Fast, High-Precision 3D Surface Inspection

Piezo Actuators Position Objectives

The best possible positioning accuracy is now essential in many technical fields. Examples of such fields range from semiconductor manufacturing and biotechnology through to optical metrology, microscopy and other imaging applications. For such applications, there is no serious alternative to nanopositioning systems with piezoelectric drives. These operate with repeatability in the nanometer range and response times below one millisecond, and with that they continually conquer new fields of applications. Often they even drive on technology, as the application in the field of microscopic metrology described hereafter shows.

With the BW-D501, Nikon Instech. Co. Ltd. has developed a new, high-speed measurement device which facilitates extremely high height resolution, 1 pico meter observations in three-dimensional, non-contact and non-destructive surface control of the most diverse materials (Fig. 1).

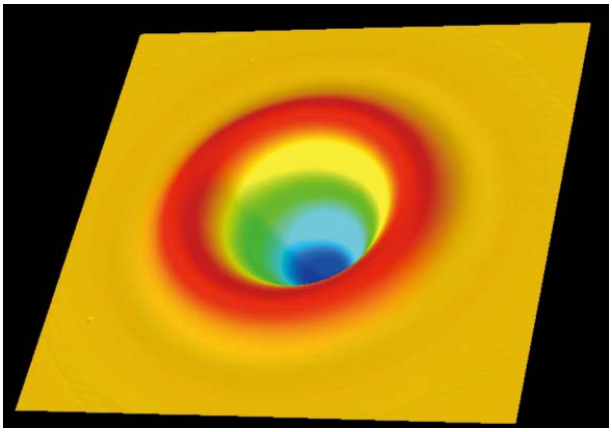

Fig. 1 Nikon BW-D501 Super High Vertical Resolution Non-Contact 3D Surface Profiler (image: Nikon/PI)

The deformation of gel samples or surface coatings when heated can thus be analyzed; a heating table required for this purpose is already integrated in the device. The inspection method is suited for numerous industrial applications since, in contrast to conventional methods, even surfaces with diffuse reflection characteristics offer no difficulty to the measurement device. Surface contours as well as the roughness of different surfaces can now be captured, visualized and analyzed with high resolution (Fig. 2).

Fig. 2 Fast, high-precision 3D surface inspection done with the BW-D501 from Nikon (image: Nikon/PI)

Capturing Roughness and Contours

The camera system of the measurement device initially examines the surface of the sample with high resolution. To get the depth of field necessary for a three-dimensional analysis, the optics is moved gradually in the direction of the Z axis. Depending on the position of the objective, different areas of the sample are put in focus. Afterwards, the individual images can be collated for analysis. Approximately 1000 images are necessary for a detailed, analyzable picture. The system works with considerable speed: Up to 2000 images are taken per second. To be able to display the detailed structure as well as the shape, as for example in an elevation map, the system additionally works with white-light interferometry. The interference pattern provides information on the shape of the surface.

The fast and precise positioning of the objectives is an important requirement for the analysis and for the assembly of the individual measurement results to meaningful pictures. For this purpose, a positioning system that moves the entire revolving nosepiece was directly integrated in the microscope (Fig. 3).

With it the all objectives mounted to the nosepiece can be moved with high precision in the direction of the Z axis.

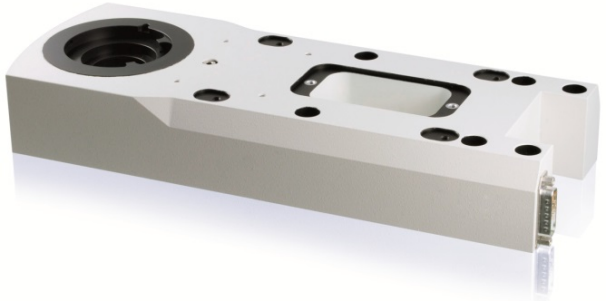

Fig. 3 The piezo-based nanopositioning system moves the entire revolving nosepiece with the different objectives in the direction of the Z axis (image: PI)

All of this can hardly be realized with conventional motor drives. The positioning system therefore is based on piezo actuators. They are supplied by the company Physik Instrumente (PI) from Karlsruhe, Germany. There were many reasons for this particular choice: Piezo actuators (Fig. 4) work without wear or friction and with no backlash.

Fig. 4 The piezo actuators work without wear or friction and with no backlash (image: PI)

In addition, they can accellerate with up to 10g and with that they are suited for high frequencies which are necessary for the real-time measurement of the 3D surface analysis. At the same time, play-free and high-precision flexure guides provide high focus stability and extremely straight motion.

This in turn means that travel ranges of up to 100 µm can be achieved in the application described above practically without lateral displacement of the objective. The accuracy of the motion of the kinematics is in the nanometer range. The flexure guides used for the transfer of force and motion operate without wear as well.

Capacitive sensors, supplied by PI, too, are employed for the precise measurement of the position while in motion. They measure the part of the mechanical system that is in motion directly and without physical contact (direct metrology) .Neither friction nor hysteresis affect the measurement. Combined with the position resolution in the subnanometer range, very good linearity values can be achieved. With this the position of the objective can be matched accurately to the corresponding image which is a necessary requirement for high-precision 3D surface inspection.

About Nikon Corporation, Instruments Company

The roots of Nikon Corporation, Instruments Company reach as far back as 1917 when three Japanese companies amalgamated to one enterprise which developed and produced high-precision optical glass. I

n 1925 already, they presented the first microscope which offered a revolving nosepiece where different objectives could be interchanged. In the coming decades, the upcoming enterprise set new standards in microscopy. Today, it is one of the market leaders in digital imaging applications and convinces again and again with innovative products. An example for this is the high-precision and real-time capable surface analysis, including the powerful and easy to use software for the analysis, described in this text.

Typical fields of application for the high-performance microscopy can today be found in the industry sector as well as in biology, medical engineering and materials research. Nikon has been actively represented on the European market since 1961.

About PI

In the past four decades, PI (Physik Instrumente) with headquarters in Karlsruhe, Germany has become the leading manufacturer of nanopositioning systems with accuracies in the nanometer range. With four company sites in Germany and fifteen sales and service offices abroad, the privately managed company operates globally.

Over 850 highly qualified employees around the world enable the PI Group to meet almost any requirement in the field of innovative precision positioning technology. All key technologies are developed in-house. This allows the company to control every step of the process, from design right down to shipment: precision mechanics and electronics as well as position sensors.

The required piezoceramic elements are manufactured by its subsidiary PI Ceramic in Lederhose, Germany, one of the global leaders for piezo actuator and sensor products.

PI miCos GmbH in Eschbach near Freiburg, Germany, is a specialist for positioning systems for ultrahigh vacuum applications as well as parallel-kinematic positioning systems with six degrees of freedom and custom-made designs.

Author

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