

# High-temperature module with the NanoTest Vantage

High-temperature testing on the nano-scale under true service conditions allows for precise evaluation and optimisation of materials and coatings used in high-temperature applications, in a time efficient manner. The NanoTest Vantage hot stage allows (1) Nanoindentation (2) Nano-scratch & wear (3) Nano-impact & fatigue to be performed at up to 500 °C or 750 °C.

## How it works

The horizontal loading design of the NanoTest Vantage is critical for accurate and reliable testing at elevated temperatures. The configuration is shown in Figure 1.

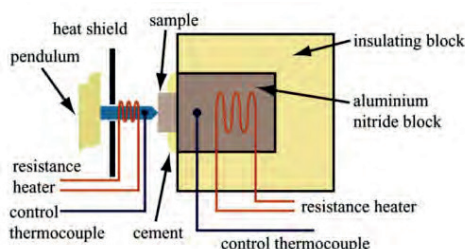
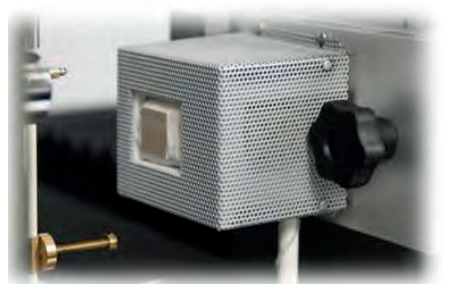


Figure 1 shows the NanoTest hot stage with separate tip and sample heaters. Image courtesy of Dr AJ Muir Wood, University of Cambridge

## Important features of high-temperature testing with the NanoTest Vantage

- **Instrument stability:** The horizontal loading mechanism ensures there are no adverse heat effects on loading head or depth measurement hardware.
- **Isothermal contact:** The NanoTest Vantage hot stage controller uses separate heating of both probe and sample to ensure no heat flow occurs during the indentation process (UK patented control method).
- **Creep tests:** As no significant thermal drift occurs during elevated temperature measurements it becomes possible to perform longer duration tests such as high temperature creep tests.
- **Test environment:** The NanoTest Vantage has a choice of a temperature controlled environmental chamber or a purging chamber that provides a choice of ambient atmospheres and in preventing the oxidation of samples.
- **Range of indenter materials:** Micro Materials Ltd offers a range of indenters for materials high-temperature testing including diamond, sapphire and C-BN.

## High-temperature nanoindentation and creep

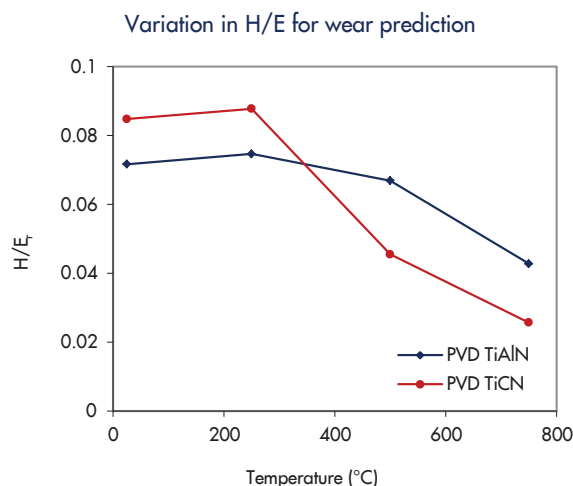


Figure 2 shows the Hardness/Modulus ratio, which strongly influences wear in a variety of tribological situations including high-temperature indentation on PVD coatings. The results show why TiAlN outperforms TiCN in high-speed turning despite having a lower hardness value at room temperature.

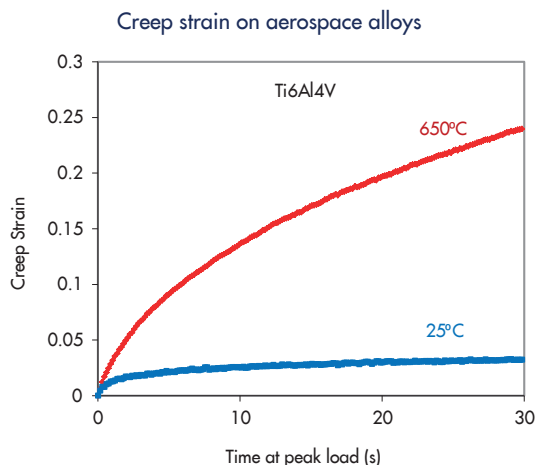
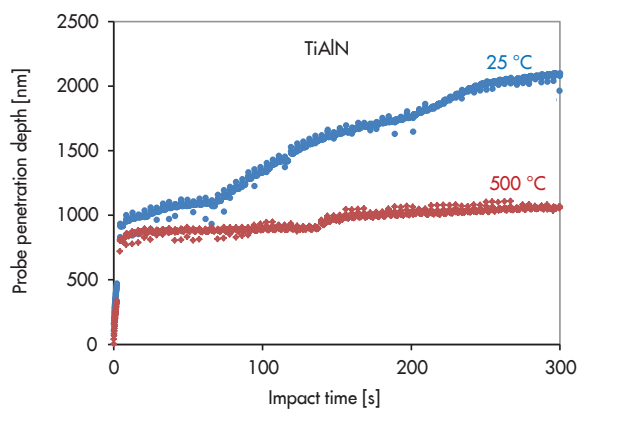


Figure 3 shows that the creep strain on Ti6Al4V is notably higher at 650 °C than 25 °C.

# High-temperature module with the NanoTest Vantage

## Optimising advanced high-speed cutting tool coatings



	Temperature °C	Fracture probability
TiAlN	25	0.8
	500	0.5
AlTiN	25	0.4
	500	<0.2

Figure 4 shows the results of high-temperature Nano-Impact on a TiAlN coating. These results are consistent with the higher plasticity shown at 500 °C in nanoindentation. Nevertheless, TiAlN still fractures at 500 °C which is supported by the increased fracturing and unstable wear compared to AlTiN in interrupted cutting applications that generate significant heat [...see also BD Beake et al, Int Heat Treat Surf Eng 5 (2011)17 and BD Beake et al Surf Coat Technol 201 (2007) 4585]

## NanoTest Vantage High-temperature module advantages

- True depth sensing indentation
- Minimal thermal drift
- Isothermal contact
- Horizontal loading
- Localised heating approach
- Separate tip and sample heaters
- Stability for low load, long duration nano-scale creep tests
- Maximum temperature 750 °C



## High-temperature wear

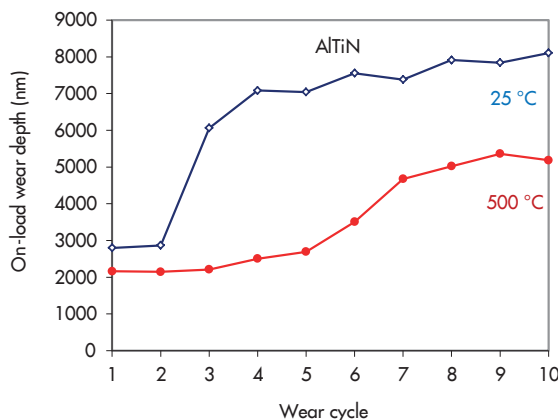


Figure 5 shows how sample behaviour changes as temperature increases when the hot stage was used in conjunction with the Nano-Scratch & Wear module in testing the sliding wear of a PVD AlTiN coating at high load. The coating fails totally during the third scan at 25 °C but shows greater ductility at 500 °C and the final wear depth is lower.