On-Machine Wavefront Evaluation of the Full-Field Extreme Ultra-Violet Lithography Exposure System

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Projection optics (P.O.) of the extreme ultra-violet lithography (EUVL) is very sensitive to the mirror displacement, and the measurement of the wavefront aberration at the stage is required. We have been developing the high accurate wavefront metrology system used at the stage of the exposure systems for several years [1-3]. Recently, we have integrated this metrology tool into the EUV1, full field exposure systems, and evaluated its accuracy.

In the wavefront metrology tool of the EUV projection optics, e.g., the point diffraction interferometer (PDI), the pinhole with 100 nm or smaller diameter is used to generate the reference wavefront [4]. In such systems, the transmitted beam intensity through the small pinhole increases drastically. However the very high bright source as synchrotron radiation is not used for on-machine metrology. We developed Talbot-interferometer based metrology tool using low bright plasma-induced source. Several 100 thousands pinholes are placed periodically at the reticle and in result, fringe intensity can be increased drastically in proportion to the number of the pinholes.

Metrology tool have integrated to the EUV1. EUV1 has the P.O. of NA0.25, the exposure field of 26 x 2 mm and the Koeler illumination systems. Reticle of this metrology tool is illuminated by the Koeler illumination systems. Wavefronts from each pinhole of the reticle pass through the projection optics and make fringes at CCD. The wavefront aberration can be obtained by the Fourier transform method.

Repeatability of measurement was obtained as about 0.03 to 0.05 nmrms. This is enough to measure the wavefront of 0.5 nm rms to 1 nmrms. An absolute accuracy is difficult to evaluate. Here, we study aberration change by displacing mirrors of the P.O. and compare the measured and the predicted aberration. By the P.O. mirror moving, aberration change of 0.4 nm rms occurs. Deviation of the measured and the preeicted aberration is just about 0.04 to 0.06 nmrms as shown in figure 1. This result shows that an accuracy of measurement is very good and the mirror position can be controlled completely.

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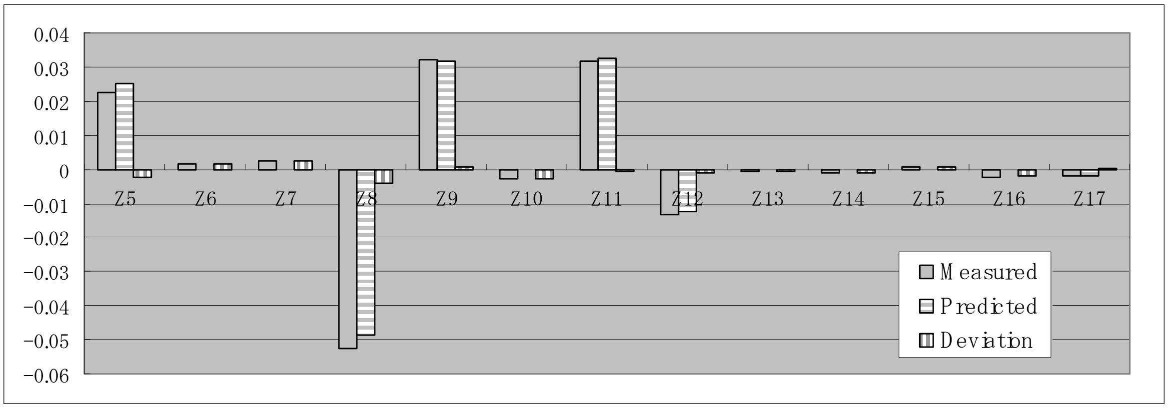

Figure1 Comparison of measured and predicted aberration change. Lateral axis is Zernike coefficients and longitudinal is wavefornt aberration (unit = lambda). Both show good agreement.