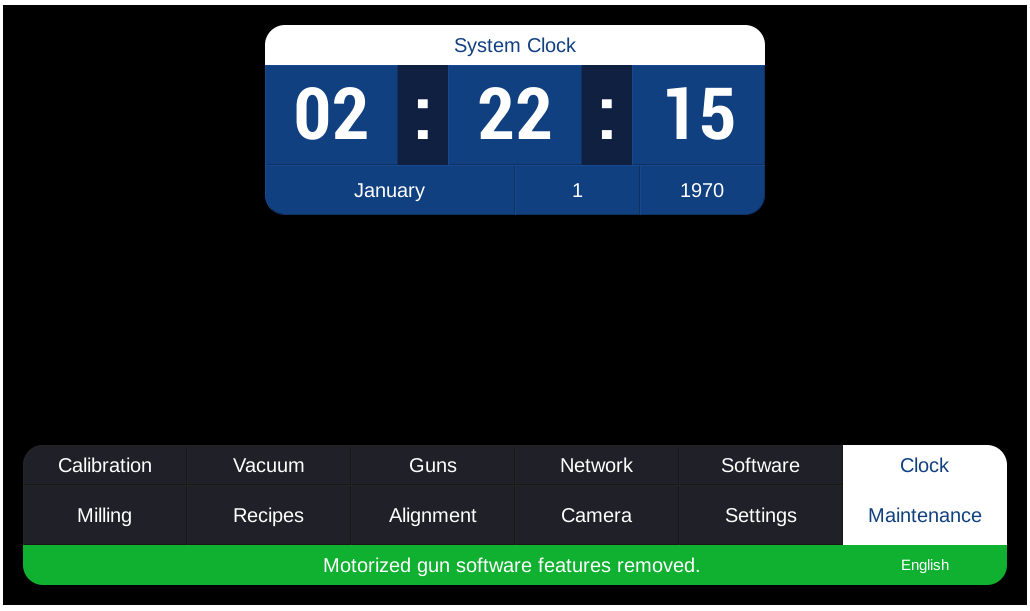


Figure 3-34 Clock

3.2. Start-up Procedure

Turn on the power to the Ilion^{+} II. The diaphragm (DP) and molecular drag pumps (MDP) will start.

Once the operating system has booted up, the milling page will be displayed.

Figure 3-35 GUI- Milling 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 (>5 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 Ilion$^+$ 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, set the gas flow back to Automatic mode.

To Purge the Guns Manually

Switch the gas flow to manual, and set both guns to 0.3 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 Loading and Unloading

Specimens are mounted either on a X/S blade or a planar milling holder. The specimen blade is inserted into a specimen mount located at the top of the Whisperlok piston. The following procedure assumes the piston/specimen mount is in the Work Chamber.

3.3.1. *To Raise the Specimen Mount/piston:*

1. **On the Milling page, go to the Stage tab and slide the bar up.**

This will raise the specimen mount/piston into the Airlock to facilitate specimen loading. The piston will not rise immediately but waits for the specimen mount to rotate to its reference or home position. The piston then rises and seals off the Work Chamber from the Airlock chamber.

2. **Vent the Airlock chamber by touching the Vent button.**

Once vented, the Airlock's cover can be removed and a new specimen blade can be inserted or an old one removed. A special pair of angled tweezers is supplied to facilitate this operation.

NOTE: Be sure not to rotate the specimen mount when exchanging specimens. Any rotation of the mount will displace the home position of the specimen and will cause misalignment for modulated milling.

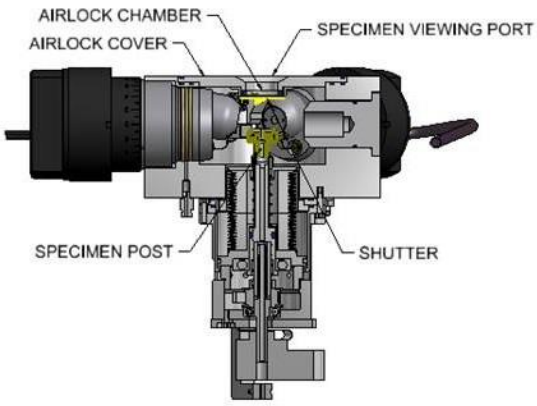
NOTE: When loading a specimen blade, make sure it is properly seated in its lowest position; the height of the blade is critical if the ion beams are to polish at the center of the specimen. Do not force the blade downward into the stage mount. It is best to gently move the blade laterally in a back and forth motion until the blade slides into place.

3.3.2. *To Lower the Specimen Mount/piston*

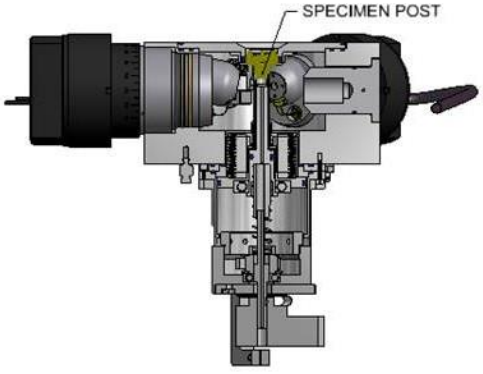
1. **Replace the Airlock cover.**

2. **On the Stage tab, slide the stage down to start evacuation and to lower the stage.**

Figure 3-36 Lowering the stage



Specimen mount in working position



Specimen mount in raised position

Figure 3-37 Specimen mount in raised and working positions

3.4. Specimen Viewing

The Ilion+ II has been designed so that the specimen is clearly visible both with the naked eye or with the stereo microscope or camera either raised (in the Airlock) or in the lowered position (in the Work Chamber). The wide-angle view with the naked eye is necessary when aligning the PIGs using the Beam Alignment Screen. The microscope/camera view is essential when determining if the milling is sufficient.

3.4.1. *Illuminator*

The Reflection (top) illuminator is controlled by the GUI. The illuminator is enabled or disabled using the button at the top of the slider. Turn the illuminator on/off by touching the View button on the Milling, Recipe, or Alignment pages or the Live View button on the Camera page. 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%.

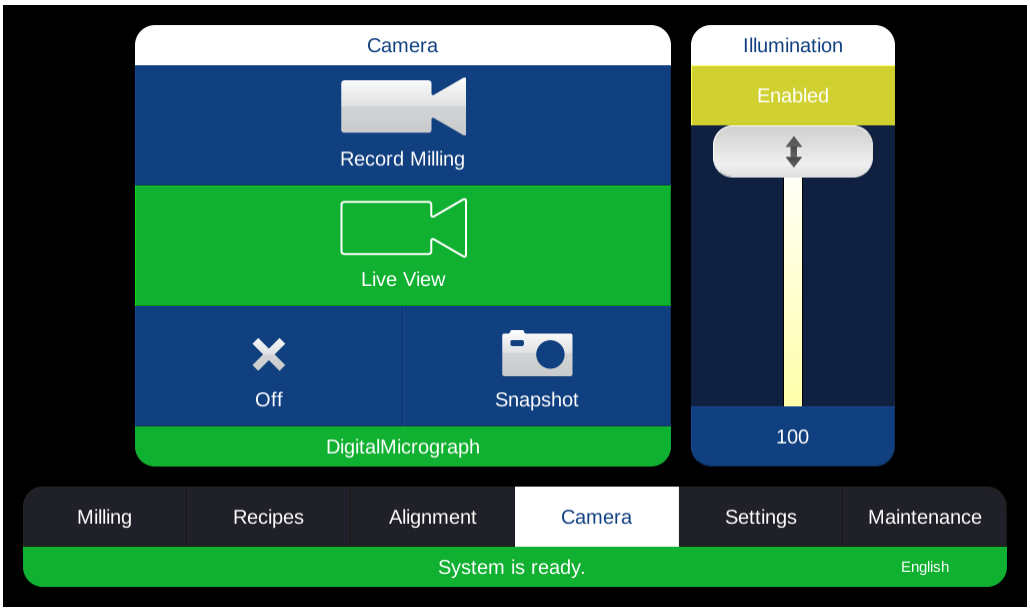


Figure 3-38 Camera page.

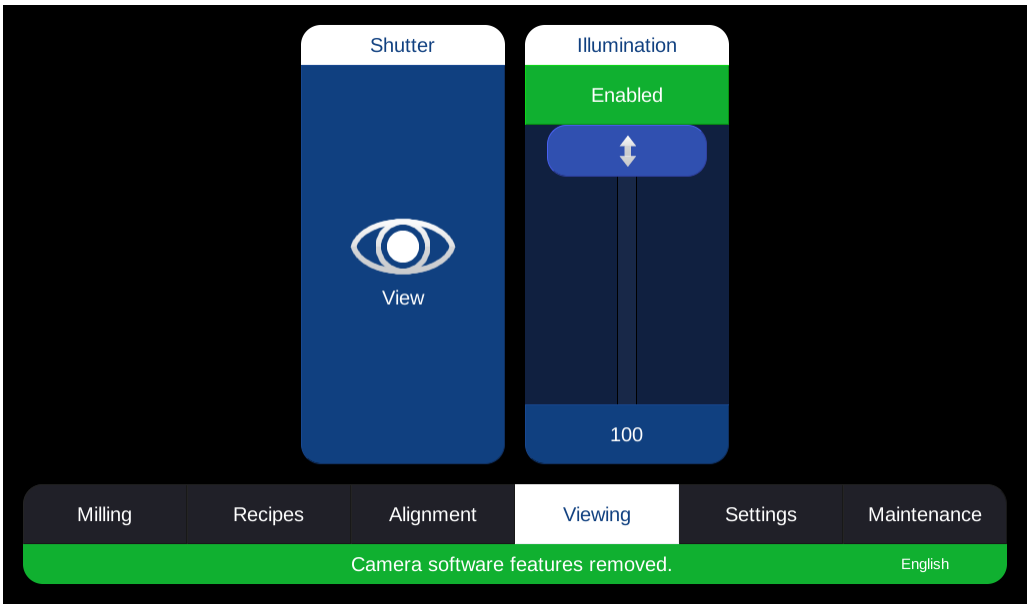


Figure 3-39. Viewing page.

3.5. Shutter Control

The Shutter protects the specimen Viewing Port from sputter deposits, operates automatically, and is keyed to the Start and View buttons in the Milling and Recipe tabs and the View and Live View buttons in the Alignment and Camera tabs respectively. It closes when milling starts and retracts when milling stops. The Shutter will also retract when the piston is raised. Similarly, the shutter retracts when 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.

3.6. 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 prior to raising the stage into the airlock.

3.7. 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.

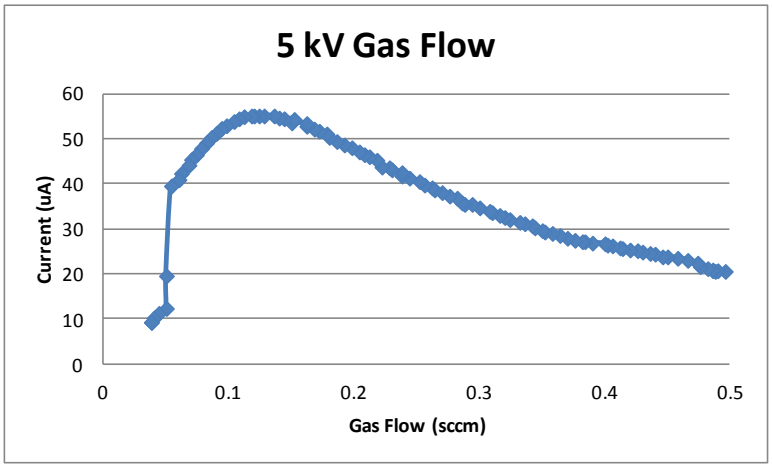


Figure 3-40 Operating characteristics of the PIG

The gas flow can be adjusted either automatic or manually. For consistent and best performance, Gatan recommends setting the gas flow to automatic.

3.7.1 *To Adjust the Gas Flow Automatically*

1. **On the Milling page, select Automatic for the Gas Mode.**
2. **Set the milling energy.**
3. **Start milling.**

3.7.2 *To Adjust the Gas Flow Manually*

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 3-41 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. **On the Milling page, select Manual for the Gas Mode.**

2. Set the Rotate Speed control to 3 rpm (Milling page, Gas flow controls).

3. Be sure Beam Modulator is set to single.

4. Lower the stage by sliding the slider on the Stage panel on Milling page. This lowers the piston to its working position.

5. Adjust the Ion Gun voltage to the desired keV. Set the gas mode to Manual, and the flow of each gun to 0.1 sccm.

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

7. Go to the Maintenance / Guns / Gun Readings page.

8. Adjust the right gun gas flow. Find the gas flow correlating to the peak current. A typical curve relating gas flow to ion current is shown in Figure 3-41. The operating point indicated has been chosen because it gives the most focused beam and the highest milling rate.

Adjust the gas flow by pressing the up and down arrows below the Faraday cup readings. Allow a few seconds for the readings to stabilize after each adjustment. Continue adjusting up and down until the maximum Faraday cup current is found. That is the optimal gas flow.

9. Adjust the left gun gas flow. Repeat for the left gun.

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.

3.8. 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 Ilion$^+$ II must be aligned mechanically. This is done with the aid of the Beam Alignment Screen.

This Screen inserts into the standard specimen mount and is precisely positioned at the standard specimen height. It consists of a large fluorescent screen with a 1.2x0.5mm hole at its center. After lowering the Screen to its standard working position the guns are turned on. The ion beams need to be aligned separately. A 5x loupe is provided to aid in viewing the beams.

3.8.1 *To Align the Beam*

1. **Insert the alignment screen and lower the stage**.

2. **On the Milling page:**

    a. Set the stage rotation speed to 6 RPM.

    b. Set the gun voltage to 5 KeV.

    c. Set the gas flow control to Automatic.

    d. Set the modulation to Single.

    e. Set the timer to 30 min.

    f. Start milling.

3. **Go to Alignment page and bring the stage to the Left Front Beam Sector of this gun.**

4. **Make sure the gun is at 0° tilt.**

5. **Open the Shutter by pressing the View button**

6. **Adjust the z-alignment drive screw (vertical adjust).** While viewing the beam contacting the phosphor screen, use the multipurpose tool or a 2 mm hex tool to adjust the z-alignment drive screw (Figure 3-42).

7. **Adjust the beam until it is evenly centered around the hole on the phosphor screen**.

8. **Do the same for the x-alignment drive screw(horizontal adjust).**

9. **On the Alignment page, rotate the stage to Right Front Beam Sector and do the same for the right gun.**

Figure 3-41 X and Z-alignment device screws

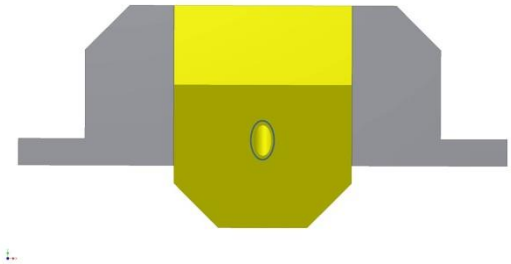


Figure 3-42 Alignment ellipse observed on the beam alignment screen.

3.8.1. *Installing gun alignment knobs*

The set screws used for alignment can be replaced with optional gun alignment knobs. This allows for faster alignment since a tool is not necessary. Since the knobs are easily accessible, they may also be accidentally bumped, which could cause misalignment. Be very careful not to bump the knobs during operation.

To install gun alignment knobs:

1. Using the alignment tool, remove the set screws from the gun knob.
2. Install the gun alignment knobs. The shorter version should be installed in the hole closest to the "TOP" label.
3. Align guns as described above.

Some systems include gun alignment knobs as part of the accessory kit. They may also be ordered as a kit: 695.09816 Kit, Alignment Knob; which includes 2 of each.

Figure 3-43 Gun knob with gun alignment knobs installed.

Caution: Gun alignment knobs MUST NOT be used with motorized guns. Doing so will result in damage to the system that is not covered by warranty.

3.9. Ion-beam Modulation

Ion-beam modulation, called single beam modulation on the gui, is used primarily for polishing cross-sectional 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. With this feature, the ion beam is turned off when the blade and attached sample are not oriented to take advantage of the beam. When using the planar sample holder the modulation is turned off as the whole area of the sample is exposed to the guns at all times.

The default sector size is 60° (±30°). This can be changed on the Milling tab, or by using a custom recipe.

3.9.1 *Ion-Beam Modulation Selection*

This panel enables selection of gun modulation as the sample rotates:

Cross Section (Single Modulation): The system is operating in the single-sector mode. This activates each gun during the polishing sector when the blade face side 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.

Planar (No Modulation): Beam modulation is disabled and there is continuous milling by both guns. This mode is typically used for planar samples.

Dual Modulation: The system is operating in the double-sector mode. This activates each gun during the polishing sector when the blade face and notched side 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. This mode is typically used for 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.

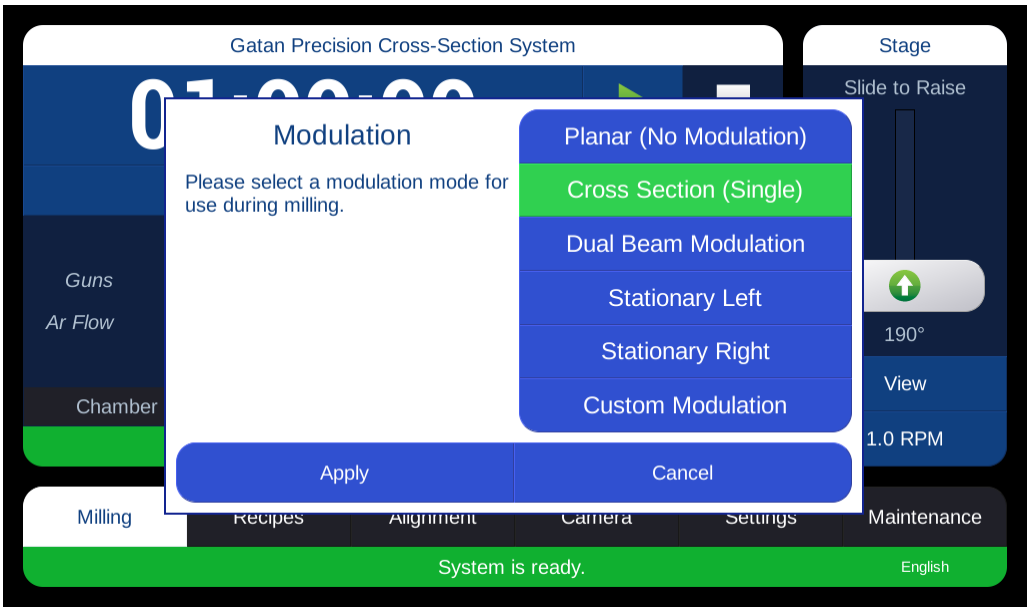


Figure 3-44 Modulation modes

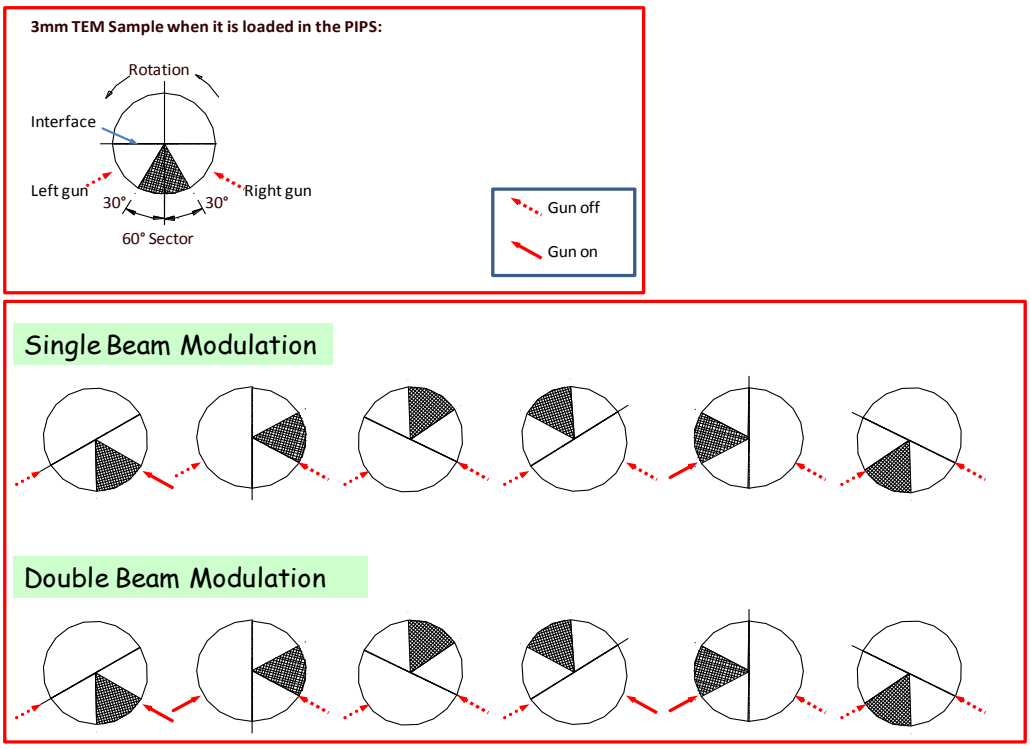


Figure 3-45 Beam modulation

3.10. Manual Shutdown Procedure

Main power to the Ilion^{+} 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.

4. Specimen Preparation

Please follow the recommendations in this section to preserve the quality of the sample blade. Mishandling of the blade will result in shortened blade life span and/or poor quality cross sections.

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

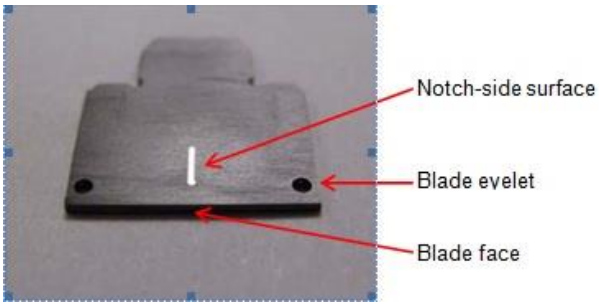
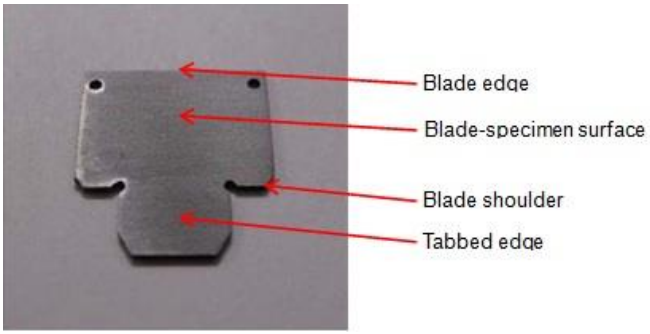


Figure 4-2 Sample blade-specimen surface



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

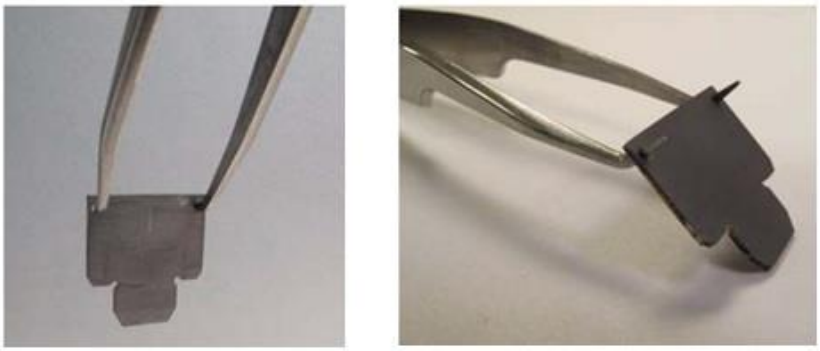
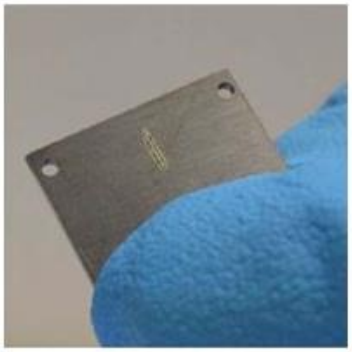


Figure 4-4 Sample blade handling without tweezers



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.

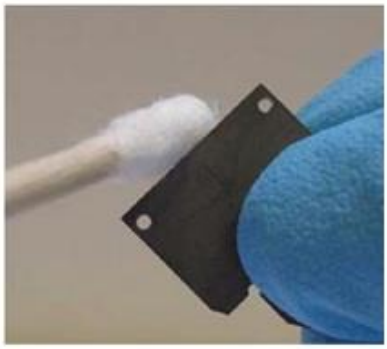
To Properly Clean a Sample Blade

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

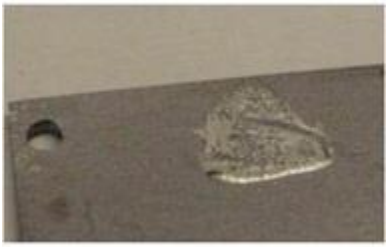


3. **Rotate the cotton swab and repeat until all visible Ag paint is removed from the blade surfaces**

   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**

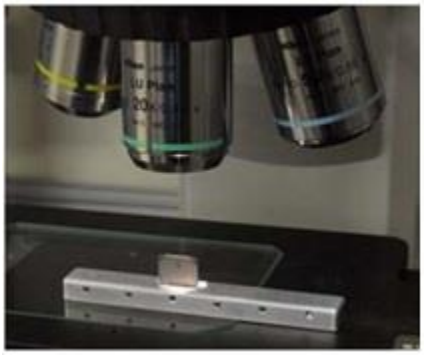
Figure 4-6 Ag paint residue on a sample blade-specimen surface



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

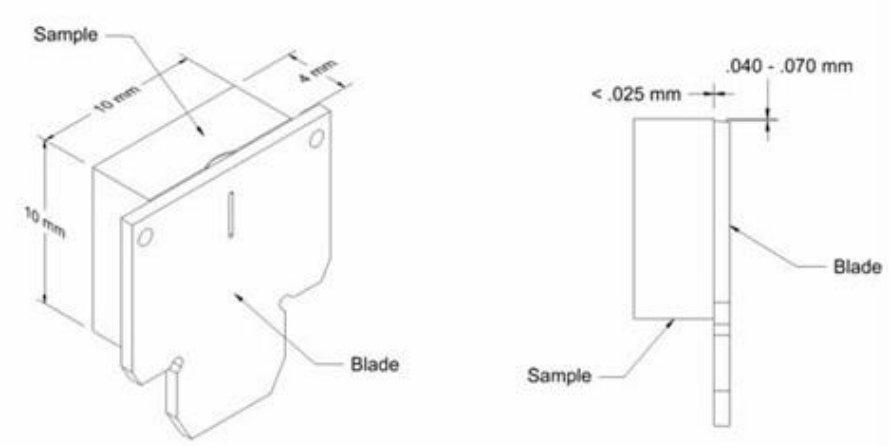
4.5. Basic Specimen Preparation

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.

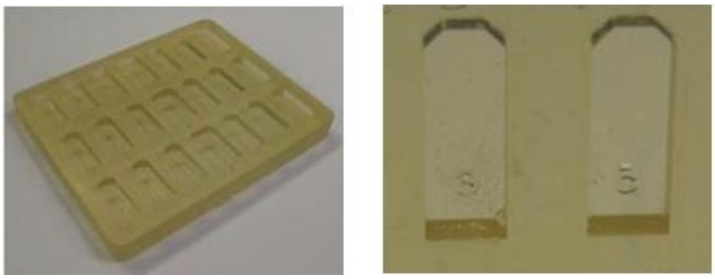
Note: Gatan recommends the following potting medium

- 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 speci- men to the mixture. Combining the particles and epoxy can be done in a mix- ing 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

1. 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

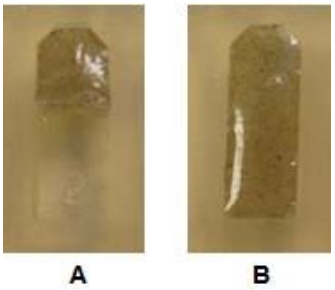


Image A exhibits the top-down view of particle mixture in a Silicone mold created with a Teflon-coated piece of Si used as a shim. In image B, the mold is completely filled with the particle mixture.

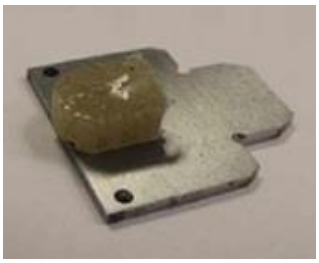
Note: The silicon rubber mold with the mixture can be inserted to a chamber connected to a vacuum pump to remove air bubbles for a more thorough embedment of the specimen. A low pressure environment is all that is required for this to function. It is the users responsibility to research and test this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

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

3. **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).

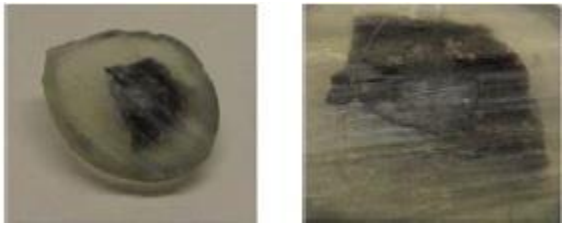
3. **Allow the epoxy time to set (refer to the manufacturer's instructions)**

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.

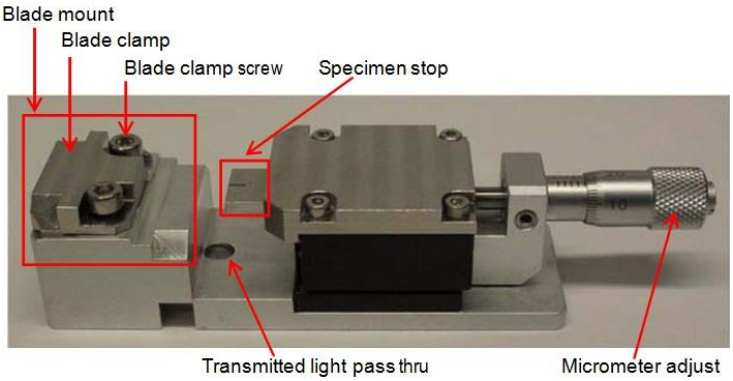
Backside Thinned-specimens

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

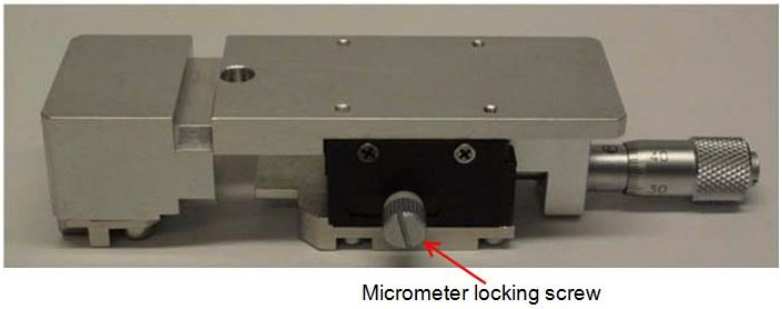
The standard loading dock is provided with the instrument. The specimen is applied face down, so the area of interest is out of view during the mounting process, therefore, it is important to follow the parameters and suggestions offered in Section 4.5. If the area of interest is a known distance from 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

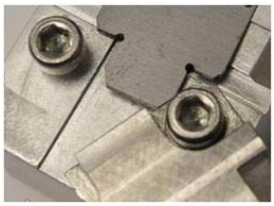
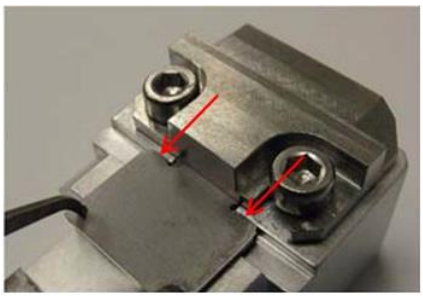


Figure 4-27 Loading the sample blade into the blade mount



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**

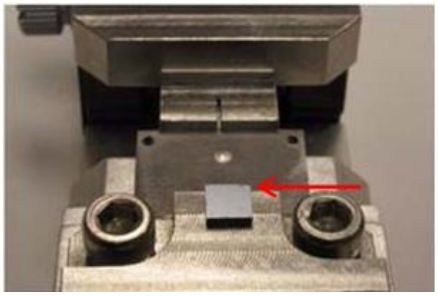
   Verify the mount and sample blade are clean. Set the specimen face down on the blade mount, cut edge toward the blade edge.

   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.**

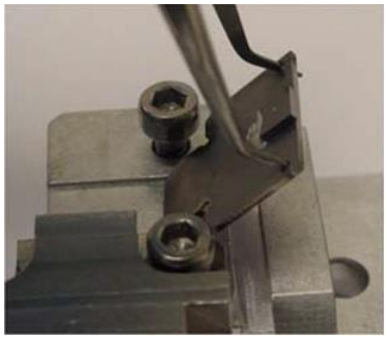
   This will help to minimize the gap distance between the blade edge and specimen surface. Remember, the distance between the blade edge and the specimen should not exceed 25 µm. Allow paint to dry (2-5 minutes or until paint is thoroughly dry).

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

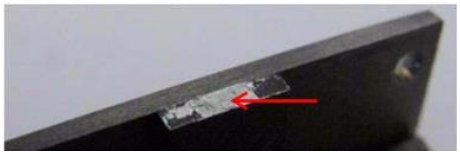
8. **While the blade clamping screws are loosened, move the blade clamp and remove the sample blade by securing it with tweezers through the eyelets.**

   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

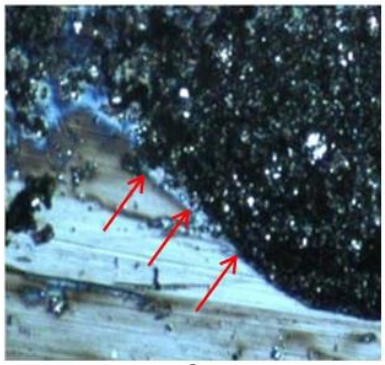


4-31 Ag paint on Si specimen

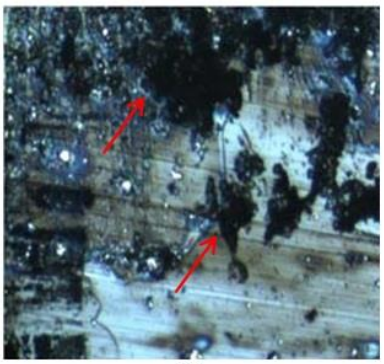


The red arrows indicate where the Ag paint is located on a polished Si specimen.

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



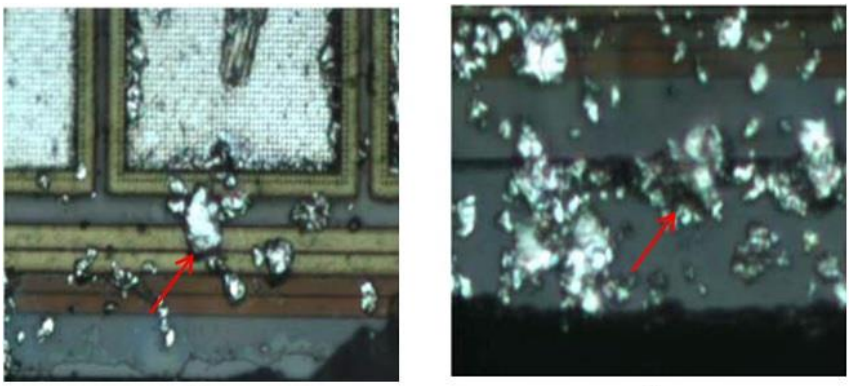
A



B

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.

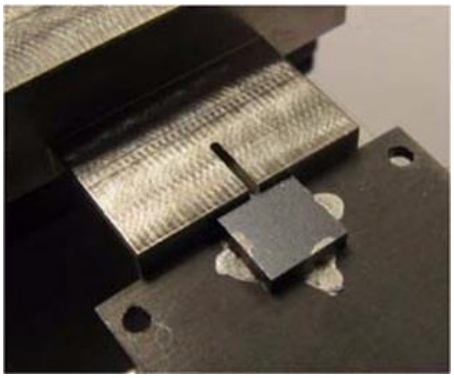
3. **Remove the loading dock from the LM stage.**

   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**

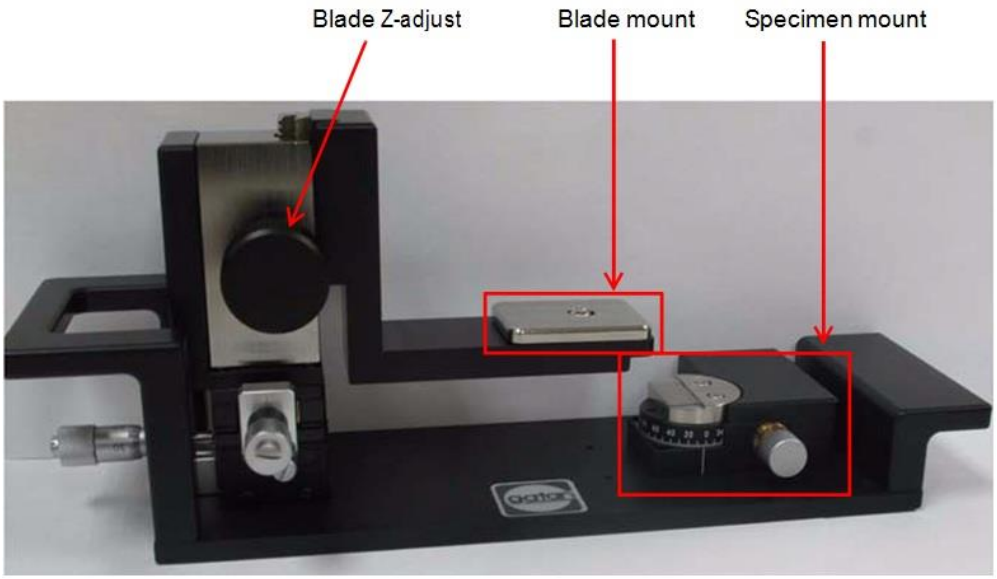
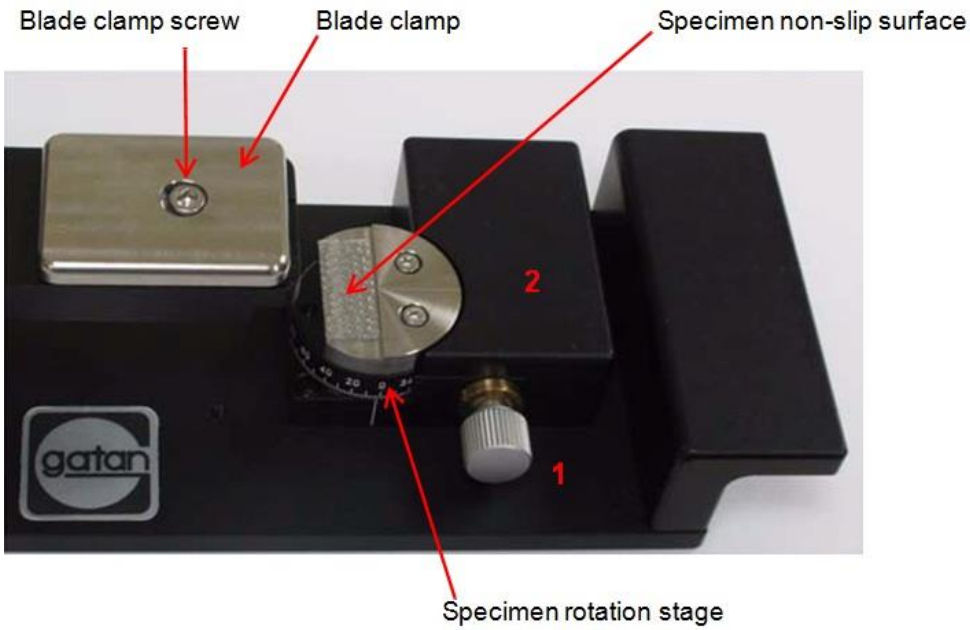
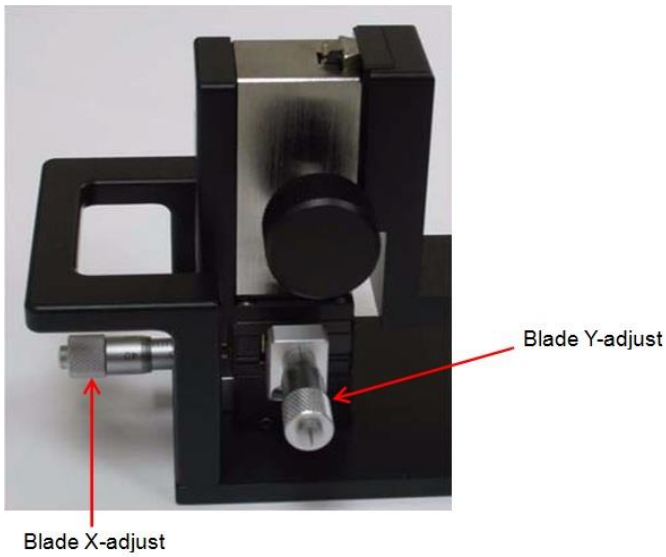


Figure 4-36 Site-specific loading dock sample blade mount and rotatable specimen mount



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.

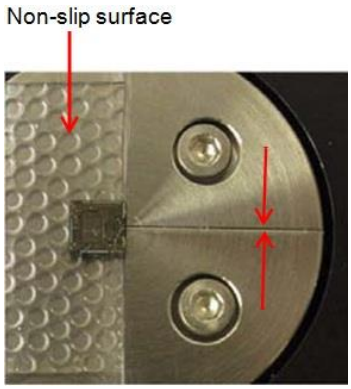
1. **Move the blade mount up, with the black blade z-adjust knobs, and away from the specimen platform, with the x-micrometer adjustment, located at the end opposite the specimen platform.**

   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).**

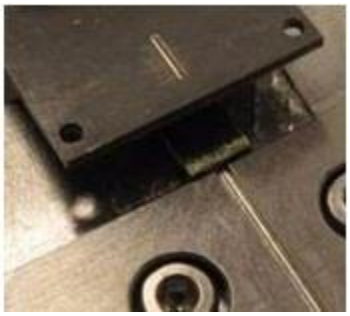
   Seat sample blade, notch-side up, and use the provided tweezers to maintain that the shoulders of the sample blade are flush against the blade mount. Tighten the clamp screw to fix the sample blade. Drive the blade mount with the y-adjust to position the blade within a few millimeters from the stop. 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.

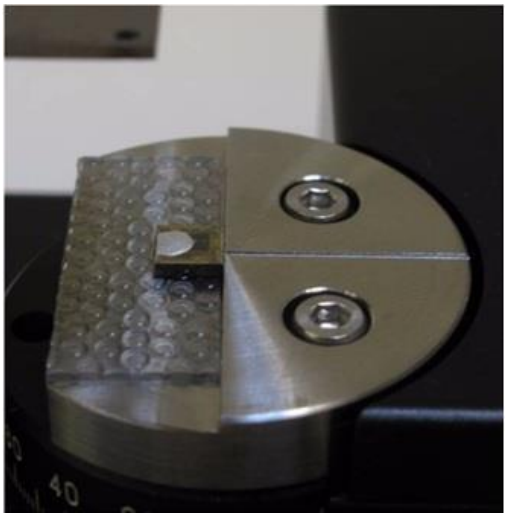
Figure 4-42 Site-specific loading dock on Light Microscope stage

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.	Weekly	Specimen viewing becomes difficult.
Clean Airlock vacuum seals.	Monthly	Piston will not fully rise into Airlock.
Clean specimen mount assy.	Every 3 months	Blade becomes difficult to insert/remove.
Clean Cold-Cathode gauge tube.	As required	Erratic vacuum reading or no reading.
Clean Shutter.	Every 3 months	Sputtered material falling onto specimen.
Dry clean the PIGs.	As required	Gun shorted.
Wet clean the PIGs.	Once a year	Excessive sputtered material.
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.
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 sample mount.	As required	Impossible to insert/remove blade.
Replace bellows assembly.	As required	Chamber vents when stage is lowered.
Set Specimen height.	As required	Specimen height incorrect.
Replace gas manifold.	As required	Ar or vacuum leak or valve malfunction.

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

5.1. Cleaning the Viewing Port

The Viewing Port should be cleaned on a weekly basis with regular use.

NOTE: This operation can be performed without requiring the Ilion$^+$ II to be shut down and vented.

NOTE: Perform this wearing latex gloves to keep skin oils off the window.

1. **Raise the stage and vent the Airlock chamber (Milling Screen).**
2. **Lift off the Viewing Port capsule.**

3. **Check the capsule O-rings. Clean them. If necessary, replace.**

4. **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.

5. **Replace the window into the capsule O-rings.**

6. **Replace the Viewing Port capsule.**

7. **Evacuate Airlock chamber.** Slide down the slider on the Stage panel, while pushing down on the window to properly seat it.

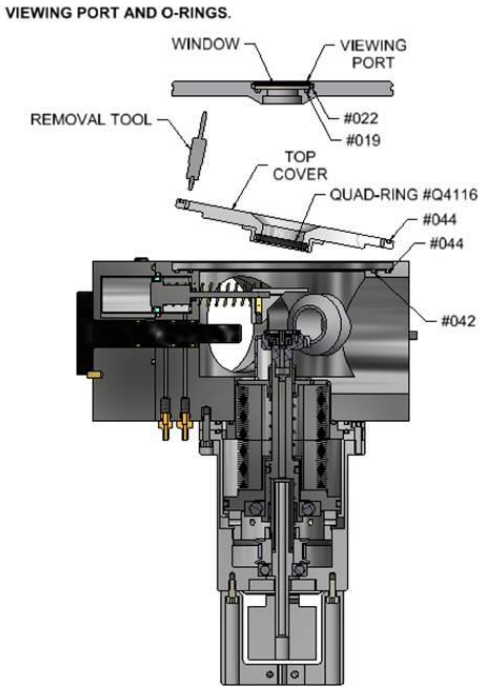


Figure 5-1 Viewing port and o-rings

5.2. Cleaning the Airlock Vacuum Seals

The Airlock vacuum seals should be cleaned on a monthly basis with regular use.

NOTE: This procedure is necessary when the piston cannot be completely raised to its upper position due to buildup of sputtered material on the Airlock O-ring.

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 Ilion$^+$ 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.

3. **Lift off the Viewing Port.** Press the Airlock piston down into the Work Chamber if it hasn't already lowered itself.

4. **Remove top cover plate.** Using the pin end of the Specimen Mount Removal Tool, insert the pin into one of the holes in the top cover plate, push gently and tilt the plate up and out for removal.

5. **Remove the large O-ring from the top cover.**

6. **Remove the smaller O-ring from its groove in the cover.** Use a wooden toothpick or o-ring removal tool to remove the O-ring. Never use a metal tool to remove an O-ring.

7. **Clean the underside of the plate and the O-ring grooves with a grease solvent.**

8. **Clean the O-rings on the chassis with with a lint-free cloth.** It is usually not necessary to lubricate these o-rings, however, if they do not seal properly after cleaning they may be lubricated with Krytox GPL-206 vacuum grease (supplied with the system).

9. **Clean the Airlock quad-ring with a grease solvent and lubricate with Krytox GPL-206 vacuum grease.**

10. **Replace the Top Cover plate, the Viewing Port, 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.

5.3. Cleaning the Specimen-mount Assembly

Sputtered material can build up inside the specimen-mount assembly, and should be cleaned if it begins to impact performance. For example, a large amount of material built up on the bench of the mount can affect the height at

which the blade is held. Disassemble the specimen-mount assembly and clean the parts with alcohol.

The system should be shut off and vented prior to disassembly of the specimen mount assembly. If you press downward on the specimen-mount assembly you could move the stage piston downward and cause an immediate venting of the vacuum chamber.

It is good practice to clean the Airlock quad-ring any time the system is vented.

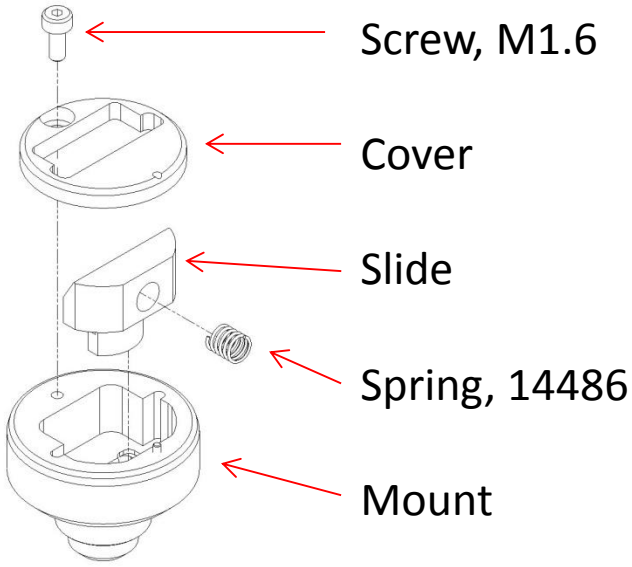


Figure 5-2. Sample mount.

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 the pressure reading on the Penning meter to read above 10^{-3} Torr. If this occurs, the gauge tube must be dismantled and cleaned as soon as conveniently possible.

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

5.4.1 *To Disassemble the Gauge Tube*

1. Shut down the power to the Ilion$^+$ 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.

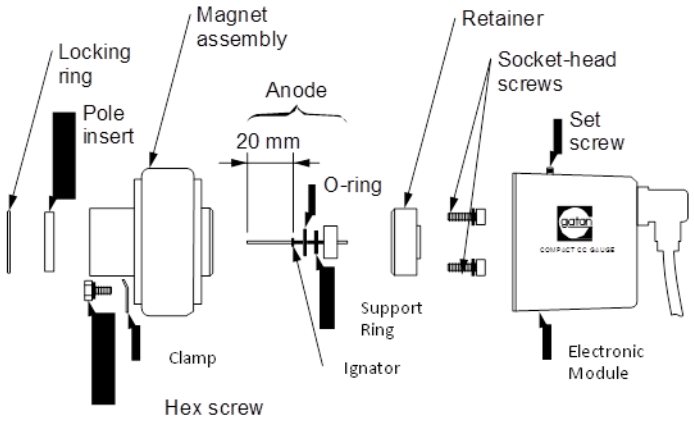


Figure 5-3 Cold-cathode gauge tube

5.4.2 *To Clean Gauge Tube Parts*

1. Clean the inside of the tube and the front pole insert. Use a "Scotchbrite" 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 Ilion$^+$ II, and pump down the system.**

Caution: Do not allow the Ilion$^+$ 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 Shutter

The pneumatically operated Shutter is designed to operate for an extended period of time with only a minimal amount of maintenance. The Shutter prevents buildup of sputtered material on the viewing window and instead accumulates material on its underside.

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 underside of the Shutter must be examined and cleaned periodically, every 3 months or so with regular use.

1. **Raise the stage and vent the Airlock chamber.**

2. **Shut down the power to the Ilion$^+$ 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.

3. **Lift off the Viewing Port.**

4. **Press the Airlock piston down into the Work Chamber.**

5. **Remove the Top Cover plate with the Removal tool.**

6. Pull out the Shutter Guide. Grasp the Shutter Guide at the front of the chamber and pull it straight out.

7. Rotate the Shutter manually 90°-180° to view the underside. It may help to pull the shutter slightly forward into the chamber to allow it to rotate easily.

8. Use a tissue saturated with freon or methanol and wipe off the underside. If the shutter is relatively clean, it may only require manual wiping.

9. Remove the Shutter for more thorough cleaning. If a more thorough cleaning is required, the Shutter must be removed by unscrewing the M2 × 6 mm retaining screw.

10. Clean the Shutter. Sputter deposits on the Shutter should be removed with an abrasive cleaner after which the Shutter should be cleaned with hot soapy water and thoroughly dried before replacing in the chamber.

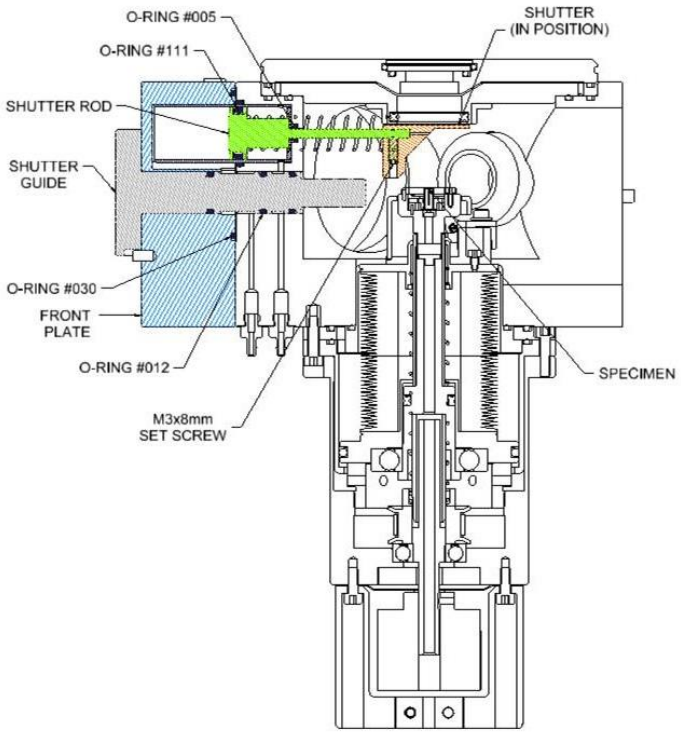


Figure 5-4 Cleaning the shutter

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

Good care and maintenance of the PIGs are absolutely essential to obtaining good specimen milling. 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 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.

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

Caution: any time the work chamber is vented, the guns must be purged for 4-5 hours before milling samples. 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 double sided tape 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.

To Remove the Gun:

1. Shut down the power to the Ilion$^+$ 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 Ilion$^+$ II.

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. 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.

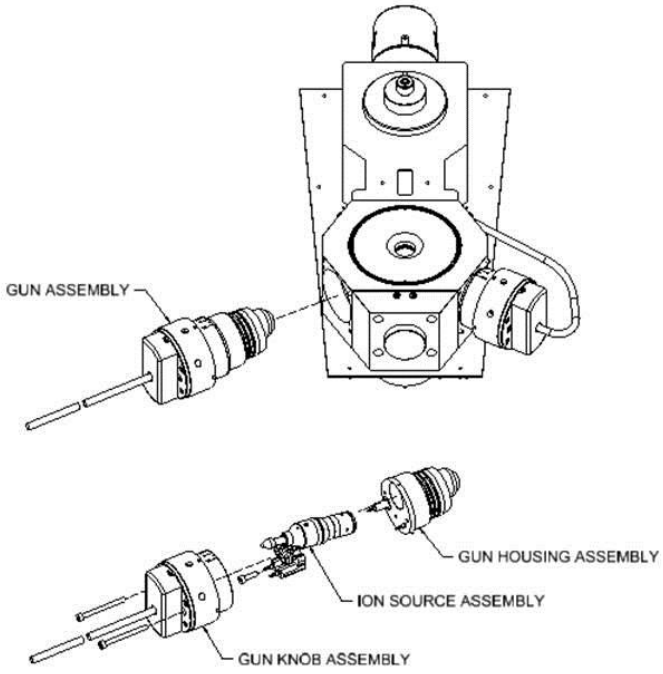


Figure 5-5. Removal and disassembly of ion guns.

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 10x stereo microscope.

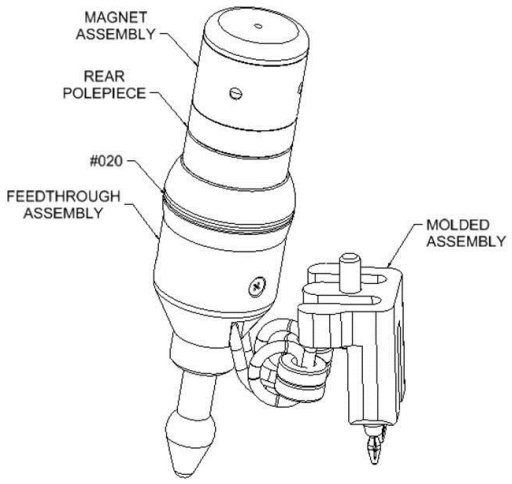


Figure 5-6 Ion source and magnet assembly

To Disassemble the Gun:

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 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 the 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.

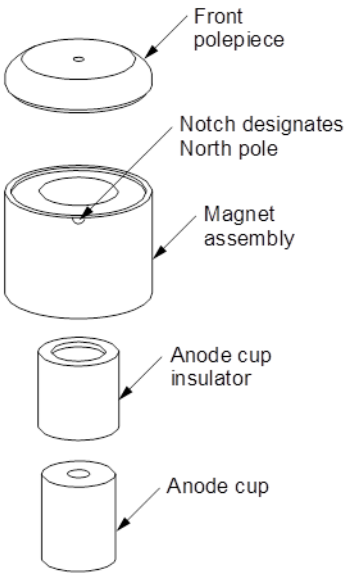


Figure 5-7 Removal of anode assembly and anode cup insulator

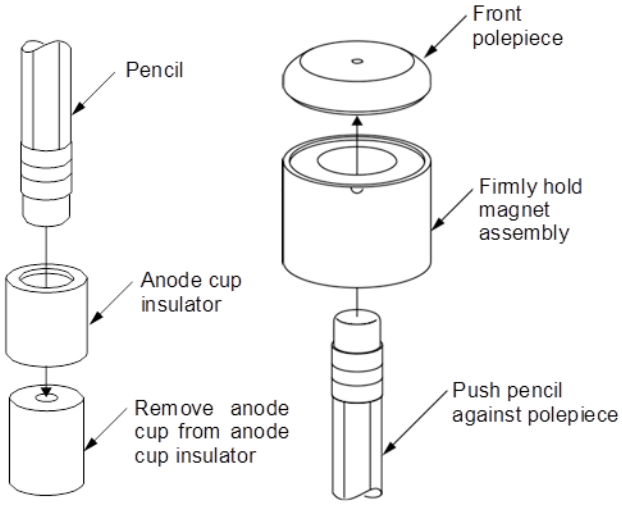


Figure 5-8 Removing anode cup assembly/front pole piece

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. 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. 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 (Fomblin), and replace.

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

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 perfectly concentric to one another.

4. Slip the ion source into the gun housing.

NOTE: 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.

NOTE: It is a good idea to clean both guns whenever you are venting the tool to clean a shorted gun.

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 is 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 Ilion$^+$ 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 Ilion$^+$ 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

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.

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.

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.

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.

NOTE: 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.

7. Align ion source in the housing.

Carefully align the white reference dot at the back of the ion source to the mating groove machined into the outside diameter of the gun 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 ohm meter 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. 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 screens.

12. 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.

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 Ilion$^+$ 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 double sided tape. 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 double sided tape.

8. Reassemble the gun housing.

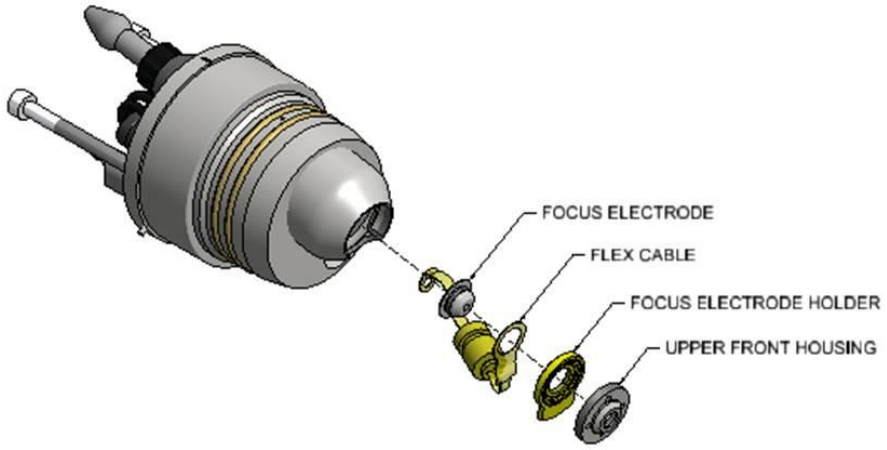


Figure 5-9 Focus electrode assembly

5.7. Removing the Cover

To remove the cover:

1. **Shut down the power to the Ilion$^+$ 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.

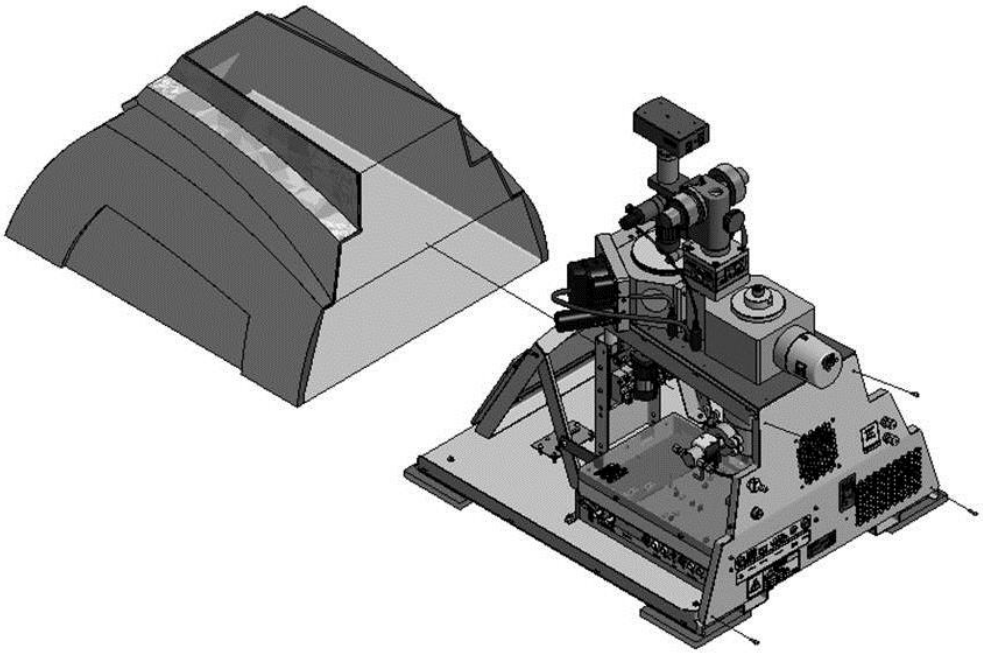


Figure 5-10 Cover removal

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 Ilion$^+$ 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 Ilion$^+$ 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.**

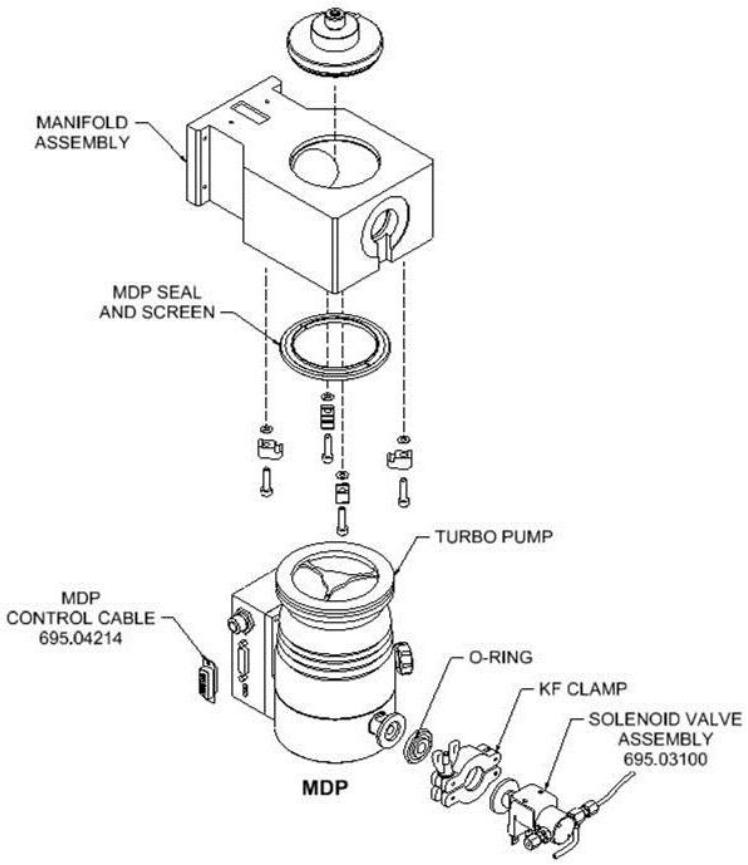


Figure 5-11 Molecular drag pump

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 HipPace 80 TurboDrag Pump Operating Instructions manual (shipped with Ilion$^+$ II).

After the MDP is reconnected to the Ilion$^+$ II, 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 Ilion$^+$ 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 Ilion$^+$ II 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 Ilion$^+$ II).

After the DP is reconnected to the PIPS, 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.

5.10.1 *To Vent and Clean the Work Chamber*

1. Raise the stage and vent the Airlock.

2. Shut down the power to the Ilion$^+$ 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. Lift off the Viewing Port and the Top Cover plate from the 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 Kimwipe. Methanol can be used but it will increase pump down time.

5. Replace the top cover plate and the Viewing Port.

Close the vent valve.

6. Power up the Ilion$^+$ II.

5.11. Cleaning the Shutter Piston

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 needs 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.

1. **Press the Airlock piston down into the Work Chamber.**

2. **Remove the Top Cover plate with the Removal tool.**

3. **Pull out the Shutter Guide.** Grasp the Shutter Guide at the front of the chamber and pull it straight out.

4. **Rotate the Shutter manually 90°-180° to view the underside.** It may help to pull the shutter slightly forward into the chamber to allow it to rotate easily.

5. **Remove the Shutter.** Loosen the M2 × 6 mm retaining screw. Remove the shutter from the shutter piston rod.

6. **Remove the front plate.** Loosen the 4 screws in the front plate. Pull the front plate straight forward. The shutter piston will be pushed out by the spring.

7. **Clean the shutter piston.** Remove any sputtered material from the shutter piston. Inspect the o-rings, replace if they are damaged. Clean and lubricate the o-rings with Krytox GPL-206. Clean and lubricate the inside of the cylinder where the o-ring contacts.

8. **Reassemble all parts.**

9. **Power up the PIPS II.**

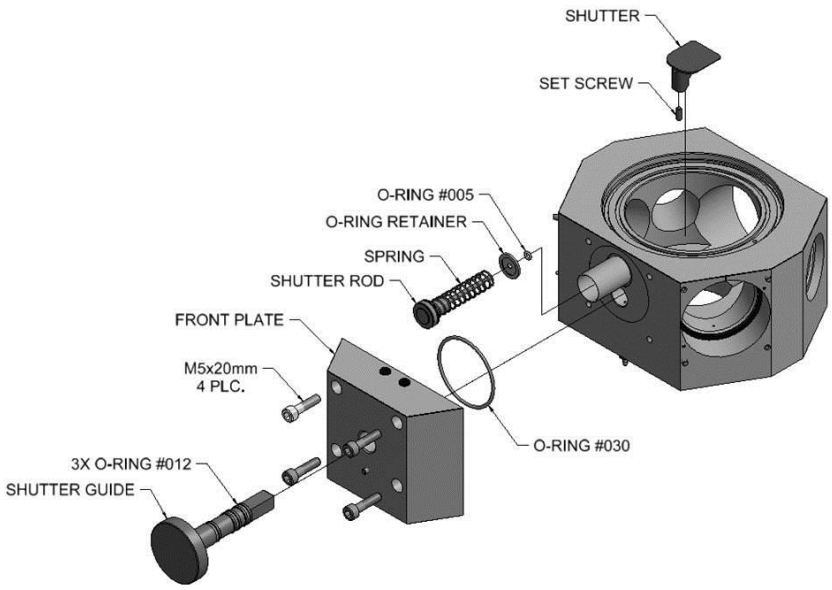


Figure 5-12 Shutter servicing.

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 Ilion$^+$ 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 PIPS 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 Ilion$^+$ II.**

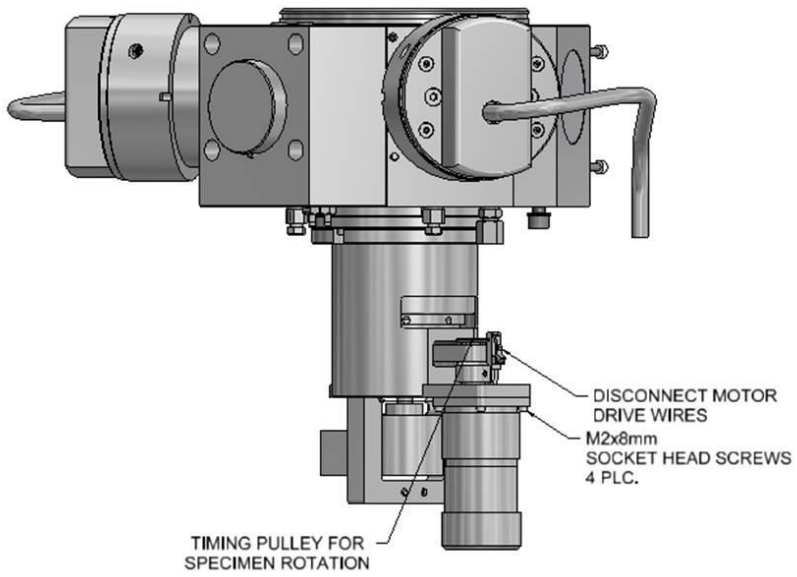


Figure 5-13 Motor Drive Removal

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 Ilion$^+$ II.** Unplug the power cable from the back of the system.

3. **Remove the cover.**

4. Mark the fiber cable with a piece of tape so you can reinstall it at the exact same place.

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

6. Loosen the 2 screws on the fiber cable clamp.

Gently pull the fiber cable downward and remove it.

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

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

9. Re-install the fiber cable.

Be sure it is not inserted farther than previously, or it will interfere with stage lowering.

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

11. Calibrate the stage home position.

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.

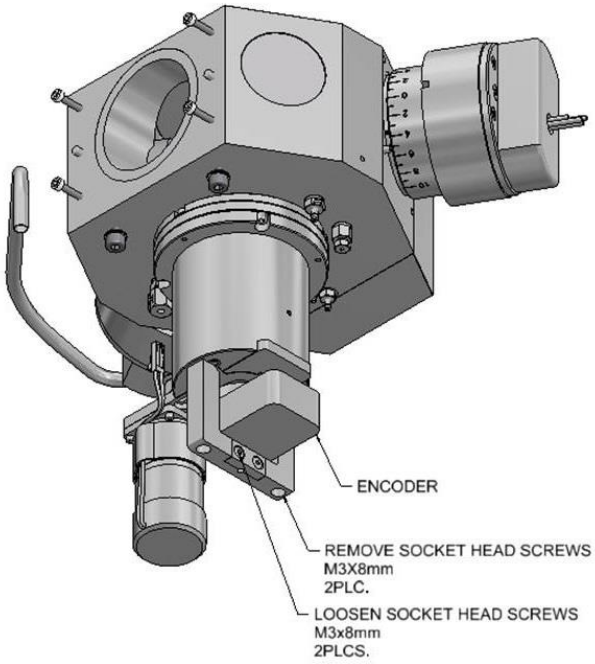


Figure 5-14 Replacing the encoder

5.14. Replacing the Sample Mount

The Sample Mount is located under at the top of the rotate shaft. It does not need to be replaced unless it fails or is damaged, which typically does not happen during the lifetime of the instrument.

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 Ilion$^+$ 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. Lift off the Viewing Port. Press the Airlock piston down into the Work Chamber if it hasn't already lowered itself.

4. Remove top cover plate. Using the pin end of the Specimen Mount Removal Tool, insert the pin into one of the holes in the top cover plate, push gently and tilt the plate up and out for removal.

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.

NOTE: If the specimen mount only rotates but does not unscrew, remove the cover from the Ilion$^+$ II cabinet and manually restrain the timing pulley at the bottom of the Whisperlok to prevent it from rotating while the specimen mount is being unscrewed.

6. Install the new Specimen mount.

7. Replace the Top Cover plate and Viewing Port.

8. Close the Vent valve and turn on the power.

9. 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.

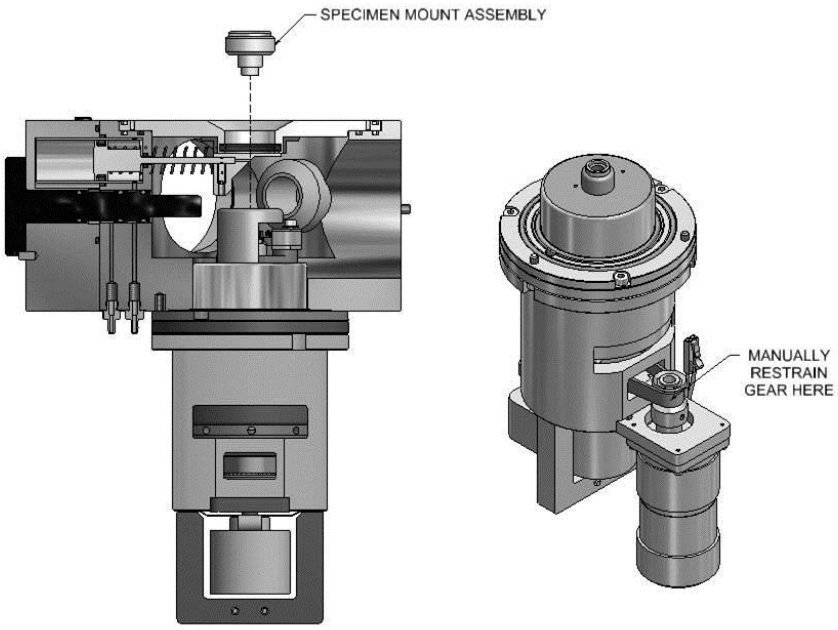


Figure 5-15 Sample mount removal

5.15. Replacing the Bellows Assembly

The Bellows Assembly is part of the Whisperlok™ assembly. It does not need to be replaced unless it fails.

5.15.1. *To Remove the Whisperlok™ Assembly*

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 Ilion+ 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. Lift off the Viewing Port. Press the Airlock piston down into the Work Chamber if it hasn't already lowered itself.

5. Remove top cover plate. Using the pin end of the Specimen Mount Removal Tool, insert the pin into one of the holes in the top cover plate, push gently and tilt the plate up and out for removal.

6. Disconnect the cold stage. If the system has a cold stage, remove the two screws and disconnect the cold stage heater from the hinged conductor assembly.

7. Remove the Whisperlok™ assembly.

a) Unplug the motor drive 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.

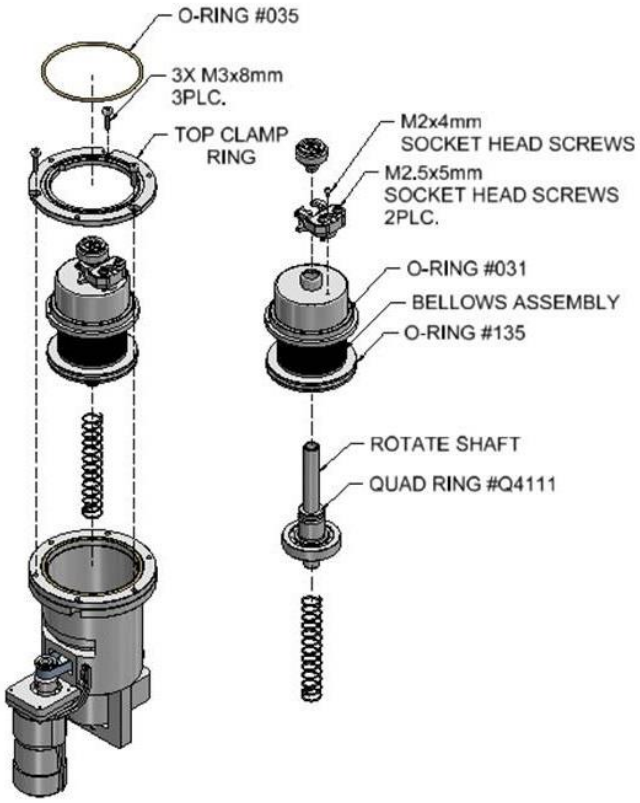


Figure 5-16 Whisperlok assembly

5.15.2. *To Dis-assemble the Whisperlok™ 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. 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.

5.15.3. *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) 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.

16. Purge the guns at least 4-5 hours before milling samples.

5.16. Cleaning the Rotate-Shaft Quad-seal

A quad-ring separates the chamber from atmosphere and allows for rotation of the piston. If this seal begins to leak, then it should be cleaned and lubricated or replaced. When this seal leaks, a pressure burst is typically observed periodically with each rotation. If this is observed, stop rotation and see if the periodic pressure bursts stop. If you see periodic pressure bursts only when the piston is rotating, then this seal is probably leaking. In this case, follow procedure 5.14 to lubricate or replace this seal.

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 hole of the beam alignment screen, then changing the gun tilt from 0 to 10 degrees. As the gun tilt is changed, the beams will increase or decrease in length and rotate about the hole in the screen. The face of the alignment screen is angled at 20 degrees, so if the beam moves upward it will appear as a shift away from the gun and if the beam moves downward it will appear as a shift toward the gun.

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 beam will move toward or away from the guns as the tilt is adjusted. This will result in a lower milling rate from positive tilt on planar samples. If the center of the beam moves by more than about 1 mm, then you should consider adjusting the specimen height as described below.

Note that a slight adjustment in gun alignment can make it seem as though the height is wrong. 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.

1. Check the specimen height during milling. The specimen height should be set so that when the tilt of a gun is rotated from 0 to 10 degreee top the beam always strikes the hole in the alignment screen. The beam is typically aligned to the proper position when striking the sample by using the Beam Alignment Screen provided with the Ilion+ II.

a) If the height is set at the correct height, the beam will strike the hole in the alignment screen from both 0 and 10 degrees top. Note that some movement of the beam is normal as the angle is adjusted.
b) If the height is set too high, the 0 degree beam will be centered and the 10 degree top beam will strike the alignment screen below the hole (toward the gun). Do not worry about left/right movement, only toward/away from the gun.
c) If the height is set too low, the 0 degree beam will be centered and the 10 degree top beam will strike the alignment screen above the hole (away from the gun). Do not worry about left/right movement, only toward/away from the gun.

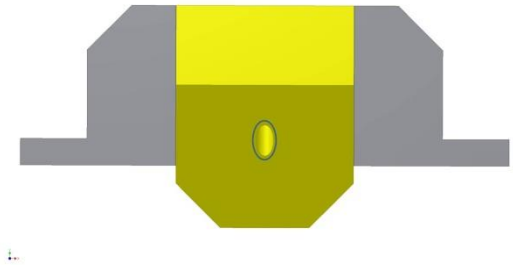


Figure 5-17 Checking the specimen height.

2. Purge the ion guns.

3. Insert the alignment screen into the Ilion$^+$ II.

4. Turn on both guns at 0°, 6.0 keV, single modulation.

5. Adjust the tilt of each gun to align both beams to the hole in the alignment screen.

6. Change the tilt from 0 to 10°, observe how much the beam moves in a vertical direction (along the axis of the beam). If the height is set properly, the beams will move less than 1 mm.

7. In necessary, adjust the height of the sample by inserting an Allen wrench in the holes of the height adjuster and moving the hole to the right or left. The height adjuster is threaded and moving the holes left or right results in lowering or raising the stage height. The stage must be raised into the airlock in order to make an adjustment. Moving the holes to the right will result in raising the stage height. Moving the holes to the left will result in lowering the stage height.

Caution: We recommend that you turn off the power to the system and unplug the power cord from the back of the cabinet before opening the cabinet. Close the cabinet before turning the system back on.

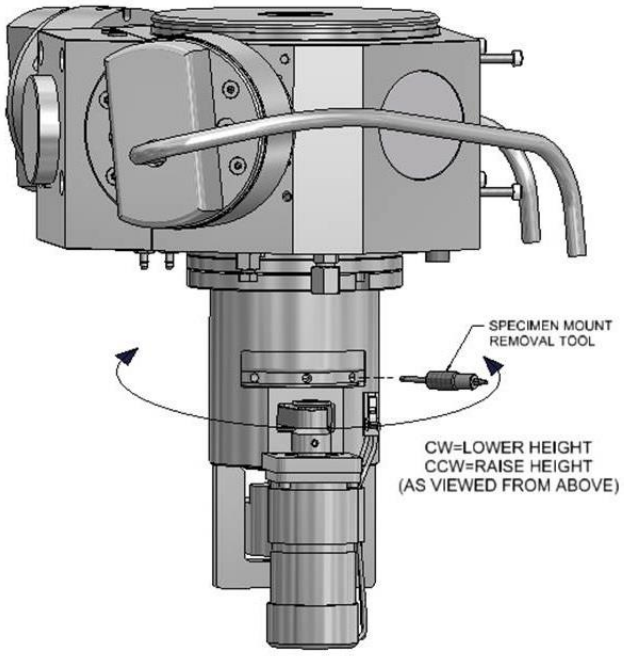


Figure 5-18 Sample height adjustment

8. Repeat the above procedure until the beams moves vertically less than ~1 mm between 0° (alignment screen - adjust tilt of guns) and 10° top (glass screen - adjust height of stage). Note that both guns may not be aligned identically. In this case, find the best compromise height for both guns.

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.

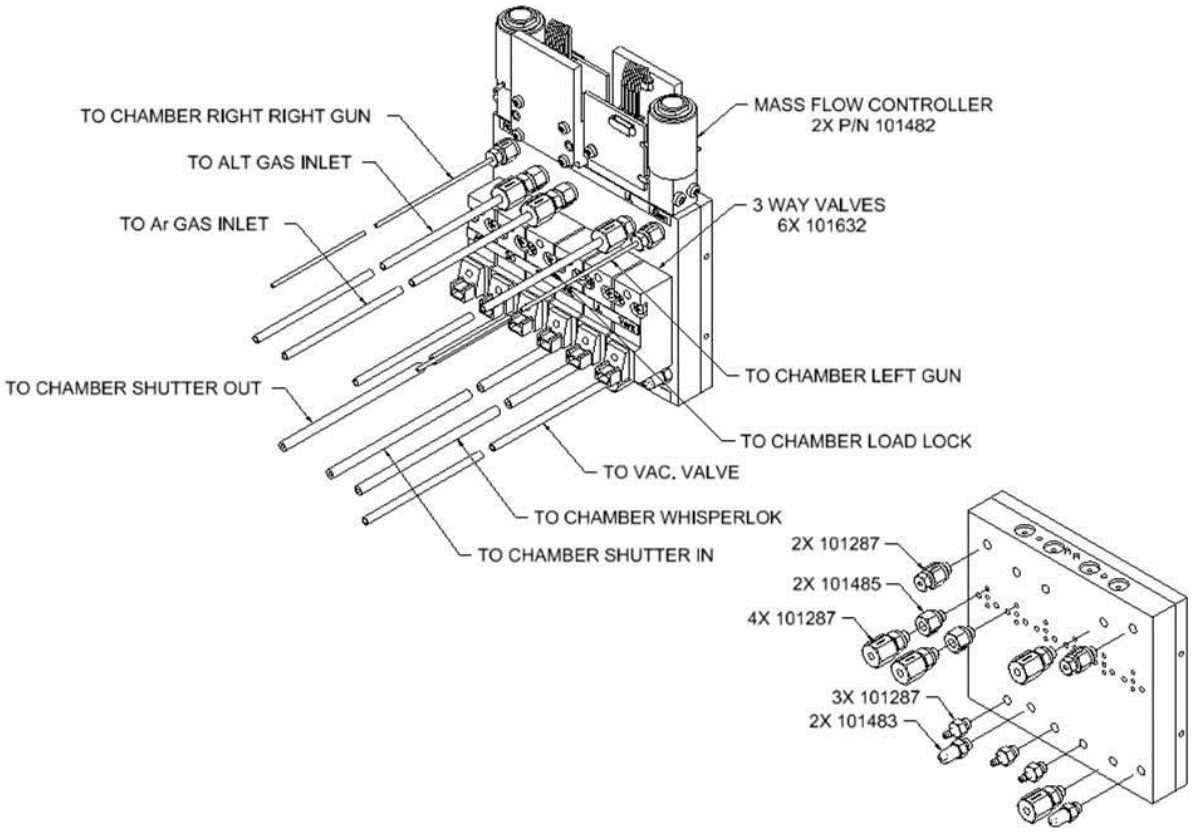


Figure 5-19 Gas manifold assembly

5.18.1 *Removing the Gas Manifold*

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 Ilion$^+$ 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. Turn off the Ar pressure at the regulator which supplies Ar to the system.

5. Unplug the electrical connectors for each of the 6 valves.

6. Unplug the electrical connectors for each of the 2 mass flow controllers.

7. Disconnect the tubing from all of the connectors on the bottom of the work chamber. Remember where each tube was connected.

8. Disconnect the tubing between the gas manifold and the Ar and Alt inputs. This should be done at the cabinet feed through side.

9. Disconnect the tubing between the gas manifold and Vac-valve assembly. This should be done at the Vac-valve assembly side.

10. 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.

11. 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 fitting at each end.

3. Attach the LL and Vac tubing to the gas manifold. This is 1/8” nylon tubing with a Beswick 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 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 PIPS 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.

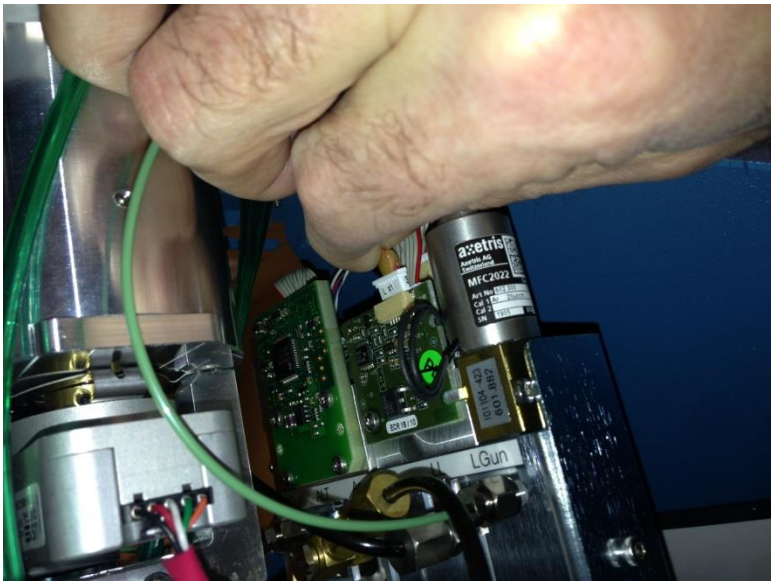


Figure 5-20. MFC removal. Unplugging the power/signal cable from the MFC.

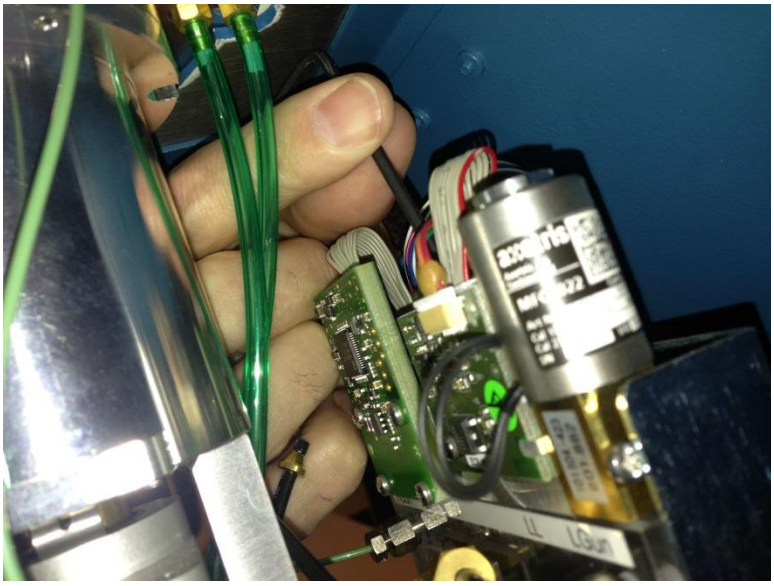


Figure 5-21. MFC removal. Loosening the M3 screw that secures the MFC.

5.20. Replacing the Touchscreen

1. **Shut down the power to the Ilion+ 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 Ilion+ II.** First plug the power cable into the power entry module.

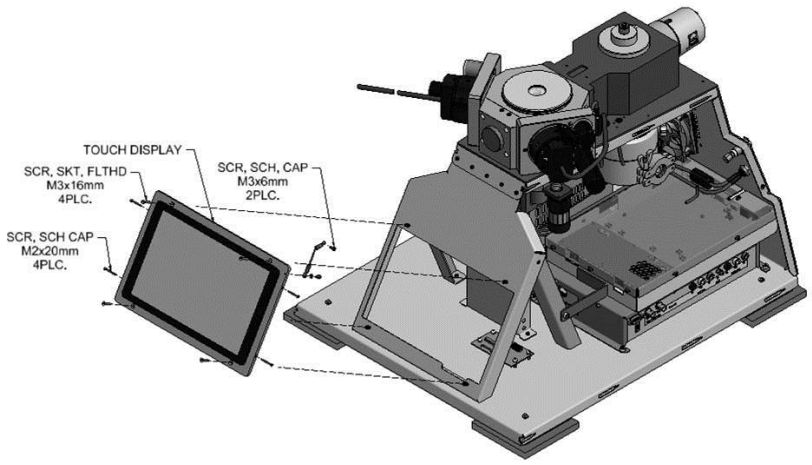


Figure 5-22 Touch display assembly

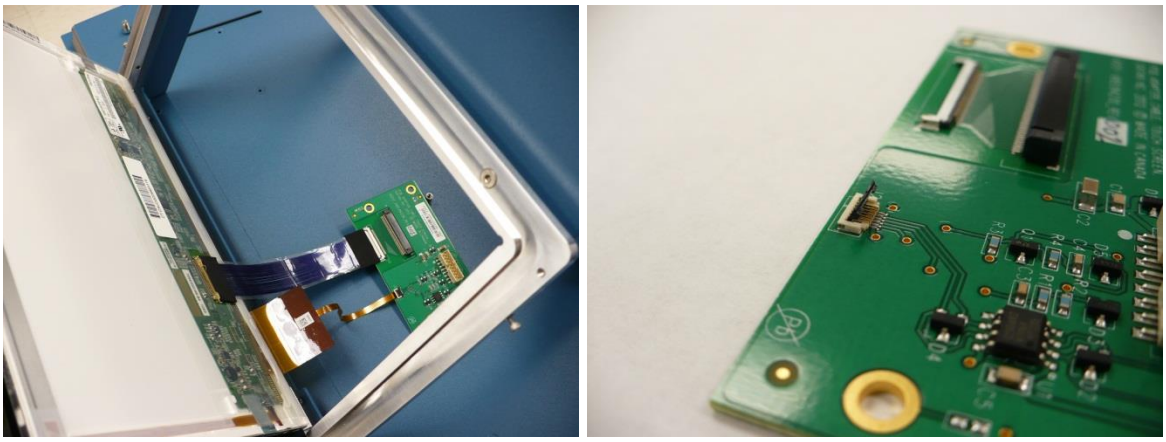


Figure 5-23 Connections for touch display

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.

5.21. Replacing the High Voltage Power Supply

1. **Shut down the power to the PIPS 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.**

8. **Reconnect all the cables to the replacement HVPS.**

9. **Replace the cover**.

10. **Power on the system.** First replace the power cable.

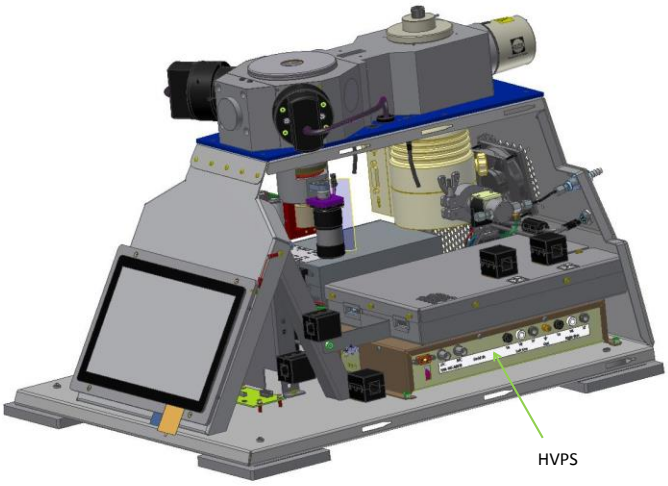


Figure 5-24 HVPS location.

5.22. Replacing the Control PCAs (CPU, I/O)

1. **Shut down the power to the Ilion$^+$ 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. Remove the fiber from the below sample illuminator (BSI) socket.

10. **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.

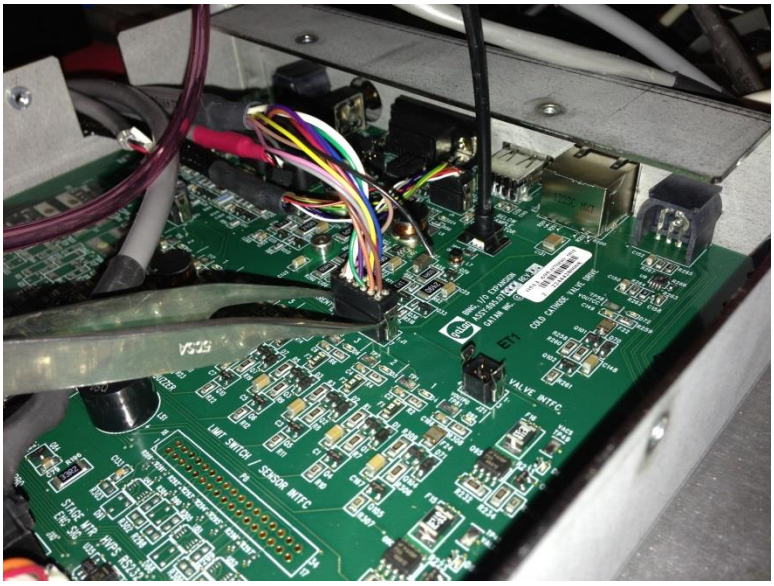


Figure 5-25. Removing cables from the I/O PCA.

11. Remove the 4 screws that secure the I/O PCA.

12. Remove the nuts from the CC Gauge and Dewar connectors on the back of the system.

13. Remove the jack screws from the RS-232 connector on the back of the system.

14. Remove the PCAs from the PCA enclosure.

15. Install the new PCAs. Replace the 4 screws, the 2 nuts, and the 2 jack screws.

16. 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.

17. Replace the electronics enclosure cover.

18. Replace the system cover.

19. Power on the system. First replace the power cable.

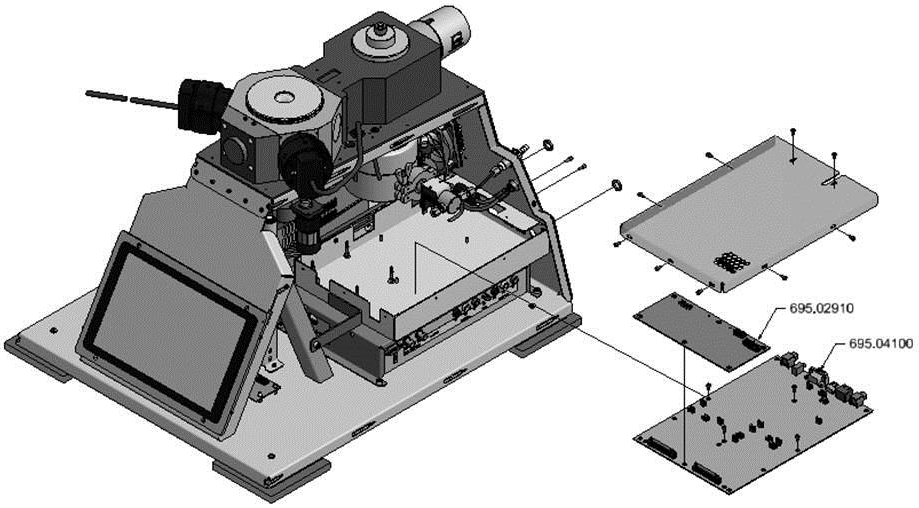


Figure 5-26 PCA assembly.

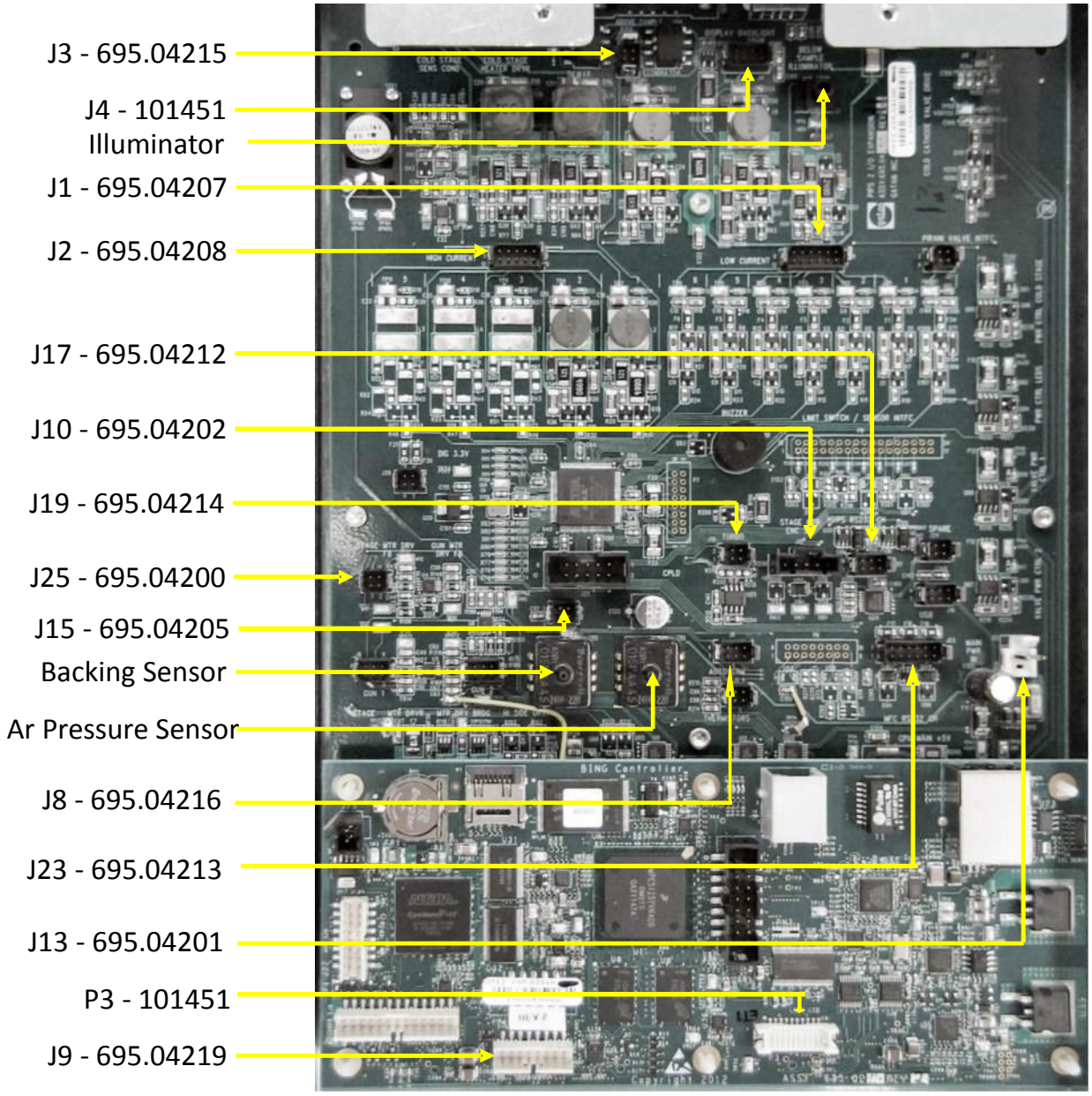


Figure 5-27 PCA connector locations and associated cable part numbers.

5.23. List of O-Rings

Description	Size	Quantity	Location
Diaphragm Pump Assembly	012	1	DP fitting
	M4.5x1.4mm	1	DP fitting
Chamber Assembly	022	1	Airlock window
	019	1	Airlock window
	044	2	Airlock/chamber top
	042	1	Chamber top
	Q4116	1	airlock
	005	1	Shutter piston
	111	1	Shutter piston
	017	1	Front plate
	030	1	Front plate
	012	3	Shutter guide
Beam Stop	022	2	Beam stop
Whisperlok Assembly	004 GLV	1	Sample mount
	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
	030	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
Cold Stage Dewar	039	1	Dewar port
	014	1	Electrical feedthru
	112	1	Vent valve
Gas Manifold	008	4	MFC

5.24. 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
Vacuum valve	695.04208	1	J2
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	695.04217	2	Top panel
Camera trigger	695.04218	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)

6. Trouble Shooting

Symptom	Problem cause	Solution
Chamber pressure display 0 on Milling screen.	MDP not up to speed. Manual vent valve open. Vacuum leak. MDP failure. DP failure.	Turn off gas flow. Verify MDP speed (Maintenance > Vacuum).
Piston will not lower. Backing pressure does not return within 5 Torr when pumping airlock.	Viewing port or window not seated properly. Vent valve failure.	Clean viewport o-rings. Press down on port and window while pressing Vac button. (Maintenance > Vacuum) Check that Vent valve LED is illuminated when the airlock is under vacuum and not illuminated when it is vented. Check vent valve cable/control.
Piston cannot be lowered into the chamber. Backing pressure does return within 5 Torr when pumping airlock.	Argon supply interrupted. WL or LL valve failure.	Check argon pressure 25 psi (1.72 bar) or main valve closed. Check WL and LL valve cable/control, be sure WL valve LED illuminated and LL valve LED not illuminated.
Specimen difficult to see in working position	Sputtered material obscuring viewing window.	Clean or replace viewing window. See Section 5.1.
Specimen will not rise fully into the airlock	Dry and coated airlock vacuum seal.	Service vacuum seal. 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 5.14.
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. See Section 5.9
Cold-cathode gauge reading fluctuates or reads excessively high.	Gauge tube contaminated.	Service/clean gauge tube. See Section 5.4.
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. See Section 3.2.
Chamber pressure very high when stage is lowered.	Leak in bellows.	Replace bellows assembly.

7. Ilion+ II Options

7.1. Cold Stage Option

Certain Ilion+ II models include a cold stage. This option must be installed at the factory on a new Ilion+ II.

The Ilion+ II Cold Stage upgrade components replace existing Ilion+ II components as follows:

- The dewar assembly replaces the existing Ilion+ II vent-valve assembly or liquid nitrogen trap.
- The cold stage Whisperlok assembly replaces the existing Whisperlok assembly.
- The Ilion+ 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, 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. When the Whisperlok is lowered into the milling position, it makes thermal contact with the cold conductor and the sample is cooled. When the Whisperlok is raised into the airlock, it no longer makes thermal contact with the cold conductor. The Whisperlok then makes thermal contact with the o-ring in the airlock and comes into thermal equilibrium with the chamber walls.

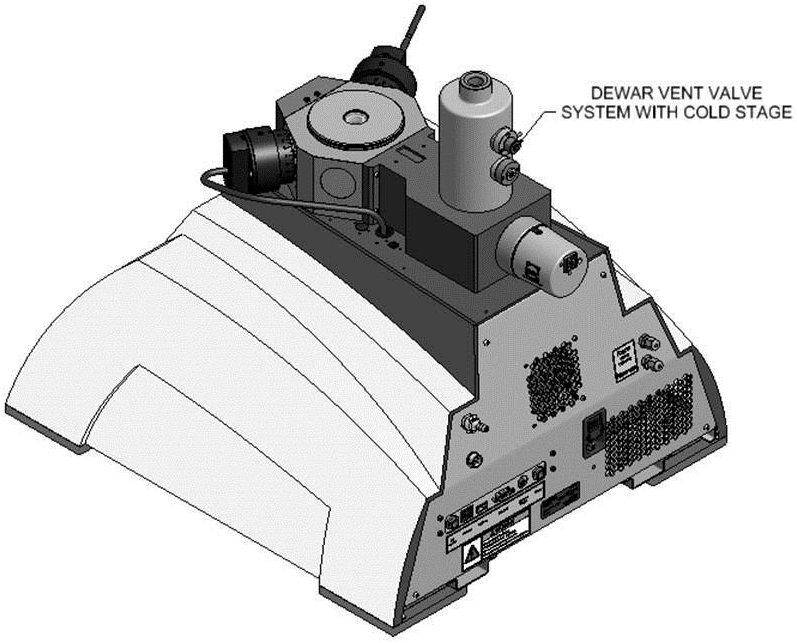


Figure 7-1 System with Cold Stage installed.

7.1.1. *Operation*

Fill the dewar with liquid nitrogen prior to loading a sample into the Ilion^{+} II. Once the stage is cold, 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 15 minutes) for the sample to warm up after raising the stage and before venting the Air- lock. 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.

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.

Filling the Dewar

1. **Raise the stage into the airlock.**

2. **Fill the dewar with liquid nitrogen.**

Do not overfill; the starting level should be just below the bottom of the dewar neck.

3. **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.

4. **After about ten minutes the boil-off rate will have slowed dramatically.**

Top off the dewar.

5. Place the supplied lid on the dewar.

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.

Removing a Sample

1. Raise the stage into the airlock.

2. Wait fifteen minutes.

3. Vent the airlock, then remove the airlock cover.

NOTE: Venting is automatically delayed for duration of the time set in Cold Stage Airlock Vent (General Settings Page).

4. Remove specimen blade.

Temperature Control

The cold stage is controlled by the GUI (Settings > Heaters).

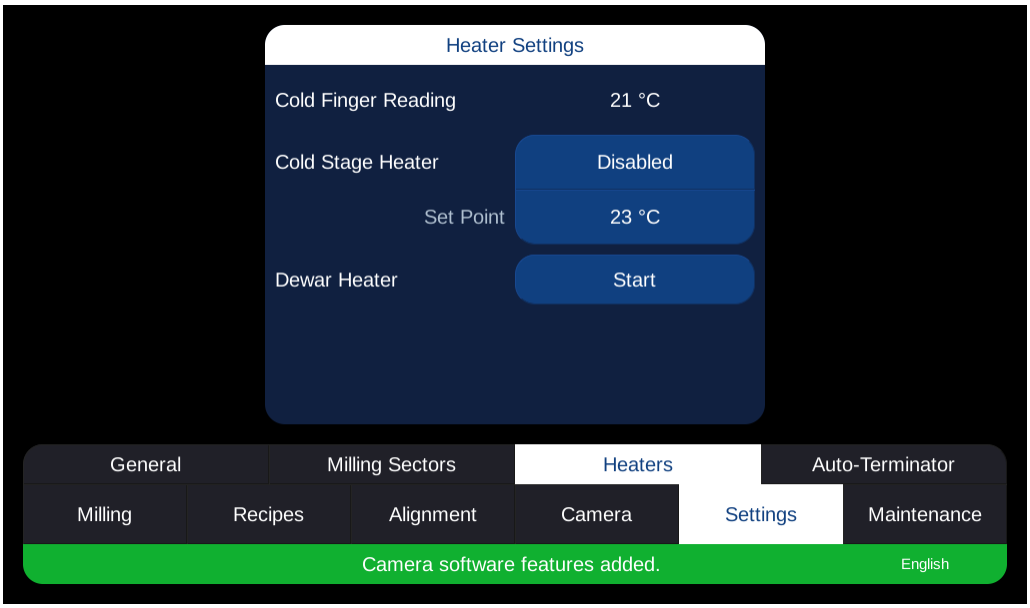


Figure 7-2 Settings Page

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

Dewar heater: Activates the dewar heater. This heater stays on continuously until the Cold Finger Temperature reaches 25° C, then it shuts off.

Raising the LN Dewar Temperature

1. **Remove the sample.**

2. **On GUI, 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.

Setting a Sample Temperature

1. **Raise the stage into the airlock.**

2. **Fill LN dewar (if not already filled).**

3. **On the Settings Page, set the Cold Stage Heater Set Point to the desired temperature.**

4. **Enable the cold Stage Heater.** The temperature will rise (Cold Finger Reading) until it reaches the set point, then will switch off. When the temperature falls below the set point, the heater will turn on again. The

controller will cycle this way as long as it is the Cold Stage Heater is Enabled. The sample will not experience temperature swings because there is a long time lag between the conductor temperature and the sample temperature.

5. **Lower the stage.**

6. **Wait fifteen minutes for the sample temperature to stabilize.**

NOTE: The range of the set point for the Conductor Heater is -200 °C to 100 °C. Setting a set-point temperature lower than the minimum temperature of the stage (~-120 °C) will not result in a lower temperature. The controller can only raise the conductor temperature.

7.1.2. *Performance*

A sample blade will reach a temperature of approximately -120 °C +/- 25 °C. The sample blade will typically cool to nearly -100 °C in fifteen minutes. It will reach its lowest temperature in 30-40 minutes. The sample will typically reach the same temperature as the blade; how long this takes depends upon the thermal conductivity of the sample and its thickness.

The temperature measured at the cold conductor is typically about 50-75 °C cooler than the temperature at the sample. In addition, there is a time delay of about fifteen minutes between a change in cold conductor temperature and the corresponding change in sample temperature. For instance, if the stage is lowered and you fill the dewar with liquid nitrogen, the conductor will reach -100 °C about fifteen minutes before the sample.

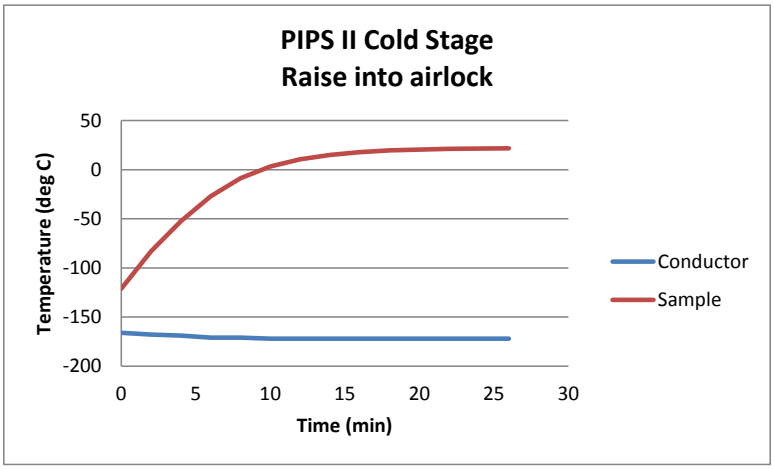


Figure 7-3 Sample and cold conductor temperature over time

Stage was lowered at zero minutes. Dewar was filled and cold prior to this test.

NOTE: When the stage is raised into the airlock, the temperature of the sample blade will typically increase to nearly room temperature in fifteen minutes.

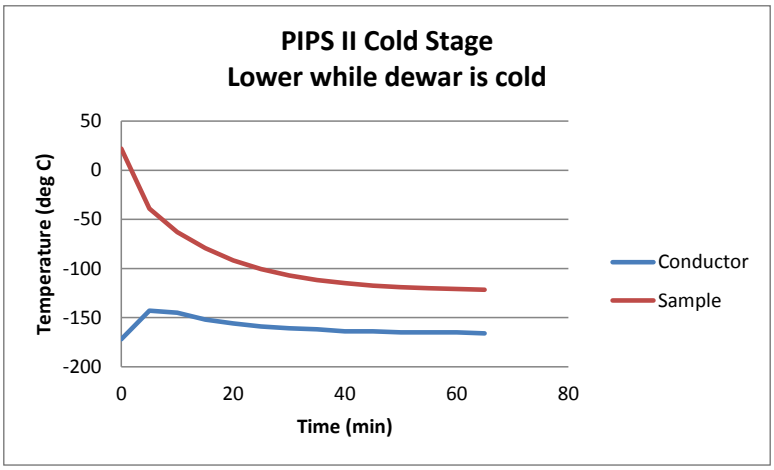


Figure 7-4 Sample and cold conductor temperature over time

Stage was raised at zero minutes

7.1.3. *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 six months. 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. **Raise the stage and vent the airlock by pressing the Vent button.**

2. **Turn off the power to the system.**

3. **Wait ten minutes for the MDP to spin down, then slowly vent the system.**

4. **Remove the viewing port.**

5. **Remove the cover using the specimen mount removal tool.**

6. **Remove the shutter using a small hex tool.** See section 5.5 for instructions.

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.

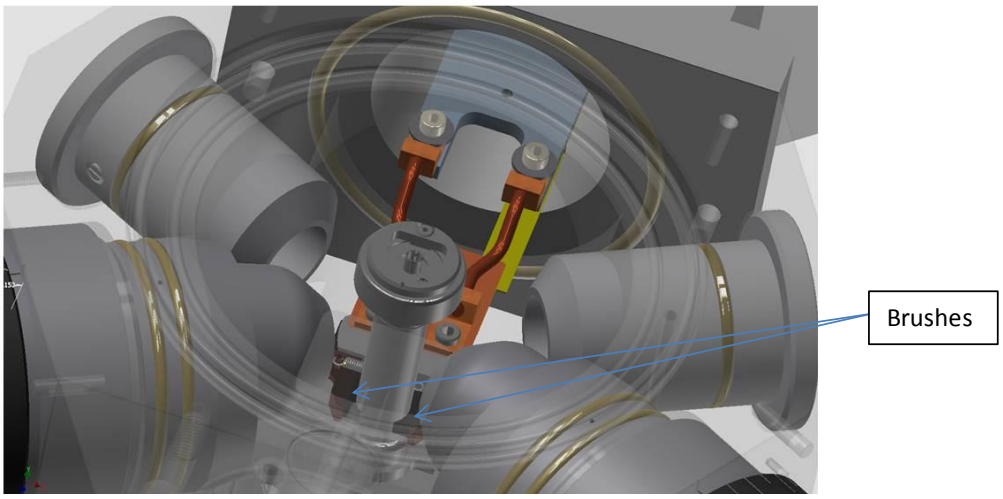


Figure 7-5 Interior chamber showing the cold conductor with new brushes.

Replacing the Hinged Conductor Assembly

1. Remove the shutter (section 5.5).

2. Remove the Sample Mount (section 5.3).

3. Remove the two M2.5 screws and washers on the top of the cold conductor assembly.

4. Move the heater out of the way.

5. Loosen the M2 screw that holds the cold conductor assembly to the bellows assembly.

6. Carefully lift the cold conductor assembly out of the chamber, making sure not to damage the brushes.

7. **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.

8. **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).

9. **Tighten the M2 screw.**

10. **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).**

11. **Attach the Cu braids and heater to the cold conductor assembly with the M2.5 screws and washers. The heater must be installed below the Cu braids.**

12. **Install the Sample Mount.**

13. **Install the shutter.**

14. **Replace the cover and viewing port.**

15. **Close the vent valve.**

16. **Turn on the power and wait for the ion gauge to turn on.**

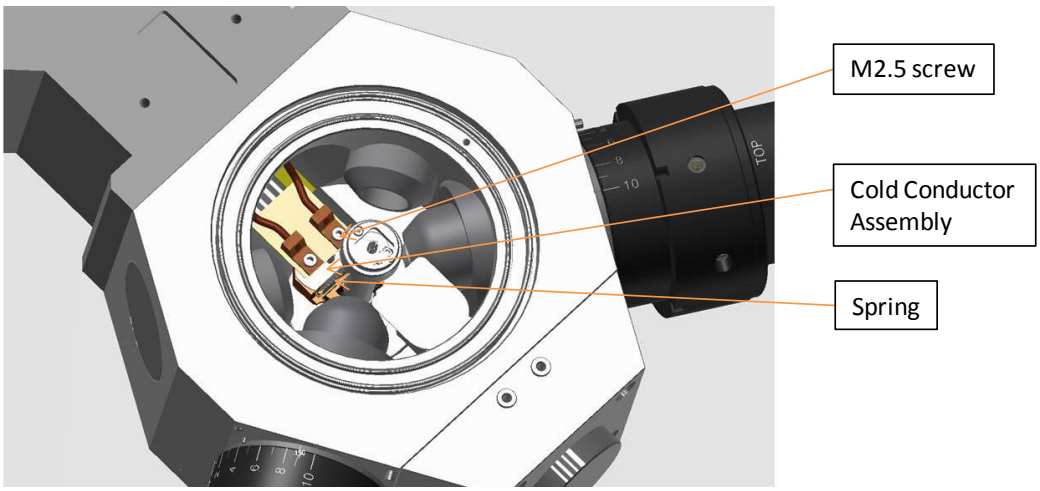


Figure 7-6 Open chamber showing access to cold stage

Replacing the Dewar Assembly

To Remove the Dewar Assembly

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 PIPS 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. **Lift off the Viewing Port.** Press the Airlock piston down into the Work Chamber if it hasn't already lowered itself.

4. **Remove top cover plate.** Using the pin end of the Specimen Mount Removal Tool, insert the pin into one of the holes in the top cover plate, push gently and tilt the plate up and out for removal.

5. **Disconnect the cold stage.** Remove the two M2.5 screws and washers and disconnect the cold stage heater from the hinged conductor assembly. See Figure 7-7.

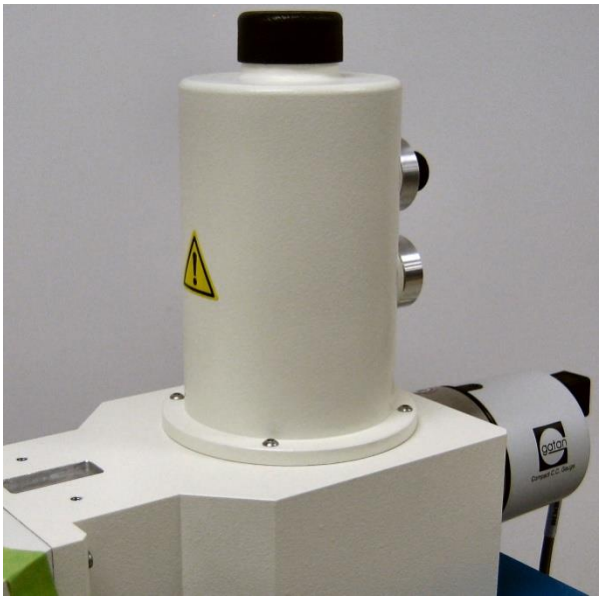


Figure 7-7. Dewar Assembly installed in manifold.

6. 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 7-7.
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.

7. 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 7-7.
c) Connect the cold stage to the hinged conductor assembly. Install the two M2.5 screws and washers that connect the cold stage heater to the hinged conductor assembly. See Figure 7-6.

8. Install the top cover plate.

9. Install the Viewing Port.

10. Turn on power to the system.

7.2. Digital Zoom Microscope Option

Certain Ilion+ II models include a digital zoom microscope option. This option must be installed at the factory on a new Ilion+ II.

The Ilion+ II digital zoom microscope option consists of the following components:

- Microscope assembly.
- Digital camera, with USB cable to the imaging PC and trigger cable to the Ilion+ II.
- Imaging PC. This PC has an Ethernet cable connected to the Ilion+ II, and a USB cable connected to the camera.
- DigitalMicrograph™ software installed on the imaging PC which controls the camera and certain functions in Ilion+ II.

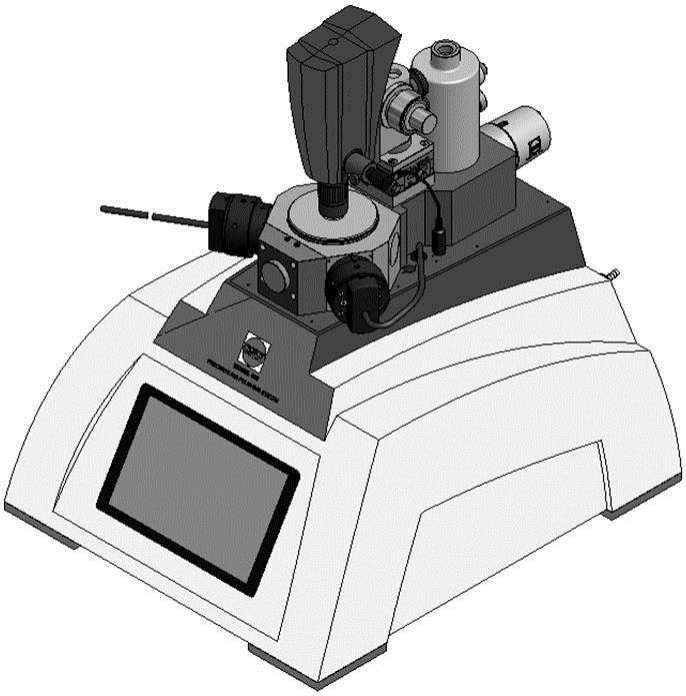


Figure 7-8 System with digital zoom microscope

7.2.1 *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.

7.2.2 *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.

7.2.3 *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

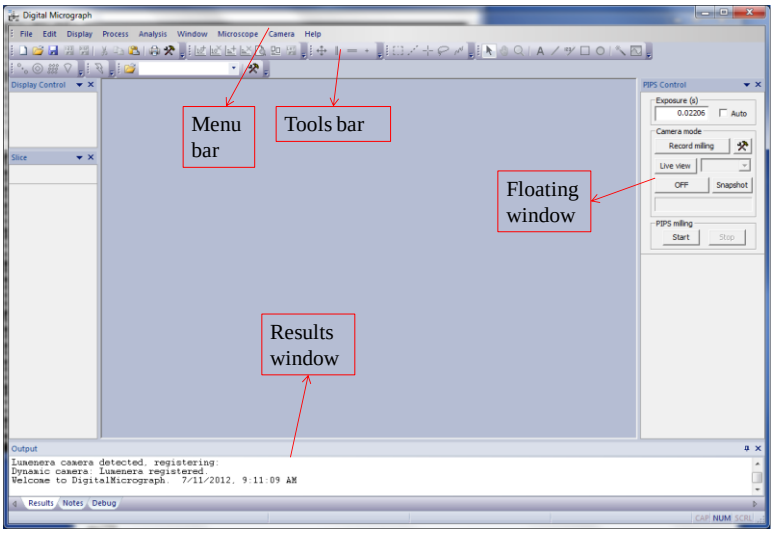


Figure 7-9 DM environment

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.

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… browse 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).

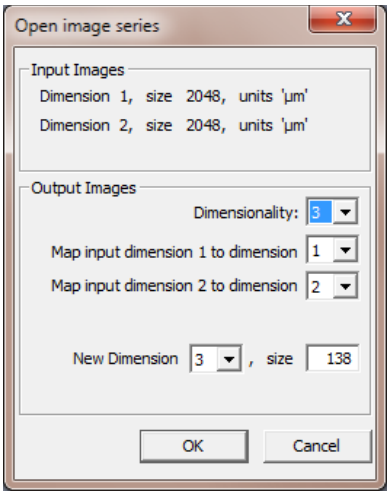


Figure 7-10 DM open image series.

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 7-11 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 7-12 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 just 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.

- 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.

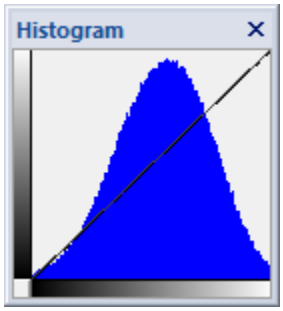


Figure 7-13 DM Histogram Window

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 7-14 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.

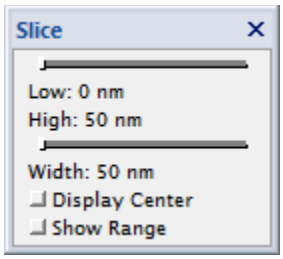


Figure 7-15 DM Slice tool

7.2.4. *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).

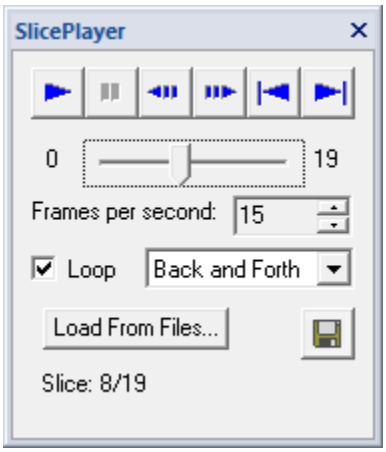


Figure 7-16 DM Slice player

It is also possible to save a .avi file, by depressing the Disk button on this window. Browse 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.

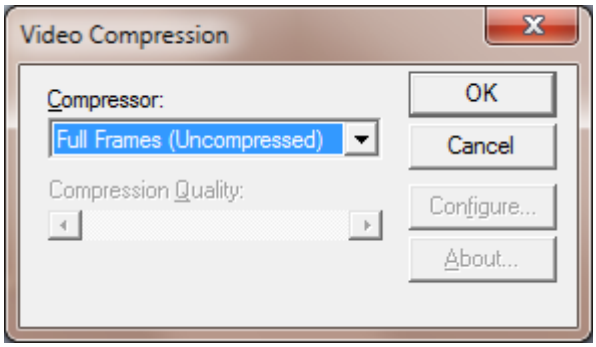


Figure 7-17 DM video compression

7.2.5. *Ilion+ II Polish Control*

The camera acquisition and Ilion^{+} II milling can be controlled using the Ion Polishing control window.

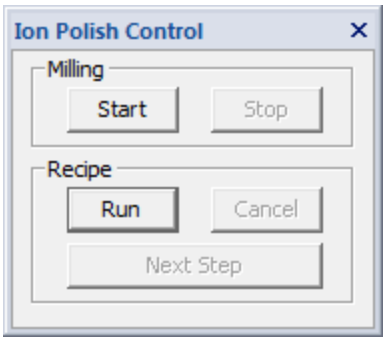


Figure 7-18 DM Ion Polish control window.

To stop milling, select Stop. This is equivalent to selecting Stop on the Ilion^{+} II Milling page.

To start milling, select Start. This is equivalent to selecting Start on the Ilion^{+} II Milling page.

Ilion^{+} II Camera Control

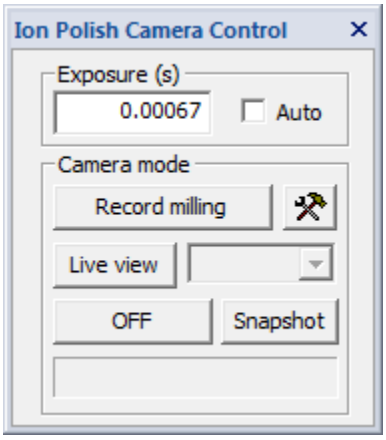


Figure 7-19 DM Ion Polish Camera Control window.

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.

NOTE: Auto exposure mode will cause the live view to be somewhat not 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 frequency at which you want these images to be saved can be set using the toolbox menu.

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 Record Options window:

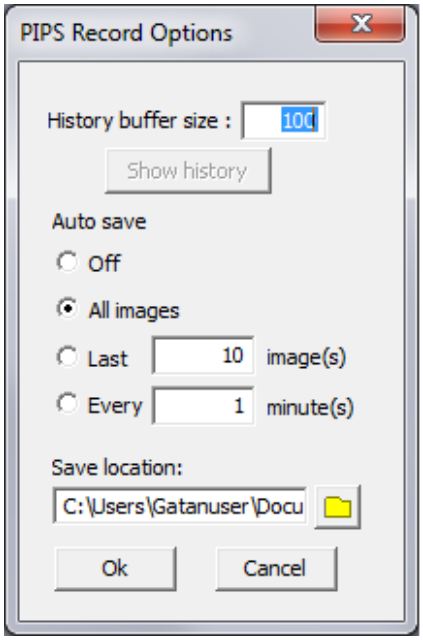


Figure 7-20 DM record options window

History buffer size: Defines the size of the stack that is displayed. This is limited by the amount of available memory on the computer. 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-minute**.

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 milling is stopped by using the Stop selection on the Milling page of the Ilion$^+$ II, 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 selection on the Milling page of the Ilion$^+$ 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. Viewing can be stopped at any time by selecting Off.

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 zooms 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

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 Ilion$^+$ II GUI, the Camera Page.

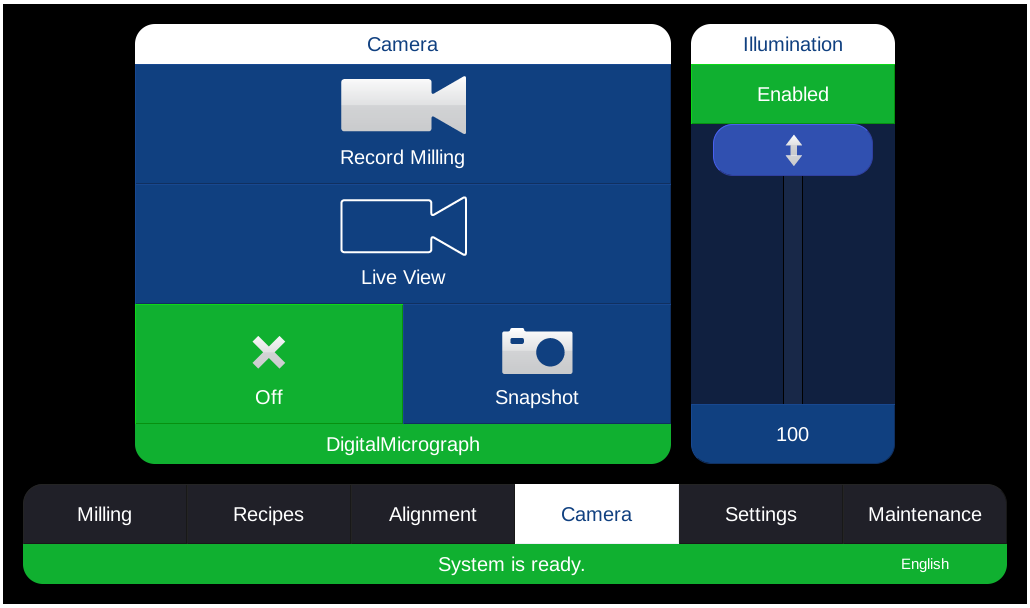


Figure 7-21 Ilion+ II camera window

7.3. Motorized Gun Tilt

Certain Ilion+ 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 Ilion+ II.

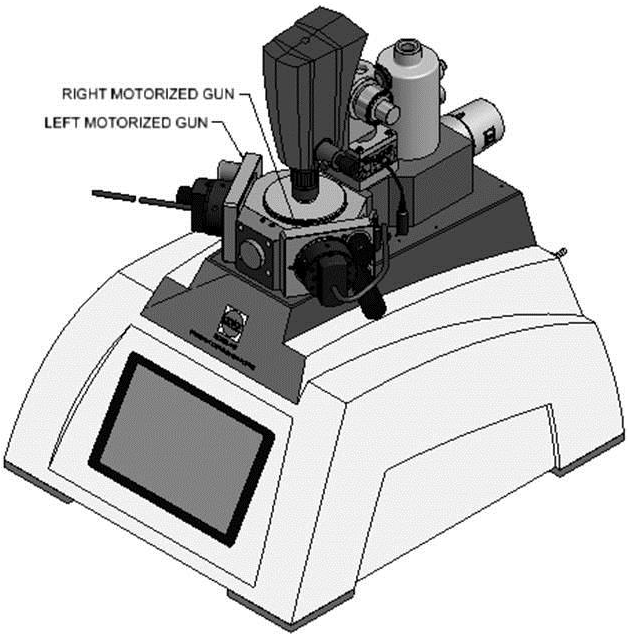


Figure 7-22 Ilion+ II with motorized gun tilt

7.3.1 *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 chamber temperature readout. 0 degree tilt is the default angle for cross section samples. Positive tilt angles may be chosen to mill slightly deeper into the cross section. Positive tilt angles also correspond to milling the top side of a planar sample. Negative angles are typically not used. Milling angles may also be set by recipe.

Figure 7-23 Gun tilt settings

7.3.2. *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 Ilion^{+} II. Unplug the power cable from the back of the system.

2. Unplug the motorized gun assembly cable from the Ilion^{+} 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 10° Top 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.

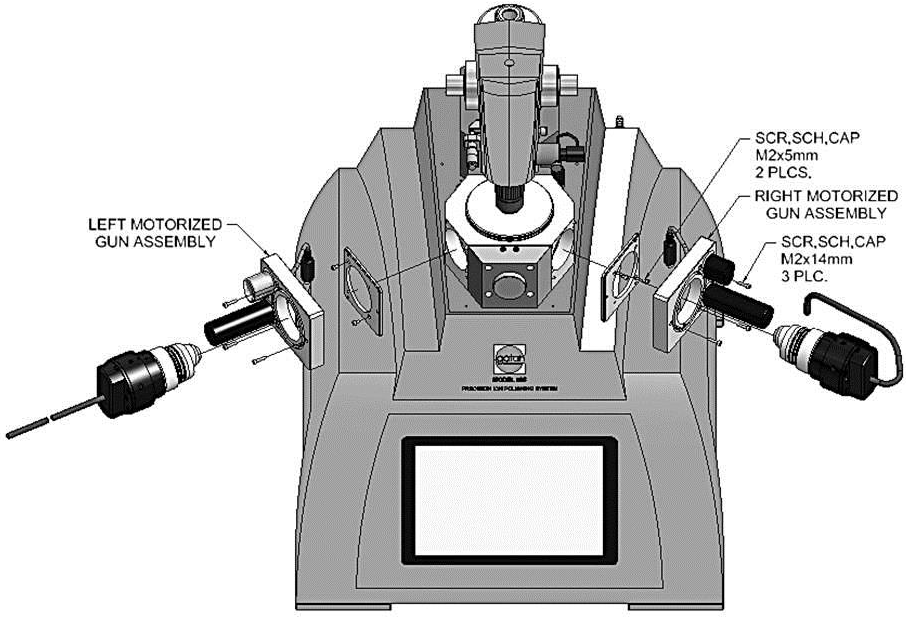


Figure 7-24 Motorized gun assemblies

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. **Unplug the cable of the motorized gun assembly to be calibrated.**
2. **Manually rotate the knob to 10 deg top.**
3. **Plug the cable back in.**
4. **Touch Maintenance > Guns > Gun Tilt**
5. **Write down the dac reading displayed for that gun.**
6. **Unplug the cable, manually set the gun to -10 deg, plug in the cable.**
7. **Write down the dac reading displayed.**
8. **Touch Maintenance > Calibrations > Guns**
9. **Enter the dac readings for the appropriate settings.**
10. **Touch Maintenance > Guns > Gun Tilt**

11. Verify that both guns can be set within the full range of -10 to +10 deg.

Figure 7-25 Gun tilt maintenance screen

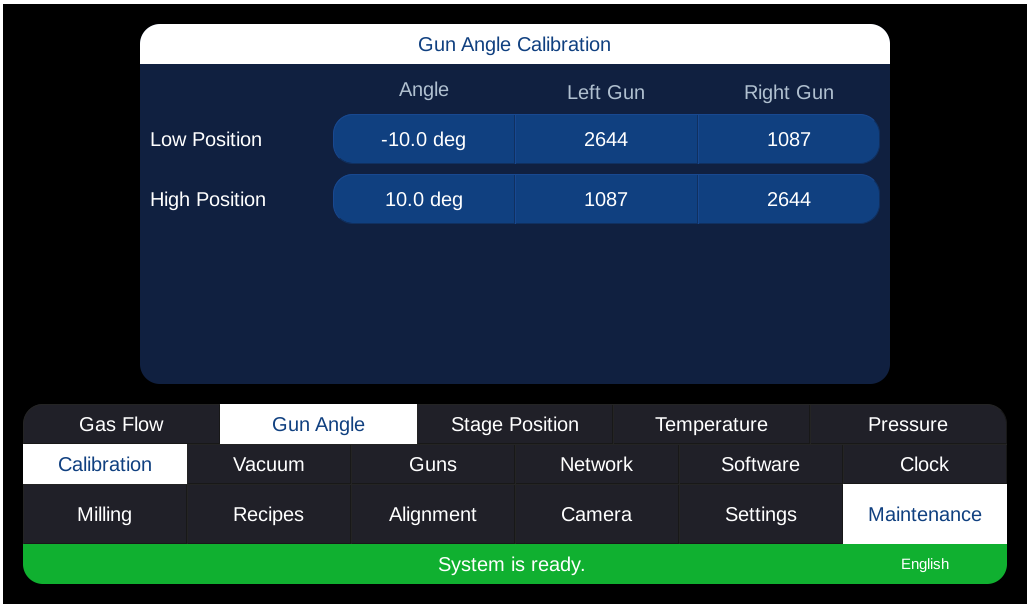


Figure 7-26 Gun tilt calibration screen

Gatan Hardware Product Warranty

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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8. LIMITED MEDIA WARRANTY. Gatan warrants the media upon which this Software is recorded to be free from defects in material and workmanship under normal use for a period of one (1) year from the date of shipment. In the event that any media proves to be defective during the Warranty Period, your remedy shall be to return the physical media to Gatan for replacement. Should Gatan be unable to replace the media within a reasonable

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