INTERFEROMETER CHARACTERIZES MICROSTRUCTURES

On the track of the nanometer

Traditional measuring systems reach their limits when they have to characterize microstructures. One solution is to use a laser vibrometer together with a technical microscope and the nanopositioning and nanomeasuring machine from Sios Meßtechnik, Ilmenau. This set-up enables motions and surfaces of objects to be measured to a resolution of 0.1 nanometers.

Micro-electromechanical systems (MEMS) are devices or machines consisting of both electrical and mechanical components which work together as a system. Their measurements typically lie in the micrometer range. Examples of micro-electromechanical systems are: AFM cantilevers, pressure sensors, acceleration sensors, printheads in inkjet printers, mechanical image stabilizers in digital cameras, and sensor chips for use in pharmacy, biology and chemistry.

In order to ensure high quality standards, comprehensive characterization is essential throughout the entire development and production processes. This involves determining a number of parameters. These include dynamic characteristic values, such as resonance frequencies of vibrating structures and their modes of vibration, as well as static variables, such as the topography of a surface and values derived from it, such as structure heights and depths, deflections of membranes and roughness values.

As a result of continuing technical development, ever smaller structure widths are also establi-

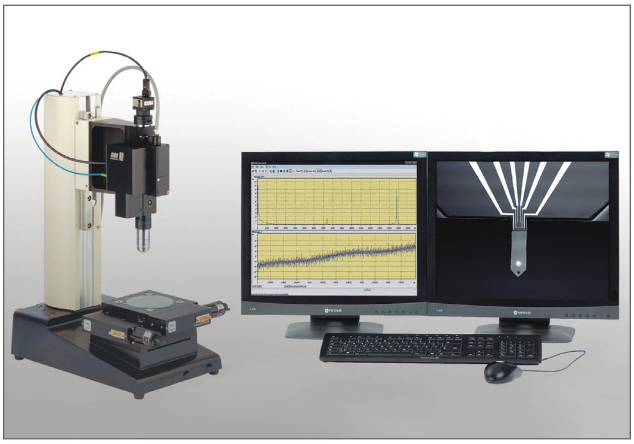

Fig. 1. The nano-vibration analyzer consists of a laserinterferometric vibrometer and a technical microscope.

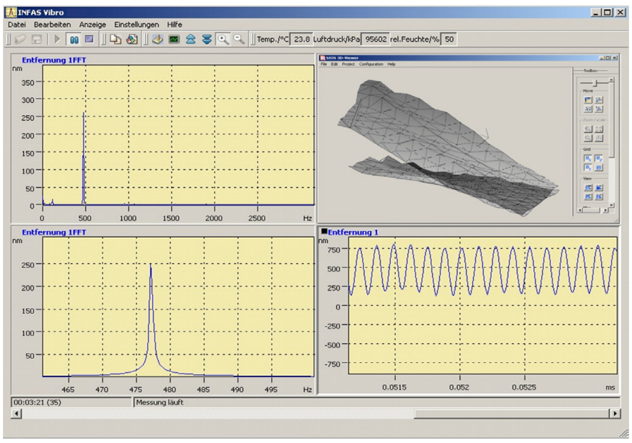

Fig. 2. The software enables surface vibration to be visualized in three-dimensions.

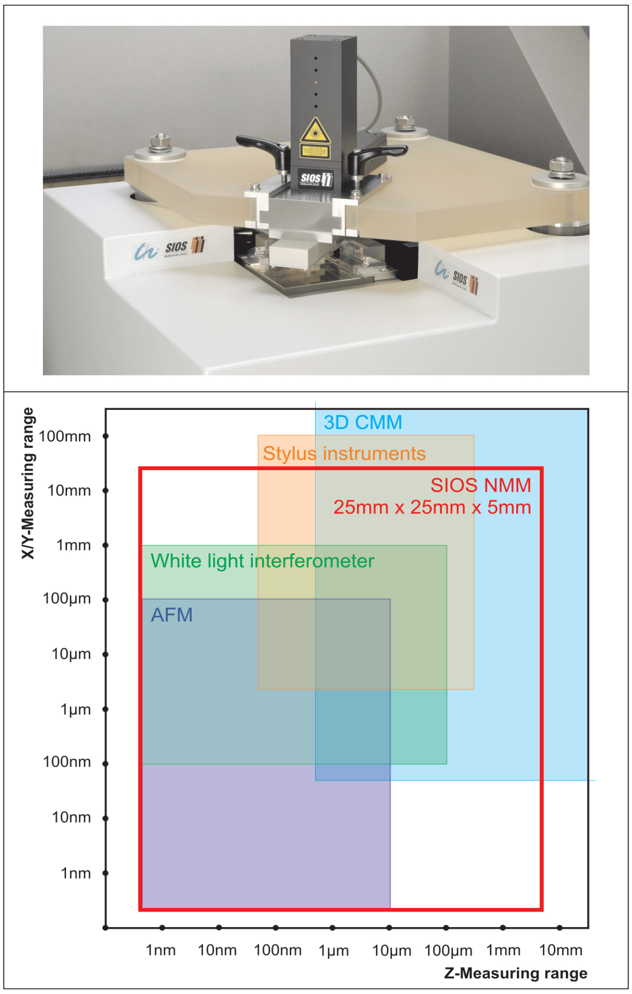

Fig. 3. The nanopositioning and nanomeasuring machine enables topographical analysis of microstructures and micro-electromechanical systems.

shing themselves in the microengineering field. This is where traditionally used measuring systems, such as tactile profilometers, reach their limits. They cannot guarantee the required location resolution in the submicrometer range. Moreover, the pressure of the probe tip may damage or destroy the object measured.
This is where laserinterferometric measuring processes offer a solution. For example, a laser vibrometer from SIOS Meßtechnik GmbH, Ilmenau, used in conjunction with a technical microscope can measure dynamic characteristics precisely and without contact. The nanopositioning and nanomeasuring machine together with various scanning systems can determine the topography of such a system with extreme precision.

Vibration analysis of microstructures

Laserinterferometric processes are suitable for measuring vibrations because they guarantee high precision, and the measurement results can be traced back to the international length standard.
The nano vibration analyzer works without contact, and consists of a laserinterferometric vibrometer together with a technical microscope. it is used for the non-contact vibration analysis of MEMS and microstructures (Fig. 1). The heart of the vibrometer is a Michelson interferometer. The optical-fiber coupling allows the use of a relatively small sensor, which is free from thermal effects of the laser. Used in conjunction a technical microscope, it forms a high-performance set-up for measuring the lengths and vibrations of MEMS, micro-objects and cantilevers.

According to the manufacturer, this device is characterized by a distance resolution of les than 0.1 nm and a frequency measuring range from 0 to 2 MHz. Interchangeable objectives enable the laser spot diameter and the working distance to the object to be varied. For example, the laser spot diameter of a 50x objective is < 2 µm. A positioning table with a 50 mm x 50 mm traversing range enables an object to be scanned. The object measured is observed by an integrated USB camera.
Special software enables the script-controlled scanning of the object measured, and also provides the possibility of spectral analysis and averaging of the measurement data. The velocity and acceleration of the movement of the vibration can be calculated, and the surface vibration displayed in 3D (Fig. 2).

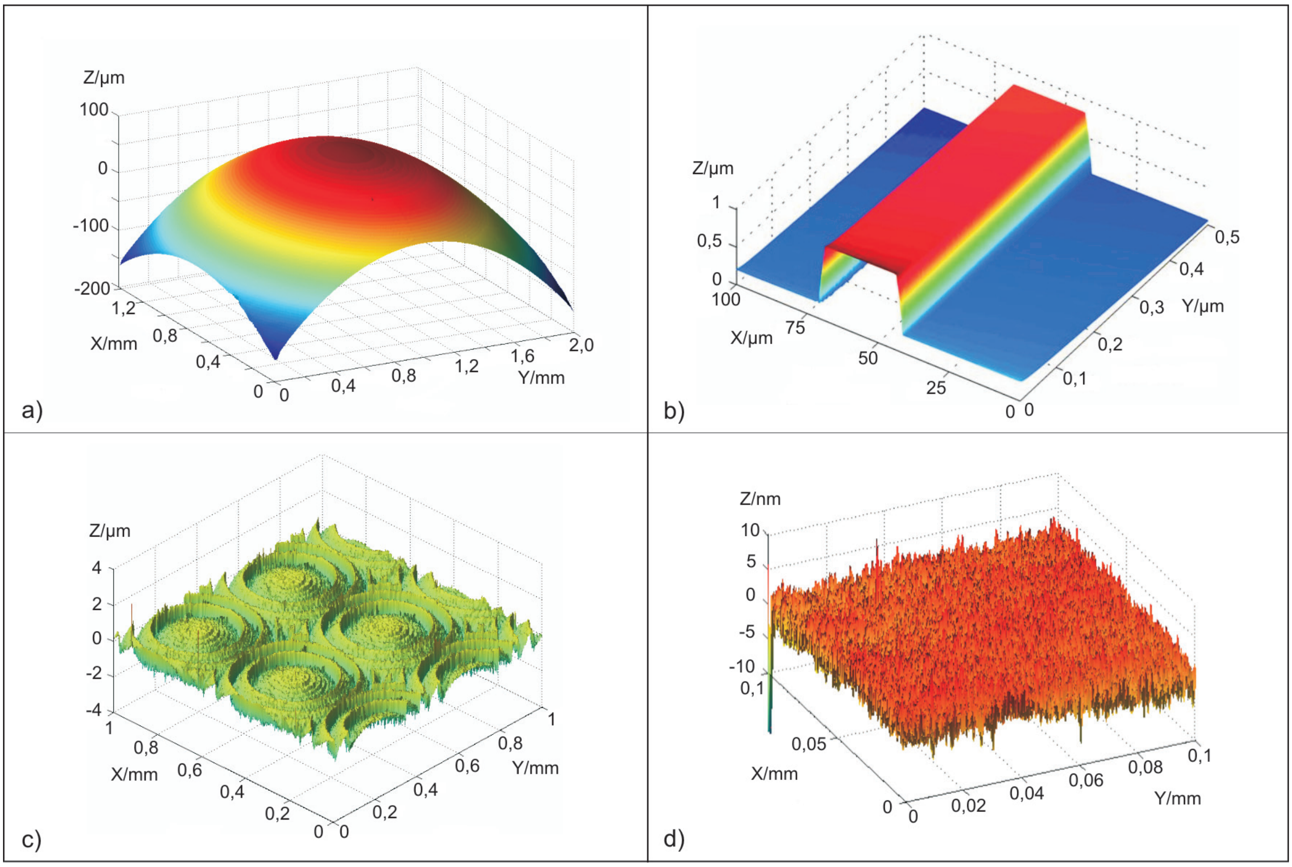

Fig. 4. Application examples of the nanopositioning and nanomeasuring machine: a) Hemispherical lens, b) Step height standard, c) Microlens array, d) Flatness standard

Analysis of the topography

The nanopositioning and nanomeasuring machine NMM-1 is an all-purpose device for analyzing the topography of microstructures and MEMS (Fig. 3). The high resolution of 0.1 nm in a measuring range of 25 mm x 25 mm x 5 mm together with the option of integrating various scanning systems enable 2D and 3D measurements to be made over a very large measuring range.

The precision of the nanopositioning and nanomeasuring machine is based on the arrangement of the three laser interferometers for position measurement. The three measuring beams meet at a point at which the scanning system also has its measuring point. This maintains the Abbe comparator principle in all three measuring axes. The scanning system serves as a zero point indicator within the nanopositioning and nanomeasuring machine. This maintains the Abbe comparator principle throughout the measurement. Optical and tactile scanning systems each have different characteristics and fields of application. Therefore it is important to select the best scanning system for each particular measuring task. All the scanning systems used have high reproducibility, and can be exchanged and mounted with the aid of a simple adapter on the metrological frame of the nanopositioning and nanomeasuring machine. The analog interface of the machine is open for the use of other, newer scanning systems. The following scanning systems are currently integrated into the nanopositioning and nanomeasuring machine:

- Laser focus sensor
- Atomic force microscope
- White-light interferometer
- 3D microsensor

These enable the machine to be used for diverse applications, such as positioning, manipulating, processing and measuring objects in fields such as microelectronics, micromechanics, optics and microsystem engineering (Fig. 4). Measuring uncertainties in the subnanometer range can be achieved. The measuring range of these high resolution measuring systems can be extended when used in conjunction with a scanning probe microscope. The nanopositioning and nanomeasuring machine is thus an all-purpose device for 2D and 3D measurement of MEMS and micro-objects.

Authors:

Dr.-Ing. Denys Dontsov
Dipl.-Ing. Enrico Langlotz

SIOS Meßtechnik GmbH
Phone: +49-3677-64470
E-Mail: info@sios.de
www.sios.de

SIOS Meßtechnik GmbH