Micro Materials
Excellence in Nanomechanics

Xtreme

Now you can perform nano-mechanical tests in vacuum.

Researchers are increasingly demanding that test conditions closely mimic real-world environments in order to provide the most reliable, accurate prediction of properties. With the NanoTest Vantage, Micro Materials already offers the most comprehensive range of nano-mechanical test options. These are now further extended with the Xtreme, which provides a vacuum environment testing from -100 to 850 °C without oxidation or frosting of samples.

Suitable for investigating the effect of more extreme environments than ever before for:

- *Low oxygen, low temperatures for satellite development*
- *High temperatures for aerospace engine components*
- *High temperatures for power station steam pipes*
- *Irradiation effects in nuclear reactor cladding*
- *The effect of cold on weld repairs in oil/gas pipelines*
- *Tool coatings for high speed machining*

Test temperatures from -100 to 850 °C

Micro Materials has considerable experience in providing instruments capable of high and low temperature testing. Until recently, the limitations of these have been oxidation at high temperatures and condensation/frosting at sub-zero temperatures. Testing under vacuum negates these and allows further expansion of the temperature capabilities of the NanoTest. The benefits to users are:

- Extended high temperature capabilities beyond the 750 °C provided by the NanoTest Vantage
- Enhanced low temperature capability to below -100 °C without frosting of samples
- Ultra-low thermal drift due to same construction principles as those used on the proven NanoTest Vantage
- Complete range of nano-mechanical tests remain available, including indentation, scratch, wear, friction and high-load impact
- Ability to backfill with gas to match material operating environments

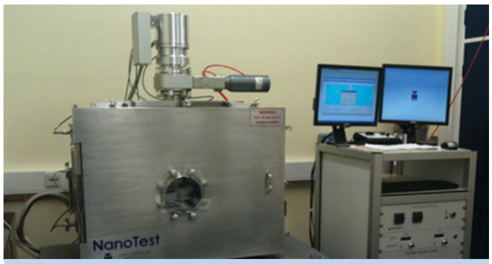

Figure 1 Vacuum chamber of the NanoTest Xtreme

Avoid the pitfalls of extrapolation

Extrapolating results from ambient or near-ambient temperatures to predict high and low temperature properties has long been shown to be unrealistic and prone to error.

Testing from -100 to 850 °C in vacuum allows simulation of some the most extreme environments encountered by engineering materials.

This capability allows accurate assessment of the behaviour of the behaviour of next generation materials in a wide variety of application areas.

The Xtreme test temperature range and vacuum environment provides the perfect capability for testing aerospace alloys in true service conditions.

Alternatively, the ability to back fill the chamber allows replication of a wider range of oxygen reduced environments such as the carbon dioxide atmosphere experienced by engine components in automotive applications.

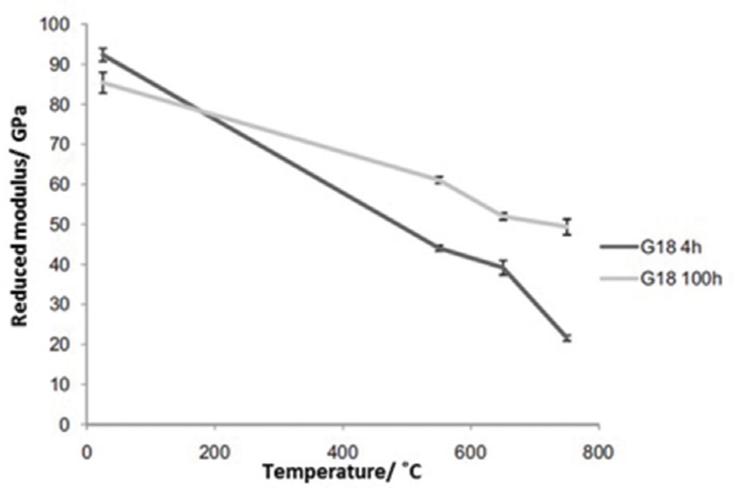

Figure 2 Modulus data from glass-ceramic solid oxide fuel cell seal material at elevated temperatures.
The results are from the same material heat treated at 800 °C for different durations. This causes a reduction in the modulus of the 100 hour treated sample at room temperature. The benefit of the treatment is that the modulus remains more stable as the temperature is increased. This demonstrates the risks of extrapolating ambient temperature results to predict service temperature performance as it is impossible to predict the stabilising effect of the heat treatment without relevant experiments

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Spearheading novel research

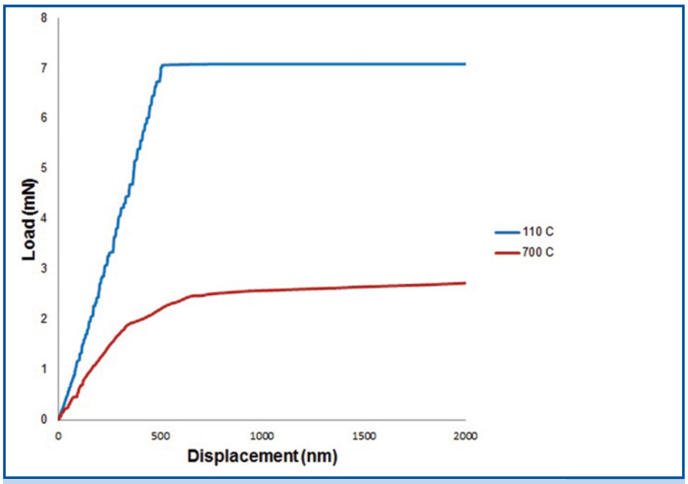

Figure 3 Data from micro-cantilever bending experiments on silicon

The NanoTest Xtreme allow scientists to undertake research in areas not accessible using conventional nanoindentation hardware. This makes the Xtreme an invaluable tool in advancing the frontiers of materials research.

Work done using the Xtreme at the University of Oxford focused on extending the fundamental understanding of the behaviour of silicon at elevated temperatures. Micro cantilever bending experiments are used to determine the mechanical properties at different temperatures in order to examine the changing deformation mechanics.

Typical load vs displacement data for bending experiments performed at 110 °C and 700 °C are shown in Figure 3. There is a clear difference in the behaviour of the silicon at the two temperatures. The silicon is brittle at 110 °C and ductile at 700 °C.

High temperature nanoindentation measurements confirm the temperature at which the silicon's behaviour transitions from brittle to ductile.

Figure 4 shows indentation experiments performed at a variety of loads at 500 °C and 650 °C.

The increased creep during the hold at peak load as well as the change in the unloading behaviour both indicate that there is a transition in the material behaviour above 500 °C.

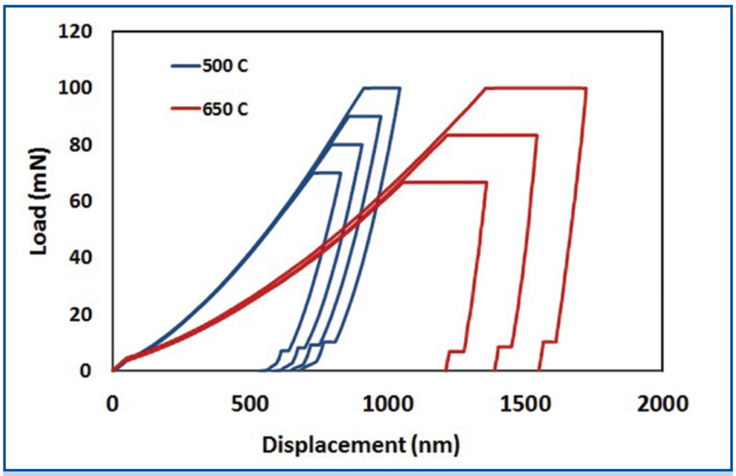

Figure 4 data from high temperature nanoindentation experiments on silicon performed in vacuum

Key Xtreme Features

- 10^{-5} mbar vacuum
- Backfill to test in alternative low oxygen environments
- 10 μN - 500 mN load range
- High temperature stage combined with the Cryo stage give a test temperature range from -100 to 850 °C
- Compatible with all standard NanoTest techniques:
  - Nanoindentation
  - Nano-scratch and wear
  - Nano-impact
  - Nano-fretting
- The Xtreme is fitted with a high resolution optical microscope as standard. This can be augmented with the 3D profiling stage.

Advantages

- Vacuum, high and low temperature capability to match the working conditions of test materials
- Proven NanoTest technology provides ultimate stability, accuracy and confidence in results
- No more extrapolating data from ambient conditions to guess the working-life performance
- Provides the hardware for understanding the mechanical behaviour of the next generation of engineering materials

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NanoTest™ Xtreme