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SURFACE TOPOGRAPHY INSPECTION IN MULTISENSOR APPROACH

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Abstract: *In contemporary solutions for surface asperities measurements some concepts appear where different sensors, basing on different physical principles are used. It is an idea from one side to measure various surfaces impossible to inspect with a standard tactile inductive probe, and from another to measure the same surface with several sensors. Thus it is possible to get more information and draw more complex and versatile conclusions. In the paper a concept of such a multisensor device was shown with a construction and some applications. Here, confocal probes as well as interferometric one and tactile sensors were used.*

Keywords: *multisensor, topography, surface*

INTRODUCTION

Modern systems for quality control require more and more versatility. With surface roughness it is sometimes critical issue, as different measurement techniques show different features causing variations in measurement results. Future trends show optics as interesting solutions, still such devices – despite their impressive speed of measurement - are nowadays very rare in industrial applications [1]. This is due to the fact that optical techniques tend to show some non-existing artifacts on the surface, what in some cases can significantly distort the whole analysis. On the other hand for more and more industry branches a need emerge to inspect surfaces too soft to be touched. This includes paper, skin, wood and biological material, bioengineering applications [2], but also plastics and sometimes graphite [3]. For this reason new ideas are tested and multisensor concept is one of them.

In many devices used in length and angle metrology manufacturers try to use different sensor obtaining thus a multisensor solution. It allows inspecting certain features with tactile and non-contact probes collecting data together and presenting measurement results together. Such examples are in CMMs where optical probes are used to compliment tactile ones or in 3D scanners where tactile probe is an auxiliary one for optics. Also in surface metrology such a solution can be very beneficial.

For this reason a concept appeared to create a multisensor device that would make it possible to measure roughness on different surfaces and to be introduced for production. This idea turned into a product is showed in this paper.

OPEN ARCHITECTURE AND MULTISENSOR CONCEPT

Altimet provides a large range of metrological solutions based on the profilometry technology (Fig. 1). The analyzed sample is scanned point by point on its surface.

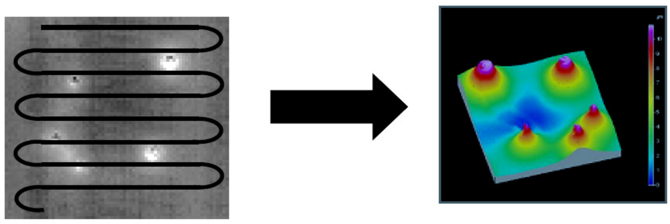


Figure 1 – Area scanning in optical profilometry

This scanning can be performed by various optical contactless sensors or by a mechanical stylus. The open architecture of the systems makes it possible to embed several types of sensor in the same device. There are two ways to scan the surface:

1. the sensor is fixed, and the object is placed on a movable stage. The movement of the stage is controlled in both directions (X and Y) with precision,
2. the other option is to move the all sensor system on top of the object.

In both solutions, the 3D mapping of the surface is performed by adding the different measured scans. An open architecture of the system offers a wide range of sensors possible to use in surface measurements. Among them, there are different solutions, both tactile and non-contact ones, used for inspection of different features of surfaces. Starting with conventional tactile sensor it is possible to check surfaces on which diamond tip would not make any harm, including steel, ceramics and hard plastics. It is also possible to another tactile probe where measuring force is significantly reduced, *i.e. a micro force sensor. This is not making any scratches even on very soft materials, what make it possible to compare a tactile probe with optical one.*

Non-contact probes comprise many different confocal sensors, depending on required range and resolution. It works on the principle shown at figure 2. An incident white light pinhole is imaged through a chromatic objective into a continuum of monochromatic images along the Z-Axis, thus providing a 'color coding' along the optical axis. When an object is present in this 'colored' field, a unique wavelength is perfectly focused at its surface and then reflected into the optical system. This backscattered beam passes through a filtering pinhole into a spectrograph in order to analyze which wavelength has been perfectly focused on the object, and then accurately determine its position in the measuring field.

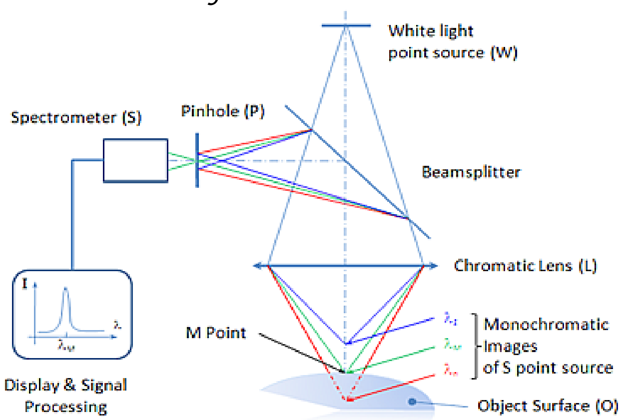


***Figure 2** – Working principle of confocal sensor*

The ranges of confocal sensors start from 110 micrometers and can reach as much as 27 millimeters.

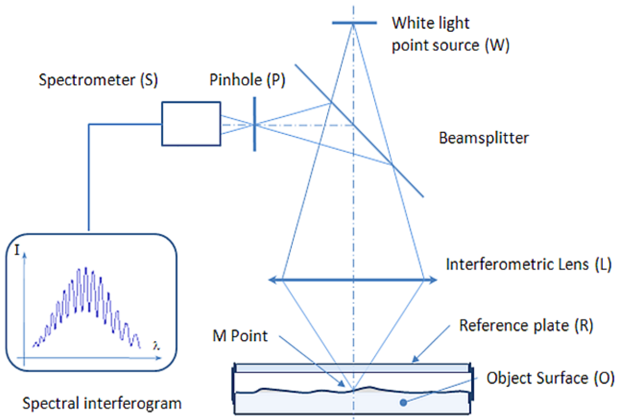


***Figure 3** – Working principle of interferometric sensor*

For more precise inspection an interferometric probe can be used. The working scheme was presented on figure 3. The light from a white-light point source W passes through an interferometric objective L and a reference plate R before it reaches the sample surface. The superposition of the light beams reflected from the sample surface and from the reference plate generates an interference phenomenon. The reflected beams pass through the interferometric lens L in the opposite direction, and arrive at a pinhole P which filters out all light rays except those originating from the object point M. The spectrometer S measures the channeled spectrum of the interference signal. The thickness of the air gap between the sample and the reference plate can be extracted with sub-nanometric resolution from the spectral phase of this spectrum.

If a measurement task is contour inspection more than purely asperities than a triangulation laser can be used. Furthermore, a system can be equipped with a CCD camera to precisely adjust a starting point or area on surface.

MEASUREMENT SYSTEM

The whole setup (Fig. 4) allows using different probes with relative distances calibrated to each other. Thanks to this feature it is possible e.g. first to use a CCD camera to find a place on the surface where roughness is to be measured. Second, a non-contact probe is applied and measurement is taken in the same place that was chosen with CCD camera. Afterwards it is possible to inspect the same (within repeatability of drives) place with another contact or non-contact sensor.

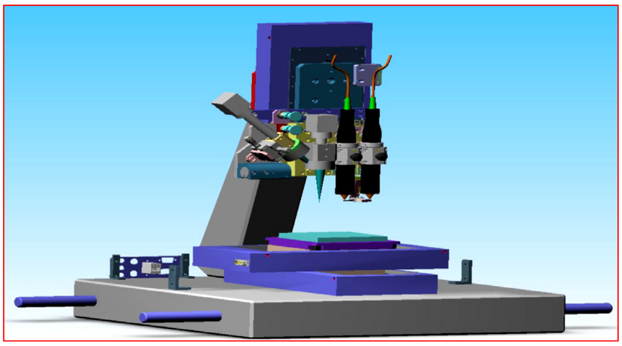


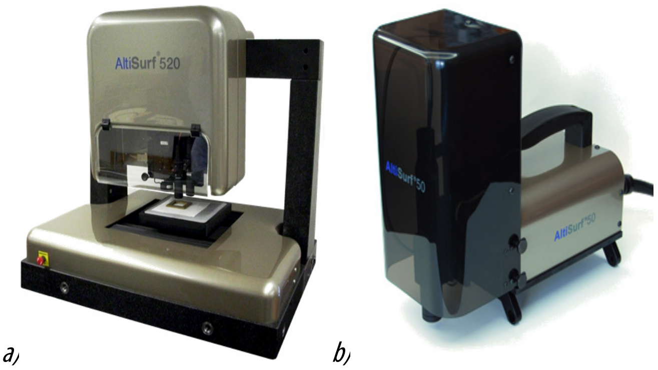
***Figure 4** – Open architecture and different sensors*

Such architecture allows using the device in multifunction configuration for different purposes:

- ✓ *to evaluate surface state parameters in polishing, erosion, grinding corrosion, tribology, fretting, adherence, rolling etc.,*
- ✓ *to elaborate flatness contact, vibration and acoustics, perform filtering,*
- ✓ *to calculate step-height features for steps and engravings,*
- ✓ *to execute reverse Boolean analysis for diameter of grinding tool, radius for tool settings, to make extraction from cylinders, spheres*
- ✓ *to check thickness of paper, film, mechanical parts, foils and boards or varnishes.*

The whole structure of open architecture concept is governed by a controller equipped with PheNix© Technology. PheNix© software is a toolbox of easy to use functions to program your measurements, calibrate, loop some actions, and select any of the sensors. PheNix© Technology means mostly modularity of the systems for a lab to line control and open architecture based on standards components available 'on the shelf'.

The measurement device was presented on figure 5a. It can have different table options from 100x100 mm to 300x300 mm and more for special requirements, equipped with precise DC motors with local flatness not exceeding 2 nm. Also Z traverse can vary from 100 mm to 300 mm. Traverse speed can reach 30 mm/s. Further rotary axis is also available. The device can work in automatic production mode with shop floor control card (green/red light), and through self-learning *function. On the other hand it can be also used in clean rooms. A portable version of presented concept allows to measure topography using confocal sensor (Fig. 5b). It has 25 mm x 25 mm x 25 mm strokes and can be located directly on top of large work pieces to be measured.*



a) b)

***Figure 5** – A standalone multisensor profiler (a) and a portable topography measuring system (b)*

EXAMPLES OF MEASUREMENT TASKS

Looking at possible fields of application we should start with mechanical engineering and what is related to it: cutting, tribology, wear etc. [4]. In this example, a metal surface has been polished using a robot with different settings. A pertinent topography measure with an accurate post-processing treatment allow for the quantification of the effect of the various settings. An example of surface image is shown on figure 6.

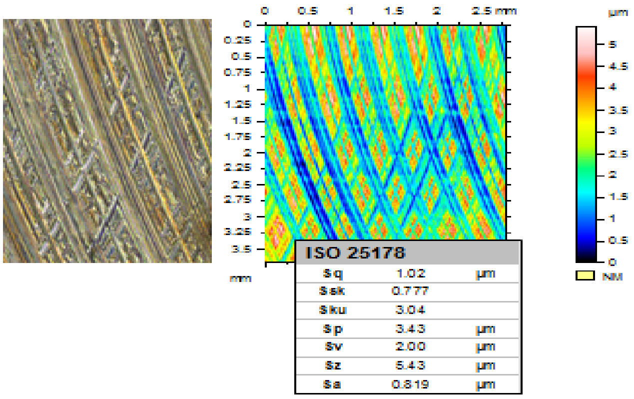


***Figure 6** – A robot polished surface*

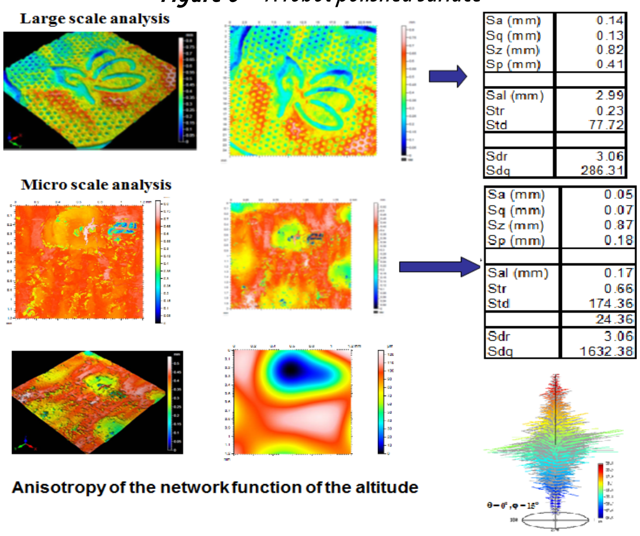


***Figure 7** – Multiscale tissue paper analysis*

As optical roughness measurements are very useful for paper measurements [5, 6], the next example shows multi-scale tissue paper analysis, concerning both: roughness and anisotropy (Fig. 7). Starting from large scale inspection it is possible to go down to micro scale analysis with parameters calculated for both scales. Furthermore modal analysis of the open porosity and fibers orientation as well as anisotropy of network function of altitude was presented.

Another important application for surface analysis is glass. Here, nano scratches were a matter of research using interferometric probe. The results are presented on figure 8.

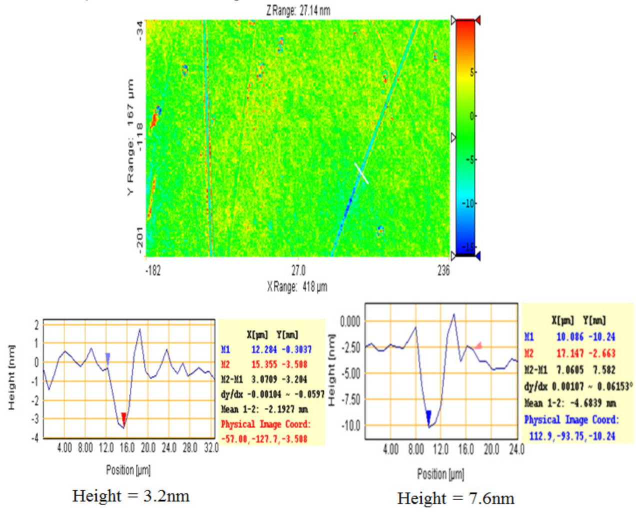


***Figure 8** – Analysis of nano scratches on glass*

Using the confocal sensor, one can determine the contact angle of liquid on a solid surface. This is particularly important for all the research works concerned with wettability [8]. Furthermore, the roughness of the solid can be taking into account and included in the calculations (Fig. 9).

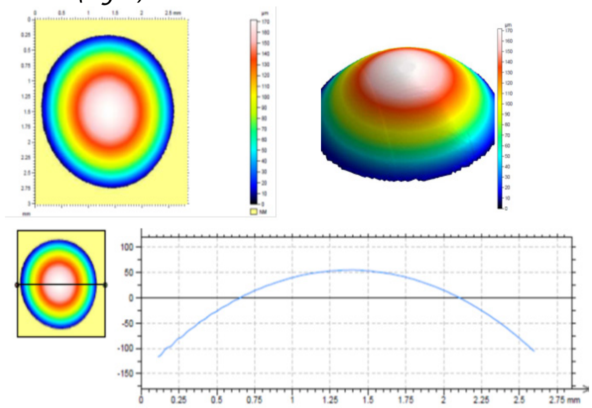


***Figure 9** – A drop of liquid on solid surface*

One of the unique attribute of the confocal technology, is measurement through a layer of glass. This is useful in biological applications [7]. Measurement through a glass layer is also a nice feature in the next presented application. By taking advantage of this interesting property, the evolution of a soft surface under compression can be studied. In this example, exactly the same area was measured at two stages of compression (the pressure is applied by the glass on top of the sponge). One can then calculate the porosity variation caused by the compression (Fig. 10).

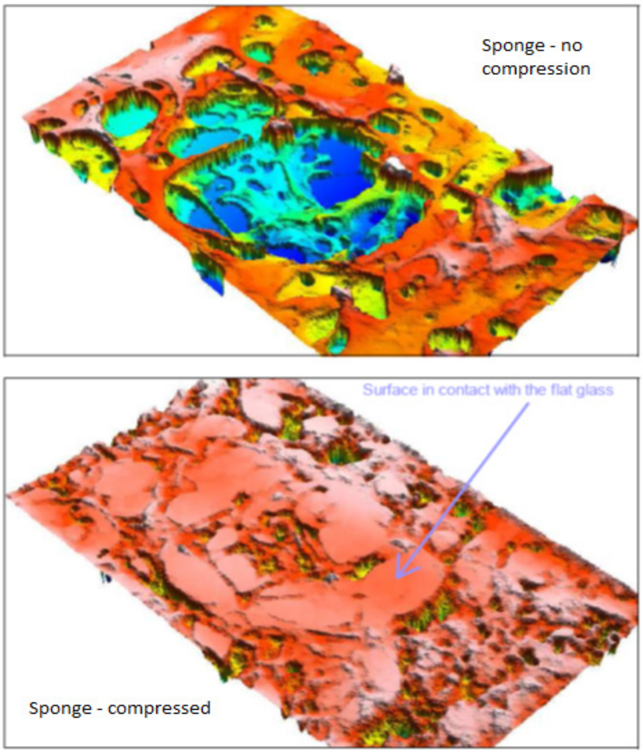


***Figure 10** – Sponge measurement in compressed and not compressed version*

These few examples show how big can be application range of multisensor profilometer. Different sensors can be used for different surfaces. Furthermore, in questionable results case, it is possible to measure the same area with two or more different sensors and compare them, verifying fidelity of representation.

Accuracy of the system after initial adjustment was verified on standards, manufactured according to ISO 5436 part 1. A and D type standards were used to get information regarding performance of tactile probes, while optical flat served for inspection of drives. These tests were performed for each probe individually. They showed that results for Ra, Rz and Rt (or Rmax) values were within uncertainty of the standard. For confocal and interferometric probes we use special standards, checked by accredited laboratory. They also show good conformity of results.

5. CONCLUSIONS

As it was pointed out, modern systems for quality control require more and more versatility. Future trends quite clearly show optics as potential solution, thanks to its impressive speed of measurement. A concept of multisensor devices to measure surface roughness proved to be a good solution in many applications. It is possible to use several sensors calibrated against each other with a CCD camera to find exactly an interesting space from measurement point of view. An open architecture and modular idea makes such a device a versatile unit for different branches of industry.

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