Measurements on rough surfaces

1. INTRODUCTION
The PICOSCALE is a contact-free displacement sensor based on a compact Michelson interferometer. In this application note, the measurement beam was aligned to surfaces with different roughness levels.

2. METHODS

A photograph of the target plate is shown in Figure 1. A standard PICOSCALE sensor head with collimated probe beam (PS-SH-C01) was aligned to each of the ground surfaces with roughness levels ($R_a$) between 0.05 $\mu$m and 1.6 $\mu$m. The working distance was about 55 mm. After the automated adjustment routine of the PICOSCALE completed, the resulting signal quality was recorded and divided by the value that was obtained with a flat silver mirror in order to obtain a relative signal quality for this specific working distance. Additionally, the noise level (amplitude spectral density) at 1 kHz was measured with the PICOSCALE Control graphical user interface. (Around this frequency the noise level is white and not fluctuating due to acoustic disturbances in the laboratory.)

3. RESULTS

The results are shown in Figure 2. Clearly, the signal quality drops for higher roughness values. At the same time, the noise level of the recorded position data increases. This is due to the fact that the automated adjustment routine optimizes the signal-to-noise ratio for every specific experimental setup. As the power reflected from the target that is actually interfering with the reference beam decreases, higher electronic gains are required for operation of the system and thus the noise level increases. We recommend roughness levels of $R_a = 0.1 \mu$m or better for optimal performance. However, surfaces with higher roughness still work fine as the PICOSCALE is relatively insensitive to the target reflectivity due to the Michelson principle. For low reflective targets (roughness levels higher than $R_a = 0.1 \mu$m), the use of the -BSR80 option in sensor heads can be advantageous. By this, the beam splitter in the sensor heads has a 80:20 beam splitting ratio and guides more light into the measurement beam. Consequently, the interference pattern is more centered around zero which is beneficial for its evaluation.

4. CONCLUSION

In this application note we show that the PICOSCALE can measure the displacement of objects whose surface is equivalent to relatively coarse grinding. This enables the integration of the sensor heads into existing setups and direct measurements on coarsely ground surfaces without the need for high quality mirrors and if maximum performance of the interferometer is not required. Even with surfaces with a roughness level of $R_a = 1.6 \mu$m displacements can be resolved with picometer resolution!

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