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Publication date:
2017

Document Version
Peer reviewed version

Citation (APA):
Feng, X., Quagliotti, D., Maculotti, G., P. Syam, W., Tosello, G., Hansen, H. N., ... Leach, R. (2017). Measurement noise of a point autofocus surface topography instrument. Abstract from 16th International Conference on Metrology and Properties of Engineering Surfaces (Met&Props 2017), Gothenburg, Sweden.

Measurement noise of a point autofocus surface topography instrument

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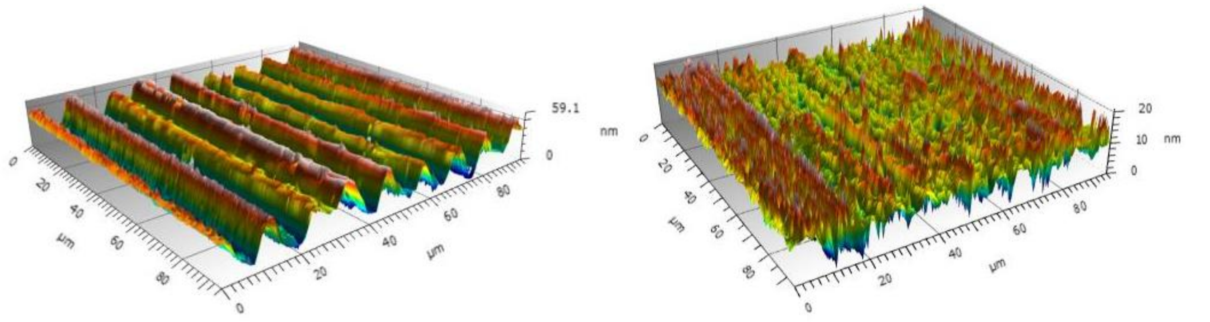
Keywords: areal, measurement, noise, surface, texture, point autofocus, optical, microscope

Abstract Optical instruments for areal topography measurement can be especially sensitive to noise when scanning is required. Such noise has different sources, including those internally generated and external sources from the environment [1]. For some instruments, it is not always possible to evaluate each single contributor. Nevertheless, it is possible to evaluate the noise added to the output during the normal use of the instrument. Such noise is defined in ISO 25178 part 605 [1] as "measurement noise". In this work, the measurement noise is assessed for a commercial point autofocus instrument (Mitaka MLP-3SP), installed in the manufacturing metrology laboratory at The University of Nottingham. The investigation is carried out by areal acquisitions of 100 µm × 100 µm with a 100× magnification objective and a sampling distance of 0.1 µm along the *x*-axis and 1 µm along the *y*-axis. The measurement noise is evaluated by applying established subtraction and averaging methods described elsewhere [2, 3]. The results reveal a maximum calculated value of 20 nm (subtraction method) and a minimum of 8 nm (subtraction method). An oscillation is observed in the acquired surface topographies, which is due to a thermal drift induced by the air conditioning system. The disturbance can be reduced using the temperature correction tool in the software of the instrument. Experiments performed when the air conditioning system is inactive, showed drift of the instrument due to the temperature which is estimated, in the worst case, as 0.9 µm/ºC (calculated as $Sz/\Delta T$), over one hour measuring time. The investigation was then repeated applying the temperature correction tool and the evaluation of the measurement noise results in a value of 2 nm (both methods). The overall temperature variation, measured in the housing chamber of the instrument, is smaller than 0.1 ºC during each repeated measurement. In conclusion, the point autofocus instrument shows a clear dependence on the environmental noise. The measurement noise uncertainty contributor in the worst case is estimated to be u_{noise} = 20 nm when the temperature correction tool

is not applied [2]. The use of the built-in temperature correction tool allows the measurement noise uncertainty contributor to be reduced to u_{noise} = 2 nm.



(a) (b)

Figure 1. (a): Areal acquisition of an optical flat; the measurement is affected by periodic disturbances. (b): areal acquisition of an optical flat applying the temperature correction tool.

Table 1. Measurement noise results for averaging method ($Sq_{noise,ave}$) and subtraction method ($Sq_{noise,sub}$) without using the temperature correction tool.

Averaged measurements	2	3	4	5	6	7	8	9	10	11	12	13
$Sq_{noise,ave}$/nm	15.6	12.5	15.0	14.7	14.0	13.3	13.1	13.4	13.4	13.7	13.7	14.1
Subtractions	1	2	3	4	5	6	7	8	9	10	11	12
$Sq_{noise,sub}$/nm	15.9	7.6	18.2	10.7	8.4	8.2	8.8	15.9	17.2	19.0	18.5	20.3

Table 2. Measurement noise results for averaging method ($Sq_{noise,ave}$) and subtraction method ($Sq_{noise,sub}$) applying the temperature correction tool.

Averaged measurements	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$Sq_{noise,ave}$/nm	1.7	2.1	1.9	2.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Subtractions	1	2	3	4	5	6	7	8	9	10	11	12	13	14
$Sq_{noise,sub}$/nm	2.1	1.9	2.0	1.8	2.3	2.3	2.2	2.1	1.8	2.1	2.1	1.9	2.0	2.2

Main References

[1] ISO 25178-605: 2014 (2014) Geometrical product specification (GPS) — Surface texture: Areal – Part 605: Nominal characteristics of non-contact (point autofocus probe) instruments (International Organization of Standardization)

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