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Author
Yashchuk, Valeriy V.

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Valeriy V. Yashchuk

For more than 20 years, the long trace profiler (LTP) remains the basic metrology tool for high accuracy testing the of X-ray optic figure with slope variations on the order of one microradian rms. The LTP records the local slope profile of a surface by measuring the reflection angle of a laser beam as the beam is transported across the surface. The LTP schematic is a realization of pencil-beam interferometer system. In the interferometer, two parallel light beams, possessing π phase difference, are made to interfere at the focus of the Fourier transform lens. The resulted interference fringe pattern recorded with a position-sensitive light detector placed at the focus has two strongly marked peaks with a minimum between the peaks. The position of the central minimum is a measure of slope of the mirror surface at the place of the beam reflection.

In the present work, the LTP systematic errors and random noise of the interference pattern positioning are analyzed. The analysis, based on linear regression methods, allows estimating the contributions to the positioning error of a number of effects, including nonuniformity of the detector photo-response and pixel pitch, detector read-out and dark signal noise, analog-to-digit converter resolution, as well as signal shot noise. The dependence of the contributions on pixel size and on total number of pixels involved in positioning is figured out analytically.

The analysis, when applied to the LTP II available at the ALS optical metrology laboratory, has shown that the main source for the random positioning error of the interference pattern is the read-out noise estimated to be approximately 0.2 microradian. The photo-diode-array photo-response and pixel pitch nonuniformity determine the magnitude of the systematic positioning error and are found to be approximately 0.3 microradian for each of the effects.

The random error can be easily suppressed with multiple measurements. Elimination of the systematic error requires precise calibration of the detector. Recommendations for an optimal fitting strategy, detector selection and calibration are provided. Following these recommendations should allow one to reduce the positioning error of the LTP interference pattern to a level, adequate for the slope measurement with 0.1-microradian accuracy.

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