

Gentle Mill

Ion beam workstation for preparing highest quality TEM/FIB samples

- Fast, reliable method for cleaning and post-processing of TEM and FIB samples
- User-independent, automated operation with pre-programmed recipes
- Application in industrial environment
- Special model for direct application of 3D sample holder of Hitachi's FIB-STEM/TEM systems



The Gentle Mill series of Technoorg has been designed for final polishing, easy cleaning and improving of samples previously treated in standard high-energy ion mills or FIB columns. Gentle Mill models are recommended to users who want to prepare

- artifact-free and
- almost damage-free

XTEM, HRTEM or STEM samples of the best possible quality.

These ion mills are also suitable for quick thinning of dimpled or thin (< 25 µm), planar, mechanically polished samples.

TOP-OF-THE-ART LOW-ENERGY ION SOURCE

The Gentle Mill ion beam workstations operate with an outstanding patented hot-cathode low-energy ion source. The extremely low energy of the ion beam guarantees minimization of surface damage and ion beam induced amorphization. The exceptional construction of the ion source allows high ion beam current densities. All ion gun parameters including accelerating voltage and cathode current are controlled automatically by a digital feedback loop, but they can always be changed manually during the sample preparation procedure. The initial values of the ion source parameters are set either automatically or manually and are continuously displayed on the computer screen.



ARTIFACT-FREE SAMPLE PREPARATION

The Gentle Mill's exclusive capability of producing damage-free samples at low-energy ion bombardment provides unique opportunity to study the real nanostructures in synthesized and natural materials in all fields of technical sciences and materials research.

AUTOMATED OPERATION

The third generation Gentle Mill 3 models are provided with full computer control utilizing an easy-to-use graphical interface. All milling parameters including ion source setup, gas flow control, setting of other milling parameters such as sample motion and tilt angle, perforation detection can be stored or pre-programmed in arbitrary number of steps. This fully automated feature allows to produce high-quality samples with minimum user intervention. Gentle Mill 3 is supplied with a software extension for in-line support, which enables instant error detection and problem elimination via the Internet.

SPECIAL MODELS FOR DIRECT APPLICATION WITH HITACHI'S FIB/STEM SYSTEMS

Hitachi and Technoorg offer a complete solution for site-specific and low-damage specimen preparation based on Hitachi's FIB/STEM systems and Technoorg's Gentle Mill ion beam workstations. The low-energy ion milling and cleaning capability of semi and fully automated Gentle Mill models is used in the final stage of FIB specimen preparation to remove the amorphized or otherwise damaged surface layers. These models allow direct insertion of Hitachi's 3D FIB/STEM sample holders, thus the sample preparation time can drastically be decreased.

SPECIFICATIONS

LOW-ENERGY ION SOURCE (ONE FIXED TYPE)

- Ion energy: 100 - 2000 eV, continuously adjustable
- Ion current density: max. 10 mA/cm²
- Beam current: 7 - 80 μ A, continuously adjustable
- Beam diameter: 750 - 1200 μ m (FWHM)
- Manually (mod. IV5) or electronically optimized working gas flow (mod. IV8)
- 28 μ m/h milling rate on c-Si at 2000 eV ion energy and at 30° angle of beam incidence

SPECIMEN STAGE

- Milling angle: 0° - 40°, electronically adjustable in 0.1° increments
- Computer controlled in-plane specimen rotation and oscillation (0° - 120° angular range, electronically adjustable in 10° increments)
- Remarkable thickness range of the accepted TEM samples (30 - 200 μ m)

SPECIMEN HANDLING

- Vacuum load-lock system for fast specimen exchange
- Fully mechanical, glueless specimen loading system
- Specially designed titanium frames and encapsulation technology for XTEM samples

VACUUM SYSTEM

- Pfeiffer vacuum system with oil-free diaphragm and turbomolecular pumps equipped with compact, full-range Pirani/Penning vacuum gauge

GAS SUPPLY SYSTEM

- 99.999% purity argon gas of 1.3 - 1.7 bar absolute pressure
- Dedicated pressure regulator for noble gas service with electronic outlet pressure monitoring
- High-precision working gas flow control via motorized needle valve for mod. IV8

IMAGING SYSTEM

- CMOS camera image for full visual control and milling supervision/termination
- High-resolution color CMOS camera
- Manual zoom video lens of 50 - 400 \times magnification range

COMPUTER CONTROL

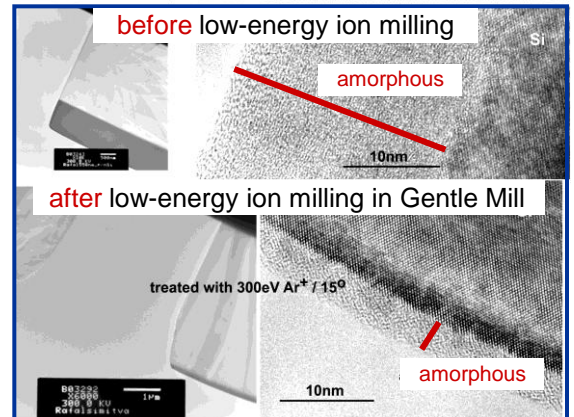
- Built-in industrial grade PC
- Easy-to-use graphical interface and image analysis module
- Easy control of all important parameters by mouse clicking or dragging
- Highly automated operating regime for minimum user intervention (mod. IV8)
- Pre-programmed or manually set milling and polishing cycles
- Automatic termination: optical termination of the milling process supported by an image analysis module (detecting the sample perforation or monitoring the surface topography)

POWER REQUIREMENTS

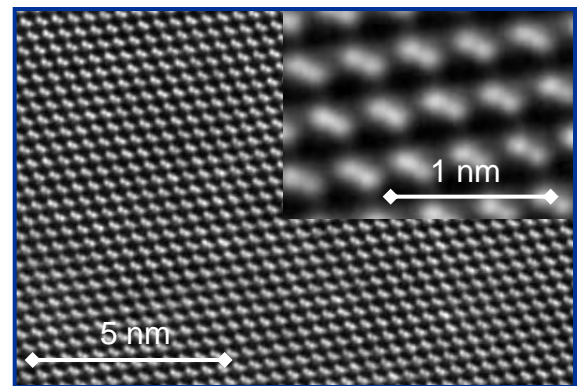
- 100 - 120 V/3.0 A/60 Hz or 220 - 240 V/1.5 A/50 Hz – single phase

MODELS

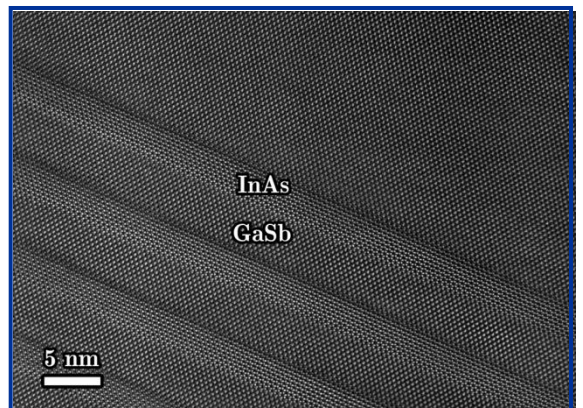
- Gentle Mill (mod. IV5) – standard model
- Gentle Mill 3 (mod. IV8) – fully automated model
- Gentle Mill Hi and Gentle Mill 3 Hi – models compatible with Hitachi FIB/STEM systems



Low-energy Ar⁺ ion milling performed by Gentle Mill on samples prepared in various FIB columns drastically decreases the thickness of the damaged, amorphous surface layers. This allows atomic level structure analysis even of the 65 nm node semiconductor devices.



Dumbbells in Si [110]. Sample was thinned by Ar⁺ ion milling using Gentle Mill at 200 eV ion energy and 3° angle of beam incidence. Images by courtesy of National Center for Electron Microscopy, Lawrence Berkeley Laboratories.



GaSb/InAs superlattice. Sample was prepared with Gentle Mill: it was thinned until perforation at 2000eV, then trimmed at 1000eV, finally it was cleaned at 300eV. Image by courtesy of Technion (Israel).