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Quagliotti, Danilo; Tosello, Guido; Hansen, Hans Nørgaard

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Objectives comparison in a confocal microscope using pseuso-random roughness artefacts

D. Quagliotti, G. Tosello and H. N. Hansen

Technical University of Denmark, Department for Mechanical Engineering, Produktionstorvet 427, DK-2800 Kgs. Lyngby

danqua@mek.dtu.dk

Abstract

The increasing importance of optical microscopy in the geometrical and dimensional assessment of structured and freeform surfaces has easily overcome many difficulties related to the use of contact instruments. Nonetheless, some concerns related to optical instruments when measuring such surfaces are still open. The working distance (WD) of some standard (ST) lenses, e.g., can prevent from freely moving alongside features at different heights and positions of structured and freeform shapes due to the risk of collisions. In such cases, the so-called long working distance (LWD) objectives allow to operate at a longer distance from the surface under measurement, saving the same field of view (FoV) but accepting lower numerical apertures.

The current work compares standard and LWD objectives available for the confocal microscope Olympus Lext. The investigation was to compare *Sa* and *Sqd* surface texture areal parameters related to the same surface, acquired by 50×, 100× ST and 50×, 100× LWD lenses.

A pseudo-random roughness metal artefact (AIR-B70) was the transfer standard. It belongs to a set of artefacts, for areal calibration of optical instruments, denominated 'Bento Box' and produced at the National Physical Laboratory (NPL) in Teddington, UK.

Results show an average *Sa* (filtered in the same way as stated in the calibration certificate), calculated from 50× ST acquisitions, about 10 % lower than the calibrated value. The deviation is deemed dependent on the different level of discretisation (number of pixels and pixel size): The calibrated values are related to a matrix 3×3 of acquisitions. One single FoV was instead acquired in the investigation not to add another influence source to the comparison (stitching of 9 FoVs).

Furthermore, no calibrated value is available for *Sdq* parameter.

This difference increased when considering the 100× ST measurement average. Nevertheless, cutting the 50× ST acquisitions to the same field of view of 100× ST ones (considering the same reference coordinates) and resampling to the same number of pixels (4096), the respective roughness parameters become congruent.

ST objectives were successively compared with the corresponding LWD ones. No filters were used at this stage. *Sa* from 50× LWD was 4 % higher with respect to the one calculated from 50× ST. This

deviation becomes much larger (700 %) for *Sdq* parameter. Regarding 100× magnification, *Sa* from LWD objective is 15 % lower than *Sa* from ST one, whilst *Sdq* from LWD is still larger 150 % than *Sdq* from ST. From a visual inspection (Fig. 1), this behaviour can be explained by the presence of spikes in LWD acquisitions.

In conclusions, ST objectives clearly show reliable acquisitions, noticing that the FoV of 100× lens is reduced and not able to get the most of the variations on the surface unless considering the 'stitching' technique.

LWD objectives introduce disturbances in the measurements above all of 50× LWD lens, which affect *Sdq* parameter. Disturbances by 100× LWD lens are quite limited but disagreement in the measurements of the metal surface are still significant.

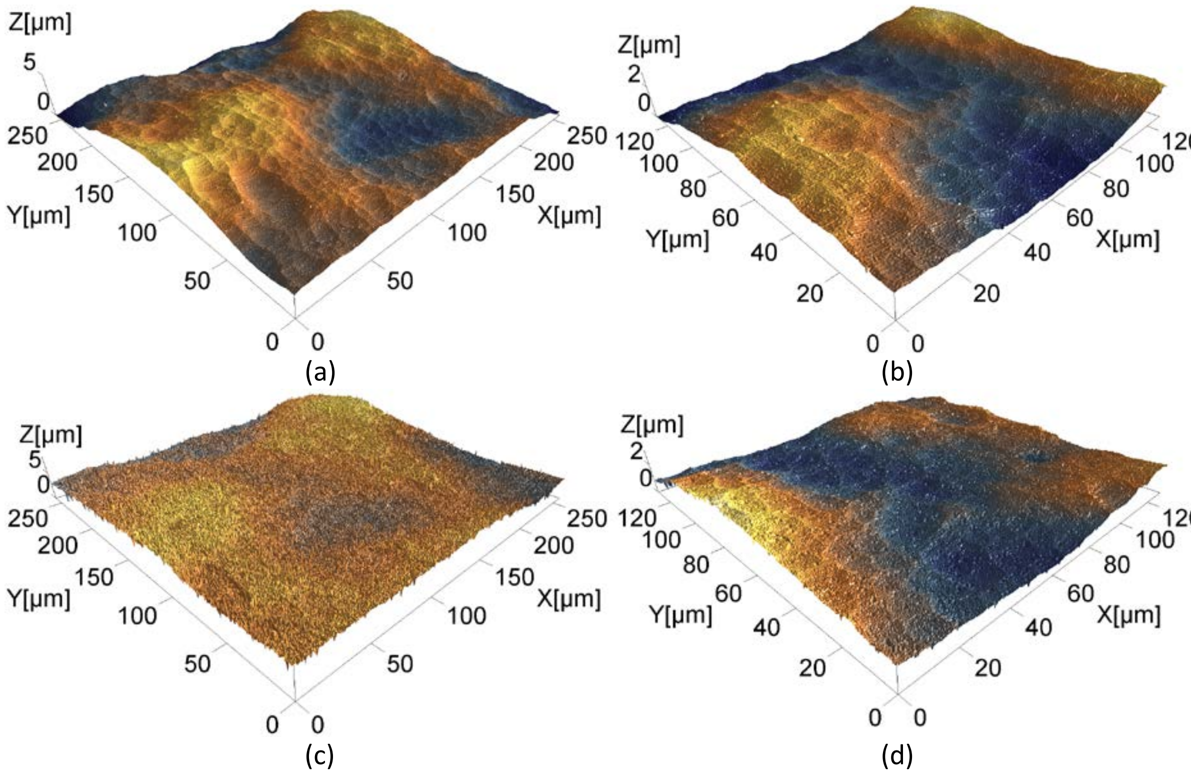

Figure 1: Example of acquisitions in the same reference coordinates using (a): 50× standard objective; (b): 100× standard objective; (c): 50× long working distance objective; (d): 100× long working distance objective.