Surface Metrology

When accuracy matters

Competence Field

Surface Metrology – Precise from the very Beginning

The need for non-contact surface metrology is growing continuously and spans all industries. No wonder, consistent performance and reliability are essential criteria to establishing oneself in the market and remaining successful in the long term.

Compliance with specified tolerances must be checked frequently, especially in industrial production. This helps to ensure correct functionality of the anufactured items and to identify defective parts in order to avoid unnecessary costs.

Very often, workpieces have specified parameters such as roughness or flatness values.

In many cases, the complete topography of a workpiece or object must be checked in the shortest possible time, for example shock absorber components.

The definition of volume removal plays an important role, for example when wear measurements must be carried out. In this case, the surfaces provide important information about tribology behaviour. The volume and topography structure can easily be evaluated with high precision.

White-Light Interferometry as Solution

Structured functional surfaces with tight tolerances require high-precision measurement systems that can rapidly scan the two-dimensional topography of a workpiece or object. Well-established white-light interferometry achieves an accuracy of a few nanometers or even subnanometers. It has therefore been playing a crucial role in industrial quality control in recent years.

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Highly Accurate Measurements

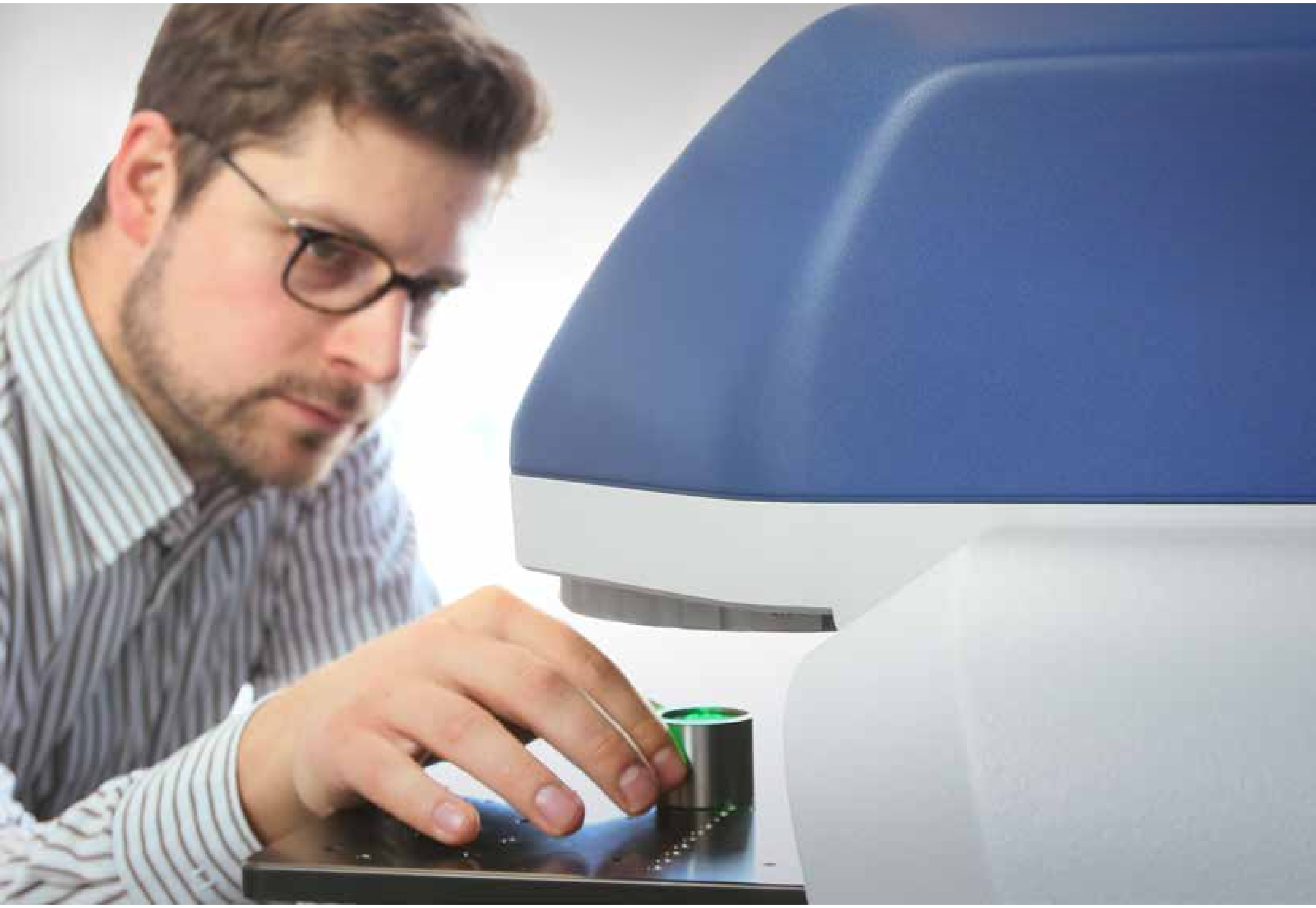
- In the controls laboratory and R&D areas
- On almost any workpiece surface
- With Z-resolution independent of field-of-view

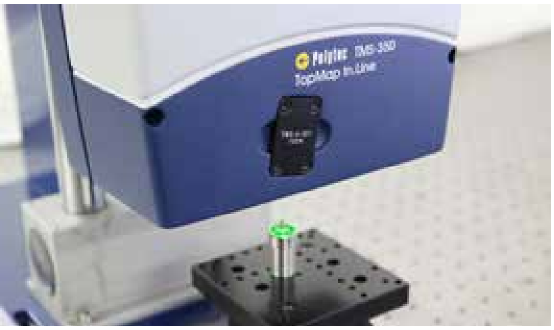
Routine Measurements

- Simple operation and automated evaluation
- One-click solution for operator-independent results
- Close to the production line or in the control laboratory

Automated Measurements

- For random or 100% checks in-line under challenging conditions on the manufacturing floor





As a successful developer of high-quality optical measurement systems, Polytec is an experienced partner for surface measurements in nearly all application fields. We have been supplying high-end solutions to automotive, aviation and aerospace, steel, engineering, chemical, textile and paper industries for more than four decades. We implement customized systems in terms of the size of the area of interest, the resolution and other special needs of each measurement task.

Measuring with Light – Non-contact, Fast and Extremely Accurate

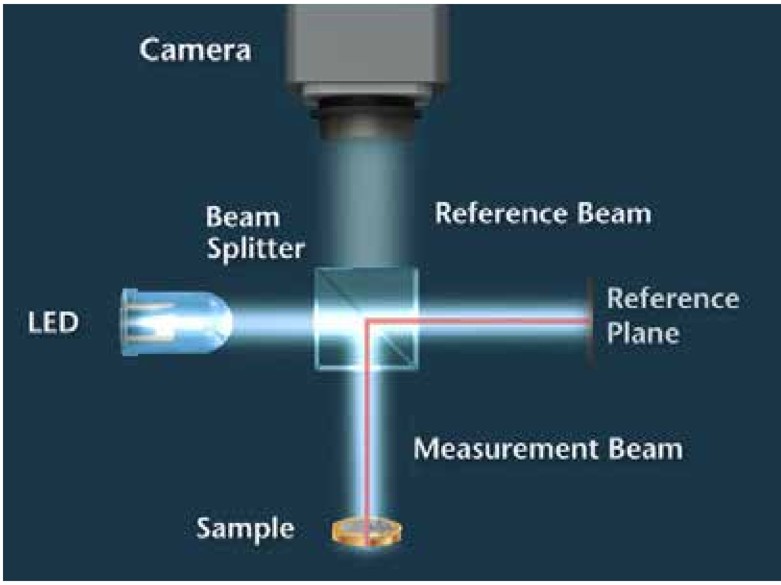
Modern white-light interferometers from Polytec use the interference effects that occur when the measured light reflection from the object is superimposed on light following the same path length reflected from a high-precision reference mirror. The object is scanned by traversing that mirror.

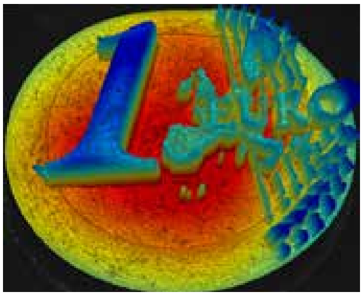
A perfect interaction of all functions ensures flexible adaptability

The measurement method is based on the principle of Michelson interferometry, where the optical configuration contains a light source with a coherence length in the µm range. A beamsplitter splits the collimated light beam into a measurement beam and a reference beam. The measurement beam strikes the object (sample), the reference beam a mirror. Light reflected from the mirror and the sample is recombined at the beamsplitter and focused onto the CCD camera. Whenever the optical path to the sample and to the mirror are the same, constructive interference takes place at all wavelengths of the light source resulting in high intensity at the corresponding camera pixel. By measuring the traversing mirror's position when pixel intensity is high for each object point, the height of all points can be mapped.

In the interferometer either the reference arm or the sample are moved relative to the beamsplitter. When traversing the measurement path, interference takes place pixel by pixel and the height of the object can therefore be determined. After the measurement is complete, the topographical structure of the sample is digitized.

Instruments with a telecentric optical configuration allow large surface areas to be measured quickly in one pass. However microscope systems are the first choice if high lateral resolution is needed because here the optical configuration including the reference arm is integrated into a high magnification objective.





Whatever your main application may be – Polytec always offers you the TopMap series model that will match.

Experts in Large Area Measurement

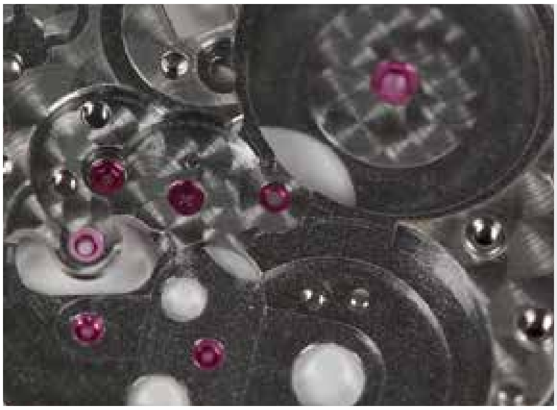
Polytec is a worldwide leader in technology for optical topographic measurement of large areas with nanometer precision. Areas to be examined are often at the base of deep holes or have large height differences – Polytec's TopMap surface measurement systems provide the solution.

Functionality requirements of technical surfaces are often very demanding, requiring more frequent compliance with the tightest tolerances.

In such cases, measurements with resolutions in the submicrometer range, or even down to a few nanometers, are necessary in order to meet those requirements.

Surfaces are Critical for Function

When the topography of functional surfaces needs to be determined, significantly shorter measurement times are achieved with white-light interferometers than with tactile systems that scan a surface one line at a time. And with structured surfaces, you achieve a high reproducibility and repeatability. Its non-contact and thus non-destructive measurement of soft or sensitive surfaces and samples with complex geometry as well as workpieces with varying surface characteristica will be your key advantage.



Your benefits from using TMS TopMap for measurements include:

- Short measurement times
- Whole field coverage: no details are overlooked
- Use it from measurement laboratory to production line for 100% inspection
- High precision and repeatability
- Low investment and operating costs
- Measurement and evaluation can be automated

Flatness and Ripple Measurements

Regarding functional surfaces, flatness is often decisively important. Examples are parts with sealing surfaces for pressure and vacuum technology, and also transparent foils for displays, semiconductor components, metal and ceramics surfaces. TopMap systems allow you to measure large areas up to 200 x 200 mm^2 and get a fast, complete characterization of the workpiece. Under optimal conditions you can achieve precision in the subnanometer range.

Relative Position of Two Surfaces

Determining parallelism, height differences or angles between several surfaces often require a large vertical dynamic range. TopMap systems offer scan ranges of up to 70 mm with which you can measure surfaces that are separated by high steps or located at the base of drilled holes. The telecentric light beam path avoids shadowing effects.

Shape and Structure

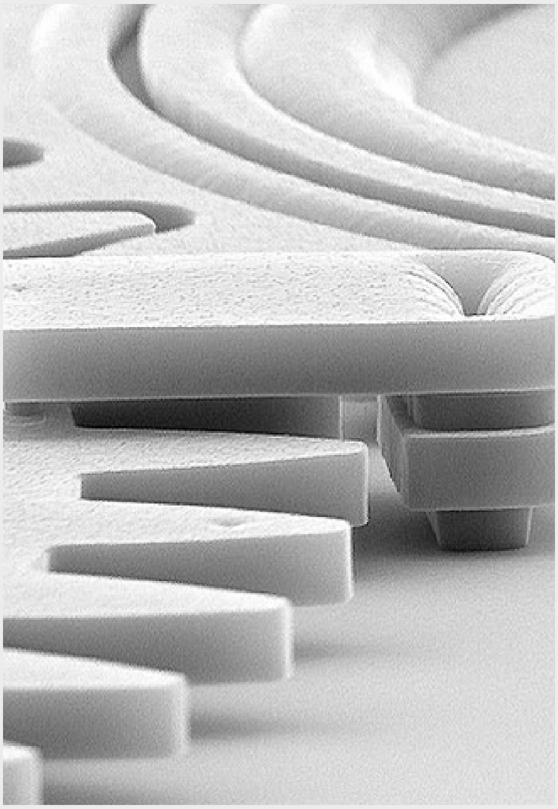
The miniaturization of functional components leads to integrated structures, whose function depends on whether the manufactured parts keep the intended dimensions and shapes. An example is a Lab-on-a-Chip system for diagnostic or bioanalytical applications. In the plastic of the diagnostic chips, channels and chambers are hollowed out according to a certain order, into which samples are introduced and where bio-chemical reactions take place.

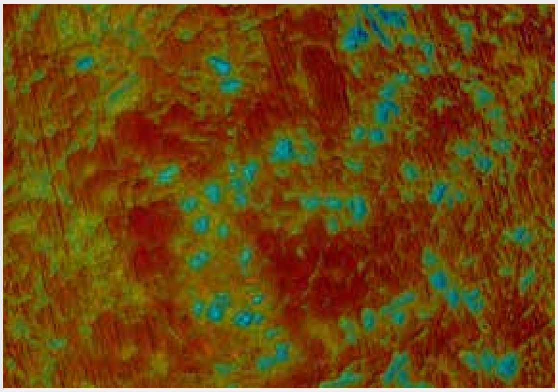
Machine Adjustment

CNC machines must be properly adjusted prior to machining to ensure that parts are manufactured to the correct flatness and curvature values. Checking workpieces during machine set-up helps to save time and money. Verify relevant parameters before production is started in order to optimize the machine settings.

Specialists in Topography of Microscopic Structures

The use of short-coherent white light lets you use the TMS-1200 TopMap µ.Lab Microscope System at a very high resolution of better than 0.5 nm, enabling fast topography measurements on microstructures. For example, measurements on micro-sensors and micro-actuators as well as structured plates and bearing surfaces. TMS-1200 TopMap µ.Lab offers high-performance evaluation functionality. Larger surfaces can be tested by stitching several measurements together.





Microstructured Surfaces

Functional surfaces often require the presence or absence of certain structural characteristics. For example, it can be very important to evaluate the type and frequency of pores used to hold lubricant between frictional surfaces in motors or connecting rod eyes. The same applies to surface structures needed for improved adhesion of coatings in the steel industry. Unwanted structures must also be analyzed because they increase frictional forces or cause unwelcome vibrations.

Microstructure Technology

Microsystems comprise very small structures. During the development or production process, you can check, with the help of topography measurements if they are within the required dimensions and tolerances. Illustrated examples include micro-electromechanical systems (MEMS) such as gyroscopes, pressure sensors, acceleration sensors and micromechanical pumps.

Material Processing

Topography measurements with high lateral resolution are important when determining the material ejected during the separation of semiconductors or in the case of deformation caused by laser treatment processes. Further examples are selective surface texturing for producing predefined frictional surfaces and hole manufacturing including drilled holes.

Many Benefits for Your Tasks

Polytec's TopMap systems are based on the established measurement principle of white-light interferometry. The height resolution is not affected by the chosen size of the field-of-view. A wide range of different surfaces, from MEMS components to sealing surfaces manufactured with high precision, can be captured with high repeatability. The TMS TopMap systems offer you efficient analyzing possibilities that can be automated, no matter whether it is in the measurement laboratory or for 100% inspection on the production-line.

No Details are Overlooked

Up to 2 million measurements are carried out simultaneously using CCD cameras. This ensures that you don't overlook any important detail on your measurement object. Moreover, you save time compared with tactile measurement methods which use single point measurements to generate line profiles that are combined to finally get to surface results.

High Precision

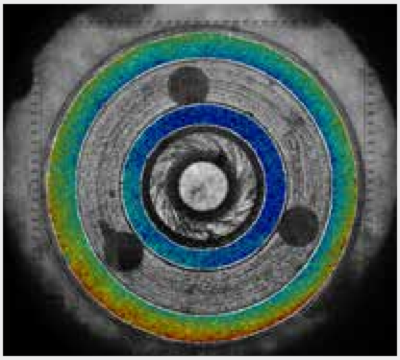
The vertical resolution of the TopMap systems is in the subnanometer range and in practice is only limited by ambient conditions, not by the measurement principle. This allows high precision measurements of the flatness and shape like semiconductor components or sealing surfaces. Vertical resolution is independent of the used magnification.

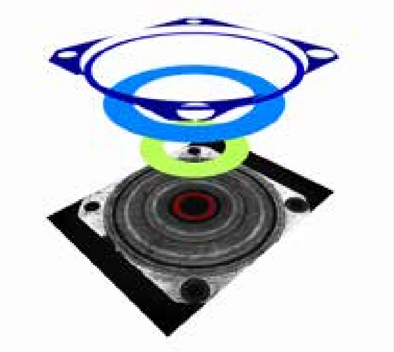
Large Surfaces Measurable

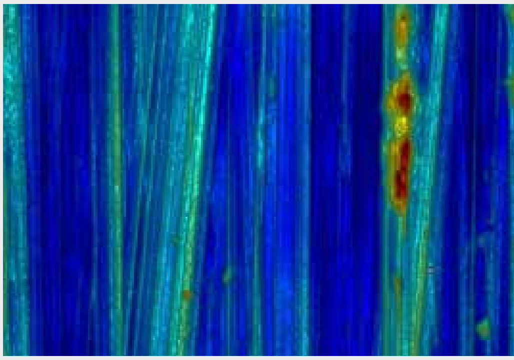
Being able to measure large workpieces over the entire surface has several advantages: You don't have to stitch together sequentially measured smaller fields-of-view and evaluate them. Thus, any inaccuracies caused by moving the hardware or software corrections are avoided and you save time. With a short measurement time you also minimize the influence of distortions from the surroundings or by changing parameters.

Extensive Post-processing is Possible

The included TMS measurement and evaluation software is used to post-process your data. In this way details that are important for you can be highlighted. Its polynomial-regression feature enables you to subtract the form, in order to more easily recognize deviations from curved surfaces.







Large Reflectivity Variations are Accomodated

Workpieces often reflect with different intensities, as on highly reflective surfaces with different viewing angles. For such cases, Polytec has developed “Smart Surface Scanning” technology that measures the surface several times with different camera exposure times. Software automatically calculates optimal exposure time and applies it for each pixel.

High Degree of Automation

Due to the inclusion of .NET, TMS TopMap software is open for programming internal processes, for example an automated sequence or a specific user interface for measurement and evaluation. Such programs can be created by your company or by Polytec.

High Flexibility with Ease of Use

TopMap‘s user-friendly software interface is built for easy measurement and evaluation. A Wizard guides even inexperienced users to safely choose the right measurement parameters. The evaluation of measurement results is made intuitive with the help of preview dialogues. These simplify the choice of the right measurement and evaluation parameters and are also used for measurements that allow you to determine repeatability.

Raw Data without Smoothing

The original data can be used to a large extent without post processing through filters or smoothing, when performing good measurements. You can significantly increase the quality of the measurement data by using “Smart Surface Scanning“ technology. With this technology you can also preset a threshold value for signal quality. Moreover, the software stores all correlograms in order to be able to evaluate the quality of every individual point later on.

Reliable Measurements in Drilled Holes

The telecentric beam path of TopMap systems also allows you to measure inside indentations of up to 70 mm depth without significant shadowing (middle picture). No other method offers you a comparable precision!

Large Surface Area and Microscopic Measurements

If you need a variety of fields-of-view and therefore different lateral resolutions, the combination of telecentric and microscopic measurement technologies is ideal. Our examples show a flatness measurement of an injection valve (left picture), measured with a field-of-view of nearly 20 mm diameter with a telecentric TopMap system. The friction marks of a surface (right picture) are perfectly resolved by the TopMap µ.Lab microscope system.

TopMap Systems – Tailored to Your Requirements

Whether you need a fast throughput in the production-line, high resolution laboratory measurements or in universal applications – Polytec offers you different models of TopMap systems, perfectly adapted to your requirements. All TopMap models are equipped with operator-friendly TMS Software from Polytec.

TopMap Topography measurement systems

System	TopMap Metro.Lab	TopMap In.Line	TopMap	TopMap µ.Lab
Version	**TMS-100**	**TMS-350**	**TMS-500**	**TMS-1200**
Optical design	Telecentric (for large surfaces)	Telecentric (for large surfaces)	Telecentric (for large surfaces)	Microscope system (for high laterial resolution)
Vertical range	70 mm	500 µm	70 mm	250 µm
Field of view (mm)	35 x 22 ≈ 80 x 80 with stitching (optional)	Different areas of interest, permanently installed min. 4.2 x 5.6 max. 13.6 x 18.3 and Ø 19	Large field-of-view: 43.3 x 32.7 (trimmed edges) Small field-of-view: 21.9 x 16.5	Depending on lens min. 0.18 x 0.13 max. 3.6 x 2.6

For Large Surfaces:
TMS-100 TopMap Metro.Lab

Ideally suited for measuring large-area topography on almost all surfaces, it can be used flexibly under difficult conditions because of its ease-of-use, compact footprint and measurement range of 70 mm. The excellent price/performance ratio means it is attractive for smaller companies with lower throughput requirements. The TMS-100 TopMap Metro.Lab is appropriate because of its shorter measurement times and detailed two-dimensional results for reliable production-related quality assurance.

For Fast Measurements in-Process:
TMS-350 TopMap In.Line

This system is ideally suited when you want to measure surfaces in challenging environments such as in production control. This system is compact and can be installed in many different ways on the production line for measuring preset specifications, for example flatness, step height and parallelism within short cycle times – quickly and completely automatically. The vertical resolution amounts to a few nanometers, guaranteeing a high degree of repeatability. There are different models with a variety of fields of view for adapting the measurement system to your exact needs. Customer-specific adaptable and automatable TMS software exports measurement data for process data analysis or into your own database.

Surface Metrology in a New Dimension:
TMS-500 TopMap

Optimally suited for fast and simple characterization of precision-made surfaces – in the measurement lab close to the production area or directly on the production line. The system's enlarged vertical measurement range until outstanding 70 mm enables also measurements of very hard to reach surfaces with high repeatability, for example in low-lying positions. The system records within in few seconds nearly 2 million points on a surface of 43 x 32 mm² – extendable to 230 x 220 mm²! Due to high lateral resolution approaching 13 µm, you don't overlook any important details. The smallest component tolerances can be checked quickly and securely in order to detect and eliminate faults at an early stage.

For Microscopic Surfaces:
TMS-1200 TopMap µ.Lab

This system sets new standards in non-contact topography measurement with its high spatial resolution. It is designed for characterizing the micro-topography of functional surfaces and microstructures in product development and quality control. The particularly large number of camera pixels resolves even the finest details. By combining (stitching) several single measurements, you can also measure larger samples while still achieving high lateral resolution. Extensive accessories guarantee that you get a solution tailored to your application.

TMS Software – User-friendly and Customer-specific

High performance TMS Software offers you all the important control and evaluation functions, including 2D, 3D, isolines and profile views. We configure the software interface optimally according to your requirements. Identical measurement results are assured for different users due to the simple, automated measurement and evaluation software.

Flexible, Automated Measurement

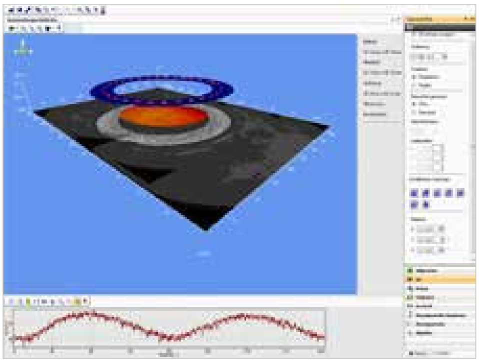
You can perform measurements and evaluations with only brief training together with help from simple menu guidance. The measurement process is automated after setting the measurement and evaluation parameters. Moreover, you benefit from an open software architecture, which can be remotely controlled via a .NET interface. Through customer-specific software-adjustments, so called add-ins, customer-specific processes can be automated very easily.

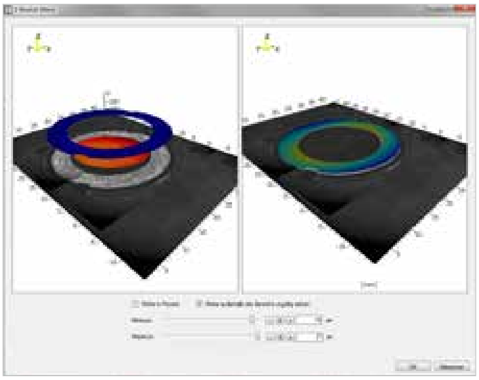
Varied and Targeted Evaluation

On the PC screen, the sample topography, shown in a 2D or 3D view, can be evaluated by you manually or automatically. The raw measurement data are not automatically smoothed, filled or filtered, so you maintain control at all times and can later systematically optimize the data if required. The data output in ASCII-format enables direct export to MS Excel, MATLAB® or other data bases. The integrated QS-STAT®Export enables a reliable data analysis process.

TMS software offers vast options for representative results from challenging surfaces:

- Automatic component location detection to eliminate the need for special component holders
- Operator-independent results through automated measurements and evaluations
- Smart Surface Scanning technology for measurements on high-contrast surfaces
- Repeated measurements and a wide choice of averaging methods, filters and linear regression algorithms
- Working with masks, profiles and layers
- ISO-conforming evaluation in terms of many different 2D and 3D surface parameters
- Increased precision even on smooth surfaces by applying special evaluation procedures





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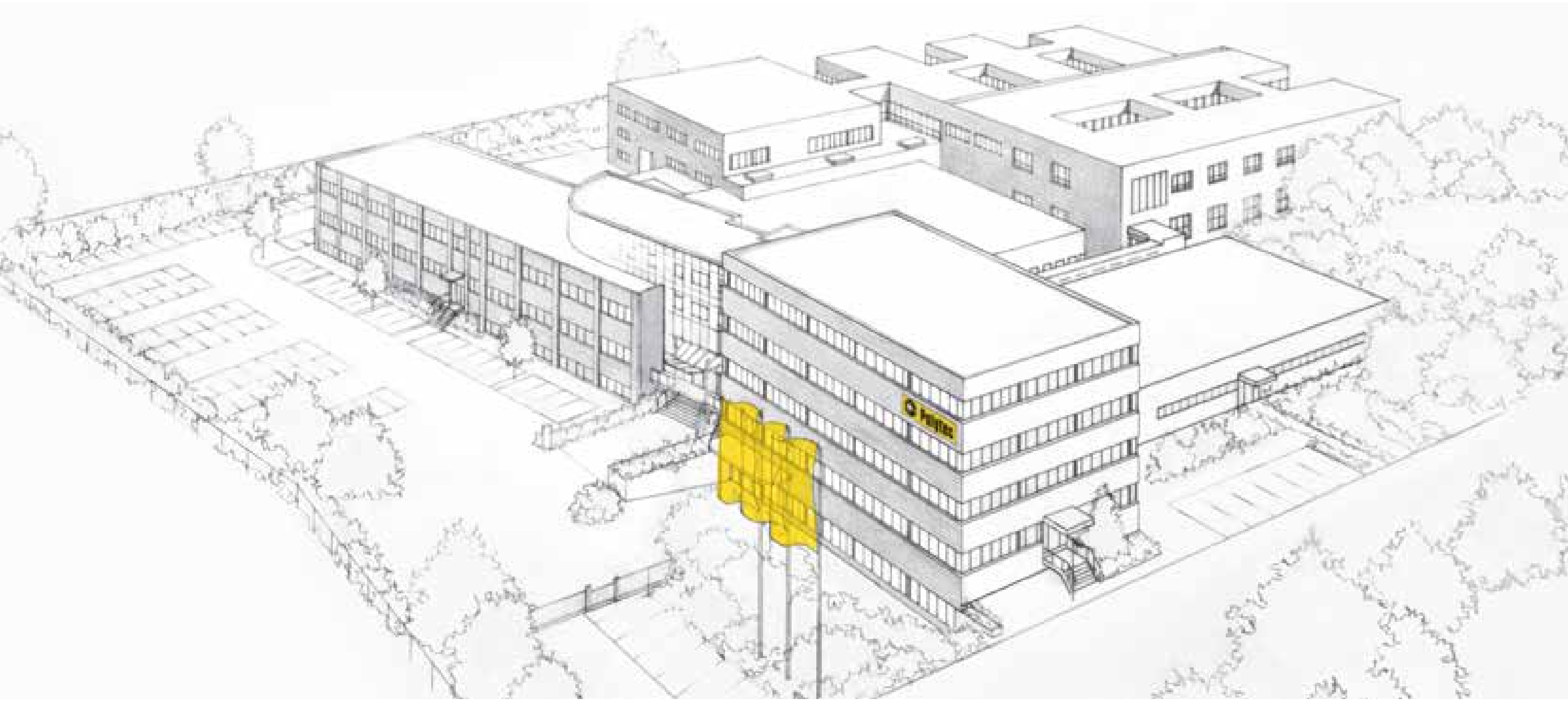

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OM_CF_Surface_Metrology_E_42360
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