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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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Abstract Measurement noise is one of the ISO-proposed metrological characteristics of areal surface texture instruments [1, 2, 3, 4]. Measurement noise includes all of the unwanted contributions to the output signals when the instrument is used in its normal operating condition [5, 6]. This paper focuses on detecting the non-linearity signature of the vertical stage of a focus variation microscope using the measurement noise and surface topography repeatability. The paper presents a procedure and material measure to determine the measurement noise and surface topography repeatability. The procedure is carried out at different height levels (5 %, 40 %, 55 % and 85 %) of the total vertical scanning range of the instrument, with equal contrast and brightness parameters. An optical flat with nano-scale surface texture is used as the material measure [7, 8]. One objective lens, with magnification of 100×, is used to measure the flat surface. Subtraction and averaging methods are used to evaluate the measurement noise. The surface topography repeatability is evaluated by calculating the standard deviation of the root mean square (Sq) surface texture parameter from several measurements taken successively under the same measurement conditions [9, 10]. The repeatability at each height level is calculated with five and ten repetitions. The results contain the signature of the non-linear motion of the vertical stage, which can be observed from the results of both the noise and the repeatability measurements. An increasing trend for both the noise and the repeatability is apparent. Using the subtraction method, the noise value is (1.1 ± 0.18) nm (see figure 1). For the surface topography repeatability, the obtained value is (0.06 ± 0.02) nm (see figure 3). The differences of measurement noise from different height levels are statistically significant. The non-linear behaviour of the vertical stage is attributed to the way in which the drive mechanism is guided and how the vertical axis is mounted on its guiding rails. In addition, the results of the motion stage non-linearity signature are compared with the results from the manufacturer (Alicona) and show good agreement (see figure 2 and 4).

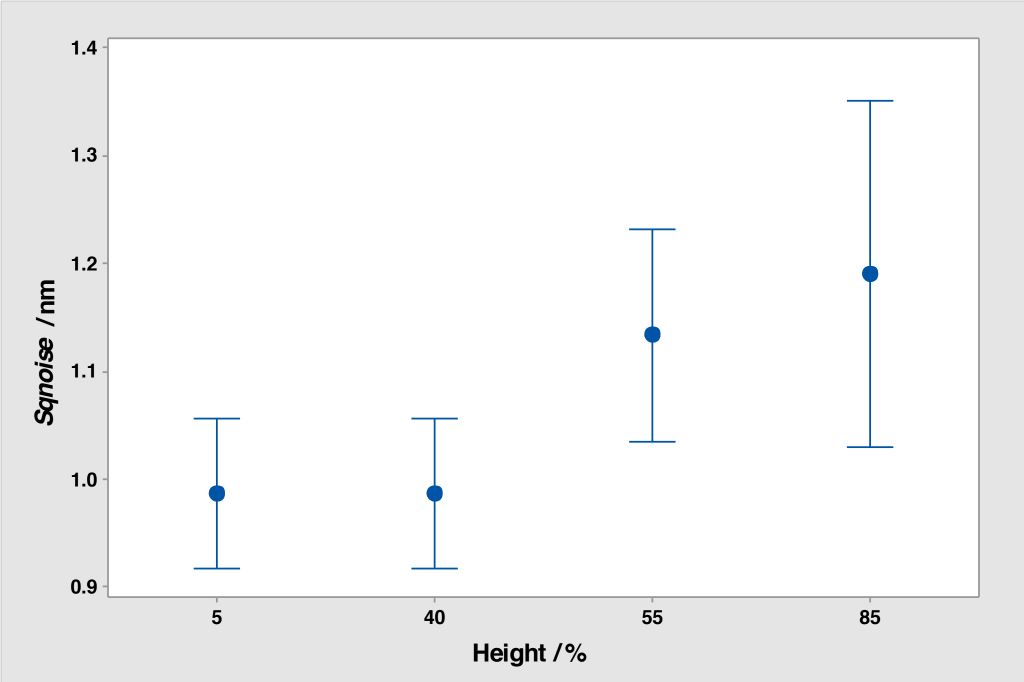

Figure 1: Measurement noise results of subtraction method for 100× objective lens

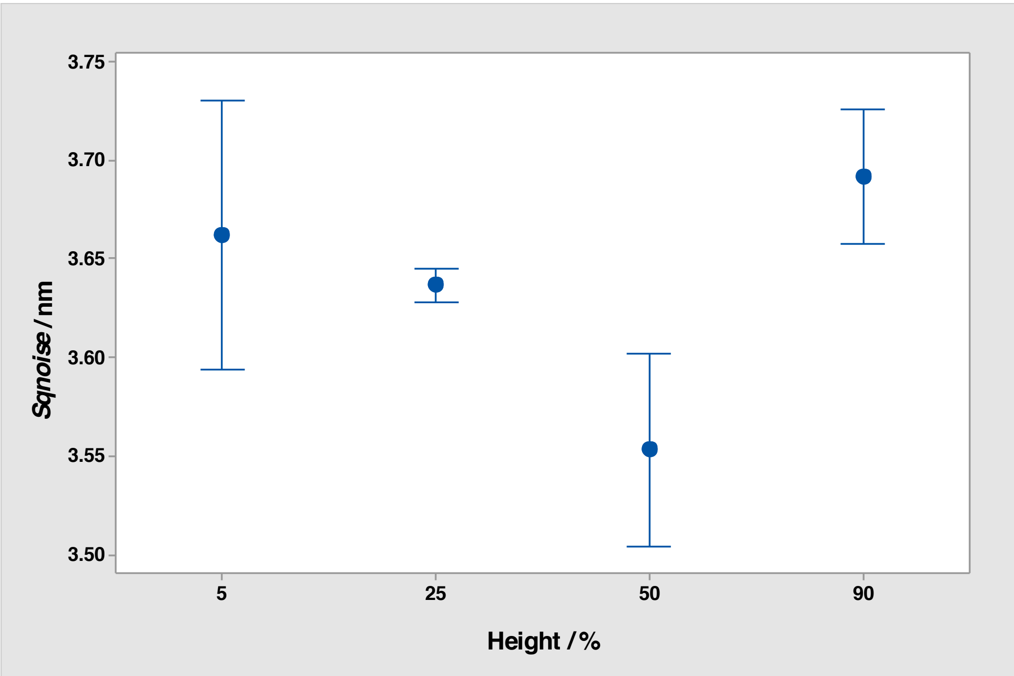

Figure 2: Measurement noise results of focus variation manufacturer (Alicona)

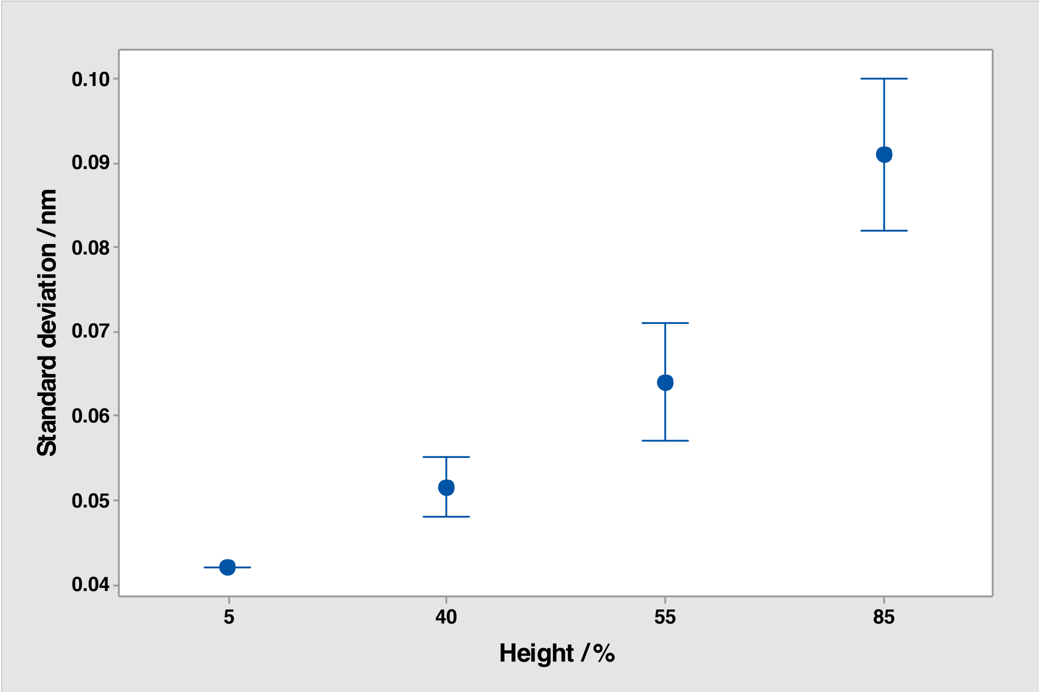

Figure 3: Measurement repeatability results of 100× objective lens

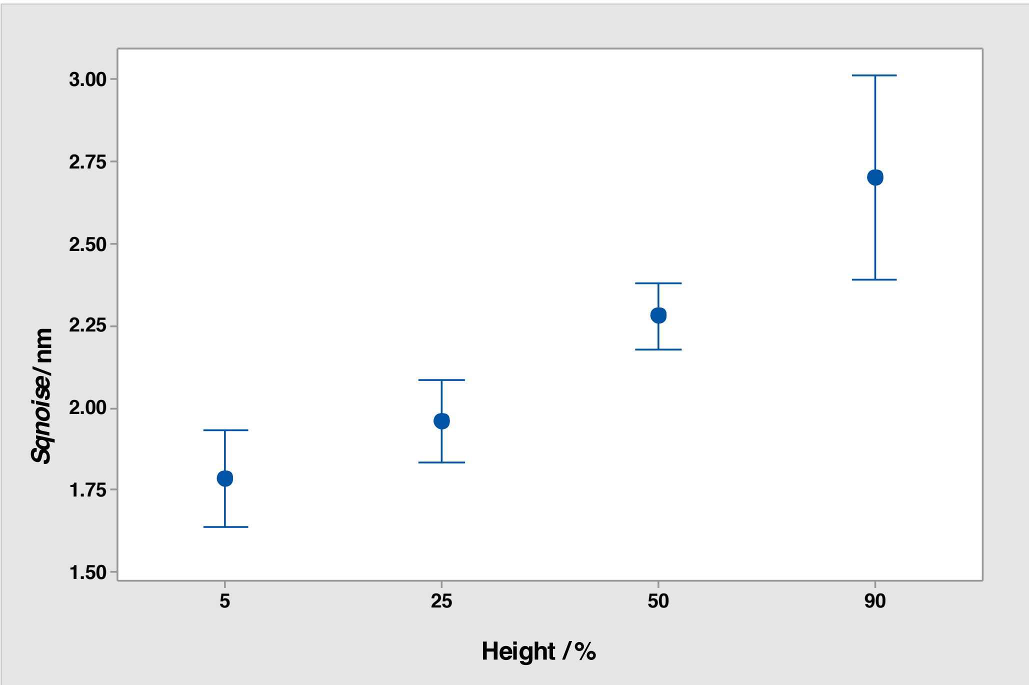

Figure 4: Measurement repeatability results of focus variation manufacturer (Alicona)

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