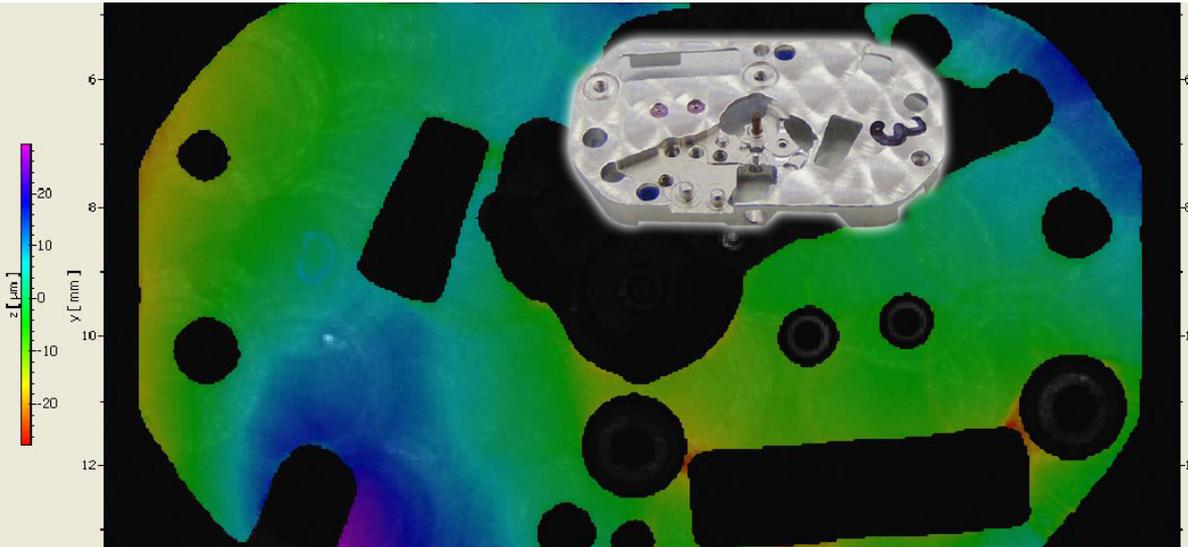


Quality Around the Clock

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Watch and Clock Part Surface Quality Depends on White-light Interferometry

Optical metrology is gaining in importance for quality assurance of precision micro-parts. Fast, high resolution measurements using a non-contact, non-reactive (zero mass loading) optical technique are particularly appealing for micro-parts. By reviewing an application from the watch and clock-making industry, the effectiveness of one technique known as white-light interferometry is examined.

Flatness of a Date Disc

In contrast to several other optical processes, such as fringe projection, white-light interferometry can be used for making measurements on both rough and optically smooth surfaces. Whereas both the well drive and the bottom plate are rough metal surfaces, the date disc (Figure 1) is an optically smooth and reflective plastic surface with an external diameter of 22 mm. The flatness must be within 50 µm as this is important for its functionality. With the TMS-300 Topography Measurement System, two-dimensional measurements can be completed within 5 seconds. The results are shown in Figure 2.



Figure 1: Date disc (diameter: 21 mm)

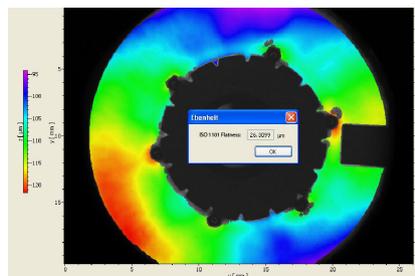


Figure 2: Flatness measurement of the date disc with the TMS-300

Surface Roughness of a Minute Wheel

A minute wheel drive from a watch is shown in Figure 3. To verify manufactured quality, the surface roughness must be measured in the area of the corrugated surface that is about 100 µm x 300 µm. Making the measurement using a tactile instrument is a problem due to the geometry of the measurement area. Optical techniques such as white-light interferometry allow the topography to be captured within a matter of seconds. In Figure 4, the results of such a measurement using the Polytec TMS-1200 microscope-based white-light interferometer are shown. To measure the surface roughness, the corrugated surface is isolated by the software (a process that can

be automated at any time) and the Ra value on a profile section is determined (Figure 3). To be sure that the correct values are determined, the filter characteristics for separating shape, roughness and ripple can be infinitely adjusted to suit the scale of the test sample. In the above example, a cutoff wavelength of $c = 80 \mu\text{m}$ and a sampling length of $L = 240 \mu\text{m}$ were used. The arithmetic mean roughness index was determined here at $R_a = 160.7 \text{ nm}$.

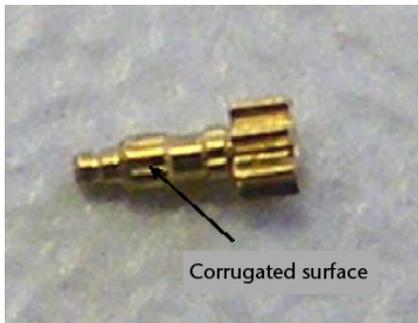


Figure 3: Minute wheel drive.

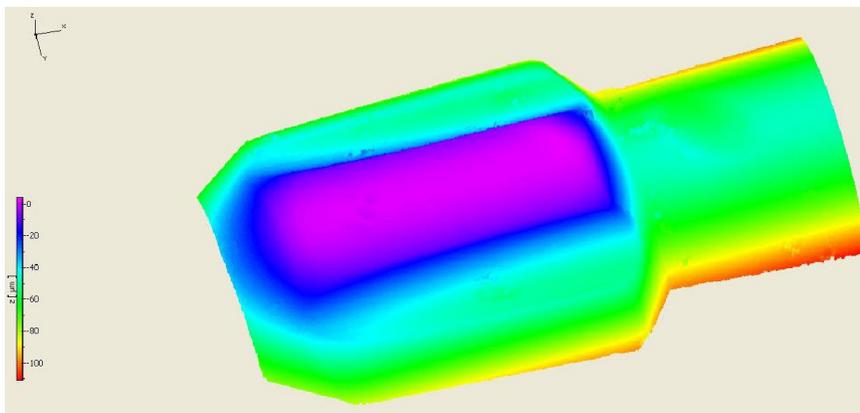


Figure 4: Topography in the area of the corrugated surface.

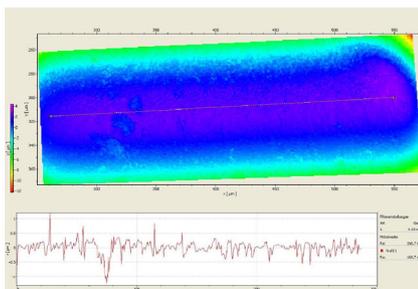


Figure 5: Calculation of the surface roughness ($R_a = 160.7 \text{ nm}$) in the area of the corrugated surface ($c = 80 \mu\text{m}$, $L = 240 \mu\text{m}$).

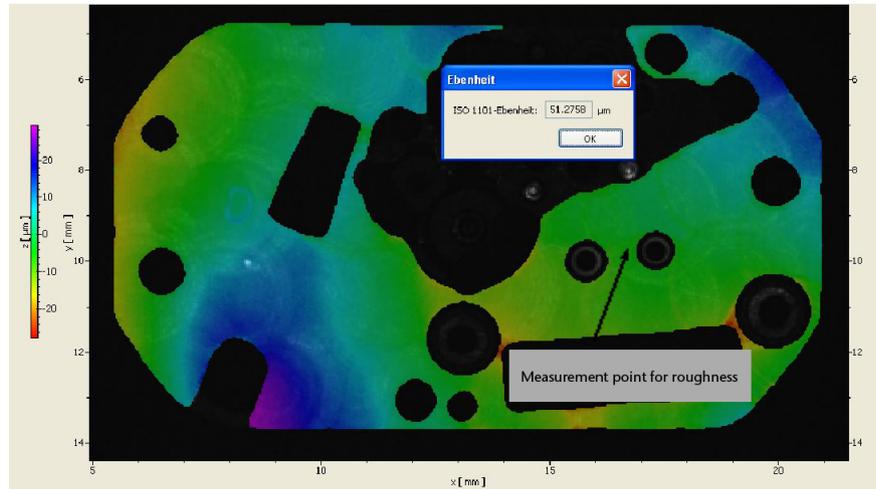


Figure 7: Determining the overall flatness of the bottom plate and the measurement point for the surface roughness.

Flatness of a Bottom Plate

The flatness of the surface of the bottom plate (Figure 6) is another test criterion. The challenge in measuring the flatness is to make a precise topography mea-



Figure 6: Bottom plate.

second, and this is done largely independently of the type of surface, in particular its roughness. In Figure 7, the results of such a flatness test are shown.

Another test criterion for the bottom plate is its surface roughness. To determine the surface roughness, a microscope-based TMS-1200 is used to capture the topography at the point shown in Figure 7 with high resolution. The results for three neighboring profiles are shown in Figure 8.

In contrast to a one dimensional tactile profile measurement, the optical acquisition of the topography across the surface offers the possibility to characterize the roughness in two dimensions. Analogously to the standard roughness parameters defined for one dimensional profiles, roughness parameters can also be applied to two dimensional data and, with the larger number of measurement points, can provide correspondingly more reliable data than individual profiles made up of only a few data points.

surement of a comparatively large area of about $15.5 \text{ mm} \times 8.5 \text{ mm}$ with micrometer accuracy. In contrast to triangulation based processes, such as confocal microscopy, white-light interferometry offers the possibility to scale the measurement surface independently of the numeric aperture in a large area without any losses to the depth resolution.

With the aid of the Polytec TMS-300 white-light interferometer, measurement surfaces of up to 19 mm in diameter can be captured with subnanometer resolution in the z-direction at one reading per

An example of such a comparative evaluation of roughness is shown in Figure 9.

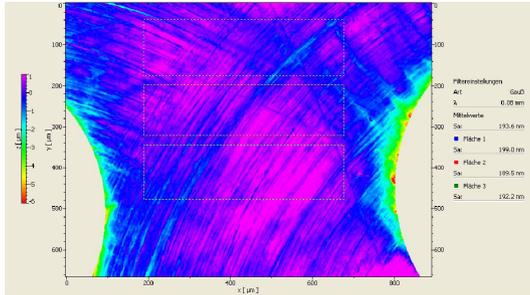


Figure 8: Two-dimensional calculation of the arithmetic mean roughness value Sa on three part surfaces

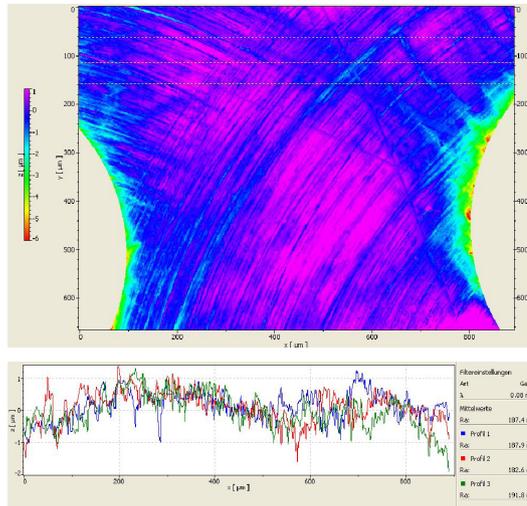


Figure 9: High resolution topography measurement of the bottom plate and calculation of the Ra index.

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You will find further information under www.topmap.info, or let our product specialists advice you: LM@polytec.de.

Polytec GmbH (Germany)
Polytec-Platz 1-7
76337 Waldbronn
Tel. + 49 (0) 7243 604-0
Fax + 49 (0) 7243 69944
info@polytec.de

Polytec France S.A.S.
32 rue Delizy
93694 Pantin Cedex
Tel. + 33 (0) 1 48 10 39 30
Fax + 33 (0) 1 48 10 09 66
info@polytec.fr

Polytec Ltd.
(Great Britain)
Lambda House, Batford Mill
Harpenden, Herts AL5 5BZ
Tel. + 44 (0) 1582 711670
Fax + 44 (0) 1582 712084
info@polytec-ltd.co.uk

Polytec Japan
Hakusan High Tech Park
1-18-2 Hakusan, Midori-ku
Yokohama-shi, 226-0006
Kanagawa-ken
Tel. +81 (0) 45 938-4960
Fax +81 (0) 45 938-4961
info@polytec.co.jp

Polytec, Inc. (USA)
North American Headquarters
16400 Bake Parkway
Suite 150 & 200
Irvine, CA 92618
Tel.+1 949 769 2626
Fax+1 949 769 2622
info@polytec.com

Midwest Office
3915 Research Park Dr.
Suite A-12
Ann Arbor, MI 48108
Tel. +1 734 662 4900
Fax +1 734 662 4451

East Coast Office
25 South Street, Suite A
Hopkinton, MA 01748
Tel. +1 508 544 1224