

Introduction

Nanoindentation is your key to unlocking quantitative mechanical properties of small volumes of materials. This technique is now a well-established method for determining elastic, plastic and visco-elastic properties of materials like hard thin films, soft films, semiconductors, teeth, bone, wood, and plastics on a micron to nanometre scale.

The IBIS System

The IBIS nanoindentation System is a result of 20 years development with the CSIRO, Australia's national standards laboratory.

Standard equipment

Every IBIS system gives you everything you need to perform accurate, reliable and repeatable nanoindentation on a wide range of specimens from soft polymers to hard thin films.

- Load frame with re-positionable head.
- Nanoindentation head. Various load ranges available from 10 mN up to 5N.
- Automatic motorized Z approach capable of testing specimens of different heights. 45 mm Z range with repositionable head.
- XY closed loop motorized sample stage with 0.25 μm accuracy
- Magnetic and mechanical sample mount plate
- Low noise electronics control unit with separate lock-in amplifiers for force and depth channels.
- Multiple frequency dynamic testing including sine mode and Fourier analysis
- Contact mechanics calculation module
- Branded Computer with 17" LCD display.
- Berkovich diamond indenter calibrated with area function.
- Traceable calibration for separate force and depth sensors.
- IBIS software for control, analysis, and diagnostics, unlimited installations
- Video microscope
- Video software custom written for nanoindentation./scratch applications allowing calculation of scratch length, crack length, etc.
- Sample mounts.
- Calibration set comprising quartz and sapphire standards with flat, parallel surfaces.
- Anti-vibration mounts.
- Acoustic lined environmental enclosure.
- Set of operating manuals and applications manual.
- **3 Year Warranty**



IBIS Authority

Options

- Wide range of indenter geometries
- Open frame for large samples
- Closed or open loop XY positioning stages
- Single or four-turret microscope
- Atomic force microscope (AFM)
- Finite element analysis (Strand 7 or Ansys)
- Scratch (lateral force) tester attachment
- Acoustic emission
- Hot stage to 500 C

Choice

When budget is limited, limited equipment versions are available with the exact same specifications as the high end Authority model but with single lens or no microscope, open loop single or dual axis motion, and so on.



IBIS Advantage



IBIS Simplus

The IBIS Nanoindentation System is a proven reliable technology that provides the utmost value for your investment. The rugged LVDT sensors are virtually unbreakable yet offer sub-nm resolution. This instrument will continue to have up to date specifications and reliable performance for many years.

Operating modes

- Nanoindentation
- Partial unload technique
- Multiple-frequency dynamic testing with Fourier analysis
- Tension/Compression
- Creep
- Scratch
- Batch (unattended) operation
- Diagnostic mode

Significant Features

- Dedicated force sensor separate from load actuator (a CSIRO world first for nanoindentation)
- Dual range force and displacement sensors
- Real time force (and displacement) feedback
- Precision PZT actuator
- Closed loop XY positioning
- Robust LVDT design can withstand significant abuse
- Unattended operation
- Automatic Z approach
- Compact design, clear span for large samples
- Easy indenter changeover (no messy clamps, special tools or service calls)

Applications

The IBIS instrument provides precision load displacement curves for testing on both soft and hard surfaces, and also rough surfaces such as those deposited by industrial processes including thermal spray coatings.

This instrument enables quantitative measurements of mechanical properties of small volumes of materials. Thin films, multi-phase metals and ceramics, biological materials, etc are the main applications for such instruments but they can also be used for viscoelastic measurements of polymers, flexure testing of MEMS and any application involving mechanical measurement on the sub-micron 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 instrument is designed to impart a controlled load and deformation of the material being tested. The mechanical response of the material is measured via force and displacement sensors. 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). 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.

Specifications

Head	Model A Low load	Model B Mid range	Model C High load
Load range (dual range)	0-10 mN & 0-100 mN	0-50 mN & 0-500 mN	0-200mN & 0-2N (5 N max option)
Digital resolution	0.015 μN	0.05 μN	3 μN
Noise floor	<0.5 μN	<1 μN	<10 μN
Minimum contact load	3 μN	5 μN	0.1 mN
Depth Range (dual range)	0-1 μm & 0-10 μm	0-2 μm & 0-20 μm	0-4 μm & 0-40 μm
Digital resolution	0.0015 nm	0.003 nm	0.006 nm
Noise floor	0.025 nm	0.05 nm	0.1 nm

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. The zero point can be offset for tension/tension/compression and compression testing.

Local representative

Fischer-Cripps Laboratories Pty Ltd

Postal Address: P.O. Box 9,
Forestville NSW 2087 Australia
Telephone: +61 2 9453 5658
Fax: +61 2 9453 5659
Email: mail@ibisonline.com.au
www.ibisonline.com.au

Introduction

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.

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.

The force sensor is completely separate to the load actuator and measures the force applied to the indenter directly, and without any subtraction of signal from support springs. The force and depth sensors are independently calibrated against international standards. Closed loop feedback can be selected from either the force or the depth sensor. Open loop mode of operation for high speed data acquisition is also selectable.

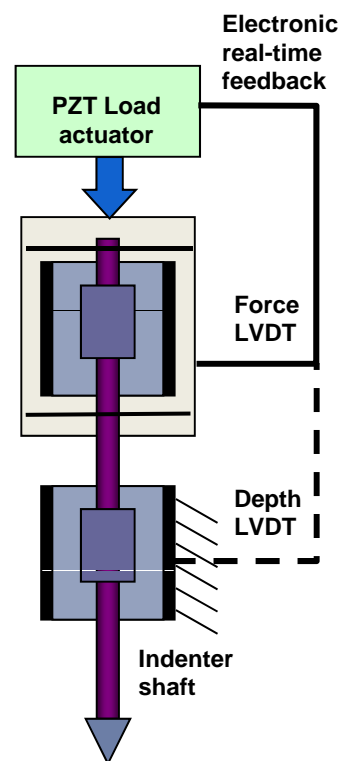
20 years experience in the field proves the PZT/LVDT combination is reliable, accurate, and provides the ultimate in longevity for your investment.

IBIS, and its predecessor UMIS, were the first to employ closed loop force feedback with LVDT sensors.

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.

Note, the closed loop feedback system used here is real-time in the electronics, not simulated in software.



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Introduction

The new IBIS2 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 comprehensive instrument control and diagnostics functions.

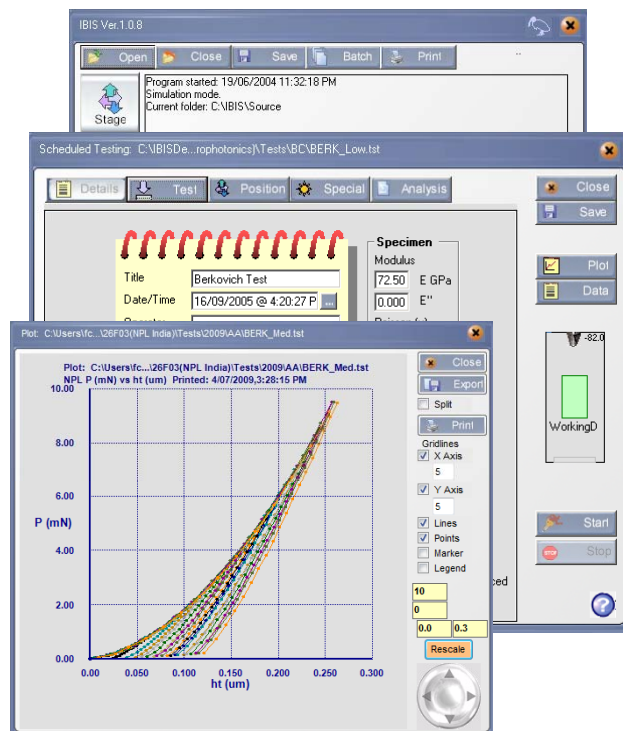
Features

- Completely flexible test specifications including standard tests to ISO 14577.
- Measurement and calculation of hardness and elastic modulus
- Dynamic testing for storage and loss moduli
- Finite element modeling interface to Strand7® or Ansys®
- Analysis of data from Berkovich, spherical, and cube corner indenters plus others.
- Hertzian contact mechanics module including full stress fields for different types of indenters.
- 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.
- Report generator
- Graphical real time output
- Statistical and mathematical functions
- Extensive diagnostics mode for trouble-shooting.
- Optional joystick control for XY and Z stage motion
- Automatic Z axis approach
- ASCII format for storage of data
- 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.

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 tutorial material as well as written documentation. Direct access to the programmer is provided for supported customers.



The theoretical basis for the functions in this software are described in detail in our book "Nanoindentation" by A.C. Fischer-Cripps, published by Springer-Verlag NY.

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The video microscope enables both precise positioning of the indentation and also automated sample movement for unattended operation for multiple indentations.

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.

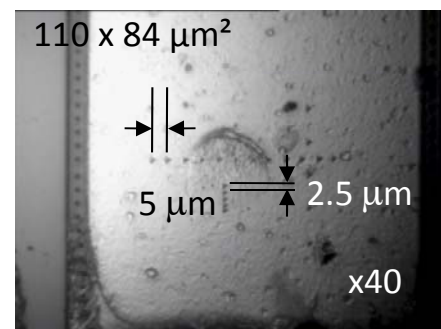
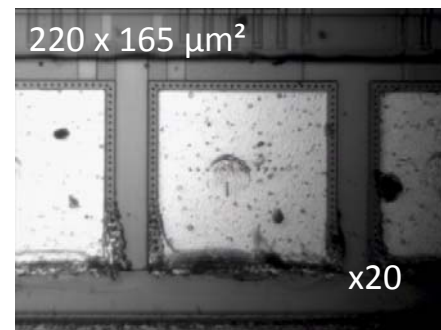
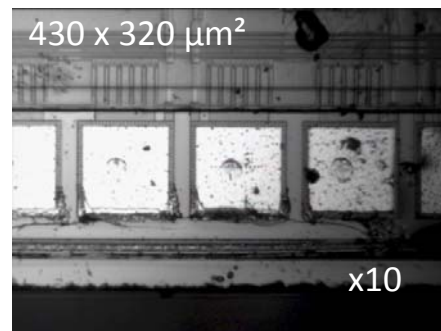
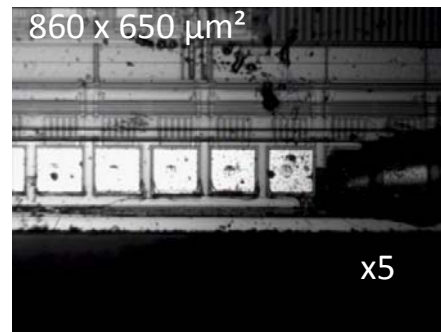
Custom-designed image analysis software allows images to be captured, and also calibrated length and area measurements to be performed on the captured image.

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 common file formats

Specifications

Lens	Field of view	Magnification
X5	860 x 650 μm	x 230
X10	430 x 320 μm	x 466
X20	220 x 165 μm	X 909
X40	110 x 84 μm	X 1800
X60	73 x 56 μm	X 2700
Camera	Monochrome CCD, 380 TV lines – 510 H x 492 V EIA composite output.	
Image card	32-bit, 33 MHz PCI, 720x488 NTSC/EIA, 720x576 PAL/CCIR Size: 121 x 70 mm.	



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Positioning stages allow precise positioning of the sample from the indentation head to the optical microscope. 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.

Open loop stepper motor

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. 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 .

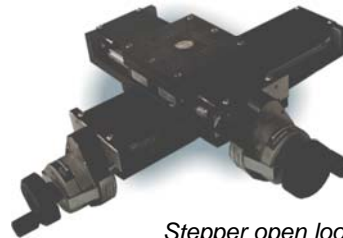
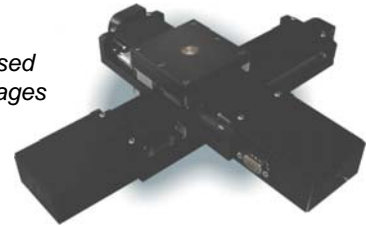
Z axis

The measurement head is repositionable on the stepper motor driven Z axis stage to allow for testing of large specimens. The long indenter shaft and clear span of the indenter and sample stage provides capability to test large or awkward shapes.

Closed loop DC motor

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

DC closed loop stages



Stepper open loop stages

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
Z travel		- 45 mm -	
XY Stroke*		120/45 mm	
Testable area		70x45 mm	
Inspectable area XY*		66x45 mm	

The specimens are mounted using a convenient magnetic mount. A specimen is typically held on to the removable mount using a thin layer of bonding adhesive (supplied). Mounts simply slide on and off the stages – no messy clamps and no damage to the mountings from screws etc.

**The stroke is the distance the stage will move from one extremity to the other. The testable area depends on the stroke and the size of the platen. The inspectable area is the size over which indentations may be placed and automatically observed in the microscope.*

** Requires Open Frame option*

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Introduction

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.

Calibration

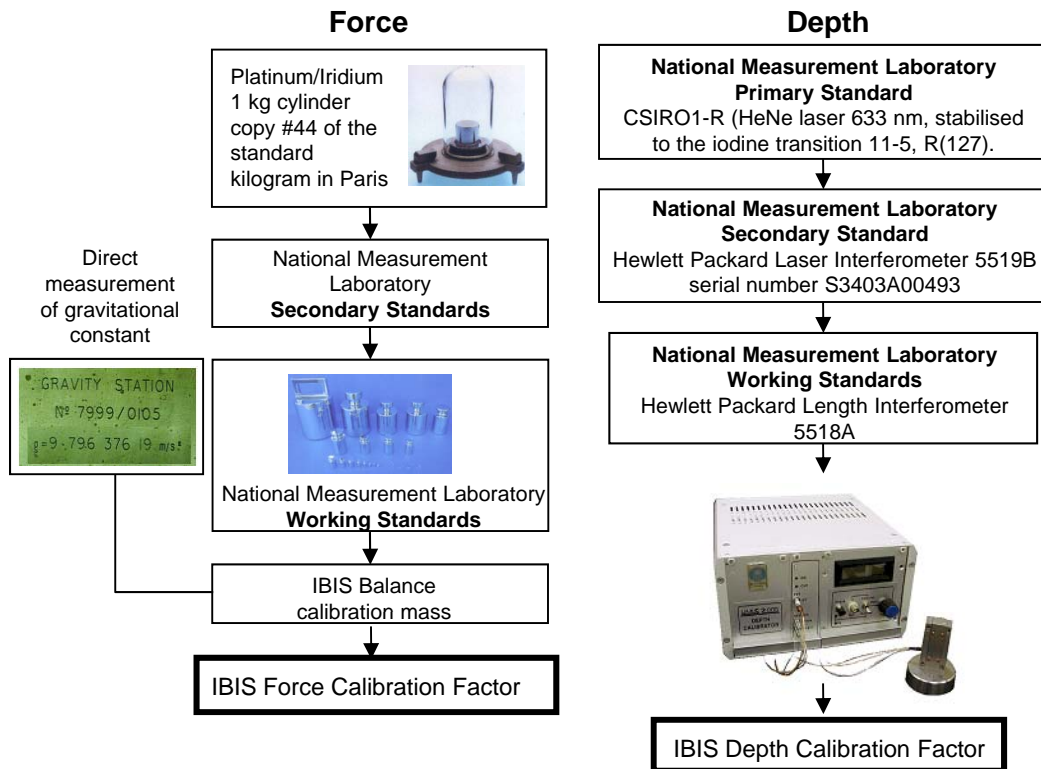
Each IBIS instrument is carefully calibrated with independent calibration of force and depth sensors. Then, the instrument is tested using three standard specimens covering a wide range of values for E and H to make sure that the results obtained are accurate throughout the range of material properties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

Standard Specimens

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. Independently certified standard specimens are also available.



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



IBIS instruments do NOT require recalibration in the field on a regular basis. Experience shows that the instrument will retain its initial calibration for upwards of 10 to 15 years.

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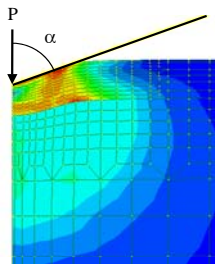
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Nanoindentation can be readily augmented by a range of additional measurement technologies. IBIS brings you the best, tried and true accessories that transform the instrument into a multi-disciplinary testing platform.

Finite element analysis

With an integrated and automated interface to commercial finite element packages, elastic-plastic stress fields for both loading and unloading can be calculated along with simulated load-displacement curves.

- 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.



Elastic plastic stress field for layered specimen



Ramped load scratch test

Scratch Testing

The IBIS lateral force module 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 μm to mm scale. The dual range device has typical ranges $\pm 200 \text{ mN}$ and $\pm 20 \text{ mN}$ with a maximum scratch length limited by the X axis.

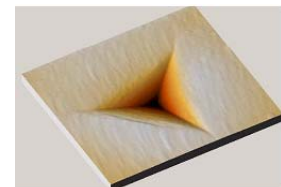
and more...

- Acoustic emission
- Hot stage
- Liquid cell
- Vacuum chuck

Atomic force microscopy

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 MFM 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.



DS95-50

- 50 x 50 μm scan size
- 2.7 μm and 5 μm z ranges
- Z resolution: Typical < 40 pm (rough sample) < 1 pm for flat samples with no physical slope.
- XY resolution: 16-bit resolution on all axis < 80 pm
- >1.5 mm approach
- Optical view 1 x 0.75 mm (x15 objective)
- AC, DC, LFM, EFM, PCM, MFM modes

DS95-200

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

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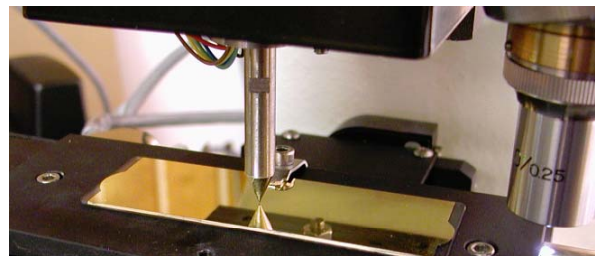
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The scratch tester accessory is an optional attachment that can be fitted to the IBIS or UMIS nanoindentation instrument for scratch testing operations. The accessory comprises a spring loaded table with a force sensor LVDT that allows the coefficient of friction to be measured during a scratch. The instrument can be used to perform a ramped increasing or steady load along a scratch path. The scratch may be repeated (wear test) many times or offset by a small distance (raster). During a scratch, the specimen is translated beneath the indenter by the X axis stage. The size or length of the scratch is limited only by the specifications of the X sample stage.



Features

- Sensitive and linear dual range LVDT lateral force sensor.
- Closed loop PZT direct acting normal force sensor maintains load for curved or sloping surfaces.
- Pre-scan for slope correction.
- Wear tests.
- Constant load or ramped load.
- Variety of indenter geometries.
- Maximum scratch length up to 136 mm.
- Full length of scratch can be scanned visually without removing or resetting specimen.
- Wide clearance for bulky specimens.
- Traceable calibration.
- Benefits from dual range normal force sensor in IBIS for use on hard materials.



When the scratch is repeated along the same path, then it is a wear test. For scratches on thin films, delamination can be observed by visual inspection and the load at that position along the scratch is the critical load for failure of the film. This is a form of adhesion testing. The scratch resistance or scratch hardness of a surface is a measure of its ability to resist permanent deformation by a moving indenter (as opposed to a stationary indenter in indentation hardness).

Specifications

Lateral force range	± 20 mN/ ± 200 mN dual range. Higher ranges available to order to ± 1 N.
Theoretical resolution	0.0006 mN/ 0.006 mN
Actual noise floor	0.005 mN/ 0.01 mN
Maximum scratch length	66 mm standard, 136 mm option
Maximum scratch speed	2000 $\mu\text{m}/\text{sec}$

Parallel scratches on gold film on glass with 5 μm spherical indenter with loads 5, 10, 15, 20 mN at 5 μm intervals.



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With current effective global communication, help with your IBIS instrument is never far away. A user support website contains downloadable training materials, program updates, and answers to frequently asked questions.

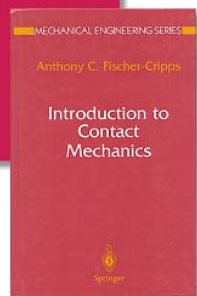
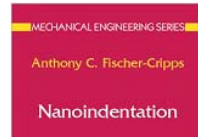
Extensive experience shows that nearly all problems can be resolved via email or by remote access to the instrument using the built-in diagnostics functions.

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



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

ISBN 0 387 22045 3



ISBN 0 387 98914 5

Upgrade policy

The IBIS instrument is a further development of the CSIRO UMIS. Many UMIS instruments are in active use even after 15 years service, and some are approaching 20 years life. Fischer-Cripps Laboratories does not “discontinue” products and offers an upgrade path for all instruments, both IBIS and UMIS, so that your investment remains current and productive long after the original users have moved on. In most cases, original instruments can be upgraded with a new computer and interface card and still remain competitive, reliable and accurate.

Testimonials

"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

"We made the right decision."
- University of Leoben, Austria

"We love our UMIS"
- Australian National University (ANU)

"I have only praise for the instrument as it has behaved impeccably since it's installation at the end of 2003"
- ICI, UK

"I am very happy with the machine and it never had any problems."
- IBM NY, USA

"The instrument is working fine and we are getting good results"
- Australian Nuclear Science and Technology Organisation, ANSTO

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

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