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Correlation analysis of systematic errors in surface metrology with a slope profiler

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We describe, and present the mathematical foundation for, a novel method for the elicitation and suppression of contributions to systematic errors of surface slope profiler metrology. The method consists of the randomization of the systematic error by the averaging of multiple measurements, specially arranged to mutually anti-correlate. We also discuss the possibility to apply correlation analysis to the entire residual surface slope distribution in order to find anti-correlation parameters of the distribution. In this case, repeated measurements with the corresponding change of the experimental arrangement (position of the surface and/or its overall tilt) can be used to identify the origin of the observed anti-correlation features by analyzing the difference between the measurements. If the corresponding minimum of the auto-correlation function is due to a systematic error, averaging over the repeated measurements will provide an efficient suppression of the systematic error. If the observed anti-correlation properties are due to the polishing process, and therefore belong to the surface itself, we suggest that the possibility of re-polishing the surface based on the correlation analysis be considered. Throughout the present work we have discussed correlation analysis of surface slope metrology data. However, a similar consideration can be applied to surface topography in the height domain measured with other metrology instrumentation, for example: interferometers and interferometric microscopes. This work is supported by the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

Keywords: surface metrology, surface slope measurement, surface profilometer, systematic error, correlation analysis, mirror polishing, fabrication tolerances, metrology of x-ray optics

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