Optical 3D Surface Measurement Analysis in Medical Technology

Medical products have to fulfill exacting requirements. That is why surface properties are increasingly analyzed with optical 3D measurement systems. Beyond the microscopic examination in the lab, these also allow automated monitoring of the manufacturing process.

Raster electron microscopy (REM) is a technique frequently used in medical technology to inspect surfaces in medical technology. However, the determination of qualitative 3D topography of the surface is extremely complicated. It is therefore quite unsuitable for accurate and production-compatible 3D surface analysis (Fig. 1). REM analysis is also associated with time-consuming sample preparation. So tactile techniques are mainly used for surface roughness measurement. These, however, entail the risk of the probe tip damaging the object measured. Another aspect is the very slow speed of tactile measurement - area measurements often take hours. Optical 3D measurement techniques, such as confocal 3D microscopy, offer an alternative. NanoFocus µsurf (Fig. 2) is based on optical filtering using a confocal spatial filter (multi-pinhole filter). A precise 3D topography is calculated on the basis of the acquisition of a large number of optically filtered height sections (Fig. 1). In contrast to interferometers, disruptive stray light is already blocked out in the optical path.
This way the surface structures can be measured and imaged precisely – and down to the smallest nanometer dimensions. Typical measuring times for the µsurf are just a few seconds.

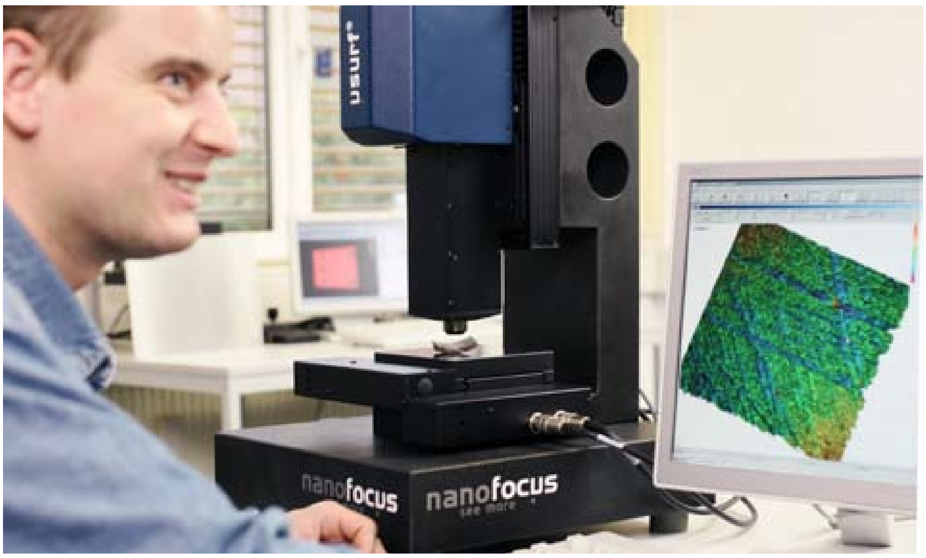

Fig. 2. Measurement with the µsurf confocal microscope: Height sections of the sample are acquired and combined to produce a 3D image

Measuring fast and precisely in a production environment

The µsurf system from NanoFocus in Oberhausen, Germany has already proven itself as a reliable and robust means of measurement in the automobile industry in many applications. Consequently, the NanoFocus expertise is also increasingly deployed in medical technology – both in research, as well as in production.
The high precision piezoelectric actuator for positioning the objective allows roughness measurements in the nanometer range. Extremely rough surfaces with steep edges can also be captured and evaluated. The accuracy and reproducibility of the measurement results is regularly verified based on ISO calibration standards.
Besides the measurement of 3D topography, confocal imaging also allows the calculation of images with infinite depth of focus. The size of the individual measurement fields varies with the objective down to 160 x 160 µm. Larger regions can also be measured through the automated composition of individual images (stitching).
The modular and compact system structure of the µsurf product series facilitates integration of the measuring head in modern production machines. The measurement and evaluation

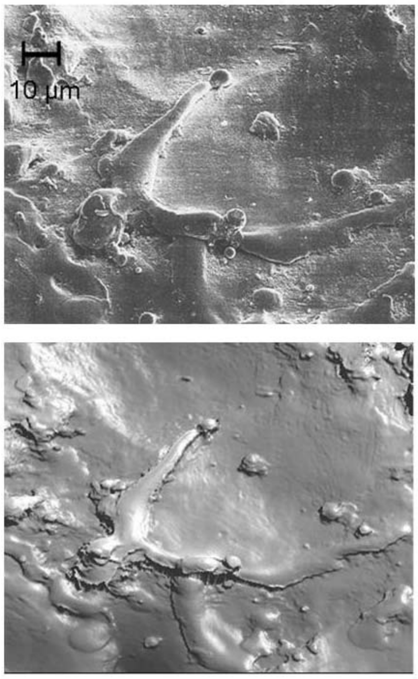

Fig. 1. Comparison between a µsurf optical 3D measurement (bottom) and a REM image (top) of an electrical discharge machined steel surface

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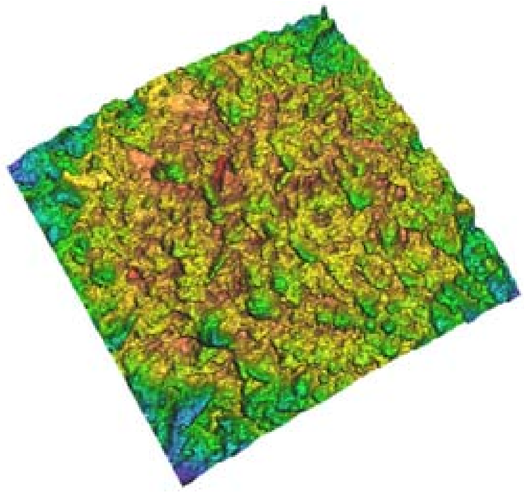

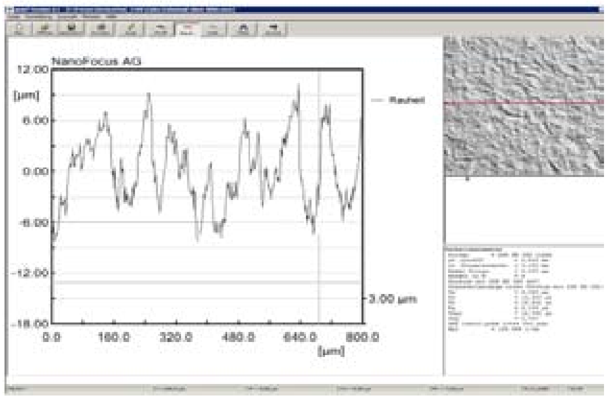

Fig. 3. Roughened structure of a dental implant, measurement field 800 x 800 µm: 3D topography (left) and roughness evaluation (right)

software µsoft serves to control the system and evaluate measurement data. Thanks to the easy-to-operate user interface, new users are in a position to perform complex measurements unaided within minutes. Besides extensive filter and masking functions, the evaluation of EN ISO roughness parameters and area-related structure analyses for tribological studies are also available to evaluate measurement data. Geometric measurement based on contour sections can be carried out directly in the measurement image.
Integration of customized evaluations and automation solutions are possible with the aid of software interfaces.

Inspection of roughness, layer thickness and topography

Surface structure is of particular importance for implants on account of the direct tissue contact. Roughening of dental implants helps healing into the jaw faster and more durably. Fig. 3 shows the structures of a dental implant roughened with sand blasting and subsequent etching (measurement field 800 x 800 µm). The ongoing measurement of the 3D surface roughness during the production process guarantees the manufacturer adherence with prescribed roughness tolerances. As well as the measurement of the 3D topography of the outer shell, the thickness of transparent coatings can also be determined on the basis of depth resolved confocal evaluation. These investigations are necessary for stents (vessel implants) to assess the homogeneity of bioactive coatings.

With the µsurf, the accuracy of measurements of this type is also in the nanometer range. Transparent layers can be captured from 1 µm upwards. Electrically operated implants call for painstaking selection of materials, as well as the characterization of the structure and bonding technique for component groups and finished products. The interface – or more accurately the surface – between the material of the electronic product and the human body is of particular interest here. Long-term interactions can occur here, such as material damage, system failures or harm to the patient.
Cytotoxic testing according to EN ISO is carried out for assessment (Fig. 4). The great advantage of this method over classical REM analysis is measurement without a preceding period of preparation. Living cell cultures can also be captured.

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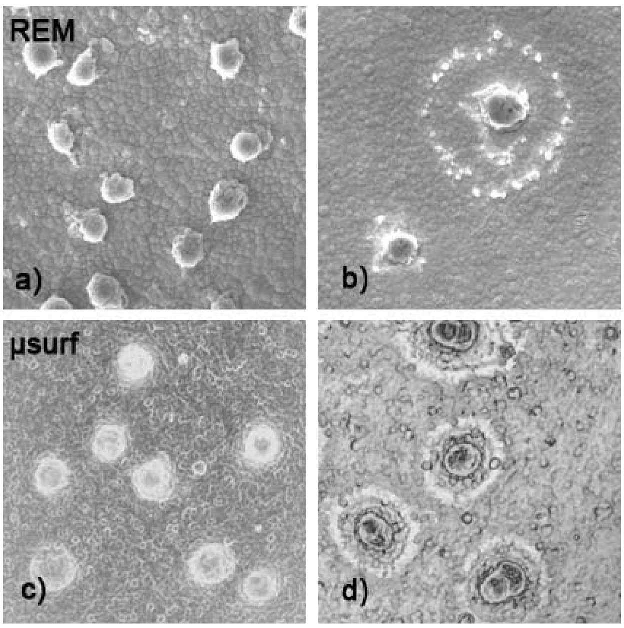

Fig. 4. Necrotic cell culture on a gold-nickel coating measured with µsurf. A change in the cell structures after 48 and 72 hours is clearly identifiable. A 100x objective with an image field of 160 x 160 µm was used for the measurement

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