TEM Mill

Tabletop precision preparation for producing high-quality TEM specimens from a wide variety of materials

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FISCHIONE INSTRUMENTS

ION MILLING

Ion milling is used on physical science specimens to reduce thickness to electron transparency. Argon, an inert gas, is ionized and then accelerated toward the specimen surface. By means of momentum transfer, the impinging ions sputter material from the specimen at a controlled rate.

MODEL **1051**
TEM Mill

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.

- **Two independently adjustable TrueFocus ion sources**
- **High energy operation for rapid milling; low energy operation for specimen polishing**
- **Ion source maintains its small beam diameter over a wide range of operating energies (100 eV to 10 keV)**
- **Faraday cups for the direct measurement of beam current from each ion source**
- **Adjustable 10-inch touch screen with a user-friendly interface for simple setup of milling parameters**
- **Independent ion source gas control**
- **Adjustable milling angle range of -15 to +10°**
- **Specimen holder and loading station with *x-y* adjustment (optional)**
- **In situ viewing and image capture during milling**
- **Specimen rocking or rotation with ion beam sequencing**
- **Automatic termination by time, temperature, or laser photodetector (optional)**
- **Liquid nitrogen-cooled specimen stage (optional)**
- **Vacuum or inert gas transfer capsule (optional)**

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 or inert gas transfer capsule (optional)

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

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.

EASY SPECIMEN LOADING

Unique specimen holder clamp design allows for simple specimen loading and double-sided milling to 0° without shadowing. Shown to the left is a standard specimen holder with a 3 mm grid secured by the holder clamps. Mounting the specimen on the specimen holder is as simple as placing the specimen on the loading station arm, opening the clamp, and sliding the arm forward.

LOAD LOCK

Load lock closed (left) and load lock opened (right).

Precise angle adjustment

The ion sources are tilted to provide the desired milling angle. The continuously adjustable ion source tilt angles range from -15 to +10°. This extended tilt angle 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 to one of the specimen's surfaces, milling rates are doubled; this capability 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 (optional)
Automated milling angle adjustment using the touch screen is an available option for the TEM Mill. Adding this capability enables you to create multi-step milling sequences that include the automatic adjustment of milling angles throughout the milling process.

MILLING ANGLE ADJUSTMENT

The base Model 1051 TEM Mill is equipped with manually adjustable milling angle controls for both ion sources. The milling angle of each ion source is independently adjustable. Automated milling angle adjustment, which is controlled through the TEM Mill's touch screen, is optional.

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 (optional)

Although milling at low angles with low ion beam energies reduces specimen heating, temperature-sensitive 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.

NEW HIGH-PERFORMANCE 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.

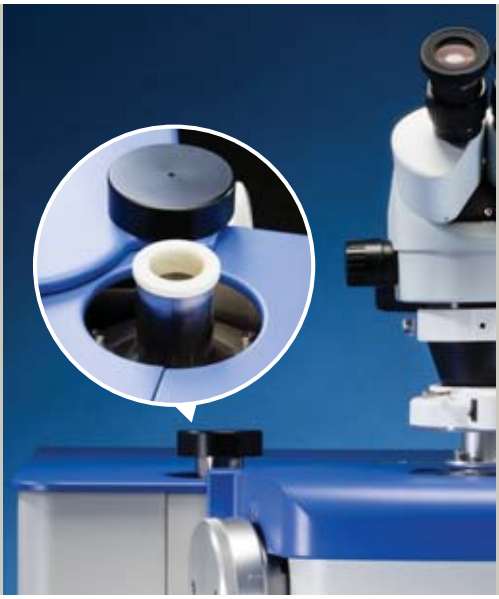
TRUEFOCUS QUICK FACTS

- 100% ionization efficiency
- Consistent beam current
- Each ion source independently controlled
- Adjustable energy range from 100 eV to 10 kV
- Ion beam spot size range from 300 µm to 5 mm
- Beam current density up to 10 mA/cm^2
- Milling rates in excess of 500 µm/hour
- Easily accessible for routine maintenance

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^2. 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.



OPTIONAL INTEGRATED STAGE COOLING

The TEM Mill's liquid nitrogen system features a dewar located within the enclosure that is fully integrated. The dewar is positioned near the operator for easy access. Two dewar options are available: a standard dewar or an extended dewar. Temperature is both programmable and continuously displayed on the touch screen.

Programmable temperature

The SEM 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.

Stereo microscope (optional)

A stereo microscope (7 to 45X) enhances specimen viewing. The microscope's long working distance allows specimen observation in situ while milling.

High magnification microscope (optional)

The TEM Mill can be configured with a 1,960X high-magnification 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 sample 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.

ERGONOMICALLY DESIGNED TOUCH SCREEN

Milling parameters are entered via a 10-inch touch screen. The touch screen can be physically positioned to your preferred height, as well as tilted or pivoted to your preferred viewing angle.

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 multi-stage diaphragm pump. This oil-free system assures a clean environment for specimen processing.

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 x 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 service@fischione.com.

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