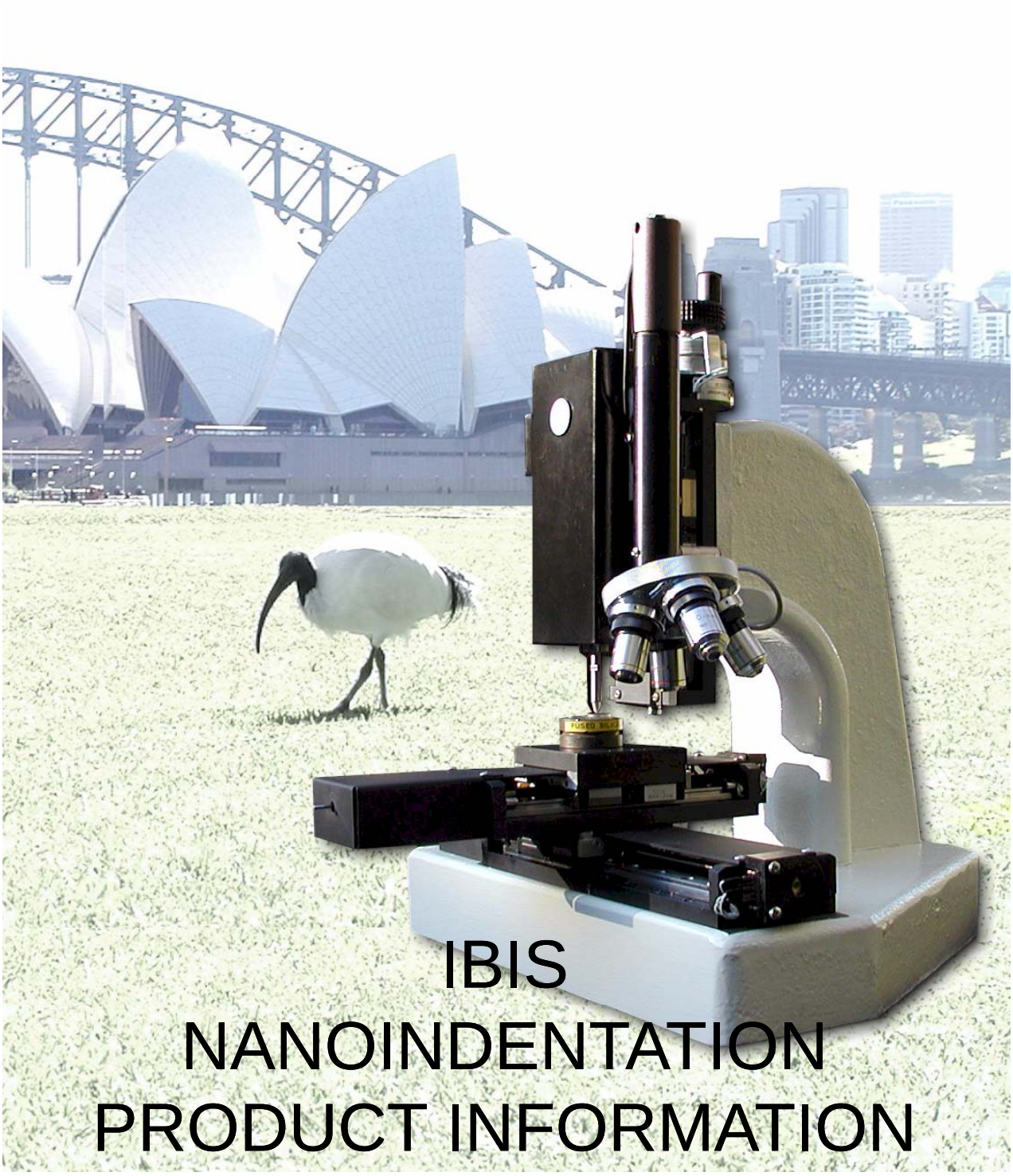
Fischer-Cripps Laboratories Pty. Limited



IBIS NANOINDENTATION PRODUCT INFORMATION

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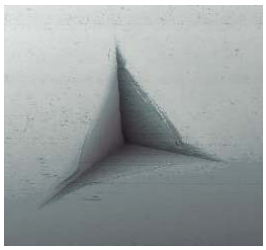
Phone: +61 2 9453 5658 Fax: +61 2 9453 5659
www.ibisonline.com.au

Nanoindentation

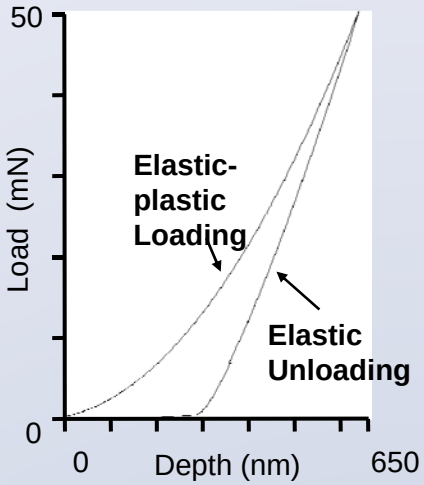


The instrument uses a diamond indenter to create a residual impression in the specimen surface. The impression is usually too small to be seen with the naked eye. The most commonly used indenter geometry is the three-sided Berkovich indenter which leaves a nice characteristic impression in the surface, here imaged by the optional AFM attachment.

It is now recognised that the performance of many real-world structures is dependent on material properties at the sub-micron scale. Often, the mechanical properties at this scale are very different to that of the same materials at larger scales. The IBIS nanoindentation system is a mechanical microprobe capable of touching the surface of very small volumes of materials in a prescribed manner and measuring the mechanical properties.

Thin films, multi-phase metals and ceramics, teeth, bone, etc are the main applications but IBIS can also be used for visco-elastic measurements of polymers, flexure testing of MEMS and any application involving mechanical measurement on the nanometre scale. The materials properties measured are elastic modulus and hardness, yield strength, and depending on the sample, storage and loss moduli, fracture toughness, scratch and wear properties.

The IBIS nanoindentation system is designed to impart a controlled load to a precisely shaped indenter in contact with the specimen surface. The mechanical response of the material is measured via force and displacement sensors in the form of a "load-displacement curve". The range and resolution of the actuator, force and displacement sensors, is very small (in the mN and μm range with nN and nm resolution). There is a very small impression left in the specimen surface (too small to be seen by the naked eye) thus making the technique useful for tests on specimens which cannot be destructively tested.



The precise nature of the measurement enables events on the micro to nano scale to be recorded. Macro-scale damage can thus be interpreted and explained by events on the sub-micron scale thus allowing the fundamental properties of the sample to be studied and tailored for specific applications.

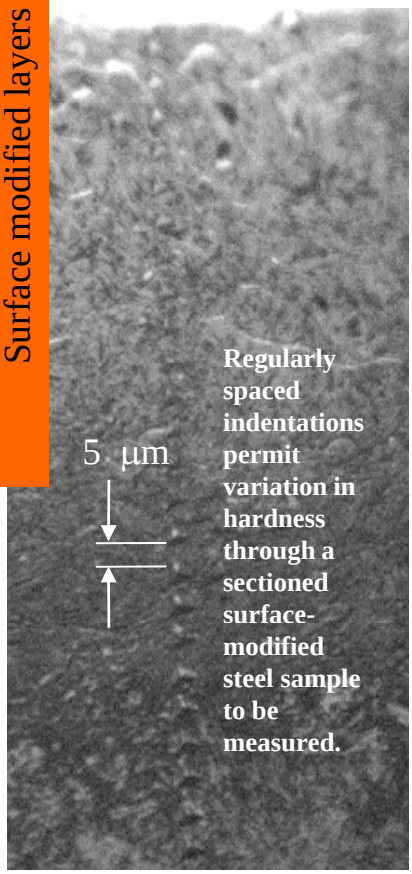
The IBIS nanoindentation system is designed to explore the sub-micron mechanical properties of materials using proven technology, a solid theoretical base, and backed by expert support. The system is a high resolution, robust package designed to allow even the most inexperienced used to benefit from this testing technique.

Applications

Functions:

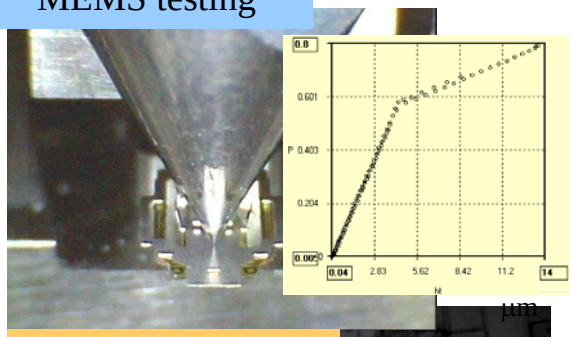
- Nanoindentation
- XY Mechanical property mapping
- Depth mechanical property profiling
- Surface height profiling
- Visco-elastic measurements (creep and oscillatory motion)
- Optional lateral force (scratch)
- Micro-tensile/compression (MEMs testing)
- Surface forces

Surface modified layers

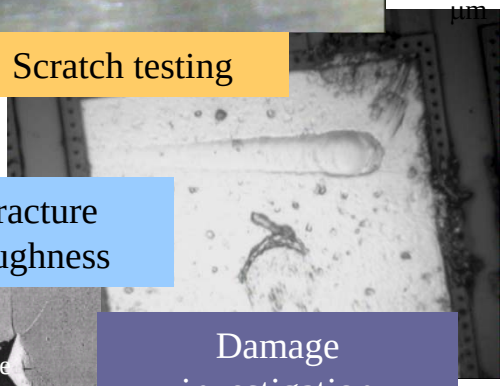


Regularly spaced indentations permit variation in hardness through a sectioned surface-modified steel sample to be measured.

MEMS testing

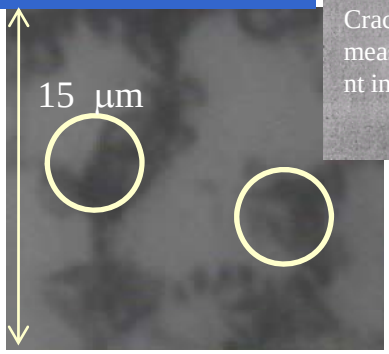


Scratch testing

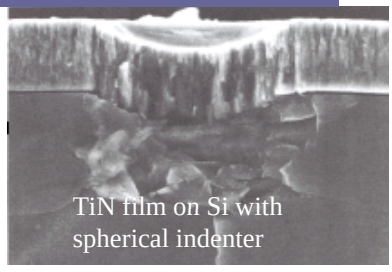


Fracture toughness

Multiphase materials



Damage investigation



Nanoindentation instruments are commonly purchased by University research departments, government research laboratories, and private industry. The IBIS nanoindentation system was developed from the UMIS instrument invented by CSIRO's national standards laboratory in Australia.

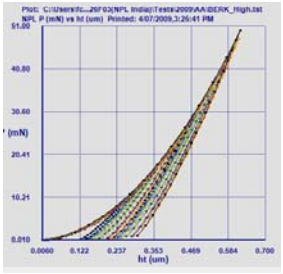
CSIRO

Past industrial customers include Ford, 3M, Intel and IBM. As well, many universities throughout the world use IBIS/UMIS instruments on a daily basis for mechanical property characterisation at the micron to nanometre scale.

Although the initial cost of any nanoindentation system is fairly high, often requiring a tender process, the IBIS system is very efficient to own. The mechanism is very robust and very seldom requires recalibration or repair even after the most arduous conditions The only effective consumable are the indenters, and the prices for these items from Fischer-Cripps Laboratories are typically 2/3 to 1/2 those of competitor companies for the same part.

IBIS Specifications

The performance of IBIS is similar to competitor instruments costing up to three times as much. Our combination of performance, reliability and price is unmatched in the field.



Operating modes

- Nanoindentation
- Partial unload technique
- Multiple-frequency dynamic testing with Fourier analysis
- Creep
- Scratch
- Batch (unattended) operation

Accessories/Options

- Lateral force (scratch) measurement
- Finite element interface
- Fluid cell, AFM and more.
- Choice of staging
- Surface reference option

Significant features

- Closed loop force/depth feedback
- Robust sensor design
- Easy indenter changeover
- Portable bench top mounting
- Traceable calibration
- Reliable (3 year warranty)

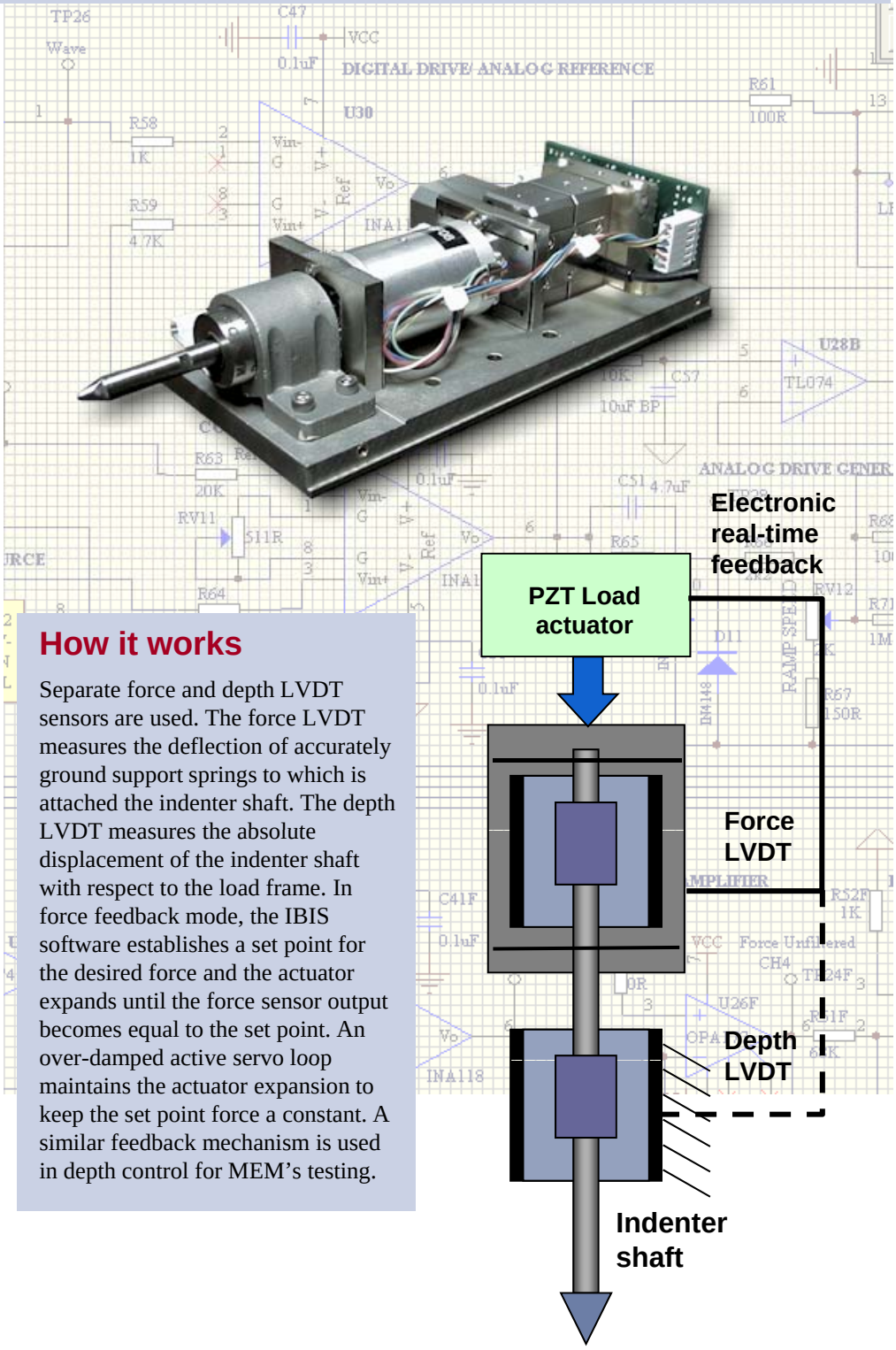
IBIS is a dual range instrument with automatic switching from low to high ranges on force during testing. Resolutions shown are for the lower range setting. For example, with head model B, the low range is 0 to 50 mN. The user can switch over to the high range 0 to 500 mN when higher indenter forces are required.

Most popular

Specifications	Head Model A	Model B	Model C
	Low load	Mid range	High load
Load range (compression)	10 mN & 100 mN	50 mN & 500 mN	2 N (5 N max option)
Digital resolution	0.015 μN	0.07 μN	3 μN
Noise floor	TBA	<1 μN	<10 μN
Minimum contact load	TBA	5 μN	0.1 mN
Depth Range	500 nm, 5 μm	2 μm, 20 μm	20 μm, 200 μm (500 μm max option)
Digital resolution	0.00076 nm	0.003 nm	0.03 nm
Noise floor	TBA	0.1 nm	5 nm

Operating principle

IBIS uses rugged LVDT sensors for both force and depth measurements. AC amplification provides a µV noise floor in this sophisticated package. Special circuitry offsets the signal to take advantage of the full range of the analog to digital interface.



How it works

Separate force and depth LVDT sensors are used. The force LVDT measures the deflection of accurately ground support springs to which is attached the indenter shaft. The depth LVDT measures the absolute displacement of the indenter shaft with respect to the load frame. In force feedback mode, the IBIS software establishes a set point for the desired force and the actuator expands until the force sensor output becomes equal to the set point. An over-damped active servo loop maintains the actuator expansion to keep the set point force a constant. A similar feedback mechanism is used in depth control for MEM's testing.

The use of LVDT measurement sensors for nanoindentation applications was pioneered by CSIRO in the late 1980's. Since then, experience has proven the technique, offering low noise sub-nanometre resolution and in a very rugged package. Unlike competitor instruments that use a capacitance sensor, the IBIS system is almost immune to mechanical breakage due to overloading of the indenter shaft because the indenter shaft passes right through the sensor and can undergo several millimetres of accidental deflection without cause for any concern.

Competitor products have generally stayed away from LVDT sensors because of cost. Use of an LVDT requires a costly PZT actuator. In competitor products, a magnetic voice coil, which is cheaper to supply, is used. Due to the high magnetic field associated with the coil type of actuator, an LVDT cannot be used, hence a fragile capacitance sensor is used instead.

20 years experience in the field proves the PZT/LVDT combination is reliable, accurate, and provides the best outcome for the customer in the long term.

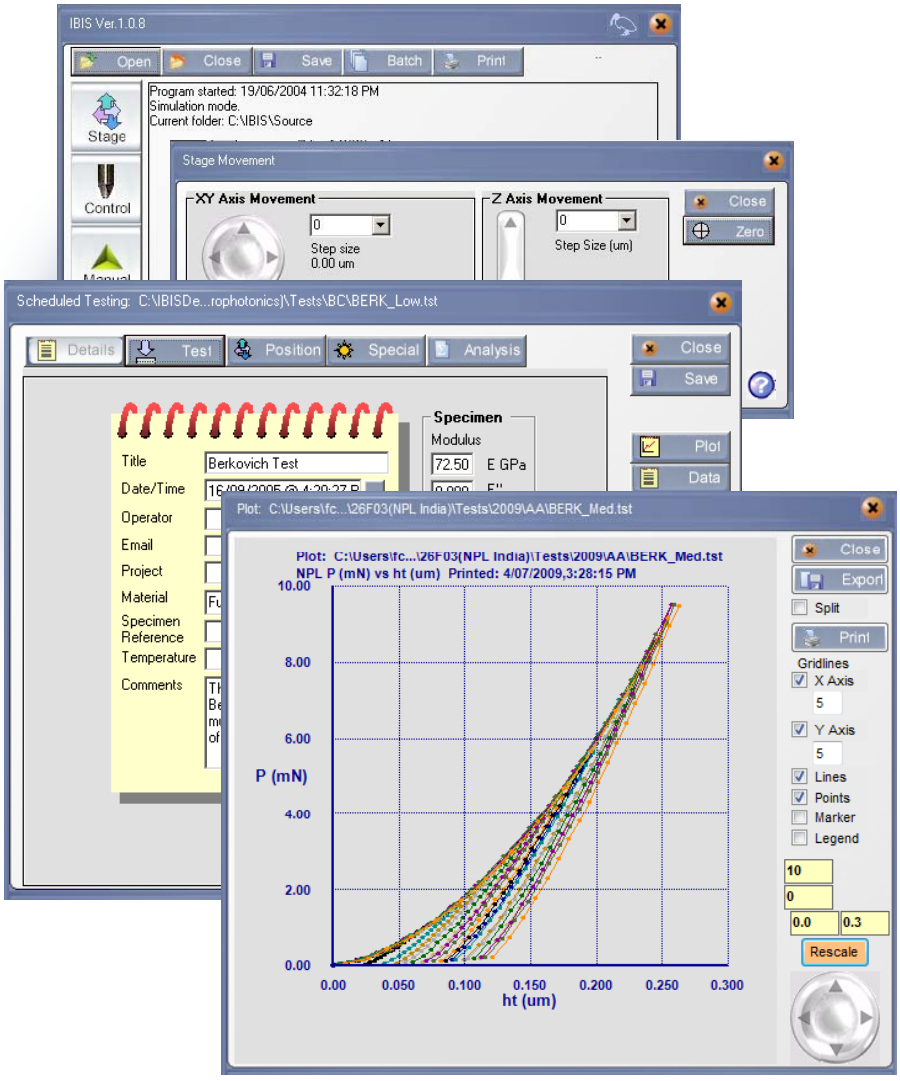
IBIS Software

Introduction: The new IBIS software builds on 20 years experience with the UMIS nanoindenter designed by CSIRO. The IBIS software is especially written for nanoindentation. This software is extensively tested, and offers analysis for both static and dynamic (including creep) tests, and contact mechanics. It also includes extensive instrument control functions.

Features:

- *Completely flexible test specifications including standard tests to ISO 14577.*
- *Dynamic testing for storage and loss moduli*
- *Finite element modeling interface to Strand7®.*
- *Analysis of data from Berkovich, spherical, and cube corner indenters plus others.*
- *Predictive calculations based upon user inputs of estimated modulus and hardness.*
- *Creep (constant force) with iterative solving for up to 4-element Maxwell-Voigt model.*
- *Force rate, strain rate control.*
- *Batch testing for automated unattended operation.*
- *Expert on-going support.*

The IBIS software is written in the modern VB.NET language thus ensuring its viability for many years on the Windows platform. It is Vista compatible.



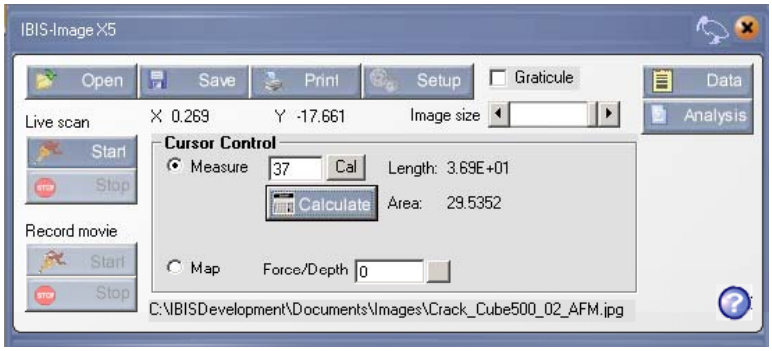
Actual screen shots showing uniformity of response of the instrument on a standard fused silica specimen.

Installation: The IBIS software can be installed on any Windows XP+ compatible personal computer for off-line data analysis without additional fees. All data files are in ASCII format. This software offers control and analysis functions and is purpose-written for nanoindentation applications. The software is supported by a web-site and on-line and written documentation.

Video microscope

There are several options for video microscopy with IBIS. The lowest cost option is a single lens with a monochrome analog camera. A further option provides four objective lenses mounted on a revolving turret. An optional high resolution digital camera can also be supplied. Illumination is via an LED and beam splitter to give top-down (through-lens) illumination of the sample surface.

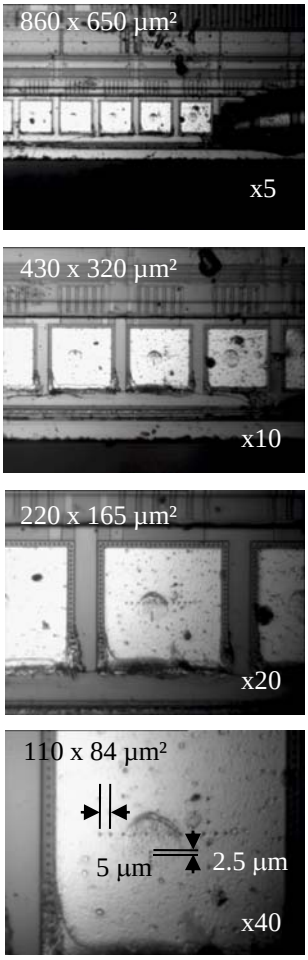
Specially-written image analysis software allows images to be captured, and also calibrated length and area measurements to be performed on the captured image.



Features:

- Point and click indentation positioning
- Measurements of crack lengths and area of contact calculation.
- Creation of IBIS Nanoindentation software MAP files.
- Captures and displays images in BMP, TIFF, JPG or AVI format.

The microscope works in conjunction with the specimen stages. Stages can range from economical open loop stepper motor drives with a step size of about 1.25 µm to high resolution dc motors with a linear track encoder giving a step size of 0.1 µm



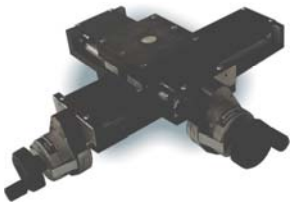
Large spherical indentation in gold bond pad followed by smaller indentations inside the residual impression to measure strain-hardening.

Specifications

Lens	Field of view	Magnification
X5	860 x 650 µm	x 230
X10	430 x 320 µm	x 470
X20	220 x 165 µm	x 900
X40	110 x 84 µm	x 1800
Analog Camera	Monochrome CCD, 380 TV lines – 510 H x 492 V EIA composite output. Hi res digital camera optional.	
Image card	32-bit, 33 MHz PCI, 720x488 NTSC/EIA, 720x576 PAL/CCIR Size: 121 x 70 mm.	

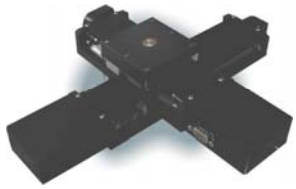
IBIS Stages

There are several options for sample movement. For situations where budget is limited, high quality stepper motor stages offer automated sample movement for unattended instrument operation. DC motor stages with linear or rotary encoders are available for high precision location of the indentation.



Option 1: Open Loop Stepper Motors

For simple applications, precise movement is not a high priority. Usually, all that is required is an automated movement of the sample to permit multiple indentations to be performed in an unattended mode. To this end, IBIS can be ordered with open loop stepper motor XY axes that are controlled directly from the IBIS electronics unit via a digital IO interface. No dedicated motor controller is required. Despite the simplicity and extremely low cost of the arrangement, special backlash compensation in the IBIS software results in a very respectable positional repeatability of about 2 µm.



Option 2: Closed Loop DC Motors

For more demanding positioning applications, the closed loop DC stages are ideal. There are two options for encoders. The rotary encoders have 1000 CPR resolution with a 1 mm lead screw providing 0.25 µm accuracy. The linear track encoders have a 0.1 µm accuracy. Both types of stages are controlled by a National Instruments motion controller card with PID servo control. These stages provide rapid movement and fast servo motion.

In both cases above, the stage mechanism is specially designed for low compliance and high precision movement. The linear motion is achieved through the use of heavy duty linear ball guides and ground rails. Unlike competitor products, these stages are not simple third-party standard products, they are custom built for nanoindentation work and only available with the IBIS system. They feature the encoder mounted on the lead screw (instead of the more common practice of on the motor) and an extremely flat trajectory for precise movement during scratch testing. These stages cannot be matched by our competitors.

Specifications	Stepper motor	DC motor	DC motor
	Open loop	Rotary encoder	Linear encoder
Step size, resolution	1.25 µm	0.25 µm	0.1 µm
X travel		-120 mm -	
Y travel		- 45 mm -	
Z travel		- 45 mm -	

IBIS Systems

Our objective is to provide a quality instrument no matter what the budget. The only difference between the systems is the load frame, stage and microscope options. The basic head specifications and performance is the same on each ensuring an easy upgrade path if ever required.

Simplus

Here is a system that provides many features of high end systems at a very low price. Tested and traceable calibration. 50/500 mN load cell, 2/20 μm depth. 3 year warranty.

Items included:
Motorized Z axis
1 x Diamond Berkovich indenter
1 x Stepper motor stage X 1.25 μm step 45 mm travel
1x Enclosure acoustic lined
1x Fused silica standard specimen
5x Specimen mounts
1x Adhesive
1x Manual set
1x Computer with LCD monitor
1x IBIS Software for control, analysis and diagnostics
Suitable for automated unattended testing where precise positioning of the indentation is not required. No microscope or air table. Supplied on air filled mounts.

Each system can be fitted with Head options A, B or C thus ensuring you receive the load and depth range most appropriate to your application.

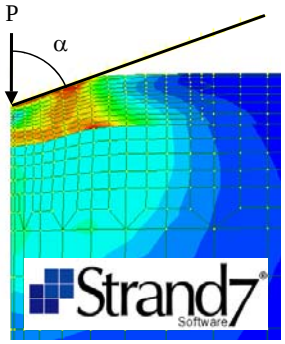
Advantage

As above but add:
2x Stepper motor stages 1.25 μm step X 120 mm Y 45 mm
1x Single Lens Microscope
Suitable for automated unattended testing where reasonable positioning accuracy and observation of pre and post indentation site is required.

Authority

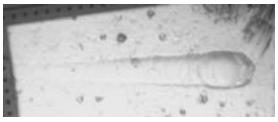
As above but delete stepper motor stages and single lens microscope and add:
1x closed loop stages 0.25 μm resolution X 120 mm Y 45 mm travel. Note, 0.1 μm resolution stages optional on this system at extra cost)
1x 4 Turret lens microscope
1 x Air table
1 x Premium load frame
Suitable for automated unattended testing where good positioning accuracy and observation of pre and post indentation site is required.

IBIS Accessories



Finite element analysis

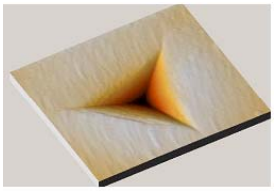
- Easy user interface to modeling optimized for indentation analysis.
- Elastic-plastic material properties with strain hardening.
- Single coating geometry.
- Interfacial friction, residual stress.
- Conical or spherical indenter geometries.
- Variety of output formats.
- No prior knowledge of finite element analysis required.



Scratch testing (lateral force)

The IBIS scratch tester uses the deflection of a spring-loaded specimen plate to obtain lateral force measurements while the XY stage is translated during an indentation test. Ramped or steady loads may be applied. Scratch length is typically um to mm scale. Lateral force range typically 100 mN.

Several other accessories can also be ordered: Liquid cell, temperature , vacuum chuck, etc.



Atomic Force Microscope

The DME Dualscope® DS series probe heads offer a unique see-through design that allows you to look directly at the back of the cantilever while scanning and for precise positioning. The distance from the IBIS indenter to AFM tip is accurately measured so that the sample can be traversed from the indenter position to the AFM position for immediate scanning. The Dualscope® AFM operates in a variety of image modes including DC and AC, LFM EFM, PCM and MF as standard with optional advanced modes upon request. The significant feature of the Dualscope® series is the ease of use, even for novice users. The tips are pre-mounted and are self-aligning. A unique Tip Guard features counteracts against unintentional breakage. The image analysis functions are extensive and allow easy interpretation of the scanned information. Danish Micro Engineering have been in this field for over 20 years and we are proud to offer their products as an accessory to IBIS.

The DME Dualscope can be configured for more scan volumes than specified here. For example, a 50 x 50 x 15 μm range is also available. More advanced modes of operation can be supplied on the "E" model including:
***CEP** Capacitance*
***E-probing** Electrical contact measurement*
***IND** Inductance*
***KEP** Kelvin Probing*
***RES** Resistance*
***STM** Scanning Tunneling Microscopy*
***STS** Scanning Tunneling Spectroscopy*
***SUP** Surface Potential (electrical)*

Specifications

DS95-50	DS95-200
• 50 x 50 μm scan size	• 200 x 200 μm scan size
• 2.7μm z range	• 15 (up to 18) μm z range
• Z resolution: Typical < 40 pm (rough sample) < 1 pm for flat samples with no physical slope.	• Z resolution: Typical < 200 pm (rough sample) < 1 pm for flat samples with no physical slope.
• XY resolution: 16-bit resolution on all axis < 80 pm	• XY resolution: 16-bit resolution on all axis < 300 pm
• >1.5 mm approach	• >1.5 mm approach
• Optical view 1 x 0.75 mm (x15 objective)	• Optical view 1 x 0.75 mm (x15 objective)
• AC, DC, LFM, EFM, PCM, MFM modes	• AC, DC, LFM, EFM, PCM, MFM modes

IBIS Calibration

Diamond indenters are manufactured by experienced craftsmen to stringent specifications. These high quality precision parts will last for many years unless misused or accidentally chipped.

Three-sided pyramidal Berkovich indenters are the most commonly used indenters in nanoindentation. Sphero-conical indenters are ground and polished to shape on a 60° cone. A range of sizes from 0.7 um to 200 um radius is available.

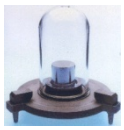
Indenters are screw-mounted using an ordinary wrench on the indenter shaft. Specimen mounts are held magnetically on the stages for convenient placement and removal.

Standard specimens are used to verify the operation of the instrument. Two specimens are of particular importance: fused silica and sapphire. The standard specimens available are manufactured in USA and are optical grade discs of the finest quality. Hundreds of indentations can be performed on each disc.

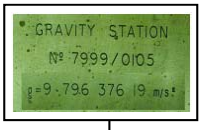
Calibration: Every IBIS instrument is carefully calibrated with an exceptionally short traceability to primary standards of measurement.
Periodic calibration is not required. Prior to delivery, every instrument is verified against three standard materials to ensure accurate and repeatable measurements.

Force

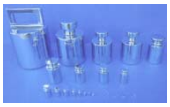
Platinum/Iridium 1 kg cylinder copy #44 of the standard kilogram in Paris



Direct measurement of gravitational constant



National Measurement Laboratory **Secondary Standards**



National Measurement Laboratory **Working Standards**

IBIS Balance calibration mass

IBIS Force Calibration Factor

Depth

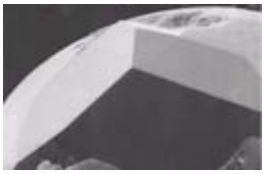
National Measurement Laboratory Primary Standard
CSIRO1-R (HeNe laser 633 nm, stabilised to the iodine transition 11-5, R(127).

National Measurement Laboratory Secondary Standard
Hewlett Packard Laser Interferometer 5519B serial number S3403A00493

National Measurement Laboratory Working Standards
Hewlett Packard Length Interferometer 5518A

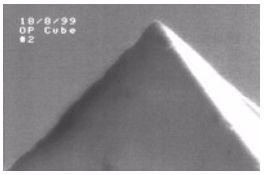
IBIS Depth Calibration Factor

Berkovich indenter



Sphero-conical indenter

Cube-corner indenter



Fused-silica standard specimen on hardened, ground steel specimen mount.

Each IBIS instrument is carefully calibrated with independent calibration of force and depth sensors. Then, the instrument is tested using three standard specimens covering a wide range of values for E and H to make sure that the results obtained are accurate throughout the range of material properties likely to be used in the field.

IBIS Support

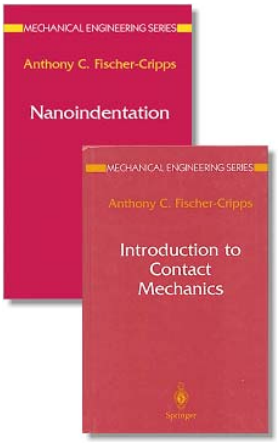
IBIS comes supplied with a built-in Help interface, Software Manual and Applications Manual.

A user support website contains downloadable training materials, program updates, and answers to frequently asked questions.

Many years experience shows that nearly all problems can be resolved via email or by remote access to the instrument.

Email support is available 7 days per week. Turnaround time depends upon your time zone but is typically within a couple of hours. Communicate direct with the engineer or scientist about your question.

ISBN 0 387 22045 3



ISBN 0 387 98914 5

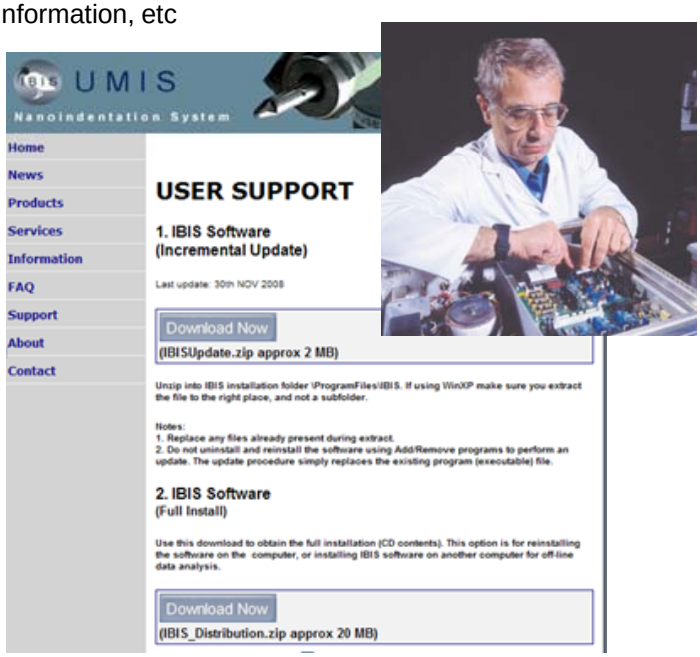
Every IBIS is backed by a solid theoretical base. We literally wrote the book on nanoindentation.

"I have been with Intel for 8 years, and in the industry for 20, and I have not run across your equal for dedication, demeanor, and knowledge for a tool or system."
- Intel Corporation USA

Fischer-Cripps Laboratories Pty Ltd was established in 1966 and has been involved with indentation testing since 1990.

Support web site

with downloadable program updates, support information, etc



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