Microhardness Product Line

Measuring Instruments for the Instrumented Indentation Test

Coating Thickness

Material Analysis

Microhardness

Knowledge, Competence, Experience

Since 1953, FISCHER has created and produced increasingly innovative, powerful and versatile technologies for measuring coating thickness and microhardness, as well as for material analysis and testing. Today, FISCHER instruments are used all around the globe – wherever trueness, precision and reliability are essential.

Research and Development

Building leading-edge products requires a strong focus on research and development. All FISCHER products are developed and manufactured in Germany, where one in five employees works in R&D.

Highly qualified specialists – with advanced degrees in physics, chemistry, electronics, engineering and computer science – continually develop new products and processes to meet the ever-changing demands of the market. FISCHER also cooperates closely with universities and research institutes.

Material Testing

"Made in Germany" Quality

Keeping its manufacturing lines largely in-house allows FISCHER to fulfill its customers' expectations with truly superior products. In FISCHER's modern, high-tech production facilities, close attention is paid to even the tiniest details in order to ensure consistently high quality. Here, "Made in Germany" is more than just a merchandise mark: It is a point of employee pride and an integral part of the FISCHER philosophy.

Pioneer in Microhardness Measurement Technology

FISCHER is one of the pioneers in the field of microhardness measurement. One recognized at an early stage the tremendous potential of the instrumented indentation test method for determining microhardness. The first microhardness measuring instrument FISCHERSCOPE® H100, which uses this method, made its market debut in 1985.

MICROHARDNESS

The name FISCHER stands for powerful, reliable and durable microhardness measuring instruments. Many of the first generation instruments from the 1980s are still in use today.

Worldwide, FISCHER customers in industry, research and science depend on the reliability and accuracy of these fine instruments. FISCHER rises to this challenge with its rigorous quality standards and relentless development strategy to produce the most technically advanced, yet practical and easy-to-use measuring systems and software on the market.

Microhardness determination at FISCHER...

Tradition
For more than 30 years, FISCHER has been developing measurement systems for instrumented indentation depth tests in the nanometer to micrometer range.

Made in Germany
FISCHER develops and manufactures exclusively in Germany. Many of the first generation instruments from the 1980s are still in use today.

1985
Delivery of the first microhardness instrument **FISCHERSCOPE® H100**

1987
Beginning of efforts to standardize the hardness measurement under load. First publication by W. Weiler and Helmut Fischer on the topic of **"Microhardness measurements at the push of a button"**

1999
DIN-Norm 50359-1 bis -3 with decisive cooperation from FISCHER

FISCHERSCOPE® H100 C: New design, improved distance measurement, higher load resolution, integration of a XY-control, new software

2000
International Standard DIN EN ISO 14577. Participation in Standards Committee: FISCHER

2004
FISCHERSCOPE® HM2000 and **PICODENTOR® HM500**: Larger load range (HM2000) and increased vibration stability for industrial applications

2011
New instrument generation with a compact and dimensionally stable design, high-precision, programmable XY-stage, motor-driven Z-axis and improved optics

Revision of DIN EN ISO 14577 Standard 1 to 3 with significant cooperation by FISCHER

Instrumented Indentation Test

All FISCHER instruments operate according to the method of the instrumented indentation test. In this manner, they can determine the plastic and elastic material properties of even thin coatings, for example on sensors, on glass or on data carriers.

This is where the classic hardness measurement quickly reaches its limits, when the indentor is pressed into the specimen under specified conditions and then the geometry of the remaining indentation is measured optically. Most often, the hardness value obtained using classic hardness measurement methods is only a measure for the plastic material properties and does not include any information about the elastic properties. For this reason, the classic hardness measurement is not suited for primarily elastic materials or for the determination of characteristic elastic material parameters.

With the instrumented indentation test, the indentor penetrates the specimen using a specified load. During this process, the indentation depth is measured continuously. Because of the high resolutions for load (≤ 100 nN to ≤ 1 µN) and distance (40 to 100 pm), the FISCHER hardness measuring instruments can be used for a broad range of applications and materials. It is possible to measure even very soft materials such as rubber.

Advantages of the Instrumented Indentation Test

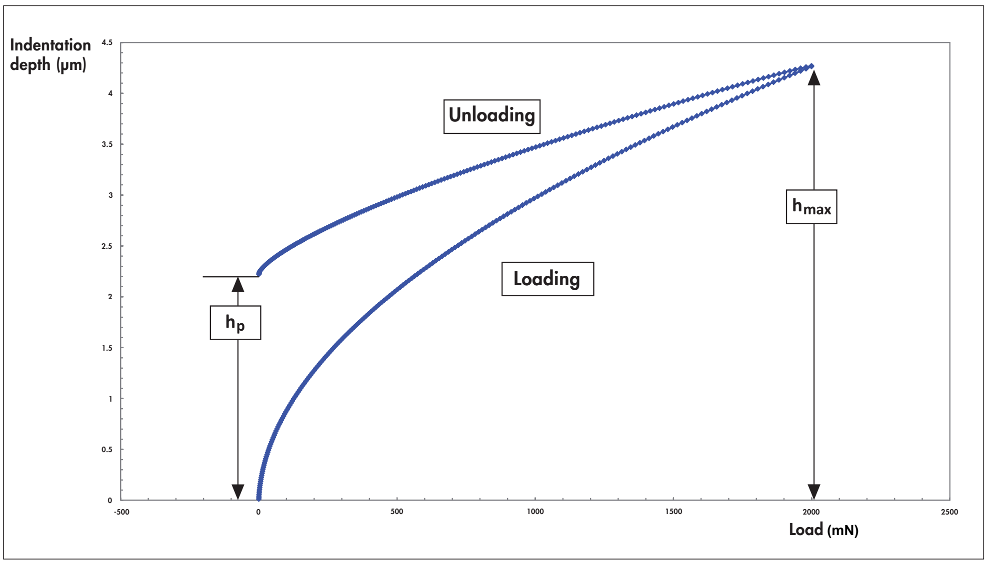
- Measuring elastic and plastic material properties with one measurement
- Measuring thin coatings without influence of the substrate material
- No influence by the operator due to partially automated measuring method

Measurable Characteristic Material Parameters

Measurement computation of characteristic material parameters according to DIN EN ISO 14577-1 and ASTM E 2546:

- Martens Hardness HM
- Indentation hardness H_{IT} (convertible to HV)
- Elastic modulus of indentation E_{IT}
- Indentation creep C_{IT}
- Elastic deformation portion η_{IT} of the indentation energy W_{elast}/W_{total} in%
- Additional characteristic parameters such as the Martens hardness at a certain test load, plastic deformation portion, etc.

Additionally all instruments feature the measuring method ESP (Enhanced Stiffness Procedure). This allows for the depth-related determination of H_{IT} and E_{IT}. For standard and ESP measurements, the test load is pre-specified.



h_{max}: *Maximum indentation depth during the test*

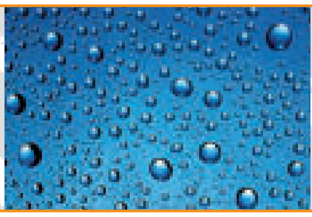
h_p: *Remaining depth of the indention after the end of the test procedure, plastic portion*

Instrumented Indentation test procedure sequence

FISCHERSCOPE® HM2000 S

The **FISCHERSCOPE® HM2000 S** is the cost-effective entry model for determining the microhardness of coatings in the micrometer range, i.e., for coating thicknesses greater than 1– 2 µm. It is very well suited for specimens that are easily positioned. With this instrument you are already able to determine the characteristic material parameters mentioned on Page 3. The HM2000 S is used by leading vehicle and paint manufacturers both in development and quality control.

The modular design allows for a later upgrade of the instrument, e.g., adding optics and a positioning device. Thus, your investment is secured for the future, even if your demands increase.



Determination of the influence of weather on paint coatings

Testing the wear resistance of thin anodic coatings on aluminum profiles

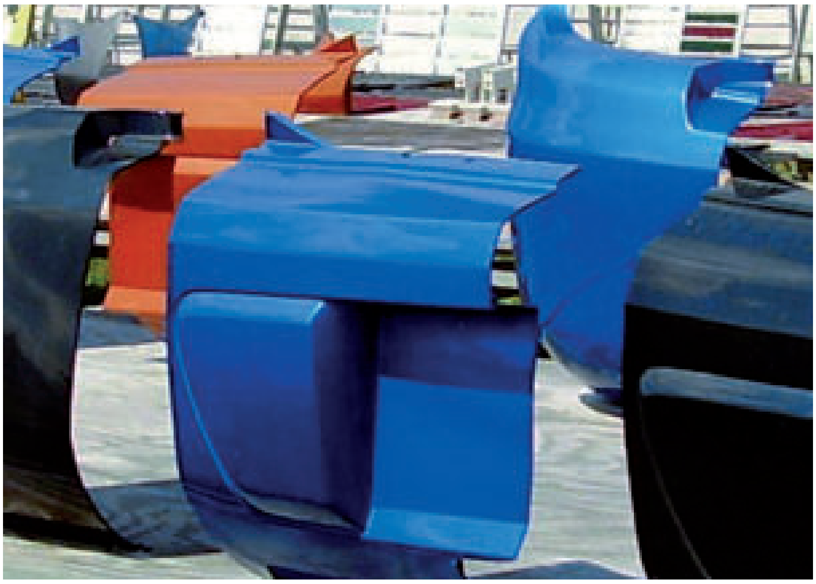
Application Example: Characterization of hard anodic coatings

Hard anodic coatings distinguish themselves through great abrasion and wear resistance as well as a high corrosion resistance. For this reason, they are also used for pistons and cylinders or for gears in the automotive industry. Using the HM2000 S, you are able to determine the wear resistance of hard anodic coatings easily via the microhardness, and this not only in the lab but also in the running production.

Application Example: Mechanical Characterization of Paint Coatings

Paint coatings can be found in various fields of applications such as the coating of metals, in household equipment or in the automotive industry. The main tasks are protection, decoration and function (in particular surface properties, e.g., altered electrical conductivity). The determination of the plastic and elastic properties of paint coatings using the instrumented indentation test allows for drawing conclusions about the hardness, the elasticity, the degree of polymerization and the resistance to UV radiation. If the results of different paints are to be compared, the same test conditions must be met for all indentation tests. You can carry out these tests quickly and easily using the HM2000 S.

To test weather influences, such as temperature fluctuations, humidity and aggressive media on the properties of the paint coatings, coated parts are exposed to various weather conditions using weathering equipment. Weather influences increase the hardness of the paint surface and the elasticity drops. You can verify the influences of the weather on paint coatings easily, quickly and precisely using the HM2000 S.



Outdoor weathering test site for testing paint against the influences of weather, Fig.: Atlas Material Testing GmbH

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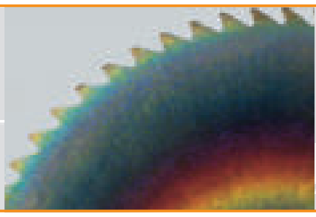
Features

- Quick measurements without extensive sample preparation, thus suited for lab and production checks
- Manual sample positioning
- Stone plate with silicon damper to reduce the vibration influence
- Intuitive operation with the individually configurable software WIN-HCU®

Typical Fields of Application

- Measurements on specimens with simple shapes
- Paint, plastic or hard material coatings (PVD, CVD)
- Electroplated coatings (decorative, functional)



Hard material coatings on tools

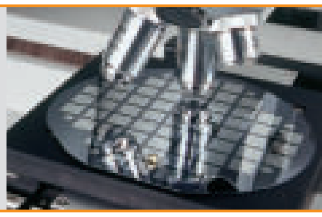
Determination of the properties of paints on various materials

FISCHERSCOPE® HM2000

The **FISCHERSCOPE® HM2000** is the measuring instrument for determining the microhardness of coatings in the micrometer range, i.e., for coating thicknesses greater than 1– 2 µm. The instrument is constructed of granite, thus ensuring a high dimensional stability. The motor-driven XY-stage and the motor-driven Z-axis allow for fully automatic measurements on multiple samples with a high throughput and with easy handling. With the integrated microscope with three magnification settings, the HM2000 is suited for demanding measuring applications with difficult positioning.

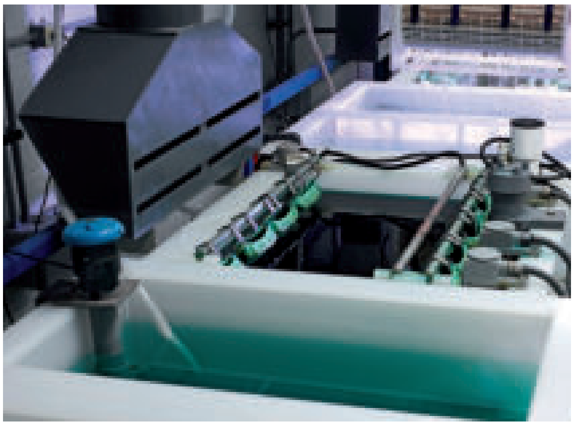
The modular design allows for a later upgrade of the instrument, e.g., adding high-resolution optics or a measuring stage with greater repeatability precision. Thus, your investment is secured for the future, even if your demands increase.

Hardness determination of hard anodic coatings on pistons



Automated measurements on a wafer

Application Example: Electroplated Coatings
The electroplating industry faces great challenges. On the one hand, regulations such as REACH demand the replacement of established chemicals with more environmentally friendly chemicals, and on the other hand industry demands on the coatings increase, e.g., increased corrosion resistance requirement in the automotive industry. Coating processed must be altered and optimized to meet these demands. The coatings can be characterized well using the instrumented indentation test. The HM2000 is capable of measuring the mechanical properties such as hardness and elasticity of coatings without the influence of the substrate material both in the lab and in monitoring the running production.



Electroplating facilities are typical areas of application for the HM2000

Application Example: Hard Material Coatings
Demands on tools in industrial production continue to increase permanently. New materials (e.g., high alloy steel) and higher cutting and processing speeds require new tool coatings that are applied with the PVD method (Physical Vapor Deposition), for example. Typical hard material coatings are TiN, TiAlN and CrN, which exhibit a Vickers hardness in a range of about 2000 to 3000 HV0.05 and coating thicknesses of about 1 to 15 µm. Quality assurance for coated tools requires reliable microhardness measurements. Conventional hardness test instruments have only limited suitability because they work with test loads that are too high. The indentors penetrate the coatings and measure a mixed hardness of protective coating and substrate material. To determine the coating hardness exactly, the indentation depth must not be greater than one tenth of the coating thickness (Bückle's Rule) – a measurement range for which the HM2000 is ideally suited.

Features
- Quick measurements without extensive sample preparation, thus suited for lab and production checks. The HM2000 requires only 30 seconds for its travel to the measuring position and the zero point determination.
- Programmable XY-stage for automated measurements
- Very user-friendly handling through motor-driven Z-axis
- Microscope with three different magnification settings for accurate positioning of the measurement location
- Due to the instrument's construction of granite, it has a high dimensional stability and is well isolated from vibrations
- Optional: Active vibration isolation table and enclosed measurement chamber to reduce the influence of vibrations
- Intuitive operation with the individually configurable software WIN-HCU®

Typical Fields of Application
- Paint, plastic or hard material coatings (PVD, CVD)
- Electroplated coatings (decorative, functional)
- Materials specifically for medical applications
- Electronic components, bond wires, etc.
- Automated measurements on several samples

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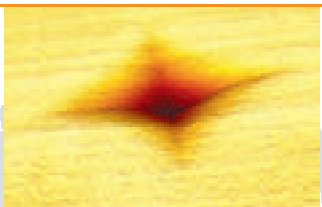
Electroplated coatings

Microhardness determination on a polished microsection

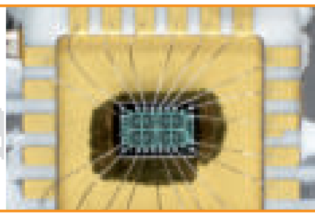
PICODENTOR® HM500

The **PICODENTOR® HM500** is the measuring instrument for the instrumented indentation test of coatings in the nanometer range, i.e., for coating thicknesses of less than 1 – 2 µm. The instrument is constructed of granite, thus ensuring a high dimensional stability. The HM500 is equipped with a high-precision, programmable XY-stage for sample positioning, an active vibration isolation table, an enclosed measurement chamber as well as a microscope with three different magnification settings. In this manner, the HM500 is suited for demanding measuring applications such as the hardness determination on polished microsections or the measurement on bond wires in the semiconductor industry.

The modular design allows for a later upgrade of the instrument, e.g., adding higher-resolution optics or an atomic force microscope that can visualize smallest material changes in the nanometer range. Thus, your investment is secured for the future, even if your demands increase.



Indentation of a Vickers diamond



Microhardness determination on bond wires

Application Example: Plug Contacts
Important properties of plug contacts such as abrasion resistance or bondability can be determined using the instrumented indentation test. The contact areas are selectively gold-coated, (depending on the alloy, the Martens hardness is between 1200 and 6000 N/mm^2) with coating thicknesses down to less than 1 µm for cost reasons.

The measuring application is demanding for two reasons: The coating thickness is less than 1 µm and the dimensions of the plug contacts require accurate positioning. You can measure such coatings easily and quickly using the PICODENTOR HM500.

Measurements of a Martens hardness of 0.2 µm thick gold coatings achieve a coefficient of variation of under 5 %.

Application Example: Eye Glasses Made of Plastic
Plastic glass in eyeglasses receives several coatings of various thicknesses in the nanometer range to achieve a scratch-resistant, soil resisting and anti-reflective surface. The test of the mechanical properties of such thin coatings requires a measuring system with high-precision distance measurement in the picometer range and load generation down to a few micro-Newtons.

Test of the protective coatings on plastic eye glasses

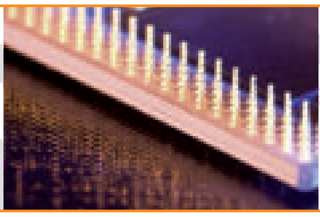
Features

- Quick measurements without extensive sample preparation, thus suited for lab and production checks. The HM500 requires only 60 seconds for its travel to the measuring position and the zero point determination.
- Measurements even on the smallest structures due to a high-precision XY-stage with a re-positioning accuracy of ≤ 0.5 µm
- Very user-friendly handling through automatic objective lens recognition and motor-driven Z-axis with auto-focus
- Microscope with three different magnification settings for accurate positioning the measurement location
- Due to the instrument's construction of granite, it has a high dimensional stability and is well isolated from vibrations
- Active vibration isolation table and enclosed measurement chamber to reduce the influence of vibrations
- Intuitive operation with the individually configurable software WIN-HCU®

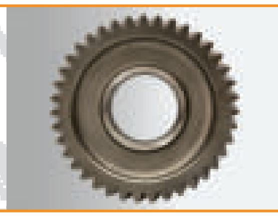
Typical Fields of Application

- Hard material coatings and ultra-thin DLC coatings
- Soil resisting coatings (e.g., Sol-Gel coatings)
- Coatings on PC hard disks / CDs
- Thinnest paint coatings
- Ion-implanted surfaces
- Nano coatings on sensors
- Implants / medical applications
- Matrix effect in alloys
- Biological materials
- Ceramic materials
- Hardness determination on polished micro-sections
- Automated measurements on several samples

MICROHARDNESS



Contact pins on chips



DLC coatings on cog wheels

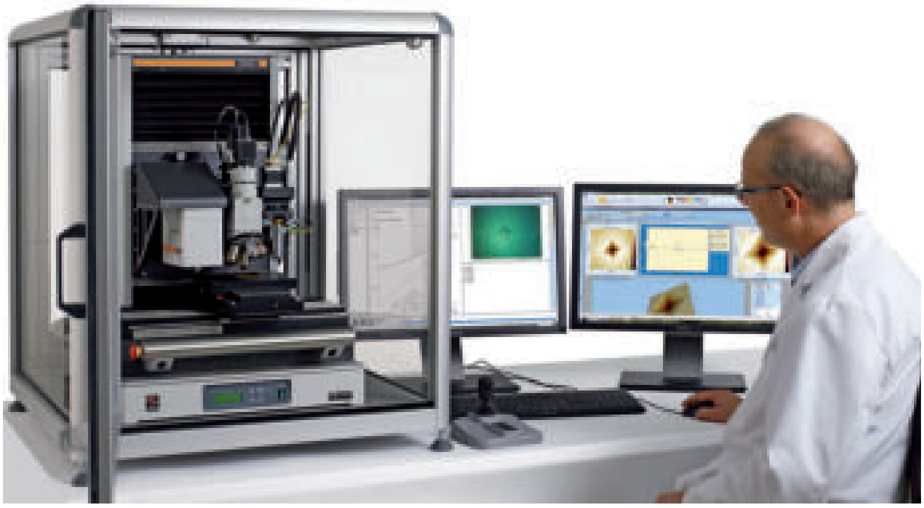


Fig. 1: PICODENTOR® HM500 with measurement chamber and atomic force microscope

Visualizing and Quantifying Structures in the Nanometer Range

To obtain further information about the material properties, the PICODENTOR HM 500 can be upgraded optionally with an atomic force microscope (AFM) (Fig. 1).

The programmable XY-stage with a re-positioning accuracy of ≤ 0.5 µm, the active vibration isolation table and the enclosed measurement chamber provide ideal conditions for additional AFM measurements.

An AFM physically scans the sample surface. For this purpose, the AFM employs a cantilever with a very fine silicon tip to measure height differences. The measurement area is scanned line by line and the height information is recorded point by point with high-precision. The resolution in the XY-direction is at about 10 nm.

The displayed data can be presented in different ways: In addition to the surface topography, which shows the height profile, the AFM also offers the capability to determine the phase and the amplitude of the cantilever oscillation. These two parameters provide additional information on material properties. In particular indentations of the indentor at the lowest maximum loads can be presented ideally using the AFM.

Fig. 2 shows the result of an AFM measurement. The typical pyramid shape of the Vickers indenter can be recognized. Thus, the AFM offers the ability to view optically no longer visible structures.

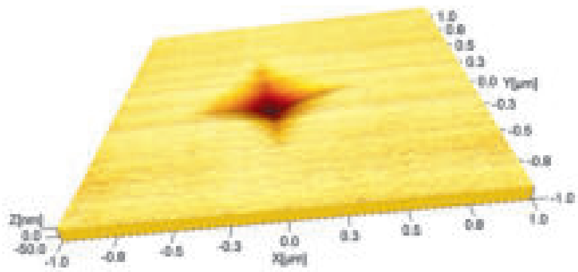


Fig. 2: AFM measurement (3D presentation) of an indentation with a maximum load of 5 mN (scale Z-axis: 50 nm)

Fig. 3 shows an additional example presenting a measurement on tungsten (F_{max}= 50 mN). The material bulges at the edge of the indenter impression, creating a pile up. The behavior is a characteristic property of tungsten and other materials. Pile ups increase the contact area at the instrumented indentation test and thus influence the characteristic parameters.

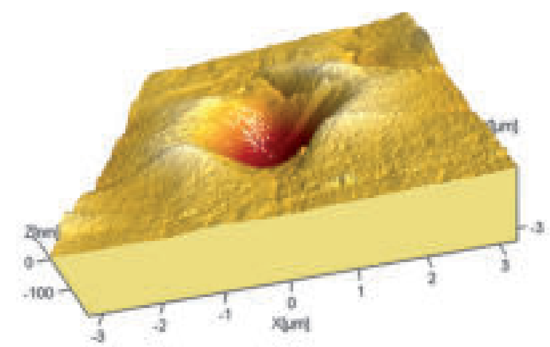


Fig. 3: Indentation of tungsten (F_{max}= 50 mN) with clearly recognizable pile ups

HM Universal Sample Support,
incl. Heating Station and Heating Plate
(Order-No.: 604-205)
For hardness measurements on up to four different specimens. The specimens are glued thermally to the sample inserts.

HM Support for Polished Microsections
(Order-No.: 604-204)
Support for polished microsection samples with a diameter of 20, 30, 40 and 50 mm and a height of 8.5 to 30 mm.

HM Foil Clamping Device
(Order-No.: 604-203)
Device for clamping thin foils for secure gap-free fixation.

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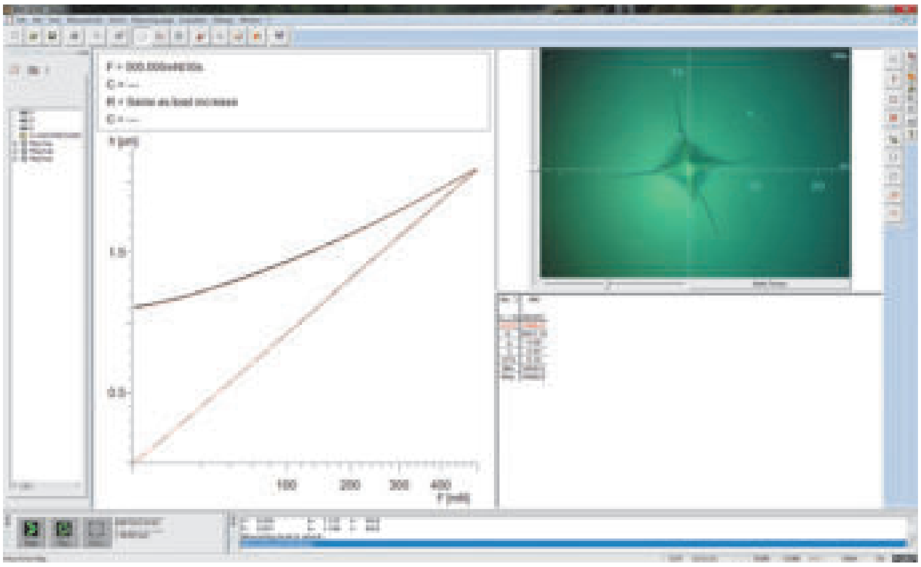
Universal Vice
(Order-No.: 604-261)
Vice for clamping specimens of different shapes.

Sound Insulation Chamber NOAH-M
(Order-No.: 604-810)
The sound insulation chamber NOAH-M is used to reduce external sound influences. For the most demanding applications in particular in connection with the PICODENTOR® HM500.

Indentors
All instruments come standard with Vickers-indentors. Optionally available are: Berkovich indentors, hard metal spheres and by request customer-specific indentors.



The main WIN-HCU window shows the video image of the measurement location- (not with the HM2000 S), the graphical presentation of the current measurement and a table with the current measurement parameters

All FISCHER hardness measuring instruments are supplied together with a Windows®-PC, where the WIN-HCU® software is installed. The software controls the hardness measuring instruments and provides the evaluation of the signals supplied by the instrument. The measured readings are stored and displayed on the monitor. Using the WIN-HCU, you can conveniently design and print the measurement results as a print form and export them to other applications (e.g., Excel®). The software is intuitive to use and can be configured individually, for example, you can set up users with different permission levels. You can also switch to a different language; Chinese and Japanese are available in addition to German and English. The software is based on the Standards DIN ISO 14577-1 and ASTM E 2546.

Programmable Test Cycle

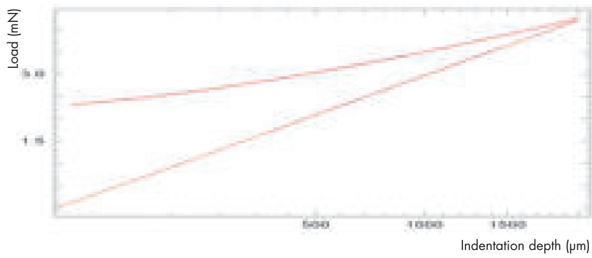
You can define the parameters for the test cycle, e.g.:

- Maximum test load
- Load decrease, creep
- Times for loading and unloading

Thus, you are able to define any desired measurement sequence. In this manner, you receive significantly more information about a material than with a conventional hardness measurement. You can save the defined parameters in order to repeat the measurement later with identical parameters, for example with different materials.

Measurements With the Standard Method

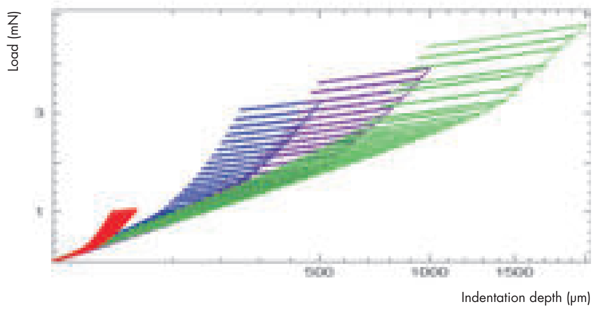
When making measurements with the standard method, the indentor presses into the specimen with a defined load over a specified period (load increase) and is then unloaded again over an additional specified time (load decrease).



Indentation depth / load diagram for a measurement with the standard method

Measurements With the ESP Method

When making measurements with the ESP method (Enhanced Stiffness Procedure), incremental loading and unloading (load increase and load decrease) is used. This allows for a quicker load and depth dependent determination of characteristic properties such as E_{IT}, H_{IT} or HV at one and the same sample location.



Indentation depth / load diagram for a measurement with the ESP method

Automated Measurements (HM2000 and HM500)
The instruments HM2000 and HM500 are equipped with a motor-driven, programmable measuring stage. This allows for programming of coordinates for the measurement spots in order to have the instrument measure automatically at various locations of the specimen.

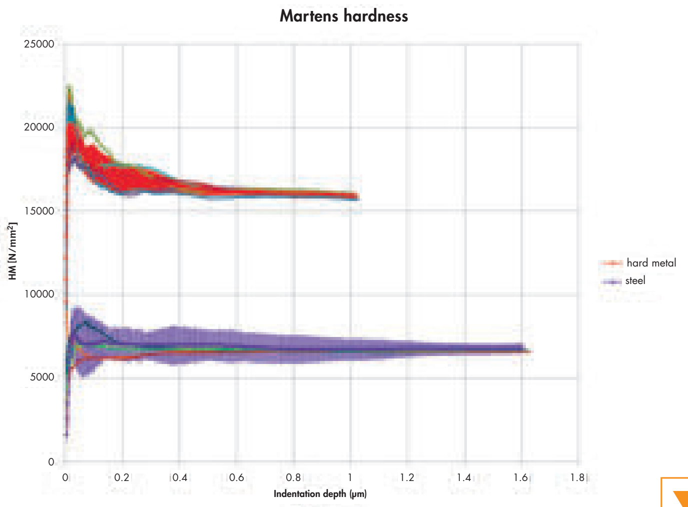
Autofocus With Contrast Grid (HM500)
The optics of the HM500 is equipped with an autofocus function. Typically, the autofocus function does not work for specimens with surfaces that are poor in contrast or transparent (e.g., glass). In order to focus even such difficult surfaces reliably, the HM500 can project a contrast grid onto the specimen surface.

Statistics
WIN-HCU automatically computes characteristic statistical parameters such as mean value, standard deviation, coefficient of variation, expected value, maximum, minimum, range.

SPC Chart
For a quick and concise verification of the quality, e.g., of a coating process in the running production, WIN-HCU offers a presentation of the measurement results in an SPC control chart with inserted control limits (UCL and LCL). In addition, the specification limits (USL and LSL) and the computed process capability factors C_p and C_{pK} are shown as numeric values. The group size can be adjusted.

Graphical Presentation
WIN-HCU offers a graphical presentation capability for all measurement results with any desired definition and scaling of the diagram axes, e.g.:
- Indentation depth / load diagrams
- Hardness / load diagrams
- Load / time diagrams

In addition, WIN-HCU is capable of computing mean value plots and presenting them as well as adding measurement plots from other measurement series for comparison purposes.



Martens hardness indentation depth diagrams of hard metal and steel

Data Export
Exporting the measurement results to Microsoft® Excel® or ASCII files is easy.

Vickers Hardness
The Vickers hardness can be determined using one of two methods: Via a conversion of the indentation hardness (H_{IT}) into a Vickers value according to DIN EN ISO 14577 or via direct optical measurement of the hardness indentation (not with the HM2000 S).

Taking Into Account the Shape Deviation of the Indentor
WIN-HCU takes into account the shape deviation (roof edge, tip radius) of the indentor through a simple determination of the correction function.

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Instrument Overview

Characteristics of all FISCHER hardness measuring instruments

The specified test load is generated with high accuracy. The measurement of the indentation depths is done with a resolution in the nanometer or picometer range. The extremely sensitive touch-down of the indentor allows for a precise determination of the zero point. The tip radius of the indenter is measured using a reference measurement and taken into account in the results. The micro-hardness measurement is computer-controlled, free of any subjective influences, and thus fully independent of a test person.

Test load
Test load range
Load resolution
Indentation depth
Max. indentation depth
Distance resolution
Positioning
Max. sample height
Support area
Re-positioning accuracy
Resolution
Objectives
Magnification
Video picture (field of vision)
Upgrade options
Typical Fields of Application

FISCHERSCOPE® HM2000 S	FISCHERSCOPE® HM2000	PICODENTOR® HM500
0.1 – 2000 mN	0.1 – 2000 mN	0.005 – 500 mN
≤ 400 nN	≤ 400 nN	≤ 100 nN
150 µm	150 µm	150 µm
100 pm	100 pm	40 pm
Manually with support stand	Motor-driven XY-stage and motor-driven Z-axis	Motor-driven XY-stage and motor-driven Z-axis
	130 mm	130 mm
	180 x 150 mm	180 x 150 mm
	≤ 1 – 2 µm	≤ 0.5 µm
	0.5 µm	0.1 µm
	• 4-, 20- and 40-x	• 5-, 20- and 50-x
	• 1600 x 1200 µm, 320 x 240 µm, 160 x 120 µm	• 1400 x 1000 µm, 350 x 250 µm, 140 x 100 µm
	• Objective lenses with greater magnification: 5-, 20-, 50- and 100-x • Precise XY-stage with a re-positioning accuracy ≤ 0.5 µm • Measurement chamber • Measurement chamber support frame	• Objective lens with 100-x magnification • Atomic force microscope (AFM) • Measurement chamber support frame • Sound Insulation Chamber NOAH-M
• Paint, plastic or hard material coatings (PVD, CVD) • Electroplated coatings (decorative, functional)	• Paint, plastic or hard material coatings (PVD, CVD) • Electroplated coatings (decorative, functional) • Materials specifically for medical applications • Electronic components, bond wires, etc. • Automated measurements on several samples	• Hard material coatings and ultra-thin DLC coatings • Soil resisting coatings (e.g., Sol-Gel coatings) • Coatings on PC hard disks / CDs • Thinnest paint coatings • Ion-implanted surfaces • Nano coatings on sensors • Implants/medical applications • Matrix effect in alloys • Biological materials • Ceramic materials • Hardness determination on polished microsections • Automated measurements on several samples

FISCHER worldwide

Those who wish to succeed in a global world must know the needs and requirements of their customers. We see ourselves as our customers' partners and, therefore, place great emphasis on excellent consultation and close cooperation. For this reason, the Helmut Fischer Group maintains its worldwide presence through independent companies and qualified sales partners; there is one near you.

In keeping with our high standards of quality and customer satisfaction, all members of the Helmut Fischer Group are certified according to DIN EN ISO 9001.

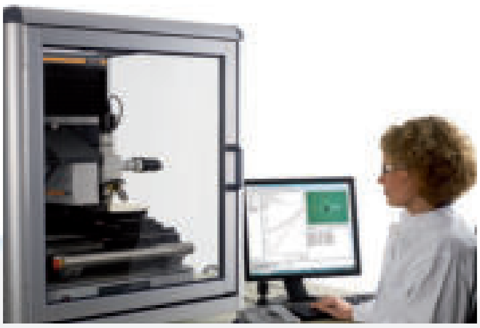
SERVICE

Service

Good service and efficient customer support are just as important to us as technically advanced and innovative products. For this reason, FISCHER has established a dense and tightly-linked network of service partners with highly qualified staffs. Offering extended services such as setup, maintenance, training, calibration, etc., we support you in every respect concerning your instruments and their uses. In this way, we ensure that the reliability and precision of FISCHER products are maintained. Worldwide.

Application Laboratories

More and more, demanding measurement applications require highly-qualified technical support. FISCHER helps its global customers meet these challenges through its strategically located Application Laboratories (Germany, Switzerland, China, USA).



Training and seminars

Because we want our customers to benefit maximally from our products, we also want to share our application know-how. Therefore, we offer trainings on measurement basics, seminars on the optimal use of the instruments and expert symposia on special topics.

FISCHER worldwide

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