The effect of scattered light sensor orientation on roughness measurement of curved polished surfaces

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The effect of scattered light sensor orientation on roughness measurement of curved polished surfaces

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Introduction

The effect of angular orientation of a scattered light sensor with respect to main curvature and surface lay on roughness measurements is evaluated. A commercial scattered light sensor OS 500-32 from Optosurf GmbH was used. The investigation was performed on polished cylindrical surfaces with crossed surface lay to document the robustness of the method. The instrument area-integrating measuring principle (figure 1) is based on a non-coherent light beam of ∅ 0.9 mm and 670 nm wavelength illuminating the measured surface, reflection of the incident light from the surface slopes in spatial directions, and its acquisition within ± 16º angular range with a linear detector array. From the distribution of the acquired scattered light intensity, a number of statistical parameters describing the surface texture are calculated, where the *Aq* parameter (variance of the scattered light distribution), is used to characterize the surface roughness.

Measurement procedure

Three polished surfaces with different surface roughness (table 1) on a cylindrical specimen of ∅ 38 mm were measured with the scattered light sensor in 12 angular positions with 15° intervals (figure 2 left). Directionality of the surface texture was assessed from surface photographs and area topography measurement using a stylus profilometer.

Results

All the three investigated surfaces had two dominant texture directions of ± 65° relative to the specimen axis (figure 3).
Surface curvature, texture directionality and roughness level were observed simultaneously affecting the measurement. The predominant effect of surface curvature causing increase of *Aq* value can be seen in figure 2 (right) in the measurements on the finest surface A from 0° to 90° of the sensor orientation. This is caused by the additional surface slope due to the curvature, widening the scattered light distribution, thus enlarging *Aq* (figure 4). In opposition to the curvature effect, surface texture directionality has a predominant effect on measurements of surfaces with higher roughness B and C, causing a decrease in *Aq.* This is due to the relative orientation of the unidirectional sensor detector with respect to the spatially reflected light from the surface slopes, causing a change in the distribution of the acquired light on the detector (figure 4). The reduction in acquired intensity *I* is due to its portion scattered outside the range of the sensor (± 16°). Simultaneous effect of the two factors, texture directionality and curvature, can be seen in figure 2 (right) in the measurements on surface B.

Conclusions

The effect of the scattered light sensor orientation on roughness measurements of polished cylindrical surfaces with crossed surface lay was investigated and documented. For the investigated surface textures, the optimal orientation of the sensor detector is collinear to the specimen axis and to the bisector of the two dominant surface lays, regardless of the roughness levels. In this way the effect of surface curvature is suppressed and the texture properly characterized.

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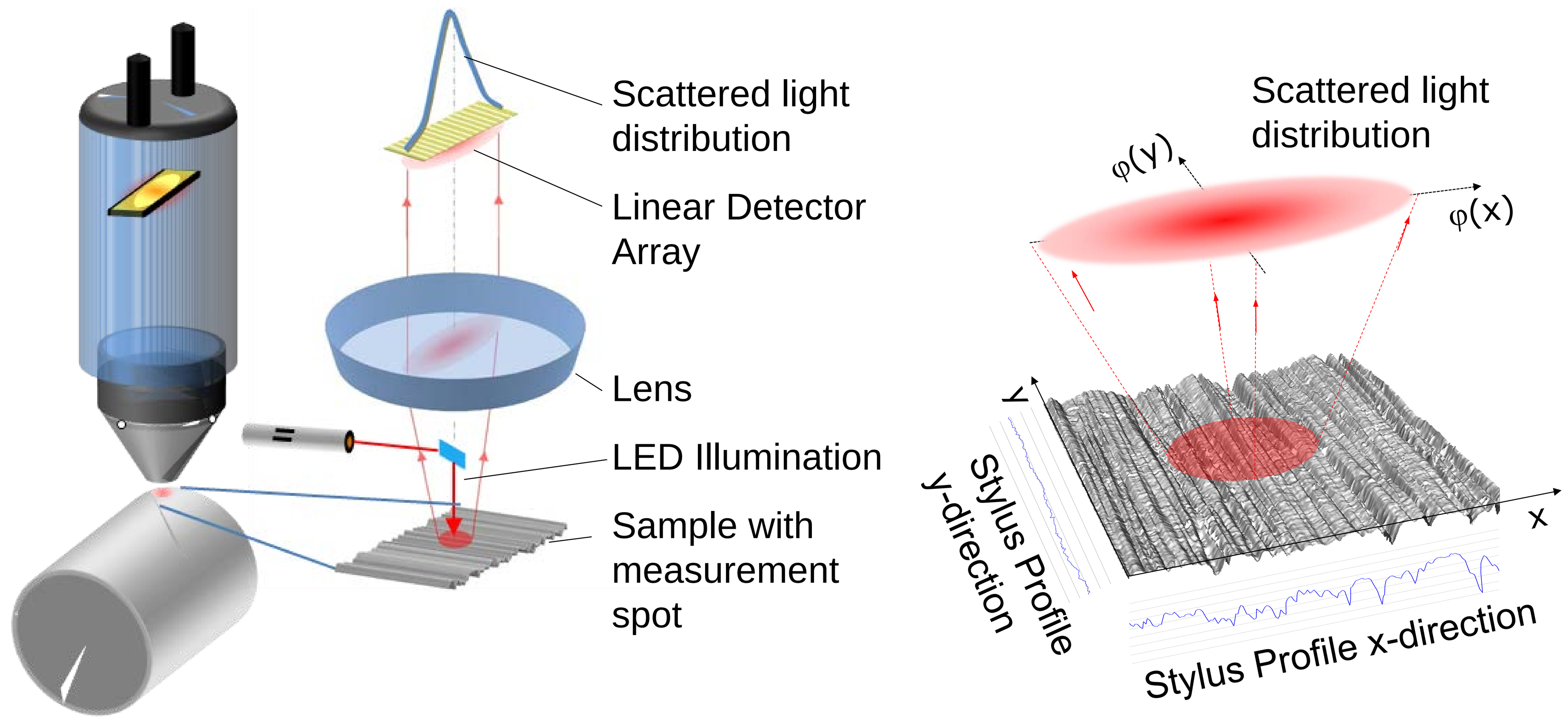

Figure 1: Sensor measuring principle (*Courtesy of Optosurf GmbH).

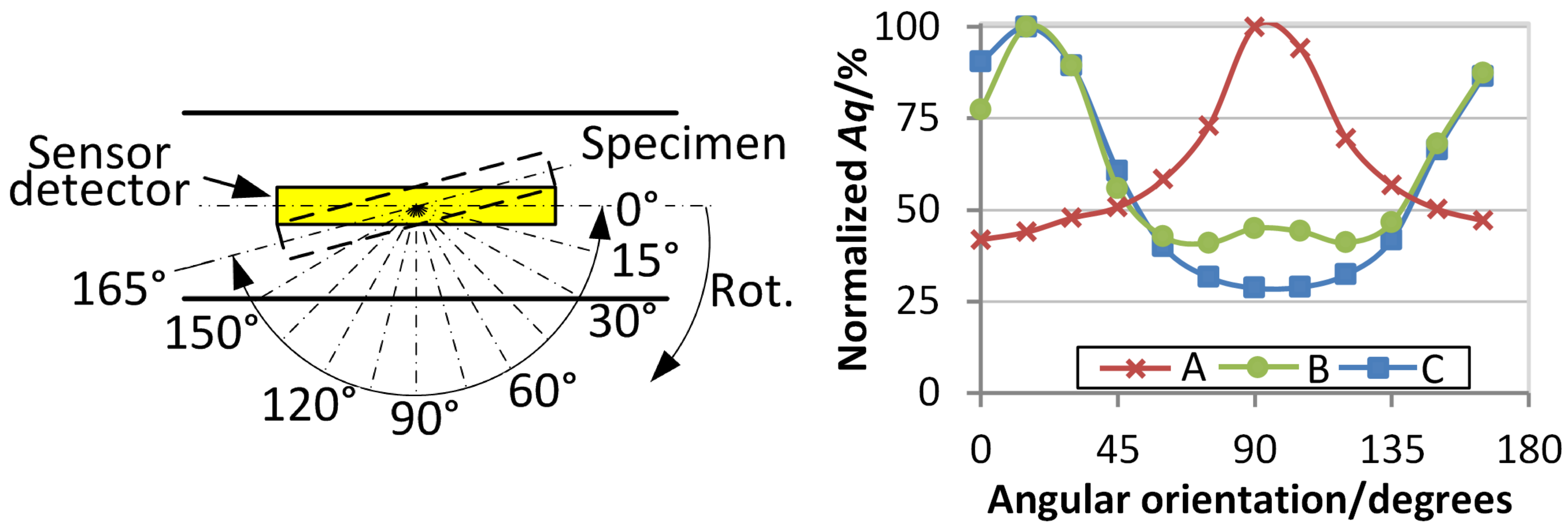

Figure 2: Orientation of the sensor detector (left) and normalized *Aq* in 12 angular sensor orientations (right). Normalized *Aq* = [(Aq/Aq_{max}) · 100].

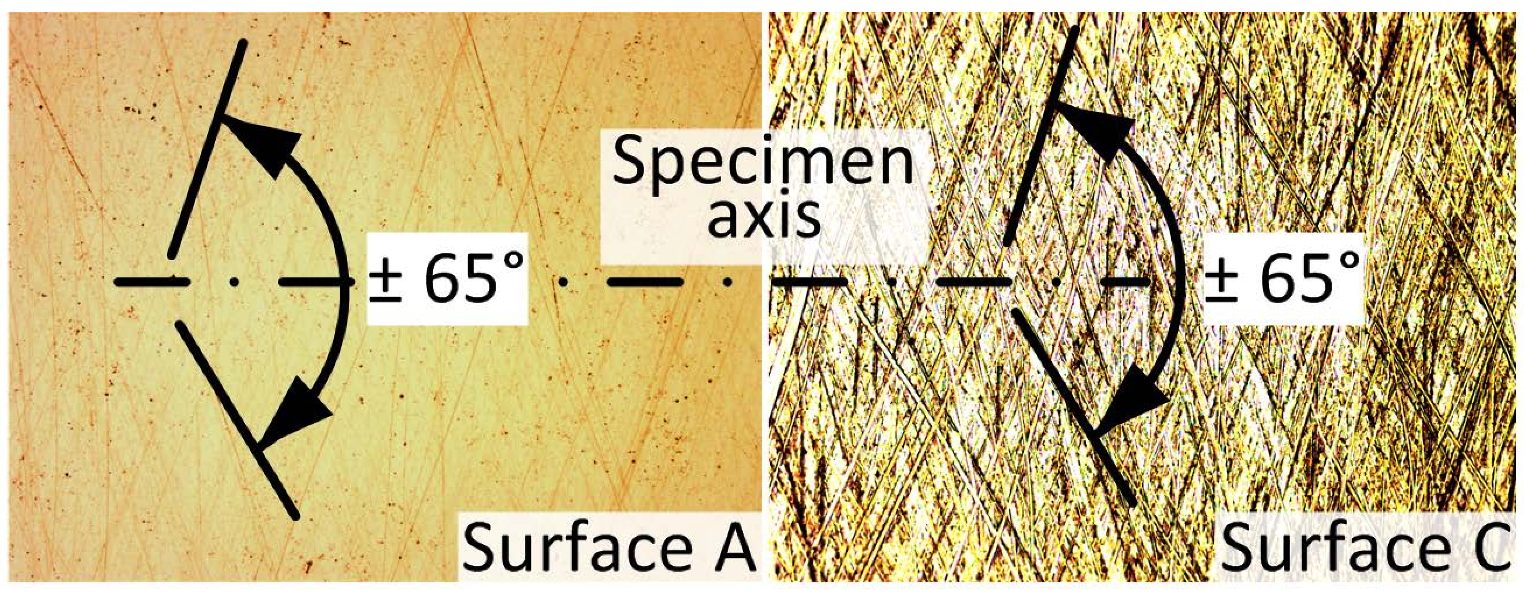

Figure 3: Photographs of surfaces A and C with 2 main texture directions.

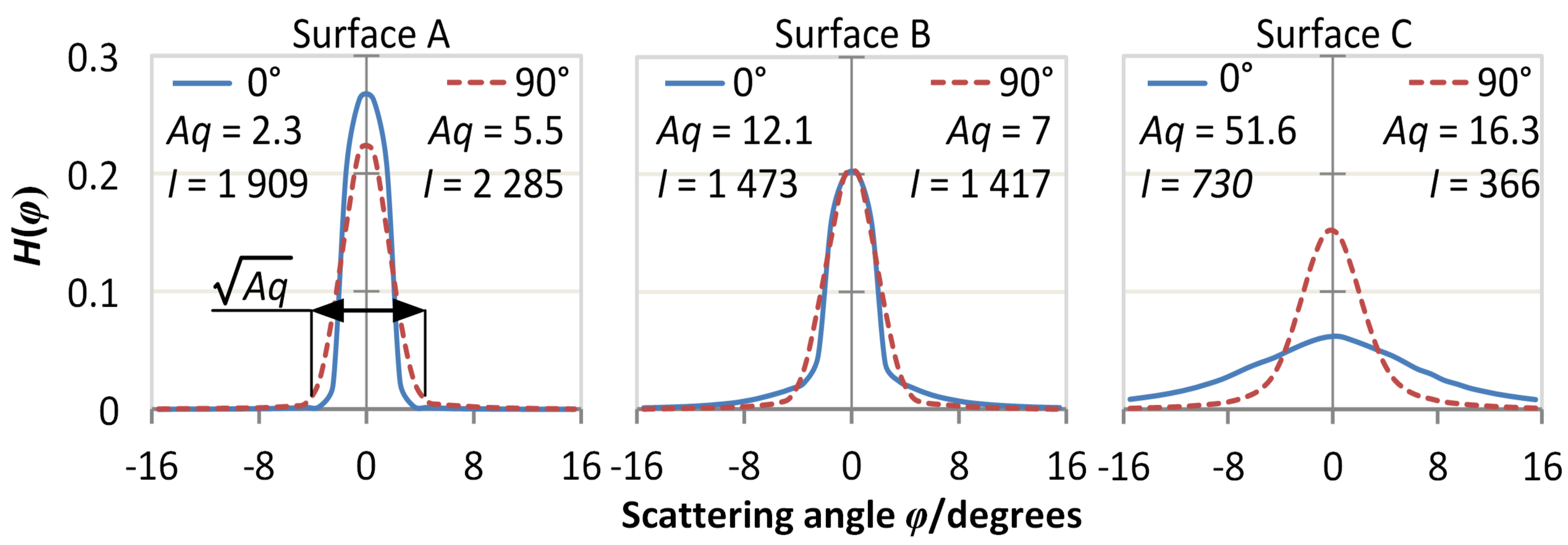

Figure 4: Normalized intensity function *H*(φ) at scattering angles *φ* on surfaces A, B and C at 0° and 90°, *Aq*/a.u., *I*/a.u. (a.u. is arbitrary unit).

Table 1: Quantified effect of the sensor orientation.
Change in % = measured value at {[(90° – 0°)/0°] · 100}

Surface	*Ra*/µm	Change in *I*/%	Change in *Aq*/%
A	0.012 ± 0.001	20	139
B	0.032 ± 0.002	-4	-42
C	0.178 ± 0.010	-50	-68

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