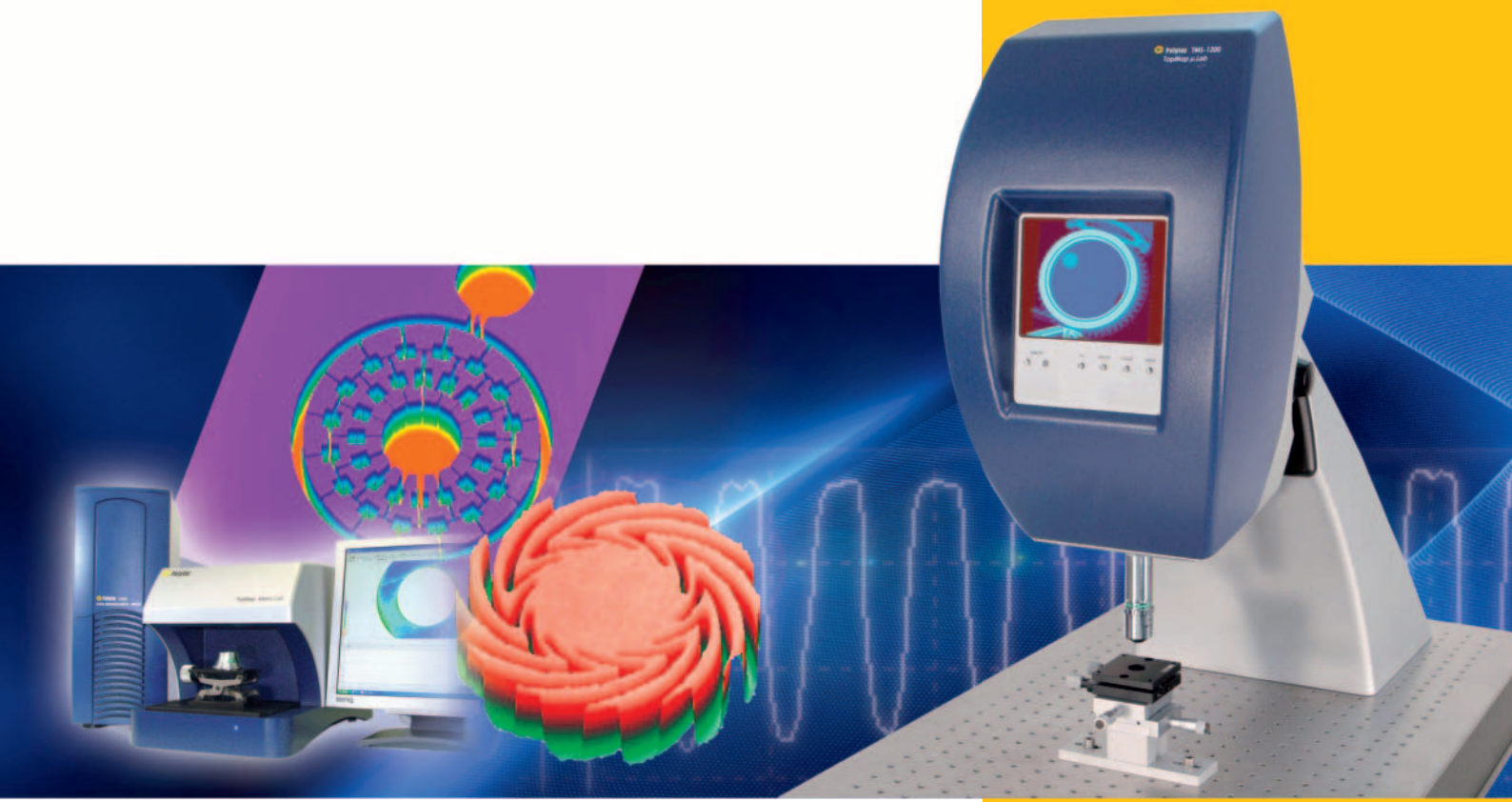
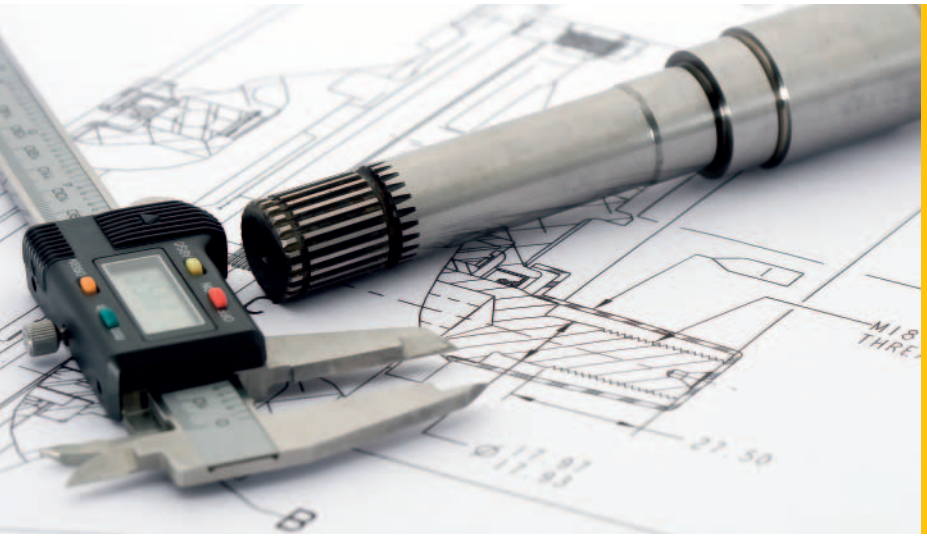
Polytec

TopMap Interferometer

Optical Surface Profilometry
Rapid, High Precision, Large Area Coverage

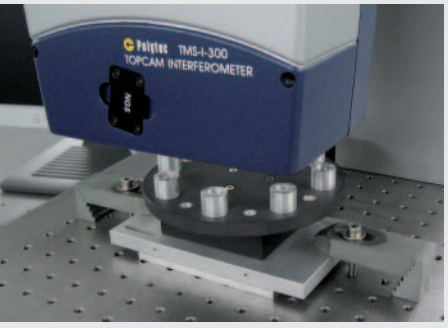


Precise Measurement of Surface Topography in Laboratory and Production Environments



Structured functional surfaces with tight manufacturing tolerances require precise verification of surface topography to assure quality and performance. Measuring with subnanometer accuracy in the vertical direction, scanning white-light interferometry is vastly superior to traditional contact measurement methods and has become the preferred tool for industrial quality control of precision geometry and surface finish.

Ultra-precise measurements
- In research and development labs
- Under optimal conditions



Simple, routine testing
- With or without partial automation
- In normal ambient conditions

Automated measurements
- For on-line quality control
- Demanding conditions
- In production environments

Non-contact, Fast and Extremely Accurate: The engineer's choice for industrial quality control, product development and research applications

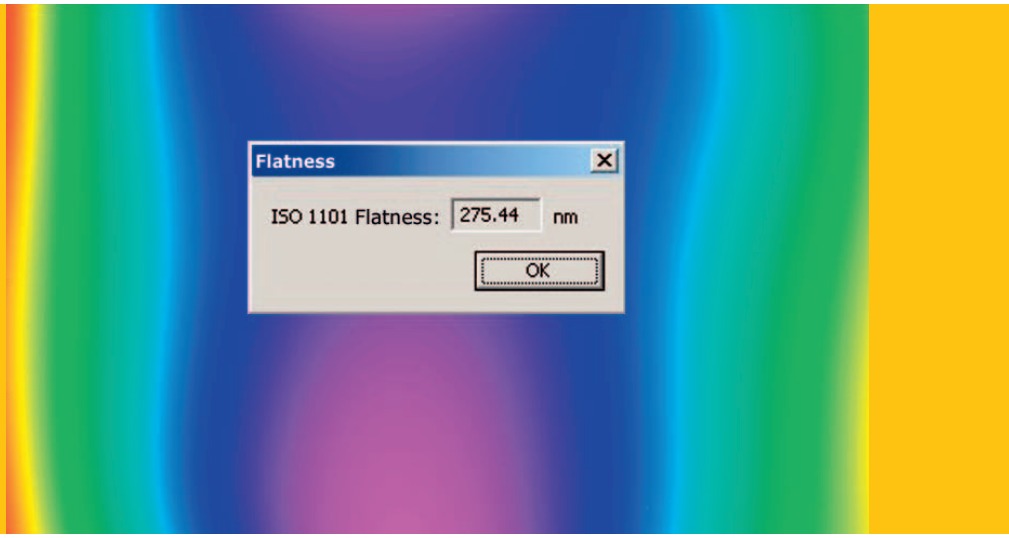
For more than four decades, Polytec has been supplying high-end measurement solutions to automotive, aerospace and defense, steel, engineering, R&D, chemical, textile and paper industries. Polytec instruments are built for the environment in which they work. Our reputation for dependable performance is well known in both R&D laboratories and in industrial facilities where maintaining accuracy under harsh conditions is a critical advantage. Our success is built on high quality products, qualified and customer-oriented service and expert advice learned from many years of technical leadership.

Working with our customers as partners, our development teams prepare hardware and software solutions that meet their needs and resolve their critical measurement problems. Polytec's attention to detail, and in-house, vertically-integrated manufacturing and assembly process, and aggressive quality control (ISO 9000) assure that our customers receive the most reliable performance from our products. Having set the gold standard for laser-based vibration measurement, Polytec is quickly leveraging this operating philosophy to develop a similar reputation for topography measurement using white-light interferometers. This non-contact measurement method enables many new and critically needed solutions in precision manufacturing and metrology.

www.topmap.info

Experts for Making Measurements on Large Surfaces

Today's precision parts are produced with high accuracy. Thus, specifications on functional surfaces require tight tolerances to be met or exceeded. This implies that optical metrology must be able to measure the topography of large surface areas with submicron or nanometer resolution.



Advancing Topography Measurement by Light

Historically, tactile (contact) instruments have been used to measure topography. Today, optical measurement systems such as white-light interferometers are exceeding the performance of tactile instruments and rapidly changing the traditional approach. Specifically, interferometry can determine the topography of functional surfaces much faster than with tactile probes, avoiding the tedious line-by-line scan methodology of point probes. In addition, with structured surfaces, large-area interferometric measurements are more reproducible and repeatable because the structures can be clearly identified.

Optical measurement techniques are non-contact, non-destructive, and can also measure surfaces of soft or delicate materials as well as workpieces with varying surface characteristics. The large measurement range, process-suited technology and easy-to-use software make the TopMap user-friendly and a perfect fit for use in industry.

Measurements can be fast enough to allow 100 % inspection

- Without limiting production throughput
- With full measurement accuracy
- At low investment and operating costs.

Measurements on Large Surfaces

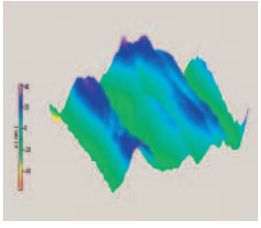
Polytec is a worldwide leader in optical topography measurement technology for large surface characterization with nanometer accuracy. Determining parallelism, flatness, radii, steps, angles and other parameters are typical tasks for this technology. The surfaces to be examined are often situated in high aspect ratio drill holes or between two surfaces that are steeply separated – an easy task for Polytec systems in contrast to other measurement methods, for example coherent interferometry. Further examples of challenging measurement tasks are defect analyses, wear and tear examinations or histograms. If necessary, the measured area can be increased by stitching of several subsequent measurements.

Ripple and Flatness Measurements

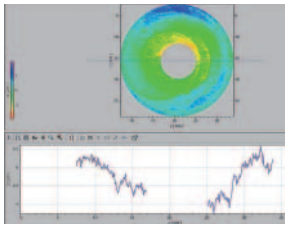
Flatness is often a critical parameter for functional surfaces, such as mating surfaces used in pressure and vacuum technology, transparent film for displays, semiconductor components, metal flanges and ceramic surfaces. The TopMap systems allow large surface area measurements (30 x 40 mm²) to quickly and comprehensively characterize the workpiece. Under optimal conditions it is possible to obtain accuracies in the sub nanometer range.

Relative Position of two Surfaces

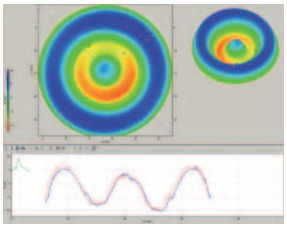
Determining parallelism, height differences or relative angles between several surfaces often requires a large vertical adjustment range. The TopMap products offer adjustment ranges up to 70 mm, allowing surfaces to be measured that are separated by large steps or deep inside drill holes. At the same time the telecentric optics of TopMap systems avoid magnification errors which can distort the image and shadow regions of interest.



Glass surface



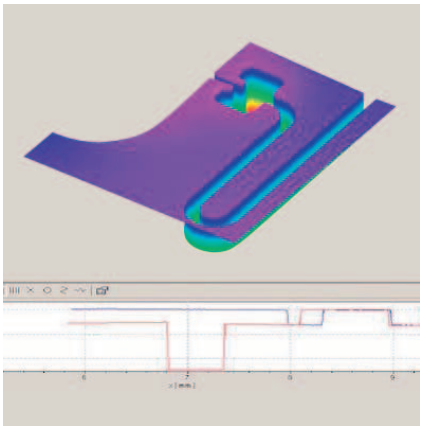
Piezo actuator



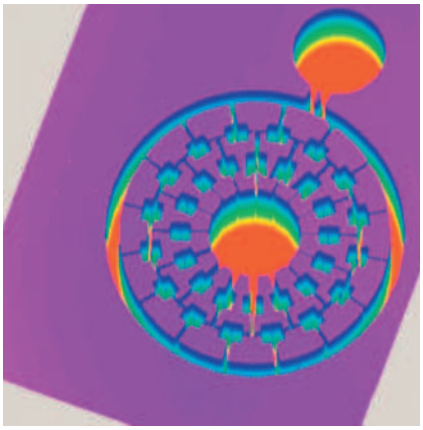
Punched part

Shape and Structure

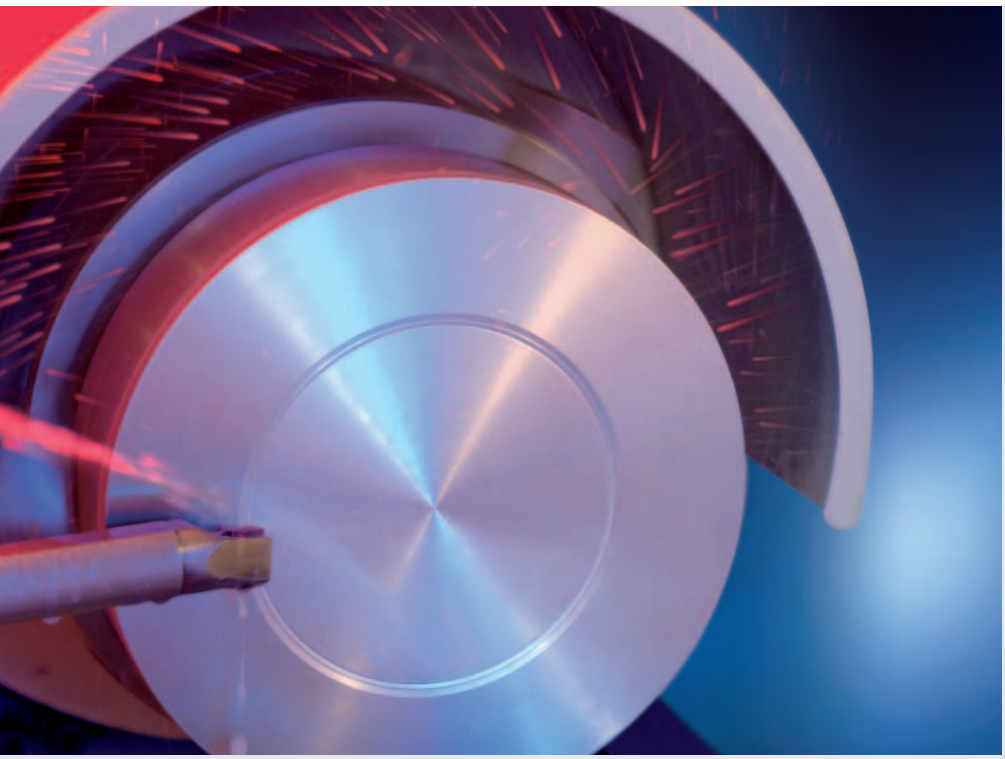
The miniaturization of functional components leads to integrated structures, whose performance depends on manufactured components complying with the specified dimensions, shapes and tolerances. In the images on the right, a Lab-on-a-Chip system for diagnostic or bioanalytical applications is shown. The diagnostic chips are made of plastic with channels and chambers that have been hollowed out. The sample is introduced and the bio-chemical reactions take place within these structures.



Lab-on-a-Chip system

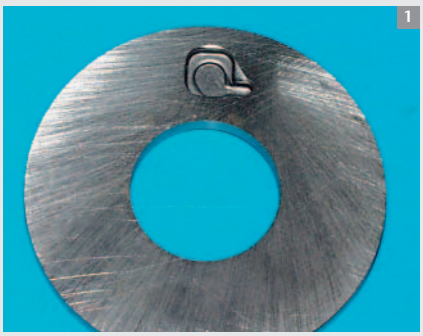


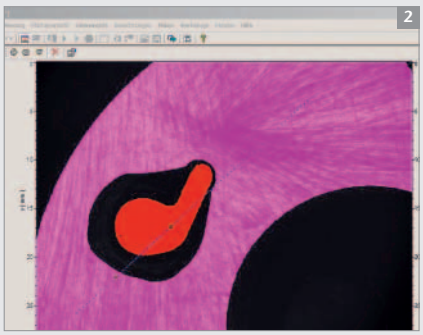
Detailed view

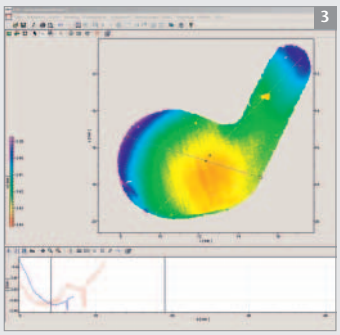


Setting up Machines

CNC machines must be properly set-up prior to machining to assure that manufactured parts have the correct flatness and design contours. Early examination of the workpiece during the setup procedure helps save both time and money. Here, the relevant parameters are checked before the CNC machine is started and the process settings are optimized. The series of images below shows a processed part with two surfaces which are stacked horizontally. The small surface which has been lowered by nearly 3 mm is measured to see how parallel it is to the upper surface (2) and how flat it is (3).







Specialists in Micro-Topography of Fine Structures

By use of short-coherent white light, the TopMap µ.Lab Microscope System features a very high lateral resolution (<0.5 nm), enabling topography measurements on microstructures. It offers high performance analysis options for characterizing micro-sensors, micro-actuators, structured plates and bearing surfaces. Large surfaces can be characterized by stitching several measurements together.

Microstructured Surfaces

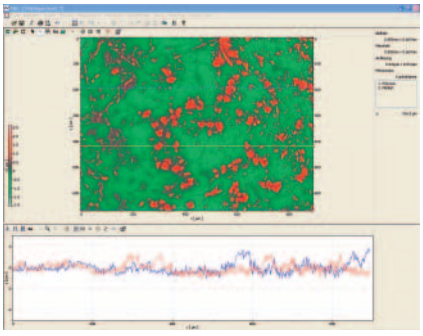
Functional surfaces often require the presence or absence of certain structural characteristics. For example, the type and frequency of pores is an important characteristic for determining the lubricant choice for a frictional surface. Additionally, in the automotive industry, engine surfaces or connecting rod eyes must match the right lubricant to avoid premature part failure; the same applies to structures for improved adhesion of coatings in the steel industry. In contrast to verifying designed structures, there are also unwanted structures which must be found and eliminated to avoid harmful frictional forces or unwelcome vibrations.

Microstructure Technology

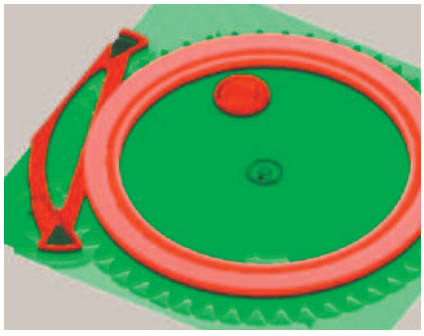
The topography of small components contained in microsystems must be verified to check that the components are within the required dimensions. Microelectromechanical systems (MEMS) and their subcomponents, such as miniature cogwheels and gears, are examples of critical next generation technologies that depend on precision metrology.

Micro Material Processing

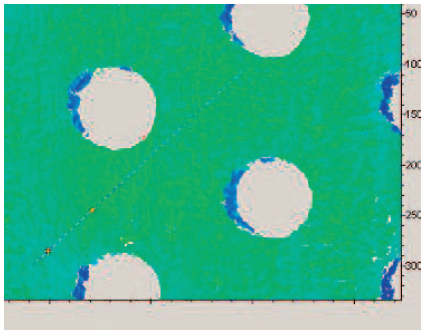
Topography measurements with high lateral resolution are also important when determining the material ejected or distorted during lift-off or deposition processes or while laser machining or etching critical features. Other examples are selective surface texturing to produce predefined frictional surfaces, and the preparation of very small drill holes.



Microstructure of an AluSil cylinder surface



Micro gearwheel



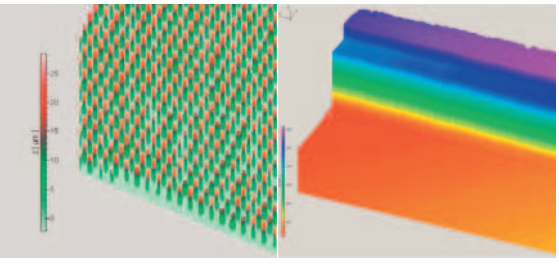
Atomizer membrane with holes and ejecta

Many Diverse Applications

Surface measurements are needed across all sorts of industries. Components and structures dimensioned from microns to centimeters can be found in semiconductors, data storage, microstructures and sensors, but also in precision manufacturing and engineering for automotive and aerospace industries. As a successful developer of high-quality optical measurement systems, Polytec is an experienced partner for topography measurements in almost all fields of application. We can provide tailor-made systems that adjust the size of the area of interest (AOI), increase the resolution and meet special requirements of your measurement tasks.

Good/bad Analysis

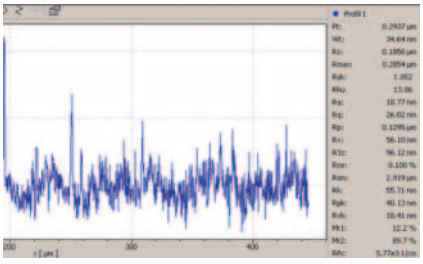
In industrial manufacturing, compliance with given tolerances needs to be checked as often as possible so that faulty parts are eliminated before any further processing steps are taken thereby avoiding additional manufacturing costs on an already defective part. When assembling SMD boards for example, all solder bumps should be the same height and the surfaces of components must be at a certain angle to each other. With white-light interferometers, many surfaces can be examined quickly and over a large surface area to check for defects, incorrect curves or radii, ejecta, and missing connections or dropouts.



Solder bumps Optical part

Parameters

Very often defined parameters, such as roughness or ripple, are stipulated for workpieces. In particular for surface area parameters, white-light interferometers can get results in seconds which would require a much longer time if using tactile processes. Many figures-of-merit such as percentage contact area or frequency distribution can be quickly determined. Roughness can be optically determined; but, the values can deviate from the results of tactile measurements to which the dimensions of the drawing and standards generally refer. New guidelines for calibrating white-light interferometers give the user the security that the measured values can be traced back to calibration standards. Optical measurements also make qualitative roughness parameters available that can help determine whether a surface is too rough leading to high frictional losses or too smooth leading to excessive adhesion.

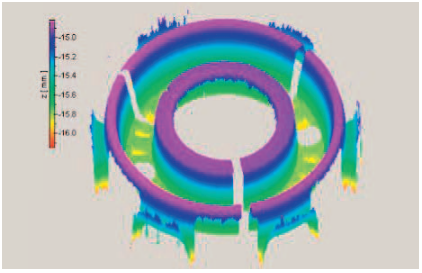


Roughness

Acquiring the Topography

In many cases, the entire topography of a workpiece or object must be checked, for example the shock absorber component shown here. Imprints, safety features and also crime scene evidence in forensics can be analyzed with nanometer accuracy using white-light interferometry.

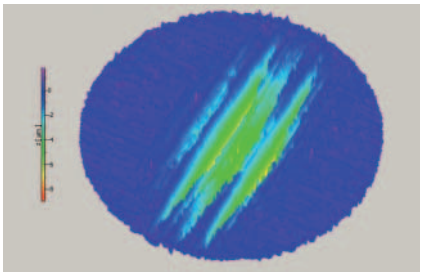
Warping and deformation requirements for structures, such as printed circuit boards, are getting much more restrictive as a consequence of the decreasing dimensions of mounted components.



Shock absorber component

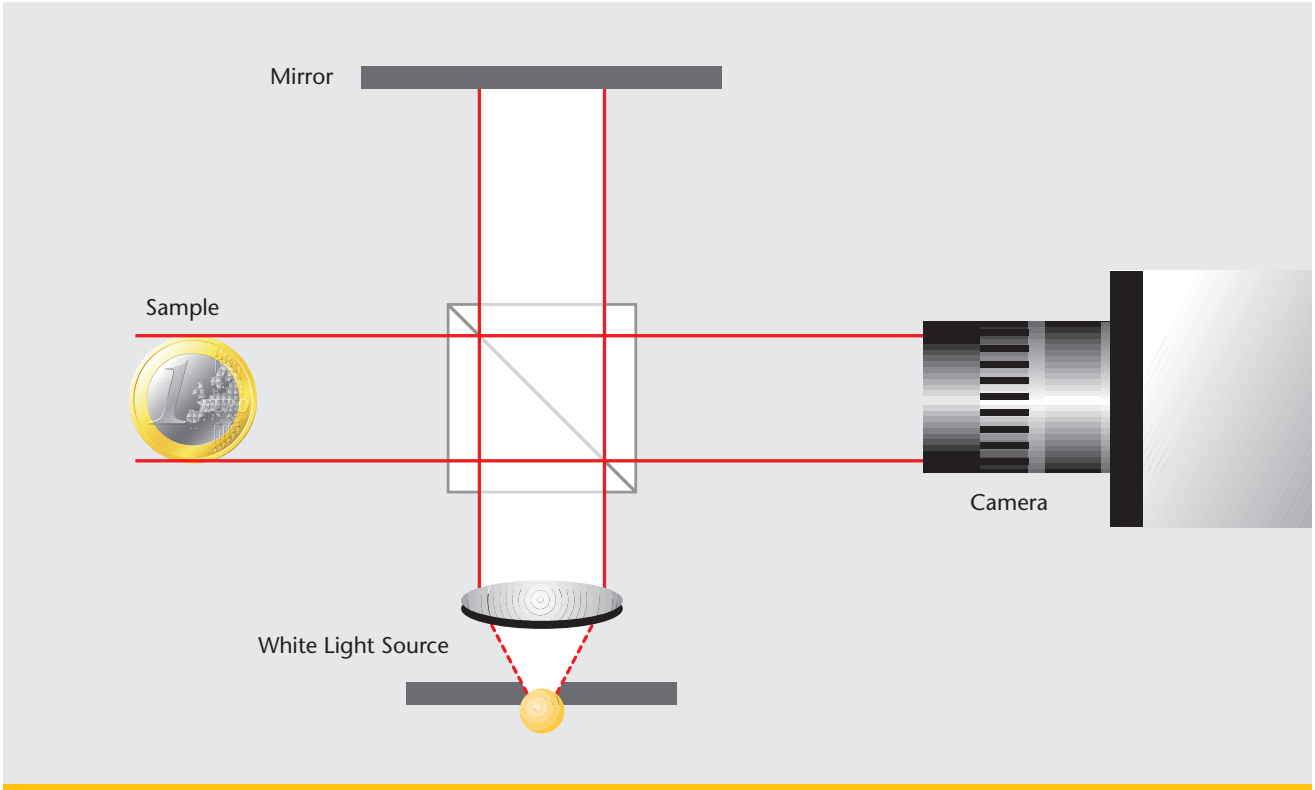
Volumes

In the case of wear measurements, determining the ejection volume plays an important role. The surfaces are often very jagged and the light reflected back shows great intensity differences. The Smart Surface Scanning Technology (page 9) of the TopMap systems guarantees optimal results in such cases as well.



Tribological pattern (ball on disc method)

Measuring with Light



Modern white-light interferometers feature a special optical configuration to use the interference effects which occur due to the interaction of the sample surface with white (broadband) light.

The measurement itself is based on the principle of the Michelson interferometer, whereby the optical configuration (image above) contains a light source with a coherence length in the µm range. The collimated light beam is split at a beam splitter into an object beam and a reference beam. The object beam hits the object and the reference beam hits a mirror. The light scattered back from the mirror and the object respectively is superimposed at the beam splitter again and is imaged into a CCD camera.

If the optical path for an object point in the measurement arm is the same as the optical path in the reference arm, then for all wavelengths in the spectrum of the light source, there is constructive interference and the camera pixel of the respective object point has a high intensity. For object points that do not fulfill this criterion, the assigned camera pixel has a much lower intensity. Consequently, a camera frame output can be processed pixel by pixel to determine which object points are at the same height.

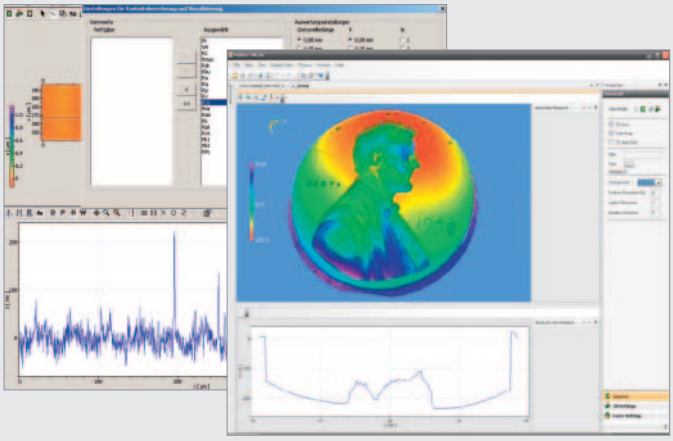
In the interferometer, only the reference arm or the object is moved relative to the beam splitter, so when traversing the evaluation length, interferences are formed pixel by pixel as the object height is scanned. After a measurement run, the camera frames are analyzed and the topographical structure of the sample is digitized.

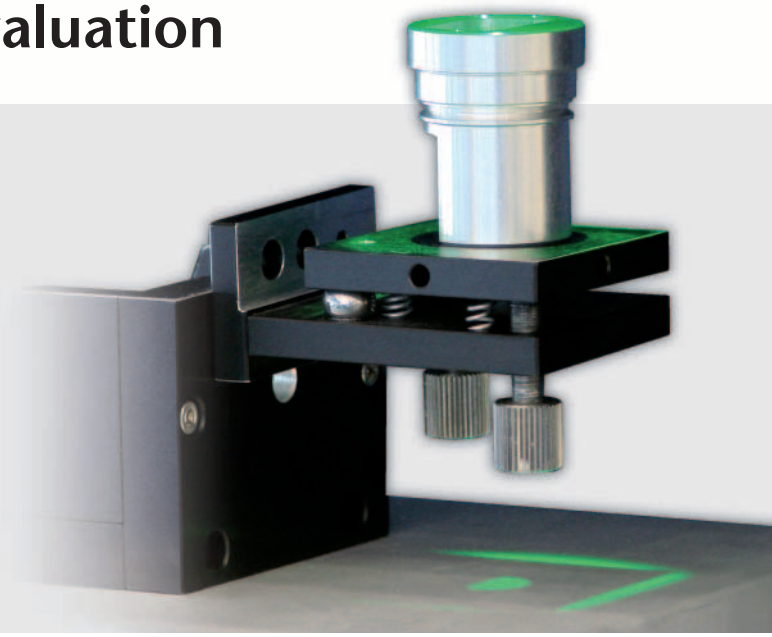
Please find more detailed information on **www.topmap.info**

Depending on the customer's application requirements, Polytec has specific TopMap models that optimize the measurement (page 11). Instruments with a telecentric configuration allow simultaneous measurement of the topography of large surface areas in a single measurement and within a short measurement time.

If high lateral resolution is required, microscope systems are more suitable where the optical configuration including the reference arm is integrated into the objective.

User-friendly Software for Measurement and Evaluation





The high performance Topography Measurement System (TMS) Software makes all important control and evaluation functions available, including 2-D, 3-D, isolines and profile views. Its open software architecture also allows routine tasks to be programmed using Visual Basic® (VB) or other appropriate software, as well as through your own user interface. All TopMap systems come with a VB engine.

Flexible and Automatic Measurement

Designed for simplicity of operation, the TMS Software allows every new operator to quickly make menu-assisted measurements and evaluate them after only a brief initial training. After setting the measurement parameters, the measurement process is automatic. With Polytec's white-light interferometers you can utilize an open software architecture. The TopMap systems can be remotely controlled using a COM/ActiveX interface or LabView™ driver from other applications. With the aid of simple Visual Basic macros, automatic process sequences can be easily integrated into customer defined applications.

Likewise, routine measurements can be easily performed with high repeatability and reproducibility, even by non-trained staff.

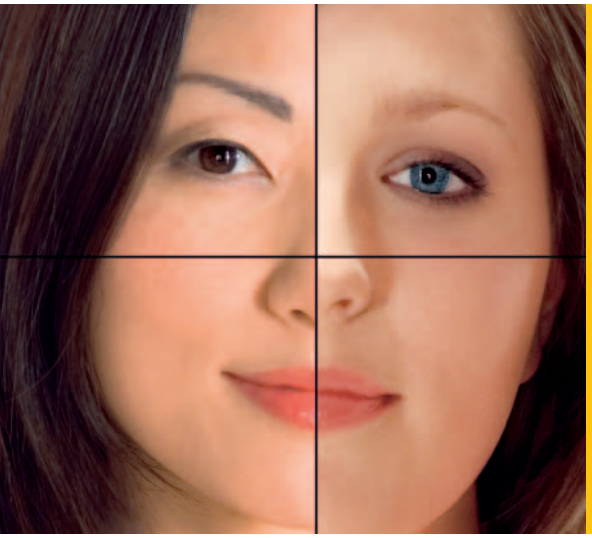
Versatile and Selective Evaluation

The topography of the sample is shown in 2-D or 3-D view on the PC screen and can be evaluated manually or automatically. The raw data of the measurement is not automatically smoothed allowing the user to determine correct processing for their application and later on, if required, can selectively optimize or recalculate the data. Because the data is made available in binary or ASCII format, it is also possible to export it directly to MS Excel, MATLAB® or in-house databases.

In addition, the TMS software contains special functions that allow topography measurement from surfaces that may be difficult to optically characterize:

- Live Video support in aligning the sample, illumination and selection of the measurement range; the video image is saved with the measurement
- Auto-optimization (reference filter)
- Smart Surface Scanning Technology for measurements on high-contrast surfaces (page 9)
- Repeated measurements and a wide choice of averaging methods, filters and linear regression algorithms
- Working with masks, profiles and layers
- Evaluation in terms of various 2-D and 3-D surface parameters
- In case of extremely flat surfaces (also including steps), the precision can be further increased by applying a special evaluation procedure. The original data remain available for other analysis steps.

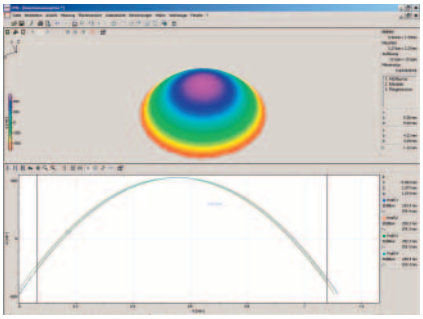
Surfaces Have Many Faces

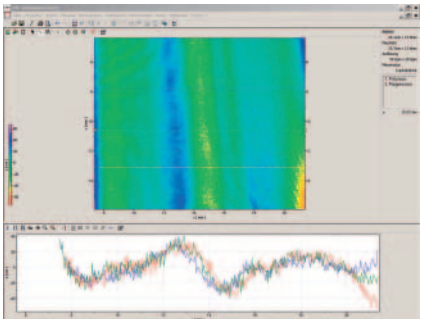


Quick topography measurements on functional surfaces open up new possibilities for development laboratories or for quality assurance. By using "incoherent" light, Polytec white-light interferometers avoid the disadvantages of coherent interferometric measurements. The requirements of the surfaces to be measured are comparatively low: even a limited transparency of the workpiece does not cause problems, in contrast to methods based on oblique light. These benefits make white-light interferometry a universal tool for determining the surface topography.

High Accuracy

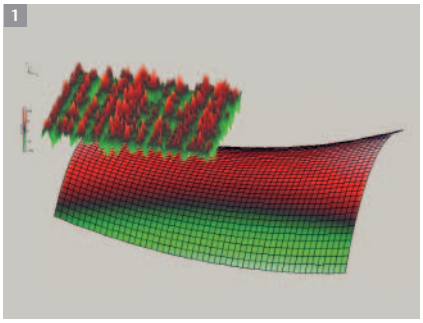
The vertical resolution of the TopMap systems can be in the subnanometer range and in practice is only limited by the ambient conditions, not by the measurement principle. This allows high precision measurements of the flatness and shape of sheets of glass or optical surfaces (see images below).

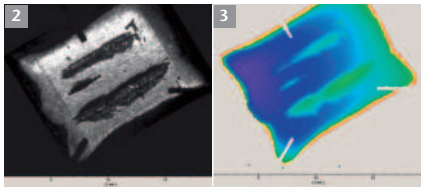




Large Surfaces

Being able to measure across the entire surface of a large workpiece has many significant advantages. No sequentially measured, smaller fields-of-view have to be stitched together and evaluated. Any inaccuracies caused by moving the hardware or through stitching software are removed. A shorter measurement time also minimizes the influence of time-dependent distortions produced by the surroundings.





Pattern Subtraction

Within the TMS Software, polynomial regression procedures enable the subtraction of a defined shape from the measured data. For instance, minimum deviations from a curved surface can be easily detected (1).

Large Intensity Differences

Workpieces often reflect with different intensities, for example in the case of highly reflective surfaces with different angles of inclination. For cases like this, Polytec has developed the Smart Surface Scanning technology which measures the surface several times with different camera exposure times. The software automatically selects the optimal exposure time for each pixel and integrates them into one image. The measurement sequence can also be programmed sequentially by setting different exposure times for different heights.

High Degree of Automation

Due to the inclusion of a VisualBasic® compatible Engine, the TMS Software can be programmed for your own specific processes; for example, an automated sequence or a customer-specific user interface for measurement and evaluation. Such programs can be created by the customer or alternatively by the Polytec software/application engineers.

High Flexibility, Yet Easy to Use

The user-friendly interface of the TMS Software is easy to operate during measurement and evaluation. Preset, optimized, standard routines that are provided to measure different categories of surfaces – such as rough, highly structured or smooth, angled surfaces – make it easier to select the correct measurement and evaluation parameters and are also used for reproducibility measurements.

Quality Raw Data without Smoothing

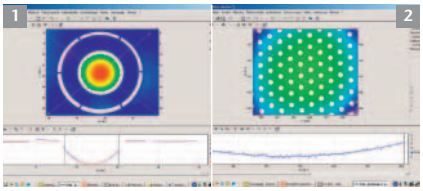
When the original measurement data has sufficient signal-to-noise, you can eliminate, to a large extent, post processing through filters or smoothing. The quality of the measurement data can be significantly increased by the Smart Surface Scanning technology – it is also possible to preset a threshold value for the signal quality. The software allows all correlograms to be saved to be able to evaluate the quality of every individual point later on. The camera image can be made visible underneath the partially transparent topography image at any time, for example, to allow allocation to a defect that can be identified visually.

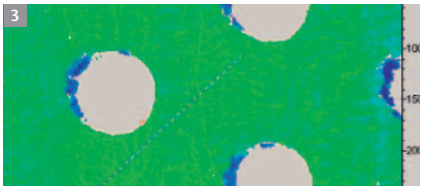
Great Depths in Drill Holes as Well

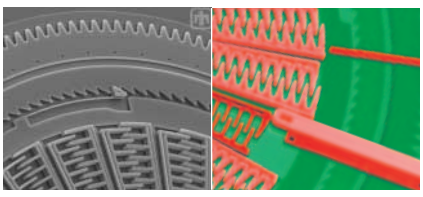
The telecentric optics allows the TopMap systems to make measurements in drill holes without appreciable shadowing due to magnification errors. Telecentric optics are the optimum choice for machine vision systems, comparable accuracy using any other method cannot be attained.

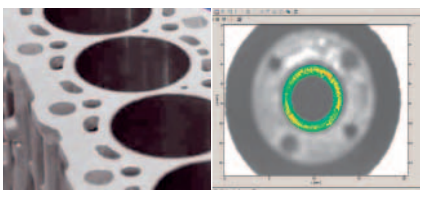
Large Surface Area and Microscopic Measurements

For measurements with different fields-of-view and different lateral resolutions, the combination of telecentric and microscopic measurement technologies is ideal. The images below show an atomizer membrane measured with a field of view of nearly 40 x 30 mm² using the telecentric TopMap system (1). The small holes in the membrane can be zoomed in with a TopMap µ.Lab microscope system (2) and if you use a 50x objective, you can even analyze the material ejected at the edges of the holes (3).







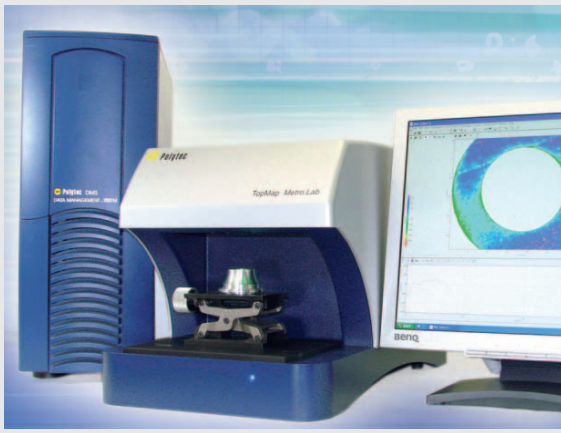


A Topography Measurement System for each Customer

For high throughput on the production line as well as high resolution measurements in the lab, Polytec has designed a family of TopMap Topography Measurement Systems to meet our customers' most pressing demands. All TopMap models are equipped with the user-friendly Polytec TMS Software. Please find more detailed information on www.topmap.info

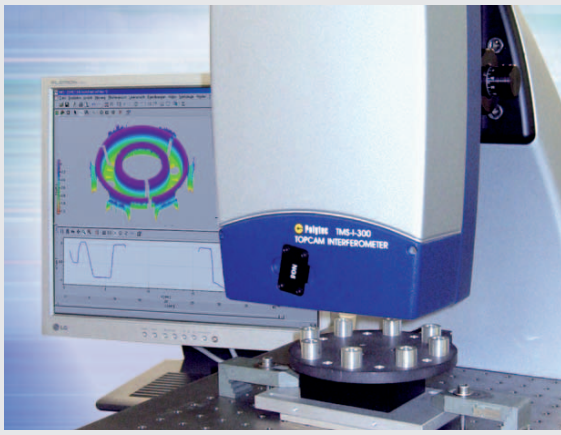
For Large Surfaces: TMS-100 TopMap Metro.Lab

Sold as a complete measurement station, TopMap Metro.Lab is ideally suited for measuring large-area topography on almost all surfaces. The large height range of 70 mm allow measurements to be made even under difficult conditions with 20 nm resolution. An excellent price/performance ratio makes the Metro.Lab attractive for small companies with limited budgets, lower throughput requirements and fewer measurement applications. The instrument is precise enough for a metrology lab and can even replace many tactile measurements or sit side-by-side with them while not negatively impacting a budget. As is the case with all TopMap systems, the open software architecture allows routine tasks or customized user interfaces to be easily programmed.



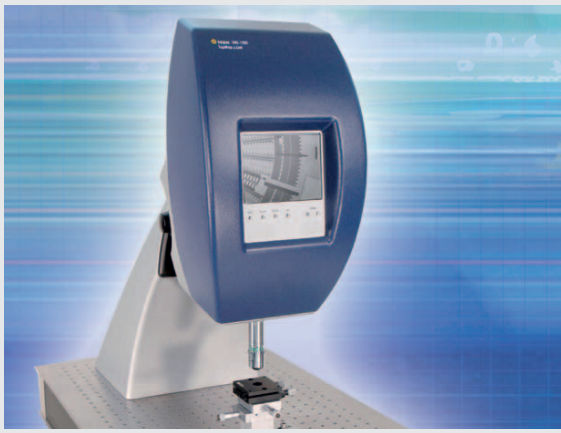
For Large-scale Process Measurements: TMS-300/-320 TopMap In.Line

This is the ideal system for precisely measuring surfaces in a challenging environment, such as in production control. The compact instrument can be mounted in many different ways on the production line and measures preset specifications (flatness, topography) while maintaining high product throughput. The measurement itself is very fast and can be completely automated. The vertical resolution is a few nanometers and depending on the task, different areas of interest are available from 4.2 mm x 5.5 mm up to 19 mm diameter. The large stand-off distance enables several unique measurement options, such as measuring topography through windows or in inaccessible places with the aid of a deflecting mirror.



For Micro-Topographies: TMS-1200 TopMap µ.Lab

With its high spatial resolution, the TopMap µ.Lab measurement microscope sets new standards in non-contact topography measurement. Simple, quick and with nanometer accuracy, it acquires the topography of functional surfaces and microstructures to determine critical parameters such as flatness, ripple and roughness. It has been especially developed to characterize the micro-topography of functional surfaces and microstructures in product development and quality control. The topography of objects which are larger than the field-of-view can be generated by moving the samples and combining the measurements of several sections (stitching), whereby travel ranges of up to 50 mm in x and y direction, respectively, are available.



High Precision Surface Measurement

Polytec has delivered high-performance light-based sensors, measurement solutions and instruments for R&D, industrial, medical, automotive, MEMS, data storage, semiconductor, photonics and aerospace markets for more than 40 years.

TopMap Topography Measurement Systems

System	TopMap Metro.Lab	TopMap In.Line		TopMap µ.Lab
Version	TMS-100	TMS-300	TMS-320	TMS-1200
Optical Design	Telecentric (for large surfaces)	Telecentric (for large surfaces)		Microscope system (high lateral resolution)
Vertical range	70 mm	500 µm	50 mm	250 µm
Area of interest (mm)	35 x 22 ≈ 80 x 80 with stitching (optional)	various areas, permanently installed min. 4.2 x 5.6 max. 13.6 x 18.3 and Ø 19		depending on lens min. 0.18 x 0.13 max. 3.6 x 2.6

Acquiring the 3rd Dimension Using Optics

Do you need a quick, efficient tool to acquire the flatness and topography with nanometer accuracy on a wide range of surfaces to improve your product development or quality control? With our TopMap Topography Measurement Systems, analyzing large surfaces, or even microstructures with a high lateral resolution becomes easy and efficient. With the aid of white-light interferometry the whole surface of the object under investigation is automatically scanned without being touched. If measurements of dynamic properties are required as well, the All-in-One Micro System Analyzer (MSA) provides a complete characterization of microstructures. This highly developed technology in combination with high performance measurement and analysis software allows complex measurement problems to be solved in research, development and production.

You will find detailed technical information and additional application examples on our homepage at **www.topmap.info**

Give us a call. We offer top quality solutions! Please contact your local Polytec sales engineer. See address list for contact details.

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

Polytec France S.A.S.
Bâtiment Orion – 1er étage
39, rue Louveau
92320 Châtillon
Tel. +33 1 496569-00
Fax +33 1 57214068
info@polytec.fr

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

Polytec Japan
Arena Tower, 13th floor
3-1-9, Shinyokohama,
Kohoku-ku, Yokohama-shi,
Kanagawa, 222-0033
Tel. +81 45 478-6980
Fax +81 45 478-6981
info@polytec.co.jp

Polytec, Inc. (USA)
North American Headquarters
16400 Bake Parkway
Suites 150 & 200
Irvine, CA 92618
Tel. +1 949 943-3033
Fax +1 949 679-0463
info@polytec.com

Central Office
1046 Baker Road
Dexter, MI 48130
Tel. +1 734 253-9428
Fax +1 734 424-9304

East Coast Office
25 South Street, Suite A
Hopkinton, MA 01748
Tel. +1 508 417-1040
Fax +1 508 544-1225

www.polytec.com

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