The SEM is a uniquely powerful tool for material scientists because of the depth of field, spatial resolution and analytical capabilities. Meanwhile, tensile / compression testing and three / four point bending play an important role in understanding the mechanical properties of materials.

The MICROTEST product range combines these benefits together to provide computer-controlled dynamic testing experiments in the SEM chamber. The SEM provides a deeper understanding of the cause of the deformation with the ability to focus on the microstructure in the region of interest where failure is propagating. This can be performed simultaneously to recording quantitative load / extension characteristics.

A MICROTEST experiment can overcome uncertainties in interpreting traditional stress / strain data performed ex-situ, and can reveal much more about the deformation as it takes place, as opposed to a traditional post failure examination. As well as graphical displays of the load / strain information, a choice of strain rates, thresholds (load, extension, time), cyclical tests and constant load can be software controlled to provide important controls and flexibility specific to the specimen and experiment.

MICROTEST modules are not simply scaled down versions of existing materials testing systems, but have been specifically designed to facilitate low drift observation of the high stress region of the sample in the SEM. Furthermore special care is taken with the compact design and components chosen specifically for the EM environment. This design also allows them to be used with optical microscopes, and some X-ray equipment.
Microtest dynamic materials testing in the SEM

MICROTEST modules cover a wide range of loads (2N to 5000N) and are therefore suitable for studying a wide variety of specimen types, shapes and sizes. The 1% noise specification on the 2N load cell system represents a sensitivity of only 2 grams.

This versatility extends new application areas, well beyond those traditional to tensile testing. Furthermore, for some modules, dynamic testing can be extended to cryogenic or high temperature regimes, and in special cases, the systems can be configured to allow the study of texture using the EBSD technique.

Alternatively, if higher pixel resolution or high signal to noise ratio in the SEM image is required, screen capture software can be used to record digital movies more appropriate to slower frame refresh times. When digital beam control systems such as Gatan’s DigiScan system are running on the same computer as the Microtest software, both images and Microtest data can be recorded simultaneously.

Applications

**Metals and coatings**  Tensile, compression, bending and cyclical tests are often used. Suitable specimen preparation allows surface sensitive SE imaging to reveal grain boundaries.

Coatings can be viewed in cross section using bending grips.

The deformation and relaxation behaviour is often important to understand in alloys at elevated temperatures and these can be achieved for thermally conductive specimens using heated grips.

Grain rotation and texture changes can be studied where the equipment is configured for EBSD operation.

**Composites**  Microscale deformation mechanisms often hold the key to composite materials ductility and strengths.

**Digital Movies of dynamic tests**

The MT Video option provides full synchronization between a digital movie from the SEM image (in the popular AVI format) and the standard graphical load, extension, time data points. Furthermore the AVI has these quantitative data embedded, and once the file is saved, specific frames from the movie can be accessed by moving the cross hairs on the stress strain graph. The MT Video option samples a TV output signal from the SEM.
Fibres  Natural and manmade fibres can be easily tested for strength using optional fibre clamps. Low load Microtest units are ideally suited to studying hair and similar strength fibres.

Textiles  Leather, nylon and knitted textiles can easily be stretched and viewed in real-time. Low vacuum microscopes allow imaging of nonconductive specimens without concerns over the break-up of coatings traditionally required in high vacuum microscopes.

Polymers  The nature of plastic flow and failure mechanisms is important to understand in many man-made materials.

Bio-medical  Dentistry, bones and medical studies.

Foodstuffs  Examples include studies of cheese, gherkins, and tomato skins. These are tested for consistency and texture.

Geology  Hot compression experiments on rocks or cold deformation mechanisms on ice cores simulate natural dynamic processes.

Bonding  Adhesion is easier to understand if failure is studied on a microscale.

Brittle materials  including ceramics. Although more challenging as deformation can be catastrophic, the high spatial resolution of electron microscopy can aid studies of brittle materials by providing knowledge on minute crack opening and blunting processes.

Sensors  or bio-engineering micro-devices often require low load and high strain resolution and benefit from in-situ experiments.

Microtest tensile/compression modules
Four different versions of the tensile tester are available, accepting load cells with full-scale forces from 2N to 5kN. Samples are mounted horizontally and clamped to a pair of jaws which are supported on stainless steel slide bearings. A dual threaded lead-screw drives the jaws symmetrically in opposite directions, keeping the sample centred in the field of view. All stages have linear scales with a resistive extensometer for accurate elongation measurement and optical encoders for accurate speed measurement.

All modules are supplied by default with a single maximum load cell for that module, e.g. 200, 300, 2kN, 5kN. Different additional lower load cells are available depending on the module. These provide additional accuracy or higher sensitivity in that regime.

All tensile/compression modules can be provided with optional horizontal 3- and 4-point bending clamps and additional gearboxes for alternative speed ranges.

If vertical 3- or 4-point bending is required, 2 additional Microtest modules are available.

Dynamic mechanical experiments sometimes need to be performed as a function of temperature. For thermally conductive specimens, heated thermally-isolated grips can be appropriate. Additionally, a nitrogen cooled cryogenic circuit can be included to provide controlled temperatures below ambient. For less conductive specimens, a central heated or cooled platform may be required, depending on the thermal contact that can be made to the specimen in this area.

The MTEST5000W version includes a water-cooling circuit to maintain sensor accuracy and safe operation if specimen heating or cooling is used.
Special Versions

Extended modules or travel
If the microscope chamber permits, extended jaw versions can be supplied which allow longer specimens to be tested.

Special extended travel versions can be supplied to provide double the strain, however larger strain is normally best accommodated by working with shorter specimens.

Modules for in-situ EBSD
The 70 deg tilt angle for EBSD studies cannot normally be accommodated by tilting the module. A specially designed module can provide both plan view and 70 deg tilt fixture positions to allow standard and in-situ EBSD studies. This module provides a standard maximum load of 1kN. A water cooled version also allows in-situ heating of the specimen grips to a maximum temperature of 400°C.

Please ask for detailed specifications on special versions.

CON Figure

The Microtest modules range in size and weight. The lighter 2-200N and 300N modules are suitable for mounting on most SEM stages and are supplied with mounting adapters. Depending on the microscope chamber and stage type, space or weight considerations may mean that the 2kN, 5kN and 5kN water-cooled versions may require an additional replacement SEM stage and microscope door (C1000XYZ).

The Microtest product contains a single controller unit which can be compatible with multiple module types.

A single, X-ray- and vacuum-tested electrical feed through is manufactured for a suitable port on the SEM. Gatan will advise and recommend an optimum configuration for your SEM.

Options and Accessories
Additional lower force load cells can be supplied. These are factory calibrated, and can be interchanged on the bench top. Lower force load cells are not essential but provide additional accuracy within the lower load region of the range.

The 2-200N product provides an especially wide choice of load cells and dynamic range and may be specified with any load cell in this range.

Optional 3- and 4-point bending clamps can be mounted in place of the standard grips. In this configuration the module can be used in tensile or compressive mode to bend the sample in cross section.

Modules are supplied with one gearbox. Additional faster or special slower gearboxes are optional and can be changed on the bench top.

A ‘compression cage’ designed for use in tensile mode can provide more controlled compression to a specimen.

Alternative jaw clamps can be considered, particular to an application need.

STANDARD SOFTWARE SPECIFICATION
• Single software platform and license for all modules.
• Windows software for control and live graphical display; current software version is 32Bit and designed
for Microsoft Windows XP SP2 (English language). Communication requires free serial port. N.B. A PC is not supplied as standard with Microtest but is an available option, MTPC.

- Real-time display of force, extension and time.
- Scale horizontal axis in mm absolute, mm extension, time or sample points.

Software is provided with all Microtest systems. Computer supplied additionally on request.

- Zoom function on graphical display.
- 6 set and additional custom sample times, 100, 200, 500ms, 1, 2, 5s.
- Software choice of 5 motor speeds; can be changed during an experiment.
- Comprehensive threshold function. Pre-specified load, time or extension request software to stop experiment, stop motor only, or start cyclical testing.
- Cyclic testing defined by threshold parameters.
- Ramp load, go-to value and return to start options.
- Test routine accurately checks strain rates.
- Cursors for accurate measurement of force, extension and time directly from curve.
- Data saved can be opened with common spreadsheets.
- Option to include sample details with data.
- Maximum horizontal sample points 256,000.
- Graphical indication on plot to show where motor was started, paused or stopped.
- Constant load for studying relaxation.

**MT VIDEO specification**

MT Video product can function in 2 modes depending on microscope hardware and software.

1. Microscope provides true TV output signal. Signal is sampled using PCI frame grabber card installed in computer running Microtest software. Suitable for microscopes with TV output connector.

2. MT Video software is installed to run on PC containing images digitally streamed using ActiveX protocol. Suitable for some PC controlled microscopes or Digital Beam control systems where Microtest software can be installed.

   - Pixel density is ½ TV density.
   - Frame rate is reciprocal of Microtest software sample time, from 0.2 to 10Hz.
   - Choice of compression formats.
   - Movie recording can be stopped or paused independent of dynamic test experiment.

**Screen Capture Specification**

Precise specification depends on pixel resolution of raw digital image and display size and resolution on monitor.

Simultaneous recording of Microtest data and specimen image is via movie. Frame rate of movie may not be synchronized with frame rate of microscope.
Mechanical Specifications

**MTEST200 module**

Tensile and compression testing
Precision slides with symmetrical stainless steel lead-screw
Secure carriage locking for load cell protection on changing specimens
X-ray safe, vacuum feed-through for electrical connections
Interfacing to SEM stage
Exchangeable, modular 200N load cell, accuracy 1% of full-scale range
Standard speed range 0.1mm/min to 1.5mm/minute with 1119:1 gearbox
Maximum extension 10mm
Linear scale for accurate position readout, resolution 3 microns, accuracy 10 microns
Maximum sample size 50 x 15 x 10 (L, B, H mm)
Dimensions 112 x 62 x 31 (L, B, H mm)
Weight ~500g

**MTEST200 Options**

**BH200** horizontal three & four point bending clamps

**LCX** exchangeable higher sensitivity load cells (X=2, 5, 10, 20, 50, 100N)

**GB200** exchangeable fast 67:1 gearbox giving 5 to 30mm/minute
Special sample clamps can be made to customers’ requirements

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**MTEST300 module**

As MTEST200 except
Integral 300N load cell, accuracy 1% of full scale range.
No secure carriage locking. Dimensions 92 x 58 x 30 (L, B, H mm)

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**MTEST300 Options**

As MTEST200 options except single optional interchangeable load cell
LC75, 75N load cell

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**MTEST2000 module**

Tensile and compression testing
Precision slides with symmetrical stainless steel lead-screw
X-ray safe, vacuum feed-through for electrical connections
Interfacing to SEM stage
Integrated 2kN load cell, accuracy 1% of full scale range
Linear scale for accurate position readout, resolution 3 microns, accuracy 10 microns
Standard speed range 0.033 to 0.4mm/min
Optical encoder fitted to motor giving speed control accuracy better than 1%
Maximum extension 10mm
Maximum sample size 67 x 20 x 10 (L, B, H mm)
Dimensions 134 x 89 x 37 (L, B, H mm)
Weight ~2kg
**MTEST2000 Options**

**BH5000** horizontal three & four point bending clamps

**LC660** and **LC150** interchangeable higher sensitivity load cells ~660N and 150N

**GB2000** optional gearboxes for faster or slower speed ranges

**C1000XYZ** replacement SEM stage and door

Special sample clamps can be made to customer requirements

**MTEST5000S module**

As MTEST2000 except

Integrated 5kN load cell, accuracy 1% of full scale range

Standard speed range 0.005 to 1.5mm/min

Dimensions 148 x 114 x 39 (L, B, H mm)

Weight ~2.5kg

**MTEST5000S Options**

As MTEST2000 options except additional **LC2000**, 2000N load cell

**GB5000** optional gearboxes for faster or slower speed ranges

**MTEST5000W module**

As MTEST5000S except includes water-cooling circuit to load cell and water feed-through on SEM flange

NB water chiller is not included

Dimensions 214 x 124 x 58 (L, B, H mm)

Weight ~4kg

**MTEST5000W Options**

**BH5000** horizontal three & four point bending clamps

**LCX**. Exchangeable optional higher sensitivity load cells (X=125, 250, 500, 1250, 2500N)

**GB5000** optional gearboxes for faster or slower speed ranges

**C1000XYZ** replacement SEM stage and door

**H5000** Thermally isolated, heated grips with controller and additional electronic feed-throughs. Manual or automatic heater control. Grip temperature RT to 600ºC. High temperature operation must be in vacuum.

**HC5000** Heated / cooled grips facility with controller. −150°C to +600°C. System configured for heating or cooling operation. Includes remote heat exchanger LN2 dewar, N2 gas- and electrical- feed throughs. High or low temperature operation must be in vacuum. Alternative or additional heating / cooling methods for less thermally-conductive specimens can be considered.
**SPECIFICATIONS**

**ED5000** Option for MTEST5000W or MTEST5000S.
Angled sub-grips for *in situ* EBSD experiments. Please consult with factory to check configuration. May require C1000XYZ.

**MTEST300B**
Vertical 3 point bending module
3- and 4-point bending inverted for microscopy
Precision slides with stainless steel leadscrew
Adjustable sample clamps (10-25mm span)
X ray safe, vacuum feed-through for electrical connections
Integrated 300N load cell, accuracy 1% of full scale range
Standard speed range 0.02 to 2mm/min
Maximum sample size; 50 x 10 x 10 (L, B, H mm)
Minimum sample size; 50 x 1 x 1 (L, B, H mm)
Maximum jaw travel 10mm
Dimensions 87 x 58 x 45 (L, B, H mm)
Weight ~500g

**MTEST2000B**
Vertical 3 point bending module
As MTEST300B except:
Integrated 2kN load cell, accuracy 1% of full scale range
Standard speed range 0.002 to 0.4mm/min
Maximum sample size; 65 x 10 x 5 (L, B, H mm)
Minimum sample size; 50 x 1 x 1 (L, B, H mm)
Maximum jaw travel 10mm
Dimensions 133 x 86 x 41 (L, B, H mm)
Weight ~1.3kg

**MTEST2000B Options**
As for MTEST2000 except BH5000 is not available.

**MTEST 1000ES**
Tensile and compression testing module for EBSD, to 1kN.
Grips can be mounted in horizontal or EBSD configurations.
*Please ask for further details.*

**MTEST 1000EH**
As MTEST1000ES but including water cooling circuit and heated grips, to 400°C.
*Please ask for further details.*

**NOTES**
Full scale load cell values may vary up to +/-10% due to the manufacturing process
MT Video software may not be appropriate for installing on some Microscope PCs due to resource conflicts.

Upgrading to new modules requires the controller to be returned to the factory.

**ORDERING INFO**

**MODEL**
MICROTEST 200
300, 2000 & 5000

**DESCRIPTION**
Microtest dynamic materials testing in the SEM

**CONTACT**
Deben UK Limited
Brickfields Business Park
Woolpit, Bury St. Edmunds,
Suffolk IP30 9QS. UK
Tel: +44 1359 244 870
Fax: +44 1359 244 879
Email: info@deben.co.uk