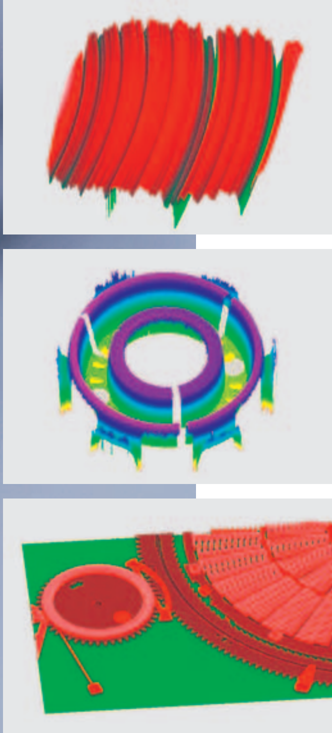

We Won’t Scratch the Surface

Precise Measurement of Structured Functional Surfaces with TopMap White-Light Interferometers

Structured functional surfaces with tight tolerances require high-precision measurement systems that can quickly record the surface topography of a work piece or object. This is why white-light interferometry, making vertical measurements with an accuracy of a few nanometers and even sub-nanometers, has become a standard tool for industrial quality control.

Introduction

White-light interferometers allow non-contact assessment of parameters such as flatness, parallelism, roughness and ripple. As an optical height gauge, white-light interferometry allows for non-destructive and rapid measurement, even of soft surfaces and – under certain conditions – determination of layer thickness.

By using short coherent light, Polytec white-light interferometers avoid the disadvantages of other interferometric measurements, which fail due to speckle effects or from fringe ambiguity when determining step heights or surfaces that are not joined.

The optical configuration of a typical modern white-light interferometer consists of a light source with a coherence length in the µm range, a beam splitter, a reference mirror, and a camera with a lens system. The operating principle is described in detail in the latest edition of the Polytec tutorial pull-out.

Polytec's TopMap topography measurement systems incorporate interferometers designed to solve specific technical applications. Please find an overview of the full range of Polytec White-Light Interferometers on our website www.topmap.info.

Telecentric Optics for Extensive Measurements

The classic Twyman-Green interferometer is an example of a system with telecentric optics. Depending on the primary use, Polytec offers various models in the TopMap series – well suited for quick throughput on a production line, for high-resolution measurements in a laboratory, or for universal applications.

In the case of interferometers with telecentric construction, lateral resolutions between 10 to 50 µm and fields-of-view in the centimeter range are typically attained (limited by lens aperture). The vertical travel range is many

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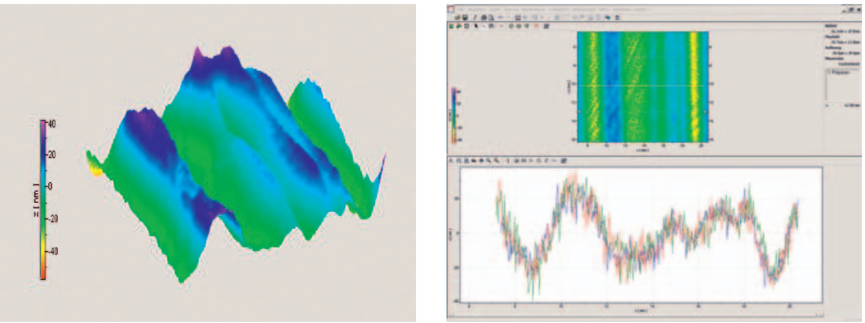

Figure 1: Monitor film (left) and polished glass surface (right).

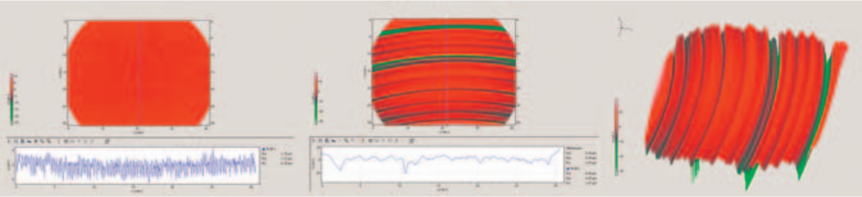

Figure 2: Wear patterns of brake disks.

centimeters, enabling measurements even in holes up to 70 mm deep.

This allows for challenging tasks to be handled, such as taking measurements in cavities it is necessary to determine distance between two surfaces, parallelity, or flatness; it also enables measurements with fields of view of up to 50 mm. Validating manufactured parts with these design parameters is very important, for example, in the automobile industry.

Microscope Optics for Lateral High-Resolution Measurements

If high lateral resolution is required, then microscope systems are the obvious choice, where the optical configuration, including the reference arm, is integrated into the lens (e.g. Mirau lenses). Depending on the lens, this allows you to attain a lateral resolution of 1 µm or less. The Polytec TopMap µ.Lab is such a system, quickly recording the topography of microstructures and offering high performance analysis options – for example when taking measurements of micro-sensors, actuators, and other MEMS components. The investigation of structured metal sheets or the bearing surfaces in crank handle housings are further applications requiring high lateral resolution.

Standardization of Surface Measurement Technologies

Surface measurement of large areas is very time consuming when using tactile (contact) sensors. Different measurement procedures generate different results according to surface structures and parameters. Depending on the interaction between the sensor and the surface, they register and display different boundary layers. With the classic profile method, errors can occur as mechanical probes cannot record small or very jagged structures, and can even damage the surface if it is soft.

Optical methods can overcome these difficulties, substantially cutting the measurement time while eliminating damage to the surface and increasing throughput and while cutting metrology costs. New national standards, as well as the current international ISO standardization activities in the area of geometric product specifications, now also include other procedures besides the profile method for setting surface standards. This means that the traceability of results is ensured and optical measurements become comparable to each other.

Polytec employs a special approach using sample-specific measurement and algorithms by means of simple Macro programs which enhance the comparability and reproducibility of the measurement results. Hence, white-light interferometry is a high-powered and reliable measurement procedure for surface parameters.

Example: Large Surface Measurement with High Accuracy Requirements

With white-light interferometry, the vertical resolution is independent of the horizontal field-of-view and, thus, from the horizontal resolution. The examples in Figure 1 with their smooth surfaces give a good idea of what height resolution can be attained under “normal” laboratory conditions. Under optimal conditions, it is even possible to attain accuracy in the sub-nanometer range. Measurements on large surfaces are fast. With TopMap's large field-of-view (FOV), it is not necessary to analyze many small FOV's and stitch them together.

Wear and tear studies are typical applications for topography measurement. In Figure 2, topography images of the abrasion behavior of brake disks are shown.The results can be used for failure analysis.

Example: Machine Setup

Checking the setup of processing machines is another application. Here, the relevant parameters are checked before the manufacturing series starts, and the processing machine settings are optimized. In Figure 3, a processed part with two surfaces touching each other is shown. The lower surface, at a depth of approximately 3.4 mm, is measured with regards to its flatness (right) and parallelity with respect to the upper surface (middle).

Source: Polytec InFocus 2/2007, Polytec GmbH

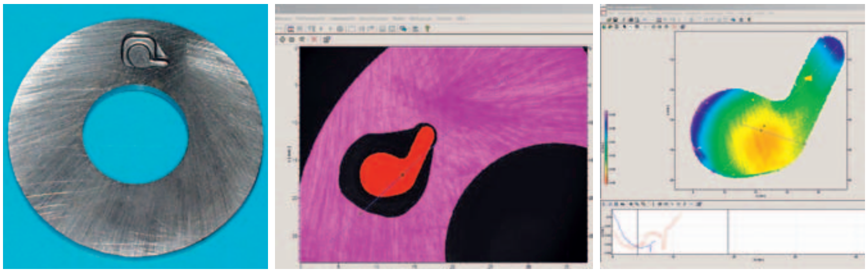

Figure 3: Position and shape of two touching surfaces.

Example: In-Line Quality Control

Industrial production testing requires measurement cycle times of only a few seconds. Within this time frame, the pass/fail analysis must be done. Inspection must be fully automated, low maintenance, and ruggedized to cope with demanding environmental conditions. To ensure a 1 µm tolerance of the sample dimensions, a measurement precision of 100 nm or better must be achieved. In Figure 4, the result is shown of a typical automated test sequence measuring a shock absorber component with regard to the average distance between two plane surfaces (left) and a circular profile (right).

Due to positioning inaccuracies that occur when loading samples, a quick screening measurement is first performed to find the height interval of interest. This measurement is subsequently retaken at higher precision and lower scan speed. The evaluation yields the sample masks and distances of the cross-sections. In addition, one of the planes is adjusted using linear regression, and tilt with regard to the other plane is calculated. The whole procedure is completed within 4 to 10 seconds in this case.

Example: Measurement of Large Surface Area and Microscopic Detail on an Atomizer Membrane

As explained above, Polytec has developed various measurement techniques for different fields-of view-and, thus, different horizontal resolutions. In Figure 5, the profile is shown of an atomizer membrane measured with a telecentric TopMap Pro.Lab (left). Horizontal resolution in this case is approximately 50 µm with a field-of-view of approximately 40 mm x 30 mm; however, the atomizer holes smaller than 50 µm are not resolved. The TopMap µ.Lab microscope system with a 20x lens can correct this problem and resolve these holes (middle), and with the 50x lens, it is even possible to analyze the topography of the ejected material on the periphery of the holes (right) with a field-of-view limited to approximately 180 µm x 230 µm.

Summary

White-light interferometry is an important tool for non-destructive quality assurance. Surface parameters can be determined, structures analyzed and faults detected. Large height jumps in a profile and grooves with large aspect ratios can be measured with white-light interferometry. The vertical resolution can be in the sub-nanometer range and, in practice, is only limited by ambient conditions, not by the technology itself.

Restrictions on the types of surfaces that can be measured are relatively few – surfaces can be smooth or rough, stepped or tilted, dark or light. As optical boundary layers are acquired, a degree of transparency in the work piece does not pose any problems, in contrast to oblique light methods, for example. All-in-all, this makes white-light interferometry a universal tool for capturing surface topography.

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Figure 4: Topography of a shock absorber component.

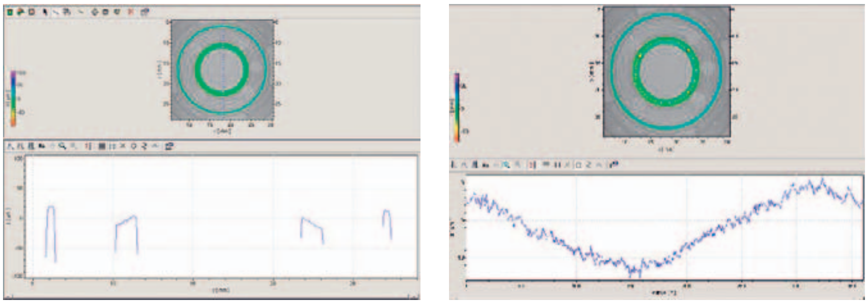
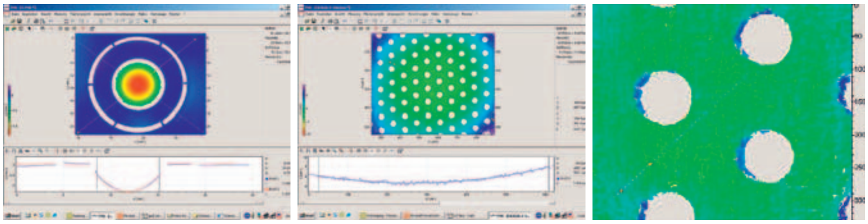


Figure 5: Topography of an atomizer membrane captured with a TopMap Pro.Lab (left) and with a TopMap µ.Lab using a 20x lens and a 50x lens (middle and right, respectively).



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