EUV Phase Shift Masks Samples

At wavelength phase shift measurements on dedicated samples

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EUV lithography is expected to be inserted for the 32 nm node and extended for the 22 nm and below. Phase shift masks are evaluated as a possible option to push the resolution limit of the Extreme Ultra violet lithography.
Understanding of phase behaviour is critical for PSM masks design and tolerancing. Etch Stop Layers or cavities inside the MoSi blank stack introduce phase non linearity. Our purpose is first to understand this mechanism and second propose innovative PSM design that benefit from those non linearity to provide π phase jump, high reflectivity ratio and low topology.
One structure with several design variable has been proposed, fabricated and tested on an interferometric set up installed on a synchrotron beam-line. Conception, technological fabrication and interferometric setup are presented. Phase shift measurements are given and discussed.

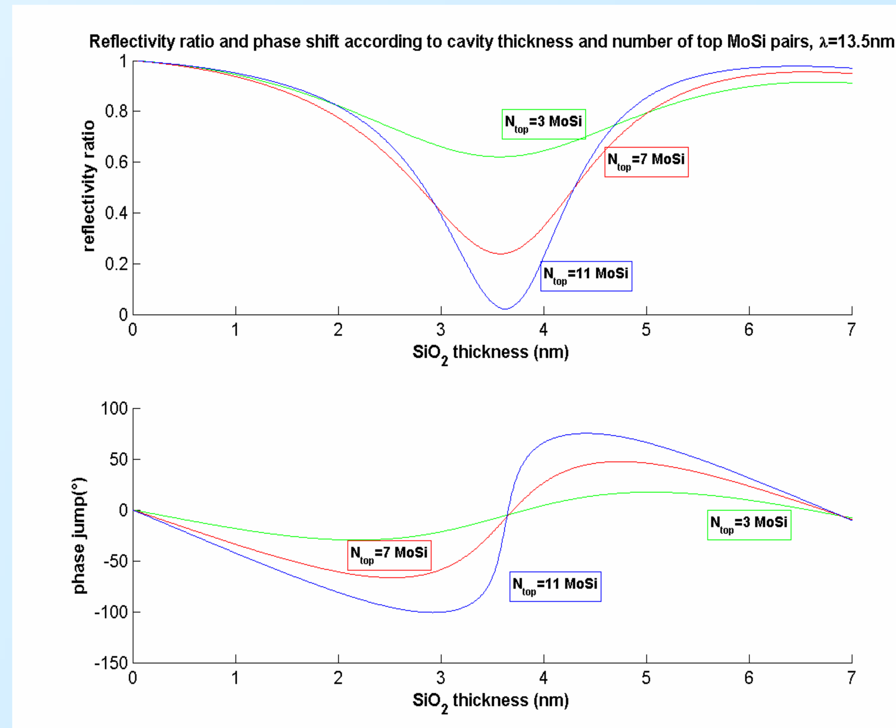
1 Conception

Objective: Understanding of phase mechanism in an embedded cavity

- Study of phase non linearity introduced by embedded layer
- Evaluation of thickness tolerance
- Evaluation of low topology innovative design for EUV lithography

Structure :

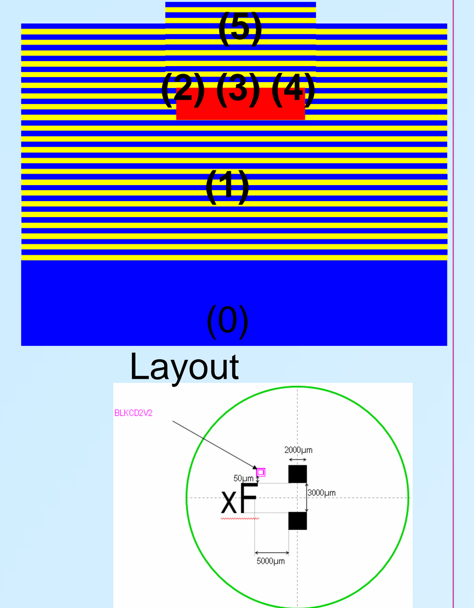
- Partially etched embedded layer behaves like a Fabry-Perot cavity between two Bragg Mirrors.
- Phase shift depends upon cavity thickness AND number of top MoSi coating pairs



2 Fabrication

0) Sample are made on Silicon high quality 1" substrates ¼ inch thick
1) 40 MoSi pairs deposited by Ion Beam Sputerring
2) SiO2 layer deposited by IBS, elected thicknesses are 25Å and 35Å controlled at +/- 7Å
3) Photolithography with positive tone resist
4) Wet etching of the SiO2 layer
5) Top MoSi Deposition by IBS, elected coatings are 3 and 7 pairs.

Layout

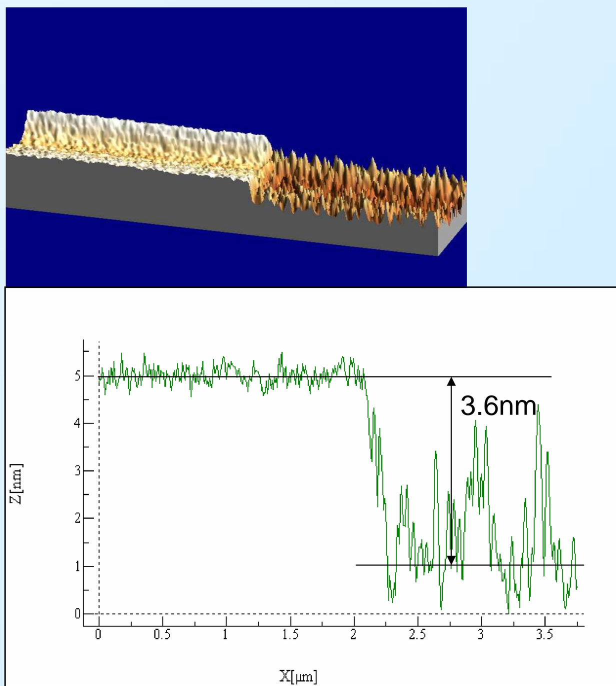


3 Morphological characterization

Sample list

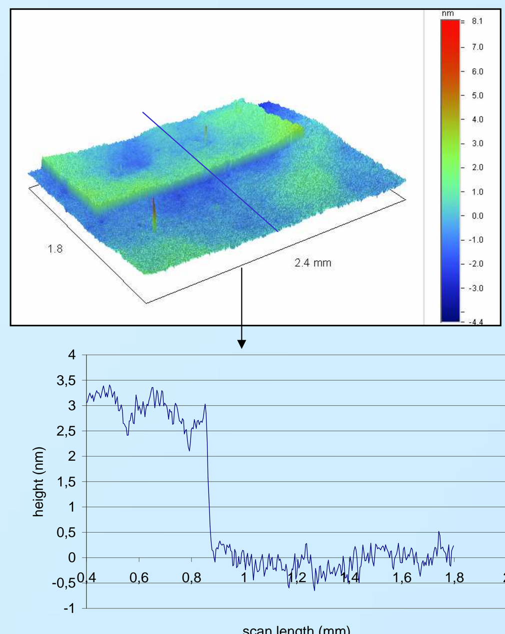
sample n°	5b	6a	6b	7b	8a	8b
blank	Si substrate + 40 MoSi pairs					
Targeted Cavity thickness	2,5 nm SiO2			3,5 nm SiO2		
Top coating	3 MoSi pairs	7 MoSi pairs	7 MoSi pairs	3 MoSi pairs	7 MoSi pairs	7 MoSi pairs
step height measurement (+/- 0.3 nm)	3,3 nm WYCO	2,8 nm WYCO	2,7 nm WYCO	3,6 nm AFM	4,6 nm WYCO	4,6 nm WYCO

AFM (sample 7b)

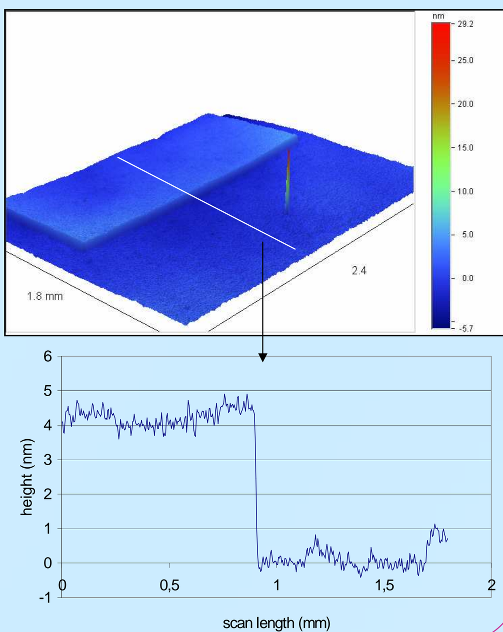


Optical profilometer (WYCO)

Sample 6b

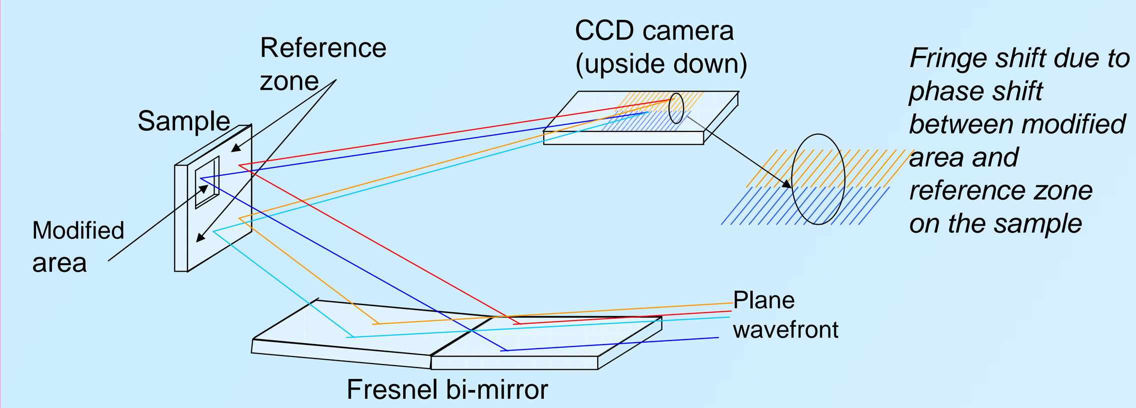


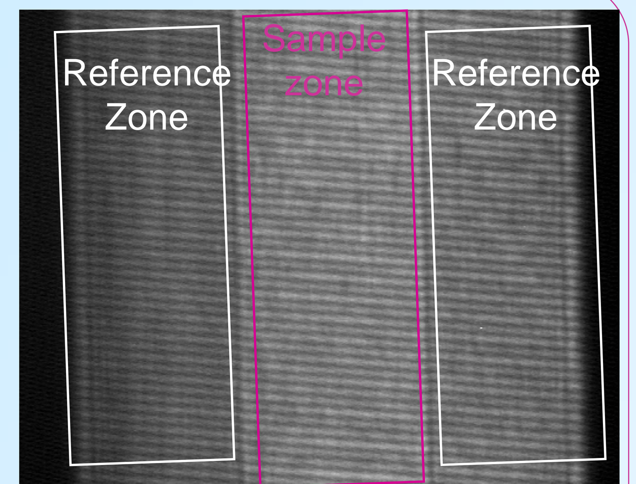
Sample 8b



4 Interferometric set up

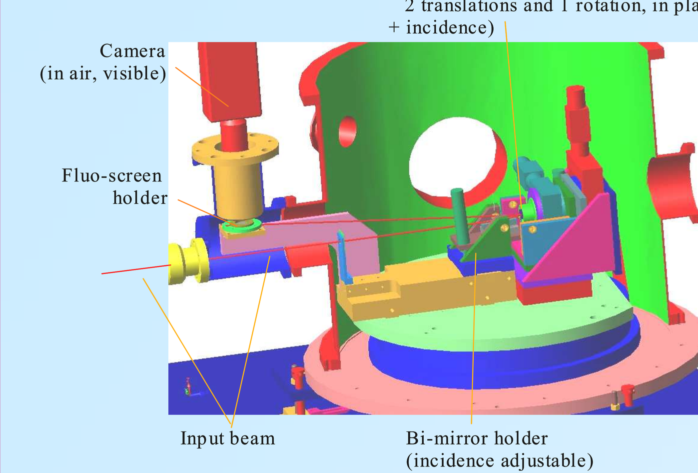
Fresnel's bimirror interferometer

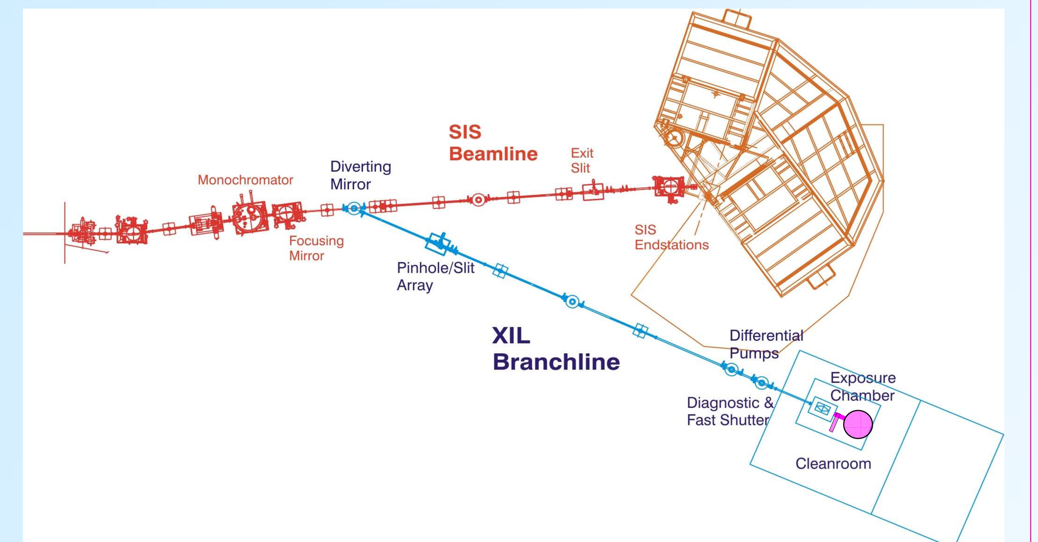




Self referenced interferogram: a part of one mirror is illuminated through the test zone. Two interferograms are generated at once, showing the phase change from the reference zone to the test zone.

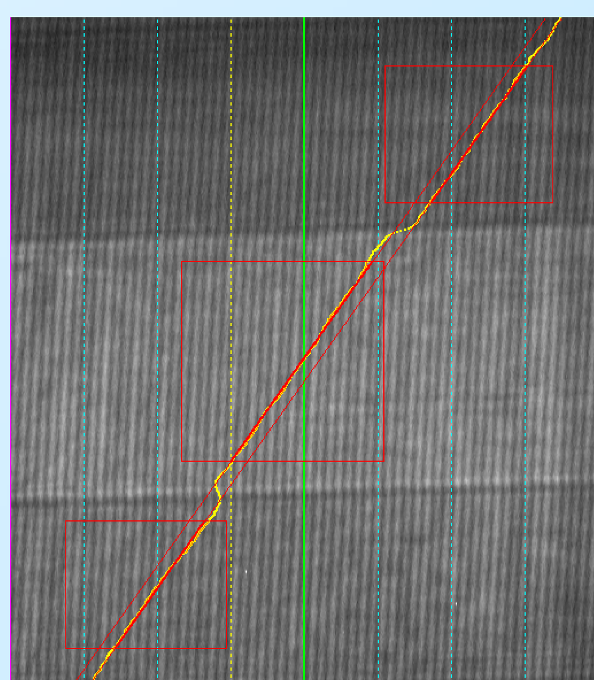
Implementation of the interferometer vacuum chamber on the XIL beamline at PSI



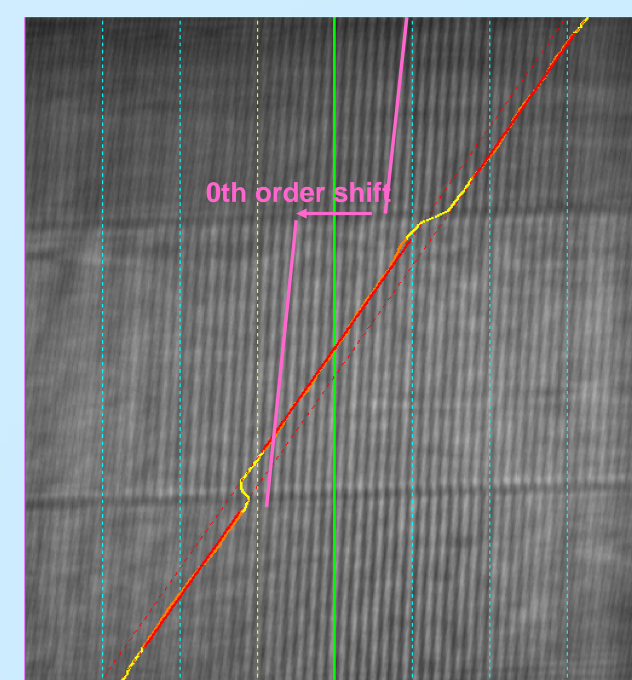


Set up has been defined to illuminate the sample with a 6°incident angle. Illumination can be Wide Band (λ +/-0.7 nm) or Narrow band (λ +/-0.07Å) .

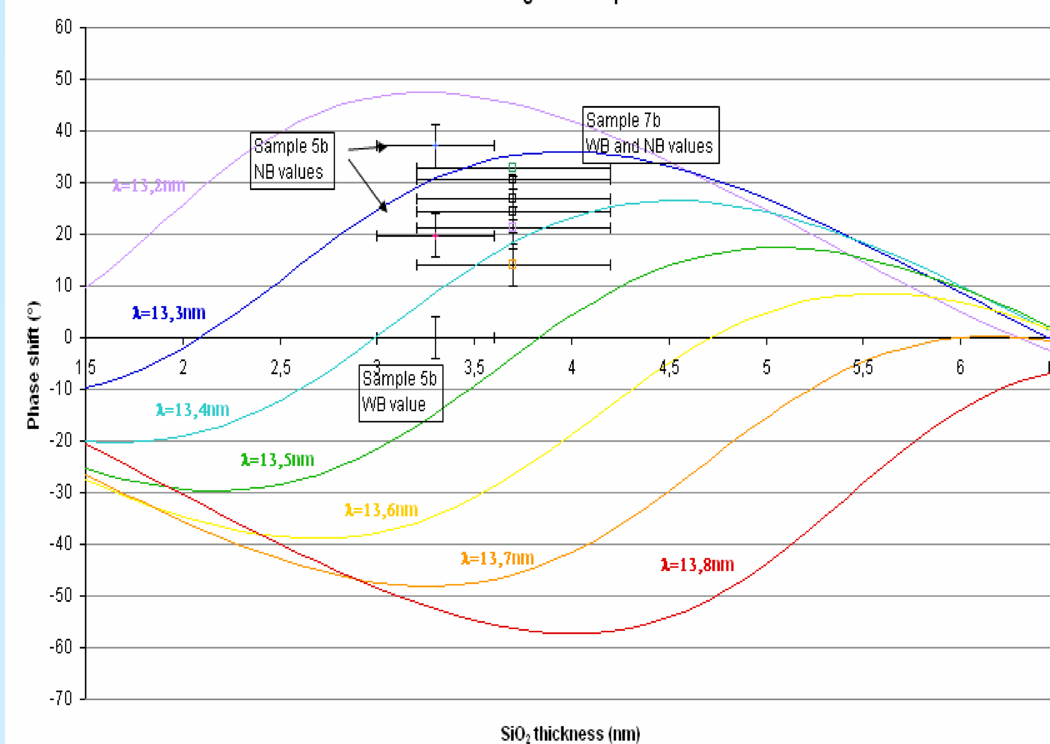
5 Phase shift measurements

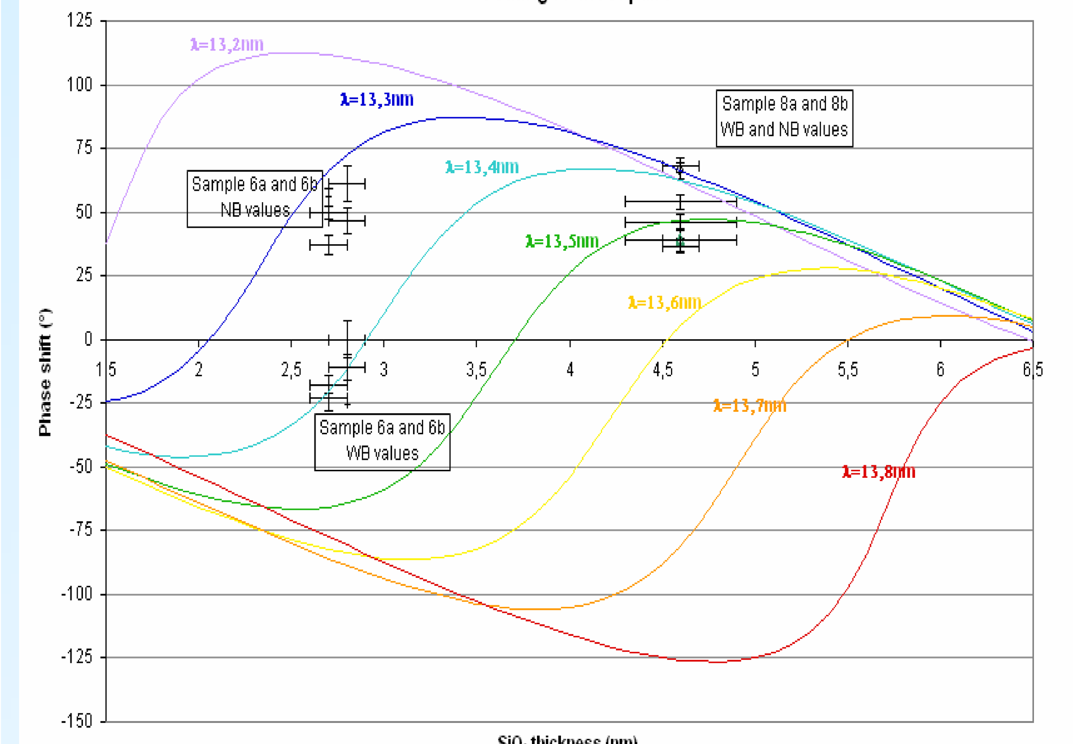


NB interferogram Sample 8a



WB interferogram Sample 8a





Observations :

- High quality interferograms
- WB lateral shift of the 0th order in the central area ~10 fringes. Hyp : due to N# of top MoSi coating above the cavity

Measured Phase shifts and comments:

- Measurements in agreement with theory given that NB illumination is 13.35nm instead of assumed 13.5nm.
- WB/NB differences can be explained by central wavelength mismatch. WB may not be centered on same wavelength as NB within a 0.05nm tolerance.
- SiO_2 thickness choice leads to chromatic/ less chromatic design

Conclusion :

- ✓ Design of nanoscale phase shift samples
- ✓ Fabrication and morphological characterization of 1" dedicated samples
- ✓ Interferometric Measurements @13.5nm on XIL beamline at PSI
- ✓ Results compared to theory
- ✓ Evidence of chromatic/less chromatic designs
- ✓ Phase shift non linearity according to embedded layer demonstrated

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