Measurement noise of a coherence scanning interferometer in an industrial environment

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Introduction

- Coherence scanning interferometry (CSI) has seen a rapid uptake in manufacturing industry for use in quality control of parts due to its relative speed and its claimed potential for nanometric height accuracy.
- Various national measurement institutes (NMIs) and standardisation bodies provide guides for CSI users, but have not considered that many CSIs in industry are frequently housed in workshops.
- The industrial situation has the result that CSIs can be significantly less accurate than their specifications. With just a small increase in the ambient vibration level, it is easily possible to have measurement noise levels > 20 nm.

Measurement noise

- Measurement noise comprises all the noise signals that add to the output signal of an instrument when the instrument is used in normal operating conditions.
- Noise can be caused by both the internal and environment noises (see figure 1).
- Both a subtraction and an averaging method are used.

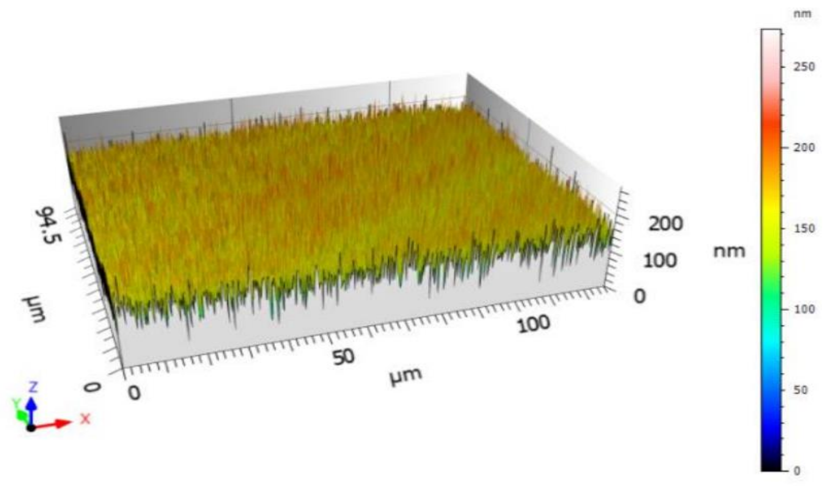

FIGURE 1. Surface after the subtraction method for calculating measurement noise was applied to an optical flat.

Result and Discussion

- The CSI used is placed under an air conditioning fan blower and is housed in a room (in a manufacturing facility building) with a SEM instrument equipped with a vacuum compressor. The CSI is mounted on a low-frequency vibration isolation table at frequencies < 4 Hz.
- Measurement parameters: a 50× lens (NA = 0.55), an optical flat artefact, the lowest measurement speed. The measurement conditions: the air conditioning fan is on and off (the SEM vacuum compressor was always on).
- The results from the averaging method did not converge and suggest that the surface data are in a non-stationary condition. Due to the non-stationary property, only the subtraction method is used. In figure 3, a ripple pattern has been observed. For comparison, figure 1 shows a subtracted surface from two statistically stationary surfaces.
- The measurement noise from the two measurement conditions shows a significant difference. Eliminating one of the vibration sources (the air conditioning fan) reduces the measurement noise (see figure 2 and table 1).

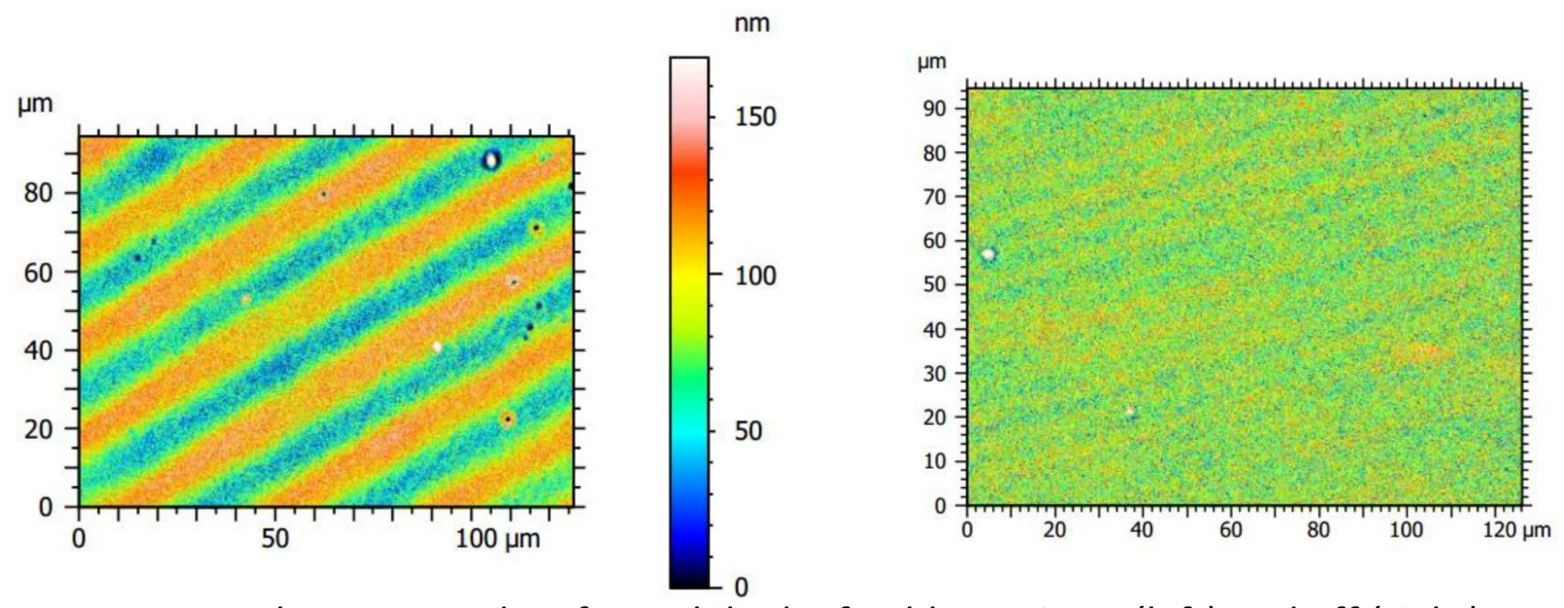

FIGURE 2. The measured surface while the fan blower is on (left) and off (right).

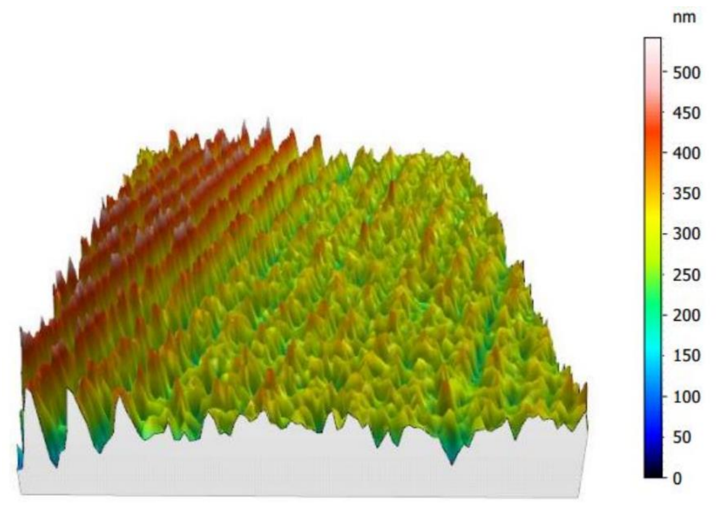

FIGURE 3. The measured surface while the air conditioner's fan blower is on.

TABLE 1. Results of measurement noise from two measurement conditions.

Air conditioner's fan	Measurement noise /nm		
	1	2	3
On	32.4	43.3	33.3
Off	26.7	29.5	24.9

- The average frequency of measuring vibration having the highest amplitude is 15 Hz ± 1 Hz (1σ) for both the measurement conditions (see figure 4 left). The SEM vacuum compressor was working at frequency 24 Hz. The compressor motor possibly contributes, to a certain degree, to the vibration noise during the CSI measurement.
- The measurement noise is significantly affected by the optical flat's surface slope with respect to CSI's objective lens. A larger measurement noise is observed when the slope angle increases (figure 4 right).

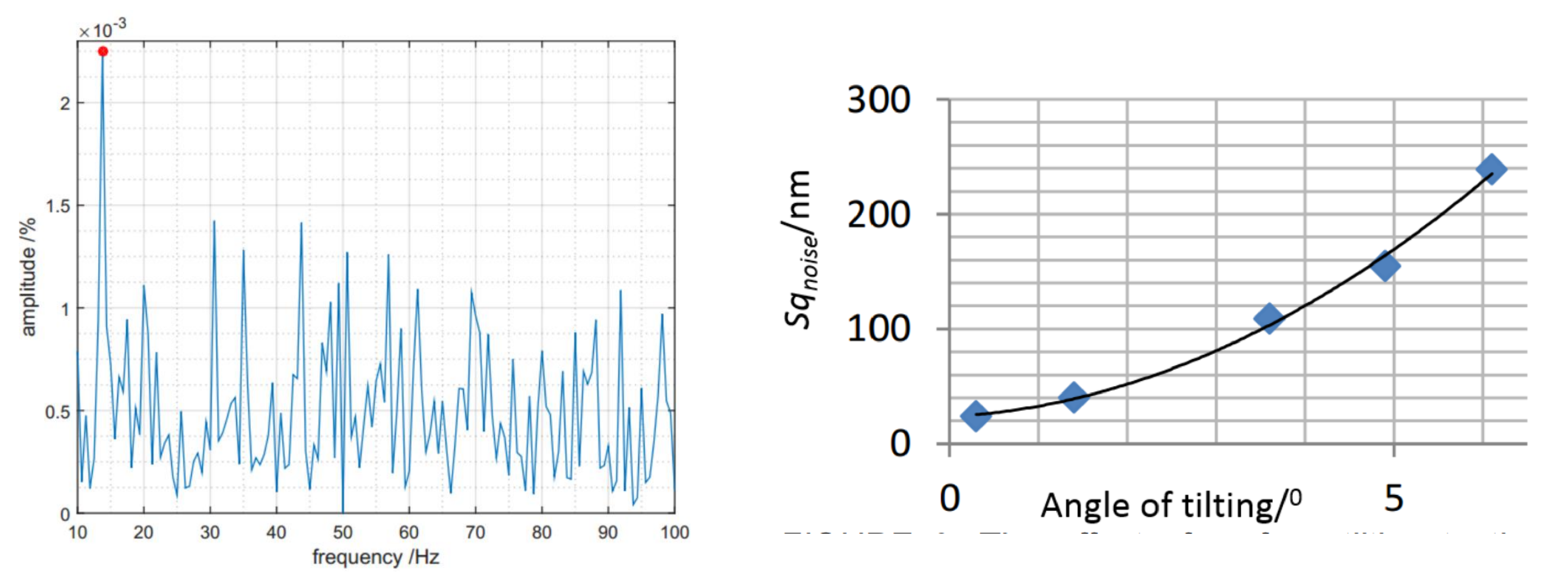

FIGURE 4. The frequency spectrum of the measured vibration signal (left) and The effect of surface tilting to the measurement noise (right).

Conclusion

- A significantly high measurement noise is observed (although it is not significant on a rough surface with *Sa* > 0.1 µm). The noise amplitude observed is around 100 nm.
- The results suggest that it is important to evaluate the measurement noise of a CSI and other instruments in the actual environment where the instrument will be operated. Continuous improvement, especially by the CSI manufacturers, should be conducted and existing knowledge related to vibration noise should be published more openly.