Compact and ultrahigh-vacuum reflectometer for EUVL applications

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A newly-built, vacuum-compatible reflectometer has been successfully operated at the 08A1BM - LSGM beamline of National Synchrotron Radiation Research Center (NSRRC) for extreme ultraviolet and x-ray applications. The detailed information of the reflectometer is presented, which include an overall equipment design, mechanical precision of the reflectometer, and a magnetic sample-holder assembly for a quick sample replacement and fixed sample surface plane. The result of the measurements on bare-silicon, Sc/Mo multilayer, EUV photoresist and underlayer samples demonstrates that the EUV reflectometer is currently capable to determine the refractive index, absorbance, and thickness properties of EUV materials within ±10% experimental uncertainty.

I. EUV Reflectometer

II. Performance of EUV Reflectometer

II.1 Precision of θ and 2θ encoders

II.2 Reference samples

Bare-silicon wafer

Cr/Sc multilayer, period of 3-nm

III. SR Beamline Conditions

- Tuning to 13.5 nm light (calibrated by Kr$^+$P$_{5/2}$)
- @ 200 um x 200 um slit opening, photon flux ~ 3×10$^{12}$ photons s$^{-1}$ (determined by Ar photoionization using a double-ion method)
- Light intensity of a 0.03 cm$^2$ beam spot ~ 1.4 mW cm$^{-2}$

IV. Results

IV.1 Run-to-run precision in a six-month period

IV.2 Actinic and in situ metrology tool

- A comparison of our work to those measured by ALS shows identical absorbance values for seven samples within the experimental uncertainty.

- Monitoring photochemical stability of films upon 13.5-nm irradiation

- Resist ablation of round-robin resist upon 13.5-nm irradiation

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Density

Si = 2.33 g/cm$^3$; this work, 2.328 g/cm$^3$

SiO$_2$ = 2.20 g/cm$^3$; this work, 2.23 g/cm$^3$

fitted SiO$_2$ thickness ~ 2 nm

Stable UL

Reactive UL

Reactive photoresist

- By EUV reflectometry
- By profilometry