# Development of a Large Reflectometer for Large EUV Optical Elements

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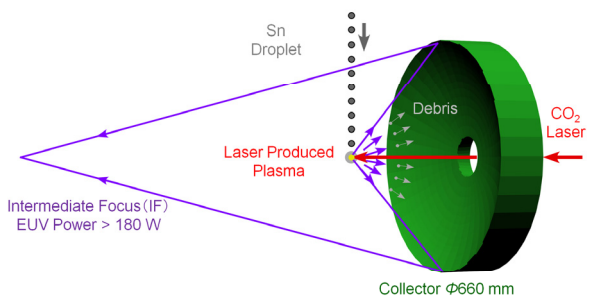
## Introduction

EUV source power is a critical issue of EUV lithography. The collector mirror performance is strongly related with the output power. At the laser produced plasma (LPP) source, tin debris is serious problem to reduce the reflectance. Reflectometer for the collector mirror is very important to develop EUV source system.




Schematic of EUV source (LPP).

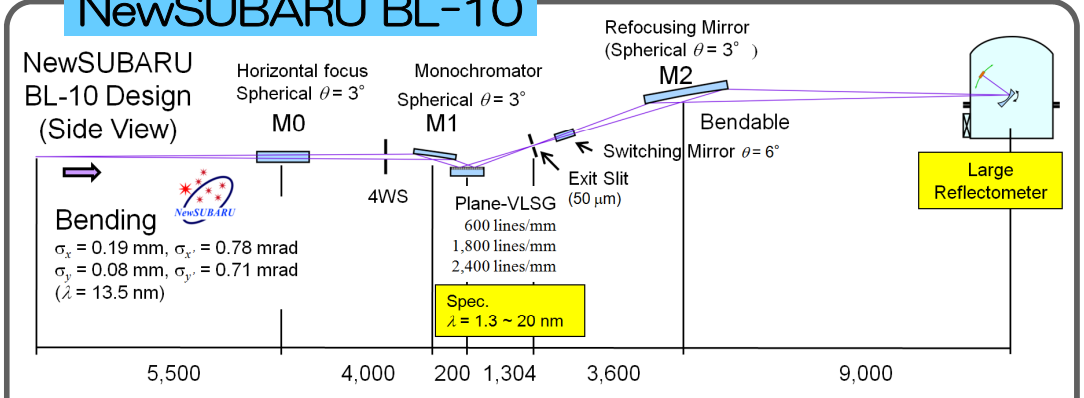
EUV Source Power ∝ Collector Performance

Sn(Tin) debris
Carbon Contamination

Measurement tool
**Reflectometer**
was required in Japan

In Japan, there are the source company and the device makers. The large reflectometer is strongly required, which is an EUV basic tool.

## NewSUBARU BL-10

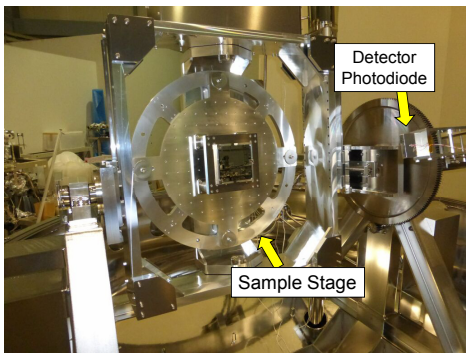



Schematic view of beamline 10 of NewSUBARU.

- A new large reflectometer is installed at BL-10 of NewSUBARU synchrotron facility. A new branch beamline was constructed for this new reflectometer.
- In past years, we developed the other reflectometer for EUV mask metrology at straight line of BL-10.
- The monochromator is Monk-Gillieson type with plane varied-line-spacing grating. The wavelength repeatability is very high of pm order.

## Large Reflectometer

A vacuum chamber.




Six-axis stage in the vacuum chamber.

**Max. Sample size**

Dia. ϕ800 mm, Thickness 250 mm, Weight 50 kg

**Specification**

- Chamber size Dia. 2.6 m x Height 2.9 m (11 $m^3$)
- Back pressure $2 \times 10^{-6}$ Pa
- Sample Stage five axis (θ, Y, Z, tilt, φ)、detector 2θ
- The entire sample surface is able to be measured using Y and rotation axis.
- Closed Loop with high precision
- All motor is not vacuum type with high torque, and packed in a small chamber unit. All the motor unit is installed in the large chamber. The stage can move without influence of chamber transform.

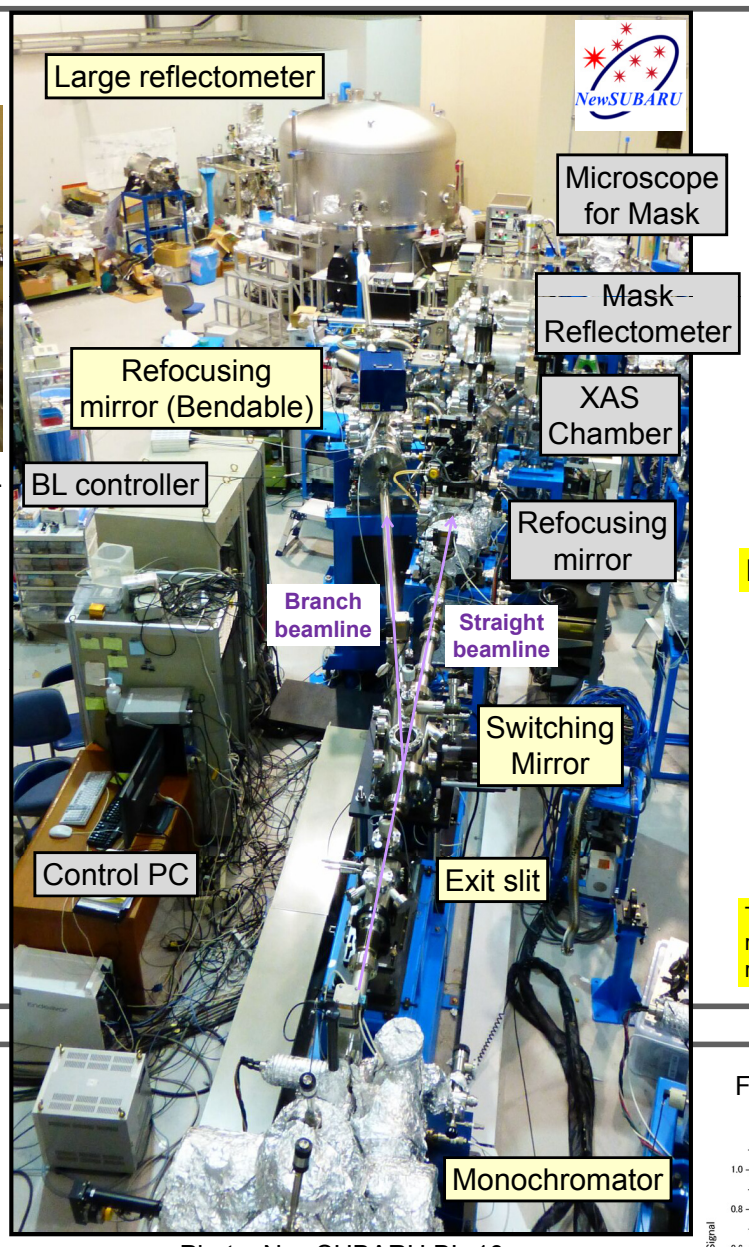
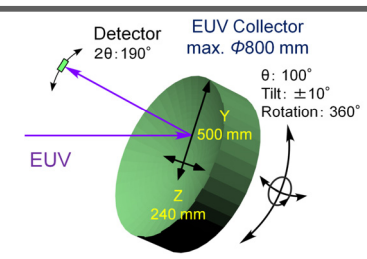



Photo. NewSUBARU BL-10.

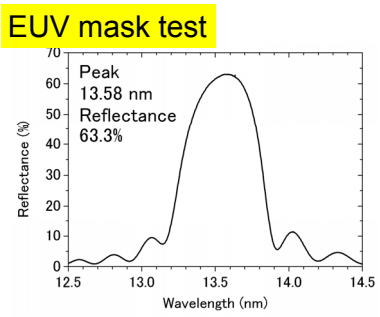



Schematic drawing of stage movement.

**Table. Stage range and precision.**

| Axis | Range | Encoder precision |
|---|---|---|
| Y | -50 mm ～ +450 mm | 100 nm |
| Z | -140 mm ～ +100 mm | 100 nm |
| φ | 360° | 0.00014° (0.5'') |
| Tilt | ±10° | 0.00014° (0.5'') |
| θ | -5° ～ +95° | 0.00016° (0.6'') |
| 2θ | -5° ～ +185° | 0.00014° (0.5'') |

**EUV mask test**




This result
Peak: 13.58 nm
R: 63.3 %
(2pt lower)

The mask reflectometer result
Peak: 13.58 nm
R: 65.3 %

Measurement result of EUV mask reflectance.

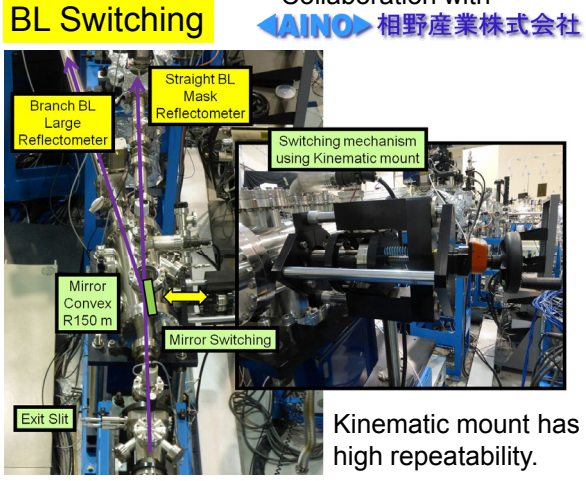
The reflectance was measured with high wavelength reproducibility. High order light from grating should be reduced to evaluate correct reflectivity.

## Branch beamline

New branch beamline was constructed for the large reflectometer.

**BL Switching**

Collaboration with AINO 相野産業株式会社

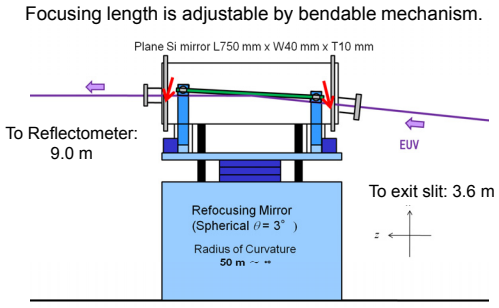



Kinematic mount has high repeatability.

Repeatability: **vertical 11 μrad, Horizontal 17 μrad**

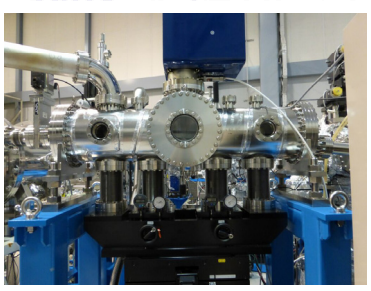
**Refocusing bendable mirror**

Focusing length is adjustable by bendable mechanism.



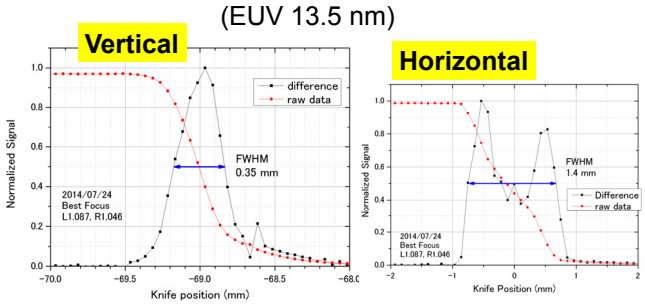

Schematic drawing of refocusing system.

Collaboration with AINO 相野産業株式会社



Photograph of refocusing system.

Focusing size measurement by knife edge test (EUV 13.5 nm)




Beam size: **Vertical 0.35 mm, Horizontal 1.4 mm**

Usually, the refocusing-optics magnification should be 1:1 to reduce the aberration. This system magnification is 2.5:1. However, the beam size was small as 0.35 mm (V), because the mirror shape can be transform to ellipsoidal shape. The bending torques of the both side were optimized.

## Summary

- A new large reflectometer has been developed to evaluate EUV collector mirror, and soft X-ray large component in NewSUBARU, JAPAN.
- Maximum sample size is ϕ800 mm, t250 mm, and 50 kg. The entire surface is able to be measured.
- This reflectometer will help the EUV source development, and soft X-ray optics development.

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