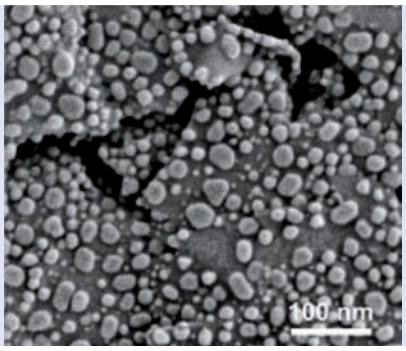
FEI COMPANY™
TOOLS FOR NANOTECH

Magellan™ XHR SEM

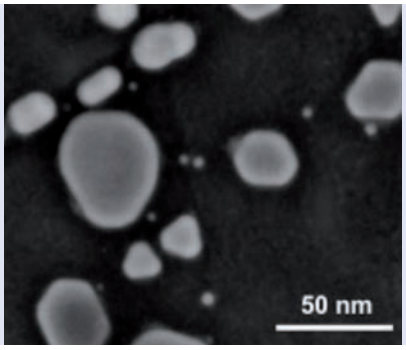
Discover the world of extreme high resolution scanning electron microscopy



Gold particles on carbon test sample imaged at 200 V and a horizontal field width (HFW) of 500 nm.

Unprecedented surface sensitivity,

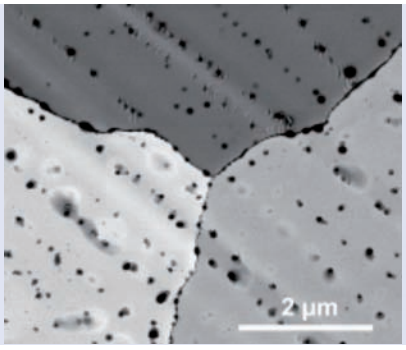
Using non destructive low and very low kV electrons, together with very high resolution.



Same gold particles on carbon test sample, this time imaged at 1 kV and a HFW of 171 nm.

Unprecedented SEM resolution,

Subnanometer resolution from 30 kV down to 1 kV.



BSE channeling contrast on a platinum surface imaged at 2 kV.

Unprecedented contrasts...

Access to highly sensitive and resolved surface and materials imaging, as well as chemical, crystallographic information and more.

...and still a SEM !

New and proven components combine to guarantee a new level of performance

- With outstanding technology maturity
- With traditional SEM ease of use
- On small and large samples, up to 4" wafers

Introducing XHR SEM and the Magellan 400 family

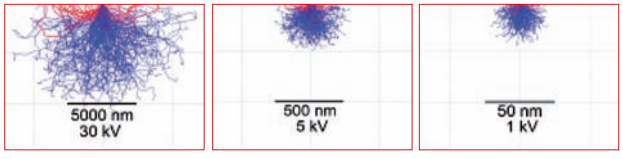
The world's first extreme high resolution (XHR) SEM, the FEI Magellan™ family, provides the research community with unmatched surface sensitive imaging at the subnanometer level. Combining new and innovative electron optical elements, together with field proven, industry leading platform and stage technologies, it delivers rock solid reliability with all the benefits of traditional SEMs: analytical capabilities, sample flexibility and ease of use.

Low voltage finally means high resolution!

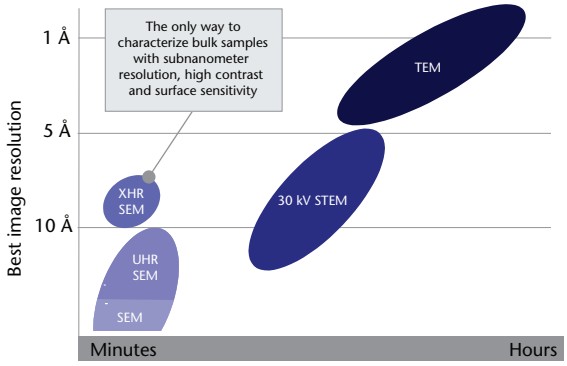
Low voltage SEM is widely acknowledged to provide characterization with reduced sample charging for non-conducting materials, reduced damage of delicate samples, and enhanced surface sensitivity, due to the significantly reduced electron range and interaction volume in bulk samples (see below). The Magellan 400 family now combines all these benefits with the resolution that high end field emission SEMs could only deliver at 15 kV and above.

Accessing new and complementary subnanometer information

With the XHR SEM, new and exciting characterization possibilities open up. On one side, the Magellan 400 family features excellent capabilities in the more traditional high energy (15 - 30 kV) SEM and STEM imaging, without however competing with dedicated S/TEM for acquiring highly resolved projection information. On the other side, the subnanometer resolution at lower beam energies is what truly differentiates the Magellan 400 family. It now becomes possible to characterize the true surface of nanoscale structures, providing new and complementary information to that obtained by S/TEM, AFM and other techniques.



Monte Carlo simulations of electron scattering in silicon illustrate the effect of beam energy on interaction volume over two orders of magnitude. Primary electrons are blue, back-scattered electrons are red.



From bulk sample to image in time

XHR SEM and S/TEM complementarity.

Magellan 400 family
Uncompromised technology

Gun technology	Energy spread
Schottky	0.5 to 1.0 eV
Cold field	0.25 to 0.35 eV
Schottky UC	< 0.2 eV

Unique technology
Schottky UC,
hot swap gun

Elstar SEM column

FEI plasma cleaner

21 port chamber

High stability platform

FEI cryo cleaner

100 mm stage + beam deceleration

A variety of sample holders and detectors can easily be adapted to characterize small and large samples.

Uncompromised detection

The combination of:
- the novel high collection efficiency in-lens detector (TLD)
- the unique low voltage, high contrast solid state detector (vCD)
- beam deceleration and immersion capabilities

allows the Magellan 400 family to support complex imaging operations and refined topographic and materials information. Samples may also be investigated in STEM mode, using an advanced 14 segment geometry. Amongst other analytical capabilities, chemical or crystallographic data can be obtained using well established EDS or EBSD techniques.

Magellan 400 family chamber and stage, here tilted at 52 °.

Uncompromised sample management

Placed in a 21 port, highly adaptative and large chamber, both small and large samples can be positioned under the beam in virtually any orientation using the Magellan 400 family stage. Designed for rock solid stability and ultra-high precision, this 5 axis piezoceramic stage allows for a travel range as large as 100 mm with a repeatability of 0.5 µm, over 20 mm in Z, and up to 60 ° tilt. When working without a loadlock, the chamber may be easily opened, closed and pumped in a couple of minutes.

Uncompromised source technology

To achieve its unique low voltage perfomance, the Magellan 400 family electron column uses a Schottky thermal emitter, providing a robust, stable and high current source for characterization, analytical and prototyping applications. The emitter is enclosed in a unique FEI proprietary hot swap module, allowing for fast gun exchange and no gun venting or contamination during this procedure.
The Magellan 400 family electron gun is combined with the most innovative part of the Magellan, the UC (UniColore) mode, which reduces the beam energy spread to less than 0.2 eV.

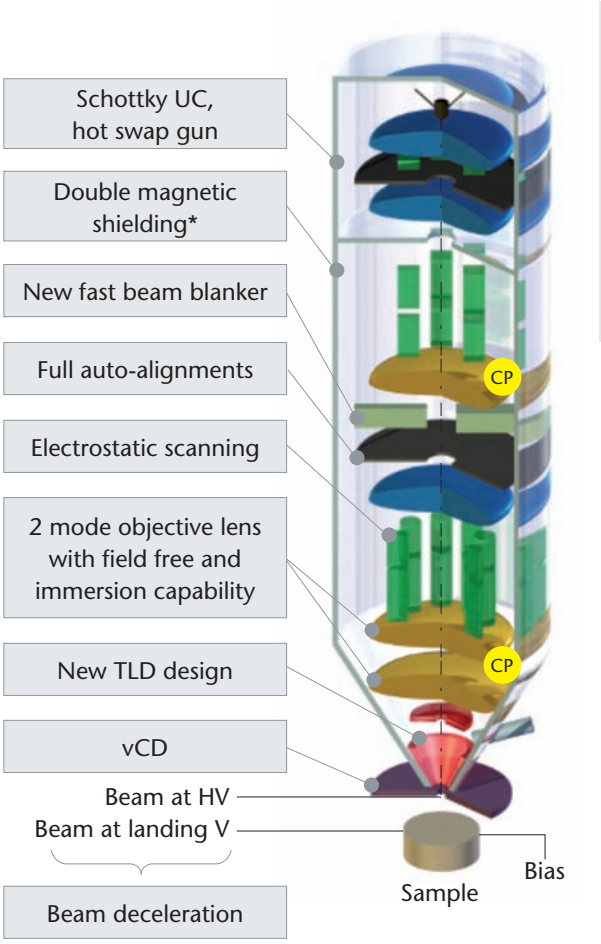
Uncompromised electron optics

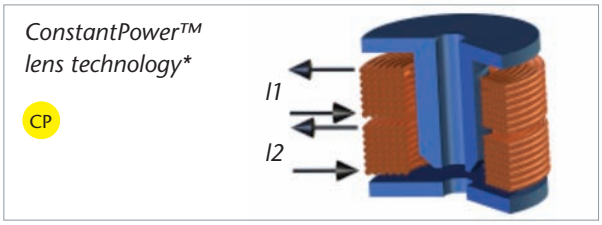
The Magellan 400 family electron optics gather all of FEI's latest technologies, including a 2 mode objective lens with immersion capability for highest resolution, beam deceleration for enhanced contrasts and very low voltages, a novel electrostatic scanning for enhanced deflection linearity and reproducibility, and an optional conjugated fast beam blanker for lithographic or prototyping applications. Auto-alignments manage the entire electron column to preserve a traditional field emission SEM ease of use.

Uncompromised stability

Following FEI's unique developments with the Titan™ TEM, both internal stability and resistance to external interferences are dealt with in the Magellan 400 family in a way which is unique to field emission SEMs:

- ConstantPower™ lenses remove any thermal drift related to changes in the settings of the lenses while they are being used
- Double column shielding protects against electromagnetic radiation
- A unique optional top of the line acoustic enclosure, to protect the Magellan 400 family from mechanical vibrations and acoustic noise





Magellan 400 family electron optics.

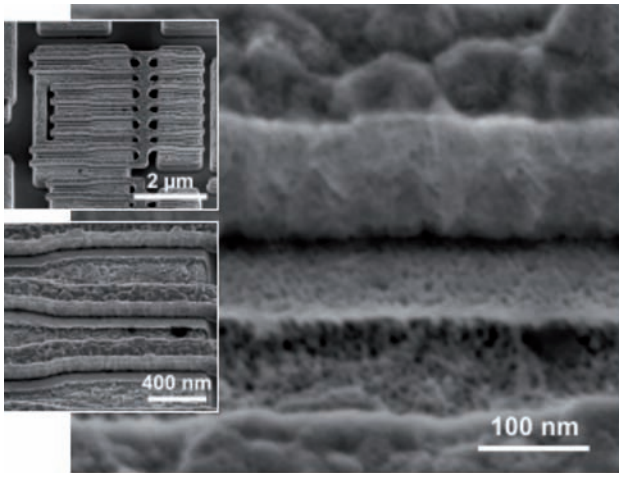
* *inherited from Titan developments*

Uncompromised cleanliness

No other SEM has ever taken greater care of clean imaging than the Magellan 400 family. On top of carefully selected and tested in-chamber components, an integrated plasma cleaner and liquid nitrogen cold trap (FEI cryo cleaner) allow for minimal sample contamination while imaging, especially at low voltages.

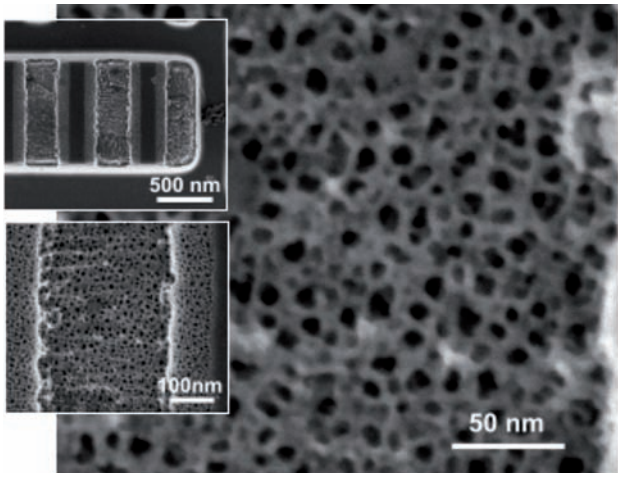
Magellan 400 family XHR SEM applications

With its extraordinary flexibility and ability to clearly see nanoscale surface details, particles and material interfaces, the Magellan 400 family enables researchers and technologists to explore further into smaller and finer details, be it for semiconductor applications to characterize the new processes being introduced with ever smaller design rules, or for the materials research and development, to investigate further nanoscale materials, such as nanoparticles, nanowires and nanotubes, interfaces between materials or details of surface processes. The following are some examples:



Detailed information from complex 3D surfaces

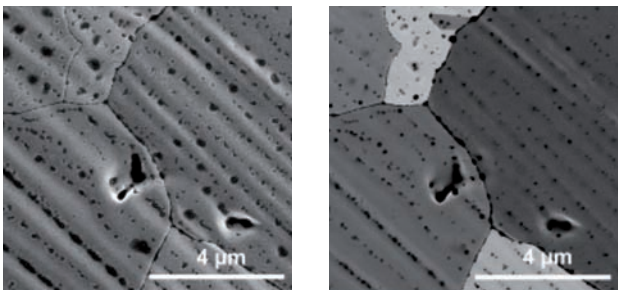
Complex 3D surfaces, such as those found in electronics devices, can now be imaged at magnifications that were not practically achievable before, with unprecedented sharp edges and contrasts.



Very detailed information captured from the surface of a deprocessed integrated circuit. The first set, imaged in tilted position (left, increasing magnifications, smallest HFW 500 nm) shows how Magellan can capture very detailed information from complex 3D surfaces, despite working at eucentric working distance (a must for tilting large samples). The second set, imaged top down at optimal working distance (right, increasing magnifications, smallest HFW 250 nm) demonstrates Magellan's excellent resolution. Courtesy of ST Microelectronics Grenoble and Malta.

Outstanding topographic and materials contrast

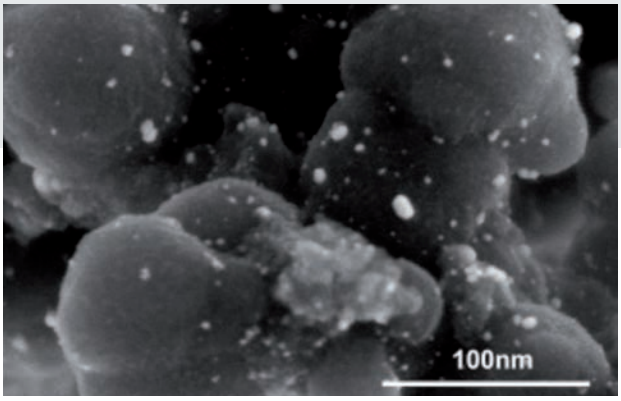
Refined information, such as topography or materials, can be obtained using the Magellan 400 family electron optics and advanced detector suite.



Sharp topographic contrast (using the TLD, left) as opposed to channeling contrast (using the vCD, right) from a rough polished platinum surface imaged at 2 kV.

Investigating the surface of nanotubes

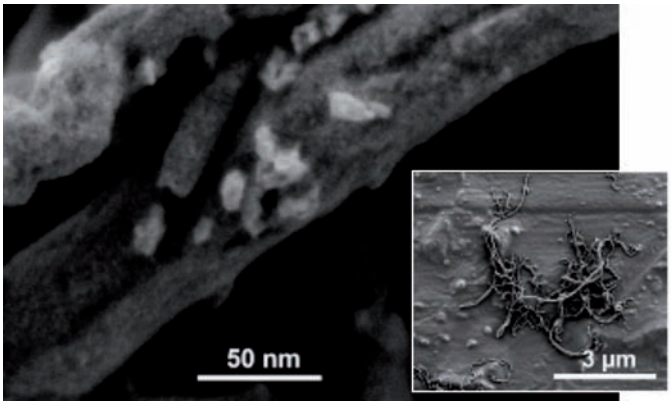
The highly resolved projection information available from S/TEM has been critical to the understanding and development of nanotubes (NT) and nanowires (NW). The Magellan now makes it possible to look at the other side of NT & NW, that is, their true surface at very high magnification, to keep scientists ahead in the breathtaking race for NT & NW processes and applications development.



Platinum catalyst nanoparticles, imaged at low energy using beam deceleration for enhanced surface details and a HFW of 300 nm.

Investigating nanoparticles

With the XHR capability and an optimal balance between topographic and materials contrast, nanoscale particles are perfectly resolved and visible against the substrate, without sample preparation. At this unprecedented magnification, smaller nanoparticles become visible for the first time. Also the nanoparticle distribution, size, shape, orientation (and more) can be ideally studied.



A nanotube with particles on its surface, imaged at very low energy for best surface details and a HFW of 250 nm. Courtesy of Prof. Raynald Gauvin and Camille Probst, McGill University.

Essential specifications

Resolution (at optimum working distance)	0.8 nm at 15 kV in SE mode, 0.9 nm at 1 kV in SE mode and 1.5 nm at 200 V in SE mode
Horizontal field width	From ≤ 100 nm to 1.5 mm
Landing energy	50 V to 30 kV
Current	1 pA to 22 nA
Electron source	Schottky thermal field emitter with UC technology (< 0.2 eV energy spread)
Detection	Secondary electron detector (ETD), in-lens detector (TLD), high contrast solid state detector (vCD), IR camera, EDS, EBSD and more
Chamber	Large analytical chamber with 21 ports
Stage	5 axes high precision and stability piezoceramic stage: XY: 100 mm, Z: ≥ 20 mm, T: - 10 ° to + 60 °, R: 360 ° continuous

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