



# Model 1050

## TEM Mill

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



EXCELLENCE...MAGNIFIED

# Model 1050 TEM Mill

- *Modular design for basic instrument operation or fully automated control.*
- *Two independently adjustable TrueFocus (patent pending) ion sources.*
- *High energy operation for rapid milling.*
- *Low energy operation for specimen polishing.*
- *The TrueFocus ion source maintains its small beam diameter over a wide range of operating energies (100eV to 6keV).*
- *Simple setup of milling parameters.*
- *Individual, automatic ion source gas control.*
- *Oil-free vacuum system.*
- *Continuously adjustable milling angle range of  $\pm 10^\circ$ .*
- *Specimen rocking or rotation with ion beam sequencing.*
- *Automatic termination.*
- *Liquid nitrogen cooled specimen stage.*
- *Stereo microscope for direct specimen observation.*
- *High-magnification microscope and CCD camera.*

**Model 1050 TEM Mill** is a state-of-the-art ion milling and polishing system. It is compact, precise, and consistently produces high-quality TEM specimens with large electron transparent areas from a wide variety of materials. Shown fully equipped



## Ion Milling

Ion milling is used on physical science specimens to reduce thickness to electron transparency. Inert gas, typically argon, 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.

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## Advanced specimen preparation

For many of today's advanced materials, analysis by transmission electron microscopy (TEM) is the best technique for studying material structure and properties.

Fischione Model 1050 TEM Mill is an excellent tool for creating the thin, electron transparent specimens needed for TEM imaging and analysis.

## Two ion sources

Two TrueFocus ion sources direct controlled-diameter ion beams to the specimen regardless of energy. They can be focused on either one or both specimen surfaces. The ion sources are physically small and require minimal gas but deliver a large range of ion beam energies.

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.

The unique design of the TrueFocus ion source maintains a small ion beam diameter, even at a low accelerating voltage, which means the ions are directed only to the specimen and sputtered material is not redeposited from the specimen holder and/or chamber onto the specimen surface.

Ion accelerating voltages are programmable and can be continuously varied from as high as 6.0keV for rapid milling to as low as 100eV for final specimen polishing. Ion beam currents can be established from hundreds of nA to tens of  $\mu$ A.

The ion sources are visually aligned from outside the vacuum using a luminescent target.

## Minimal maintenance

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 and maintenance.

When connected to the Internet, the Model 1050 can be accessed remotely for diagnostic purposes.

## 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.

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## Fully integrated dry vacuum system

The fully 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 70lps turbomolecular drag pump produces an operating system vacuum of approximately  $5 \times 10^{-4}$  mbar. The vacuum level is measured with a Pirani gauge and is continuously indicated.

## Contamination-free specimen mounting

The specimen holder accommodates double-sided milling to zero degrees without specimen shadowing. Because the specimen is clamped, there is no possibility of specimen contamination from an adhesive.

A loading station provides a platform for the specimen so it can be easily positioned into the specimen holder. The loading station also activates the specimen clamps.



Specimen holder

## Chamber

The Model 1050'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. The small chamber size makes it easy to clean during periodic maintenance.

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## Quick specimen transfer

The Model 1050 features a vacuum load lock for rapid specimen exchange. Once the specimen holder is placed onto the stage, evacuation of the load lock occurs within a few seconds. A mechanical elevator then moves the stage with 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. The main chamber remains under a continuous vacuum during the specimen exchange.

After venting, the specimen can be rapidly transferred to the TEM, thus reducing contamination from the ambient.



Load lock closed



Load lock open

## Precise angle adjustment

With the specimen stage fixed in position, the ion sources are tilted to provide the desired milling angle. Tilt angles are continuously adjustable in the range from  $-10^\circ$  to  $+10^\circ$ .

Ion beam impingement angles are independently adjustable so that the beams can be directed either to the same or opposite specimen surfaces. Different milling angles can be employed for each specimen surface.

When both ion sources are directed to one specimen surface, milling rates are doubled for applications such as back-sided thinning or planar polishing.

Simultaneous milling of both sides avoids redeposition of sputtered material.

Ion milling with low angles of incidence (less than  $10^\circ$ ), combined with low-energy ion source operation, minimizes irradiation damage and specimen heating. Since 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.

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## Programmable specimen motion

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

The Model 1050 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.

When milling the bottom surface of the specimen, 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.

In addition, the specimen can be rocked in relation to the ion beam so that interfaces or glue lines are never parallel to the direction of the ion beam. Rocking angles ranging from 40° to 60° are typically employed.

## Integrated stage cooling (optional)

Although milling at low angles and 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 liquid nitrogen system features a dewar located within the enclosure that is fully integrated and interlocked through the Model 1050's advanced control. Stage temperature is continuously displayed.

At the conclusion of milling at cryogenic temperatures, the stage temperature is automatically increased to ambient before venting to avoid specimen contamination by condensation.

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 a laser photodetection system.

**Time:** A timer allows milling to continue for a predetermined time, and then de-energizes the ion sources while keeping the specimen under vacuum until the user vents the load lock to extract the specimen.

**Temperature:** The thermal safeguard associated with the specimen cooling system 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.

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## Specimen viewing

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

The specimen is illuminated by two independently controlled light sources, one above the specimen (reflected light) and one below (transmitted).

**Stereo microscope (optional)** The Model 1050 TEM Mill accepts a stereo microscope to enhance specimen viewing. The microscope's long working distance allows the specimen to be observed in situ while milling.

**High magnification microscope (optional)** The Model 1050 can be configured with an imaging system including a high magnification microscope coupled to a CCD camera and video monitor to capture and display images. This system is ideal for preparing site-specific specimens.

When the high magnification microscope and CCD camera are used, the specimen is brought into the load lock for image capture and then returned to the milling position to continue the milling process.

## Instrument operation

The Model 1050 TEM Mill features a universal control platform that manages total instrument operation. The basic version of the Model 1050 is for users who require only primary level instrumentation function. The premium version of the Model 1050 adds full computer control for setting, operating, and recording a broad variety of instrument parameters.

Feature	Basic version	Premium version
Touchscreen control	Yes	Yes
Computer control		Yes
Single-step recipe	Yes	Yes
Multiple-step recipe		Yes
Recipe storage and recall		Yes
Real-time milling conditions display	Yes	Yes
Manual milling angle adjustment	Yes	
Automated milling angle adjustment		Yes
Independent ion source voltage control		Yes*

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## Instrument operation (continued)

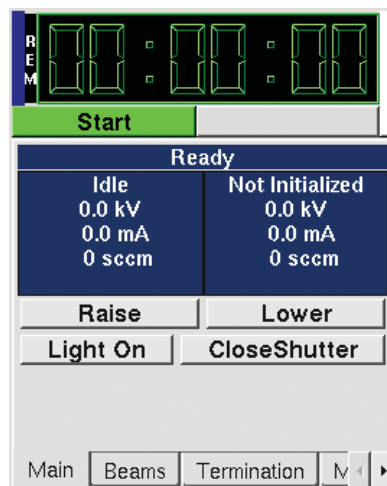
Feature	Basic version	Premium version
Unattended operation	Yes	Yes
Image capture		Yes*
Maintenance and log files		Yes
Remote access and process monitoring (single or multiple TEM Mills)		Yes*
Remote diagnostics		Yes

\*Optional

## Basic version

The basic version is programmed via a touchscreen embedded module.

Initially, milling angles are established by manually positioning the ion sources to their desired orientations. A single-step recipe of parameters including ion beam energy, specimen motion, specimen position (load lock or milling), and process termination is then readily programmed through the touchscreen. Once the user initiates the process, the instrument automatically executes the recipe and continuously displays the real-time milling conditions.



Touchscreen window

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## Premium version

The premium version is connected to a dedicated computer to provide enhanced programming capabilities and an expanded interface, thus minimizing the need for user intervention during the milling process.

The interface facilitates programming of ion beam energy, milling angle, specimen motion, specimen position, and process termination.

For effective, unattended operation, a series of operational sequences can be established. Typical methodology starts with rapid milling; then as the specimen thins, a slower milling rate eliminates artifacts. Milling recipes can readily be stored and recalled.

Advanced functionality includes structured management of specimen data, image acquisition and storage, maintenance and log files, as well as remote access and diagnostics.

The software allows secure access to the various instrument controls corresponding to levels of user expertise and needs for instrument operation. Administrative rights can be provided to qualified maintenance staff.

During operation, relevant parameters are displayed in real time on the computer monitor. When controlled by the computer, the touchscreen displays a Pause button so that, if necessary, instrument operation can be quickly suspended.



TEM Mill program window

The premium version has the optional capability of remote monitoring via a network connection. This allows the instrument to be both monitored and paused remotely. Multiple Model 1050 TEM Mills can be networked.

## Model 1050 specifications

<b>Ion sources</b>	Two TrueFocus ion sources Variable energy (100eV to 6.0keV) operation, continuously adjustable Beam current density up to 10mA/cm <sup>2</sup> Choice of single or dual ion source operation Independent ion source energy control (optional on premium version)
<b>Specimen stage</b>	Milling angle range of -10° to +10° 360° specimen rotation with motion sequencing Specimen rocking
<b>Specimen cooling (optional)</b>	Liquid nitrogen conductive cooling with integral dewar and automatic temperature interlocks
<b>Vacuum system</b>	Turbomolecular drag pump backed by an oil-free diaphragm pump Vacuum sensing with a Pirani gauge
<b>Process gas</b>	Argon, 99.999% purity Flow rate approximately 0.2sccm/ion source, nominal 15psi delivery pressure required Automatic gas control using two mass flow controllers for unattended operation
<b>Pneumatic supply</b>	Ar, N <sub>2</sub> , or dry air, nominal 40psi delivery pressure required
<b>User interface (basic version)</b>	Touchscreen embedded module for primary-level instrument functionality
<b>User interface (premium version)</b>	PC-based, fully programmable milling cycles with system status displayed Operation indicator stack light (red/amber/green) (optional)
<b>Specimen illumination</b>	Independently actuated transmitted and reflected lights
<b>Automatic termination</b>	Automatic termination by timer, temperature, or laser detector (optional)
<b>Microscope (optional)</b>	Load lock window accommodates a 7-45X stereo microscope attachment for direct specimen observation and a 2,000X high-magnification microscope and camera system for site specific image acquisition and display
<b>Enclosure</b>	<b>Weight:</b> 161 lb (73 kg) <b>Dimensions:</b> <b>TEM Mill (basic):</b> 26.7" (678mm) W x 14.6" (371mm) H (to top of cabinet) x 29.0" (737mm) H (to top of microscope) x 19.2" (488mm) D <b>TEM Mill (premium):</b> 42.0" (1,067mm) W including computer display x 14.6" (371mm) H (to top of cabinet) x 29.0" (737mm) H (to top of microscope) x 19.2" (488mm) D
<b>Power requirements</b>	100/120/220/240 VAC, 50/60 Hz, 720 Watts
<b>Warranty</b>	One year



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E.A. Fischione Instruments, Inc.  
9003 Corporate Circle  
Export, PA 15632 USA  
Tel: 724.325.5444  
Fax: 724.325.5443  
E-mail: info@fischione.com  
Website: www.fischione.com