Value and Excellence in SEMs

TESCAN

PERFORMANCE IN NANOSPACE

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Tescan, s.r.o. is a Czech private company focused on research, development and manufacturing of scientific instruments and laboratory equipment like:

- Scanning Electron Microscopes
- Supplementary accessories for SEMs
- Special Products

Tescan was established in the summer of 1991 and has changed from a small company into a company with a distinct structure that is subordinate to the main objectives of the company – i.e. to the development, manufacturing and sales of scanning electron microscopes.

Tescan Today

TESCAN is a global supplier of scanning electron microscopes used for research, and manufacturing in the areas of automotive and aerospace, biotechnology, nanomaterials, metallurgy, education, and forensic science. The company is located in Brno, the Czech Republic, a region with a long tradition of electron optics research that includes over sixty years' history designing and producing electron microscopes. Tescan has over fifteen years of experience, with over 400 VEGA SEMs installed in over 30 countries. Currently, more than 80 employees work in a modern manufacturing facility that includes: metal working shops, clean rooms, assembly, final testing, research engineering and application laboratories.

The History of Tescan's Success

2007 LYRA Focused Ion Beam SEM

2006 VEGA\\ 3D Metrology SEM

2005 MIRA Field Emission SEM with In-Flight Beam Tracing

2004 New VEGA\\ conventional and variable pressure SEM series with Wide Field Optics
Certificate CSN EN ISO 14001, CSN EN ISO 9001

2003 Patented LVSTD Tescan Low Vacuum Secondary Electron Detector

2002 VEGA large chamber SEM

2001 Gold Medal for VEGA TS 5130 MM on 43rd International Engineering Fair in Brno

2000 VEGA variable pressure SEM introduced

1999 VEGA SEM with built-in remote control introduced

1996 First compact, fully PC controlled SEM PROXIMA

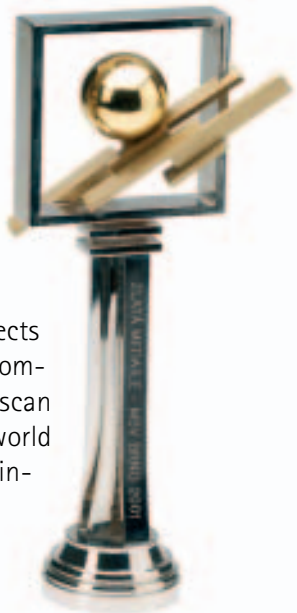
1992 Image processors for digital SEM image acquisition

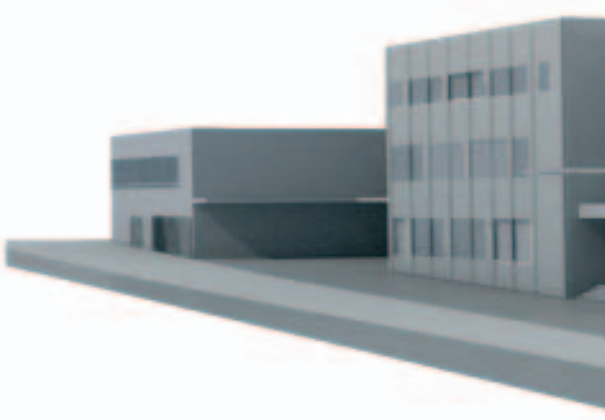
1991 Tescan established

Tescan for the Future

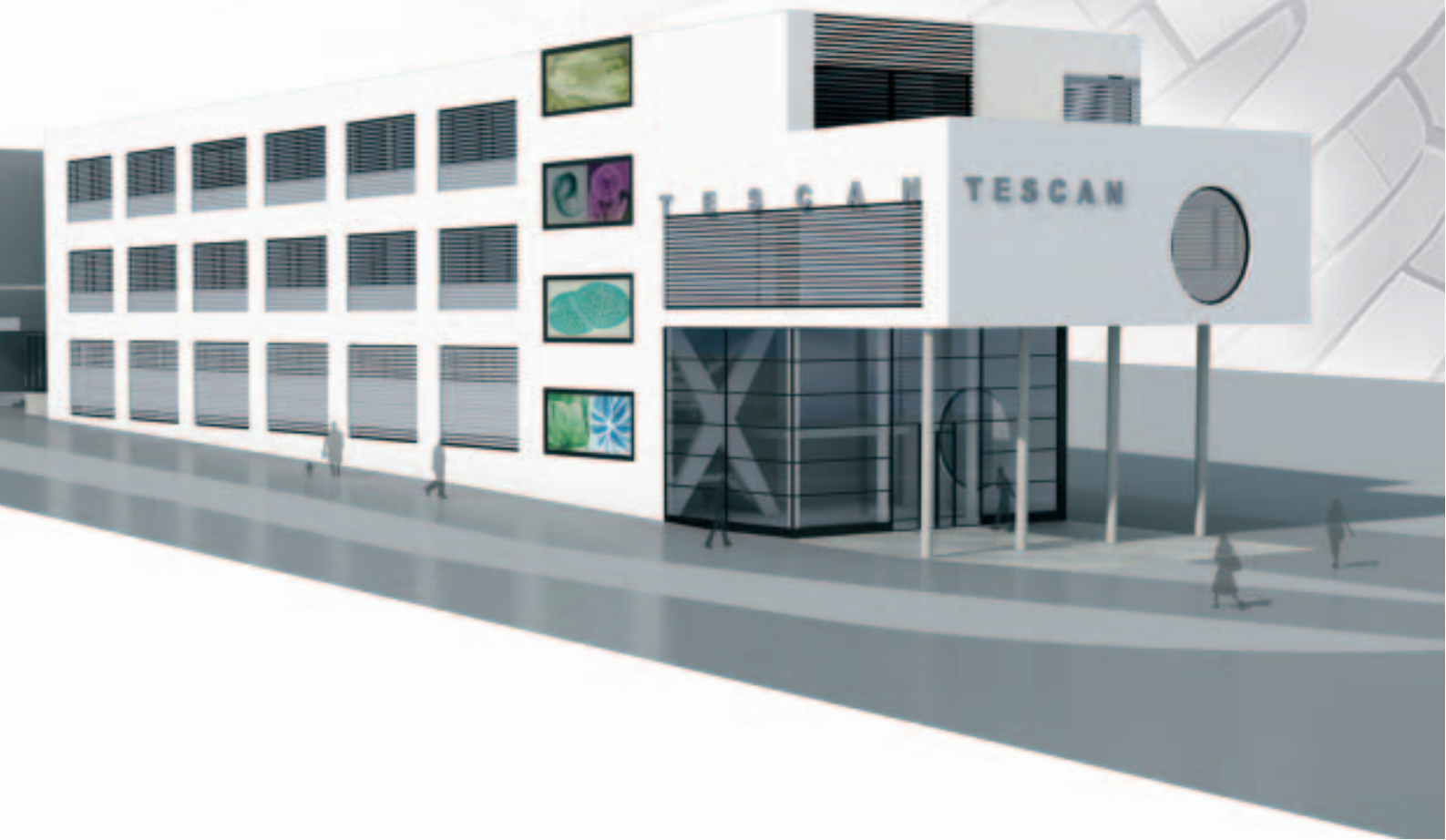
Tescan is committed to supporting its customers in the future by supplying the most modern, innovative SEMs that maintain their high level of ease of use and reliability and follow main trends in science development and technology research.

By participating in top research projects and by co-operation with the leading companies in electron microscopy, the Tescan branch successfully enters the future world of nano and microtechnology by its instrumentation.





Value and Excellence in Nanotechnology



By following progress in electron microscopy together with pioneering and applying new technological possibilities, Tescan is producing its microscopes as state of technical excellence. With Tescan superior tools you will taste using the most recent and modern instrumentation.

Carefully selected combinations of parts for various imaging and analytical purposes with reference to great performance to price ratio have led to the following product families.

Tungsten Heated Filament Scanning Electron Microscopes (VEGA Series)

The unique Wide Field Optics, ingenious technical design, optimized port geometry and easy to use hardware and software interfaces make from Tescan's microscopes versatile analytical tools for their usage in material science and metallurgy, automotive, aeronautical and engineering industries, semiconductors and electronic components, nuclear, petroleum, chemical, pharmaceutical and textile industries, biology and life sciences, forensic science, archeology, museology, art conservation and higher education.

High Resolution Schottky Field Emission Scanning Electron Microscopes (MIRA series)

A unique three-lens Wide Field Optics design offering a variety of working and displaying modes and real time In-Flight Beam Tracing for the performance and spot optimization allows high quality imaging at very high rates as well as high resolution which are essential for the usage in different demanding industrial as well as research applications, like defect and failure detection and analyses, 3D metrology, Particle detection and characterization, materials qualification, nanometrology, device testing, biomedical applications, etc.

Nanotechnology Tools, Focused Ion Beam Tools (LYRA FIB/SEM) and Devices for Special Applications

A favorable combination of electron and ion sources and optic columns attached onto one chamber, supplements imaging qualities of a scanning electron microscope with the possibility of micromachining by focused and accelerated ions. With Lyra FIB/SEM, you will enter the NanoSpace physically with its milling/depositioning capabilities. It enables new possibilities in nanotechnology instrumentation. A wide range of Tescan device modifications tailored to the customer's needs allows usage of Tescan devices for different special applications like electron lithography systems, manipulation with nano objects, systems for the investigation of active materials, etc.

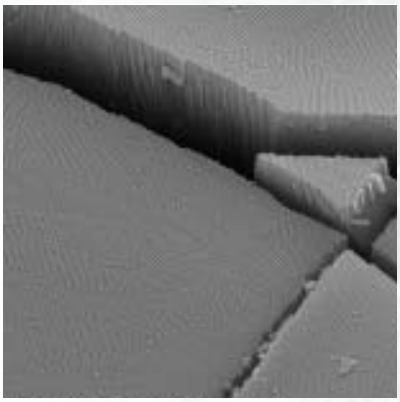
Detectors, Analyzers and Accessories

Tescan provides microscopes with first class detectors. Based on the technology of synthetic crystals, Tescan detectors provide very fast and efficient solutions that enhance high imaging quality.

Ingenious ports geometry creates favorable conditions for complex specimen analysis, using fully compatible third party microanalyzers as well as for attaching additional tools like the Peltier cooling stage, CryoSEM sample preparation tools, or Electron Beam Lithography systems.

Control and Image Processing Software

Since the beginning, the company is focused on producing superior digital image processing tools. Powerful image processing is integrated in the microscope's controlling software, or it is produced as stand-alone applications for use with a wide range of imaging devices such as optical microscopes etc. Modular software architecture opens up more possibilities for advanced image processing, measurement and a range of additional modules for various purposes.



Excellent Imaging

- Unique optical design
- Fast digital image acquisition in superior quality

Ingenious Design

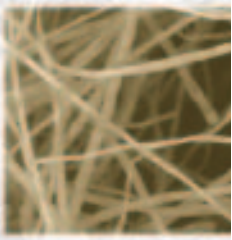
- Designed for maximum performance and imaging quality
- Vast analytical potential
- Variable pressure mode support
- Self diagnostic system
- Ergonomic and stylish look

Ease of Use

- Designed for effortless operation and maintenance
- Fully automated microscope set-up
- Easy to use software interface with extension modules and internationalization support
- Detailed on-line help
- Network operation

Worldwide Support

- Well-established sales and service network
- Remote diagnostics
- Skilled staff for customers' training
- Competitive price/performance ratio



Value and Excellence in SEMs

The Unique Wide Field Optics™ Design

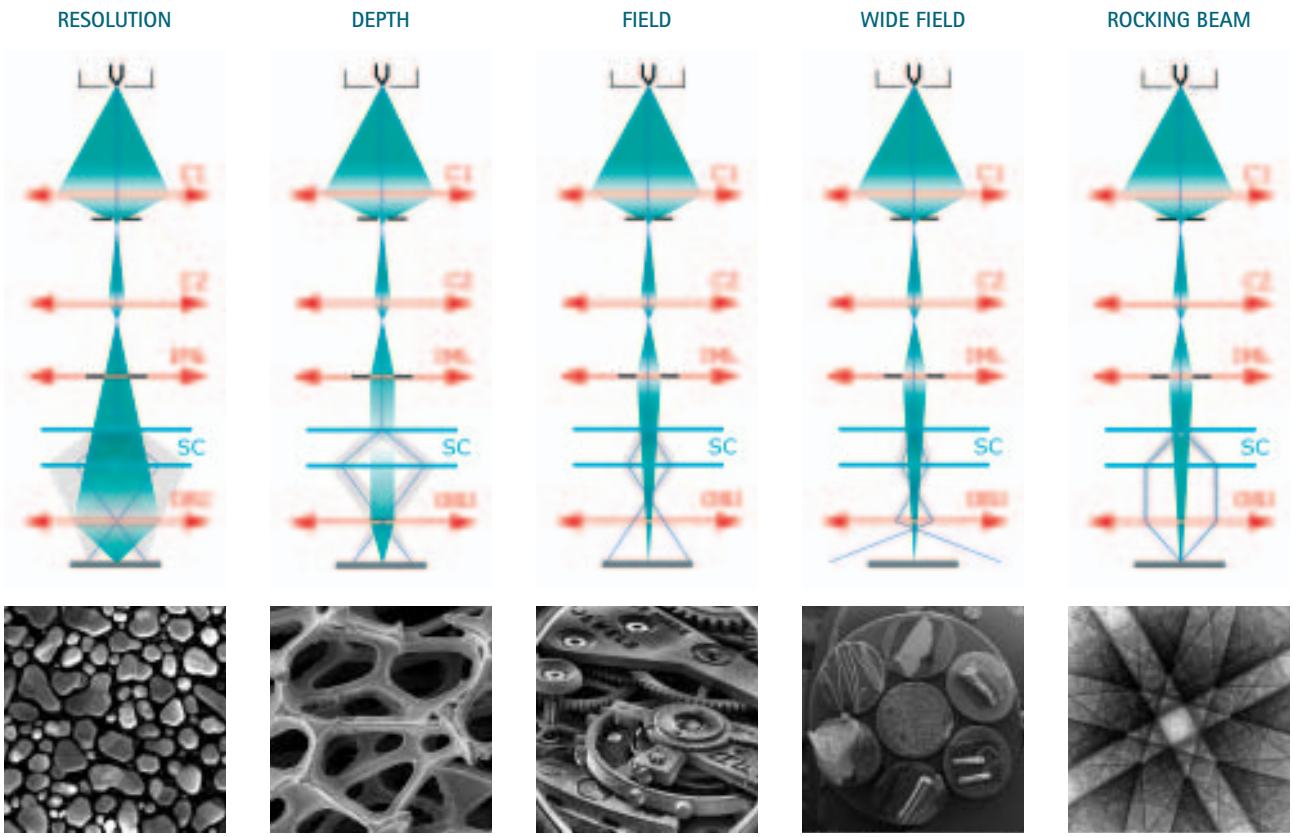
The Wide Field Optics™ design is a unique electron optical design, embodying Tescan proprietary intermediate lens. It allows imaging in various modes from the highest possible resolution in the Resolution mode to the great depth of focus in the Depth mode and extra large field of view in the Wide Field mode.

The Wide Field Optics technology is included in all Tescan SEM types with four lenses for VEGA and three lenses for the MIRA series.

Modes:

RESOLUTION mode:	configures the column to produce the highest resolution for the chosen working conditions automatically.
DEPTH mode:	sets the column up in a mode which enhances the depth of focus.
FIELD mode:	optimizes the column to provide large non-distorted field of view.
WIDE FIELD mode:	provides an extra low mangnification imaging with possibility of measurement.
ROCKING BEAM mode:	scans one point by tilting the beam around. The result of this mode can be e.g. a backscattered channelling pattern.

Schematics of the VEGA four-lens Wide Field Optics scanning modes



Low Vacuum Operations

The vacuum system consists of powerful rotary and turbomolecular pumps and needs no cooling water. Obtaining of the working vacuum is quick. It typically takes less than 3 minutes.

An autonomous vacuum control unit, equipped with a microprocessor, reads the current state of the system using gauges and various sensors. The unit communicates with the main computer and ensures vacuum stability.

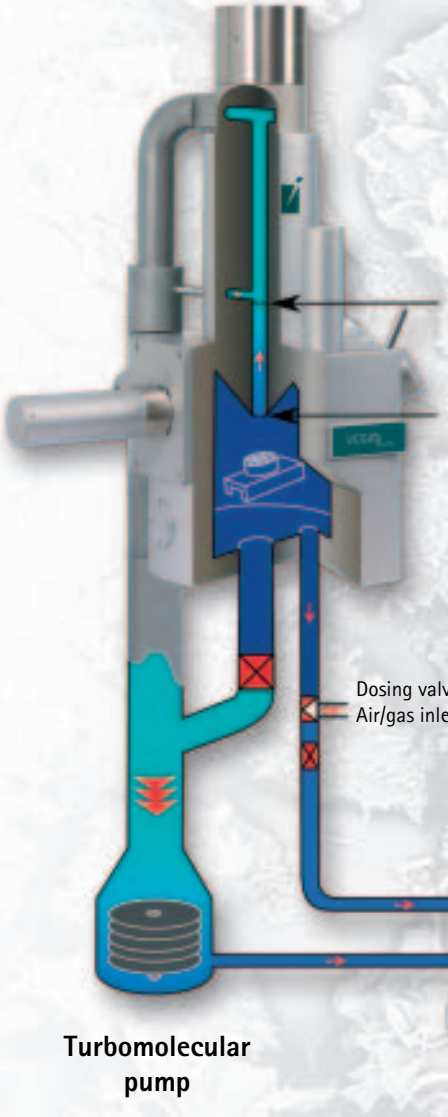
The vacuum system of TESCAN microscopes is designed to support two modifications that lead into two microscope categories – a high vacuum type or in short the **HiVac** and a variable pressure **UniVac** type.

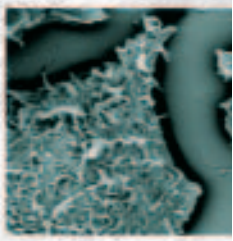
HiVac – conventional models operating at a high vacuum in the range of 10^{-3} Pa in the specimen chamber.

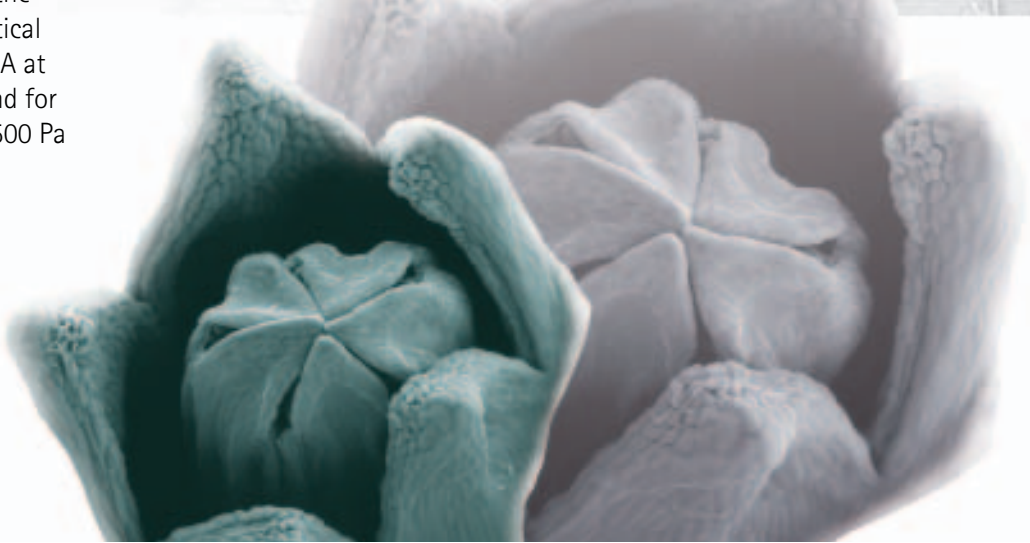
UniVac – a variable pressure microscope modification that supplements all the advantages of the high vacuum model, with an extended facility for low vacuum operation. Switching from the high to the low vacuum mode is quick and easy for the user.

In the low vacuum mode, nonconductive specimens can be investigated in their natural, uncoated state, using all the working modes of the optical system for VEGA and MIRA at pressures up to 150 Pa and for VEGA at pressures up to 500 Pa in the Resolution mode (operation at chamber pressures up to 2000 Pa is optionally available).

VEGA UniVac Vacuum System Scheme







Advanced Scanning Features

High quality and precise scanning generators together with modern electronics allow image acquisition up to the size of 8 192 x 8 192 pixels in 16-bit imaging quality.

A complex control of scanning and focusing coils allows unprecedented scanning features. This includes a modifying scanning scene like image shift and continuous rotation, tilt correction and a scalable focus window of any rectangular shape.

Point and Line Scan

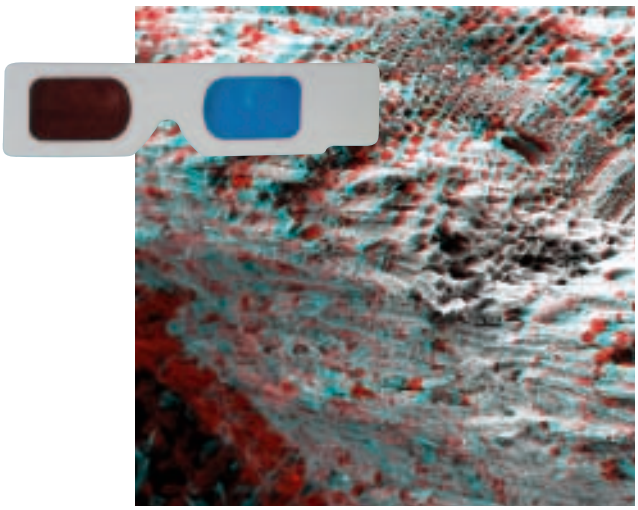
These useful scanning features for measurement or point analysis became a standard in scanning electron microscopy.

Dynamic Focus

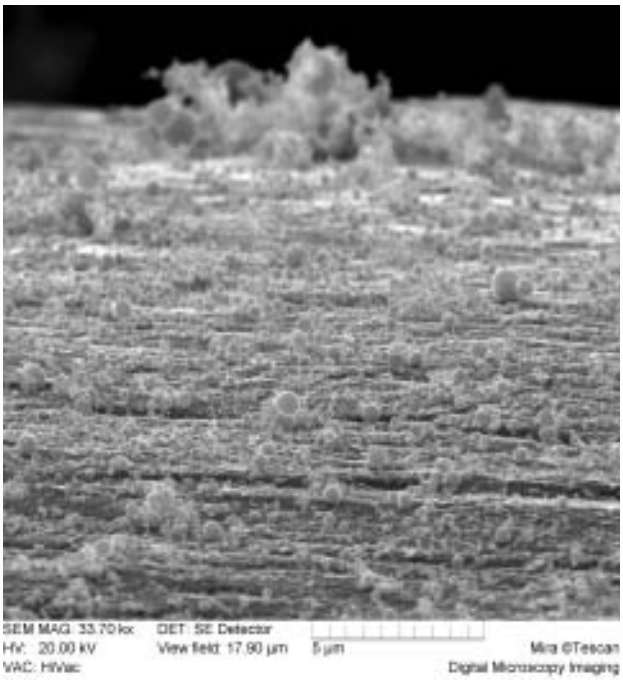
Scanning in a tilted plane is now possible by changing the working distance during scanning dynamically. You will get an extraordinary depth of focus for scanning in a tilted plane.

3D Beam

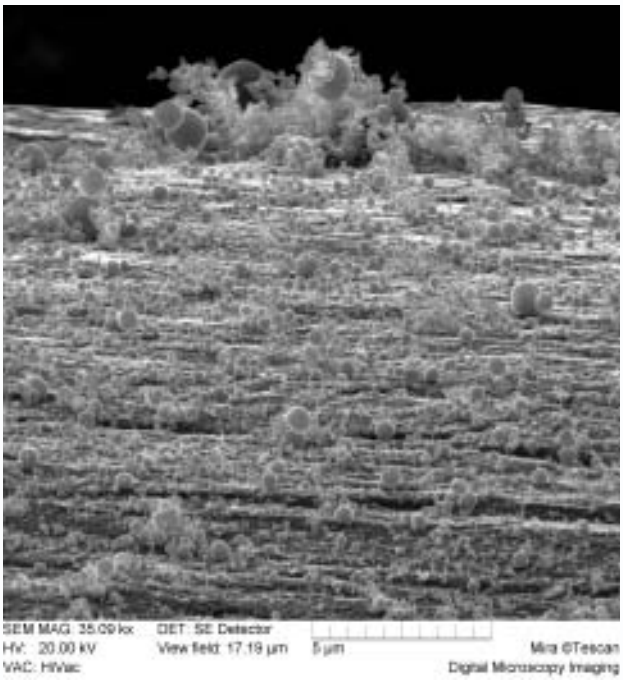
This advanced feature allows the scanning's axis to tilt around the center of view field and therefore true live stereo-imaging is possible. Together with 3D reconstruction software, it makes a revolutionary tool for 3D surface analysis.



Stereo image of spruce wood structure



Standard imaging without Dynamic Focus



Using Dynamic Focus allows advanced imaging capabilities

The MIRA\ In-Flight Beam Tracing™

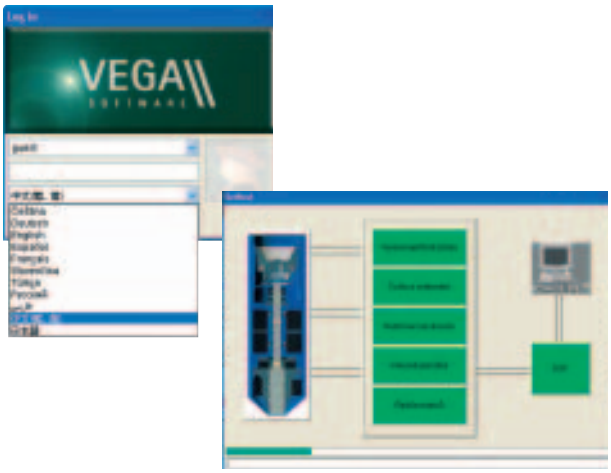
The originally developed method represents an active way of controlling the Mira optical system parameters. It is possible to control the probe current precisely or the spot size continuously for the whole range of the beam energy by using this ultra fast computation method for real-time beam tracing,

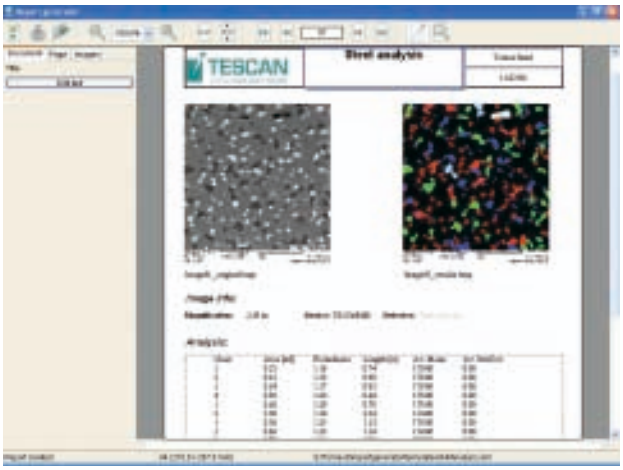
Real-time mathematical model controls electron-optics set-up

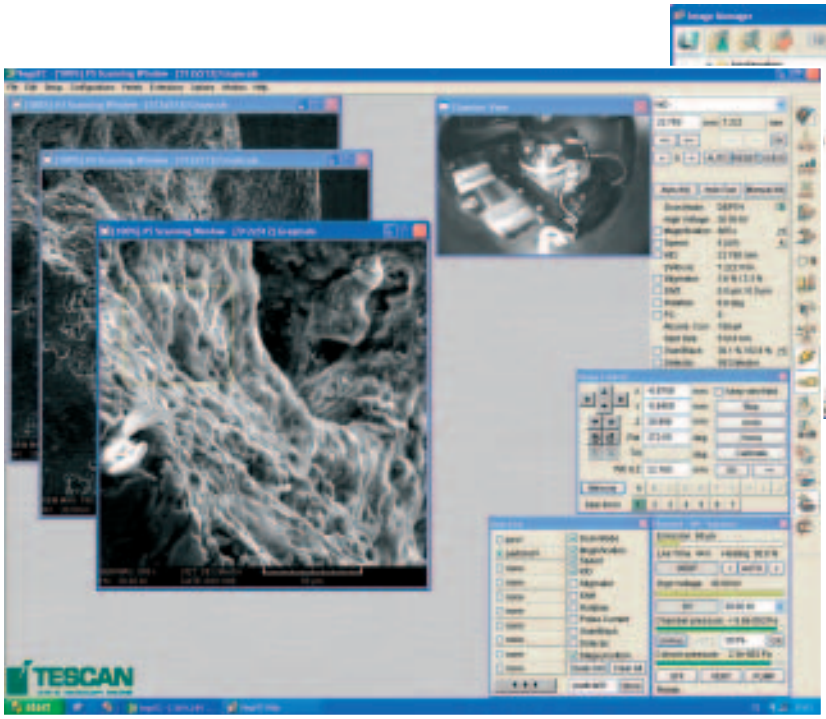
Tescan SEMs Controlling Software

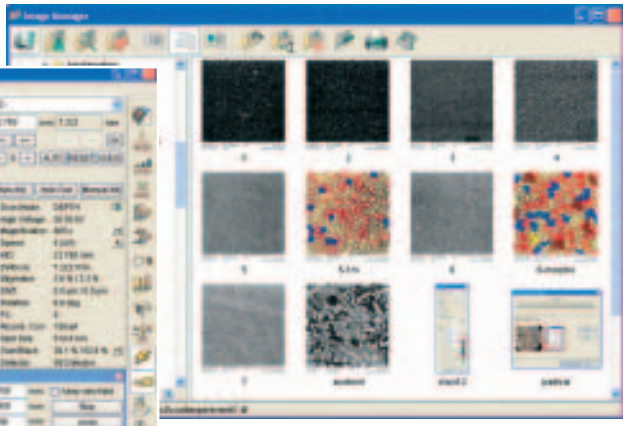
The Windows™ based controlling software provides complete control of the microscope by means of the mouse, the keyboard and the trackball.

- Capability to open up to eight scanning windows with different operating conditions
- Up to size of 8,192 x 8,192 pixels 16-bit image acquisition, processing and archiving in standard TIFF, BMP, JPEG, JPEG 2000, GIF, PNG or PGM and PPM format
- Build-in tools for advanced image processing, measurement and analysis
- Password-protected accounts can be assigned to an unlimited number of users with individual set-up conditions of the microscope
- A window-like style of control panels allows simultaneous work on multiple monitors
- Detailed on-line help
- Remote access via TCP/IP. Remote client for full network access/control is included in the standard software package delivered with all Tescan microscopes.
- Possibility of localization in any language environment









Comfortable Operation

Compucentric Stage

Advanced motorized stages with precise eucentric movements are fully PC controlled with the possibility to keep the current view field during rotation or tilt for the whole range of working distances.

Besides absolute and relative movements, restoring saved positions, moving to pre-set specimen positions, click-to-center moving and WD & Z movement synchronization are possible.

Easy Sample Navigation

Even specimens with a very uncommon shape or size can easily be navigated to the requested position without conflict.

The IR Chamber View Camera together with an ultra low magnification imaging in the **Wide Field** mode does sample manipulation effortless.

The Touch Alarm stops stage movements immediately when the sample touches any part of the chamber or detector.

User Key

The locking/reloading features of the microscope setup, as well as loading conditions from previously acquired images, saves the time to get another image in the same quality.

Stylish and Ergonomic Design

Professionally designed shapes and selected materials of the operator's desk ensure high comfort for all-day work.

Fast Maintenance

Keeping the microscope at peak condition is now easy and takes a minimum of the microscope's offline time. Every detail was carefully designed to maximize the microscope's performance and minimize the operator's effort.

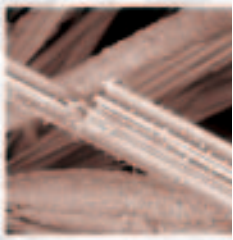
Factory Pre-centered Cathodes

The exchanging of blown filaments takes less time with specially designed cathode cartridges. A blown cathode cartridge can simply be replaced with another precise factory pre-centered one.

Automated Procedures

Filament heating and alignment of the gun to the finest beam performance is automatically done just by one click.

Many other automated functions reduce the tune-up time like probe current or spot size optimisation at current magnification, scanning speed optimization for low noise image, auto contrast & brightness, automatic focus and stigmator setup.



Back Channel Diagnostics and Remote Service

A precise self-test runs every time the microscope is turned on. It finds out whether every part is working well. The software notifies you if any problem occurs. You can also easily send a package of log and configuration files to the diagnostic service center for preliminary analysis.

VEGA\\ Scanning Electron Microscopes

The creation of favourable conditions for complex analysis of specimens, combined with high performance imaging capabilities, were a high priority in the design of the VEGA microscopes from the beginning. The conical objective lens, carefully considered chamber design, high precision eucentric stages, wide choice of detectors and supplementary accessories, all combine to make the VEGA SEM a versatile analytical tool.

The VEGA Series

The Vega column with a tungsten heated cathode forms the basis of a family of high quality, fully PC-controlled Scanning Electron Microscopes with a host of merits:

- An innovative and powerful four lens **Wide Field Optics**™ design, offering a variety of working and displaying modes
- A range of chambers to suit all applications and a wide choice of supplementary accessories
- Fast and precise motorised specimen stages
- Excellent analytical qualities with optimized ports geometry
- Turbomolecular and rotary pumps ensure quick and easy sample exchange and short times to reach a working vacuum
- Sophisticated and easy-to-use software for microscope control using a Windows™ platform
- Fully automated microscope set-up and remote diagnostics
- Comprehensive software for image archiving, processing, evaluation, and network operations comes as standard
- Minimal requirements on space, power supply, and environment
- Competitive price/performance ratio

Recently the second VEGA\\ generation of advanced SEM has been launched.

New Features of the VEGA\\ generation

- Great effort was devoted to the increasing image quality
- New, modern, high-performance electronics allows faster acquiring and processing of high quality and high resolution images and thus decreasing the time needed to obtain an image
- Enhanced network operations and remote diagnostics
- Excellent self-diagnostics provided by Back Channel serves for fast and effective service support
- Advanced scanning features like 3D Beam or Dynamic Focus
- New stylish and ergonomic design

The VEGA\\ Family Basic Overview

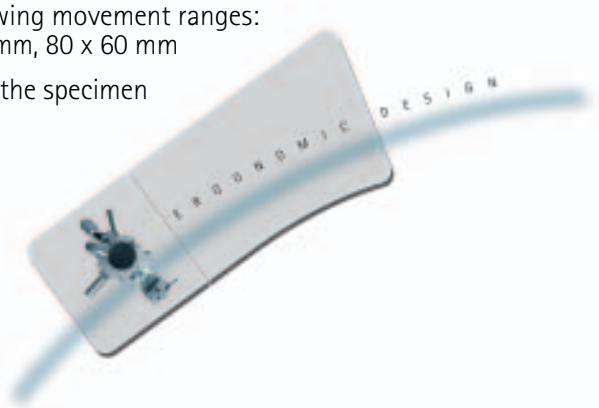
Electron gun	Tungsten heated filament
Resolution	
In high vacuum mode (SE)	3.0 nm at 30 kV
In low, medium vacuum mode (BSE)	3.5 nm at 30 kV
Magnification	Continuous from 4x to 1,000,000x
Accelerating voltage	200 V to 30 kV
Probe current	1 pA to 2 µA

Based on carefully selected chamber geometries and two vacuum types, the VEGA\\ family currently contains eight excellent SEM models that cover a whole range of applications.

Chamber type	SB	LS	LM	XM
VEGA\\ HiVac	VEGA\\SBH	VEGA\\LSH	VEGA\\LMH	VEGA\\XMH
VEGA\\ UniVac	VEGA\\SBU	VEGA\\LSU	VEGA\\LMU	VEGA\\XMU
Internal dimensions	∅ 160 mm	∅ 230 mm	∅ 230 mm	300 mm (width) x 330 mm (depth)
Door	120 mm (width)	148 mm (width)	148 mm (width)	280 mm (width) x 310 mm (height)
Number of ports	8	11	11	9
Chamber suspension	mechanic	mechanic	pneumatic	pneumatic
Specimen stage	manual	fully motorized	fully motorized	fully motorized
Type	eucentric	compucentric	compucentric	compucentric
Movements	X= 40 mm Y= 24 mm Z= 27 mm Z'= 6 mm Rotation: 360° cont. Tilt: -90° to +90°	X= 40 mm* Y= 40 mm* Z= 47 mm Rot.: 360° cont. Tilt: -75° to +50° **	X= 80 mm Y= 60 mm Z= 47 mm Rot.: 360° cont. Tilt: -75° to +50° **	X= 130 mm Y= 130 mm Z= 100 mm Rot.: 360° cont. Tilt: -20° to +80°
Specimen height	maximum 30 mm	maximum 60 mm	maximum 60 mm	maximum 143 mm

* Available manipulator options with the following movement ranges:
40 x 60 mm, 60 x 40 mm, 60 x 60 mm 80 x 40 mm, 80 x 60 mm

** from WD 15 mm and for eucentric height of the specimen



MIRA\ High Resolution Schottky FE SEM

Following the most recent trends in nanotechnology research, Tescan has proudly introduced the new Mira series of high performance microscopes equipped with a Schottky field emission electron gun.

Key features of the Mira microscope are:

- High brightness Schottky emitter for high-resolution / high-current / low-noise imaging and fast imaging rate
- Unique three-lens **Wide Field Optics™** design offering a variety of working and displaying modes embodying the Tescan proprietary Intermediate Lens for the beam aperture optimisation
- Real time **In-Flight Beam Tracing™** for the performance and spot optimisation integrating the well established Electron Optical Design software
- High-throughput large-area automation, e.g. automated particle location and analysis
- Fully automated microscope set-up including electron optics set-up and alignment
- Sophisticated software for SEM control, image acquisition, archiving, processing and analysis
- Network operations and built-in remote access/diagnostics come as Tescan standard
- Integrated active vibration isolation and external magnetic field cancelling systems are optionally available

The MIRA\ Family Basic Overview

Electron gun	High brightness Schottky field emitter
Resolution	
In high vacuum mode (SE)	1.5 nm at 30 kV; 3.0 nm at 3kV
In low, medium vacuum mode (BSE)	2.5 nm at 30 kV; 3.5 nm at 3kV
Magnification	Continuous from 4x to 1,000,000x
Accelerating voltage	500 V to 30 kV
Probe current	2 pA to 20 nA

Based on carefully selected chamber geometries and two vacuum types, the MIRA\ family currently contains four excellent SEM models.

Chamber type	LM	XM
MIRA\ HiVac	MIRA\LMH	MIRA\XMH
MIRA\ UniVac	MIRA\LMU	MIRA\XMU
Internal dimensions	∅ 230 mm	300 mm (width) x 330 mm (depth)
Door	148 mm	280 mm (width) x 310 mm (height)
Number of ports	11	9
Chamber suspension	pneumatic	pneumatic
Specimen stage	fully motorized	fully motorized
Type	compucentric	compucentric
Movements	X= 80 mm Y= 60 mm Z= 47 mm Rot.: 360° cont. Tilt: –75° to +50° *	X= 130 mm Y= 130 mm Z= 100 mm Rot.: 360° cont. Tilt: –20° to +80°
Specimen height	maximum 60 mm	maximum 143 mm

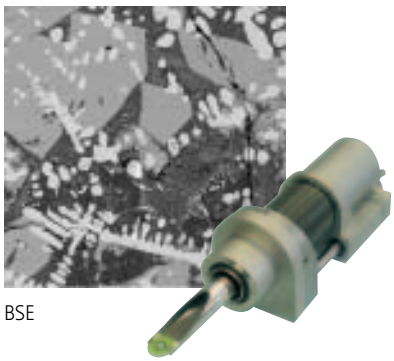
* from WD 15 mm and for eucentric height of the specimen

Various signals rise in the chamber as a result of the interaction of the incident electron beam with the specimen surface and these can be collected using appropriate detectors.

The detectable signals include secondary electrons, backscattered electrons, transmitted electrons, characteristic X-rays and cathodoluminescence, and contain information about the structural, crystallographic, morphological, and element content of the sample.

SE Detector

A first class Everhardt-Thornley type secondary electron detector is standard equipment for every Tescan SEM. The detector is fitted with a YAG scintillation crystal that excel in speed, efficiency and lifetime.



BSE

BSE Detectors

Tescan produces several types of backscattered electron detectors. A high speed and efficient **YAG scintillator detector** is the best for material contrast, a **dual scintillator** detector for compositional/topographical contrast. Tescan also develop a **four-quadrant** semiconductor detector for advanced imaging.

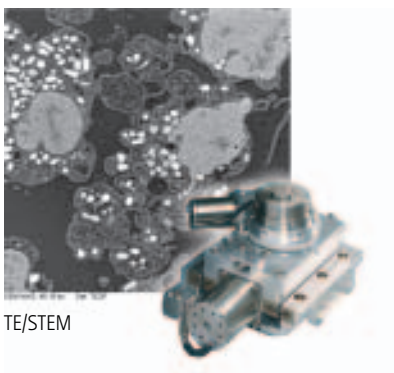
LVSTD

LVSTD Detector

The originally developed Low Vacuum Secondary Tescan Detector patented by Tescan uses a modified design of the E-T detector, with a separated and differentially pumped detection chamber. The detection chamber is located behind a Microlens Differential Barrier and is pumped by means of a small turbomolecular pump.

TE/STEM Detector

The transmission electron detector adaptor is an easy to use removable stage-top detector for scanning transmission electron microscopy imaging. It is designed for ultra-thin TE specimens, e.g. high resolution histology, placed on a standard 3.5 mm grid.



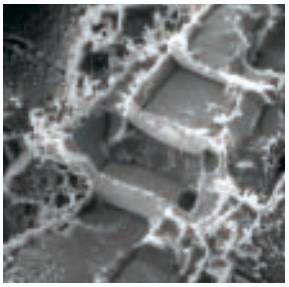
TE/STEM

CL Detector

The detection of cathodoluminescence complements the detection of the above signals generated in the specimen. The main field of use is mineralogy.

EBIC Detector

Imaging using electron beam induced current for checking P-N junction.



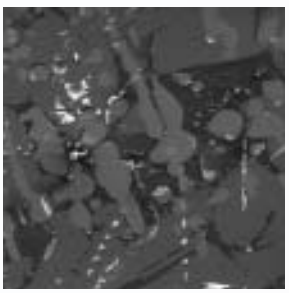
Peltier Cooling Stage

It is necessary to avoid evaporation for the investigation of specimens containing water e.g. biological material. The combination of low vacuum operation and cooling or freezing of the specimen are the ways to do it without damaging the specimen.

Attaching Tescan's Peltier Cooling Stage onto the manipulator is an elegant, easy to use solution. The Peltier Cooling stage can reach up to –70°C below the temperature of the cooling liquid.

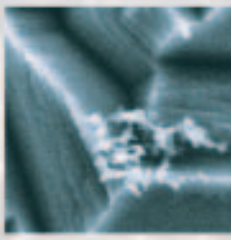
Great Analytical Potential

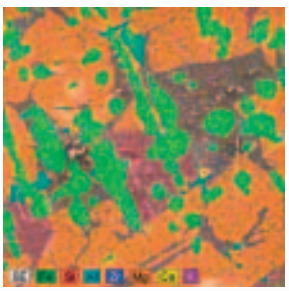
The analytical geometry of Tescan microscopes is optimized for attaching numerous third party microanalyzers. Established partnerships with all main producers of EDX, WDX and EBSD are a guaranty of its compatibility.

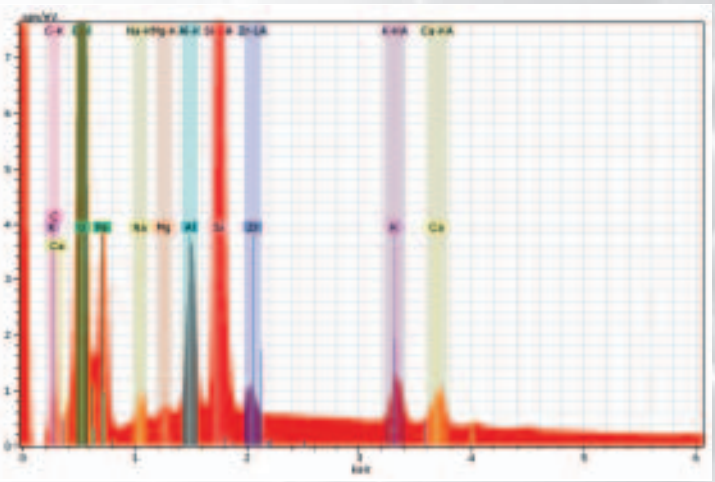


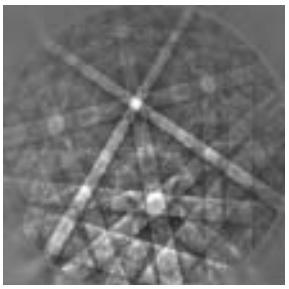
EDX, WDX

Elemental microanalysis using characteristic X-Rays brings a new dimension of chemical composition information to your SEM images.









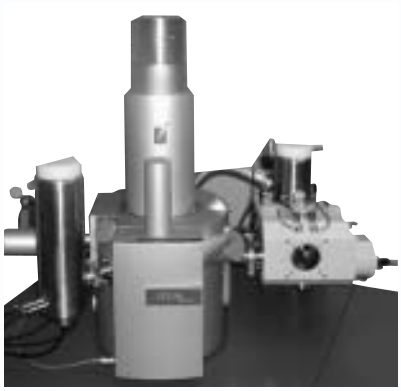
EBSD

Gets information about crystallographic orientation in every SEM image point using electron backscattered diffraction. Simultaneous EBSD and EDX/WDX microanalysis is now possible.

Special Chambers and Applications

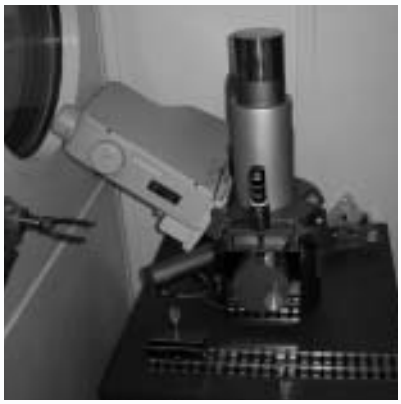
Special chamber modifications customized for various detectors and accessories represent tailor-made systems available on request.

Cryo-SEM



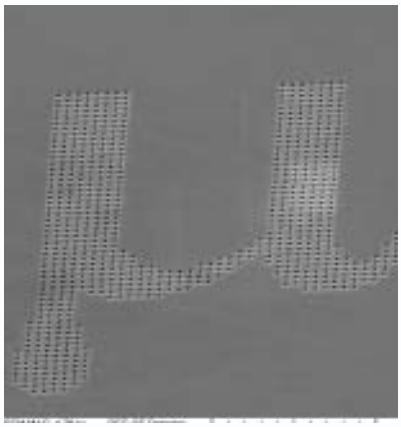
Tescan SEM with Cryo-SEM preparation system by Quorum Technologies.

Hot Cell SEM

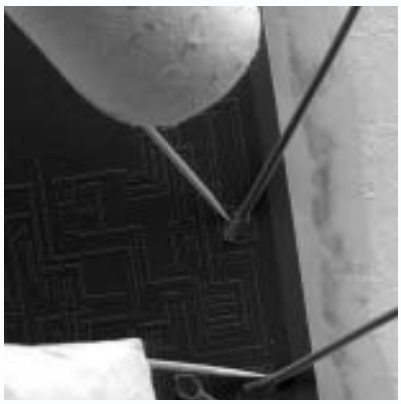


Remote controlled Tescan VEGA SEM placed in a "Hot Cell"

Electron Lithography Systems



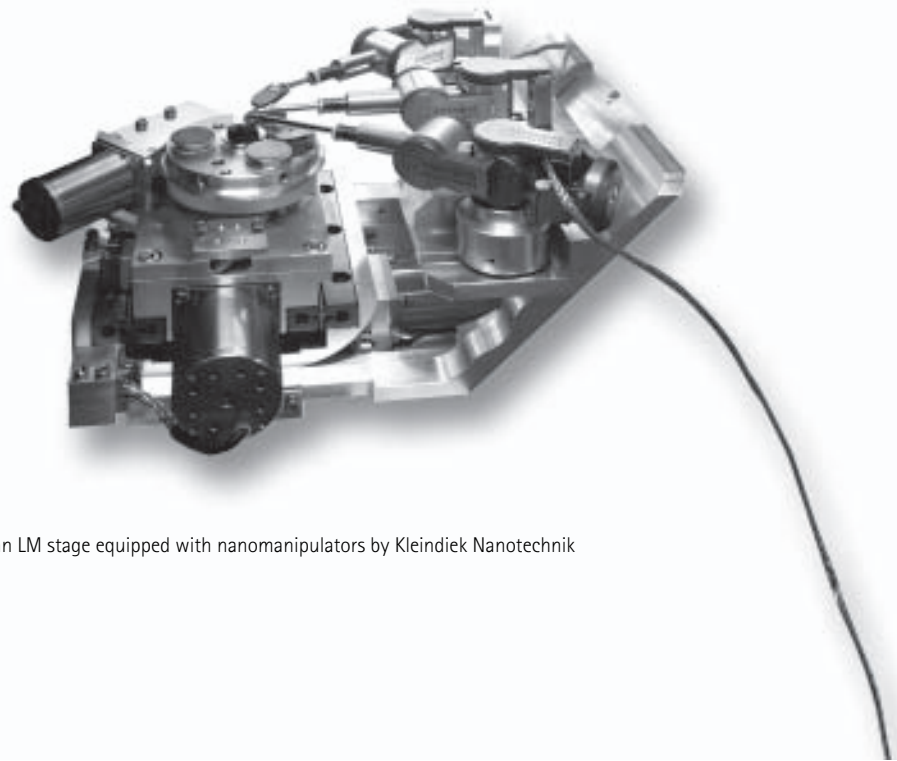
Preparation of high precision lithography patterns



Nanotechnology Tools

Nano-manipulators

The microscope is transformed from an observational instrument into a hands-on-tool suitable for accurate manipulation of nanoparticles, carbon nanotubes and other samples at a nanoscale with a nanomanipulation tool.



Tescan LM stage equipped with nanomanipulators by Kleindiek Nanotechnik

Value and Excellence in SEMs

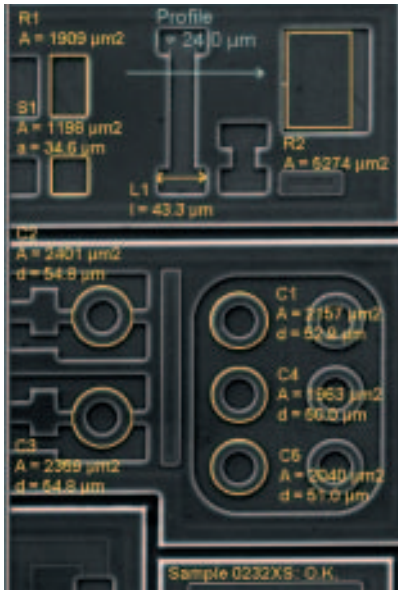


Image Processing

A comprehensive set of professional algorithms for image processing and analysis can be used to accentuate desirable characteristics of an image, such as brightness & contrast correction, sharpening or noise reduction etc.

Image Operations

The module intended for performing standard image operations such as colourmapping, planes merging, arithmetic and binary operations etc.

Measurement

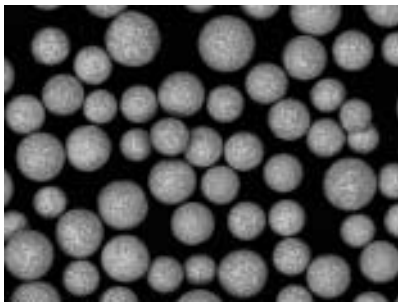
The module allows interactive measurement of objects in stored as well as in live images with the possibility of statistical evaluation.

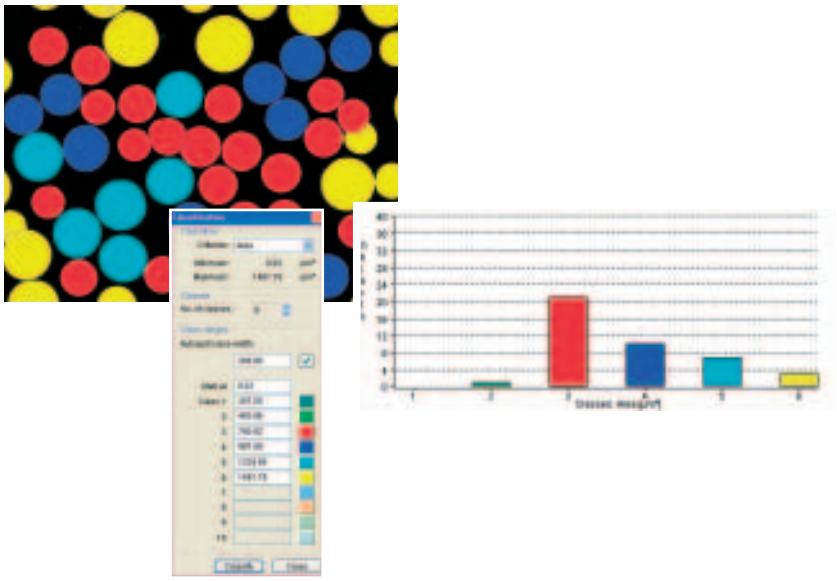
Object Area

The module intended for quick determination of the area part of an image such as the phase area percentage or porosity.

Morphology

Morphology is a module intended for automatic identification, size & shape analysis and classification of objects.





Particle Analysis

Particle analysis takes the advantages of the Tescan SEM's integrated stage automation to extend the functionality of the Morphology module. It allows automatic detection, analysis and classification of objects in multiple fields of view. Users can interactively define multiple areas on multiple samples.

■ Sample Observer

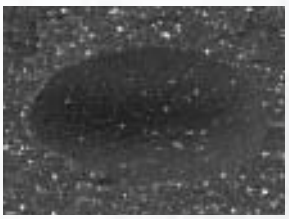
The module for the automated acquiring of images with defined delays as well as making a video sequence is suitable for the investigation of long lasting experiments.

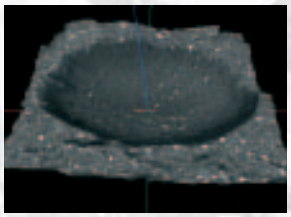
■ Image Snapper

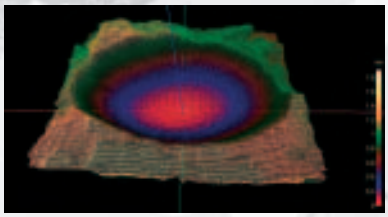
The module automatically performs a large area sample observation. It scans a selected area field by field using stage movements and subsequent stitching fields into the one large panoramic image.

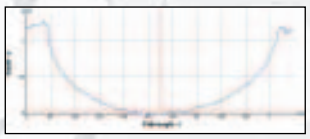
■ 3D Metrology

3D surface reconstruction and analysis module. A dedicated software by Alicona Imaging.







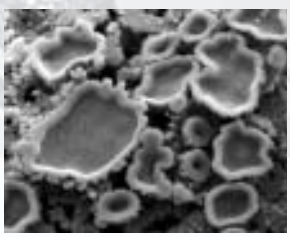


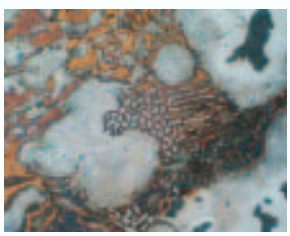
■ MouseLink

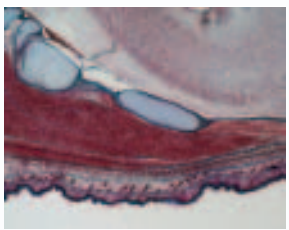
It is a useful stand-alone tool for controlling two or more computers by only one mouse and one keyboard.

Atlas – The Universal Image Processor

Atlas software is a combination of a fully compatible offline tool for SEM image manipulation and a powerful image grabber for acquiring static or live images from optical devices. Atlas represents a complementary stand-alone software solution for your laboratory. Built-in image analysis, archiving and processing tools are based on advanced algorithms.

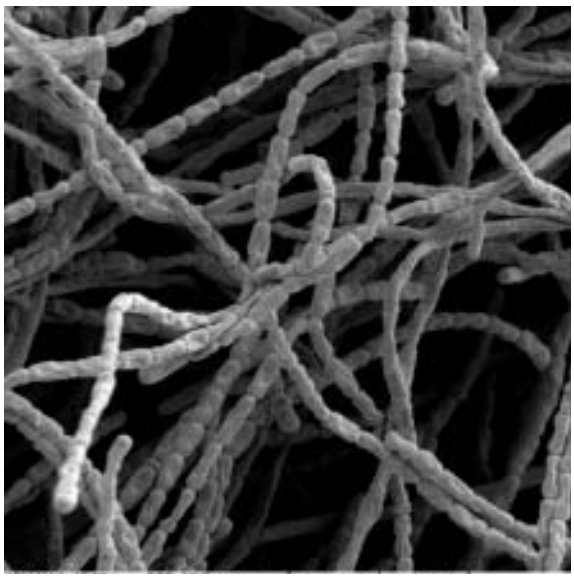




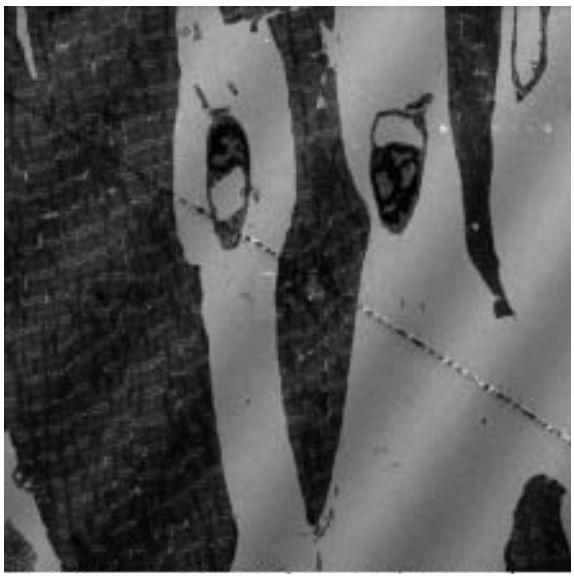


Medical and Pharmaceutical Applications

Investigations and measurements in microbiology and pharmaceutics are just an example of branches where small specimens are used. High resolution histology using a scanning electron microscope equipped with a transmitted electron detector is another useful application for medicine.



Mycelium streptomycet

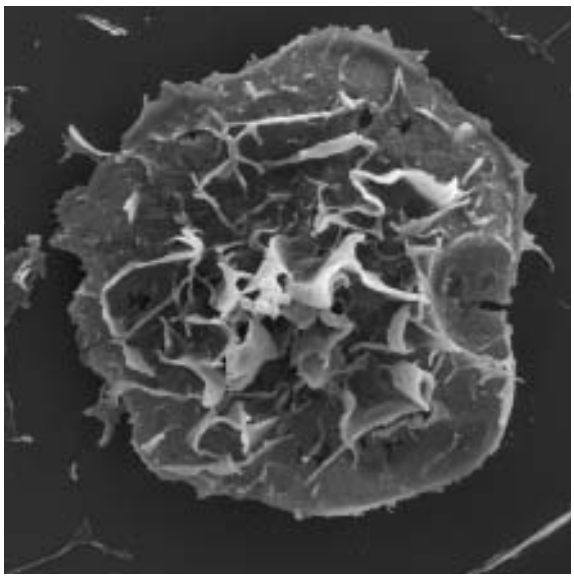


An ultrathin section through rabbit cardiac muscle

Life Science Applications

The investigation of flora and fauna in their natural state is a vital issue and Tescan microscopes represent it par excellence. By using the low vacuum mode with Tescan's original LVSTD or backscattered electron detector, the microscope gives brilliant imaging capabilities.

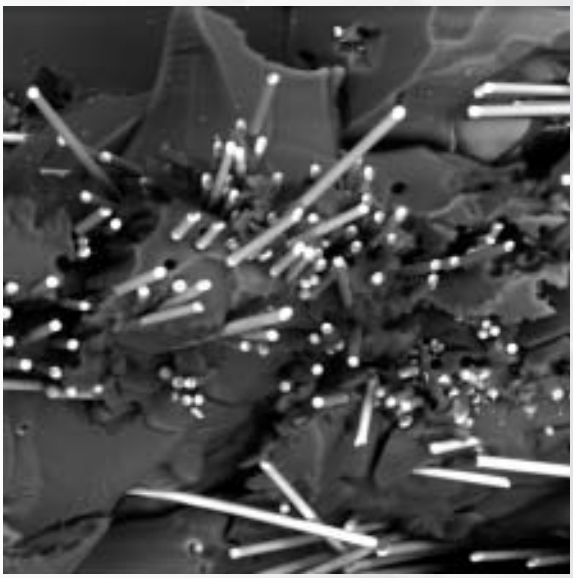
Pistil with pollen grains



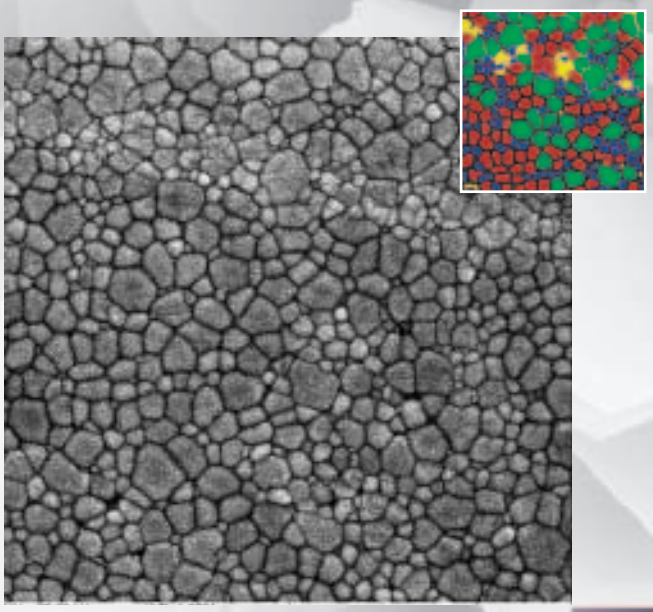
Cells grown on an a glass slide

Application in Material Science and Industry

Investigation of fracture surface and microanalysis of inclusions or phases are the most common failure-cause identification methods in material science. Ingenious Vega chamber geometry allows simultaneous EDX and EBSD analysis as a complement to high resolution metallography.



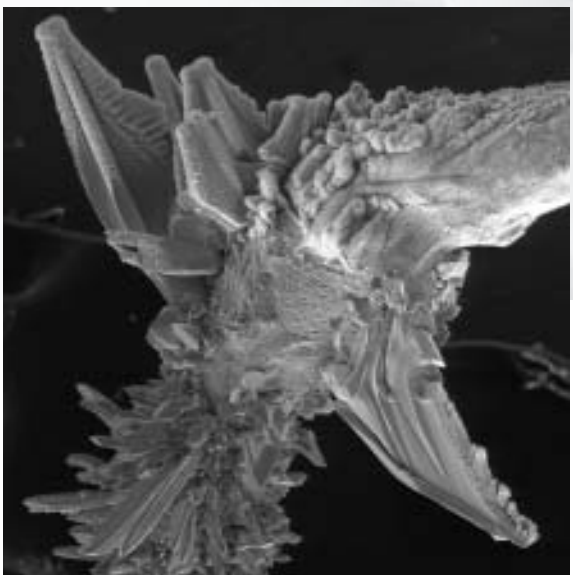
Backscattered electron image of PMMA – Glass fibre composite fracture surface. Uncoated sample was observed using low vacuum in the chamber.



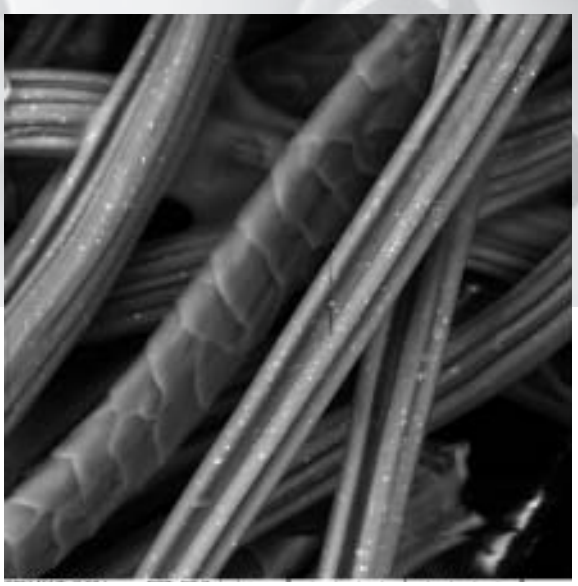
Microstructure of nanocrystalline Zirconia

Forensic Applications

There are many forensic applications that can be resolved using SEM like gunshot residue analysis (GSR), bullets and cartridge investigation, after car crash filament and bulb investigation, tool marks investigation, analysis of hairs, textiles and papers, paints, prints and ink analysis, counterfeited bank notes determination, minerals, soils and metals analysis.



Bulb filament has crystallized after a car accident. It is a sign that the head lamps had been turned on.



Comparing sheep hair and viscose fibres

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PERFORMANCE IN NANOSPACE

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