3D Optical Microscopy

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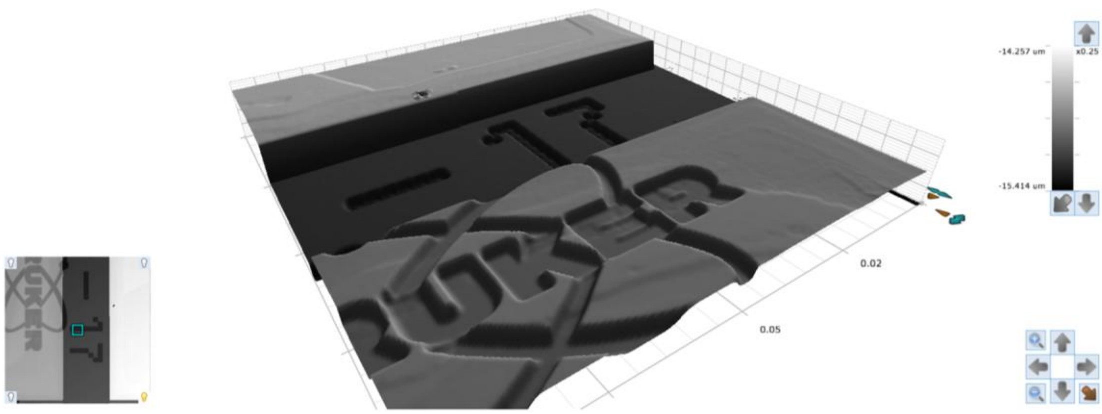
Measuring surface topography and the size and shape of microscopic surface features is critical in many different industries to ensure the quality of production processes. The variety of instruments used for this task, such as stylus profilometers, atomic force microscopes and Fizeau interferometers, each have their own advantages and limitations.

3D optical microscopes can use white light interferometry to provide a complete 3D surface profile of a sample or product. The latest generation of 3D optical microscopes delivers a powerful combination of high-speed operation, an ability to function in factory environments, and uncommon accuracy, including sub-nanometer resolution in the vertical (z) axis. As a result, this technology is being used in an increasingly wide range of applications, such as inspecting critical wear of surfaces in the automotive, aerospace and other industrial markets. Other examples run the complete gambit of manufacturing, from the characterization of the tooling used to produce contact and intraocular lenses (IOLs) to measuring the patterned sapphire substrates used in high-brightness light-emitting diodes (HB-LEDs).



3D optical microscopes provide detailed surface topography data

3D optical metrology

Different industries have different surface metrology challenges. For example, rotary dynamic sealing applications in the automotive and aerospace industries depend upon the performance of the shaft and the seal interface to avoid leakage and premature wear that can reduce performance and service life. These applications require precision measurement of the surface texture of the shaft, as well as characterization of the presence of spiral grooves on the shaft, known as “lead” or “twist,” that contribute to sealing system failure and leakage.

The ophthalmics industry, on the other hand, faces the need to measure a new generation of contact lenses and IOLs that contain surface features with nanometer level geometry as well as aspheric and diffractive designs with non-symmetric geometries in different axes. Patterned sapphire substrate features used to enhance light extraction efficiency in HB-LEDs require rapid measurement of height, width and pitch to identify problems which adversely affect yields.

Bruker ContourGT-I 3D Optical Microscope

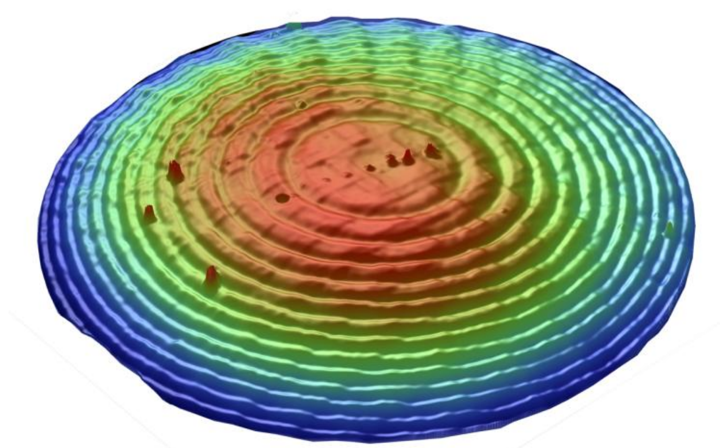
3D optical microscopes have demonstrated the ability to meet these challenges. In an optical profiler, light approaching the sample is split and directed partly at the sample and partly at a high-quality reference surface. The light reflected from these two surfaces is then recombined. Where the sample is near focus, the light interacts to form a pattern of bright and dark lines that track the surface shape. The microscope is scanned vertically with respect to the surface so that each point of the test surface passes through focus. The location of the maximum contrast in the bright and dark lines indicates the best focus position for each pixel, and a full 3D surface map of the surface within the field of view of the microscope is generated. Onboard software is then employed to analyze these data to calculate different parameters of interest such as surface texture, roughness or other critical geometric dimensional information.

Dynamic sealing surfaces

3D optical microscopes can accurately perform dimensional measurements and characterize surface texture, functions critical to inspection of rotary dynamic sealing surfaces. In addition to traditional 2D surface measurements such as Ra, Rz and Rpm, the 3D optical microscope provides data on 3D topography that enables computation of 3D S-parameters, such as Sa, Sz and Spm. These 3D data can be used to build a global surface representation over which to assess lead angle and other critical surface parameters for sealing applications. Additionally, these 3D data are generally a more accurate representation of the critical sealing area of a shaft and are insensitive to alignment during measurement. These advantages provide key benefits over traditional 2D stylus inspection tools for manufacturers involved in the production of shafts for dynamic sealing systems.

Ophthalmics

In the ophthalmic industry, 3D optical microscopes provide a much more complete representation of the surface under test than is produced via a 2D stylus trace, and also provide comparison to best-fit surface models and comparison to design intent. 3D optical microscopes provide the capability to measure significant step heights and so can be used to measure diffractive structures that are sometimes used in the production of bifocal lenses or IOLs that cannot be measured easily via stylus or Fizeau interferometry due to the discontinuous nature of the surfaces. The more complete and accurate measurements provided by 3D optical microscopes can provide tooling level feedback for ophthalmic manufacturing that is not possible to obtain by a stylus system alone.



3D image of bifocal contact lens

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HB-LEDs

> **"3D optical microscopes can accurately perform dimensional measurements and characterize surface texture."**

Patterned sapphire substrates (PSS) have been widely adopted in the fabrication of HB-LEDs. A PSS wafer is a substrate that has been conditioned to present a repetitive grid structure as the base upon which to build epitaxial layers for the construction of LED devices. This patterning in turn positively influences the emission of light from the device through a few mechanisms. As manufacturers move to larger substrate wafers, increased need for metrology to monitor the key dimensional parameters for PSS is evident. Proper metrology can have a major impact on wafer yield. Highly accurate 3D optical microscopes can quantify the height, width and pitch of PSS features on production wafers as well as identify failing material in a production environment. Due to greater operating speed, higher sampling ratios relative to other measurement techniques can be achieved. A 3D optical microscope based on interferometry improves PSS yield by substantially reducing the time required to make 3D measurements of parameters of interest and enabling binning as well as rejection of failed material near the production line.

Measuring surface topography and the size and shape of microscopic surface features plays an important role in many industrial processes. The 3D optical microscope, based on white light interferometry, is an ideal tool for many of these surface metrology applications, providing non-contact, quantitative measurement with sub-nanometer resolution in the vertical (z) axis.