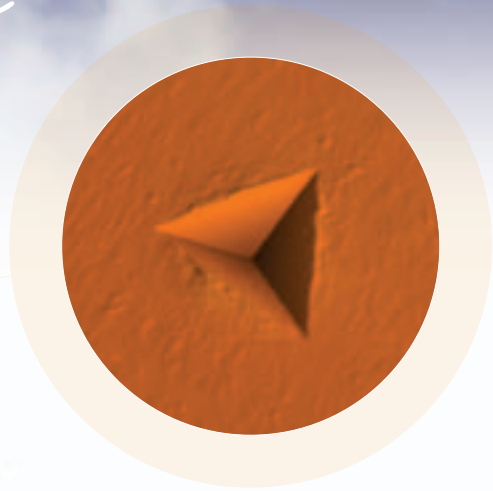


NanoTestTM Vantage

THE NANOTEST VANTAGE: NEXT GENERATION
NANOMECHANICAL TESTING AND MATERIALS
DEVELOPMENT FOR THE **AEROSPACE** SECTOR

- ▶ PVD thermal barrier coatings
- ▶ Lead-free solders
- ▶ Machining of hard-to-cut aerospace alloys
- ▶ C/C composites
- ▶ Polymer-derived ceramic composites
- ▶ Plasma-sprayed TBCs
- ▶ Superalloys
- ▶ CNT-epoxy composites
- ▶ Ti metal matrix composites
- ▶ PVD coatings to replace hard chrome



Nanomechanical test for aerospace applications

Advanced materials

Advanced materials used in aerospace applications have to withstand harsh operating environments. For example, to meet environmental and commercial concerns researchers are developing advanced materials and coating systems for greater fuel efficiency in gas turbine engines. Increasing turbine entry temperature requires more efficient thermal barrier coatings (TBCs) to protect the components from the increased temperature, so efficiency and reliability are closely interlinked. Microstructural optimisation for wear resistance is an essential step in designing for improved efficiency coupled with reliability.

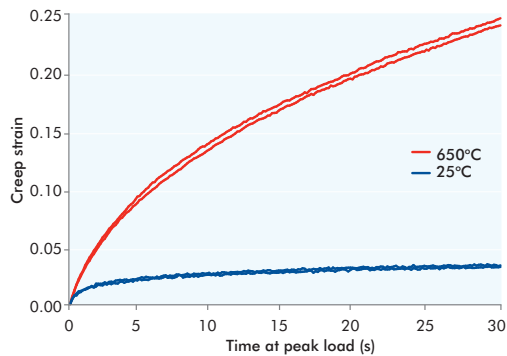
Avionics

Similarly, in avionics, external life-cycle factors, with more extreme thermal cycling that components are exposed to compared to more conventional ground applications result in formation of intermetallic phases in solder joints that can significantly affect the joint reliability due to their brittleness.

Unique capabilities of the NanoTest Vantage – such as the capability to perform nanomechanical testing at temperatures up to 750°C – mean that it is increasingly being used for measurements of the mechanical properties of high-temperature and high performance materials for a wide range of applications in the aerospace industry from airframe to avionics to engine development.

◀ The NanoTest Vantage can be configured with nanoindentation, nano-scratch, nano-impact and nano-fretting.

Creep behaviour of titanium

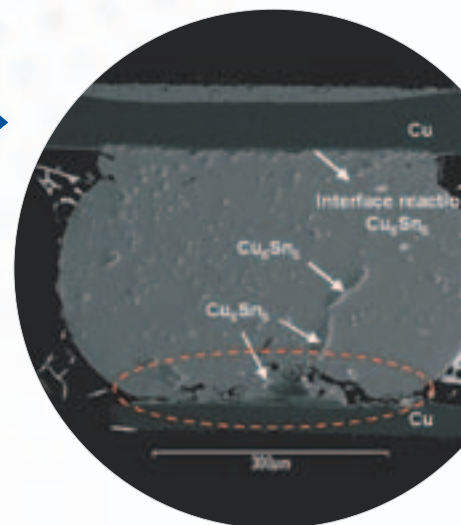


▲ Nanoindentation creep on Ti6Al4V alloy at 25°C and 650°C. Two repeat tests are shown at each temperature to demonstrate the reproducibility of the NanoTest. It is also possible to study the creep behaviour of superalloys with this same technique up to an elevated temperature of 750°C and for extended test times, due to the NanoTest's industry leading thermal drift stability.



▲ SEM image of the backside of C/C composite showing reproducible push-out of fibres from the matrix. Courtesy of Dr Stephane Jouvannigot, LCTS, Bordeaux.

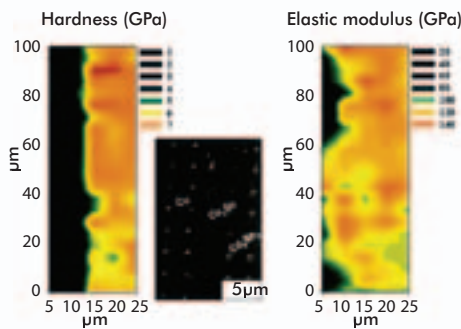
▶ Solder bond failure due to intermetallic compound formation, courtesy of Begbroke Nano, University of Oxford.



Small measurements can solve big problems

Lead-free solder

Lead-containing (Sn-Pb) solder joints have been used extensively in the aerospace industry for decades. Whilst promising lead-free solders such as SAC (Sn-Ag-Cu) have been developed for domestic use, concerns remain over their reliability as they are much less well characterised. This is particularly true in relation to characterisation under harsh environments as experienced in aerospace applications, where industrial studies have shown that failure rates are too high and degradation mechanisms differ from those in domestic uses.



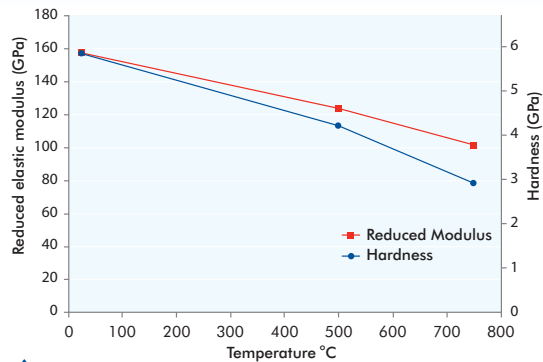
▲ Mapping across solder joint interface after metallographic polishing, courtesy of Begbroke Nano, University of Oxford.

Fast, automatic mapping of mechanical properties at the correct length scale by nanoindentation allows quantitative characterisation of the elastic and plastic properties of intermetallics formed in the bulk of the solder and at the interface of the solder and PCB. Mapping their growth under thermal cycling conditions relevant to avionics, with subsequent correlation of the nanomechanical data with electron microscopy (EDX) is a powerful tool for joint reliability analysis.

Thermal barrier coatings

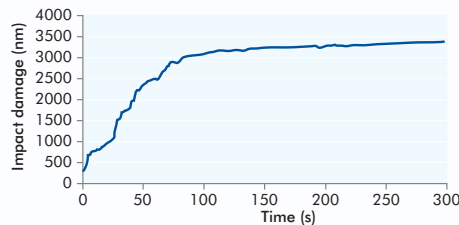
Nanoindentation has proved a valuable tool in the optimisation of mechanical properties of TBC top coats. The understanding of their variation with ageing and with testing temperatures will help to minimise the risk of debonding under erosive impact and subsequent turbine blade failure.

At the UK High Temperature Research Centre at Cranfield University, Prof Nicholls and colleagues have used micro and nanoindentation at elevated temperature to characterise heterogeneous and columnar Electron beam-PVD deposited Ytria-stabilised zirconia (YSZ) top coats in TBCs. During solid particle erosion, the contact footprint is on the scale of the individual columns, so nanoindentation and nano-impact is necessary to determine the local properties.



▲ Variation in TBC top coat mechanical properties with temperature.

The NanoTest's maximum test temperature, 750°C, is sufficiently close to the operating temperature in the engine to enable column hardness and elastic modulus measurements to be extracted for erosion modelling and lifetime prediction. The variation in the TBC hardness and modulus with temperature can be seen below. The lateral movement of the columns under the indenter – observed at room temperature – is also seen in the elevated temperature measurements, showing that cross-column sintering is not significant at 750°C.



▲ Nano-impact damage (nm) vs time (s) for YSZ TBC coating on zirconia after ageing for 24 hours at 1500°C.

NanoTest Vantage: the user benefits

High temperature measurements

Allows the testing of samples at temperatures up to 750°C, allowing evaluation of true 'in-service' mechanical properties.

User friendly software

A simplified interface, while allowing full flexibility, makes the software easier to navigate and more intuitive - making it ideal for both new and inexperienced users.

Industry-leading stability

The system has a dedicated environmental enclosure and a high thermal mass frame, ensuring ultimate instrument stability.

High automatic throughput

The automatic scheduling facility allows maximum throughput without the need for user intervention, enabling the equipment to be used 24/7.

Unrivalled flexibility

The NanoTest Vantage software offers a wide range of selectable parameters, allowing the user optimum flexibility of experiment design.

Purpose-designed for experiments

A large working area between the motor stage and the indenter allows you to set up custom experiments.

Application/material	NanoTest advantages - aerospace
Thermal barrier coatings	High temperature nanoindentation to 750°C with tip heating to minimise/eliminate instrumental drift. Dual loading heads (nano- and micro-) mounted simultaneously.
Lead-free solder	High temperature nanoindentation – low/no drift enables accurate creep tests.
C/C composites	Accurate and reliable repositioning to ~0.5 µm enables fibre push out tests. Ease of indenter exchange.
Superalloys	Creep and micro-compression testing at elevated temperature
Coatings for high speed machining of aerospace alloys	High temperature nanoindentation. Nano-impact (repetitive fracture fatigue resistance) capability.

Modular design to grow your research options

The NanoTest Vantage is a fully modular system that allows the user to configure the system to meet their individual needs and can be expanded at a later date to include further modules.

Comprehensive after sales service & care

Our strong customer after sale care includes direct access to our expert engineering team who can help with your experiment design and custom software setup.

Peer-collaboration and knowledge exchange

Many of our testing modules have been developed in response to the needs of our customers. You too can opt to be part of this collaborative approach.

Cutting edge technology for enhanced research

We apply the very latest and most accurate technology in our NanoTest Systems which allows you to break through into new and pioneering research.

Patented nano-impact and fatigue testing

This technique helps you design better materials or coatings for erosive protection, cutting tool, engine and other applications.

Liquid cell facility

Allows the testing of a sample fully immersed in a fluid without indenter buoyancy problems associated with vertical loaded indentation.

Load / partial-unload technique

This enables users to rapidly build up a complete profile of the variation of hardness and modulus with depth.

Wide load range 10µN - 20N

With our micro and nano load heads you have a wide range of loads to choose from which adds to the flexibility of use for the system.

FIND OUT THE FULL STORY

This has been a brief appraisal of the NanoTest Vantage's operating capabilities. To find out how one of the new generation models could transform your testing capabilities, get in touch and we can provide a detailed analysis of how it could benefit your operation.

To see the NanoTest Vantage in action (either at our UK headquarters, through one of our worldwide distributors or through a videolink) running test experiments that have relevance to you, again, just get in touch and we will do the rest.

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