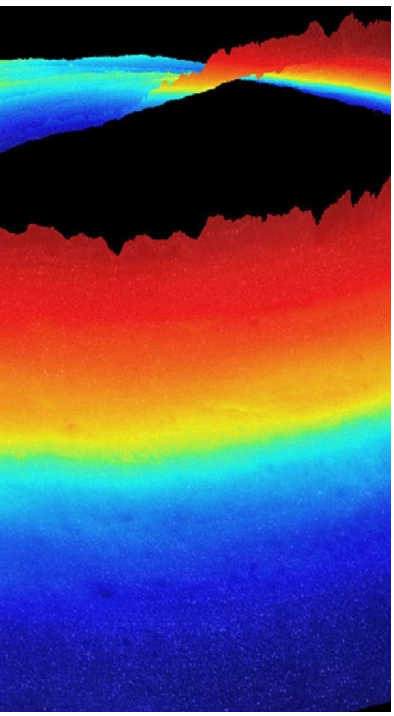
Polytec



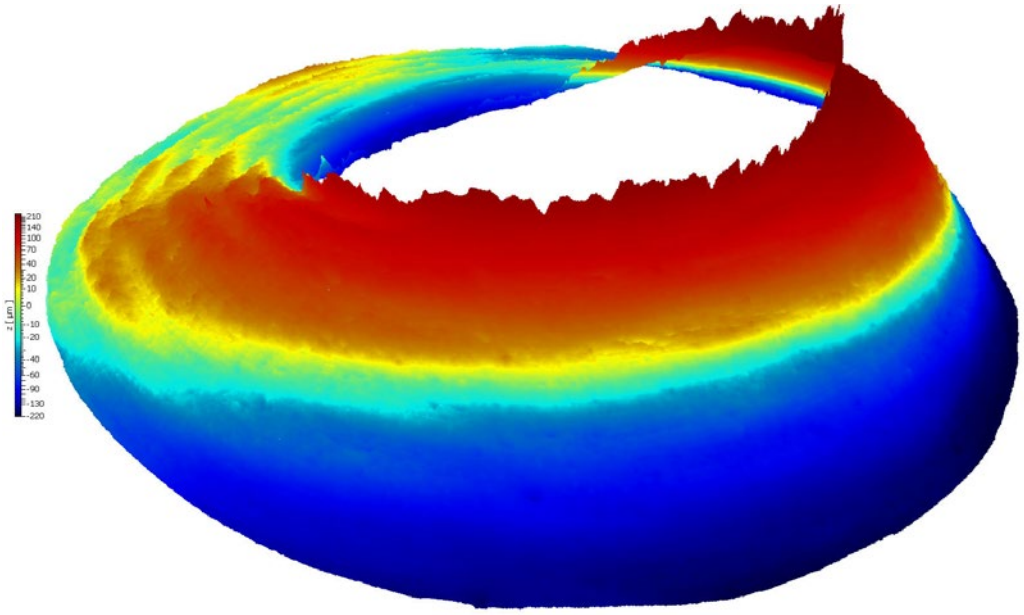
Areal 3D topography of sealing surfaces

Characterizing flatness, waviness, roughness, wear and surface texture for leakproof sealings

Application note

Characterizing flatness as sealing quality indicator in pumps, valves, injectors and more

The mechanical surfaces of a sealing surface should be flat. The flatness of sealing surfaces ensures an even film of fluid not only around the entire circumference of the seal face, but also radially from the outer diameter (OD) to the inner diameter (ID). This can be checked with an optical flat with the aid of a light box and Helium (He) light bands. This approach offers no numerical documentation and typically relies on the evaluation by an experienced operator. An alternative approach is the use of large area coherence scanning interferometers like TopMap optical 3D profilometers. These are non-contact profilers designed for automated measurements and numerical representation of flat sealing surfaces as part of the quality control process. Flatness is measured and qualified according to DIN EN ISO 1101.



1
60 mm diameter moulded matt black rubber sealing surface as measured by the TopMap Pro.Surf showing flatness, forming ripples and an inner edge burr. Flatness = 532 µm

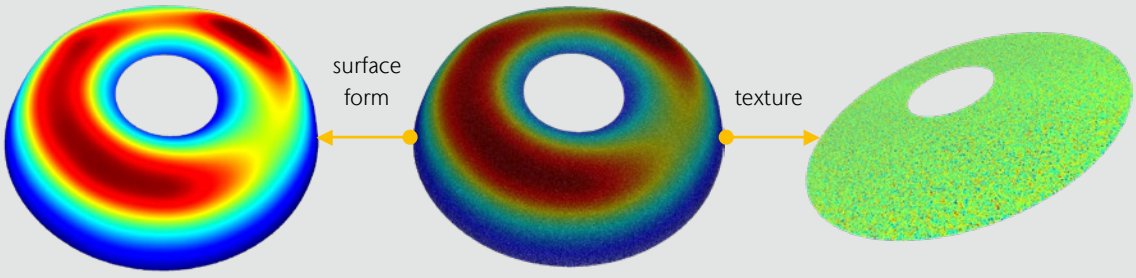
Flatness or roughness for sealing surfaces?

There is often confusion between the difference of the flatness and the roughness (or surface finish) of the sealing surface. In mechanical seals, it is common for flatness to describe the overall (large-scale or low spatial frequency) deviation from a plane and the surface finish to describe small-scale texture deviations (high spatial frequency). The surface texture of the sealing surface is equally important as the flatness is not always the primary consideration when discussing/measuring mechanical seals. However, with the multi-sensor TopMap Pro.Surf+ it is possible to measure both surface form (flatness) and texture with one instrument.

A contacting mechanical seal operates on a thin fluid film and the leakage rate is a function of the film thickness. In most contemporary liquid seals, the seal faces operate in a mixed lubrication regime where the surfaces are lightly contacting on the asperities between the seal faces. This is necessary to reduce any leakage down to an acceptable level while minimizing face wear and heat generation. It is reasonable to assume that faces with very smooth surfaces would produce thinner effective fluid films and minimize seal leakage. While this is true, it can produce some undesirable effects, e.g. stiction.

Sealing surfaces are manufactured from every surface finish type from highly polished “mirrored” finished through to rougher and duller surface types. A highly polished surface can have the reflectivity of a mirror and the appearance of this surface type is free from any visible roughness, scratches or defects. Sealing manufactures recognize that the surface finish of the sealing surface is a critical factor in establishing a stable fluid film and dependent upon the applications and the nature of the seal; at this point, a rougher or duller looking surface may prove preferable to a highly polished surface.

Dull pressed composite sealing surface



Flatness = 0.414 µm; areal roughness Sa = 88.56 nm

4
Automated pattern recognition for setting masks and filters for custom evaluation of both form and texture parameter

It is for this reason a manufacturer will design and specify specific surface finishes requirements intended to optimize the formation of the fluid film while minimizing leakage. The most common finishes can have very small scratches crisscrossing the sealing surface without generating any great concerns for the leakage. These surface finishes are created during the machining process such as lapping or grinding. By varying parameters to control the manufacturing process, quality control, time and efficiency gains, can be achieved within production to produce specific and reproducible surface finishes, regardless of whether the process is pressing, grinding, lapping or polishing. When using a TopMap Pro.Surf system flatness is accurately measured, with correct controlling data filters; applied via data masking. Data masking is automatically fitted by pattern recognition for fully automated push button measurement routines.

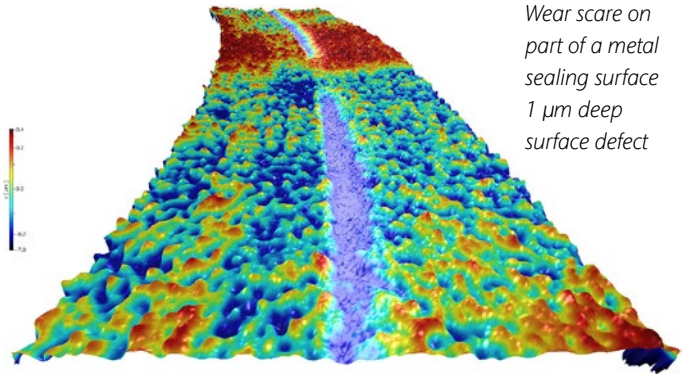
This ability to control the surface finish also gives the seal manufacturer the ability to produce special surface finishes for challenging applications. In some applications, it may be difficult to establish a fluid film due to factors such as a high viscosity fluid. In these cases, the seal manufacturer may specify a higher roughness on the surface to allow for a more stable film and to reduce heat generation during operation. This type of surface modification is often termed a “matt” lap since the surface finish has a matte dull appearance.

An end user should rightfully be concerned about using seal faces that have chips, cracks, or other damage. They also must recognize that the seal face is an engineered surface and that some roughness on the faces is intentional and may be a critical part of the design. All these features, surface flatness, texture or damage, can be quantified and numerically represented by a member of Polytec’s TopMap family.

65 mm diameter flat lapped ceramic sealing ring

No.	Flatness µm
1	0.571
2	0.571
...	...
...	...
25	0.593
26	0.592
27	0.585
28	0.582
29	0.588
30	0.578
AVG	0.578
StDev	0.016

5
Measured 30 times GR&R with an average value of 0.578 µm and standard measurement deviation of 16 nm using automated pattern matching. Good repeatability is important for quality control

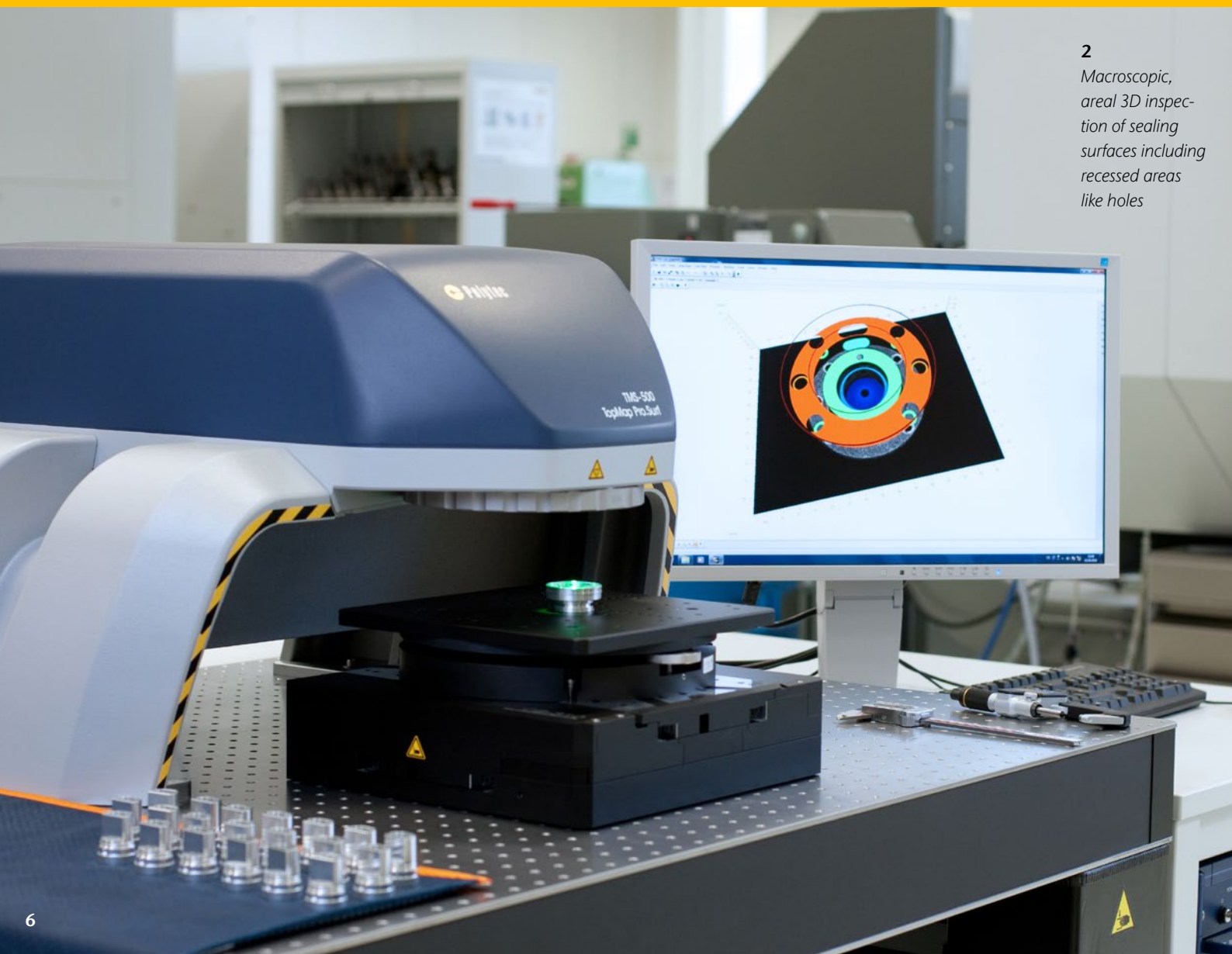


6
Wear scare on part of a metal sealing surface 1 µm deep surface defect

Areal 3D surface inspections, evaluating both form parameters, roughness and texture details

Polytec's range of Coherence Scanning Interferometers (CSI) covers options for both large area macro scanning and small area microscope surface profiling. All instruments have similar nanometer or sub-nanometer Z resolution independent of the field of view and the XY sampling making it possible to measure flatness to the sub-micron range.

TopMap optical 3D surface metrology adresses measurement applications including 2D and 3D areal surface flatness, step height, roughness and wear measurements. The solutions also cover macro lens wide area scanning systems for large samples as well as a multi-sensor insturment for areal form parameter and roughness line profile measuremet in one system.

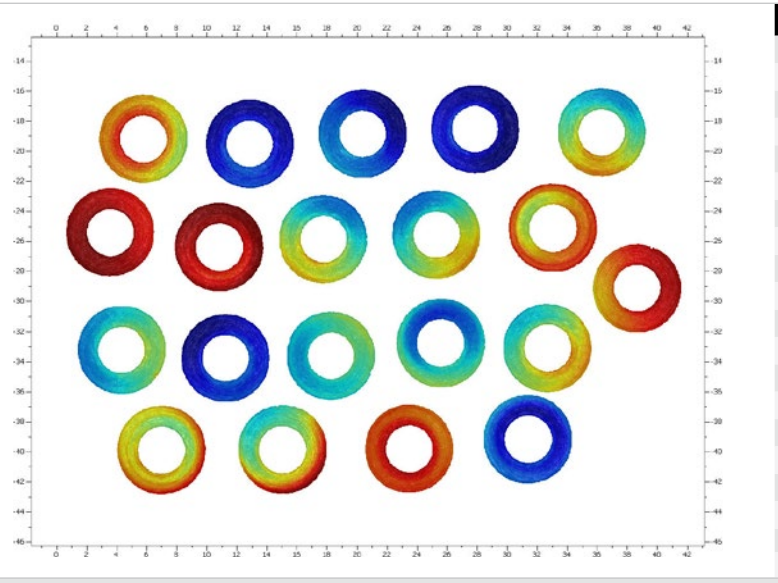


2
Macroscopic, areal 3D inspection of sealing surfaces including recessed areas like holes

The TopMap Pro.Surf is a wide area optical metrology tool that includes a large field of view in XY of 44.9 mm x 33.8 mm and with image stitching accommodating areas over 200 mm in XY directions.

With its Z resolution to the nanometer it can reliably detect wear, surface texture and flatness deviation of sealing surfaces. Many surface types can be measured and characterized, including metal, plastic, ceramic, composite and rubber. TopMap coherence scanning interferometers can capture data from super smooth, polished, shiny, dull, rough, low contrasting and even worn surface types that could include a variation of surface brightness properties.

The TopMap Pro.Surf+ multi-sensor profiler includes a confocal roughness sensor that supports high lateral resolution measurements. This multi-sensor system enables both surface form (flatness, waviness) and surface texture measurements whenever areal and specific line profiles are of interest.



No.	Flatness µm
1	7.60
2	5.46
3	4.63
4	5.22
5	5.00
6	5.06
7	10.68
8	3.90
9	4.16
10	8.89
11	3.57
12	4.97
13	5.44
14	4.08
15	10.00
16	4.71
17	10.01
18	11.34
19	7.30
20	10.05

3
Automatic sample recognition and large field of view measurements allow multi-sample inspection in a single shot for efficient pass-fail decisions

Batch inspection of metal washers for reliable OK/nOK decisions

With large area data capture and fast measurement routines, full automation is possible via advanced pattern matching software, so that multiple objects can be measured, analysed and processed all at the same time without the need for a specific smaple fixture with single button click ■ Pass/ ■ Fail parameters.

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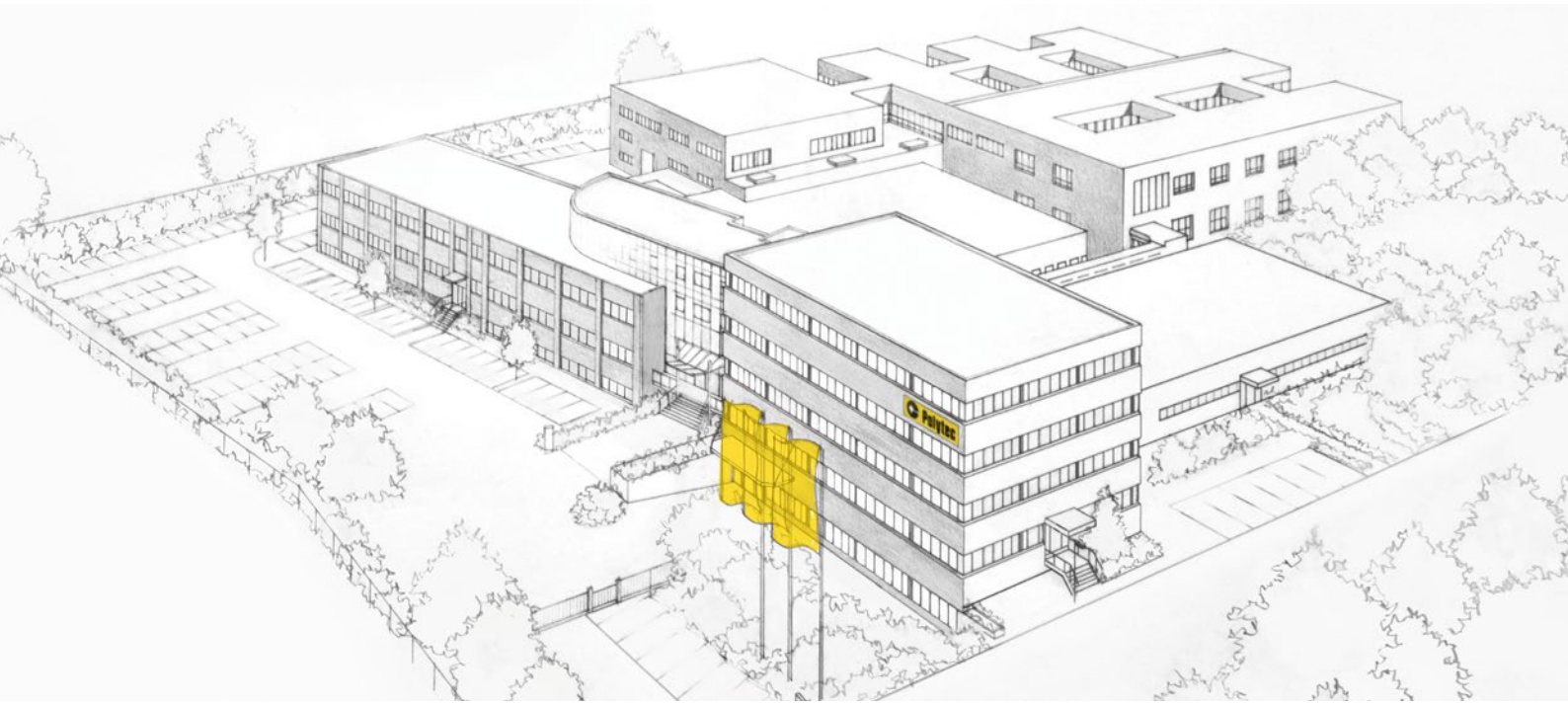

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2023/11 - Technical specifications are subject to change without notice.