EUV interferometry on multilayer reflection phase manipulation by surface milling

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Interferometric detection of reflection phase of an EUV multilayer mirror has been performed by a Young type interferometer in the reflection configuration where a multilayer mirror masked with a double slit aperture is used as a reflection double slit. The purpose is to measure the reflection phase change when the several periods of a multilayer surface were removed. Quite a small phase change is expected because the optical path decrease in the mirror material will nearly equal to the optical path increase in vacuum, which we are planning to apply to accurate wavefront correction of multilayer mirrors.

A Mo/Si multilayer of 40 period number was deposited on a Si wafer. The period thickness measured by X-ray reflectometry was 7.4 nm. The spectral reflectance was measured at BL-12A, the Photon Factory. At an angle of incidence of 5° the peak wavelength and reflectance were 14.2 nm and 52.5%, respectively. The multilayer surface was partially milled by 10 periods using our recently developed ion milling apparatus, which will cause 2/3 π reflection phase change, while the optical path in vacuum will increase about 10 wavelengths. The multilayer was coated with photoresist with apertures of a double slit pattern. The measured reflectance of the photoresist was lower than 0.5% in 13−15 nm wavelength region. Figure 1 shows the reflection double slit structure in front view and in side views from four directions. The slit width and the slit separation are 30 µm and 80 µm, respectively. The milled area boundary between slits is sharp enough. The boundary in the direction of the slits was gradated to avoid the fringe jump. The left area will generate the same Young's interference fringe as an ordinary transmission double slit. The interference fringe generated by the right area will shift reflecting the phase change of the milled area. A crank shape will appear in the middle.

The fringe observation was performed at BL-12A, the Photon Factory using the one-meter size reflectometer chamber. The experimental setup is illustrated in Fig. 2 in plan view. The reflection double slit was put at the downstream end in the chamber. The slits are orientated horizontally so that the direction of the slit separation should coincide with the direction of high spatial coherence of synchrotron radiation. The angle of incidence was 5° in the horizontal plane. An in-vacuum CCD camera was put at a distance of 560 mm from the reflection double slit. A fringe pattern observed at a wavelength of 13.5 nm is shown in Fig. 3. Apparently the pattern is consecutive and shifts downward in the right area. At longer wavelength, the shift became smaller. All the results are in good agreement with our expectation.

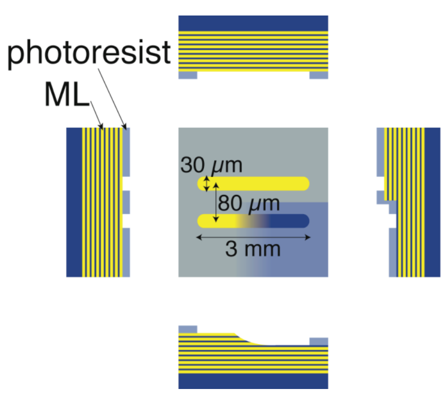

Fig. 1. Reflection double slit structure.

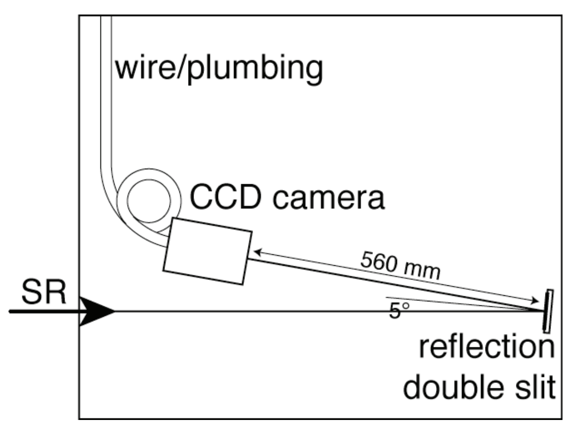

Fig. 2. Experimental setup at BL-12A, PF.

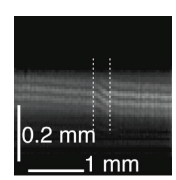

Fig. 3. Observed fringe pattern.