

The Model 1051 TEM Mill is the subject of United States patent number 9,214,313. All trademarks and registered trademarks are the property of their respective owners.

©2019 E.A. Fischione Instruments, Inc. All rights reserved.

# Contents

Warnings and cautions	1
Warranty	1
Model 1051 TEM Mill features	3
Installing the TEM Mill	9
Accessory kit	9
Initializing and purging the instrument	12
Setting up stage cooling	13
Preparing for milling operations	13
Preparing specimens for milling	15
Logging in to an account	15
Mounting specimens	16
Mounting a specimen on a post-style holder	16
Mounting a specimen on an X-Y adjustable holder	
Aligning the grid or specimen on the area of interest	20
Loading the post-style or X-Y adjustable specimen holder in the TEM Mill	22
Loading a specimen into the vacuum/inert gas transfer capsule	23
Mounting the vacuum/inert gas transfer capsule onto the TEM Mill	24
Working with recipes	27
Building a recipe	27
Purging the gas line	27
Defining milling parameters	28
Inserting a delay in the recipe	32
Unloading the specimen	33
Defining a multi-step milling cycle	34
Setting up image capture	35

Including an image capture step in a recipe	
Taking a snapshot during milling	
Saving a recipe	
Loading a saved recipe	40
Editing a saved recipe	
Changing the order of recipe steps	
Milling a specimen	43
Milling all types of specimen mounts	43
Removing a specimen from the TEM Mill	
Removing a specimen holder (post-style or X-Y adjustable) from the load lock	
Removing the vacuum/inert gas transfer capsule from the load lock	50
Working with image files	51
Viewing the image files directory	51
Copying image files to a USB drive	52
Deleting image files	54
Performing administrative tasks	55
Logging instrument activity	55
Tracking ion source maintenance and lifetime use	56
Changing ion source tracking limits	
Resetting ion source tracking counters	60
Tracking instrument use by user account	61
Working with user accounts	62
Understanding permissions	62
Logging into a user account	63
Managing users	65
Adding a user account	65
Editing an existing user account	67
Deleting a user account	68
Setting the instrument date and time	69
Copying, moving, or deleting recipe files	71
Copying recipe files	71
Moving recipe files	72
Deleting recipe files	73
Viewing TEM Mill software version information	74

### MODEL 1051 TEM Mill instruction manual

Viewing and modifying advanced system properties	
Viewing the vacuum system status and controls	75
Initializing the TEM Mill	
Venting the chamber	77
Holding the chamber at vacuum during system restart	
Modifying the system motion properties	
Displaying the motion system status	
Homing the stage	
Homing the ion sources	
Adjusting the Z-axis	
Adjusting the angle of the ion sources	
Adjusting the R-axis	
Changing the R-axis angle	
Adjusting ion source parameters	
Displaying the left and right ion source parameters	
Controlling thermal properties	
Displaying thermal status	
Turning stage cooling on	86
Warming the stage	86
Turning off stage cooling	86
Troubleshooting	
Reset button	
Motion fault	
Vacuum fault	
Process Interruption dialog	
Gas failure	
Homing failure	
lon beam timeout	
Lighting failure	
Motion obstructed	
Motion time out	
Positioning failure	
Source failure	
Thermal shutdown	

### MODEL 1051 TEM Mill instruction manual

Unstable gas flow	96
Vacuum failure	96
Vacuum timeout	
Contacting Fischione Instruments	

\_

# Warnings and cautions



**Important.** Please read these instructions completely before installing or operating the TEM Mill. See Model 1051 TEM Mill Service Manual (document number 041-6075) for warnings and cautions associated with preventive maintenance and service.



**Warning: Electrical shock hazard.** Removing the instrument enclosure can expose the user to potentially harmful voltages. DO NOT OPERATE THE INSTRUMENT WITH THE COVERS REMOVED. Operation of the instrument without the covers installed should only be performed by qualified service personnel.



**Warning: Laser light class II.** A class II laser is available for milling process termination. Do not aim or direct the laser at other people or look into the laser.



**Warning: Liquid nitrogen hazards.** Liquid nitrogen can cause asphyxia (suffocation), as well as severe eye and skin burns. Use and store liquid nitrogen in a well-ventilated area. Ensure that the oxygen concentration of the area where the instrument is located remains above 19.5%. While handling liquid nitrogen, wear a full-face shield with safety goggles, heavy, loose fitting leather or cryogenic gloves, and a long-sleeve shirt (or other arm protection).

Warning: Broken glass hazard. Dropping the high-magnification microscope zoom lens into the load lock can shatter the load lock window. Glass fragments can be ejected outward causing severe cuts.



**Warning: Compressed gas.** Compressed gas cylinders should be stored in a cool, dry, well-protected, well-ventilated area that meets all applicable local, state, and federal regulations and located more than 20 ft. [6.1 m] from combustible materials. Gas cylinders should be properly secured at all times to prevent tipping or falling.



**Caution.** If you open the shutter during milling, make sure to clean the load lock window with isopropyl alcohol and a lint-free cloth at the conclusion of milling operations. Frequent cleaning will prevent the accumulation of sputter on the window. Do not use any type of abrasive cleaning materials; this can damage the coating on the window and compromise in situ viewing and imaging. Best practices are to clean the shutter before and after milling operations to ensure load lock window cleanliness.

# Warranty

See <u>www.fischione.com</u> for product warranty information.

\_\_\_\_\_

# Model 1051 TEM Mill features

E.A. Fischione Instruments' Model 1051 TEM Mill is a state-of-the-art ion milling and polishing system offering reliable, high performance specimen preparation. It is compact, precise, and consistently produces high-quality transmission electron microscopy (TEM) specimens with large electron transparent areas from a wide variety of materials.



# Advanced specimen preparation

For many of today's advanced materials, analysis by TEM is the best technique for studying material structure and properties. Fischione Model 1051 TEM Mill is an excellent tool for creating the thin, electron transparent specimens needed for TEM imaging and analysis. Ion milling with low angles of incidence, combined with low-energy ion source operation, minimizes irradiation damage and specimen heating. Because it facilitates the uniform thinning of dissimilar materials, low-angle milling is highly beneficial when preparing layered or composite materials, as well as cross-sectional TEM (XTEM) specimens.

# Contamination-free specimen mounting

The TEM Mill's specimen holder design allows for easy specimen loading. The specimen holder accommodates double-sided milling to 0° without specimen shadowing. Because the specimen is clamped in place on the holder, there is no possibility of specimen contamination from an adhesive. The loading station provides a platform for the specimen so that it can be easily positioned in the specimen holder.

# Adjustable X-Y specimen holder and X-Y loading station (optional)

An additional specimen holder and loading station are available for customers who desire *X-Y* adjustment capability.

If an area of interest is off the axis of rotation, you can adjust the specimen *X-Y* position to optimize milling.



# Quick specimen transfer

The TEM Mill features a vacuum load lock for rapid specimen exchange. The load lock is ergonomically designed; simply lift the load lock cover to load the specimen holder onto the stage.



Replace the cover and evacuation of the load lock occurs within a few seconds. The vacuum secures the load lock cover in

place during ion milling. An electronically controlled elevator then moves the specimen into the milling position.

At the conclusion of the milling process, the specimen holder returns to the load lock, but remains under vacuum until vented by the user. Venting takes only a few seconds. After venting, you can rapidly transfer the specimen to a TEM specimen holder, thus reducing the potential for

contamination from the ambient environment.

### Vacuum/inert gas transfer capsule (optional)

An optional vacuum/ inert gas capsule allows you to transfer the specimen to the TEM under vacuum or in an inert gas.



# TrueFocus ion sources

Fischione's history of innovation continues with the introduction of the next generation of

ion source technology. Our patented TrueFocus ion sources are now optimized to perform at near 100% ionization efficiency – the result



is a highly efficient ion source that maintains a consistent beam current. This technology is built into the Model 1051 TEM Mill.

TrueFocus ion sources maintain a small ion beam diameter, even at a low accelerating voltage, which means that the ions are directed only to the specimen and that sputtered material is not redeposited from the specimen holder or chamber onto the specimen.

Accelerating voltages are programmable and can be continuously varied from as high as 10 keV for rapid milling to as low as 100 eV for final specimen polishing. Beam current density is adjustable up to 10 mA/cm<sup>2</sup>. The ion sources are physically small and require minimal gas, but deliver a wide range of ion beam energies. You can direct controlled-diameter ion beams to either one or both specimen surfaces.

When operated in the upper energy range, milling is rapid, even at low angles. When operated at low energy, material is gradually sputtered from the specimen without inducing artifacts.

TrueFocus ion sources are easily accessible for routine maintenance.

# Chamber

The TEM Mill's vacuum chamber remains under continuous vacuum during operation. A load lock isolates the high chamber vacuum from ambient during specimen exchange, ensuring optimal vacuum conditions.

# Precise angle adjustment

The continuously adjustable ion source tilt angles range from -15 to  $+10^{\circ}$ . This tilt range accommodates specimens mounted on slotted grids. The ion source angles are adjusted using the left and right ion source controls.



You may choose to use one or both of the TrueFocus ion sources. If you are using both ion sources, you can adjust the beam angles independently.

You may also choose to ion mill either one or both specimen surfaces. When both ion beams are directed at one surfaces, milling rates are doubled, which is useful for applications such as back-side thinning or planar polishing of specimens. If you set the ion sources to mill both specimen surfaces simultaneously, you avoid redeposition of sputtered material.

### Automated milling angle adjustment

Automated milling angle adjustment enables you to create multi-step milling sequences that include the automatic adjustment of milling angles throughout the milling process.

# Programmable specimen motion

Specimen rotation is in-plane and continuous throughout 360°.

The TEM Mill is ideally suited to preparing XTEM specimens from heterogeneous or layered materials. Specimen motion control in relation to the ion beam minimizes preferential milling, which can occur when a glue bond line exists in XTEM specimens or when lower atomic number (Z) materials are contained in layered composite specimens.

Ion beam sequencing electrically interrupts the flow of ions to the specimen as the specimen holder is rotated through an angle that coincides with the ion beam. This avoids sputtering of the specimen holder. The specimen can also be rocked in relation to the ion beam so that interfaces or glue lines are never parallel to the direction of the ion beam.

Faraday cups allow for the direct measurement of beam current from each ion source, which enables optimization and adjustment of the ion source parameters for specific applications.

# Integrated stage cooling

Although milling at low angles with low ion beam energies reduces specimen heating, temperaturesensitive specimens may require further cooling. Liquid nitrogen cooling of the specimen stage is very effective in eliminating heat-induced artifacts.



The TEM Mill's liquid nitrogen system features a dewar located within the enclosure that is fully integrated and interlocked. The dewar is positioned near the operator for easy access. Two dewar options are available: a standard dewar for applications that require 3 to 5 hours of cooling during ion milling, or an extended dewar for applications that require 18+ hours of operation under cryogenic conditions. Temperature is continuously displayed on the touch screen.

### Programmable temperature

The TEM Mill enables you to program and maintain a specific temperature between ambient and cryogenic. At the conclusion of milling, the stage temperature is automatically increased to ambient before venting to avoid specimen frost and contamination.

A thermal safeguard can be programmed to a specific stage temperature threshold at which the ion sources will be deactivated if the liquid nitrogen in the dewar becomes depleted.

# Automatic termination

The ion milling process can be automatically terminated by elapsed time, by temperature, or by an optional laser photodetection system.

#### Time

A timer allows milling to continue for a predetermined time and then turns off energy to the ion sources. The specimen remains under vacuum until the load lock is vented.

### Temperature

The specimen cooling system thermal safeguard will stop the process if the specimen stage reaches a preset temperature.

### Autotermination (optional)

A laser light source and a photodetector sense transmission of light through the specimen. A programmable sensitivity control automatically stops the ion milling process as the specimen becomes translucent.

# In situ specimen viewing

The ion milling process can be monitored in situ in the milling position when using either of the optional microscopes.

The viewing window is protected by a shutter, which prevents buildup of sputtered material that could interfere with specimen observation.

**Stereomicroscope**. A stereomicroscope (7 to 45X) enhances specimen viewing. The microscope's long working distance allows the specimen to be observed in situ while milling.

High-magnification (1,960X) microscope. The TEM Mill can be configured with a 1,960X highmagnification microscope coupled to a CMOS (complementary metal oxide semiconductor) camera and video monitor to view specimens and capture images in situ during milling. This system is ideal for preparing site-specific specimens.

### **Specimen illumination**

A light positioned beneath the specimen provides user adjustable, transmitted specimen illumination.

Both the high-magnification and stereo microscopes have light sources that provide top-down, user adjustable, reflected specimen illumination.

# Touch screen control

Milling parameters are entered via a 10-inch touch screen, which can be adjusted to your preferred height and viewing angle. From the touch screen, you can control a broad variety of instrument parameters, such as ion beam energy, milling angle, specimen motion, specimen position, and process termination.

For automated, unattended operation, you can program a series of milling sequences. A typical approach is to begin with rapid milling to remove larger amounts of specimen material; then, as the specimen thins, a lower milling rate to polish the specimen. These milling sequences can be easily stored and recalled for future use.

During milling operations, milling sequence progress and instrument status are displayed in real time on the touch screen.

Advanced functionality includes tools for managing specimen data, maintenance and log files, and image storage, as well as remote access, which allows you to oversee milling operations via a remote computer if the TEM Mill is networked with your facility's intranet.

Access to instrument configuration, administrative and diagnostic tools, and maintenance and log files, is controlled through privileges granted to the various user levels and require login credentials.

## Stack light system status indicator (optional)

An optional stack light allows you to view the system status from a distance.

Because the gas requirements of the TrueFocus ion source are small, the 70 lps turbomolecular drag pump produces an operating system vacuum of approximately  $5 \ge 10^{-4}$  mbar. The vacuum level is measured with a cold cathode, full-range gauge and is continuously displayed on the touch screen.

### Minimal maintenance

Due to the efficiency of ionization, maintenance of the TrueFocus ion source is minimal and the components have an extremely long life. Material sputtered from the ion source is negligible, minimizing both specimen contamination and component maintenance. Automated shuttering prevents the buildup of sputtered material on the viewing window. All system components are easily accessible for routine cleaning.

#### **Remote diagnostics**

Fischione Instruments is committed to support maximum instrument uptime. To that end, the TEM Mill has remote diagnostics capabilities built

> in. When connected to the Internet, the TEM Mill can be accessed remotely by Fischione Global Service for rapid troubleshooting and diagnostics support.

# Service and preventive maintenance

To learn more about Fischione Global Service's

comprehensive service and preventive maintenance programs, contact <u>service@</u><u>fischione.com</u>.

### Automatic gas control

Two mass flow controllers provide independent and automatic regulation of process gas for the ion sources. The gas control algorithm produces stable ion beams over a wide variety of ion source milling parameters. The process gas is ultra-high purity (99.999%) argon.

### Fully integrated dry vacuum system

The integrated vacuum system includes a turbomolecular drag pump backed by a multistage diaphragm pump. This oil-free system assures a clean environment for specimen processing.



\_

# Installing the TEM Mill

If you are going to self-install the Model 1051 TEM Mill at your facility, please refer to the following documents:

- Model 1051 TEM Mill facility requirements (document number 041-6088)
- Model 1051 TEM Mill installation instructions (document number 041-6154)
- Model 1051 TEM Mill service manual (document number 041-6075)

Contact <u>service@fischione.com</u> to receive a copies of the above documents.

# Accessory kit

The Model 1051 TEM Mill includes an accessory kit (part number 041-5658) that contains tools and components for the maintenance and use of the instrument.

Number	Quantity	Description	<b>Image</b> (not to scale)
009-0432	1 package of 3 disks	Alignment Disk; 3 mm Diameter; Pyrex	
041-5101	2	Sample Holder; Model 1051; Post Style	
		Shown with 041-5638; Stand; Holder; TEM Mill (left) and without stand (right)	
041-5110	1	Assembly; Loading Station; TEM Mill	

# MODEL 1051 TEM Mill instruction manual

Number	Quantity	Description	<b>Image</b> (not to scale)
041-5472	1	Nut Tool Assembly; Ion Mill	
041-5551	1	Body; Alignment Holder; Model 1051	
041-5555	1	Alignment Holder Assembly; Model 1051	
041-5560	1	Alignment Pin; Ion Source; TrueFocus; Gen 2	C
041-5561	2	Screw Assembly; Holder; Model 1051	
041-5679	1	Holder; Load Lock; Ion Mill	
041-5721	1	Disk Drive; USB Flash; 2 GB; TEM Mill	

Number	Quantity	Description	<b>Image</b> (not to scale)
041-5847	1	Grippers; TEM Pin Stub; 12.7 mm Diameter; 65° Bend	
041-5885	1	Cratex Stick; 2 in. Long; Fine Grit	
041-5886	2	Scotch-Brite Pad; 1.5 in. Square	
438-0154	1	Hex Balldriver; 3 mm; Standard Length	
500-2383	4	O-Ring; Viton; -122	0
500-3041	1	Eye Loupe; 2X	
500-3129	1	Fitting; Reducer; 6 mm Compression to 1/4 Stem; Stainless Steel	
500-3903	2	O-ring; Viton; -241	$\bigcirc$
500-4461	1	Box; Plastic; Translucent, Hinged Lid 3-18 Compartments (9 1/8 Length x 4 3/8 in. Width)	

# Initializing and purging the instrument

If the instrument is already running, this task is not necessary. You only need to initialize the instrument if it was powered off. *You must have administrator, service, or superuser permission to perform the purge task. If you do not, see your lab manager for assistance in initializing and purging the instrument. For more information on permissions, see* Understanding permissions, page 62.

 Locate the power switch on the back panel of the instrument; press the switch so that it is in the "on" position (**O**).



- When the touch screen displays the Startup dialog and prompts Initialize the system?, press Yes. Wait until the instrument completes the initialization process.
- **3.** Log in to an account with administrator, service, or superuser permissions. If you need instructions for logging in, see <u>Logging into a</u> <u>user account, page 63</u>.
- 4. Create a 1 hour and 20 minute purge:
  - a. Press Purge. The Purge screen opens.
  - **b.** Use the keypad to enter the time length of the purge. For a recently started instrument, Fischione Instruments recommends a purge time of 1 hour and 20 minutes.
  - c. Press ENTER.

The **Purge** screen closes and you are returned to the home screen. The purge step has been added to the recipe.

**d.** Press **Start**. The purge step begins. Do not operate the ion sources until the purge has completed.

If you wish to use cooling, see <u>Setting up stage</u> <u>cooling</u>, page 13, while you are waiting for the purge to complete.

When not in use, the TEM Mill power should remain on and the chamber at vacuum.



# Setting up stage cooling

Stage cooling capability is an optional feature of the TEM Mill. If your TEM Mill has a dewar, you may choose to use stage cooling during ion milling.



**Warning.** Liquid nitrogen can cause asphyxia (suffocation), as well as severe eye and skin burns. Use and store liquid nitrogen in a well-ventilated area. Ensure that the oxygen concentration of the area where the instrument is located remains above 19.5%. While handling liquid nitrogen, wear a full-face shield with safety goggles, heavy, loose fitting leather or cryogenic gloves, and a long-sleeve shirt (or other arm protection).

- 1. Remove the dewar cap from the dewar.
- **2.** Fill the dewar with liquid nitrogen.
- 3. Wait for the liquid nitrogen to stop boiling.
- 4. Add more liquid nitrogen to the dewar to fill it.
- **5.** Replace the dewar cap.
- 6. You can configure the cooling parameters when you create a recipe (see <u>Defining milling</u> parameters, page 28.)

Alternatively, if you would like to start stage cooling in advance of milling operations, you can use the **\*** > **Thermal** settings (see <u>Turning</u> <u>stage cooling on</u>, page 86). Access to these settings is controlled by permissions; if you do not have access to these settings, see your lab manager.

# Preparing for milling operations

Following installation, the TEM Mill should remain with the power on and the chamber under vacuum. The instrument should be logged into a user account with restricted permissions; Fischione Instruments recommends either *user* or *superuser* account permissions for most facility personnel.

To learn more about:

- user account types and permissions, see Working with user accounts, page 62
- changing default passwords or adding user accounts, see Working with user accounts, page 62
- logging into a different account, see Logging into a user account, page 63
- resetting the instrument clock, see Setting the instrument date and time, page 69
- stage cooling, see Controlling thermal properties, page 85



# Preparing specimens for milling

# Logging in to an account

The tasks that you can perform on the instrument are controlled by the permissions associated with the active user account. If you do not know which account you should use or you need to create a new account, see your lab administrator.

The user account to which the instrument is currently logged in is displayed next to **1**. In this example, the user name is "User."

### 1. Press **1**.

The User Log In dialog and keyboard open. The name of the active user account appears in the User field with the user account name highlighted.

- **2.** Use the touch screen keyboard to enter the name of the user account that you would like to log into.
- **3.** Touch the **Password** field to select it; use the keyboard to enter the password for the user account.
- 4. Press OK.

The User Log In dialog and keyboard close. The name of the user account you logged in to now appears next to the user icon. You will now be working with the permissions associated with this user account.





# Mounting specimens

The specimen holders accommodates double-sided milling to 0° without specimen shadowing. Because the specimen is clamped, there is no possibility of specimen contamination from an adhesive. The instrument accepts 3 mm specimens or grids.

Specimen holder options include:

- **Post-style specimen holder** (part number 041-5101), which is included in the Model 1051 TEM Mill Accessory Kit (part number 041-5658). Use the included loading station (part number 041-5110) to load the specimen. See <u>Mounting a specimen on a post-style holder</u>, page 16.
- X-Y adjustable specimen holder (part number 041-5108), which is an optional specimen holder that allows precise positioning of 3 mm specimens or grids on the axis of rotation. Use the optional X-Y alignment station (part number 041-5800) to load the specimen. See <u>Mounting a specimen on an X-Y adjustable holder</u>, page 18.
- Vacuum/inert gas transfer capsule (part number 041-5857), which enables you to transfer an argon ionmilled specimen under vacuum or an inert gas environment. See <u>Loading a specimen into the vacuum/inert</u> gas transfer capsule, page 23

### Mounting a specimen on a post-style holder

The loading station (part number 041-5110) is used for loading and unloading specimens from the post-style specimen holder (part number 041-5101). Both the loading station and post-style holder are included with the instrument's accessory kit (part number 041-5658). Once the specimen is loaded in the holder, you can transfer the specimen holder to the instrument's load lock in preparation for milling operations.

#### To mount a 3 mm grid or specimen on a post-style holder:

Use the loading station (part number 041-5110) to load a 3 mm grid or specimen onto the X-Y adjustable specimen holder.



 Check the hole in the loading station where the specimen holder is inserted to verify that it is unobstructed. If it is obstructed, rotate the loading station knobs to clear the obstruction.



**2.** Use TEM stub grippers (part number 041-5847) to lift the specimen holder and insert it into the loading station.

Align the pin on the specimen holder with the slot on the loading station.

When the holder collar is flush with the loading station, it is properly seated.

- 3. Load the 3 mm grid or specimen onto the tip of the loading station slider.
- 4. Turn a loading station knob toward the holder to open the holder clamps; hold the knob in this position while slowly advancing the slider toward the specimen holder. When fully extended, the slider will position the 3 mm grid or specimen within the specimen holder clamps.
- 5. When the 3 mm grid is in the correct position, release the knob to close the clamps and secure the grid or specimen in place.
- 6. Retract the slider.
- 7. Turn a loading station knob away from the holder to unseat the holder from the loading station.
- 8. Use TEM stub grippers to transfer the specimen holder to the TEM Mill.

See Loading the post-style or X-Y adjustable specimen holder in the TEM Mill, page 22.

### Mounting a specimen on an X-Y adjustable holder

The X-Y adjustable specimen holder (part number 041-5108) is an optional specimen holder that allows precise positioning of 3 mm specimens or grids on the axis of rotation. Use the optional X-Y alignment station (part number 041-5800) to load the specimen. The loading station (part number 041-5110) is also used in this procedure. Once the specimen is loaded in the holder, you can transfer the specimen holder to the instrument's load lock in preparation for milling operations.

#### To mount a 3 mm grid or specimen on a X-Y adjustable specimen holder:

1. Inspect the X-Y adjustable specimen holder to see if the clamp mechanism is centered in the body of the holder.



**2.** If it is not centered, grip the holder body firmly while gently applying pressure to the large clamps to center the clamp mechanism.



**Caution.** Do not push the X-Y adjustable specimen holder's small clamps when adjusting the clamp mechanism's position in the holder body; this will damage the specimen holder.



Hole

Knob

Knob

Slot

**3.** Use the loading station (part number 041-5110), which is a Model 1051 TEM Mill accessory, to load the 3 mm grid and specimen onto the X-Y adjustable specimen holder.

- Check the hole in the loading station where the Obstructed specimen holder is inserted to verify that it is unobstructed. If it is obstructed, rotate the loading station knobs to clear the obstruction.
- **b.** Use TEM stub grippers to lift the X-Y adjustable specimen holder and insert it into the loading station.

Align the pin on the X-Y adjustable specimen holder with the slot on the loading station.

When the holder collar is flush with the loading station, it is properly seated.

Load the 3 mm grid with specimen onto the tip of C. the loading station slider.







Unobstructed

a.

- **d.** Turn a loading station knob toward the holder to open the holder clamps; hold the knob in this position while slowly advancing the slider toward the specimen holder. When fully extended, the slider will position the 3 mm grid within the specimen holder clamps.
- e. When the 3 mm grid is in the correct position, release the knob to close the clamps and secure the 3 mm grid in place.
- f. Retract the slider.
- **g.** Turn a loading station knob away from the holder to unseat the holder from the loading station.
- 4. Use TEM stub grippers to transfer the specimen holder to the X-Y alignment station.

### Aligning the grid or specimen on the area of interest

#### To align a 3 mm grid or specimen on a X-Y adjustable specimen holder:

1. Align the pin in the specimen holder stub with the slot in the X-Y alignment station.

**2.** Loosen a thumbscrew and then push the thumbscrew pin block forward to engage the pin with the holder.

Tighten the thumbscrew once the pin is in position. Repeat the same actions with the second thumbscrew.



E.A. FISCHIONE INSTRUMENTS, INC.





0

C

Tick mark

equals

10 µm

**Micrometers** 

Tick mark equals 0.5 mm

**3.** Use the micrometers to advance the remaining pins until they engage with the holder.

**4.** Adjust the micrometers to move the specimen's area of interest to the center of the specimen holder (the specimen holder mechanism can be moved in both the X and Y direction within the holder body). Center the area of interest on the axis of rotation.

You may choose to place the X-Y alignment station under a stereo microscope to help locate and center the area of interest.

**5.** Loosen the thumbscrews and then slide the thumbscrews away from the holder to retract the thumbscrew pins.

Always retract the thumbscrew pins first. The spring-loaded thumbscrew pins will push the specimen holder mechanism out of position if you retract the micrometer pins first.

- **6.** Use the micrometers to retract the micrometer pins.
- **7.** Use TEM stub grippers to remove the X-Y adjustable specimen holder from the alignment station.

The specimen is now ready for insertion into the Model 1051 TEM Mill load lock.

See Loading the post-style or X-Y adjustable specimen holder in the TEM Mill, below.





# Loading the post-style or X-Y adjustable specimen holder in the TEM Mill

The post-style and X-Y adjustable specimen holders are loaded into the TEM Mill in the same manner.

1. On the f screen, press Vent to release the load lock vacuum.



- 2. If the microscope is positioned over the load lock cover:
  - Stereomicroscope. Rotate the microscope until it is clear of the load lock cover.
  - High-magnification microscope. Tip the microscope back until it is clear of the load lock cover and is resting securely on the microscope stand.
- **3.** Remove the load lock cover. If you are unable to remove the cover, wait a minute or two until the load lock reaches atmosphere and then try again.



**4.** Place the load lock cover into the load lock holder (part number 041-5679) so that the load lock window does not get scratched.



**5.** Insert the specimen holder into the stage; make sure to align the hole in the holder with the indexing pin on the stage.



**6.** Replace the load lock cover.



7. Press **Pump** to evacuate the load lock.

You are now ready to set the parameters for milling the specimen. If you would like to:

- create your own milling recipe, see Building a recipe, page 27
- load an existing milling recipe, see Loading a saved recipe, page 40

# Loading a specimen into the vacuum/inert gas transfer capsule

The optional vacuum/inert gas transfer capsule (part number 041-5857) enables you to mount a specimen in vacuum or an inert gas environment and transfer it to the TEM Mill for ion milling under vacuum or inert gas conditions.

If you intend to share the TEM Mill's argon supply with the vacuum/inert gas transfer capsule, install a T-connector to the argon gas line and purge the TEM Mill for 1 hour and 20 minutes before performing milling operations.



#### MODEL 1051 TEM Mill instruction manual

The optional stereo or high-magnification microscopes cannot be used when the capsule is in place on the load lock.

#### To load a specimen into the vacuum/inert gas transfer capsule:

- Within a glove box, place the capsule in the capsule stand. The box should be a positive pressure environment; the box can also be filled with an inert gas, such as argon.
- **2.** Push the capsule door control down to open the door at the base of the capsule.
- **3.** Push the specimen holder control down to extend the holder past the base of the capsule.
- **4.** Affix the 3 mm grid or specimen to the vacuum/ inert gas transfer specimen holder.
- **5.** Pull the capsule holder control up to retract the specimen holder into the capsule.
- **6.** Pull the capsule door control up to close the capsule door.
- 7. Ensure that the gas valve control is tightened.



### Mounting the vacuum/inert gas transfer capsule onto the TEM Mill

- 1. If the microscope is positioned over the load lock cover:
  - Stereomicroscope. Rotate the microscope until it is clear of the load lock cover.
  - High-magnification microscope. Tip the microscope back until it is clear of the load lock cover and is resting securely on the microscope stand.
- 2. On the for screen, press Vent to release the load lock vacuum.



#### MODEL 1051 TEM Mill instruction manual

**3.** Remove the load lock cover.



**4.** Remove the capsule from the glove box and place the capsule over the load lock.



**5.** Press **Pump** to evacuate the load lock and Vacuum/inert gas transfer capsule..

 FISCHIONE
 Model 1051 TEM Mill

 IN STRUMENTS
 Model 1051 TEM Mill

 Load Lock
 Mame

 Pump
 Recipe

 Vent
 Milling

- 6. You are now ready to set the parameters for milling the specimen. If you would like to:
  - create your own milling recipe, see <u>Building a recipe</u>, page 27
  - load an existing milling recipe, see Loading a saved recipe, page 40

# Working with recipes

One of the most useful features of the TEM Mill is the ability to define complex milling processes that consist of multiple steps, each having unique instrument settings or parameters. These processes are called recipes, which may be defined, saved, and recalled for future use.

A recipe is a list of milling steps that will be executed sequentially. It is a method to program a complex set of operations that can be performed automatically and repeatedly by the TEM Mill. In addition to milling steps, recipes enable you to customize and standardize automated operation. This can include gas line purges, milling parameters, programmed delays, and other functionality.

You must have superuser, service, or administrator permissions to build and save recipes. See <u>Understanding</u> <u>permissions</u>, page 68.

Recipe topics in this section include:

- Building a recipe, page 27
- Saving a recipe, page 39
- Loading a saved recipe, page 40
- Editing a saved recipe, page 41
- Changing the order of recipe steps, page 42

If you wish to make a backup copy of recipe files, you can do so by saving a copy of the recipe files (.rcp) onto a USB drive. See <u>Copying recipe files, page 71</u>.

### Building a recipe

#### Purging the gas line

Fischione Instruments recommends a short purge step at the start of every milling operation. Purging the gas eliminates any voids in the argon gas supply line.

1. On the for screen, press Purge.

The Purge screen opens.

- **2.** Use the keypad to enter the time length of the purge. Fischione Instruments recommends a purge of 15 to 45 seconds.
- 3. Press ENTER.

The **Purge** screen closes and you are returned to the **f** screen. The purge step has been added to the recipe.



### **Defining milling parameters**

The milling parameters include independent control of both ion source's energy and angle settings, stage rocking and rotation, and stage cooling.

1. On the **f** screen, press Milling.



The Milling screen is displayed.

- 2. If you would like to use the left ion source during milling; press the Left Ion Source box to select it.
  - **a.** Press the **Voltage kV** field to select it and then use the keypad on the right side of the touch screen to enter the desired left ion source voltage (range: 100 e to 10 keV).
  - **b.** Press the **Angle**° field to select it and then use the keypad to enter the left ion source beam angle (range: -15 to +10°).
- **3.** Repeat step 2 to set the beam parameters for the right ion source, if desired.

Step 2: Milling	Reset Delete Cancel ENTER	
Left Ion Source Voltage XV Angle*   Right Ion Source Voltage XV Angle*   Specimen Rotation RPM  None  Continuous Angle*±  Rocking	Time Limit Hour Min Sec 	1         2         3           4         6         6           7         8         9            0         Tab            4         5
Voltage kV Angle* 4 3 Right Ion Source Voltage kV Angle* 	Cooling Off O Protection On O Regulation	Min Sec : : - % Sec : - *C

For TEM Mills without the optional motorized ion sources: If you have two or more milling steps in which the ion source angle changes (for example, milling step 1 has a beam angle of 2° and milling step 2 has a beam angle of 1°), you need to add a delay step to the recipe so that you will have time to manually change the ion source beam angle in between milling steps. Otherwise, the second milling step will occur with the ion source beam angles set to the same beam angle as was used in the previous milling step. See Inserting a delay in the recipe, page 32.

- 4. Select the desired stage motion:
  - None: The stage will not rotate nor rock the specimen during milling.

None			
O Continuous	Angle*±	Rotation Offset Angle <sup>®</sup>	
O Bocking			

- **Continuous:** The stage rotates the specimen continuously during the milling step. This option is typically used for planar specimens.
  - **a.** Enter the number of rotations per minute in the **RPM** field (range: 1 to 10 rpm).
  - **b.** Press the **Beam Sequencing** check box to enable/disable beam sequencing.

Beam sequencing is only selectable when **Continuous Rotation** is enabled. As the stage rotates, the ion beams automatically switch on and off to avoid hitting the specimen clamps on the specimen holder.

- **Rocking**: The stage continuously rocks the specimen during the milling step.
  - **a.** Enter the number of rotations per minute in the **RPM** field (range: 1 to 10 rpm).
  - b. Enter the angle at which the specimen will be rocked in the Angle<sup>o</sup>± field (range: 0 to 180°).
  - c. Enter a Rotation Offset value if the specimen rotation is set to Rocking and you want to offset the angle of rotation (the degree of offset from the normal rotation angle).
- 5. To control the length of the milling step, press Time Limit. Milling will stop when the userentered time is reached.

Enter the desired milling time length in the **Hour**, **Min**, and **Sec** fields.

6. Press the Laser Penetration check box to enable laser penetration. This option is only available if the optional autotermination system (part number 041-5449) is installed on top of the load lock.

) None	3	Beam Sequencing
Continuous	Angle*±	Rotation Offset Angle <sup>®</sup>
Rocking		

O None	3		
) Continuous	Angle®±	Rotation Offset Angle <sup>®</sup>	
Rocking	15	20	

Time Limit	Hour 00	Min : 20	Se ]:	。 00			
MI accer Depotration	] %	Sec			1	2	3
	20	0			4	5	6

When enabled, laser penetration functionality monitors the specimen to determine when the laser can be detected by the photodetector in the base of the chamber, which indicates that the ion beam(s) has penetrated the specimen. When the laser beam is detected, the instrument terminates the milling operation.
• Enter the percentage of laser light transmission.

A higher laser penetration percentage setting means that more light is required to trigger termination. Conversely, a lower percentage means less light is required to trigger termination.

In specimens that can achieve translucence, it is possible (by experimenting with low percentage settings) to terminate the milling process when translucence is achieved, but before an actual hole is created.

Range: 0 to 100%.

• Enter the frequency, in seconds, that the shutter will open so that the user can perform a laser termination check.

If this value is set to 0 (zero) seconds, then the shutter will remain open throughout the milling process, thus enabling the user to check for milling termination at any time. However, expected results will be achieved only when continuous rotation is employed.

Range: 0 to 300 seconds.

- 7. If your instrument has the optional cooling functionality installed and you wish to cool the specimen during milling, select one of the following options:
  - Off: Stage cooling is not enabled; the specimen will not be cooled during milling operations.
  - On: Stage cooling is enabled; Fischione Instruments recommends that you wait approximately 15 minutes after adding liquid nitrogen to the dewar before beginning milling operations. (See <u>Controlling thermal</u> properties, page 85.)
  - **Protection**: Stage cooling is enabled and the instrument will stop milling operations if the temperature of the stage rises above the value you enter in the °C field.
  - **Regulation**: Stage cooling is enabled and the instrument will employ heating and cooling functionality to maintain the stage temperature that you enter in the °C field.







**8.** Review the milling parameters and make any necessary changes.

Press:

- Reset to return to the default settings.
- Delete to delete the settings you entered.
- Cancel to leave the Milling screen and return to the 
  screen without saving your settings. The milling step is not added to the recipe.
- Enter to save the milling parameters and return to the for screen. The milling step is added to the recipe.

A brief summary of the milling parameters is listed beneath the step in the comment field. If you touch the comment field, a keyboard opens and you can enter additional comments.



Delete

Reset

Cancel

ENTER

#### Inserting a delay in the recipe

The delay functionality allows you to place a pause in the recipe; either a pause of a specific time length or a pause that waits for user action.

1. On the fraction screen, press Delay.



The **Delay** screen opens.

Two delay options are presented:

- **Timed**: Allows you to enter a specific delay length after which the recipe continues onto the next recipe step.
- Wait for user action: Allows an indefinite pause; the recipe continues on to the next recipe step when the user manually resumes it.

This type of delay is useful if you need to manually change the ion source beam angle between milling steps.

Step 3: Delay		Reset	Delete	Cancel	ENTER			
		Hour	Min :	Sec .		1	2	
	• Timed	:	:(			4	5	
	O Wait for user	action				7	8	-
							0	1 1000 1

- 2. Select the type of delay you desire. If you select a **Timed** delay, enter the delay time length in the **Hour**, **Min**, and **Sec** fields.
- 3. Press Enter to save the delay settings and return to the **n** screen.

 Add New Step
 Recipe

 Image: Milling
 1
 Purge 00:00:45

 Image: Purge
 2
 Mill 00:45:00

 Image: Purge
 2
 Mill 00:45:00

 Image: Delay
 Image: Purge
 3

 Image: Delay
 Image: Purge
 1

 Image: D

The delay step is added to the recipe.

#### Unloading the specimen

The unload functionality will raise the stage from the chamber and into the load lock. The specimen will remain in the load lock under vacuum until you remove the specimen from the TEM Mill.

If you are using stage cooling functionality, the unload step will not over-ride stage temperature settings. Therefore, the instrument will not allow the stage to move into the load lock until the specimen temperature has had time to warm up. This protection helps to avoid added stress to the specimen caused by rapid warm up To add an unload the specimen step:.

1. On the **f** screen, press Unload.

Add New Step Recipe Vent Purge 00:00:45 1 Milling Specimen Mill 00:45:00 Purge Left Beam [Voltage: 4 kV, Angle: 3°, Focus: 5 Continuous Rotate Chamber Delay Delay (no time limit) Stage: Load Lock: 1 Unload Chamber: 9.6E-06 Torr **↓** Cycle **Back Light** Delete Cancel Step 6: Unload ENTER

The Unload screen opens.

2. Press ENTER to add an unload step.

The unload step is added to the recipe.

#### Defining a multi-step milling cycle

You can write and save repetitive, multi-step milling operations using cycles. To define a cycle, you must first define the step sequences that comprise it.

#### Example

Mill the specimen in the normal orientation using one ion source for 5 minutes and then rotate the specimen 180° using a rotation offset to mill from the other side for another 5 minutes. Repeat the two-step recipe six times.

The milling steps will be:

Step 1. Mill 00:05:00

Left Beam [Voltage: 3 kV, Angle: 2°, Focus: 50%] Right Beam [disabled] Rocking Rotate

Step 2. Mill 00:05:00

Left Beam [Voltage: 3 kV, Angle: 2°, Focus: 50%] Vertical Offset 180° Right Beam [disabled] Rocking Rotate

To repeat this 10 minute sequence for 1 hour, add another step to define step number 1 as the start of the cycle and repeat the two-step recipe 6 times, as shown below.

#### To create a cycle step:

1. On the fraction screen, press Cycle.

The Cycle screen opens.

- **2.** Determine the cycle parameters:
  - a. Enter the number of steps in the cycle in the Number of Steps to Cycle field.

In the example above, there are three steps: two milling steps and one unload step.

- **b.** Enter the number of times you wish the cycle to be repeated in the **Number of Cycle Iterations** field.
- c. Press ENTER to save the cycle settings and return to the frequencies.

The cycle step is added to the recipe.

Step 3: Cycle	Reset	Delete	Cancel	ENTER
				$\frac{1}{7}$
	Number of Steps to Cycle	2		
	Number of Cycle Iterations	6		
Recipe				
1 Mill 00:05:00				
Left Beam [Disabled] Right	Beam [Voltage: 4	kV, Angle: 5	"] Rocking	10°
2 Mill 00:05:00				
Left Beam [Disabled] Right Rotation Offset 180°	Beam [Voltage: 4	kV, Angle: 3	°] Rocking	10°
3 Cycle				
2 steps; 6 iterations				

#### Setting up image capture

Image capture is an optional feature of the TEM Mill. If your TEM Mill has a high-magnification microscope, you can add an image capture step to your recipe. Captured images are saved to the computer mounted on the back of the monitor that is included with the high-magnification microscope/image capture functionality. The captured image files can be copied onto a USB drive and transferred to another computer.

If your TEM Mill does not have image capture functionality, the **Capture** button will not be displayed on the touch screen.

You can also capture an image at any time by pressing **Snapshot** in the image capture application interface; it does not have to be part of a multi-step recipe. The image capture application is displayed on the monitor (not the touch screen). Use the provided keyboard and mouse to interact with the image capture application.

In this section you will find information on:

- Including an image capture step in a recipe, below
- Taking a snapshot during milling, page 39

#### Including an image capture step in a recipe

1. On the fraction screen, press Capture.



A capture step is added to the recipe.

During milling operations, when the recipe reaches the capture step, it will capture images based on the parameters you define in the image capture application.



**2.** Carefully tip the microscope forward and slowly lower it into place over the load lock cover.

**3.** Click **Start** on the image capture application, which is displayed on the monitor.



4. On the touch screen, press **Chamber** to lower the specimen into the chamber. Moving the specimen into the chamber allows you to adjust the Illuminator so that the optimal amount of light is used to illuminate the specimen during milling.

You should be able to view the specimen in the image capture interface.

- **5.** Enter a value in the **Illuminator** % field. Try various settings to determine the optimal percentage of light required to obtain a good image. Range 0 to 100%.
- 6. Enter a value in the Exposure field, in milliseconds (ms).

The exposure is the amount of light received by the image sensor. Exposure is determined by the intensity of light received by the sensor (number of photons) and the duration of time that the sensor is exposed to the light. Range is 1 to 30,000 ms (3 seconds).

7. Enter a value in the Gain field.

The gain value represents the relationship between the number of electrons acquired on an image sensor and the analog-to-digital units (ADUs) that are generated, representing the image signal. Increasing the gain amplifies the signal by increasing the ratio of ADUs to electrons acquired on the sensor. The result is that increasing gain increases the apparent brightness of an image at a given exposure. Range is 100 to 383.

8. On the touch screen, press Load Lock to return the specimen to the load lock in preparation for milling operations.

9. Determine the image capture parameters:

Enter the name of the project in the **Project** field. All images captured under the same project name will be grouped in the same folder; if the folder does not already exist in the directory, it will be created automatically. This field is optional. If you do not specify a project, all images will be saved at the top level of the directory.

- **c.** Enter a prefix in the **Prefix** field that will be added to each captured image file name. For example, you may want to add "specimen02" to the beginning of each image file. This field is optional.
- **b.** Select **Fast Focus Mode** if you want the image to be captured quickly. Images captured in Fast Focus Mode may be of lower quality than those images captured at normal acquisition speed.
- c. Select either Numbered or Time Stamped image file names.

Captured images are automatically assigned file names that are either numbered consecutively or time stamped at the time of capture. For example, captured images with the user-specified prefix, "specimen02", will be named the following if you select:

- Numbered: The first image captured with that prefix creates an image file with the name, "specimen02\_0001".
- Time stamped: Each image captured with the prefix creates an image file with the prefix plus the date and time, such as: "specimen02\_2018-02-23\_17\_22\_14.png" (prefix\_YYYY-MM-DD\_HH\_ MM\_SS.png).

Images are saved in the .png format.

When an image is captured, the name of the image file is displayed beneath the **Numbered** and **Time Stamped** options.

d. If you wish to capture a series of images during milling operations at a specified time interval, select Sequential Capture while Milling.

If you select this option, specify the time interval for image capture in the H (hours), M (minutes), and S (seconds) fields.

When you start the milling recipe, an image will be captured immediately to document the specimen before ion milling. Subsequent images will be captured based on the time interval you specified.

e. Press SET to save your time selections.

The recipe is now ready to capture images according to the parameters you set in the image application. See <u>Working with image files</u>, page 51, for information on managing image files.

#### Taking a snapshot during milling

You can also perform image capture outside of a multi-step recipe:

- 1. Position the microscope over the load lock.
- 2. Click Start on the image capture application.
- 3. Adjust the Illuminator.
- 4. Enter a Project Name or image file Prefix, if desired.
- 5. Press Snapshot.

The shutter will automatically open, capture the image, and then close the shutter.

**6.** Press **Stop** on the image capture application when you are finished. This will return the **Illuminator** setting to 0%.



**Caution.** If you open the shutter during milling, make sure to clean the load lock window with isopropyl alcohol and a lint-free cloth at the conclusion of milling operations. Frequent cleaning will prevent the accumulation of sputter on the window. Do not use any type of abrasive cleaning materials; this can damage the coating on the window and compromise in situ viewing and imaging. Best practices are to clean the shutter before and after milling operations to ensure load lock window cleanliness.

# Saving a recipe

You can save a recipe for future use; however, you must have superuser, service, or administrator permissions. See <u>Understanding permissions</u>, page 68.

1. On the **f** screen, touch the Name field.



#### MODEL 1051 TEM Mill instruction manual

A cursor appears in the Name field and the keyboard opens

- 2. Use the keyboard to enter a name for the recipe.
- 3. Press Exit on the keyboard.
- 4. Press Save.
- 5. If you are ready to begin milling, see <u>Milling a</u> <u>specimen</u>, page 43.



# Loading a saved recipe

Recipes that have been saved can be loaded for use at a later time.

1. On the fraction screen, press Load.



The Load Recipe dialog opens.

2. Navigate to: /opt/Fischione/M1051/var/recipes.

The list of saved recipes are displayed.

- **3.** Select the name of the recipe you would like to load from the directory listing.
- 4. Press Open.

The Load Recipe dialog closes. The saved recipe that you selected is now displayed on the screen.

You can run the saved recipe as is, or edit the recipe steps. See <u>Editing a saved recipe</u>, below.



# Editing a saved recipe

You can easily change the parameters of a saved recipe; however, you must have superuser, service, or administrator permission. See <u>Understanding permissions</u>, page 68.

On the for screen, press the step that you would like to edit.

In this example, we are editing the Delay step.



The Delay screen opens.

2. Change the parameters you desire.

In this example, instead of a 15-minute delay, we are selecting **Wait for user action**.

**3.** Press ENTER to save your changes and return to the **f** screen.

In this example, changing the **Delay** step from 15 minutes to **Wait for user action** results in the step, "Delay (no time limit)."

Step 3: Delay		Reset	Delete	Cancel	ENTER
	O Timed	Hour	Min 5	Sec	
5	• Wait for use	er action			

Reci	pe
1	Purge 00:00:45
2	Mill 00:20:00
-	Left Beam [Voltage: 4 kV, Angle: 3°, Focus: 50%] Right Beam [Voltage: 4 kV, Angle: Continuous Rotate
3	Delay (no time limit)
4	Mill 00:20:00

#### MODEL 1051 TEM Mill instruction manual

#### Changing the order of recipe steps

You can use drag and drop steps to easily change the order of steps in a recipe.

 On the f screen, press and hold the step that you would like to edit.

In this example, we will move the **Delay** (step 4), in between the two milling steps (steps 2 and 3).



The selected step changes into a solid rectangle.

2. Drag the step to the position you desire.

![](_page_47_Picture_8.jpeg)

3. Release the step.

The **Delay** is now step 3, in between the two milling steps (steps 2 and 4).

![](_page_47_Picture_11.jpeg)

# Milling a specimen

# Milling all types of specimen mounts

Follow the instructions below to begin milling specimens mounted:

- on a post-style specimen holders
- on an X-Y adjustable specimen holders
- in the Vacuum/inert gas vacuum transfer holder

#### To start specimen milling:

- 1. If you are using stage cooling:
  - a. Press 🛠 to display the System screen.
  - **b.** If the **Thermal** screen is not already displayed, press **Thermal**.
  - c. Verify that stage cooling has reached the desired temperature for milling. Depending on when you added liquid nitrogen to the dewar and the temperature you are trying to reach, you may need to wait a few minutes before you can start milling operations.

![](_page_48_Figure_12.jpeg)

2. Clean the load lock view window to remove any sputter that may remain from previous milling operations. Good laboratory practice is to clean the view window before and after each milling operation. This will ensure that sputter does not build up on the view window.

![](_page_48_Picture_14.jpeg)

**Caution.** If you open the shutter during milling, make sure to clean the load lock window with isopropyl alcohol and a lint-free cloth at the conclusion of milling operations. Frequent cleaning will prevent the accumulation of sputter on the window. Do not use any type of abrasive cleaning materials; this can damage the coating on the window and compromise in situ viewing and imaging. Best practices are to clean the shutter before and after milling operations to ensure load lock window cleanliness.

#### MODEL 1051 TEM Mill instruction manual

- **3.** If your TEM Mill has an optional high-magnification microscope and you have added an image capture step(s) to your recipe:
  - **c.** Carefully tip the microscope forward so that it rests above the load lock.
  - **b.** Click **Start** on the image capture application.

![](_page_49_Picture_4.jpeg)

4. If your TEM Mill does not have the optional automatic beam angle adjustment functionality, manually position the ion sources to match the beam angle of your recipe's first milling step.

For example, if the beam angle of your first milling step is 3°, manually position one or both ion sources (depending on whether you are milling with one or two ion sources), to 3°.

Align knob with the fiducial mark. The beam angle range on the TEM Mill is 0 to +10°.

![](_page_49_Picture_8.jpeg)

- **5.** If you are milling a specimen using the Vacuum/ inert gas vacuum transfer holder:
  - **a.** Look down through the top of the capsule to view the capsule door and specimen holder (planar stub or cross-section holder).

The image to the right shows a SEM sample holder; not a TEM post-style specimen holder. The procedure for use, however, is the same.

![](_page_49_Picture_12.jpeg)

**b.** Push the capsule door control down to open the door at the base of the capsule.

The image to the right shows a SEM sample holder; not a TEM post-style specimen holder. The procedure for use, however, is the same.

c. Push the specimen holder control down to extend the holder past the base of the capsule and into the TEM Mill stage.

The image to the right shows a SEM sample holder; not a TEM post-style specimen holder. The procedure for use, however, is the same.

![](_page_50_Picture_5.jpeg)

![](_page_50_Picture_6.jpeg)

- d. Turn the holder control to unthread the holder from the holder control rod.
- e. When the rod is free from the holder, pull the holder control up to retract the rod from the load lock and into the capsule.
- f. Pull the capsule door control up to close the capsule door.
- 6. On the fraction screen, press Start.

The milling operations screen opens.

The shutter controls (**Open/Close**) are on the left. In general, it is best to keep the shutter closed during milling to keep the viewing window free of sputter. If you have programmed a **Capture** step in the recipe, the instrument will automatically open the shutter, capture the image of the specimen in the chamber, and then close the shutter.

utter	lon So	urces
Open	LEFT	RIGHT
Close	Running	Running
Close	4.0 kV	4.0 kV
	51.4 µm	49.9 µm
	0.11 sccm	0.11 sccm
	3°	3°

The left and right ion source settings and statuses are displayed to the right of the shutter controls.

The remaining recipe time is displayed beneath the ion source information. If you press **Total Time**, it will toggle the remaining time display to show the remaining step time. That is, the remaining **Step Time** displayed refers to the step currently highlighted on the right side of the screen.

If your instrument has stage cooling capability, the status of the cooling system is displayed beneath the **Total Time/Step Time** button.

The recipe steps are displayed on the right side of the screen; the current step is highlighted.

![](_page_51_Figure_5.jpeg)

Left Beam [Voltage: 4 kV, Angle: 3°, Focus: 50%] Right Beam

Mill 00:20:00

Delay 00:00:15

Capture

2

Controls for managing the execution of the recipe are located at the bottom of the screen.

Control	Description
••	Press to move one step backward in the recipe.
► Start	Press to start milling operations; operations will begin at the currently selected recipe step. Once <b>Start</b> is pressed, the button toggles to <b>Stop</b> .*
II Pause	Press to pause the recipe. Once <b>Pause</b> is pressed, the button toggles to <b>Resume</b> . Press Resume to continue milling operations at the same place they were paused.
••	Press to move one step forward in the recipe.
END	Press to stop the recipe and exit milling operations. You will be returned to the for screen.

\*If you press **Stop**, the Process Interruption dialog is displayed; it presents you with the following options:

- Start next step. The operation advances to the next recipe step and executes the step and any other recipe steps that follow it.
- **Restart current step.** The currently selected recipe step is restarted. For example, if the step was a 45-second purge and you pressed **Pause** after 15 seconds of the purge had elapsed, the 45-second purge would restart, giving you a total purge time of 1 minute.
- Terminate recipe. This option will stop milling operations. You will remain on the milling screen. You may chose to restart milling operations or to press END and return to the for screen.

 Start	Pause		END

![](_page_52_Figure_8.jpeg)

- 7. During the execution of a recipe, you may want to view the specimen in the chamber. To do so, you must open the shutter.
  - a. Press Open to open the shutter.

The shutter opens. If you have a:

- Stereomicroscope, you will be to see the specimen in the chamber through the microscope eye pieces.
- High-magnification microscope, the specimen image will be displayed on the microscope monitor.
- **b.** After you have finished viewing the specimen, make certain to press **Close**. This will protect the view window from sputter when you resume milling operations.

![](_page_53_Figure_7.jpeg)

**Caution.** If you open the shutter during milling, make sure to clean the load lock window with isopropyl alcohol and a lint-free cloth at the conclusion of milling operations. Frequent cleaning will prevent the accumulation of sputter on the window. Do not use any type of abrasive cleaning materials; this can damage the coating on the window and compromise in situ viewing and imaging. Best practices are to clean the shutter before and after milling operations to ensure load lock window cleanliness.

If your TEM Mill has a Stack Light (optional), you can oversee milling operations from a distance. Below is a list of the Stack Light color indicators and a description of what the colors signal:

Color	Description
Red	TEM Mill is in a fault condition;
	operation cannot continue until
	the fault is cleared.
Yellow	TEM Mill is unavailable because
	it is completing a user initiated
	task, such as placing the
	chamber at vacuum.
Green	TEM Mill is available for use.
Yellow and	Milling operations are underway.
green	
None	TEM Mill power is off.

![](_page_53_Picture_11.jpeg)

8. When the recipe is finished, the Sequence Complete dialog is displayed.

Press OK to close the dialog and return to the screen.

![](_page_54_Picture_3.jpeg)

# Removing a specimen from the TEM Mill

#### Removing a specimen holder (post-style or X-Y adjustable) from the load lock

1. If the specimen is still in the chamber, press Load Lock.

The stage moves the specimen from the chamber to the load lock.

- 2. On the **f** screen, press Vent to release the load lock vacuum.
- **3.** Remove the load lock cover. If you are unable to remove the cover, wait a minute until the load lock reaches atmosphere.

Place the load lock cover into the load lock holder (part number 041-5679) so that the load lock window does not get scratched.

- **4.** Use the TEM tweezers (part number 041-5831) to grip the holder and then lift the holder from the stage.
- 5. Replace the load lock cover.

![](_page_54_Picture_13.jpeg)

**Caution.** If you open the shutter during milling, make sure to clean the load lock window with isopropyl alcohol and a lint-free cloth at the conclusion of milling operations. Frequent cleaning will prevent the accumulation of sputter on the window. Do not use any type of abrasive cleaning materials; this can damage the coating on the window and compromise in situ viewing and imaging. Best practices are to clean the shutter before and after milling operations to ensure load lock window cleanliness.

6. On the fraction screen, press Pump to return the load lock to vacuum.

#### Removing the vacuum/inert gas transfer capsule from the load lock

- 1. If the stage and holder have not returned to the chamber following milling, press Load Lock.
- **2.** If desired, connect the argon gas supply to the gas valve connector and then open the capsule gas valve to flood the capsule with argon.
- **3.** Close the gas valve and then disconnect the gas supply from the capsule.
- **4.** Push the capsule door control down to open the door at the base of the capsule.
- 5. Push the specimen holder control down to extend the rod past the base of the capsule and into the specimen holder.
- 6. Thread the rod into the specimen holder.
- **7.** Pull the capsule holder control up to retract the specimen holder into the capsule.
- **8.** Pull the capsule door control up to close the capsule door.
- 9. Press Vent to release the load lock vacuum.
- 10. Remove the vacuum/inert gas transfer capsule from the TEM Mill and return it to the glove box.
- 11. Place the load lock cover on the load lock.

![](_page_55_Figure_15.jpeg)

# Working with image files

Image capture is an optional feature of the TEM Mill that is available with the high-magnification microscopes (525X or 1,960X); it is not available with the stereo microscope option. For information on capturing images during milling operations, see <u>Unloading the specimen, page 33</u>.

Captured images are in the .png file format and are saved to the computer that is mounted on the back of the microscope monitor.

# Viewing the image files directory

Press Manage Images... to open the directory and view the captured image files.

![](_page_56_Picture_6.jpeg)

The Gwenview directory opens. Gwenview is image manager that allows you to view and manage captured image files.

Gwenview documentation is available at:

https://docs.kde.org/stable5/en/kdegraphics/ gwenview

![](_page_57_Figure_4.jpeg)

# Copying image files to a USB drive

You can copy captured images from the monitor computer to a USB drive.

1. Insert a USB drive into the open USB port on the computer mounted on the back of the monitor.

The USB port on the back of the TEM Mill is used for software updates, service, and transferring copies of saved recipe files (.rcp); this USB port is not to be confused with the USB port on the back of the microscope monitor, which is used for image file transfer.

![](_page_57_Picture_9.jpeg)

**2.** Press **Manage Images...** to open the Gwenview image file directory.

![](_page_58_Picture_2.jpeg)

- 3. Navigate to the directory that contains the image or folder that you would like to copy to the USB drive.
- **4.** Right-click on the image or folder to display its object menu.
- 5. Select Move to... from the object menu.

![](_page_58_Picture_6.jpeg)

The Move to... dialog opens.

- **6.** Select the USB drive from the directory on the left side of the dialog.
- 7. Click Move.

A copy of the file is saved to the USB drive.

8. Click Remove USB when you are ready to remove the USB drive from the monitor computer.

![](_page_58_Picture_12.jpeg)

- **9.** Click **Remove USB** when you are ready to remove the USB drive from the monitor computer.
- **10.** Remove the USB drive.

![](_page_59_Figure_3.jpeg)

# Deleting image files

You can copy captured images from the monitor computer to a USB drive.

- 1. Navigate to the directory that contains the image or folder that you would like to delete..
- 2. Highlight the folder(s) or images(s) that you would like to delete.
- 3. Right-click on one of the highlighted folders or images to display its object menu.
- 4. Select Delete from the object menu.
- 5. The selected folder(s) or image(s) are deleted.

# Performing administrative tasks

The TEM Mill offers various tools that help you record and manage instrument use:

- **Console**: Log instrument activities, including faults. This information can be useful for troubleshooting instrument performance issues. See <u>Logging instrument activity</u>, page <u>55</u>.
- Tracking: Track left and right ion source maintenance and longevity. See <u>Tracking ion source maintenance</u> and lifetime use, page 56.
- Usage: Track instrument activity based on user log in. See <u>Tracking instrument use by user account, page</u> <u>61</u>.
- Users: Manage user accounts. See Managing users, page 65.
- Time: Set instrument time and date. See <u>Setting the instrument date and time, page 69</u>.
- Files: Copy, move, or delete recipe files from the TEM Mill internal drive. See <u>Copying, moving, or deleting</u> recipe files, page 71.
- Info: View TEM Mill software version information. See <u>Viewing TEM Mill software version information</u>, page 74.

#### Logging instrument activity

The **Console** log is a detailed record of instrument operations and provides a historical account of instrument use. Reviewing the log can be helpful when troubleshooting instrument issues.

1. On the **f** screen, press **l**.

The Diagnostics screen opens.

**2.** If the Console log is not currently displayed, press **Console**.

![](_page_61_Picture_2.jpeg)

Instrument activity is displayed on the right side of the screen, preceded by a time stamp (HH:MM:SS).

## Tracking ion source maintenance and lifetime use

You can track the maintenance and lifetime use of the ion sources. You can also use tracking to set ion source maintenance and replacement schedules.

Ion source maintenance (cleaning) requirements and longevity are highly influenced by the manner in which the instrument is used. For example, if your lab uses the TEM Mill a few times per week and generally performs short, low voltage milling, the ion sources are likely to have greater longevity than ion sources used in a high throughput environment where higher voltages are employed. The same is true for ion source cleaning: instruments used sporadically at low voltages will not require ion source cleaning as frequently as instruments used daily at high voltages.

Tracking ion source maintenance and longevity allows you to gain a better understanding of how your TEM Mill is being used. For example, if you notice a decrease in beam quality, you can adjust your maintenance schedule so that the ion sources are cleaned more frequently, thus ensuring a more consistent beam quality.

The TEM Mill tracks each ion source independently by:

- Cycles: The number of times an ion source turns on and emits plasma. For example, if you have a multistep recipe that has three milling steps 5 kV, 3 kV, and 1 kV the ion source will turn on and emit plasma three times, which would be counted as three cycles.
- Hours: The cumulative number of hours that the ion source is on and emitting plasma.

1. On the factor = 1 screen, press

The Diagnostics screen is displayed.

Diagnostics

**2.** If the Tracking screen is not displayed already, press **Tracking**.

The Tracking screen is displayed.

**3.** Use the drop-down menu to select the ion source (Left Ion Source or Right Ion Source).

The current lifetime cycles and hours are displayed in the Life/Total section of the screen

The actual cycles and hours values are displayed in the **Counters** column.

The user-defined limits are displayed in the **Limits** column. User-defined limits indicate when you might want to replace the ion source.

![](_page_62_Picture_8.jpeg)

When the instrument reaches either the cycles or hours limit, an alert will be displayed; no changes in instrument functionality will occur, however.

To remove the alert, either:

- Enter a higher limit if the ion sources are still performing well. See <u>Changing ion source</u> <u>tracking limits, page 59</u>. The alert will not disappear immediately, it will remain until you operate the ion sources again.
- Replace the ion source(s) and reset the cycles and hours counters to zero. See <u>Resetting ion</u> source tracking counters, page 60.

For information on replacing the ion sources, see the *Model 1051 TEM Mill Service Manual* (document number 041-6075).

The current maintenance period cycles and hours are displayed in the Maintenance Period section of the screen.

The actual cycles and hours values are displayed in the **Counters** column.

The user-defined limits are displayed in the **Limits** column. User-defined limits indicate when you might want to clean the ion source.

e/Total 2018-0	2-07 12:09	Manage		
002 cycles	4000 cyc	Reset Counters	۹ 🔒 .	
514.3 hours	2000 hrs	Define Limits	9	
	riod 2018-02-07 12	:09		
Counters	Limits	Manage		
Counters 273 cycles	Limits 400 cyc	Manage Reset Counters	٩	

Right Ion Sou	rce Hours			
Life/Total 2018- Counters	02-07 12:09 Limits	Manage		
2207 cycles	4000 cyc	Reset Counters	٩	
614.3 hours	2000 hrs	Define Limits	٩	
Maintenance P Counters	eriod 2018-02-07 12 Limits	2:09 Manage		
273 cycles	400 cyc	Reset Counters	٩	$\leftarrow$
20.0 haura	200 bro	Define Limits	ę	

When the instrument reaches either the cycles or hours limit, an alert is displayed; no changes in instrument functionality will occur, however.

To remove the alert, either:

- Enter a higher limit if the ion sources are still performing well. See <u>Changing ion source</u> <u>tracking limits, page 59</u>. The alert will not disappear immediately, it will remain until you operate the ion sources again.
- Clean the ion source(s) and reset the cycles and hours counters to zero. See <u>Resetting ion</u> source tracking counters, page 60.

For information on how to clean the ion sources, see the *Model 1051 TEM Mill Service Manual* (document number 041-6075).

![](_page_64_Figure_6.jpeg)

#### Changing ion source tracking limits

The ion source tracking limits are locked to prevent accidental changes to the limit settings. However, if your user account has permission to change the limits, the settings are easily unlocked (see <u>Understanding</u> <u>permissions</u>, page 62). Remember that you are changing limits one source at a time. After you change the limits for one ion source, you will have to repeat it for the other ion source if you want them to have equal limits.

- 1. To change the:
  - Life/Total cycles and hours limits

Press the **7** in the Life/Total section to unlock the Life/Total Limits fields.

• Maintenance Period cycles and hours limits

Press the **T** in the Maintenance Period section to unlock the Maintenance Period Limits fields.

![](_page_64_Figure_14.jpeg)

- **2.** Highlight the value that you would like to change in the limits field.
- 3. Use the touch screen keypad to enter a new value. Alternatively, use the field's control to select a new value.

![](_page_65_Picture_3.jpeg)

- 4. Press 🔒 to lock the limits fields.
- 5. If you wish to make the same changes to the limits for the other ion source, select the other ion source from the drop-down menu and repeat this procedure.

![](_page_65_Picture_6.jpeg)

#### Resetting ion source tracking counters

The ion source tracking **Reset Counters** button is locked to prevent accidental reset. However, if your user account has permission to reset the counters (see <u>Understanding permissions</u>, page 62), then the button is easily unlocked.

- 1. To reset the:
  - Life/Total cycles and hours counters to zero:

Press the **f** in the Life/Total section to unlock the Reset Counters button.

• Maintenance Period cycles and hours counters to zero:

Press the **7** in the **Maintenance Period** section to unlock the **Reset Counters** button.

![](_page_65_Picture_14.jpeg)

ife/Total 2018- Counters	02-07 12:09 Limits	Manage	
2207 cycles	4000 cyc	Reset Counters	Ŷ
614.3 hours	2000 hrs	Define Limits	Ŷ
Maintenance Po Counters	eriod 2018-02-07 12 Limits	::09 Manage	
273 cycles	400 cyc	Reset Counters	۴ 🔶
	000 h	Diofine Limite	•

2. Press Reset Counters.

The values in the first column are reset to zero. The **Reset Counters** button automatically locks.

**3.** If you wish to reset counters on the other ion source, select the other ion source from the drop-down menu and repeat this procedure.

-ife/Total 2018- Counters	02-07 12:09 Limits	Manage			
2207 cycles	4000 cyc	Reset Counters	f		
614.3 hours	2000 hrs	Define Limits	٩		
Maintenance Po Counters	eriod 2018-02-07 12 Limits	:09 Manage	_		/
	100	Beset Counters			
0 cycles	400 Cyc				
0 cycles	400 Cyc				
0 cycles 0.0 hours	200 hrs	Define Limits	Ŷ		
0 cycles 0.0 hours eft Ion Source	200 hrs	Define Limits	f		
0 cycles 0.0 hours Left Ion Sourc	e Hours	Define Limits	Ŷ		<b>•</b>
0 cycles 0.0 hours Left Ion Sourc ner rotal 2018- Counters 2207 cycles	e Hours Limits 4000 cyc	Define Limits	Ŷ	<mark>`</mark>	

٩

٩

400 cyc

200 hrs

0 cycles

0.0 hours

# Tracking instrument use by user account

The Usage log is a record of instrument activity based on user logins.

1. On the **f** screen, press

The Diagnostics screen opens.

2. If the usage log is not currently displayed, press Usage.

Diagnostics	
E Console	
🔊 Tracking	
L Usage	

Activity is displayed on the right side of the screen:

- Logins: The number of times the user has logged in. For example, if a person logged in three times using the user account, "Operator," there would be three unique log entries (1, 2, and 3) with the information for each login listed separately.
- Login Time: The time at which the login occurred (HH:MM:SS).
- **Runs**: The number of times the ion sources were lit during the unique login.
- **Run time**: The cumulative length of time the ion sources were lit during the unique login.
- User: The user name associated with the login.

Diagnostics					
Console	Logins	Login Time	Runs	Run Time	User
Tracking		14:12:56	3	0:27:13	Operator
	1	03:16:24	0	0:00:00	Group lead
L Usage	3	07:35:01	2	0:10:00	Operator
	4 5	14:12:50		1:30:00	Operator Operator
		03:16:24	.0	0:00:00	Operator
		07:35:01		0:10:00	Operator
	8	14:12:56	3	0.27:13	Operator
		03:16:24	0	0:00:00	Group lead
		07:35:01		0:10:00	Group lead
		14:12:56	3	0:27:13	Sys Admin
		03:16:24	0	0:00:00	Sys Admin
	9	07:35:01	2	0:10:00	Operator
	10	17:09:56	3	0:27:13	Operator
	11	03:16:24	0	0:00:00	Operator
	12	07:07:23		0:10:00	Operator
	13	20:14:37		0:27:13	Operator
		02:48:23		0:00:00	Operator
		01:41:01		0:10:00	Group lead
		21:24:56		0:27:13	Operator
	16	01:41:12		0:00:00	Operator

# Working with user accounts

The TEM Mill has five default users accounts, each of which has an assigned login, password, permission type, and display name.

User name	Login name	Default password	Permission type	Display name
user	user	[no password]	user	User
super	super	super	superuser	Super User
expert	expert	expert	service	Expert
admin	admin	admin	administrator	Administrator

You must be logged in as *admin* to add, edit, or delete user accounts.

When setting up your TEM Mill, Fischione Instruments recommends that the lab manager/system administrator change the default passwords shown in the table above.

#### **Understanding permissions**

The instrument offers five types of permissions. The permission types are none, user, superuser, service, and administrator. Use the following table to determine which activities are available for each permission type. In general, Fischione Instruments recommends that service and administrator permissions be reserved for facility management or service personnel.

#### MODEL 1051 TEM Mill instruction manual

	-	None	User	Superuser	Service	Administrator	X	No permission
	Top navigation	X	✓ <sub>except</sub>	✓ <sub>except</sub>	✓ <sub>except</sub>	$\checkmark$	$\checkmark$	Permission
	Left-side controls	X	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$	1	Read only
Home	Load recipes	X	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$		
Tiome	Create/edit recipes	X	X	$\checkmark$	$\checkmark$	$\checkmark$		
	Start milling	X	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$		
. ه.	Console	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$		
	Tracking	X	X	/	$\checkmark$	$\checkmark$		
Diagnostics	Usage	X	X	X	X	$\checkmark$		
	Vacuum	/	/	/	$\checkmark$	$\checkmark$		
	Motion	X	X	/	$\checkmark$	$\checkmark$		
<b>X</b> Svetom	Left ion (source)	X	X	/	$\checkmark$	$\checkmark$		
System	Right ion (source)	X	X	/	$\checkmark$	$\checkmark$		
	Thermal	X	X	$\checkmark$	$\checkmark$	$\checkmark$		
Tools	Users	X	X	X	X	$\checkmark$		
	Time	X	X	X	X	$\checkmark$		
	Files	X	X	X	X	$\checkmark$		
0								
Information		$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$	✓		

#### Permission type

### Logging into a user account

The user account to which the instrument is currently logged in is displayed next to  $\blacksquare$  at the top of the screen. In the image to the right, the active account is "User."

The tasks that you can perform on the instrument are controlled by the permissions associated with the active user account. See <u>Understanding permissions</u>, <u>page 62</u> to learn which tasks are associated with the various permission types.

1. To log into a different user account, press **1**.

![](_page_68_Picture_7.jpeg)

The User Log In dialog and keyboard opens.

The user name "operator" is highlighted in the User field.

- 2. Use the keyboard to enter the name of the user account into the User field. For this example, we will enter "admin" so that we can log into an account with administrator permissions.
- Touch the Password field to select it; use the keyboard to enter the password for the user account. For this example, we will enter the default password for the Administrator account – "admin".

To preserve the confidentiality of the password, characters entered into the password field appear as circles.

4. Press OK.

The User Log In dialog closes. The display name of the user account that you switched to now appears next to **1**. For this example, the display name is "Administrator."

You will now be working with the permissions associated with the new account. In addition, instrument activities will now be logged in the Usage tables under this user account (see <u>Tracking instrument use by user account</u>, page 61).

![](_page_69_Figure_9.jpeg)

![](_page_69_Figure_10.jpeg)

![](_page_69_Picture_11.jpeg)

#### **Managing users**

In facilities where many users will be accessing the instrument, two different approaches may be used for granting user authorization:

- Use a single user ID for each class of user. For example, all lab technicians can use a single User account; the instrument remains logged into the same account most of the time. This approach is appropriate in environments where individual user accountability is unimportant.
- Give each individual a separate user account. The activities of each user are tracked individually by the instrument.

The following options are available for managing user accounts:

- Adding a user account, page 65
- Editing an existing user account, page 67
- <u>Deleting a user account, page 68</u>

#### Adding a user account

1. On the **f** screen, press **f**.

The Tools screen opens.

If the Users screen is not displayed, press Users.

Tools	
L Users	
() Time	
🗁 Files	

The user account management dialog and touch screen keyboard are displayed. Existing user accounts are listed on the left.

- 2. Press <New User>.
- 3. Enter the properties of the new user account:
  - ID: Touch the ID field to select it and then use the keyboard to enter an ID name or number in the field. This will be the user account name that will be added to the list of user accounts on the left and will be the account name entered into the User field when logging in to the instrument. See <u>Understanding permissions</u>, page 62. Once you save this new user account, the ID cannot be edited; however, the account can be deleted. See <u>Editing an existing user account</u>, page 67 and <u>Deleting a user account</u>, page 68.
  - Display Name: Touch the Display Name field to select it and then use the keyboard to enter the name of the user account. The display name is the name that is listed next to 2 when logged into a user account. See <u>Understanding permissions</u>, page 62.
  - Password: Touch the Password field to select it and then use the keyboard to enter the password for the user account. Passwords are not required, but are recommended for accounts with permission levels above user. See <u>Managing users</u>, page 65 for guidance.
  - Permissions: Touch the Permissions dropdown menu to display the options. Select the desired permission level from the menu: None, User, Superuser, Service, or Administrator. See <u>Managing users</u>, page 65 for guidance.

	lew Us er	er>			DI						
super expert				Disp	Display Name						
ad se	admin service				Pass	Password					
					Pern	Permissions					
						Sa	ave	De	lete		
1	2	3	4	5	6	7	8	9	0	Tab	
٩	w	e	•	t	У	U	i.	•	P	Caps	
a	5	d	1	9	h	j.	k	1	~	Space	
z	x	c	v	ь	n	m	•	(	)	×	
•	-	•	+	/	•	%	±	μ	•	Exit	

<new user=""></new>	ID					
user	Labmgr					
super expert admin	Display Name					
	Lab Manager					
service	Password					
	q+318~					
	Permissions					
	Superuser					
	None					
	User					
	Superuser					
	Service Administrator					
- 4. Press:
  - Save to save the new user account. The user account is added to the list of user accounts.
  - Delete to delete the proposed account.

<new user=""></new>	ID					
user	Labmgr Display Name Lab Manager					
super						
admin						
sorvico	Password					
Labmgr						
	Permissions					
	Superuser					
	Save	Delete				

#### Editing an existing user account

1. On the 🏫 screen, press 🚔.

The Tools screen opens.

If the Users screen is not displayed, press Users.

Tools	
L Users	$\leftarrow$
() Time	
🖶 Files	

The user account management dialog and touch screen keyboard are displayed. Existing user accounts are listed on the left.

- 2. Touch the name of the user account that you would like to edit. The properties of the user account are displayed on the right (except for the password).
- 3. Edit the properties you would like change:
  - ID: This field cannot be edited; however, the account can be deleted and replaced with a new user account with the ID you desire. See <u>Deleting a user account</u>, page 68.
  - **Display Name**: Touch the **Display Name** field to select it and then use the keyboard to enter a new display name.
  - **Password**: Touch the **Password** field to select it and then use the keyboard to enter a new password.
  - **Permissions**: Touch the **Permissions** dropdown menu to display the options. Select the desired permission level from the menu. See <u>Managing users</u>, page 65 for guidance.
- 4. Press:
  - Save to save the account changes.
  - Delete to delete the selected account.

#### Deleting a user account

1. On the 🏫 screen, press 💼

The Tools screen opens.

If the Users screen is not displayed, press Users.

<n< th=""><th>lew Use</th><th>er&gt;</th><th></th><th></th><th>ID</th><th></th><th></th><th></th><th></th><th></th></n<>	lew Use	er>			ID								
us	er				Labmgr								
su	per				Disp	Display Name							
ad	min				Lab	Lab Manager							
- 50	rvico				Pass	sword							
La	bmgr												
					Perr	nissions	5						
					Sup	oeruser							
						Sa	10	De	lata				
						ou			ie te				
1	2	3	4	5	6	7	8	9	•	Tab			
٩	w	e	•	t	У	u	i	•	р	Caps			
a	s	d	f	g	h	j	k	1	~	Space			
z	×	c	v	ь	n	m	•	(	)	×			
	-	•	+	1	•	%	±	۴	•	Exit			



The user account management dialog and touch screen keyboard are displayed. Existing user accounts are listed on the left.

- **2.** Touch the name of the user account that you would like to delete.
- 3. Press Delete.

The user account is deleted.

## Setting the instrument date and time

You should set the instrument date and time as the TEM Mill is installed or after the TEM Mill has been shut down for a prolonged period of time. The system operates on a 24-hour clock (e.g., 18:00 is equal to 6:00 p.m.).

1. On the 🏫 screen, press 🚍

The Tools screen opens.

If the Time screen is not displayed, press Time.

Tools

Users

Time
Files

The set date and time controls are displayed. The month is highlighted by default for editing.

- 2. To change the date:
  - **a.** Touch the **Date/Time Setting** drop-down menu to display the calendar.
  - **b.** Select the current date from the calendar.

The selected date is entered into the Date/ Time Setting field.

Alternatively, highlight the month and use the keypad to enter the month. Repeat for day and year.

3. To change the time, highlight the time in the **Date/Time Setting** field and then use the keypad to enter a new time.



	1217	2111		2010	~			122	6
un	Mont	Jai	uary a	2010	-	Sat			
31	1	2	3	4	5	6		1	-
	8		10		12	13	7	8	9
	15	16		18	19	20		0.000	
	22	23	24	25	26	27			
8	29	30	31	1	2	3			Tal
				8		10		0	Tal

- **4.** To change the region:
  - **a.** Touch the **Region** drop-down menu to display a list of regions/countries.
  - **b.** Select your region from the menu.

The selected region is entered into the **Region** field.

01/04/2018 08:	52:32	<b>~</b>
Region/Zone		
US	<ul> <li>Eastern</li> </ul>	-
Australia		
Brazil		
Canada	ve	
Chile		
Europe		
Indian		
Mexico		
Mideast		
Pacific		
US		

- 5. To change the zone:
  - **a.** Touch the **Zone** drop-down menu to display a list of time zones in the selected region/ country.
  - **b.** Select your time zone from the menu.

The selected time zone is be entered in the **Zone** field.

- Date/Time Setting 01/04/2018 08:52:32 Region/Zone US Daylight Saving Time Alaska Aleutian Arizona Central Eastern Hawaii Indiana-Starke Michigan Mountain Alaska Aleutian Arizona Central Centr
- If you would like the instrument clock to automatically adjust the time for Daylight Saving Time, check the Daylight Saving Time box.



7. Press Save to save your date and time selections.



# Copying, moving, or deleting recipe files

You can copy, move, or delete recipe files from the instrument hard drive. Recipe files can be:

- copied from one hard drive directory to another hard drive directory or to a USB drive
- moved from one hard drive directory to another hard drive directory or to a USB drive
- deleted from a hard drive directory

#### **Copying recipe files**

1. On the **f** screen, press **e**.

The Tools screen opens.

If the Files screen is not displayed, press Files.

Lusers © Time Files

Tools

2. If you are copying recipe files to a USB drive, insert the USB drive into the back of the TEM Mill.

The USB port on the back of the TEM Mill is used for software updates, service, and transferring copies of saved recipe files (.rcp); this USB port is not to be confused with the USB port on the back of the microscope monitor computer (optional), which is used for image capture file transfer.



The file management options are displayed: copy, move, and delete files.

3. Press Copy Files...

The **Files to Copy** dialog opens and prompts you to select the recipe file(s) that you wish to copy.

**4.** Select the recipe file (or a folder with recipe files) and press **Copy**.

The **Copy to Directory** dialog opens and prompts you to select the location where you would like to copy the file (or folder).

- **5.** Navigate to the location where you would like to copy the file.
- 6. Press Choose.

The file is copied to the new location and the dialog closes.

# Moving recipe files

1. On the **f** screen, press **e**.

The Tools screen opens.

If the Files screen is not displayed, press Files.

File Management	
Copy Files	
Move File	
Delete File	



**2.** If you are copying files to a USB drive, insert the USB drive into the back of the instrument.

The USB port on the back of the TEM Mill is used for software updates, service, and transferring copies of saved recipe files (.rcp); this USB port is not to be confused with the USB port on the back of the microscope monitor computer (optional), which is used for image capture file transfer.



#### MODEL 1051 TEM Mill instruction manual

The file management options are displayed: copy, move, and delete files.

3. Press Move File...

The Files to Move dialog opens and prompts you to select the recipe file that you wish to move.

4. Select the recipe file and press Move.

The **Move to Directory** dialog opens and prompts you to select the location where you would like to move the file (or folder).

- **5.** Navigate to the location where you would like to move the file.
- 6. Press Choose.

The file is moved to the new location and the dialog closes.

#### **Deleting recipe files**

1. On the **f** screen, press **b**.

The Tools screen opens.

If the Files screen is not displayed, press Files.

File Management	
Copy Files	
Move File	]
Delete File	

Tools	
L Users	
() Time	
🖨 Files	

The file management options are displayed: copy, move, and delete files.

2. Press Delete File...

The File to Delete dialog opens and prompts you to select the recipe file that you wish to delete.

3. Select the recipe file and press Delete.

The file is deleted and the dialog closes.

File Management	
Copy Files	
Move File	
Delete File	]

# Viewing TEM Mill software version information

The software version information is sometimes helpful when troubleshooting issues with Fischione Instruments. You may be asked to provide this information when working with Fischione Service.

#### Press **f**.

The Information screen is displayed.

The control and operator console software versions are shown.. You may be asked by Fischione Instruments to provide the number in brackets during a service call. E. A. Fischione Instruments, Inc. Control Sytem v1.0.24 Operator Console Jan 19 2018 09:51:47 [4367]

# Viewing and modifying advanced system properties

The 🛠 (system) screen presents advanced instrument feedback, settings, and controls for the TEM Mill's systems. The information is presented on five screens:

- Vacuum; see Viewing the vacuum system status and controls, page 75
- Motion; see Modifying the system motion properties, page 78
- Left ion (source); see Changing the R-axis angle, page 81
- Right ion (source); see Changing the R-axis angle, page 81
- Thermal; see Controlling thermal properties, page 85

Access and use of these screens are controlled by permissions.

		Permission type						
		None	User	Superuser	Service	Administrator	X	No permission
<b>X</b> System	Vacuum	/	/	/	$\checkmark$	$\checkmark$	<ul> <li>✓</li> </ul>	Permission
	Motion	X	X	/	$\checkmark$	$\checkmark$	/	Read only
	Left ion (source)	X	X	/	$\checkmark$	$\checkmark$		
	Right ion (source)	X	X	/	$\checkmark$	$\checkmark$		
	Thermal	X	X	$\checkmark$	$\checkmark$	$\checkmark$		

In general, only individuals with service or administrator permissions may edit these advanced system settings. Before making changes to the vacuum, motion, or ion source parameters, please read the relevant service procedures in the *Model 1051 TEM Mill Service Manual* (document number 041-6075).

# Viewing the vacuum system status and controls

The Vacuum screen displays the system's current vacuum status, as well as provides controls for managing the vacuum system. Users of all permission types are able to view the vacuum system status, but only users with service or administrator permission are able to use the controls.

1. On the f screen, press . ↔.

The System screen is displayed.

2. If the Vacuum screen is not displayed already, press Vacuum.



The Vacuum screen is displayed.

The center of the screen displays the vacuum system status, including turbo pump speed, chamber pressure, and load lock pressure.

The buttons on the right side of the screen allow you to control various aspects of the vacuum system.

See:

- Initializing the TEM Mill, page 77
- Venting the chamber, page 77
- <u>Holding the chamber at vacuum during</u> system restart, page 78

Vacuum System Pump Running Load Lock Under Vacuum Turbo Pump Running Turbo Pump Speed 100.0% Chamber: 9.0E-06 Torr Load Lock: 1.5E+01 Torr



#### Initializing the TEM Mill

After completing various service and maintenance tasks, you may need to initialize the TEM Mill, which includes homing the ion sources, homing the stage, and restarting the vacuum system. When you are ready to restart the system:

#### Press Startup.

The ion sources and stage are homed and the turbo pump restarts.

Refer to the relevant service procedures in the *Model 1051 TEM Mill Service Manual* (document number 041-6075).



#### Venting the chamber

When performing various service and maintenance tasks, you will need to vent the chamber. Venting the chamber from the  $\bigstar$  screen is no different than venting the chamber using the control on the  $\bigstar$  screen.

Press Vent Chamber to vent the TEM Mill's chamber. As the chamber vents, the current chamber pressure is updated in the status display.

Refer to the relevant service procedures in the *Model 1051 TEM Mill Service Manual* (document number 041-6075).



#### Holding the chamber at vacuum during system restart

If for any reason you need to shut down the TEM Mill and then restart, you may want to prevent the chamber from venting during the shut down process.

Press Hold Chamber before restarting the TEM Mill to keep the chamber under vacuum during restart.

Refer to the relevant service procedures in the *Model 1051 TEM Mill Service Manual* (document number 041-6075).



# Modifying the system motion properties

Most of the controls on the **Motion** screen are the same as the motion controls available on the **Milling** screen when building a recipe (see <u>Defining milling parameters</u>, page 28). Changes made to the motion settings from the **Motion** screen do not override settings entered by users who have recipe building permission. Users with superuser, service, and administrator permissions are able to view the **Motion** screen; users with service or administrator permission are able to use the **Motion** screen controls.

The motion controls are conveniently presented on the **Motion** screen for use when performing service and maintenance activities. Read the relevant service procedures in the *Model 1051 TEM Mill Service Manual* (document number 041-6075) before modifying system motion properties.

#### Displaying the motion system status

1. On the **↑** screen, press **☆**.

The System screen is displayed.

**2.** If the Motion screen is not displayed already, press **Motion**.



The Motion screen is displayed.

The motion system status is displayed, which includes the status of the stage, the axes, and the ion sources.

#### Homing the stage

The specimen holder hole aligns with the stage pin; this design forces a specific orientation between the specimen holder and the stage. The stage home position locates the pin at the 6 o'clock position (the front of the instrument). Use the **Home Stage** control to return the stage to the home position.

#### On the 🌣 > Motion screen, press Home Stage.



#### Homing the ion sources

If the TEM Mill has the optional automated milling angle adjustment functionality, pressing **Home Sources** rotates both ion sources to the home (0°) position.

On the **X** > **Motion** screen, press **Home Sources**.



### Adjusting the Z-axis

The position of the Z-axis determines the relationship of the specimen and stage to the ion sources.

# On the **X** > **Motion** screen, adjust the Z-axis **Position**:

1. Press • to decrease the value; press • to increase the value.

When is deselected, the value increases/ decreases by 1; when is selected, the value increases/decreases by 0.1. Press to toggle between the two settings.

The SET indicator changes to yellow to warn you that the value has changed, but not saved.

2. Press SET to save your changes.

#### Adjusting the angle of the ion sources

On the **X** > **Motion** screen, adjust the left and right ion source angles:

1. Press • to decrease the value; press • to increase the value.

The SET indicator changes to yellow to warn you that the value has changed, but not saved.

**2.** Press **SET** to save your changes.

#### Adjusting the R-axis

During service and maintenance, use the R-axis controls to set stage motion, rocking angle, and rotation values.





#### On the 🌣 > Motion screen:

- 1. Select the stage motion:
  - None: The stage will not rotate or rock the specimen during milling.
  - **Continuous**: The stage rotates the specimen continuously during the milling step.
  - **Rocking:** The stage continuously rocks the specimen during the milling step.
- 2. Select the stage **Rocking Angle** (this option is available only if the stage motion is set to **Rocking**):
  - **a.** Press **-** to decrease the value; press **+** to increase the value.

The SET indicator changes to yellow to warn you that the value has changed, but not saved.

- **b.** Press **SET** to save your changes.
- 3. Select the stage **Speed** of rotation (this option is available only if the stage motion is set to **Rocking** or **Continuous**):
  - **a.** Press **-** to decrease the value; press **+** to increase the value.

The SET indicator changes to yellow to warn you that the value has changed, but not saved.

**b.** Press **SET** to save your changes.

#### Changing the R-axis angle

The position of the R-axis determines the relationship of the stage rotation to the home position. The R-axis home position is when the stage alignment pin is rotated to location closest to the front of the TEM Mill (the 6:00 position).



On the **X** > **Motion** screen, adjust the R-axis rotation using the **Set Position** control:

1. Press • to decrease the angle; press • to increase the angle.

When is deselected, the angle increases/ decreases by 1; when is selected, the angle increases/decreases by 0.1. Press to toggle between the two settings.

The SET indicator changes to yellow to warn you that the angle has changed, but not saved.

2. Press SET to save your changes.

# Adjusting ion source parameters

The controls on the Left Ion and Right Ion (source) screens are used for calibrating ion sources and viewing actual (feedback) values from the ion sources. Changes made to the left and right ion source settings affect the quality of the ion beam during milling operations. Because the TEM Mill ion sources are independently controlled, they must be calibrated independently.

Users with superuser, service, and administrator permissions may view the Left Ion and Right Ion screens; only users with service and administrator permissions may use the controls.

Read the relevant service procedures in the *Model 1051 TEM Mill Service Manual* (document number 041-6075) before modifying ion source parameters.

#### Displaying the left and right ion source parameters

1. On the **↑** screen, press **☆**.

The System screen is displayed.



- 2. Press:
  - Left ion to display the left ion source screen
  - **Right ion** to display the right ion source screen



# The selected ion source screen is displayed. (*The Left Ion Source Calibration screen is shown at the right.*)

During calibration, touch the field you wish to edit and then use the keypad to enter a new value.

Alternatively, use press - to decrease the value; press + to increase the value.

**3.** You will calibrate the ion source at different voltages. Use the **Voltage** control to select the accelerating voltage (1 to 10 kV).

The SET indicator changes to yellow to warn you that the value has changed, but not saved.

Press SET to enable the selection.





- **4.** Use the following controls during calibration:
  - **Default Calibration**: Changes the settings to the default calibration settings; you can define and set new default calibrations if you desire.
  - Load Calibration: Opens a file directory from which you can choose a previously saved calibration to populate the fields.
  - **Start Calibration**: Initiates the calibration process.
  - Enable Source: Turns the ion source on.
  - Enable HV: Turns the high voltage power supply on. This button is not selectable if there is a specimen in the chamber. Move a specimen into the load lock, then you can enable the high voltage power supply.
  - Save Calibration: Opens a file directory that prompts you to enter a name for the calibration and save the calibration file to the TEM Mill's internal drive.
  - Set Defaults: Saves the current settings as the new default setting.
- 5. Use the Anode, Cathode, Anticathode, Focus, and Gas settings to adjust the beam.

The SET indicator changes to yellow to warn you that the value has changed, but not saved.

Press SET to save the selection.

Start Calibration	Save Calibration	
Load Calibration	Default Calibration	Set Defaults
Enable Source	Enable HV	

Left Ion Source Cal	ibration				Vol
Anode:	0 V	-	4000	+	SET
Cathode:	0 V	-	-670	+	SET
Anticathode:	0 V	-	-670	+	SET
Focus:	0 V	-	-1000	+	SET
Gas:	0.00 sccm	-	0.11	+	SET

Electrode Currents values (system feedback) are presented for your reference.

Enable the **Faraday** option to view ion beam current values (system feedback).

# Controlling thermal properties

Stage cooling is an option on the TEM Mill. If your instrument does not have a dewar, then it does not have stage cooling capability.

Regulating stage temperature can be programmed into a recipe (see <u>Defining milling parameters</u>, page 28), or it can be controlled via **X** > **Thermal** screen. If your TEM Mill does not have stage cooling capability, you will not be able to view the **Thermal** screen.

#### **Displaying thermal status**

1. On the ft screen, press . ↔.

The System screen is displayed.

**2.** If the **Thermal** screen is not displayed already, press **Thermal**.



The Thermal screen is displayed.

The current temperature of the stage, as well as the type of cooling (off, on, protected, unregulated, or regulated) is shown.

To learn more about stage cooling, see:

- <u>Setting up stage cooling</u>, page 13
- Defining milling parameters, page 28

# Turning stage cooling on

The stage must be in the chamber before you can turn on stage cooling.

## On the 🌣 > Thermal screen, press Cool Stage.

Stage cooling will start; the current stage temperature is displayed in the status message area above the **Cool Stage** button.



## Warming the stage

The stage must be in the chamber before you can warm the stage.

#### On the 🌣 > Thermal screen, press Warm Stage.

Stage warming will start; the current stage temperature is displayed in the status message above the **Warm Stage** button. Stage heating will continue until the stage reaches room temperature (approximately 20 °C).



## Turning off stage cooling

Turning off stage cooling stops all cooling and other thermal regulating activities.

Temperature: -161.9 °C Thermal System State: Unregulated Cooling

#### On the 🌣 > Thermal screen, press Off.

The thermal system is turned off. The status message will change to "Thermal system status: Idle."

If you wish to remove the liquid nitrogen from the dewar, remove the dewar cap and allow the liquid nitrogen to evaporate.



# Troubleshooting

You may encounter system messages that indicate that an error has occurred. Use the following troubleshooting information to determine the nature of the error messages and possible solutions.

Access to some of the screens required for troubleshooting tasks requires administrator or service permissions. See <u>Understanding permissions</u>, page 62.

# Reset button

The **RESET** button can appear on many screens; however, it is always located in the upper-left corner of the touch screen.

The appearance of **RESET** can indicate a vacuum or motion error.

1. Press **RESET** to resolve the issue.

If the issue:

• Is resolved

**RESET** will disappear and you will be able to continue with your task.

• Is not resolved

**RESET** will disappear, but then shortly reappear.\* If this occurs, press **RESET** again.

\*If **RESET** reappears only after the stage starts to move into the chamber, this is an indication that the laser detector window needs to be cleaned. See the *Model 1051 TEM Mill service manual* (part number 041-6075) for instructions on how to clean the laser detector window.

2. If the issue is not resolved, press it to display the **Diagnostics** screen.

RESET	Model 105	1 TEM	Mill
Shutter	lon	Sourc	es
Open	LEFT		RIGHT
Close	Running		Running
CIUSE	4.0 kV		4.0 kV
	51.4 µm		49.9 µm
	0.11 sccm		0.11 sccm
	3°		3°
Stage: Moving Load Lock:	00: Thermal	17: Total Tim	<b>:42</b> e ed -175 ℃

- 3. If the Console log is not displayed, press Console.
- **4.** Review the system activities logged at the approximate time **RESET** was displayed; try to determine if the situation was caused by a motion system fault (i.e., stage movement) or a vacuum system fault (e.g., load lock or chamber vacuum state).

Determining the type of fault will enable you to determine which steps to take next. If both motion and vacuum faults occurred in short time span, try to determine which type of fault occurred first.

If the fault is a:

- motion fault, see Motion fault, below
- vacuum fault, see Vacuum fault, below

#### **Motion fault**

- 1. Home the stage:
  - **a.** Press **X** to display the **System** screen.
  - b. If the Motion screen is not displayed, press Motion.
  - c. Press Home Stage.
- 2. If the fault persists, take a photo of the **Console** log that shows the motion fault log entry. Email the photo to <u>service@fischione.com</u>.

#### Vacuum fault

Perform the following tasks in the order in which they are presented. If a task does not clear the fault state, complete the task that follows it.

- 1. Verify that the load lock cover is firmly seated in the load lock.
- 2. Verify that the load lock cover O-ring is clean and free of debris.
- **3.** Verify that the diaphragm pump is plugged in to a functioning power source, the diaphragm pump power is turned on, and that the diaphragm pump tubing is securely connected to both the diaphragm pump and the TEM Mill.
- 4. Shut down and then restart the TEM Mill:
  - a. Press the power switch on the back of the instrument to turn off the power.
  - **b.** Wait 10 seconds.
  - c. Press the power switch again to turn on the power.
  - d. When the touch screen displays the Startup dialog and prompts Initialize the system?, press Yes.

Wait until the instrument completes the initialization process.

If the fault persists, contact <u>service@fischione.com</u>.

# Process Interruption dialog

The **Process Interruption** dialog is displayed during milling operations when an error is encountered during the course of recipe execution. Beneath "Recipe Fault" on the dialog, the type of fault is displayed. In the example to the right, the type of fault is "Gas Failure." Identify the type of fault and then use this information to troubleshoot the issue.

Fault type	See:
Gas failure	<u>Gas failure,</u> page 91
Homing failure	Homing failure, page 92
Ion Beam timeout	<u>Ion beam timeout,</u> page 93
Lighting failure	<u>lon beam timeout,</u> page 93
Motion obstructed	Motion obstructed, page 94
Motion timeout	Motion time out, page 94
Positioning failure	Positioning failure, page 95
Source failure	<u>Gas failure,</u> page 91 <u>Ion beam timeout</u> , page 93
Thermal shutdown	Thermal shutdown, page 95
Unstable gas flow	<u>Gas failure</u> , page 91
Unstable gas flow Vacuum failure	Gas failure, page 91 <u>Vacuum failure,</u> page 96



Depending upon the nature of the fault, you may choose to:

- Start next step,
- Restart current step, or
- Terminate recipe.

In some instances, moving on to the next step or restarting the current step will resolve the fault. If you find that is not the case and you receive the fault message again, terminate the recipe and try to resolve the underlying fault condition before restarting milling operations.

#### **Gas failure**

- 1. Press ★ to display the System screen.
- 2. Press Left ion to display the Left Ion Source Calibration screen.
- 3. Set the Gas flow to 0.1 sccm.
- 4. Press SET.

Wait approximately 10 seconds for the gas flow to stabilize. If the actual gas flow value returns to 0.1 sccm, then the left ion source gas flow is working.

5. Press Right ion to display the Right Ion Source Calibration screen.

- 6. Repeat steps 3 and 4 to confirm right ion source gas flow.
- 7. If either the left or right ion source gas flow is compromised, shut down and then restart the TEM Mill:
  - a. Press the power switch on the back of the instrument to turn off the power.
  - **b.** Wait 10 seconds.
  - c. Press the power switch again to turn on the power.
  - d. When the touch screen displays the Startup dialog and prompts Initialize the system?, press Yes.Wait until the instrument completes the initialization process.
- 8. Repeat steps 1 through 6. If either the left or right ion source gas flow is compromised, check the gas supply, gas supply line, and gas pressure (15 psi delivery pressure).

If the fault persists, contact <a href="mailto:service@fischione.com">service@fischione.com</a>.

#### Homing failure

Shut down and then restart the TEM Mill:

- 1. Press the power switch on the back of the instrument to turn off the power.
- 2. Wait 10 seconds.
- 3. Press the power switch again to turn on the power.
- When the touch screen displays the Startup dialog and prompts Initialize the system?, press Yes.
   Wait until the instrument completes the initialization process.

If the fault persists, contact <a href="mailto:service@fischione.com">service@fischione.com</a>.

#### Ion beam timeout

- 1. When the **Ion Beam Timeout** recipe fault dialog appears, select the **Restart current step** option and then press **OK**.
- 2. Repeat step 1 if the fault persists.
- 3. If the fault persists after restarting the current step twice, press to display the System screen.

- 4. Press Left ion or Right ion to display the Ion Source Calibration screen. *Left ion source calibration is shown.*
- 5. Press Start Calibration.

Wait approximately 10 seconds for the gas flow to stabilize.

- 6. Press Enable HV.
- **7.** Review the anode current feedback value. If the anode current is:
  - 0.1 µA or greater

Add a 30-second purge and a 30-second delay before the milling step on which the fault occurred and skip to step 9.

• 0.0 µA

Shut down and restart the TEM Mill. Continue on to step 8.



System	Left Ion Source Cal	ibration			Vol	tage 4	kV 🔤	4
Vacuum	Anode:	οv	-	4000	SET SET		2	з
Motion	Cathode:	0 V	-	-670	📑 इन	4	5	6
Left ion	Anticathode:	0 V		-670	SET.	7	8	9
Right ion	Focus:	0 V	-	-1000	SET			Tab
Thermal	Gas:	0.00 sccm	-	0.11	SET			×
	Electrode Currents			_				
	Anode:	0.0 µA			Start	Sa	ive	
	Cathode:	0.00 μA			alloration	Callo	ration	
	Anticathode:	0.00 µA		С	alibration	Calib	ration	De
	Focus:	0.00 mA			Enable	En	able	
	Faraday	0.0 μA			Source	ŀ	IV	

Electrode Currents	
Anode:	11.6 µA
Cathode:	40.29 µA
Anticathode:	40.90 µA
Focus:	0.00 mA
Faraday	0.0 µA

- 8. Shut down and then restart the TEM Mill:
  - a. Press the power switch on the back of the instrument to turn off the power.
  - **b.** Wait 10 seconds.
  - c. Press the power switch again to turn on the power.
  - d. When the touch screen displays the Startup dialog and prompts Initialize the system?, press Yes.

Wait until the instrument completes the initialization process.

**9.** Restart the recipe. If an ion beam timeout fault or lighting failure fault reoccurs, yet an anode current is still present, clean the ion sources. See *Model 1051 TEM Service Manual* (part number 041-6075) for instructions on cleaning the ion sources.

#### **Lighting failure**

Follow the troubleshooting instructions for Ion beam timeout, page 93.

#### Motion obstructed

This fault is typically related to the shutter. Perform the following tasks in the order in which they are presented. If a task does not clear the fault state, complete the task that follows it.

- 1. From the recipe screen, try to open and close the shutter.
- 2. Verify that the specimen size is within the TEM Mill specifications: 3 mm diameter x 250 µm thick.
- **3.** Verify that any positive milling offset programmed into the recipe is reasonable. See <u>Defining milling</u> <u>parameters</u>, page 28.
- 4. Shut down and then restart the TEM Mill:
  - a. Press the power switch on the back of the instrument to turn off the power.
  - **b.** Wait 10 seconds.
  - c. Press the power switch again to turn on the power.
  - d. When the touch screen displays the Startup dialog and prompts Initialize the system?, press Yes.Wait until the instrument completes the initialization process.

If the fault persists, contact service@fischione.com.

#### Motion time out

Perform the following tasks in the order in which they are presented. If a task does not clear the fault state, complete the task that follows it.

- 1. Use Startup to reset the system:
  - **a.** Press **X** to display the **System** screen.

- b. If the Vacuum screen is not displayed, press Vacuum.
- c. Press Startup.
- 2. Shut down and then restart the TEM Mill:
  - a. Press the power switch on the back of the instrument to turn off the power.
  - b. Wait 10 seconds.
  - c. Press the power switch again to turn on the power.
  - d. When the touch screen displays the Startup dialog and prompts Initialize the system?, press Yes.Wait until the instrument completes the initialization process.

If the fault persists, contact <a href="mailto:service@fischione.com">service@fischione.com</a>.

#### **Positioning failure**

Perform the following tasks in the order in which they are presented. If a task does not clear the fault state, complete the task that follows it.

- 1. Check for motion system errors:
  - **a.** Press **X** to display the **System** screen.
  - **b.** If the Motion screen is not displayed, press Motion.
  - c. Review the motion system status messages and see if there is an indication as to if the problem is related to the motion system. Note any issues; this information may be helpful if you need to discuss the problem with Fischione Service.
- 2. Use Startup to reset the system:
  - **a.** On the **☆** screen, press **Vacuum**.
  - **b.** Press Startup.

If the fault persists, contact <u>service@fischione.com</u>.

#### Source failure

This type of failure appeared in older versions of the TEM Mill operating system software and could describe several fault types. To troubleshoot this fault, try the following troubleshooting instructions:

- Gas failure, page 91
- <u>Ion beam timeout</u>, page 93

#### Thermal shutdown

This fault occurs when you are performing milling operations using the thermal protection option. It typically indicates that the TEM Mill has run out of liquid nitrogen.

1. Refill the dewar and allow the stage to cool down.

2. Restart milling.

If the fault reoccurs, contact <u>service@fischione.com</u>.

#### Unstable gas flow

Follow the troubleshooting instructions for Gas failure, page 91.

#### Vacuum failure

Perform the following tasks in the order in which they are presented. If a task does not clear the fault state, complete the task that follows it.

- 1. Use Startup to reset the system:
  - a. Press 🌣 to display the System screen.
  - b. If the Vacuum screen is not displayed, press Vacuum.
  - c. Press Startup.
- 2. Repeat step 1.
- 3. Shut down and then restart the TEM Mill:
  - a. Press the power switch on the back of the instrument to turn off the power.
  - **b.** Wait 10 seconds.
  - c. Press the power switch again to turn on the power.
  - d. When the touch screen displays the Startup dialog and prompts Initialize the system?, press Yes.

Wait until the instrument completes the initialization process.

- 4. Verify that the load lock cover is firmly seated in the load lock.
- 5. Verify that the load lock cover O-ring is clean and free of debris.
- 6. Verify that the diaphragm pump is plugged in to a functioning power source, the diaphragm pump power is turned on, and that the diaphragm pump tubing is securely connected to both the diaphragm pump and the TEM Mill.

If the fault persists, contact service@fischione.com.

#### Vacuum timeout

Perform the following tasks in the order in which they are presented. If a task does not clear the fault state, complete the task that follows it.

- 1. Verify that the load lock cover is firmly seated in the load lock.
- 2. Verify that the load lock cover O-ring is clean and free of debris.
- 3. Verify that the load lock is reaching vacuum.

**4.** Verify that the diaphragm pump is plugged in to a functioning power source, the diaphragm pump power is turned on, and that the diaphragm pump tubing is securely connected to both the diaphragm pump and the TEM Mill.

If the fault persists, contact service@fischione.com.

# Contacting Fischione Instruments

E.A. Fischione Instruments, Inc. 9003 Corporate Circle Export, PA 15632 USA

Tel +1 724.325.5444 Fax +1 724.325.5443

Global salessales@fischione.comGlobal serviceservice@fischione.comApplications supportapplications@fischione.comWeb sitewww.fischione.com



#### E.A. Fischione Instruments, Inc.

9003 Corporate Circle Export, PA 15632 USA Tel: +1 724.325.5444 Fax: +1 724.325.5443 info@fischione.com www.fischione.com

©2019 E.A. Fischione Instruments, Inc. All rights reserved. Document Number 041-5743 Revision 0.0 12/2019