MANUFACTURING METROLOGY TEAM

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Detecting the signature of motion stage non-linearity for focus variation microscopy using measurement noise and surface topography repeatability

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Introduction

- Measurement noise, as discussed in ISO 25178, is one of the metrological characteristics of areal surface texture instruments
- Measurement noise is a combination of environmental noises (external noises) and the internal noises of an instrument
- The measurement of noise can be performed using a smooth flat surface such as optical flat surface artefact
- Surface topography repeatability can be used to estimate measurement noise

Method

- The non-linearity detection of vertical stage is examined by applying the measurement noise (subtraction method) and by surface topography repeatability
- Different height levels (5 %, 40 %, 55 % and 85 %) of the total vertical scanning range (FIGURE 1) are chosen
- An optical flat with nano-scale surface texture is used as the artefact (FIGURE 2)
- An objective lens with magnification of 100× is used

Table 1: Information for the experiment design

Instrument	Lens	Height range	Data number	Contrast	Brightness / µm	Artefact type
Focus Variation Microscopy	100x	5 %, 40 %, 55 % and 85 %	20 data /each height	1	142	optical-flat artefact with nano-texture coating

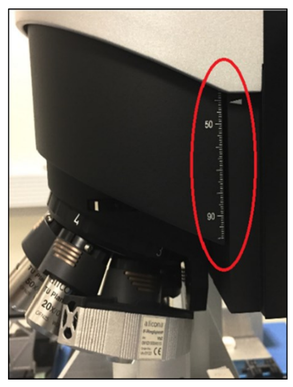

Figure 1: The vertical height scale of the instrument

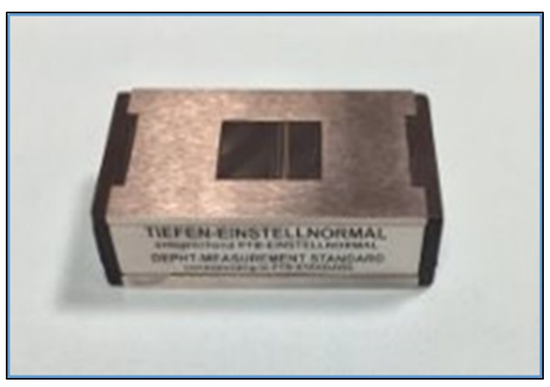

Figure 2: The Halle optical-flat artefact

Results

- An increasing trend for both the noise and the repeatability is apparent
- Using the subtraction method, the noise value is found to be (1.1 ± 0.10) nm (FIGURE 3)
- Similar results are obtained by the manufacturer (FIGURE 4)

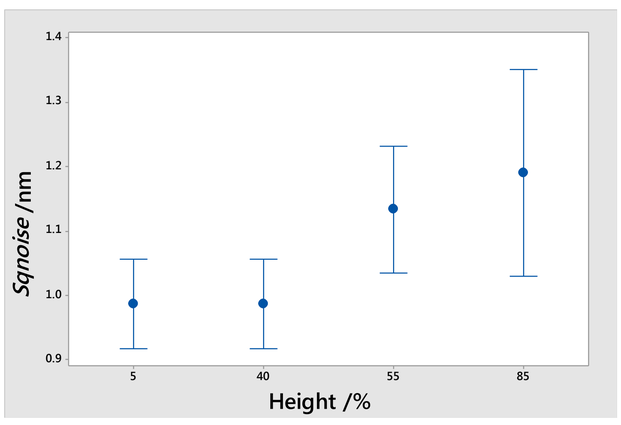

Figure 3: Measurement noise results of subtraction method for 100× objective lens

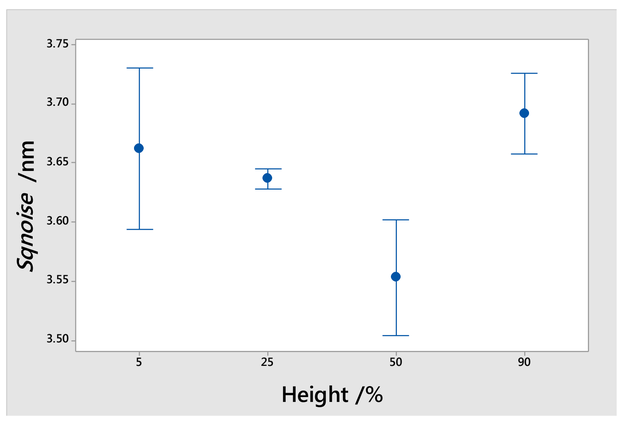

Figure 4: Measurement noise results of focus variation manufacturer

- For the surface topography repeatability, the obtained value is (0.06 ± 0.01) nm (FIGURE 5)
- The experimental results of surface topography repeatability are similar to the manufacturer's results (FIGURE 6)
- The surface topography repeatability data increase when the vertical height increase

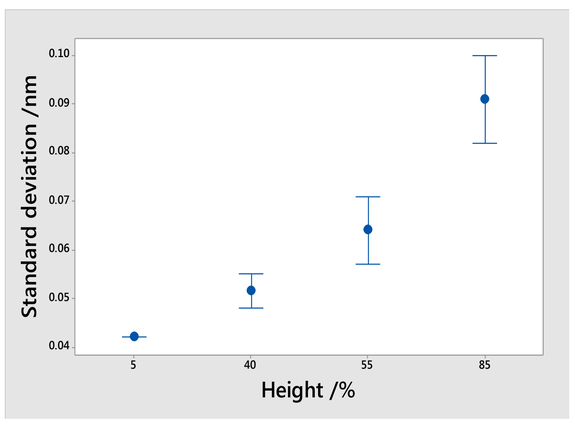

Figure 5: Surface topography repeatability results of 100× objective lens

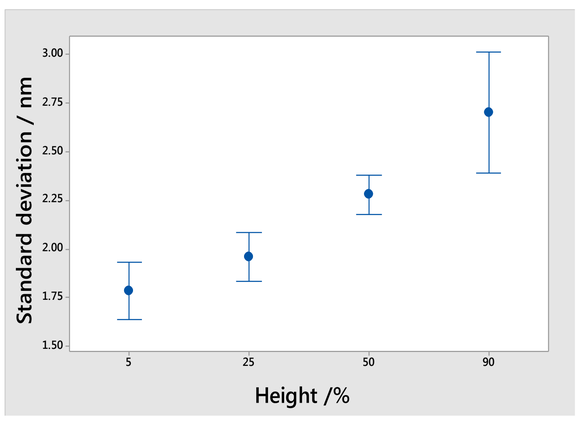

Figure 6: Surface topography repeatability results of focus variation manufacturer

Conclusion

- The vertical stage tends to be non-linear
- The noise seems to increase for both the measurement noise and the surface topography repeatability
- The noise between the different vertical heights is statistically significant (P-value=0.25)
- The non-linearity could be caused by the way in which the drive train is guided and how the *Z* axis is mounted on the guiding rails