

Nano Measurement in the 3rd Dimension

July 6 2009



The micro probe used in the micro-nano CMM measures the form and the spacing of two reference spheres with diameters of two millimetres each. The figure shows a survey of the system and the proportions of measuring probe and measurement object in detail. (Image: PTB)

From the motion sensor to the computer chip - in many products of daily life components are used whose functioning is based on smallest structures of the size of thousandths - or even millionths - of millimetres. These micro and nano structures must be manufactured and assembled with the highest precision so that in the end, the overall system will function smoothly.

Thereby, details are important - and therefore scientists at the Physikalisch-Technische Bundesanstalt (PTB, Germany) have developed a metrological scanning probe microscope into a micro and nano

coordinate measuring instrument. This now allows dimensional quantities with nanometer resolution also to be measured on three-dimensional objects in an extraordinarily large measurement range of 25 mm x 25 mm x 5 mm. The new device is already extensively being used at PTB - to a large part for calibration orders from industry and research.

Often, such small dimensions can be grasped only when they are transferred to everyday life. If we assume, for example, that someone lost a cube of sugar within an area of 25 square kilometres - the new micro and nano coordinate measuring instrument would not only be able to find it, but it would also be able to determine its exact position and shape. This does not only apply to plane surfaces, but also to three-dimensional landscapes, for example if the cube of sugar were stuck to a steep wall.

As increasingly, components with structures in the micro- and nanometer range are being used in industry, dimensional metrology on such structures is becoming increasingly important. To meet the increasing requirements for 3D measurements of micro and nano structures, 3D measuring probes newly developed at PTB were incorporated in a metrological scanning probe microscope based on a commercial nanopositioning system with integrated laser displacement sensors of the company SIOS Messtechnik GmbH. The new functionalities given by the measuring probe and the software extend the scanning probe microscope to a metrological micro/nano coordinate measuring machine (CMM) which also allows 3D measurements conforming to standards to be performed on micro and nano structures.

International intercomparisons on step-height standards and lattice structures have shown that the measuring system is worldwide one of the most precise of its kind. For step heights, measurement uncertainties in the subnanometer range - and for measurements of the mean structure spacing on extensive lattice standards even in the range of 10 picometers

- have been achieved and confirmed in comparison with optical diffraction measurements.

The new measuring instrument is available for dimensional precision measurements with nm resolution on 3D micro and nano structures such as micro gears, micro balls, hardness indenters and nano lattice standards as well as for comparisons of measures; moreover, it serves as a platform for research and development tasks. It is an important link between nano, micro and macro coordinate metrology.

Source: Physikalisch-Technische Bundesanstalt (PTB)

Citation: Nano Measurement in the 3rd Dimension (2009, July 6) retrieved 19 April 2024 from <https://phys.org/news/2009-07-nano-3rd-dimension.html>

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