NanoResearch

Solutions for:
3D NanoCharacterization
3D NanoPrototyping
in situ NanoProcesses
Nanotechnology – beyond the state-of-the-art

Much that occurs in the macro-world of our everyday experience is ultimately determined by processes and phenomena that operate on the nanoscale – the scale of individual atoms and molecules, and the forces that act between them. This realization itself is not new. What is new is the growing collection of tools that allows us to explore and manipulate our world at this fundamental scale – Tools for Nanotech™. This realization, these tools, and the creativity and ingenuity of individual researchers and their organizations together constitute the nanotechnology revolution.

Research in nanotechnology is in the midst of a critical transition, from a discovery driven process in which the majority of new products are the serendipitous result of investigations into fundamental properties and behaviors at the nanoscale, to an application driven process, ‘nanomaterials by design’, in which new products are developed to meet specific requirements based on an understanding of the fundamental processes. As development activity moves into an industrial setting, researchers will demand tools that deliver not only state of the art performance, but also reliability, usability and economic efficiency – qualities for which FEI is well known across a broad range of industries including semiconductors, data storage, mining, forensics, chemicals and materials.

Nanotechnology has the potential to impact nearly every aspect of our daily lives. Practical applications already exist, from stain-resistant fabrics to scratch-resistant automotive coatings, but these are only the beginning. Researchers are exploring new applications in chemistry, materials, space, energy, information, communication, transportation, and conservation. Some of these new applications will create new industries or radically change existing ones. New industries will create new economies, may pose new dangers or opportunities, and ultimately reweave the very fabric of our societies.

Our future is driven by your challenges

Nanotechnology is a broad term – some might say too broad – and its breadth creates a unique set of challenges for those who would work there. It is by nature multidisciplinary, and success requires collaboration across traditionally separate fields of knowledge. At FEI Company we embrace this collaborative model at every level. It shapes our organization, directs our research, informs our new product development, designs our facilities, and directs our communications. One example is our network of ‘NanoPorts’, expressly designed to seek out opportunities to work with our customers to understand and solve their research problems. At the other end of the scale, in the design of hardware and software, we strive to incorporate networking, communication and data sharing capabilities at every level.

At FEI we make the invisible visible – so that your work advances and your organization succeeds

We are FEI Company

At FEI we know that our success depends on yours, and you, in turn, rely on the quality and reliability of the tools we provide. The nano revolution is still young, and though its promise is widely recognized, so too are its risks. Successful execution on early opportunities can provide huge rewards, but such enterprises are fraught with uncertainties and there are plenty of competitors waiting to capitalize on mistakes. The selection of your most fundamental tools will be among the most important decisions you will make.

Of course the tools you select must provide the best possible performance against the criteria you define today, but equally important they must have the flexibility and expandability to address the requirements you won’t discover until tomorrow. No system that you buy today can possibly accommodate all possible future needs. So, in choosing a system you are also choosing a partner, one that you will need to rely on for the life of the instrument, not only to support its current capabilities but also to develop new capabilities to address needs that are as yet unknown.

Our desire to meet future needs does not reduce our commitment to current needs. Quality and reliability are built into our products at every level and our global service organization is second to none. We offer extensive training programs that range from basic operation and maintenance to advanced technique and collaborative methods development.
We are FEI Company

We make Tools for Nanotech – scanning and transmission electron microscopes (SEM and TEM) and focused ion beam (FIB) systems – that allow you to visualize, analyze and manipulate your world at the nanoscale. We are a global technology company with more than 6 decades of leadership in imaging and analytical instrumentation. Throughout that time we have been pioneers in our chosen technologies, introducing one of the first commercial TEMs in 1949, and the first DualBeam™ (FIB/SEM) system in 1993. Our new Titan™ family of S/TEMs offers the best imaging resolution available today, as good as 0.5 Ångstrom, sufficient to resolve individual atoms in many materials.

We are determined to continue to lead our industry and we know that to do so we must nurture and maintain relationships with leading scientists and research organizations among our customers. The knowledge network that this approach creates is a resource that works both ways, providing us with an awareness of current and future needs in the research marketplace, and our customers with access to knowledge and solutions across a broad range of applications. Together with our customers we strive to be thought-leaders, offering creative and innovative solutions that will drive the continuing development of nanotechnology.

Continuous Innovation

Technology waits for no one. Our desire to play a leading role in the development of nanotechnology requires that we embrace a culture of continuous innovation. The leading edge of a revolutionary technology is not often a comfortable place to be, but a willingness to accept risk is the ante to play in this high-stakes game. Breakthrough results are seldom discovered along a well trodden path.

Our new Titan S/TEM family, which offers unprecedented improvement in image resolution, is a case-in-point. Though the aberration correction technology that underlies the improvement is well known, FEI alone took the risk of incorporating it in a new TEM. As a result the Titan offers directly interpretable image resolution 2 to 3 times better than uncorrected TEMs.

As is often the case, innovation begets innovation. The incorporation of aberration correctors permits the design of larger lenses which in turn allows room for new technologies that maintain or control the sample environment. We can use this freedom to expand the types of samples and in situ procedures possible in an electron microscope. We want to relieve the researcher of the burden of adapting the sample to the microscope – instead, adapting the microscope to the sample.
FEI’s tools for NanoResearch

**FEI tools deliver critical capability in three essential application categories:**

- **2D and 3D NanoCharacterization**
- **in situ NanoProcesses**
- **3D NanoPrototyping**

**SEMs like the Quanta™ FEG can visualize surface topography with a resolution of 1 - 2 nm resolution over an extended range of in-situ environmental conditions.**

- The Nova™ NanoSEM 30 improves on the resolution of the SEMs by using an ‘immersion’ type objective lens.

- The new Helios NanoLab™ 400 SEM is the first SEM to offer subnanometer resolution over the full 1 kV to 30 kV electron energy range, effectively establishing a new performance category known as XHR SEM. Its extraordinary low voltage performance provides extreme high resolution, surface specific information that is simply unavailable from other techniques.

- Quanta 3D FEG is the most versatile high resolution, low vacuum SEM/RIB for prototyping and sample manipulation.

- The new Tecnai™ TEMs are research grade instruments that offer sub-Angstrom precision in a wide variety of lens configurations.

- The Titan S/TEM family offers aberration correction for directly interpretable, sub-Angstrom image resolution.

---

### NanoCharacterization

<table>
<thead>
<tr>
<th>3D NanoCharacterization</th>
<th>3D NanoPrototyping</th>
</tr>
</thead>
<tbody>
<tr>
<td>High magnification HR image (image) of a 1st order carbon nanotube filled with carbon nanotube included in the atomic lattice.</td>
<td>Nanostructures created by using electron beam lithography.</td>
</tr>
<tr>
<td>Low voltage HREM image (image) of a silicon sample, demonstrating the atomic lattice.</td>
<td>Nanostructures created by using electron beam lithography.</td>
</tr>
<tr>
<td>High resolution low voltage image (image) of a silicon sample, demonstrating the atomic lattice.</td>
<td>Nanostructures created by using electron beam lithography.</td>
</tr>
<tr>
<td>Characterizing electrical properties in situ using a cryostat.</td>
<td>Characterizing electrical properties in situ using a cryostat.</td>
</tr>
<tr>
<td>Low voltage surface analysis of silicon crystal boundaries.</td>
<td>Electron loss and backscattered electron imaging.</td>
</tr>
<tr>
<td>Low-voltage imaging of a silicon crystal boundary.</td>
<td>Characterizing electrical properties in situ using a cryostat.</td>
</tr>
<tr>
<td>Electron tomography reveals the crystal lattice of a silicon crystal boundary.</td>
<td>Electron tomography reveals the crystal lattice of a silicon crystal boundary.</td>
</tr>
<tr>
<td>Electron tomography reveals the crystal lattice of a silicon crystal boundary.</td>
<td>Electron tomography reveals the crystal lattice of a silicon crystal boundary.</td>
</tr>
<tr>
<td>High resolution images of a silicon crystal boundary.</td>
<td>Electron tomography reveals the crystal lattice of a silicon crystal boundary.</td>
</tr>
<tr>
<td>Electron tomography reveals the crystal lattice of a silicon crystal boundary.</td>
<td>Electron tomography reveals the crystal lattice of a silicon crystal boundary.</td>
</tr>
<tr>
<td>Electron tomography reveals the crystal lattice of a silicon crystal boundary.</td>
<td>Electron tomography reveals the crystal lattice of a silicon crystal boundary.</td>
</tr>
<tr>
<td>Electron tomography reveals the crystal lattice of a silicon crystal boundary.</td>
<td>Electron tomography reveals the crystal lattice of a silicon crystal boundary.</td>
</tr>
<tr>
<td>Electron tomography reveals the crystal lattice of a silicon crystal boundary.</td>
<td>Electron tomography reveals the crystal lattice of a silicon crystal boundary.</td>
</tr>
<tr>
<td>Electron tomography reveals the crystal lattice of a silicon crystal boundary.</td>
<td>Electron tomography reveals the crystal lattice of a silicon crystal boundary.</td>
</tr>
</tbody>
</table>

---

### in situ NanoProcesses

- **Magellan family**
  - **Quanta 3D FEG**
  - **Helios NanoLab**
  - **Tecnai G² series**
  - **Titan family**
3D NanoCharacterization

The latest SEM, DualBeam, aberration-corrected and monochromated S/TEM imaging and spectroscopic capabilities already give outstanding performance, but nanocharacterization moves to an altogether new level with 3D techniques. DualBeam technology combines electron and ion beam processing and imaging that affords 3D visualisation down to the nanoscale, while S/TEM tomography goes beyond the state-of-the-art with 3D reconstruction at the nanoscale and the possibility to go down to the atomic level. And it doesn’t stop there: Analytical techniques such as electron backscatter diffraction (EBSD), x-ray microanalysis (EDS) and energy filtered TEM (EFTEM) can all be extended to three dimensions, giving a world of new information on the inter-relationships between heterogeneous media.

3D NanoPrototyping

Nanoprototyping is a fast, simple way to design, fabricate and test small-scale structures and devices using either an electron beam or focused ion beam to modify the specimen, and involves site-specific milling, lithography or chemical vapor deposition at the nanoscale. The combination of world-leading optics, high-precision beam patterning, accurate stage movements and the widest range of gas injector processes available add up to the delivery of high-quality 3D nanoprototyped structures. User-friendly protocols and software, built on a wealth of experience, help to give rapid, repeatable results, even for the most challenging substrates.

In situ NanoProcesses

The electron microscope has truly evolved into a lab in a chamber. ESEM, DualBeam and ETEM technologies allow the introduction of gases and, with a variety of stages for heating and cooling (plus micromanipulators and injectors for ESEM and DualBeam), this potentially allows a host of in situ processes to be investigated, including those at the atomic level. This opens the way to the development of a more fundamental understanding of chemical and physical phenomena, helping us to visualise and correlate the structure, property and function of materials as they undergo processes such as catalysis, oxidation, reduction, polymerisation, deformation, thermally induced phase transformations and much, much more.
Exploring & discovering together

Our continued commitment, dedication and support includes a range of activities such as:

Scientific collaborations
Ongoing links between FEI Company and research in academia and industry around the globe.

FEI Academy
Training courses to help you get the most from your microscope.

UserClub meetings
Bringing regional and worldwide scientific communities together for discussion, networking and innovation.

FEI Connect
Our thriving, members-only online community for owners and users.

Collaboratory
Adopting the philosophy of providing ‘...technology, tools and infrastructure that allow scientists to work with remote facilities and each other as if they were co-located’.

FEI received awards

With a rich history of electron microscopy innovation, product design and cutting edge nanotechnology solutions, FEI Company has been the honored recipient of numerous awards and recognitions from industry organizations and publications worldwide.

Titan™ 80-300 S/TEM
- iF Design Award
- State Technology Magazine, Top Products of 2005
- Micro Magazine, Greatest Hits of 2005
- Innovative Product of the Year Award, Oregon Tech Awards 2005
- R&D 100 Award 2006
- IBO's 2006 Silver Design Award
- Award for Technical Excellence, Nano Tech Japan 2008

Tecnai TEM
- Good Design Award (G-Mark), Japanese Industrial Design Promotion Organization (JIDPO)

Phenom™ microscope
- Red Dot product design awards 2007
- Recognition of Excellence in Innovation
TÜV Certification for design, manufacture, installation and support of focused ion- and electron-beam microscopes for the NanoElectronics, NanoBiology, NanoResearch and Industry markets.

©2008. We are constantly improving the performance of our products, so all specifications are subject to change without notice. The FEI logo, Tools for Nanotech, Quanta, Nova, Helios Nanolab, Tecnai, DualBeam, ESEM, Titan and AutoSlice and View are trademarks of FEI Company.