MODEL 1030

Automated Sample Prep (ASaP) System

Self-contained automatic plasma cleaning, ion beam etching, reactive ion etching, and ion beam sputter coating preparation for electron microscopy samples

FISCHIONE INSTRUMENTS

MODEL **1030**

Automated Sample Preparation (ASaP) System

Self-contained automatic plasma cleaning, ion beam etching, reactive ion etching, and ion beam sputter coating for scanning electron microscopy (SEM).

- Four functions in continuous vacuum
- Rapid sample processing
- Automatic operation with user-defined process sequence
- Easy-to-use interface
- Samples up to 1.0 in (25 mm) diameter and 1.0 in (25 mm) thick
- Closed loop operation yields consistent results
- Computer automation of instrument parameters
- Automatic sample height detection
- Rapidly pumped sample exchange load lock
- Oil-free vacuum system

ENHANCE IMAGE QUALITY

Prepare samples that have been created by cleaving, grinding, cutting, or sectioning. The final sample configuration is ideal for analysis in a scanning electron microscope (SEM). Processing with the ASaP system significantly enhances the image quality and analytical data obtained from the sample. Operation is fully programmable and automatic, completing sample preparation rapidly enough for high-throughput applications.

Enhanced image quality and analytical data

The powerful and flexible Model 1030 Automated Sample Prep (ASaP) System prepares samples that have been created by cleaving, grinding, cutting, or sectioning. The final sample configuration is ideal for analysis in a scanning electron microscope (SEM).

Processing with the ASaP system significantly enhances the image quality and analytical data obtained from the sample. Operation is fully programmable and automatic, completing sample preparation rapidly enough for high-throughput applications.

User friendly interface

The ASaP system provides plasma cleaning, planarization, surface feature enhancement, and surface coating using a variety of functions. Processing parameters can be individually adjusted for each step.

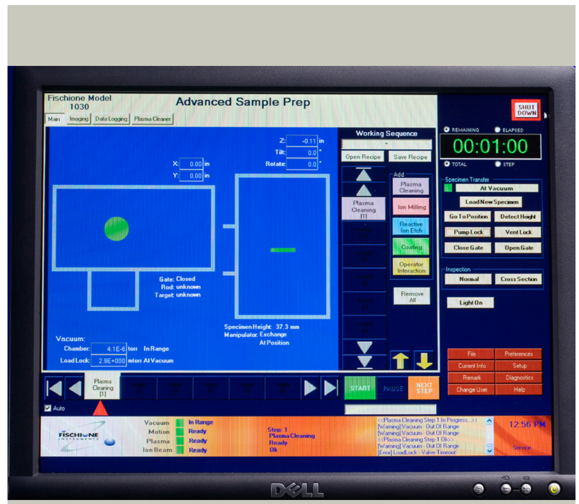
The sequence of processing steps can be loaded from memory using a predefined recipe or can be individually tailored for a given sample. Programming a new sequence is simple: click the buttons for the desired operations and build the recipe. Choose any process step in any sequence, depending on the sample requirements.

Once the sample is loaded and the sequence begins, the ASaP system automatically advances through the complete process while the interface continuously indicates status.

At the conclusion of the process, the sample remains under a dry vacuum until the user acknowledges that the process is finished and removes the sample through the load lock.

Automatic operation

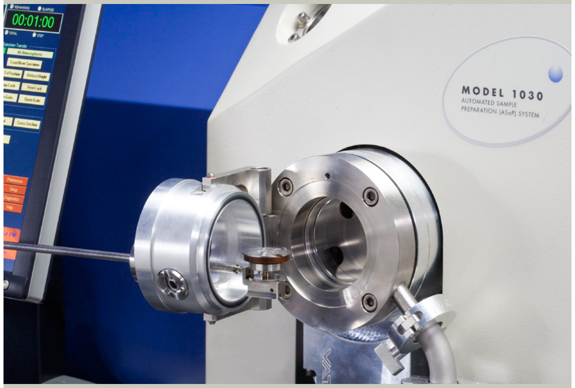
The ASaP system features a load lock for rapid sample exchange. Load the sample into one of the specially designed holders. The holder is then attached to a transfer rod. Once the load lock door is closed and the load lock is evacuated, an automatic gate valve opens. Manually insert the sample holder into the ASaP system's sample stage using the transfer rod. The sample holder can be continuously observed through a viewing window during transfer to and from the sample stage. A chamber light facilitates the transfer process.



Highly interactive user control with a real-time representation of both the process parameters and the operating status.

The laser and photodetector automatically determine the height of the sample, which ensures eucentric sample motion and proper sample placement.

Select a stored recipe or create a customized recipe using the interface. The ASaP system's sophisticated control automatically adjusts all parameters to ensure reproducible sample processing. Press the Run button and the ASaP system takes control. The sample automatically moves from process step to process step as determined by the program sequence. The stage control positions and manipulates the sample, including changing the ion beam's angle of



Load lock opened

Load lock closed

incidence and controlling sample rotation or rocking.

Optical encoders are used on all axes of motion for highly reliable performance. At the conclusion of the process, the sample can be rapidly transferred to the SEM, thus reducing sample contamination from ambient conditions.

Advanced vacuum and gas flow technology

The ASaP system's oil-free vacuum system consists of a turbomolecular drag pump backed by a multistage diaphragm pump. All process gas flows are regulated using mass flow control technology. A butterfly valve regulates the pressure in the chamber to establish consistent operating parameters and prolong pump life.

Today's microscopy requires advanced sample preparation

SEM is a powerful technique for analyzing a broad variety of materials on the nanometer scale. Field emission scanning electron microscopy (FESEM) yields resolution to better than one nanometer with field emission sources operating at low accelerating voltages.

Concurrent with the improvements in imaging and low voltage operation of the FESEM, feature sizes in the semiconductor and nanotechnology fields are ever decreasing. Also, today's advanced materials systems have more complex microstructures on progressively smaller scales. Therefore, greater importance is placed on the quality of the sample surface.

Plasma cleaning

Plasma cleaning prior to analysis to remove organic contamination has become widely accepted for transmission electron microscopy (TEM). This is especially useful for samples that are subjected to fine probe microanalysis using instruments with high-brightness electron sources.

Plasma cleaning has also become essential for effective imaging and analysis of FESEM samples. As resolution improves and accelerating voltages decrease, greater emphasis is placed on the surface characteristics of the sample. Hydrocarbon contamination often obscures imaging and makes it impossible to obtain meaningful analytical data.

The ASaP system creates a capacitively coupled plasma from an oxygen/argon gas mixture. Oxygen radicals produced in the plasma chemically react with the carbonaceous material, converting it to CO, CO_2, and H_2O. The plasma is highly effective in removing contamination caused by rastering of the electron beam during previous SEM observations or analysis on samples that have not been plasma cleaned.

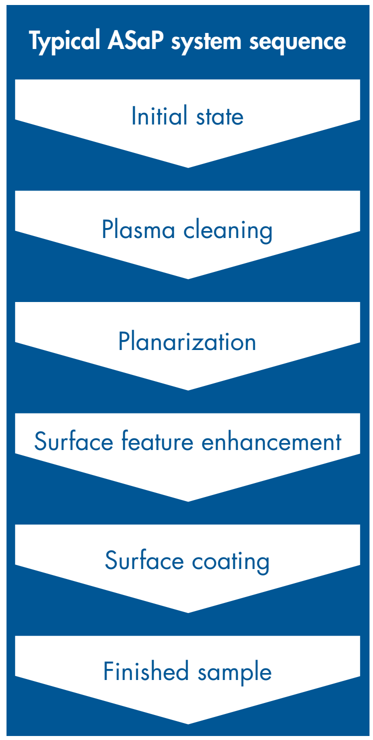
Ion energies from the plasma are less than 12 eV. Because of the extremely low ion energies, organic contamination is successfully removed without altering the sample's properties.

Planarization

Planarization sputters surface defects, such as smearing and scratching, and flattens the sample surface.

The ASaP system incorporates ion beam etching (IBE) technology for planarization. A single hollow-anode discharge (HAD) ion source directs argon ions to the sample at angles ranging from 0° to 90°. The ion source's accelerating voltage and beam current parameters are easily adjusted to allow for either rapid material removal or more gradual surface polishing. A Faraday cup positioned in the ion source shutter monitors beam current, affording consistent ion milling performance.

For bulk materials, such as those used in electron backscattered diffraction studies, the sample can be rotated 360° with respect to the ion beam to obtain the best planarization. When preparing cross-sectional or layered materials, the sample can be rocked in relation to the ion beam to minimize shadowing or trenching of features. Rocking is particularly useful when the sample includes materials that sputter at different rates.



Surface feature enhancement

The ASaP system offers multiple technologies to enhance the sample's surface characteristics either by exposing grain structures or by providing topographical differentiation between given layers or device microstructures.

Ion beam etching (IBE) can apply energetic ions normal to the sample surface, removing material from the sample by momentum transfer. Because material removal rates vary with atomic number, selective milling of the sample is possible.

A parallel-plate reactive ion etch (RIE) system is included for selective treatment of device microstructures. In RIE, a process gas is introduced into the space between two plates electrically biased with RF power. A reactive plasma is formed and, through combined chemical and ion bombardment effects, sample material is rapidly and selectively removed.

The ASaP system allows up to 6 process gases to be introduced individually or blended for material-specific etching to "decorate" the sample surface. Each gas flow is regulated using mass flow control technology. The ASaP system uses an RF power autotuning-matching network to ensure consistent and repeatable processing conditions.

Specific concentrations of CF_4 and O_2 are extremely effective for processing many types of semiconductor samples and in particular for the preferential etching of Si versus SiO_2. Ti-based microstructures can also be selectively etched using these gases.

The ASaP system is cooled by an integral liquid nitrogen cooling system to avoid thermally induced damage during RIE.

SAMPLE ENHANCEMENT

Samples are typically created with processes that may damage the sample's microstructure, such as cleaving, mechanical grinding, or focused ion beam (FIB) cutting.

Cleaving often creates irregular surface characteristics and delamination of device layers.

Mechanical polishing can create micron-size scratches and subsurface damage or, in the case of soft sample materials such as copper, can smear and mask grain boundaries and create voids and inclusions.

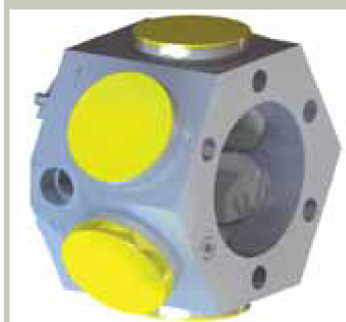
FIB cutting is a powerful tool for preparing samples; however, it can cause irradiation damage.

The ASaP system prepares the sample so that it is ready for advanced FESEM analysis.

Sample coating

To eliminate the effects of charging on image quality in the SEM, the ASaP system employs high-resolution ion beam assisted sputter coating (IBSC) technology. Six targets are included in a carousel, which is interchangeable through the load lock; therefore, there is no need to break vacuum when replacing a worn target. You can select the desired coating target material for a given application.

If required, you can apply multiple coatings to a given sample. The ASaP system automatically positions the target with respect to the ion beam. The rate of deposition and the desired coating thickness are selectable by the user. Typical coating materials are W, Cr, Pt, Ir, Ta, and C, although others can be easily substituted as required.



Target carousel

Sample holders

A complete series of sample holders greatly enhance the applicability of the ASaP system. They are designed to accept both planar and cross-sectional samples and provide proper orientation for various treatments.

Sample holders

Sample observation

The ASaP system has a high-magnification microscope and CCD camera (1,000 X), which allow you to view the sample preparation progress without breaking vacuum. You can program an inspection step in the recipe so that the process pauses automatically and the sample stage moves into the viewing position. The image is displayed on the ASaP system's monitor. You can adjust the microscope's magnification, focus, and illumination intensity through the interface.

SAMPLE FEATURES OF INTEREST

Advanced FESEM samples in the physical sciences include semiconductor devices, nanotechnology structures, metal matrix composites, thermal barrier coatings, and micro electromechanical systems (MEMS) components. In many cases, microstructural features or particle sizes are on the nanometer or subnanometer scale. Often, the features of interest are boundaries between dissimilar materials, for example an advanced semiconductor device containing Cu, Si, SiO_2, Ta, Ti, W, subnanometer oxide and nitride layers, and low-K dielectrics, often consisting of complex polymers.

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