Quality around the clock

The surface quality of watch and clock parts depends on white-light-interferometry. Optical metrology is gaining 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. This story takes a closer look over the watchmaker's shoulder to see, how white-light interferometry can support their precision engineering.

Figure 1: Close-up of the pure date disc of a clock (diameter: 21 mm)

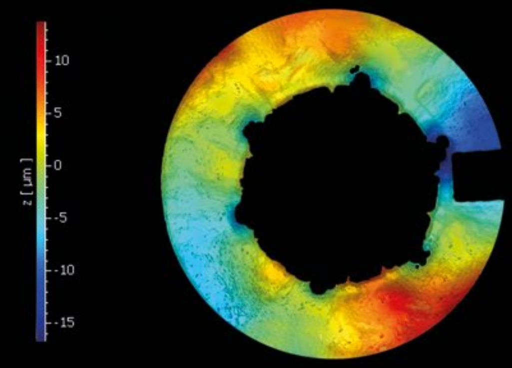


Figure 2: Respective flatness evaluation of the date disc, using a TopMap In.Line surface profiler

Flatness of a date disc

In contrast to several other optical surface metrology methods, such as fringe projection or focus variation, white-light interferometry can be used for measurements on both rough and optically smooth surfaces. Whereas 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 has to stay within 50 µm as this is crucial for its functionality. Figure 2 shows the measurement result performed with a TopMap In.Line surface profiler.

Surface roughness of a minute wheel

Figure 3: Minute wheel drive

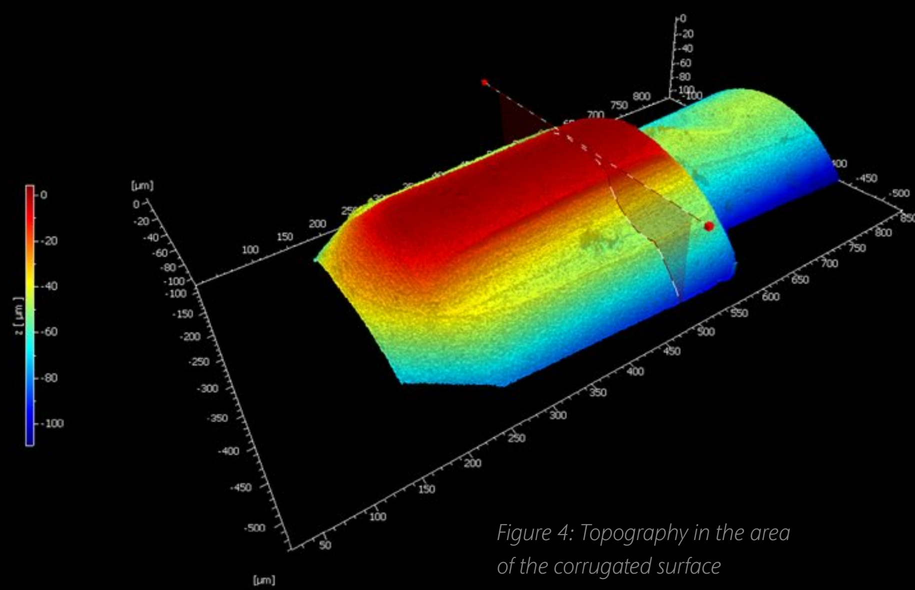


Figure 4: Topography in the area of the corrugated surface

A minute wheel drive from a watch is shown in Figure 3. To verify manufactured quality, the surface roughness on the inclined area, which is about 100 x 300 µm^2 must be measured. Making the measurement using a tactile instrument is a problem due to the geometry of the measurement area on the other hand 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 a Polytec TopMap µ.Lab microscope-based white-light interferometer is shown. To measure the surface roughness, the corrugated surface is isolated by TMS software (a process that can be automated at any time) and the Ra value on a profile section is determined (Figure 5). 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 λ = 80 µm and a sampling length of L = 240 µm were used. The arithmetic mean roughness index was determined here at Ra = 161.2 nm.

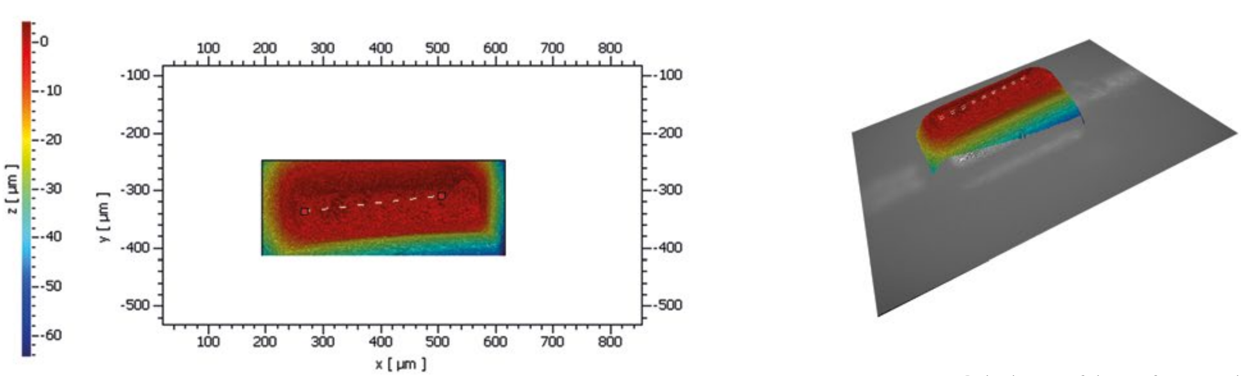
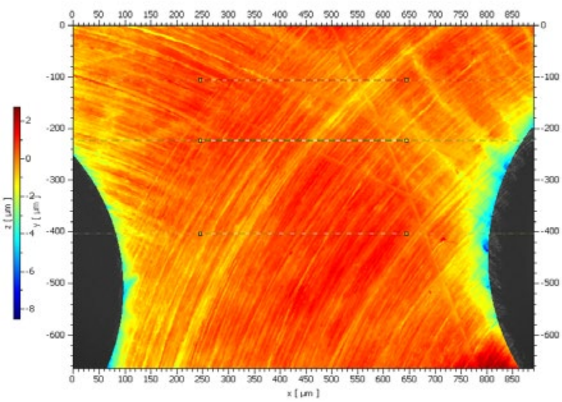
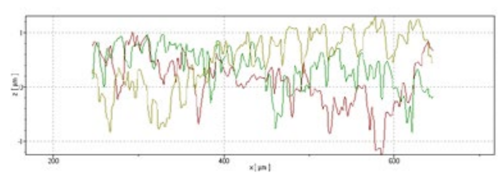
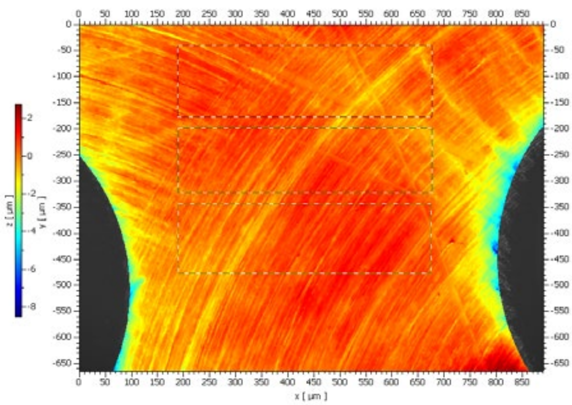


Figure 5: Calculation of the surface roughness (Ra = 161.2 nm) in the area of the corrugated surface (c = 80 µm, L = 240 µm)

Flatness of a bottom plate







Characteristic: All Characteristics — 8 / 8

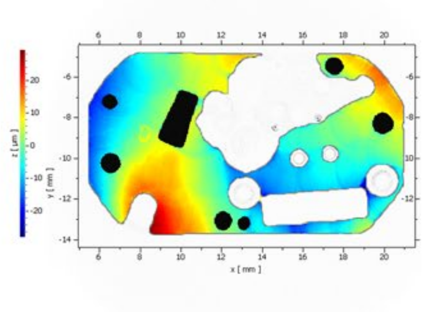
Evaluation	Region / Profile	Nominal Value	Value
Ra	[Horizontal] - Profile 1	0.0 nm	184.3 nm
Ra	[Horizontal] - Profile 2	0.0 nm	186.8 nm
Ra	[Horizontal] - Profile 3	0.00 nm	194.77 nm
Ra (Average)	[Horizontal] - Profile 1, 2, 3	0.00 nm	188.63 nm
Sa	Mask 1	0.0 nm	193.7 nm
Sa	Mask 2	0.0 nm	184.2 nm
Sa	Mask 3	0.0 nm	188.6 nm
Sa (Average)	Mask 1, 2, 3	0.0 nm	188.8 nm

Figure 8: Calculation of the arithmetic mean roughness based on profile (Ra) and based on areal (Sa) information

The flatness of the bottom plate (Figure 6) is another test criterion. The challenge is flatness measurement on a comparatively large area of about 15.5 x 8.5 mm². In contrast to other optical measurement techniques, such as confocal microscopy, the vertical resolution of white-light interferometers is independent from the objective magnification, thereby resolving even large surfaces in a very short time. With the aid of the Polytec TopMap white-light interferometer, larger surfaces can be captured with nanometer resolution in the z-direction at one single measurement. In Figure 7, the results of such a flatness measurement are shown, between holes on the bottom plate are places and the results are 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.

Similar to the standard roughness parameters defined for one dimensional profiles, roughness parameters can also be applied to two dimensional data (areal) 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. Please see Figure 8 for a comparison of areal and profile based evaluation.

Figure 6: Bottom plate



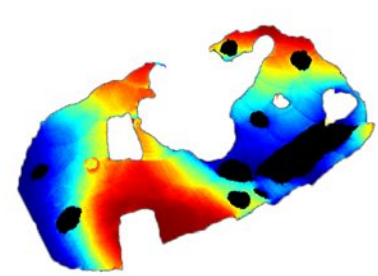


Figure 7: Determining the overall flatness of the bottom plate and the measurement point for the surface roughness