FEI COMPANY™

Magellan™ SEM

Like You've Never Seen Before

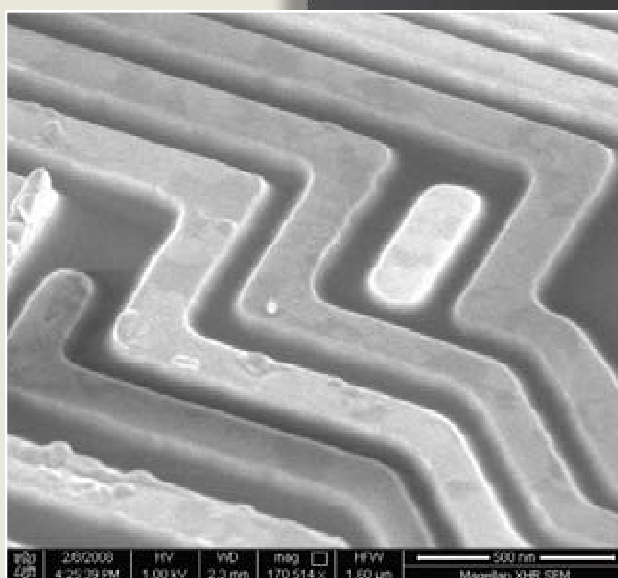
Introducing the FEI Magellan Extreme High Resolution SEM

…maximize resolution, surface detail and contrast at very low voltages.

SEM Like You've Never Seen Before

The world's first extreme high-resolution (XHR) SEM, the FEI® Magellan™ 400L system delivers unmatched surface-sensitive imaging performance at sub-nanometer resolution, without compromising the analytical capabilities, sample flexibility or ease of use of a traditional analytical SEM. With sub-nm resolution at voltages from 1 to 30 kV, plus a large tiltable stage for 3-D surface imaging of large or multiple samples, this revolutionary new XHR SEM from FEI lets you see things you've never seen before. New and innovative electron-optical elements together with field-proven, industry-leading stage technology deliver breathtaking performance and rock-solid reliability.

The Magellan 400L combines a number of industry firsts to help you see more than you've ever seen before. Its patented UC Technology, beam deceleration capabilities and a new solid-state backscatter detector work together to maximize resolution, surface detail and contrast at very low voltages. Constant power lenses optimize beam stability during operation, and electrostatic scanning improves response time. At the same time, the industry-leading, five-axis stage speeds imaging from virtually any angle.



A deprocessed semiconductor sample where poly lines have been exposed. This Magellan XHR SEM image shows much better surface detail than would be possible with a UHR SEM that uses higher voltage to achieve this resolution.

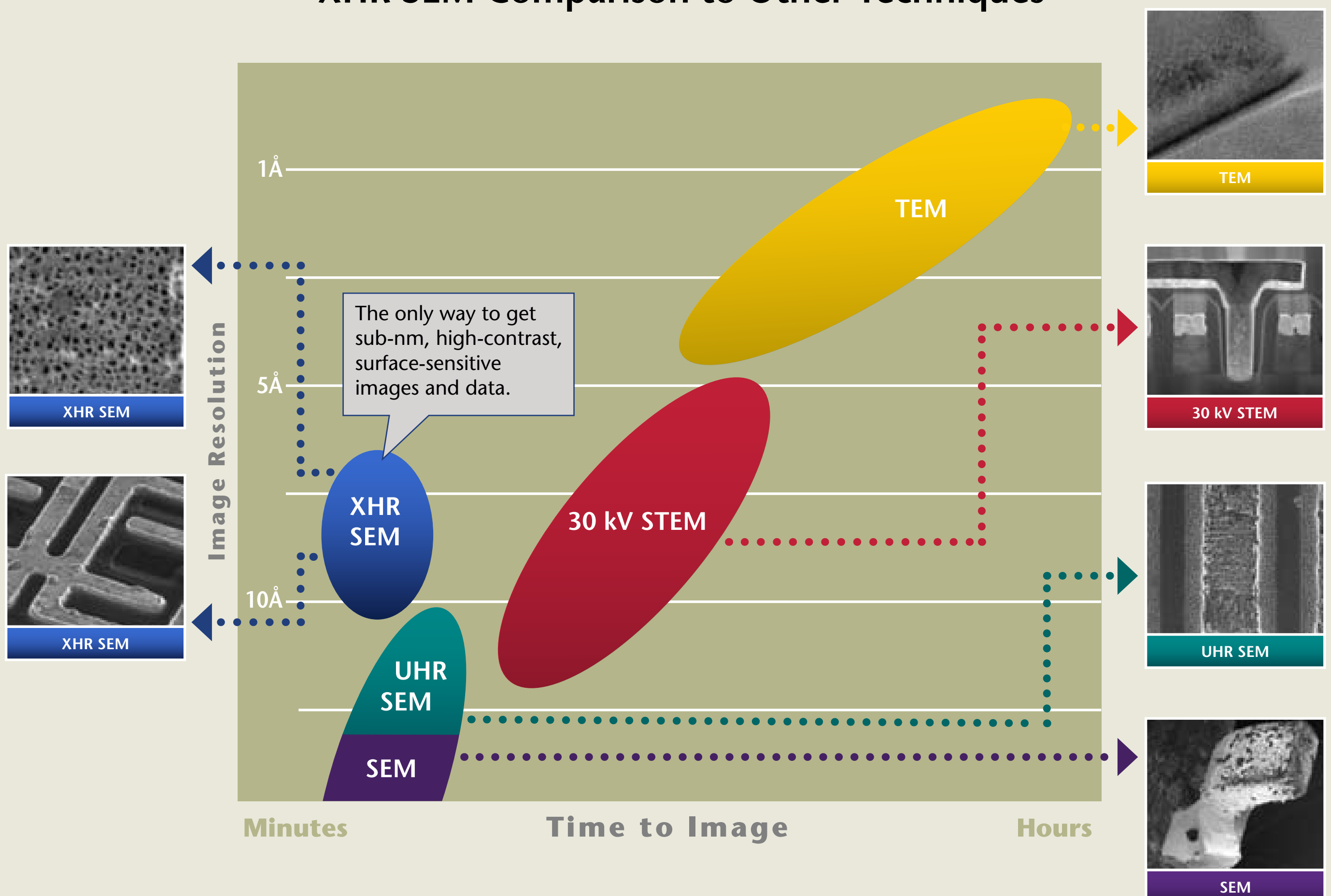
The SEM's analytical-sized chamber features FEI's automated Loadlock for rapid throughput. The chamber's open environment easily accommodates large or multiple samples and a variety of analytical detectors. An optional acoustical enclosure is available to reduce ambient interference, enabling high-resolution, flag-free imaging in a wide variety of lab environments.

Process Development before XHR SEM

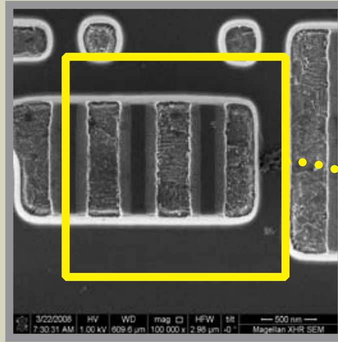
Until now, lab managers have struggled to find a solution that provides surface-sensitive imaging at sub-nanometer resolution. They need to apply this capability to diverse samples, such as multiple cross-sections or full-sized wafers.

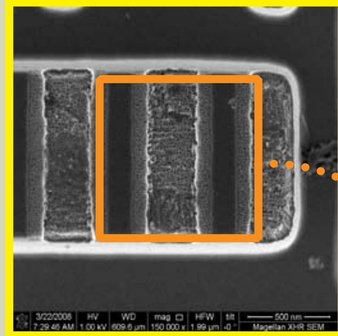
Ultra high-resolution (UHR) SEMs, in-lens SEMs and STEMs cannot deliver the required sub-nanometer surface detail and contrast. STEMs and in-lens SEMs operate only with very small samples and cannot compete with SEM sample volumes. In-lens SEMs with correctors also require more user training and introduce other operational and maintenance complexities.

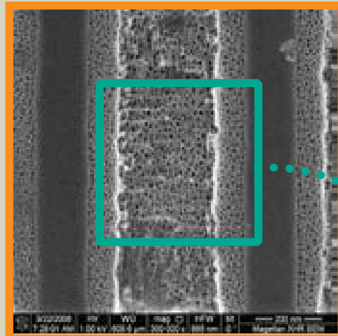
XHR SEM Comparison to Other Techniques

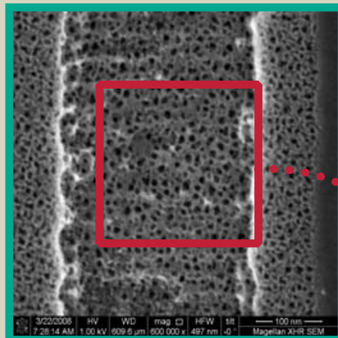


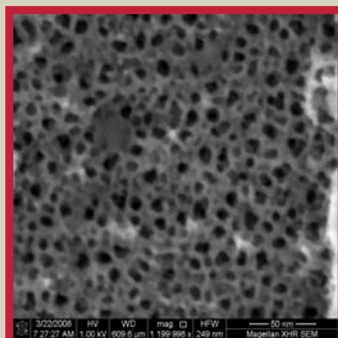
As seen in the chart of current electron microscope options, there is a significant trade-off in time-to-image to achieve sub-nanometer resolution using 30 kV STEM and TEM techniques. XHR SEMs deliver the most surface-sensitive images at sub-nanometer resolutions.











Unprecedented flexibility, See what no one has seen before, without compromising sample diversity, ease of use, and analytic capabilities of traditional SEMs. In this application, a deprocessed sample, stripped back to the poly-silicon level, is magnified from 100,000 to 1,200,000 times. The images demonstrate using XHR SEM to inspect complex surface details at sub-nanometer resolution. The sample can be navigated around at lower magnification and then areas of interest can be zoomed into for closer imaging and analysis. *Images courtesy of STMicroelectronics, Malta/ Grenoble.*

Process Development with the Magellan 400L XHR SEM

The Magellan 400L XHR SEM provides sub-nanometer resolution with beam currents that range from less than 1kV to as high as 30 kV accelerating voltage. Semiconductor labs can rapidly acquire surface-sensitive images on advanced tri-gate or Fin-FET structures at sub-nanometer resolution from virtually any angle on a highly stable, tilting/rotating stage. The ability to quickly load large and/or multiple samples via FEI's automated Loadlock facilitates the generation of many more images than previously possible.

In addition to the extraordinary sub-nanometer, surface-sensitive SEM imaging performance, this SEM integrates analytical capabilities such as energy dispersive spectroscopy (EDS), wavelength dispersive spectroscopy (WDS), and electron backscattered diffraction (EBSD) to help semiconductor labs turn images into actionable information.

Process Monitoring and Control Before XHR SEM

To support faster ramp-to-volume for new devices, manufacturing support labs need better imaging performance at higher throughput. Lab managers often struggle to meet service-level agreements with engineers for more and better data with shorter turnaround times.

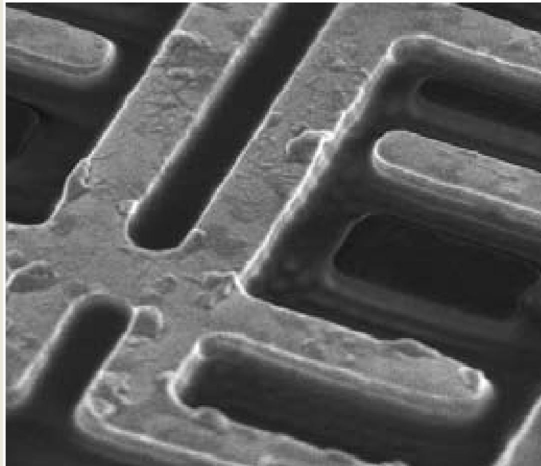
For example, memory manufacturers require high-resolution, high-contrast imaging of Oxide-Nitride-Oxide (ONO) layers for many processes at 32 nm and below. In earlier nodes, higher accelerating voltages (typically 5 to 10 kV) were needed to adequately resolve the structures. However, higher accelerating voltages cause larger interaction volumes and less surface detail, resulting in inadequate information at advanced design nodes. Today, UHR SEM products cannot produce sufficient resolution at less than 5 kV to see surface details of such fine interfaces and structures.

Process Monitoring and Control with the Magellan 400L

Magellan 400L XHR SEM creates high-resolution, high-contrast images at very low kVs to minimize sample interaction volume and maximize surface detail. In addition, its automated Loadlock reduces chamber pump-down time to maximize sample throughput.

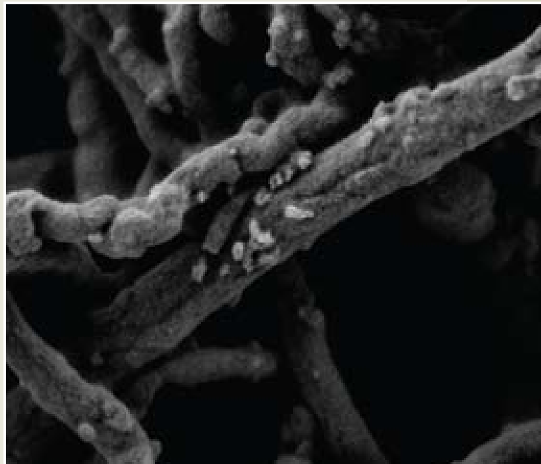
For example, lab engineers may load as many as 40 cleaved samples onto the best-in-class, five-axis, piezo-ceramic, 100-mm stage and begin imaging in less than 100 seconds. The automated Loadlock can easily handle larger samples, up to 100 mm in diameter, as well.

Fast and accurate sample navigation coupled with an intuitive user-interface enables the collection of hundreds of usable images per day. This significant increase in image generation gives engineers the insight they need to more quickly monitor and improve overall production yields.



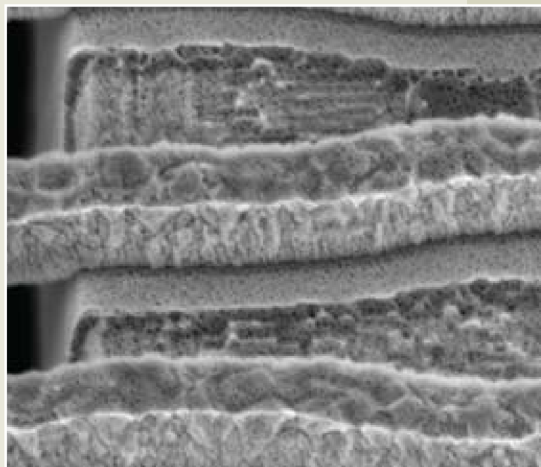
A deprocessed semiconductor sample where poly lines have been exposed, imaged at 1 kV at 170,000 times magnification, viewed at a sample tilt of around 40 degrees. The XHR image shows superior high-resolution surface sensitivity especially on the edges and sidewalls of the metal lines.

Unprecedented surface detail, See surface details using 1 kV and lower beam voltages for minimal volume interaction, yet at greater resolution than a UHR SEM operating at higher voltages.



Nanotubes imaged 200V (0.2 kV) at 600,000 times magnification, with contrast and surface detail not possible on other instruments.

Unprecedented contrasts, Image highly sensitive materials and particles at extreme high resolution.



40° tilted view of deprocessed sample at 300,000 times magnification, using 1 kV beam voltage. *Image courtesy of STMicroelectronics, Malta/Grenoble.*

Unprecedented SEM resolution and analysis, Sub-nanometer resolution down to 1 kV, together with analytic capabilities up to 30 kV for elemental mapping, and more.

XHR SEM platform – easy to use, highly reliable, field proven flexibility

UC Technology

sub-nm resolution @ 1 kV to 30 kV

Schottky UC, hot swap gun

Double magnetic shielding*

New fast beam blanker

Full auto-alignments

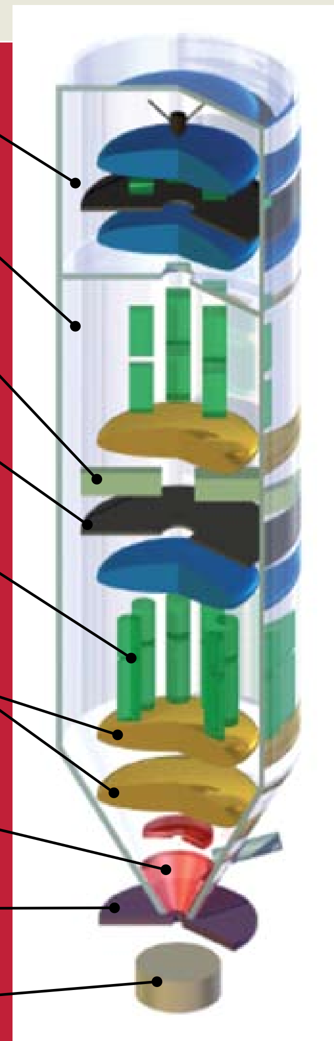
Electrostatic scanning

2 mode objective lens with field free and immersion capability

New TLD design

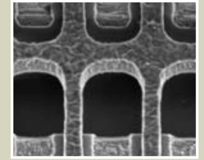
vCD

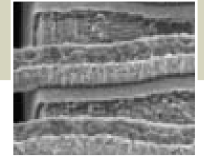
Sample

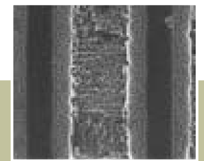


100-mm Tilt Stage
Large samples and/or many cross-section samples imaged from -10° to + 60°

Loadlock
Less than 100 seconds for load or unload







Features and Specifications of the Magellan 400L XHR SEM

XHR SEM resolution: <1 nm at voltages between 1 and 30 kV

- *New gun technology for best imaging across a wide range of operating voltages*
- *Beam deceleration for additional low-voltage XHR surface imaging and contrast capabilities*
- *Schottky emitter gun with hot-swap capability allows for highest stability emission and high beam current modes*
- *Two-mode final lens, including the immersion lens, allows for optimized secondary electron collection for samples in flat and tilted positions, and also at larger working distances*
- *Constant power lenses for best beam stability during operation*
- *Electrostatic scanning speeds response time and is more linear than traditional magnetic scanning*

Advanced acoustical enclosure

- *Based on the proven Titan3™ S/TEM design to reduce ambient noise (optional)*

Most advanced detectors and components:

- *Elstar TLD, ETD, vCD, STEM, EDS, WDS, EBSD*
- *16-bit integrated pattern engine*
- *Quad user-interface software displays images from different detectors live on one screen*

Large, high-throughput chamber and stage:

- *Analytical-sized chamber allows for large or multiple samples and optional analytical detectors*
- *Automated Loadlock for rapid throughput*
- *High-precision, five-axis, piezo-ceramic 100-mm stage allows rapid imaging from virtually any angle*

Highest versatility:

- *Resolution: <0.9 nm at 1 kV, <0.8 nm at 2 kV, <0.8 nm at 15 kV*
- *Sample size: up to 100 mm—minimal or no sample prep required*

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