P3 P4 P5

Expanding the capabilities of your NanoTest

Micro Materials

Excellence in Nanomechanics

One system, infinite possibilities…

Base system
Control electronics
Platform
Optical microscope
Computer + software
Anti-vibration system
Enclosure

Loading Heads
Nano (up to 500 mN)
Micro (up to 30 N)

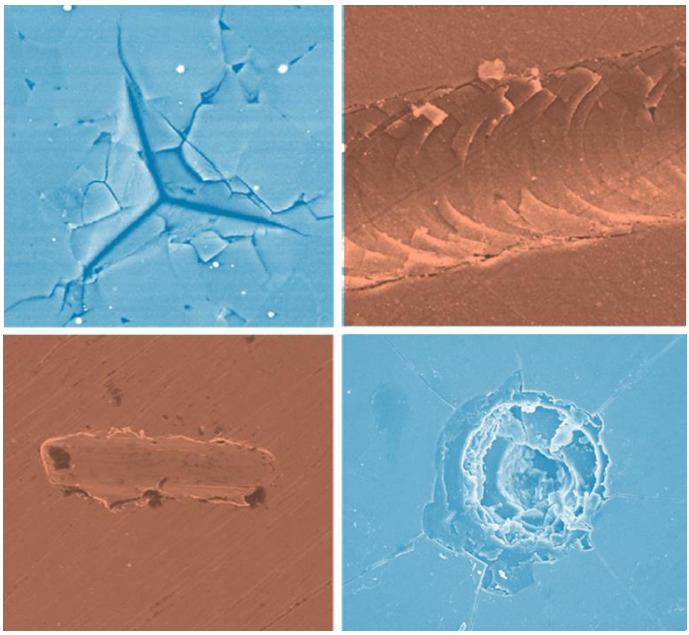
Experiment modes
Indentation
Scratch and wear
Impact
Fretting
NanoTriboTest

Imaging
3D nanopositioner *
AFM

Environment
High temp (450 or 850˚C)
Low temp (-20˚C) *
Purge chamber
Liquid cell
Humidity cell *

Experiment Add-ons
Acoustic emission
Electrical contact resistance
Electrochemical cell

** For low load head (nano) only*



Introduction

NanoTest instruments have always offered materials researchers the possibility to combine multiple testing modes into a single instrument platform.

The possibility to measure mechanical properties and then to switch to another test mode to test material performance under application relevant conditions can provide great efficiency gains in research and development projects by helping to better understand property / performance relationships.

This brochure aims to introduce the wide range of test techniques available from Micro Materials and which may be added to your NanoTest instrument.

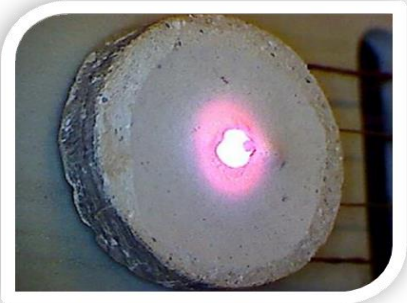
All the options covered are directly applicable to Platform 4 and Platform 5 instruments and several are available for Platform 3 instruments. Direct applicability of each upgrade is indicated by the corner flashes on each page.

Where direct applicability is not possible then please contact Micro Materials to discuss how your older platform instrument may be upgraded to Platform 5, bringing new life and possibilities to your instrument.

Micro Materials understands the challenges and obstacles that must be overcome when buying new capital equipment and will always be happy to explore what possibilities exist to get the absolute best value out of your instrument.

High Temperature Stage

P3 P4 P5

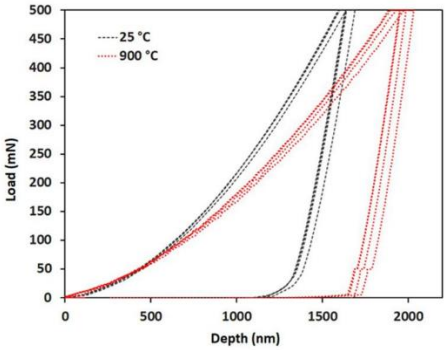


Available for both load heads, the high temperature option allows you to do sample testing up to 1000 °C in vacuum and 850 °C in air and inert gas environments.

Active tip heating – the indenter and the sample are both actively and independently heated. Ensures isothermal contact and therefore the lowest possible thermal drift rates.

Horizontal loading – The NanoTest load head design prevents excessive heat transfer on to sensitive components, contributing further to low drift rates.

Highly localised heating – The heated zone is small and well isolated from the rest of the instrument. Short heating and stabilisation times.



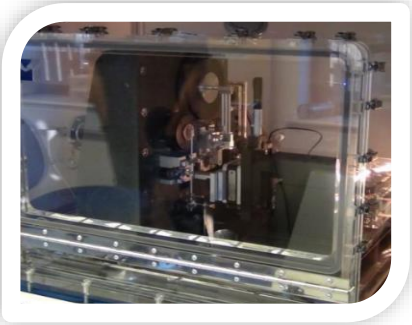
The combination of a robust load head design, unique indenter and sample heating technologies and the best know-how in choosing the right indenter material for any given sample results in highly reliable data up to the highest temperatures.

Patented control protocol - Indenter and sample temperatures are controlled using unique and patented methodologies

Time-dependent properties - Low rates of thermal drift mean that phenomena such as creep may be measured in small volumes of material and coatings not testable with traditional larger scale methods

Low Temperature Stage

P3 P4 P5

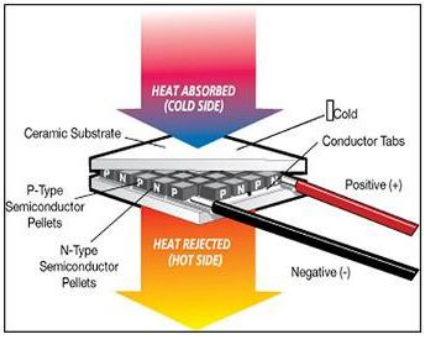


Both the indenter and sample are actively cooled using independent cooler systems.

Low rates of thermal drift are achieved through isothermal contact of the indenter and sample. This allows long contact times without loss of accuracy.

Test versatility – The cold stage is compatible with the indentation, scratch and impact test modules.

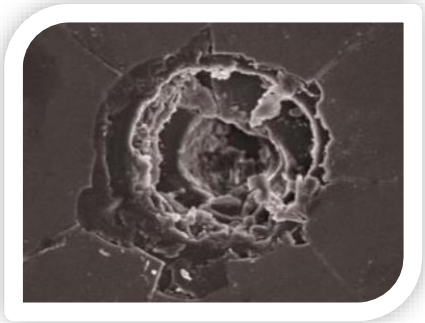
Understanding the effects of cold environments on mechanical performance of materials via testing either side of brittle-to-ductile transition or glass transition temperatures is essential for many engineering applications.



Dedicated thermoelectric coolers are used for both the sample and the indenter to achieve an isothermal contact and minimise thermal drift.

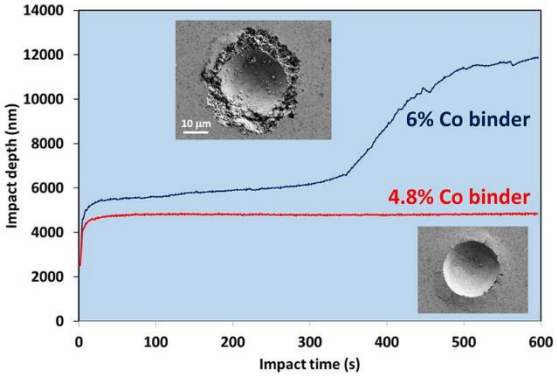
Impact

P3 P4 P5



Predicting how materials (bulk and coated) respond to sudden or repetitive high-strain rate loading based on quasi-static measurement data is unreliable and prone to assumption-based errors. The ability to quickly interrogate them under application specific conditions is essential and Nano / Micro Impact testing is the ideal technique. Two techniques are available…

True Impact mode for low cycle fatigue and high strain rates – The perfect method for testing even the toughest materials and coatings to destruction! Single or multiple true impact contacts are made with the sample surface. Simple change in depth vs impact number or advanced energy absorption analysis is possible.

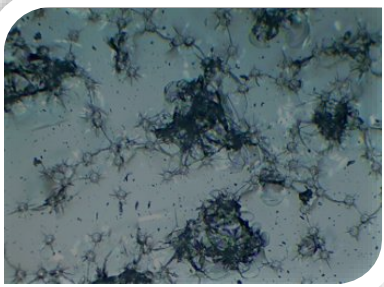


Micro Impact testing clearly differentiating between two WC-Co materials. Clear depth changes in 6% Co material and are not seen in the lower binder content material.

Sample Oscillation mode for high cycle fatigue – Piezo-electric based oscillation of the sample with a constant applied static indenter load. Great for studying fatigue under repetitive cycle compression-compression deformation. Allows hundreds of thousands or even millions of cycles. Failure events are identified by probe depth change events.

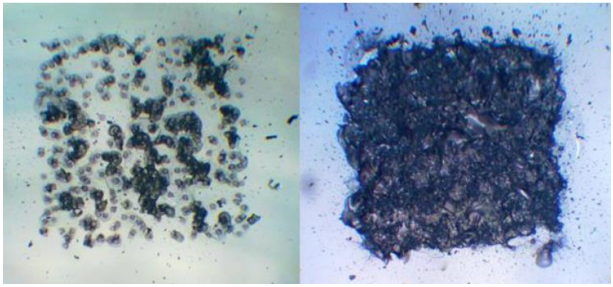
Impact - Randomised

P4 P5



In many real-world engineering systems, components are subjected to solid particle erosion where the multiple impact events are spatially distributed across a surface. For example, microscopic debris contacting an aero-engine blade, or suspended particles colliding with slurry pump and valve components.

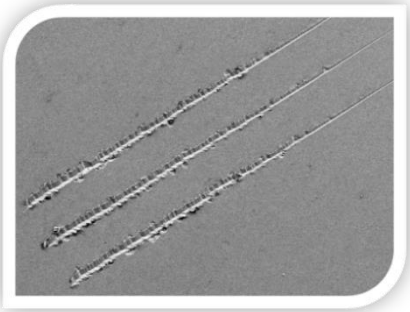
A user defined number of impact events may be programmed to occur within a defined test area. The distribution of these may be truly random or gaussian where most events are concentrated towards the centre of the test area. As with normal impact testing, high acquisition rate data are gathered for every impact allowing multiple analysis methods including quantification of dissipated energy.



Randomised impact testing highlights major differences between Fused Silica (left) and BK7 consistent with their differences in erosion resistance.

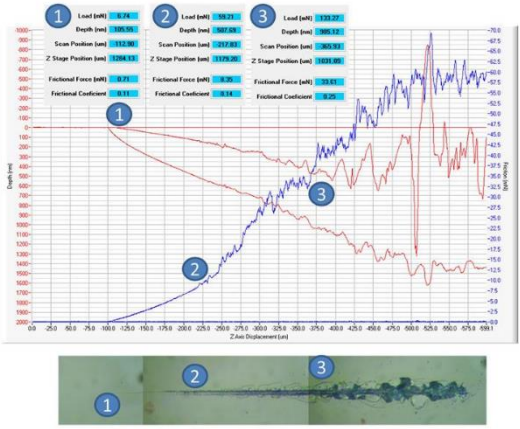
Scratch, Wear and Friction

P3 P4 P5



Utilising the same load heads as for indentation, the scratch and wear package for the NanoTest Vantage allows researchers to gain a great insight into the nano- and micro-tribological performance of coated and bulk materials.

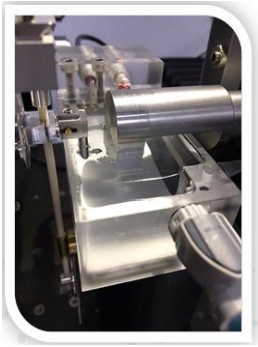
Allowing visualisation of on- and off-load probe depth, and friction force, scratch testing can identify how material failure initiates. The software includes a full reporting function and is compatible with the relevant CEN standard.



The advanced software package – provides a great degree of experiment customisation. Multiple segment load histories, visualisation of multiple cycle wear evolution, randomised position parallel scratch testing to better simulate real world erosion, full report creation and compatibility with advanced Saxonian Institute of Surface Mechanics computational analysis packages.

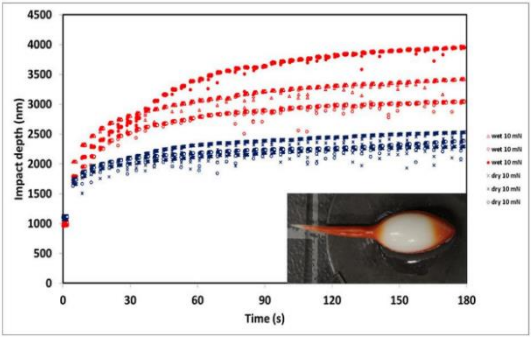
With the 30 N high load head, it is possible to perform micro-scratch tests to study thicker coatings and investigate the influence of hardened sub-layers on scratch test critical loads and failure mechanisms.

Liquid Cell



The liquid cell allows comprehensive small-scale mechanical testing under full fluid submersion. Metals and ceramics for prosthetic joints, soft bio and synthetic materials for implantable devices, lubricious layers for eye surgery applications, and even paints have been successfully studied using indentation, scratch and impact testing in the Micro Materials liquid cell. To achieve even closer replication of real-world conditions, there is a heated cell available.

Wet and dry nano-impact testing of a mantis shrimp dactyl club. A combination of material structures achieve mechanical properties greatly exceeding expectation and have been a source of “bio-inspiration” for Prof. David Kissailus and his group at UC Irvine.

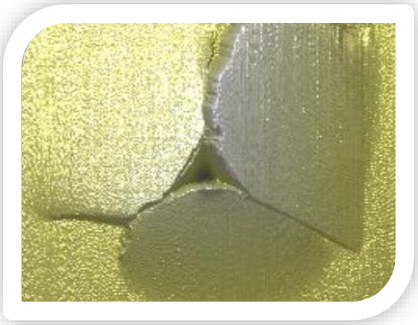


Combination with other techniques – The liquid cell design has been designed to offer accessibility to users for the integration of other equipment and instrumentation. For example, potentiostats and pH meters have both been successfully applied to control or monitor conditions in the cell.

Nanopositioning Stage

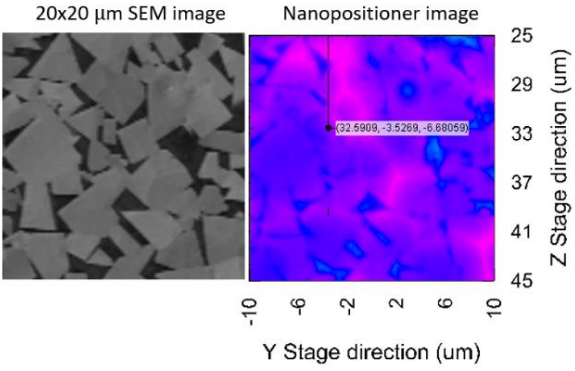
3-D Imaging

P3 P4 P5



The SPM Nanopositioner enables 3-D imaging of sample surfaces and measurements on user defined selection with nanometre precision. With a large scanning range of 100 µm x 100 µm, the SPM Nanopositioner has a closed-loop repositioning accuracy of 2 nm. Additionally, it only takes a few milliseconds for point-to-point movement whilst keeping the same repositioning accuracy. The SPM Nanopositioner is compatible with all environmental options including the high temperature option.

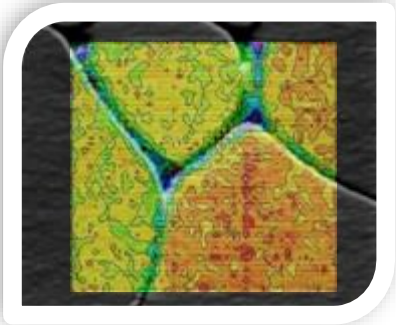
The precise feature targeting procedure allows easy testing of areas of interest on the sample. Images approach SEM resolution, even at high temperatures.



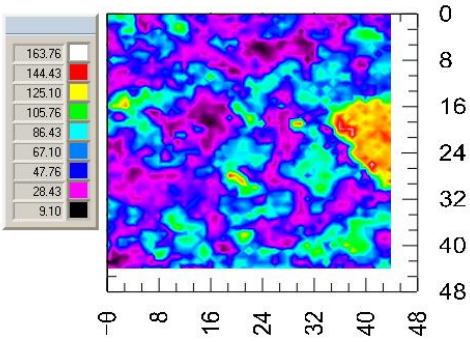
Data courtesy NPL

Nanopositioning Stage

High speed nanoindentation



The addition of the SPM Nanopositioner enables high speed indentation, taking advantage of the rapid movement of the stage when moving between indentation positions. Up to 100 indents per 10 minutes is possible and up to a maximum of 10,000 indentations per experiment. Full load-displacement curves recorded for review and analysis.



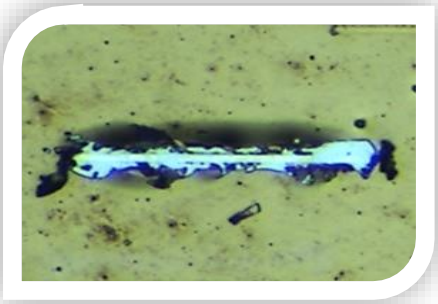
Stiffer mineral phases can be seen embedded in the less stiff organic clay matrix

High resolution mechanical property maps – These maps can be generated from large indentation datasets. Statistical k-means clustering analysis and results replot enables quick identification of statistically similar groups in terms of hardness, elastic modulus, H/E etc

Nanopositioning Stage

Reciprocating Nano-wear

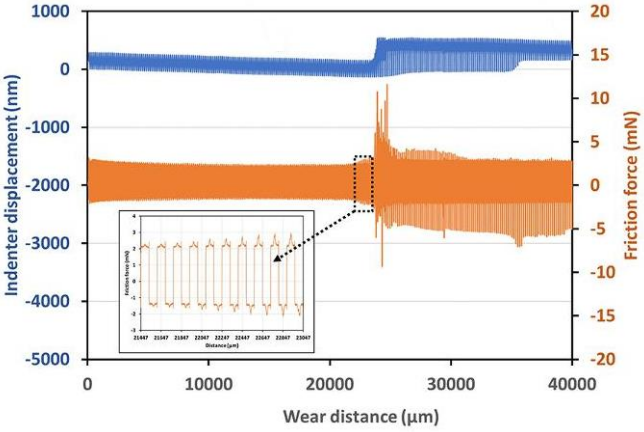
P4 P5



The nano-wear test module uses the SPM nanopositioner stage to provide a reciprocating sample motion. This module allows a sample to be oscillated perpendicular to the direction of loading to acquire friction and probe depth data as a function of sliding distance. Wear tests may be performed with track lengths up to 90 µm.

Allows the investigation of:

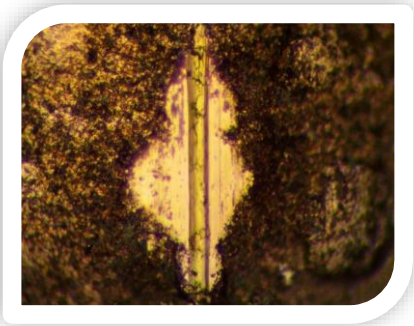
- Classic fretting wear (no slip, partial slip through to gross slip)
- The transition from fretting to small-scale sliding wear
- Wear mechanisms of successive layers of single or multi-layer coatings
- Volume of material removed using wear box experiments



Depth, friction (and friction coefficient) can be displayed vs wear distance/cycle number or time as shown in this example on a TiN coating

TriboTest

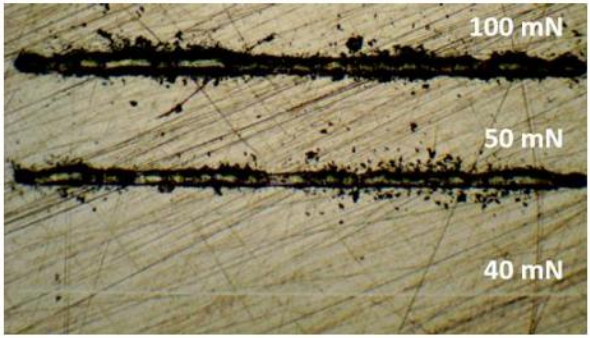
P4 P5



Used for examining friction and wear in sliding contacts, the TriboTest allows researchers to operate experiments using a wide range of parameters such as wear track length, sliding velocity, normal load, and duration of time. This then gathers analytical data showcasing any significant tribological phenomena that may have occurred.

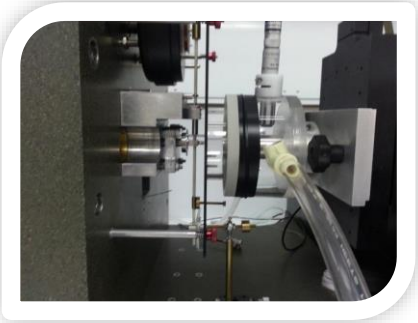
The TriboTest extends the range of nano-tribological tests possible with the NanoTest Vantage. Obtainable parameters including friction loops, energy dissipation per cycle (sliding distance x friction) and cumulative energy dissipation are automatically calculated in the NanoTest software.

TriboTest wear tracks on a Ti6Al4V alloy, commonly used for biomedical and aerospace applications, under three loads. At 40 mN the native oxide layer had protected the underlying metal from severe wear which is seen at 50 and 100 mN.



Humidity

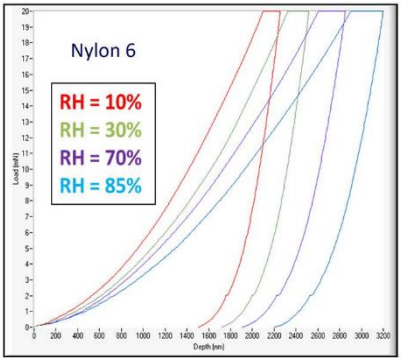
P4 / P5



The Humidity cell allows samples to be tested in environments of between 10 and 95% RH. The test cell volume is sufficiently small to attain the target set point quickly but large enough to test samples up to several cm square in size. It is possible to heat samples up to 90 °C.

Available Techniques – A wide range of test techniques are possible using the humidity option. These include indentation, scratch and wear and the impact technique.

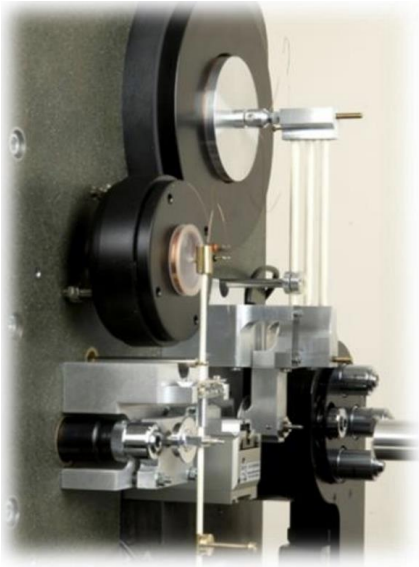
Desiccant drying and piezoelectric water atomisation humidification via closed-loop control allow consistent RH to be held irrespective of ambient conditions. With rapid control of humidity from 10% RH to 90% RH.



Nylon 6 is a very hygroscopic polymer. Its mechanical properties are very sensitive to humidity and this is quickly and easily quantified using the humidity cell.

High Load Head

P3 P4 P5



The High Load Head extends the test force range of the NanoTest up to 30 N.

It is a multifunctional load head which allows all of the test modes possible with the low load head and most of the environmental control options.

It is compliant with the relevant standards for instrumented indentation and scratch testing and is simultaneously mounted with the low load head – no need to exchange heads when switching between low and high load ranges.

The ability to perform mechanical property measurements and tribological tests across a wider force range greatly enhances instrument flexibility and allows a deeper understanding of structure / performance relationships and coating / substrate interaction for example.

Electrical Contact Resistance

The ECR module allows voltage or current controlled electrical charge to flow between indenter and the sample during any of the nano/micro mechanical measurements (nanoindentation, nano-scratch, nano-impact, reciprocating nano-wear) possible in the NanoTest Vantage. ECR equipped measurement allows a wide range of studies ranging from fundamental material behaviour during indentation through to friction, wear and endurance analysis of sliding metallic connectors and multilayer coating systems when used in conjunction with the various tribological test techniques available.

Acoustic Emission

High frequency Acoustic Emission monitoring during nanomechanical tests such as nanoindentation, nano-scratch, nano-impact, micro-pillar compression and micro-cantilever bending provides valuable additional information to improve our understanding of material behaviour at the nano-scale.

The Acoustic Emission option offers improved accuracy in scratch test critical load, uncovers cracking events in nanoindentation, it differentiates between slip and fracture in impact, it studies yield behaviour an improves the understanding of nanotribological tests.

www.micromaterials.co.uk

email: info@micromaterials.co.uk

Micro Materials Ltd, Willow House, Yale Business Village, Ellice Way, Wrexham LL13 7YL, UK

Registered in England and Wales No. 2332065
Registered Office: Willow House, Yale Business Village, Ellice Way, Wrexham LL13 7YL
info@micromaterials.co.uk