Elevated Temperature

High Temperature module with the NanoTest Vantage

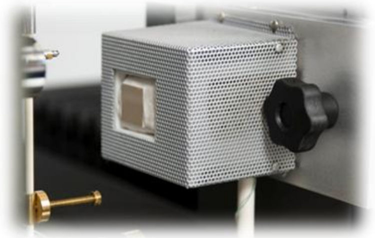
High temperature testing on the nano-scale under true service conditions allows for precise evaluation and optimisation of materials and coatings used in high temperature applications, in a time efficient manner. The NanoTest Vantage hot stage allows (1) Nanoindentation (2) Nano-Scratch & Wear (3) Nano-Impact & 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.

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 arrange of indenter s for materials high temperature testing including diamond, sapphire and C-BN.



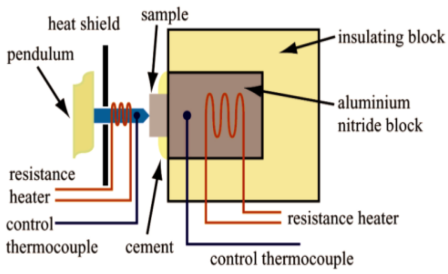
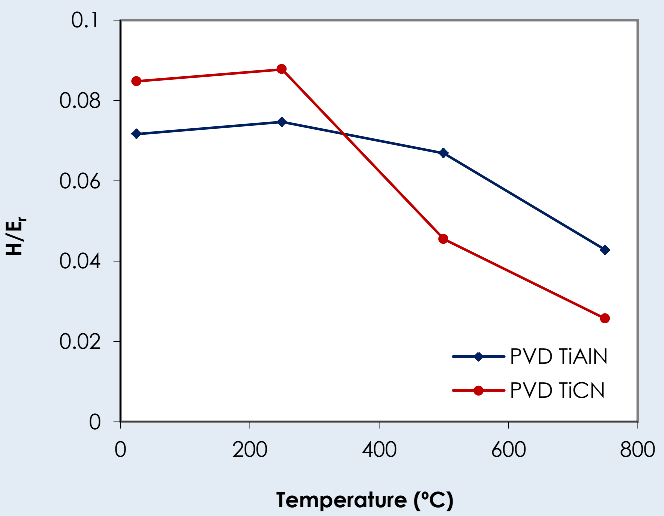


***Figure 1** shows the NanoTest hot stage with separate tip and sample heaters. Image courtesy of Dr AJ Muir Wood, University of Cambridge*

High Temperature Nanoindentation and Creep

Variation in H/E for wear prediction



Creep strain on aerospace alloys

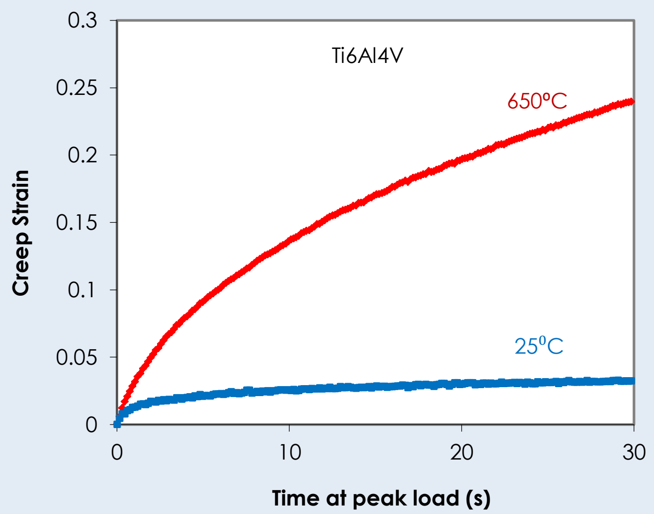


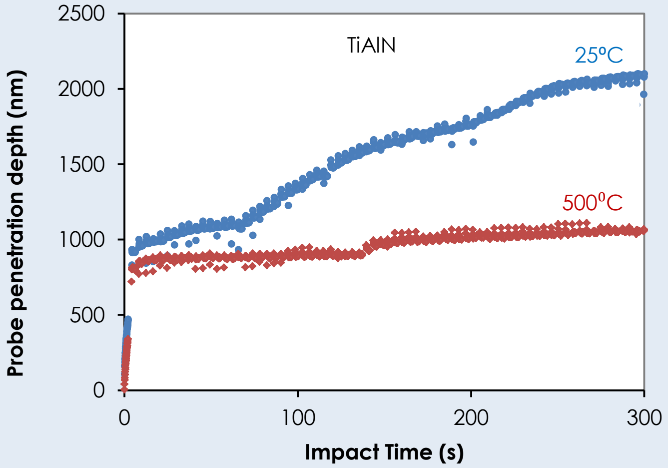
Figure 2 shows the Hardness/Modulus ratio, which strongly influences wear in a variety of tribological situations including high temperature indentation on PVD coatings. The results show why TiAlN outperforms TiCN in high speed turning despite having a lower hardness value at room temperature.

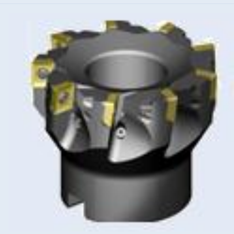
Figure 3 shows that the creep strain on Ti6Al4V is notably higher at 650 °C than 25 °C.

Micro Materials
Excellence in Nanomechanics

Elevated Temperature

Optimising wear resistance of high speed cutting tools at high temperature





	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]*

- **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

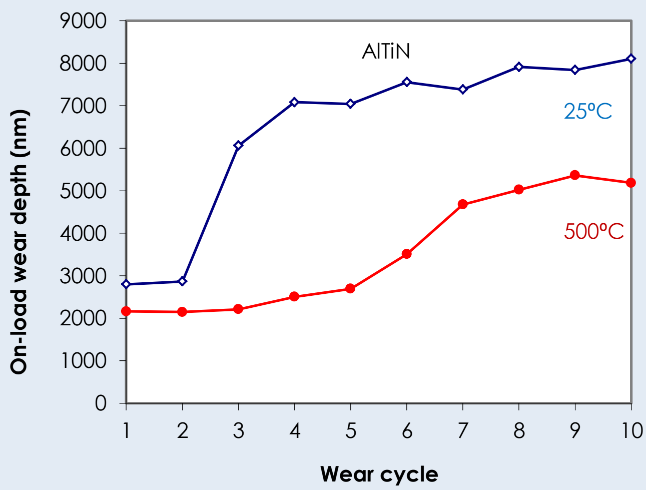


Figure 5 shows how sample behaviour changes as temperature increases when the hot stage was used in conjunction with the Nano-Scratch & Wear module in testing the sliding wear of a PVD AlTiN coating at high load. The coating fails totally during the third scan at 25 °C but shows greater ductility at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

Local MML Representative

Micro Materials Ltd
Willow House, Yale Business Village
Ellice Way, Wrexham LL13 7YL, UK
Tel: +44 1978 261615

info@micromaterials.co.uk
www.micromaterials.co.uk

NanoTest Vantage