Sensitivity Analysis for Lens Aberration Measurement in Lithographic Tools Using CTC-Based Quadratic Aberration Model

Shuang Xu, Xiaofei Wu
Wuhan National Laboratory for Optoelectronics, Huazhong University of Science and Technology, Wuhan 430074, China.

Tielin Shi, Zirong Tang, Shiyuan Liu
State Key Laboratory of Digital Manufacturing Equipment and Technology, Huazhong University of Science and Technology, Wuhan 430074, China.
shyliu@mail.hust.edu.cn

With ever decreasing of feature size, aberration metrology is increasingly critical to the manufacture of high-quality lens in lithographic tools. Recently, we proposed a quadratic aberration model (QAM) for lens aberration measurement using a cross triple correlation (CTC) based fast algorithm[1]. The QAM takes into account not only the linear terms of Zernike coefficients, but also the quadratic terms. The measurement accuracy of the QAM method depends dramatically on the sensitivity of the test mask pattern to the aberrations, thus the sensitivity analysis of the test mask pattern is highly desirable.

In this paper we propose a method for sensitivity analysis to evaluate the effect of each Zernike terms on the aerial image. The aim is to design a test mask pattern with high sensitivity to lens aberrations. In the CTC-based QAM, the total aerial image intensity can be separated into aberration-free intensity, linearly aberrated intensity, and quadratically aberrated intensity. The aberrated intensity can be further decomposed into basis intensities corresponding to Zernike terms. Therefore, we can easily evaluate the sensitivity of each individual Zernike coefficient to the total aerial image by using the Frobenius bound norm of basis intensities.

Figure 1 shows the overall flowchart of the QAM-based method for lens aberration measurement, including CTC-based quadratic aberration model, the regression algorithm, and the sensitivity analysis model. For any given test mask pattern, the basis intensities are calculated using the CTC-based algorithm and further applied to evaluate the sensitivities. Figure 2 shows the calculated sensitivities of the linear and quadratic terms for a given mask pattern. It is demonstrated that the sensitivity can be evaluated quickly and easily for any mask pattern, thus this sensitivity analysis method will have applications in optimal design of the test mask pattern and in-situ metrology of lens aberration in lithographic tools.

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[1] S Y Liu, W Liu, and T T Zhou, J. Micro/Nanolith. MEMS MOEMS, ***023007***, 2011.

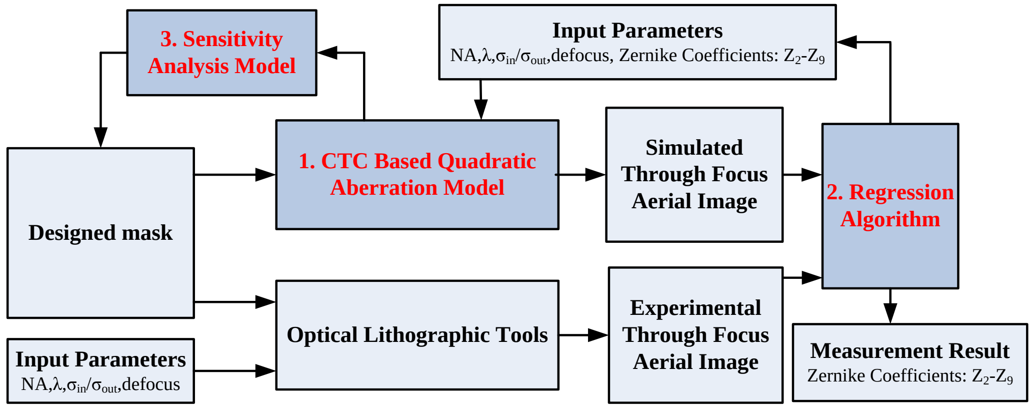

Figure 1: Overall flowchart of the aberration measurement method using the CTC-based quadratic aberration model. The individual basis intensities are calculated by the CTC-based quadratic aberration model. The designed test mask pattern is optimized by the sensitivity analysis model, and the Zernike coefficients are extracted by the regression algorithm from the test aerial image data.

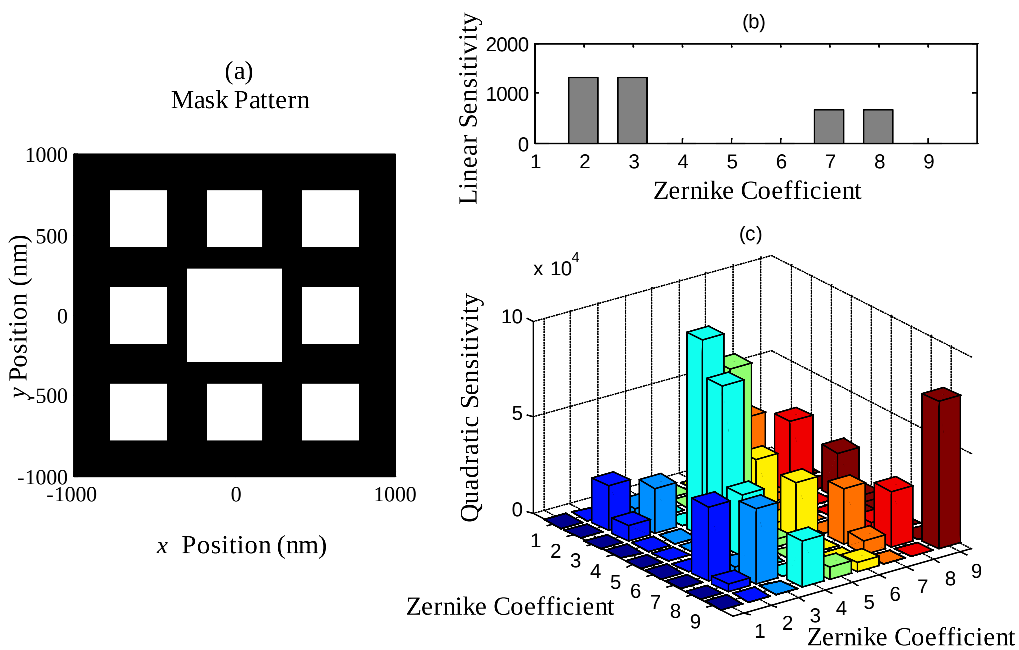

Figure 2: Simulation results of sensitivities for a given test mask pattern. The lithographic tool is with a quadrupole source (σ_{in}/σ_{out}/degree=0.4/0.8/45°), λ=193nm, and NA=0.75. Sensitivities of the linear terms and quadratic terms to Zernike coefficients of Z_2 to Z_9 are shown as examples.