
Evaluation of Mo/Si multilayer for EUVL mask blank

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Background
EUV-reflectivity measurement system
Multilayer deposition system
Evaluation of Mo/Si multilayer
Summary

Background

high-precision reflectometry of multilayer

[dominant factors]

- wavelength calibration
- resolution
- elimination of stray light
- accuracy and repeatability of detector
- noise (detector or AMP
- goniometer



- construction of ASET beamline for EUV reflectometry
- resolution of grating
- repeatability of detector

multilayer fabrication

[dominant factors]

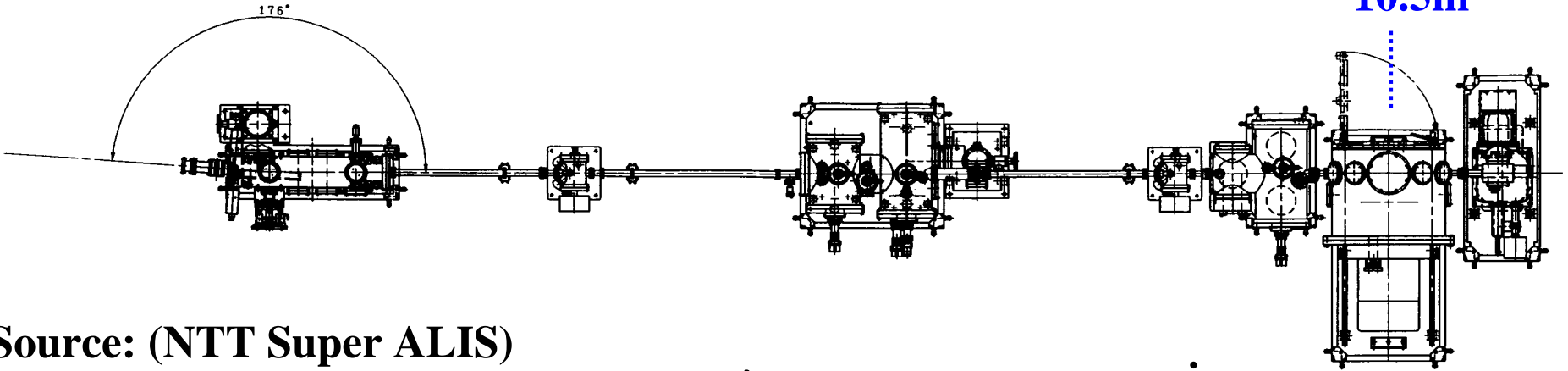
- high-reflectivity
- low-defect
- uniformity



- development of multilayer deposition system

ASET EUVL Beamline

10.5m



Source: (NTT Super ALIS)

SR light

mirror×2

slit

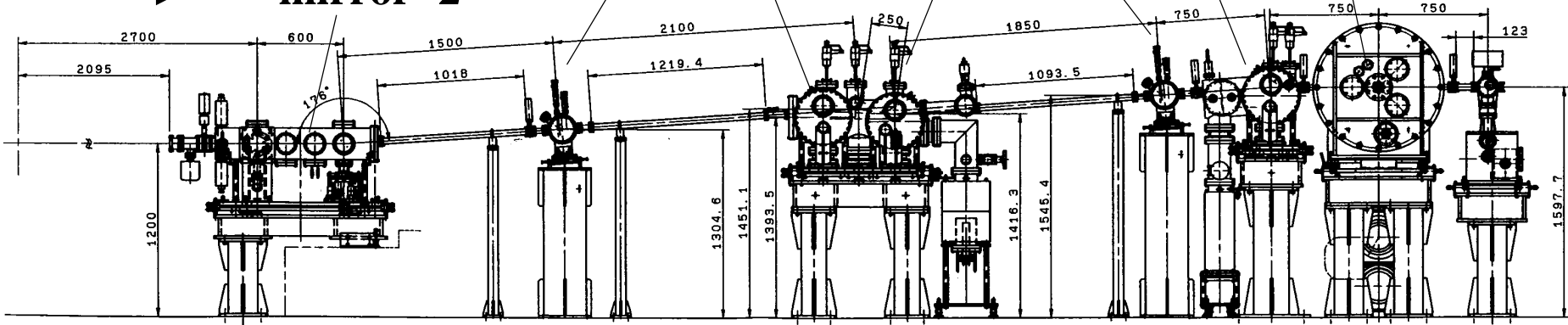
mirror

grating

slit

mirror

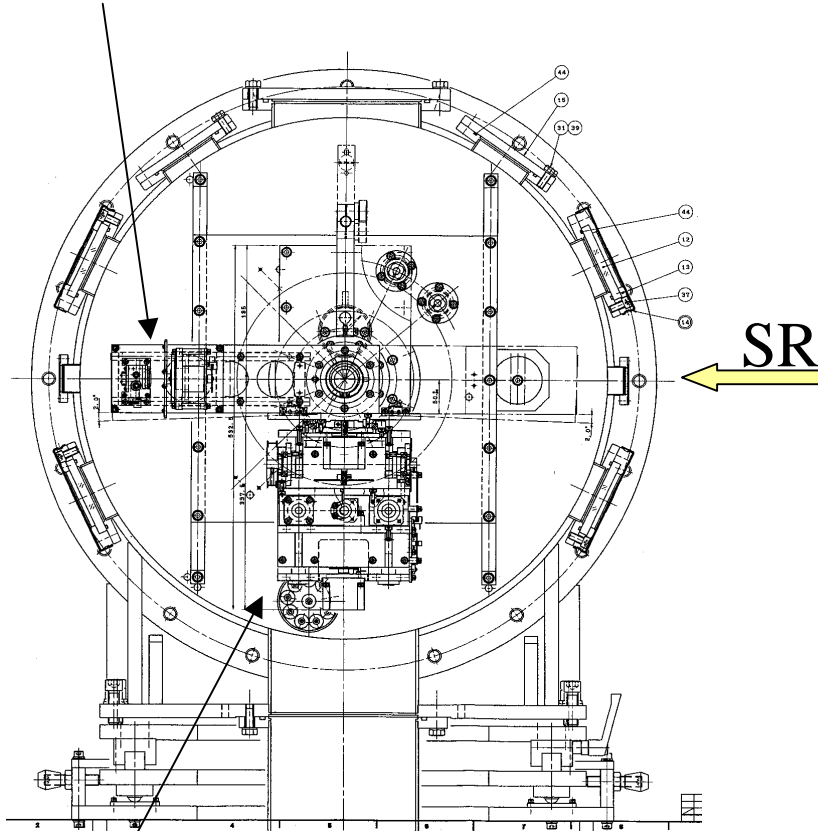
reflectometer



Reflectometer of EUVL Beamline



2 θ arm and detector (Si photodiode)



θ arm and sample stage

scan modes

- 1) λ scan, θ scan , 2θ scan
- 2) θ - 2θ scan
- 3) line scan ($\theta, 2\theta, \lambda$ fixed)

sample

mask blanks/mirror
diameter: 200mm ϕ
thickness: 50mm

measurement modes

reflectivity(multilayers)
transmission(resist film)

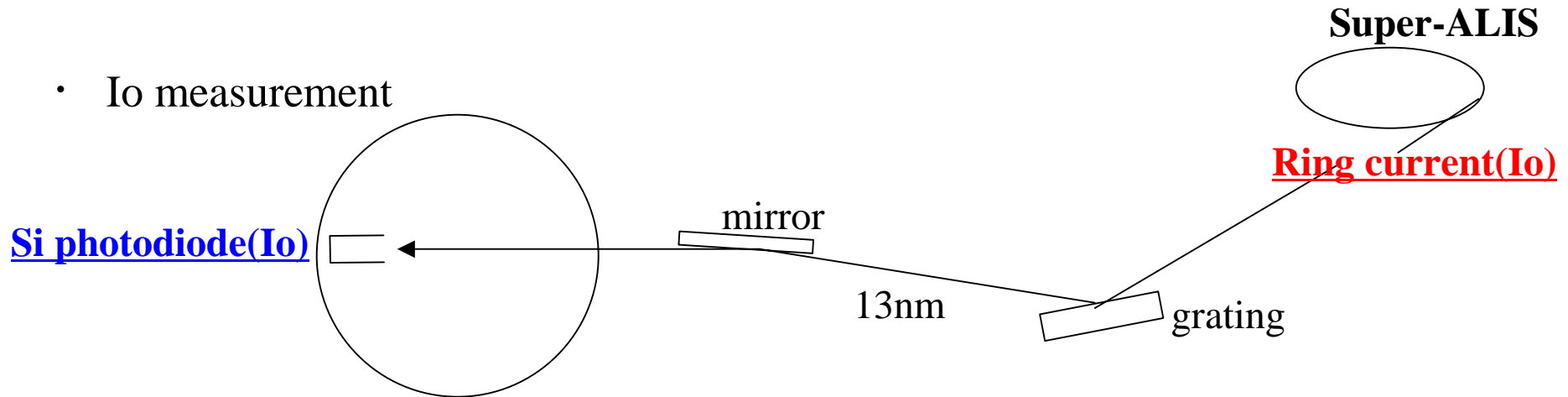
specification

reproducibility (Reflectivity)
< R \pm 0.5%

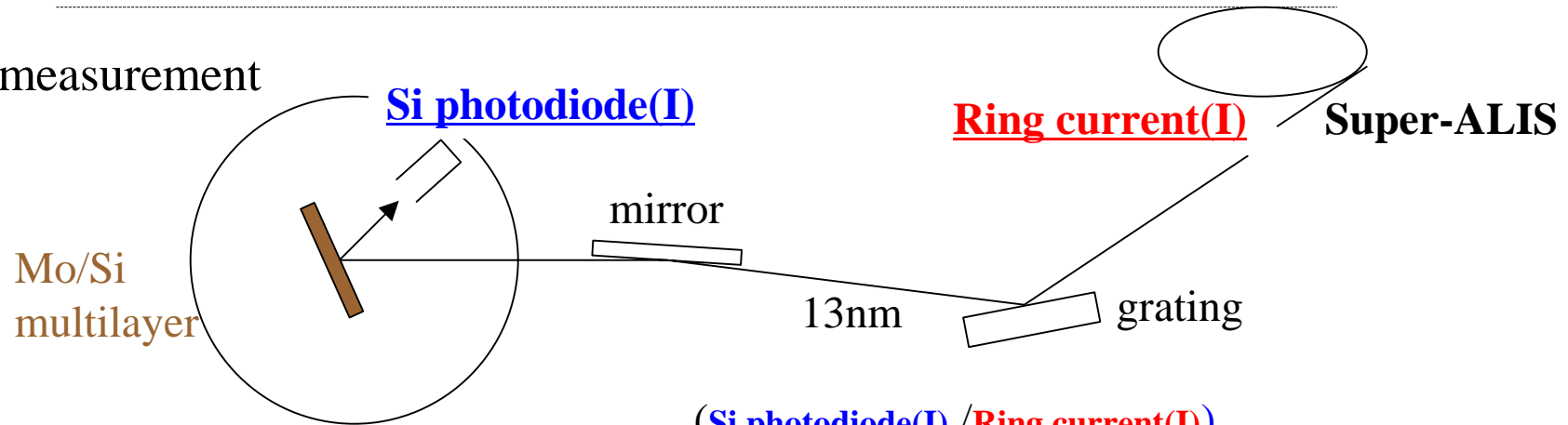


EUV Reflectivity Measurement Flow

- I₀ measurement



- I measurement



$$\text{Reflectivity} = \frac{(\text{Si photodiode(I)} / \text{Ring current(I)})}{(\text{Si photodiode(I}_0) / \text{Ring current(I}_0))}$$

Repeatability of Reflectivity-measurement Caused by Detector

	standard deviation/average value
① Si photodiode	0.051%
② ring current	0.016%

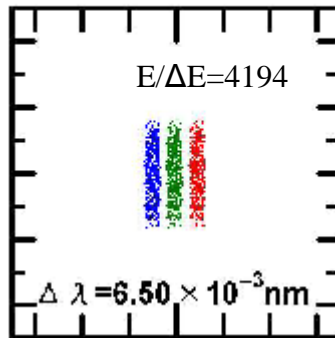
<u>condition</u>	ring current	photodiode+AMP
I ₀ measurement	350 mA	10.0 V
I measurement	345 mA	5.91 V

repeatability (σ) : 0.060% < 0.5% Specification repeatability

Spectral Resolution

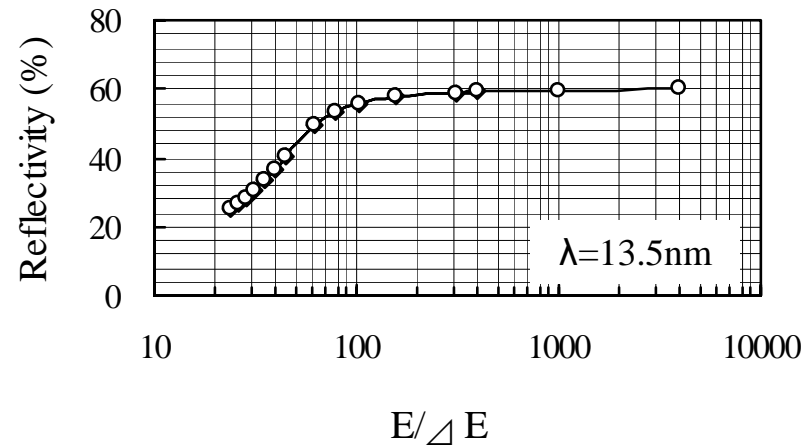
Spot diagram at exit slit

$\lambda=13\text{nm}$



Measured reflectivity

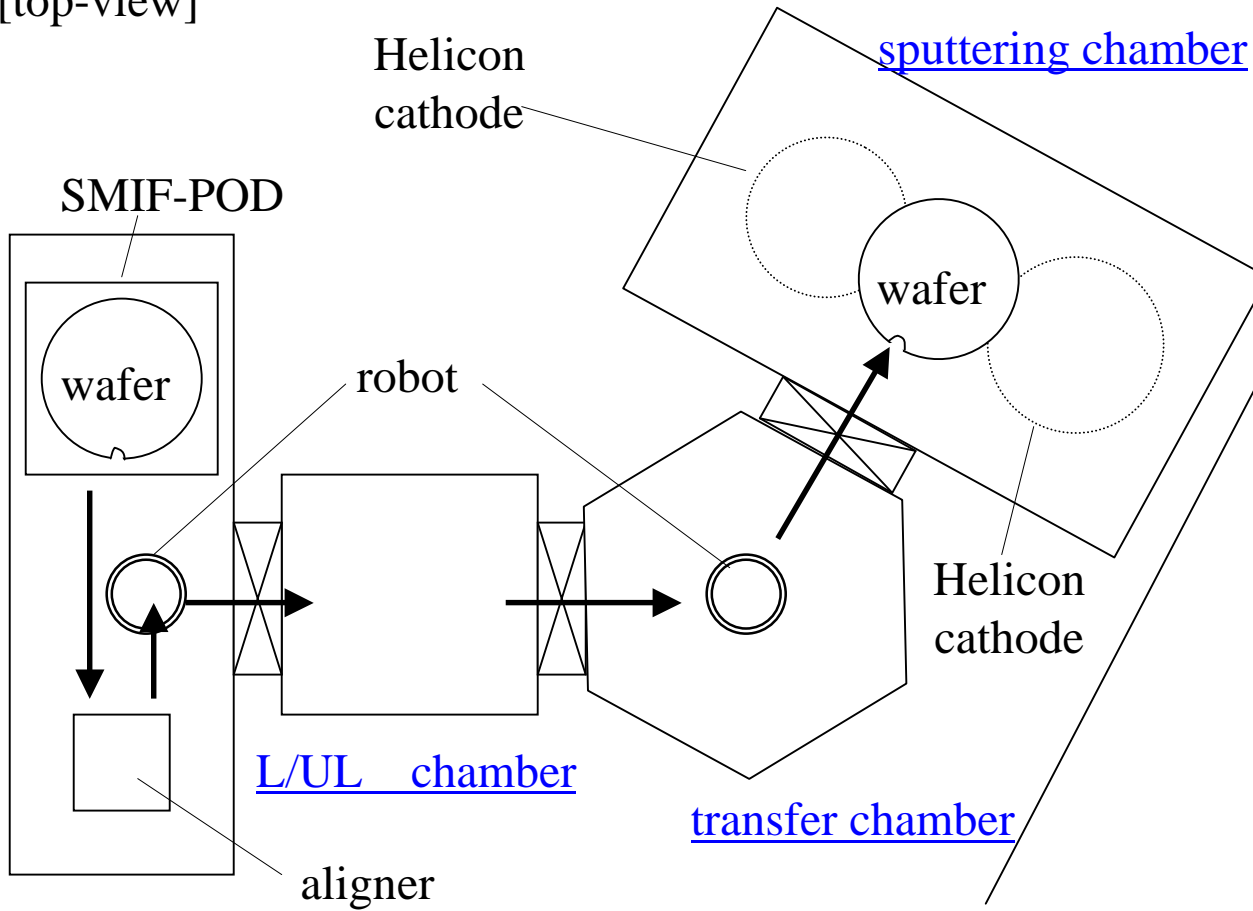
as a function of resolution



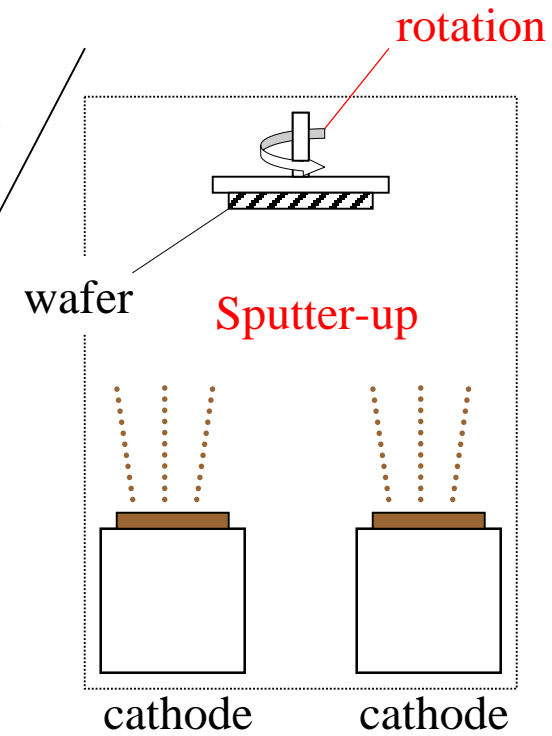
This grating has enough resolution to measure multilayer reflectivity

Multilayer Deposition System

[top-view]



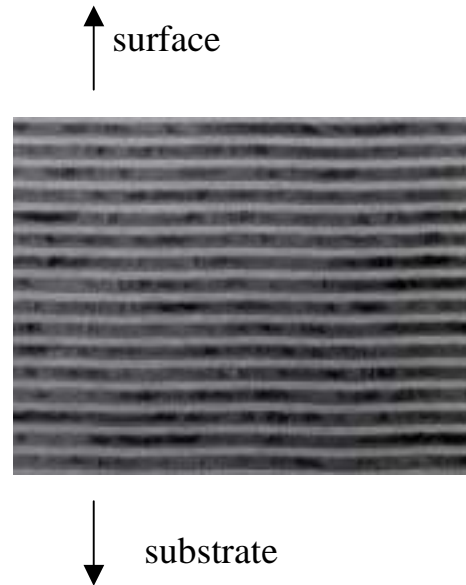
[side-view]



sputtering condition

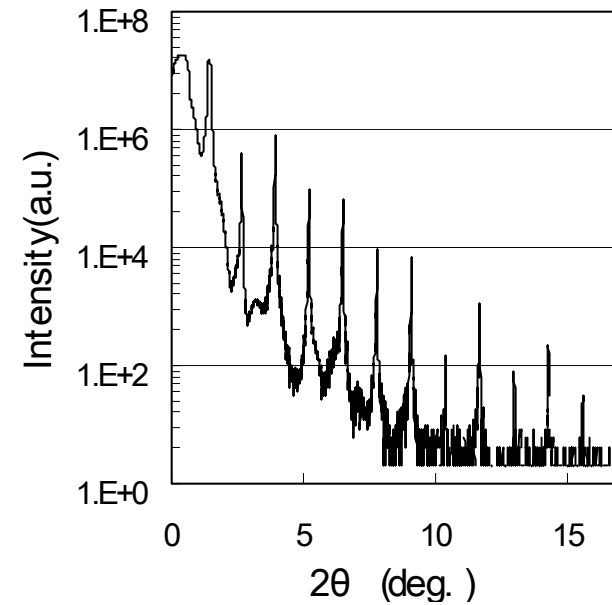
	Mo	Si
Ar Pressure	0.20 Pa	0.07 Pa
Power	500W (DC)	1kW (RF)
deposition rate	0.4Å/s	0.4Å /s
substrate	Si wafer (200mm)	

TEM cross section
for (Mo/Si) multilayer

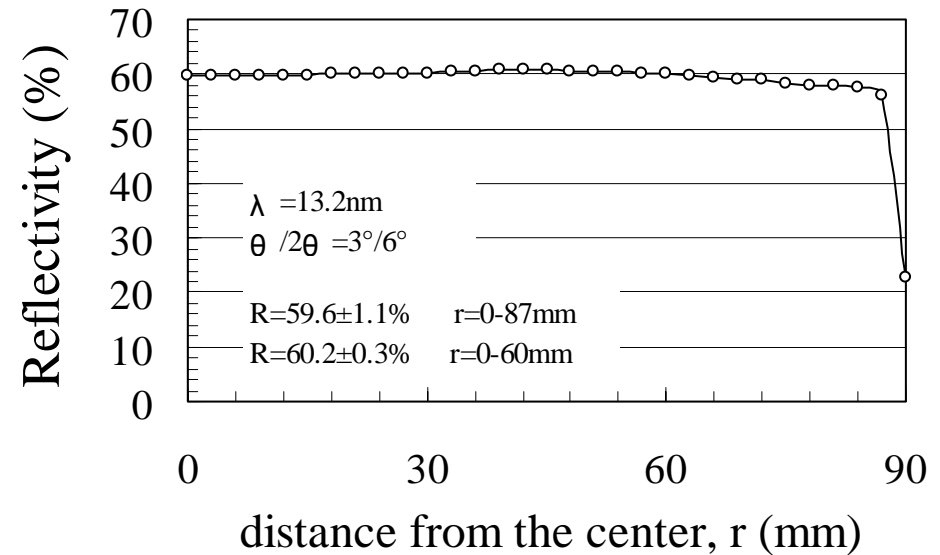
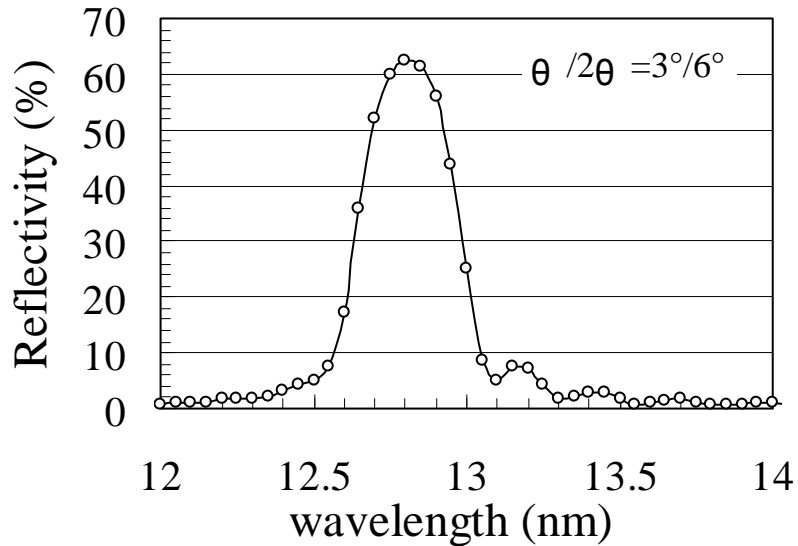


dark : Mo layer
light : Si layer

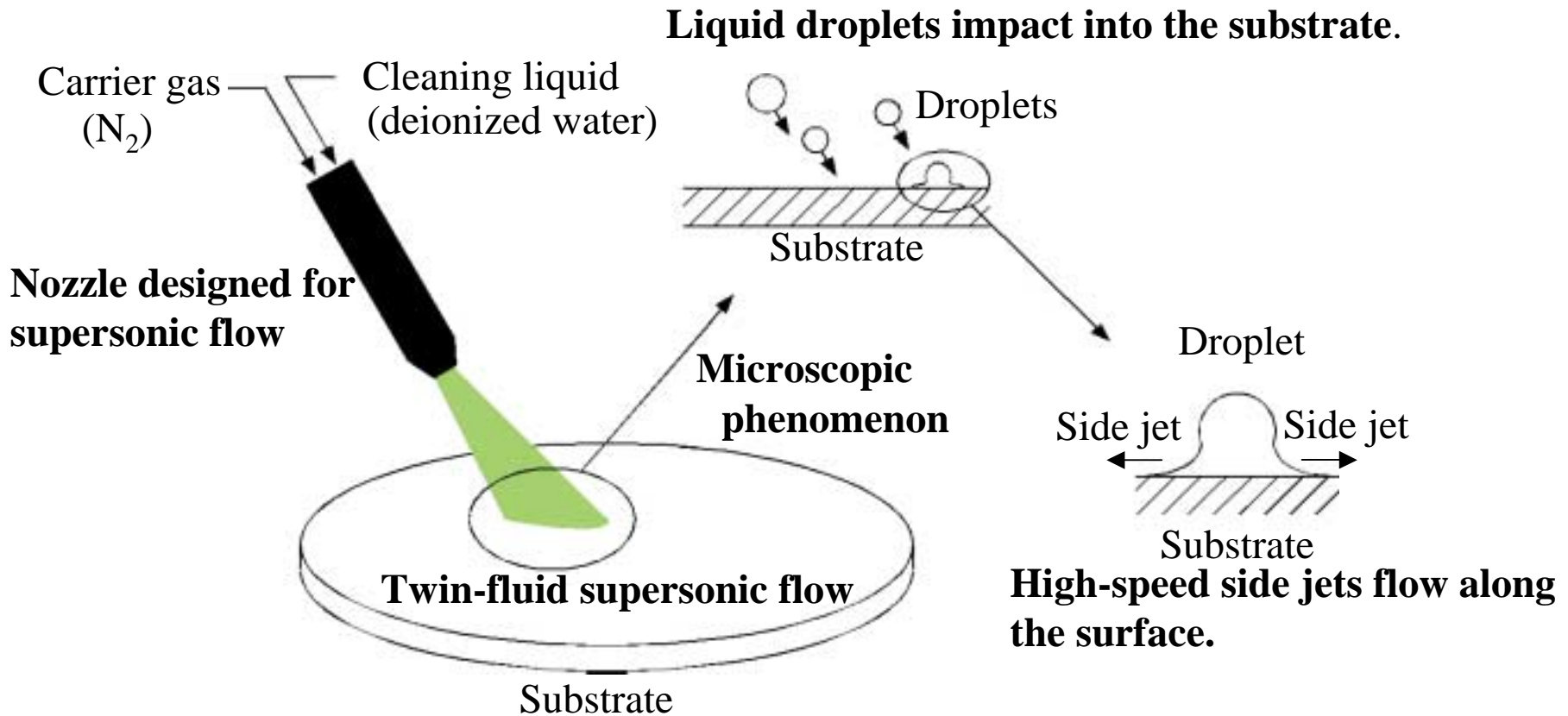
Measured hard X-ray curve
of (Mo/Si) multilayer



EUV Reflectivity of (Mo/Si) Multilayer

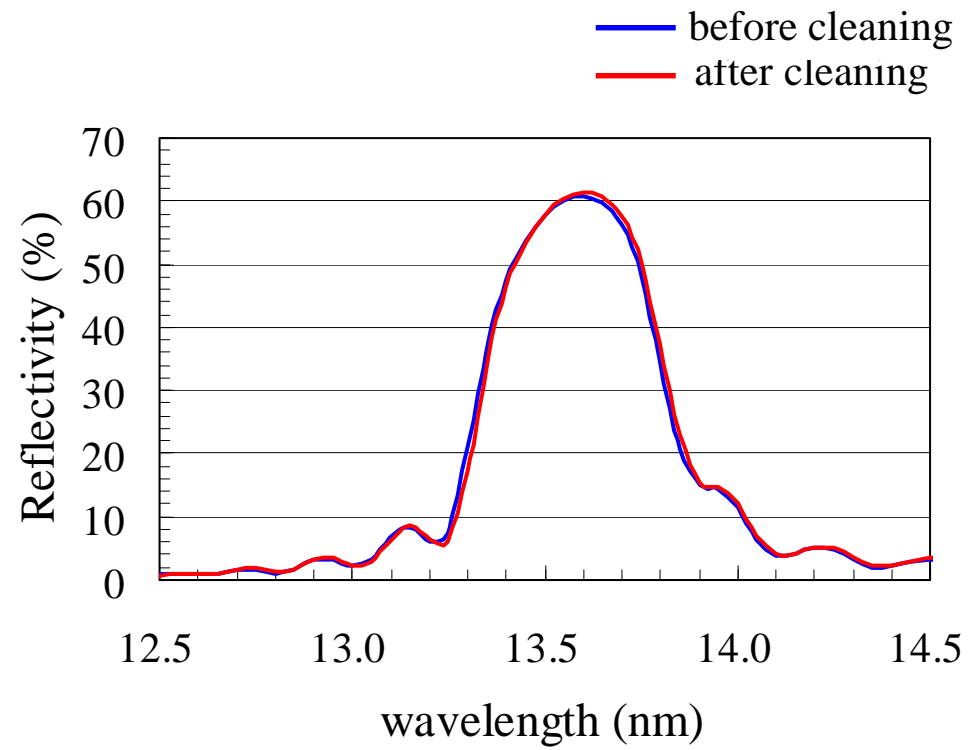


Supersonic Hydro-cleaning Technique



This technique was developed at ASET SPC Laboratory.

Results



Summary

- **EUV reflectivity measurement system can be applied to the evaluation of Mo/Si multilayer for mask blanks and mask fabrication process.**
- **EUV reflectivity of Mo/Si multilayer which was deposited by helico sputtering was measured using ASET EUVL Beamline.**
 - **reflectivity : R > 60%**
R=59.6±1.1% r=0-
 - **in-plane distribution**
87mm
R=60.2±0.3% r=0-60mm

Acknowledgements

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