Surface Topography Measurement by Confocal Spectral Interferometry

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Contactless metrology becomes more and more important for all steps of production quality control. Automotive industry and producers of microsystems and advanced components need fast and accurate measurements of small structures, surface topography, and layer thickness, where a lateral resolution of a few microns is required. The accuracy of the distance measured between the object and a reference plane usually needs to be better than 0.1 µm. Evidently, only optical systems are capable to operate with such needs.

The **chromatic coding** based on chromatic aberration of a lens where the axial position of the focal point depends on the wavelength of the radiation to be converged [1]. This principle is applied for **confocal imaging** as illustrated in figure (1), where a converging lens (L) illuminates a very small area of an object surface. Thus the radiation of wavelength λ_m is focused at a point M of the surface where the other radiations are defocused. The focusing lens (L) receives the backscattered light from the object's surface and focuses it into an optical fiber. Due to that confocal arrangement, light with the wavelength λ_m is focused to the front of the fiber and enters without cutting. All other spectral components are stretched on a much bigger area. The light fed through the fiber to a spectrometer is almost monochromatic, it´s wavelength λ_m being a chromatic code about the axial position of the backscattering surface. However, the heights of the asperities of the scattering surface can be translated by the respective positions of the spectrometer frequencies and thus a calibration of the spectrometer scale is possible [2], [3].

Spectral Interferometry consists in the analysis of the interference pattern of two back reflected wavefronts produced by the two faces of a transparent sample (or two near points of rough surface) [4]. The interferometric signal is a channeled spectrum from which the spectral phase is calculated using a numerical phase shifting algorithm allowing measurement of the local height of the analyzed surface with a sub-nanometric resolution [1]. The **confocal spectral interferometry** (CSI), based on the combination of two optical principles mentioned above, is used to explore a surface to establish its topography.

In the **present work** a non-contact sensor called “Micromesure 2” of STIL [4], based on CSI principle is used, giving roughness profiles much faster than a classical tactile probe; it measure the heights (z-coordinate) of the surface points located on its optical axis.
Five comparators called "rugotests" with indicated standard roughness values are investigated. The figure (2) shows, in left, the 2D-Intensity distribution, in middle, the 3D-Intensity distribution, and at the right, the surface topography. From the heights of the asperities of the topography, the mean arithmetic roughness and the rms roughness are calculated (table I).
For comparison, the figure (3) displays the arithmetic roughness values obtained by CSI and the standard arithmetic roughness values indicated for the five rugotests.

We **conclude** that the CSI is a non-invasive optical method used to generate the topography of surfaces. To verify its ability to evaluate surface roughness, we investigated five comparators of known standard roughness called "rugotests", and the results are in good agreement.
Furthermore, the *rms* roughness, a more significant parameter for characterizing surface roughness, can be determined by this technique. Then the advantage of the CSI is to give both the topography and the roughness parameters of a surface.

References

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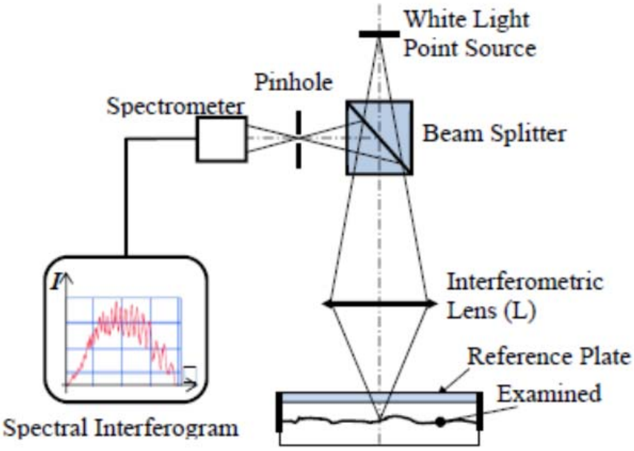

Fig. 1. Confocal spectral interferometry set-up

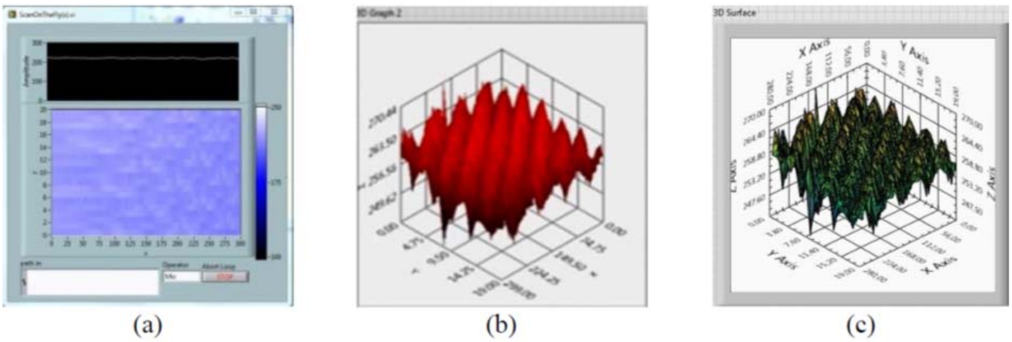

Fig. 2. Surface topography of rugotest with $R_z = 6.3\mu m$, (a) 2D-Intensity distribution, (b) 3D-Intensity, c) topography.

Rugotest	*Ra* (µm)	*rms* (µm)
1	0.238	0.101
2	0.467	0.404
3	1.017	0.815
4	1.230	0.912
5	4.306	3.403

Table I. Arithmetic roughness and RMS determined by CSI

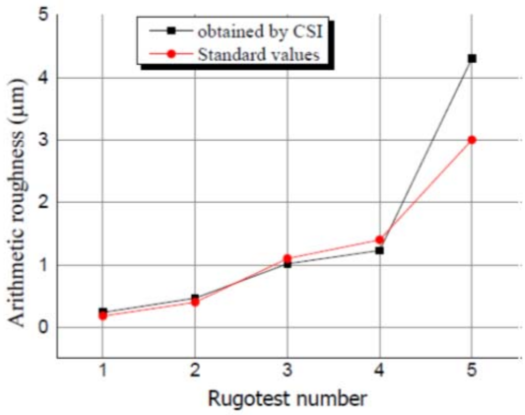

Fig. 3. Arithmetic roughness R_a obtained by CSI and the standard values