Point Diffraction Interferometer for Inspection of High-Magnification Objective for Extreme Ultraviolet Microscopy

M. Toyoda, R. Sunayama, M. Yanagihara
Institute of Multidisciplinary Research for Advanced Materials, Tohoku Univ.,
2-1-1 Katahira, Aoba-ku, Sendai, Miyagi, 980-8577, Japan.
toyoda@tagen.tohoku.ac.jp

For at-wavelength imaging of lithography masks, an EUV microscope made of a high-magnification objective (magnification: m=1460, numerical aperture: NA=0.25, wavelength: λ=13.5 nm) with three multilayer mirrors has been developed [1-3]. To provide the diffraction-limited spatial resolution with the EUV microscope, wave aberrations of the objective should be corrected below extremely small value, i.e., 1 nm rms., to satisfy Maréchal criterion at the operating wavelength. For realizing the objectives with high resolution, firstly, we need to develop an interferometer that can measure a wavefront of the objective with high enough sensing accuracy, i.e., 0.1 nm rms. In this paper, we describe detail of optical design and instrumentation of the Point Diffraction Interferometer (PDI), so as to provide high enough sensing accuracy for optical alignment of the high-magnification objective

As shown in Fig. 1, a DPSS laser light (wavelength: λ= 473 nm) was split into two beams by using a reflection grating as a beam splitting element. Then, the both beams were focused with the objective on the pinhole and window (PW) plate, which has a small pinhole (600 nm in diameter) and window (20μm in diameter), so as to produce the reference and test beam. On the pinhole, an ideal spherical wave for a reference beam should be generated as a result of a spatial filtering effect. However, there has been a technical issue that amplitude and phase of the reference beam were modulated by stray lights which pass through the window. For realizing sub-nm accuracy, we developed novel optical device that can generate ideal spherical wave required as the reference beam, as shown in Fig. 2. To reduce the stray lights, we applied a photonic-crystal half waveplate (HWP) that can control polarization of light. We placed HWP on the window, while the pinhole was illuminated with a linear-polarized light. Then, the reference beam and stray lights have two-orthogonal polarizations, and the stray light can be eliminated by an analyzer on a CCD camera. We clearly confirmed that the intensity of the stray lights was reduced about 1/860. In the presentation, we also discuss sources of systematic error of the PDI, and report recent experimental results to confirm high measuring accuracy of below 0.1nm rms.

References:
[1] M. Toyoda, Adv. Opt. Tech., **4** (4), 339-346 (2015).
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[3] M. Toyoda, et.al., Appl. Phys. Express, **7**, 102502 (2014).

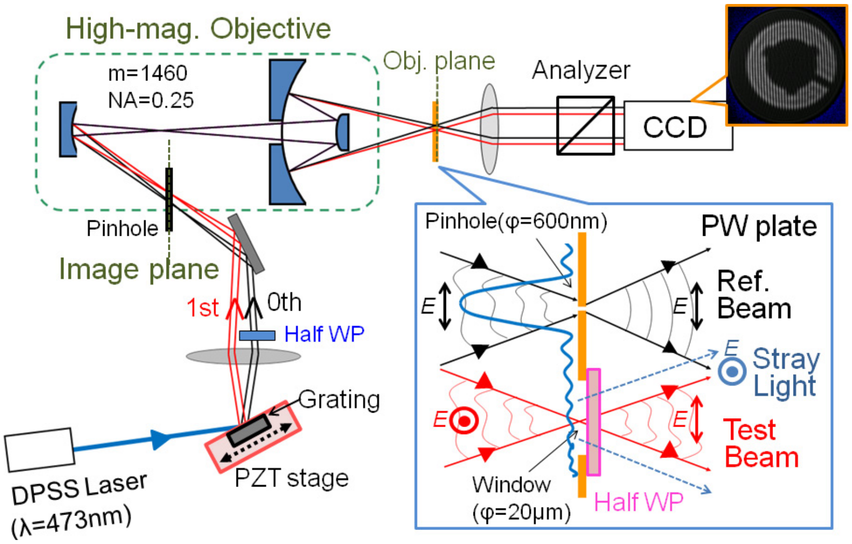

Figure 1: Schematic layout of the Point Diffraction Interferometer (PDI). Since the mirror objective has no chromatic aberration, we applied a visible blue DPSS laser (SLIM473S-20, Oxxius: linear polarized). For phase-shift interferometry, a brazed grating (300 lines/mm) was laterally shifted by using an one-axis PZT stage (P-752 High Precision Nanopositioning Stage, PI).

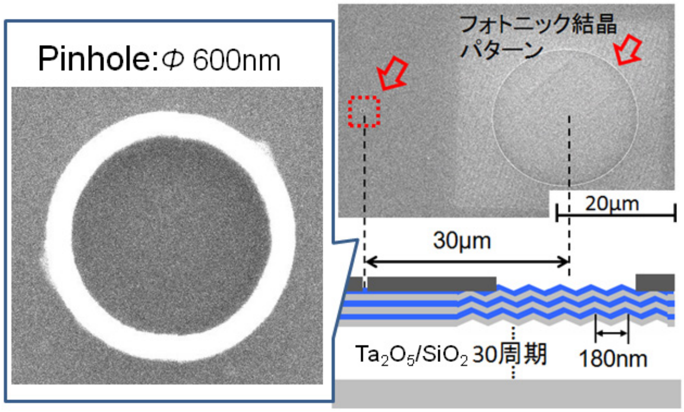

Figure 2: SEM photographs of pinhole and window patterns (red arrows) of the PW plate. The PW plate was made of a Cr absorber layer and photonic crystals on glass substrate. The patterns on 150-nm thick Cr layer were fabricated with electron-beam lithography technique. Rectangular shadow outside the window shows photonic crystals (Ta_2O_5/SiO_2, 30 by-layers), which is act as a half waveplate for stray light reduction.