Determination of topography fidelity with optical surface texture measuring instruments

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Introduction

The advances in the sectors of advanced manufacturing and precision engineering have resulted in a demand for structures with complex surface specifications. Current industrial calibration methods, though mature, do not facilitate an environment for **uncertainty evaluation** making the quality control of a manufacturing process a difficult task.

The metrological characteristics framework introduced in ISO 25178 – 600 goes some way towards establishing **instrument traceability** by combining the influence factors that contribute to the uncertainty of a measurement into a list of explicitly stated **metrological characteristics** (MC). However, a method for determining topography fidelity still eludes.

Table 1: List of metrological characteristics

Metrological characteristic	Main potential error along
Measurement noise	z
Flatness deviation	z
Amplification coefficient	x ,y ,z
Linearity deviation	x ,y ,z
x-y mapping deviation	x ,y
Topographic spatial resolution	z
Topography fidelity	x ,y ,z

Objective

Development of a method for the determination of topography fidelity and how it can be incorporated in an uncertainty budget.

Methodology

- Creation of virtual twin of the physical instrument using the 3D surface transfer function, magnification objective and error characteristics.
- Comparison of the output of the virtual instrument to the physical.

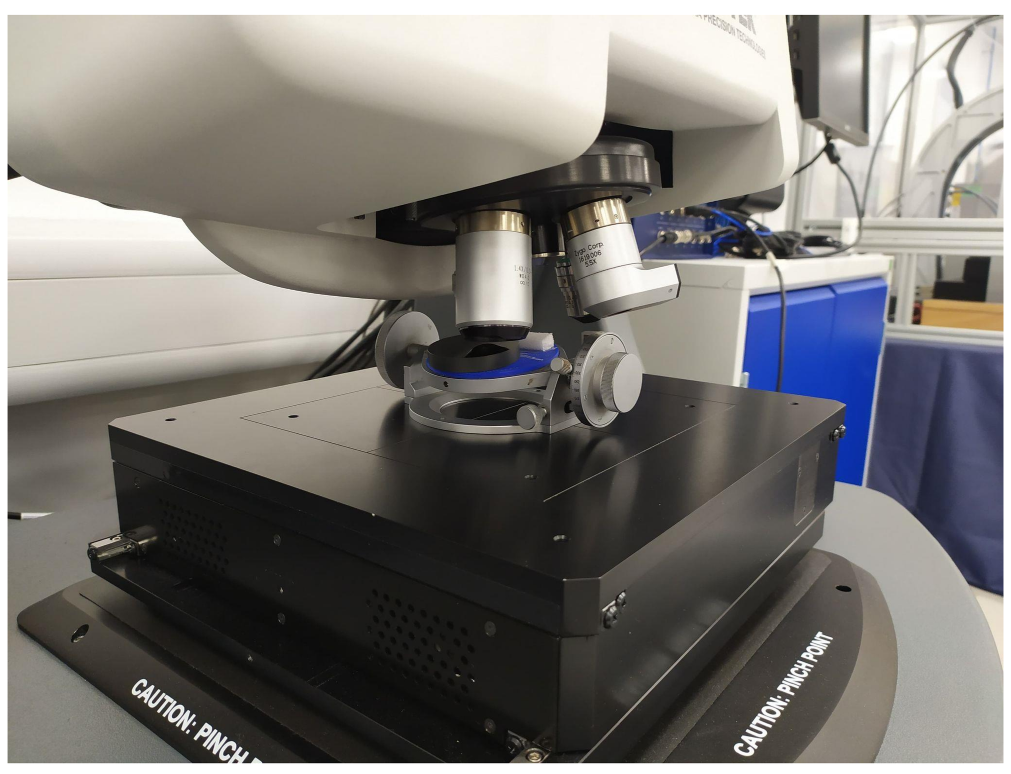

Figure 1: Measurement of a tilted flat using an optical instrument.

Results

The measurement of a tilted surface in an coherence scanning interferometer (CSI) produces tilt fringes because of the vibration of the instrument's scanner but also increases the measurement noise due to the influence of random errors present during the measurement.

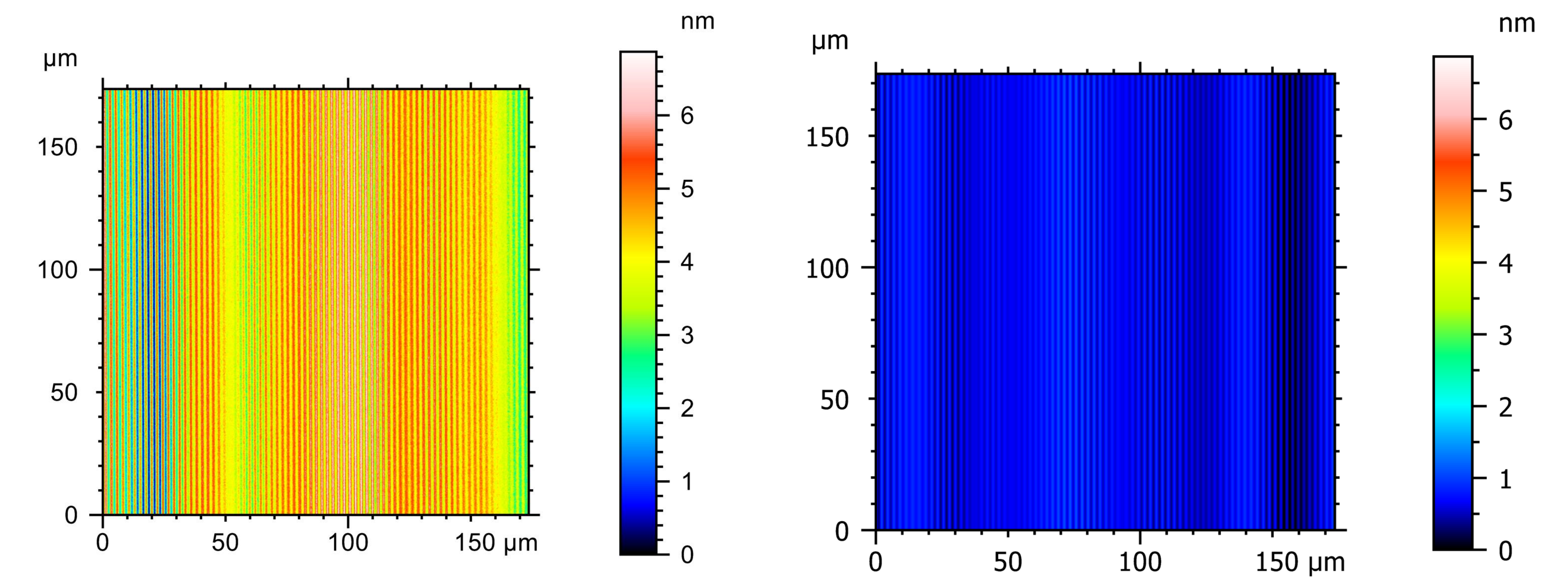

Figure 2: Noise map for a tilted flat at 4° degrees left) physical instrument right) virtual instrument

The default method for the determination of measurement noise removes all systematic errors present in the measurement, thus leaving only random errors to influence the instrument's output.

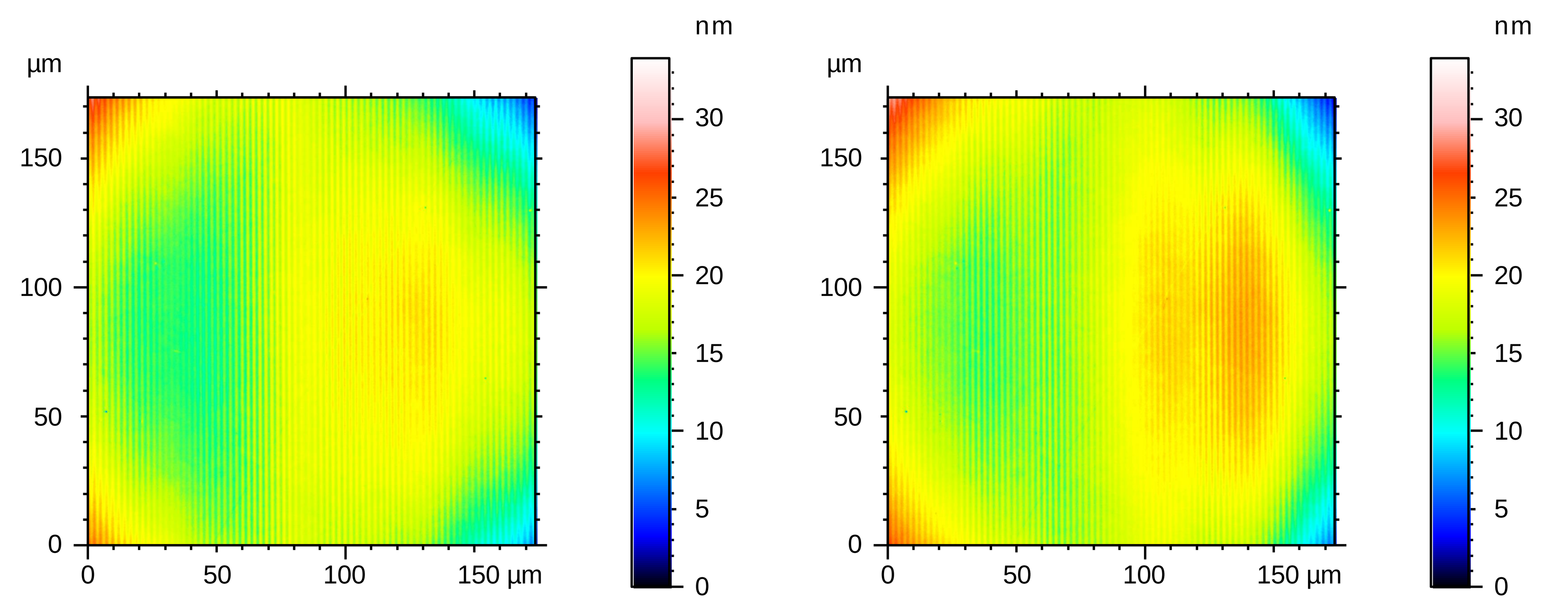

Figure 3: Illustration of the random error caused by retrace error on the topography of a levelled tilted flat.

Future work

The tilt angles examined demonstrated the same measurement noise value and as such the range of angles for the comparison needs to be expanded to include both lower angles where the retrace effect is lesser and higher angles where the effect is higher in magnitude.

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