BERKELEY LAB

EUV Pellicle Transmission Measurements

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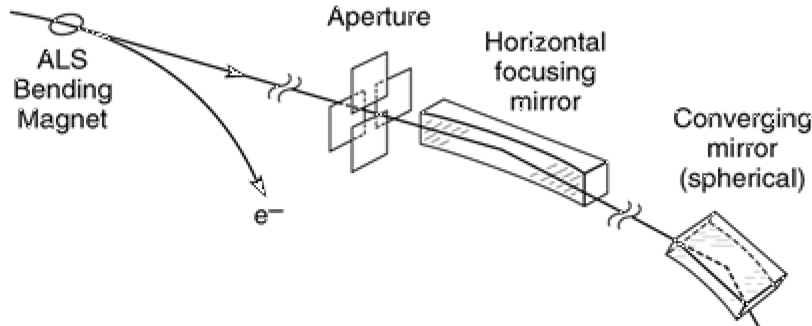
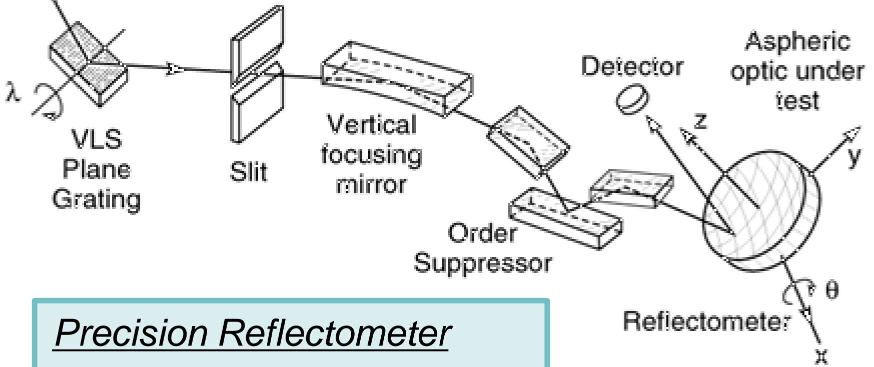
ALS Reflectometry and Scattering Beamline

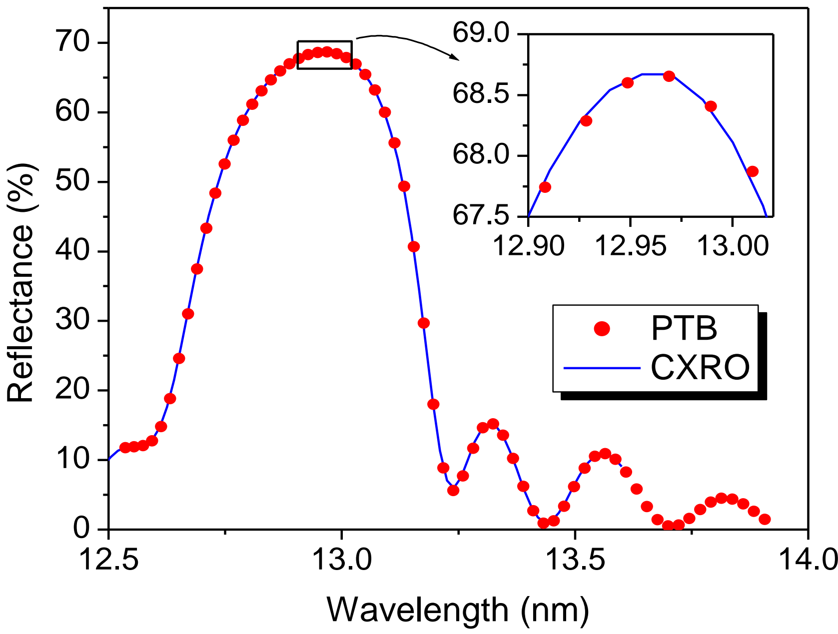


Beamline Specifications

1-50 nm wavelength range

- Wavelength precision: 0.007%
- Wavelength uncertainty: 0.013%
- Reflectance precision: 0.08%
- Reflectance uncertainty: 0.08%
- Spectral purity: 99.98%
- Dynamic range: 10^{10}



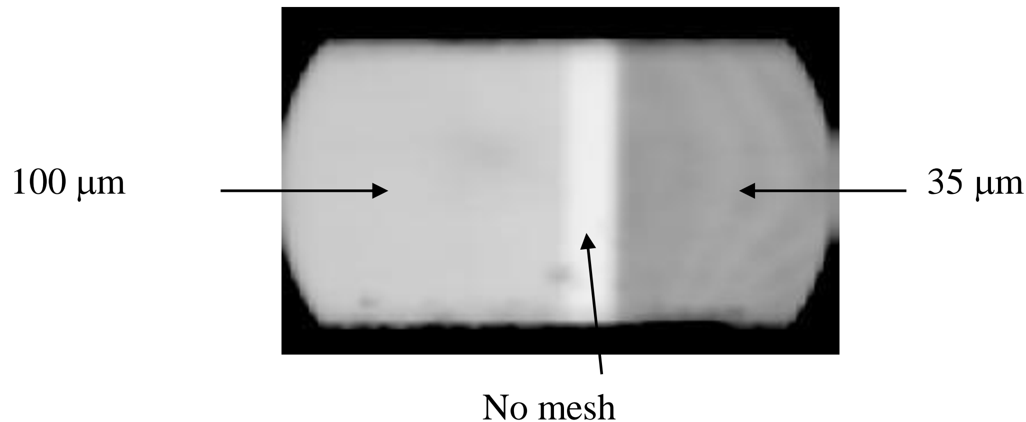


Precision Reflectometer

- 10 × 150 micron beam size
- 10 micron positioning
- Angular precision 0.01 deg
- 6 degrees of freedom
- Sample size up to 300 mm

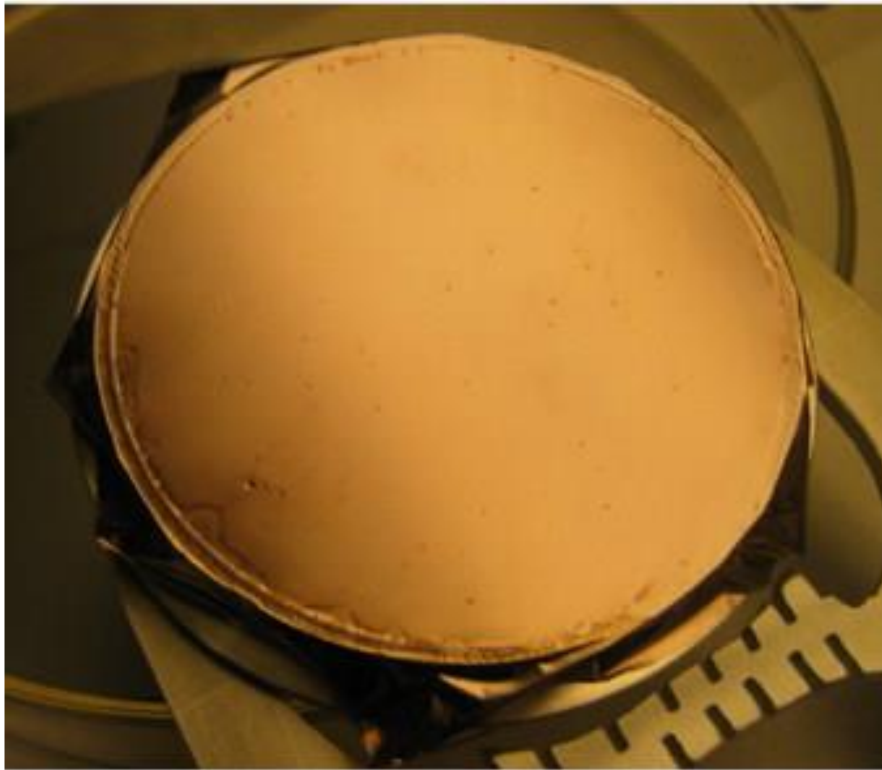
Si Pellicle with 1 micron support mesh

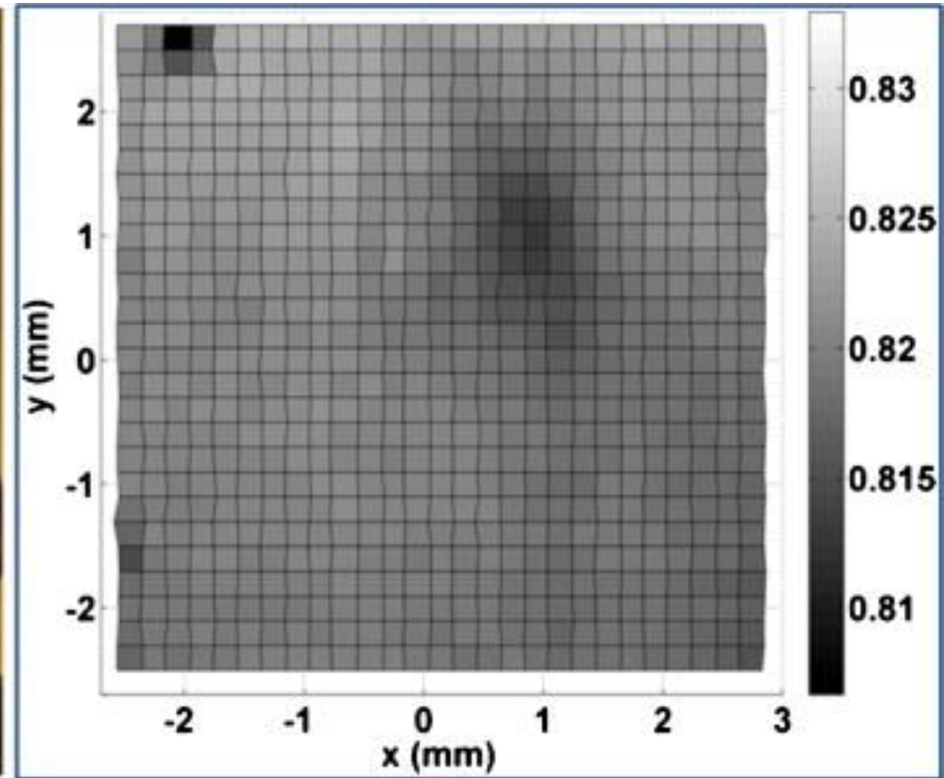
Linewidth (μm)	Pitch (μm)	T_{mesh} expected	T_{mesh} measured	$T_{pellicle}$ measured
1	35	94%	94.5%	79.5%
1	100	98%	97.5%	81.9%



(50 nm Si + Ru cap Transmission = 84% at 13.5 nm.)

Example: 75 mm diameter a-Si pellicle





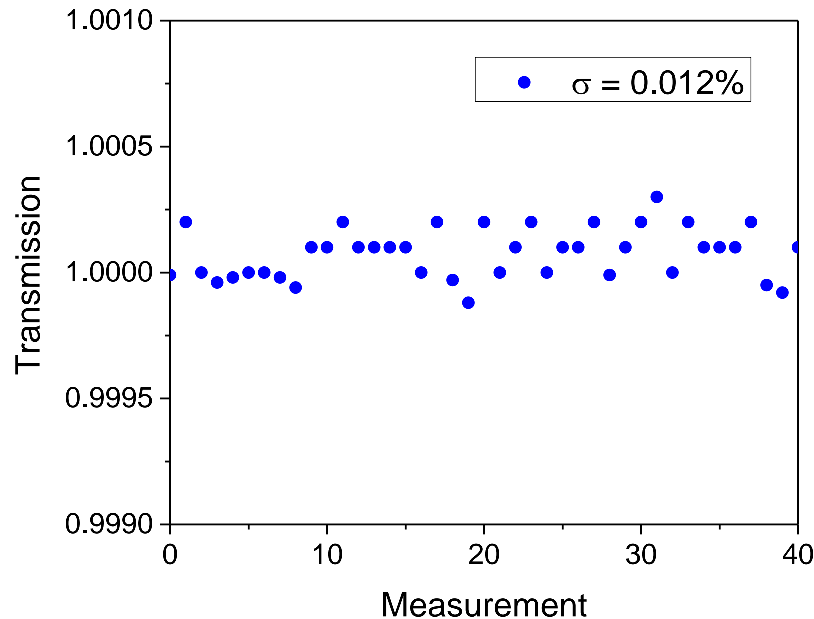
(a) (b)

Wire-grid dimensions are 1/100 μm, 50 nm Si with 2 mn Ru cap. EUV transmission 82% with 1.6% non-uniformity.

Y. Shroff, M Leeson, Pei-Yang Yan, E. Gullikson, F Salmassi, J. Vac. Sci. Technol. B 28, C6E36 (2010)

High precision transmission measurements

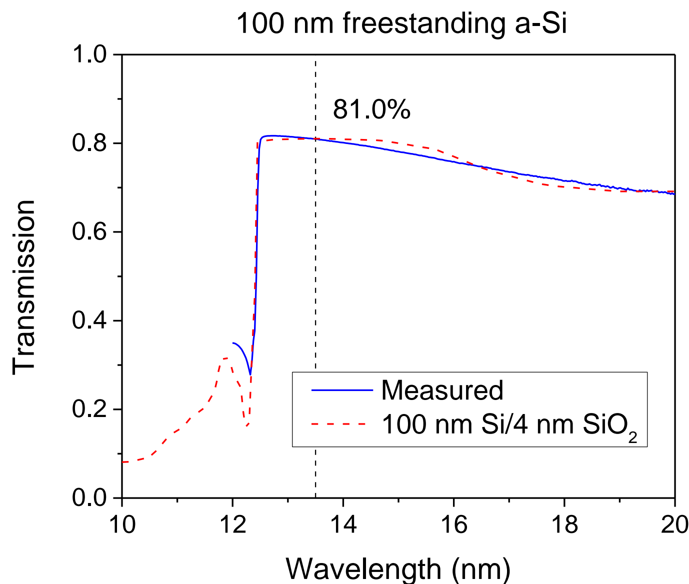
High precision and accuracy is available at the Synchrotron beamlines.

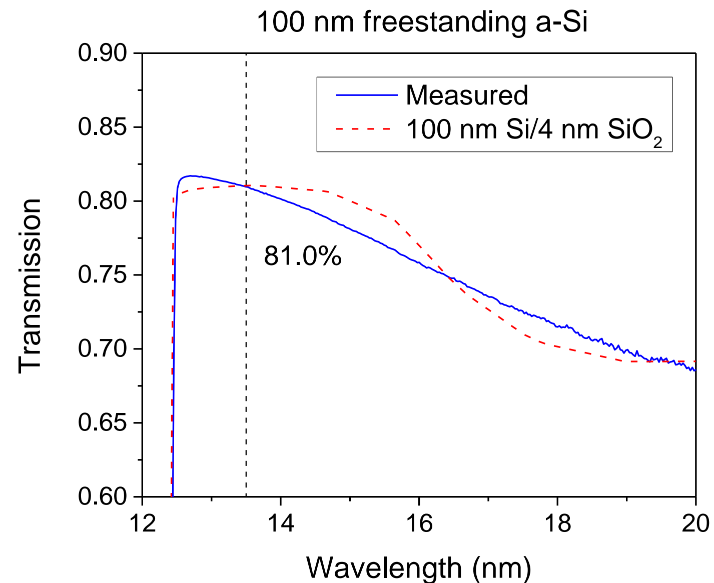


Measurements of pellicle uniformity < 0.2% are possible.

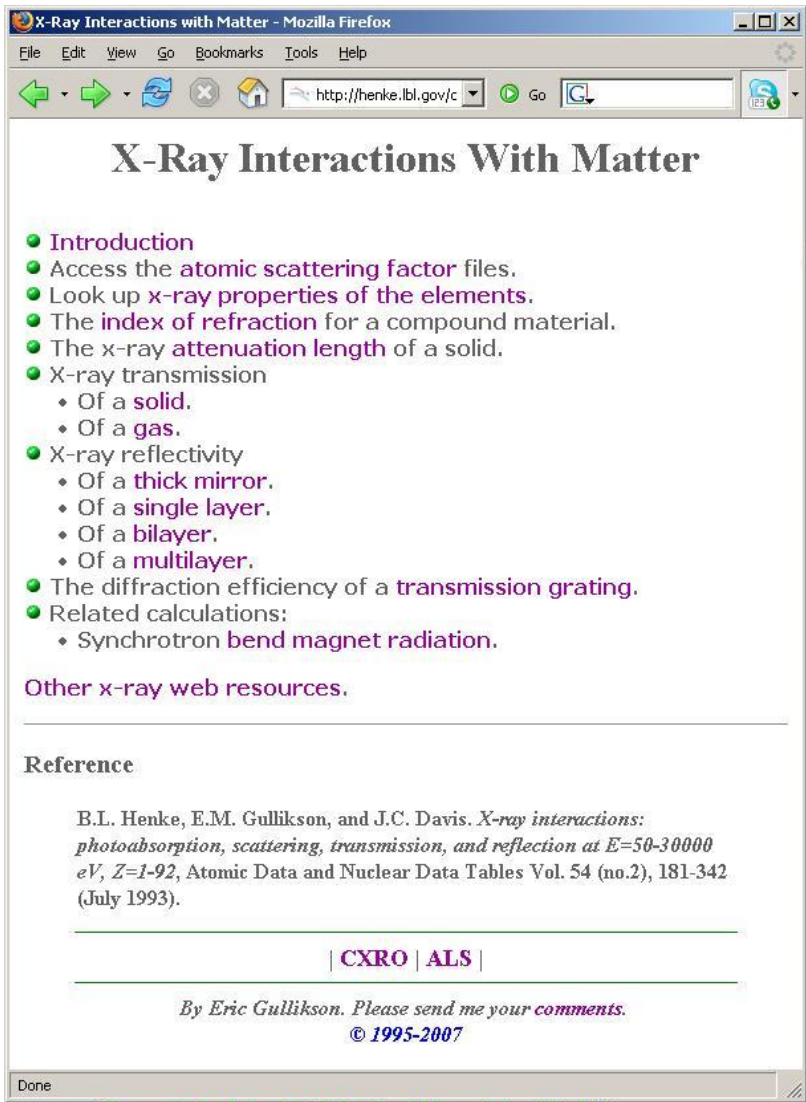
Wavelength dependence of freestanding Silicon

There is a difference between the amorphous Si deposited by Magnetron sputtering and the calculated transmission which is based on measurements of single crystal Silicon.





Atomic scattering factors



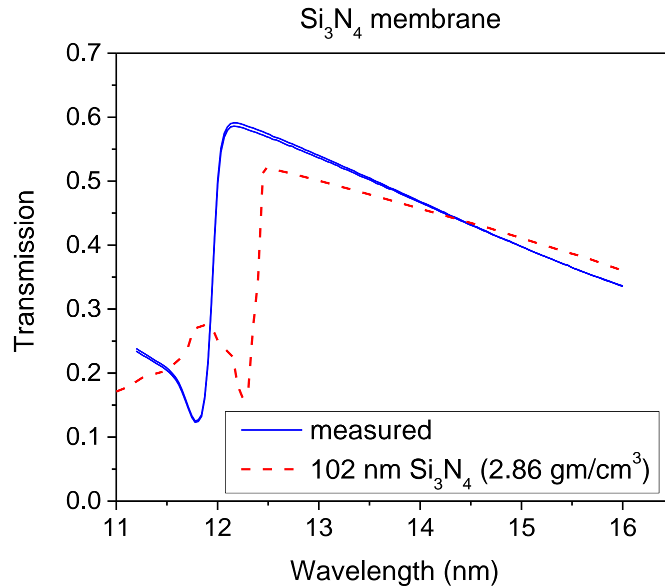
- www.cxro.lbl.gov
- Worldwide standard reference
- More than 1 million accesses per year

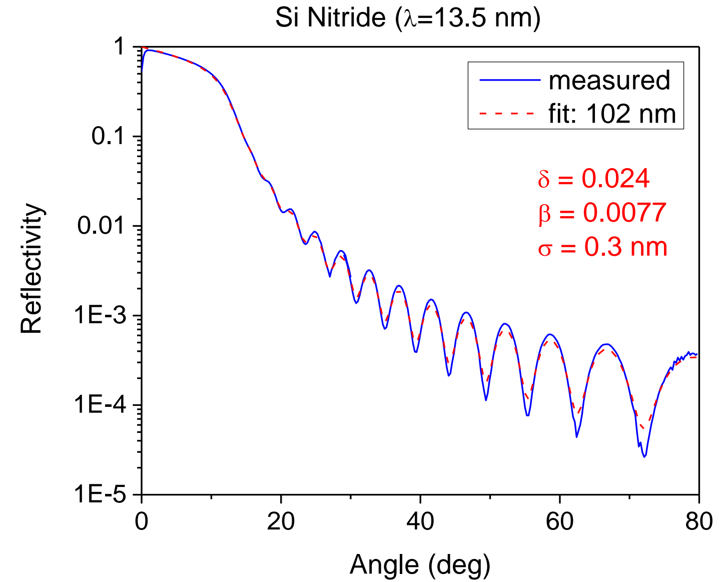
Measurements at Beamline 6.3.2

- Be - R. Soufli *et al.*
- Si - R. Soufli (*thesis*)
- Mo - R. Soufli (*thesis*)
- Mg - E. Gullikson *et al.*
- Al - E. Gullikson *et al.*
- Ru - U. Schlegel (*thesis*)
- Y - B. Sae-Lao (*thesis*)
- Pt - E. Gullikson *et al.*
- Ir - D. Graessle *et al.*
- Sc – A. Aquila *et al.*

Transmission and reflectivity of silicon nitride

The film thickness and optical constants can be obtained from the reflectivity.





Edge is shifted to shorter wavelength.
Wavelength dependence is off.
Depends in stochiometry and density.

$$T = \exp\left(-\frac{4\pi\beta}{\lambda} d\right)$$

$$T = 48\%$$

Summary

• High accuracy and precision transmission measurements can be made at the ALS.
• Transmission uniformity < 0.2% is measurable.
• Some discrepancies are observed between the measured and modeled transmission using the atomic scattering factors.

Thank you!