At-wavelength EUV lithography mask observation using a high-magnification objective with three multilayer mirrors

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Outline

1. **Motivation**

   Early studies and technical issues

2. **Experimental**

   Innovative optics utilizing high-magnification

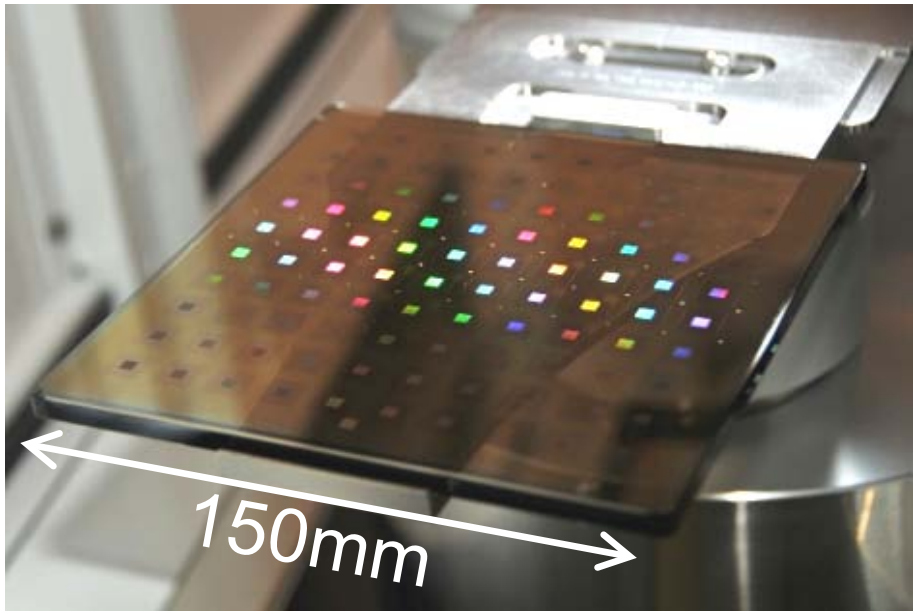
3. **Highlight data**

   EUVL mask images with improved resolution

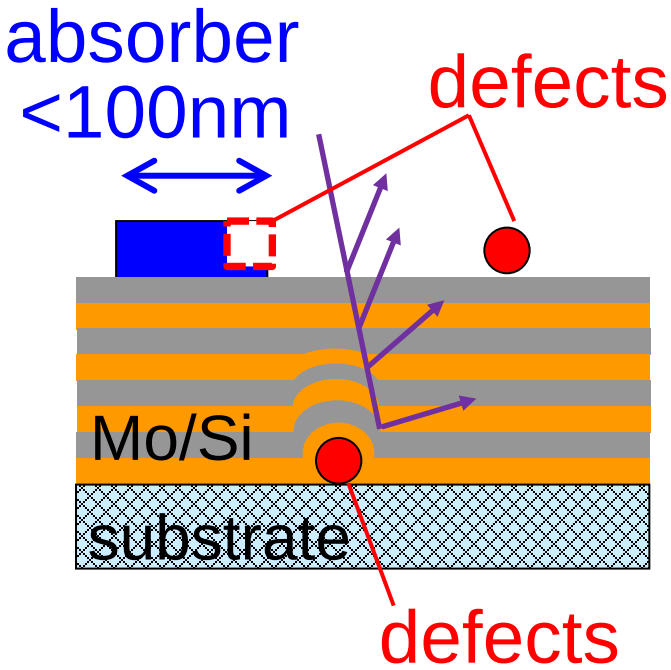
4. **Summary and future plans**

1. Motivation

At-wavelength inspection of EUVL mask



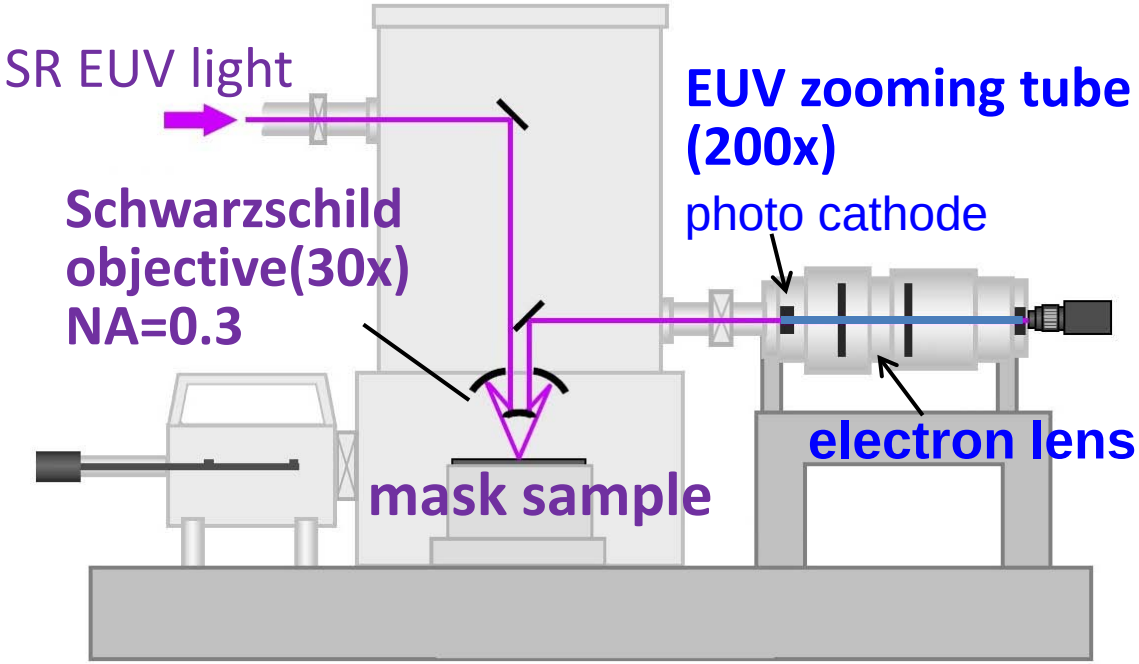
http://semimd.com/blog/tag/euv-lithography/



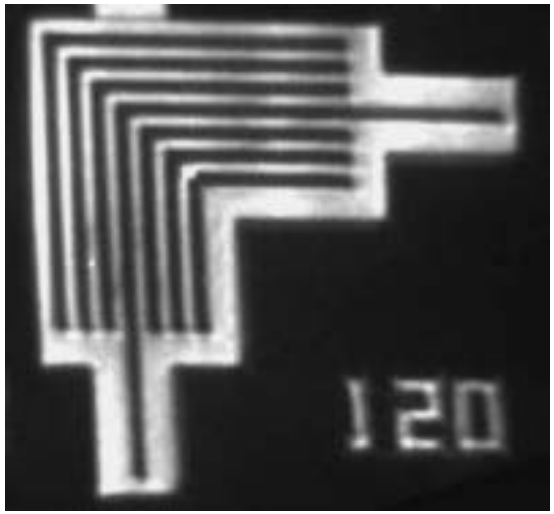
Requirements for an inspection tool

- ✓At-wavelength observation (λ=13.5nm)
- ✓High spatial resolution (δ<40nm)
- ✓Wide field of view for a rapid whole mask inspection

Early study: EUV Microscope on NewSUBARU



Line width 480nm
(120nm on wafer)



H. Kinoshita, Jpn. J. Appl. Phys. **49**(2010)06GD07.

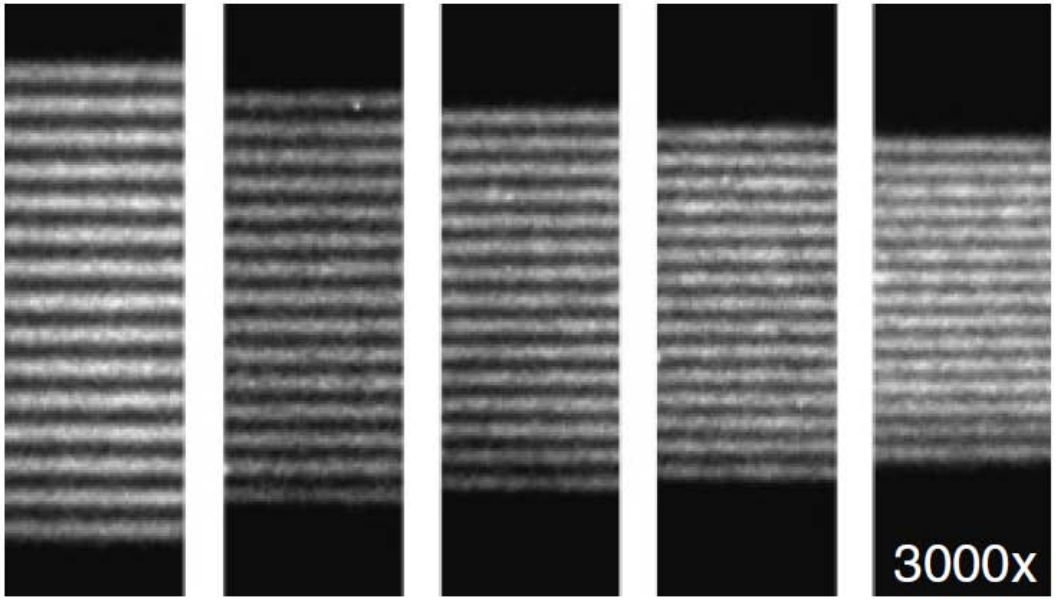
EUV⇒electron

✓Bright field image at λ=13.5 nm

✓Rayleigh's limit δ=30 nm

✓Field of view Φ=20μm

Technical issues of the EUV Microscope



Aim of this work

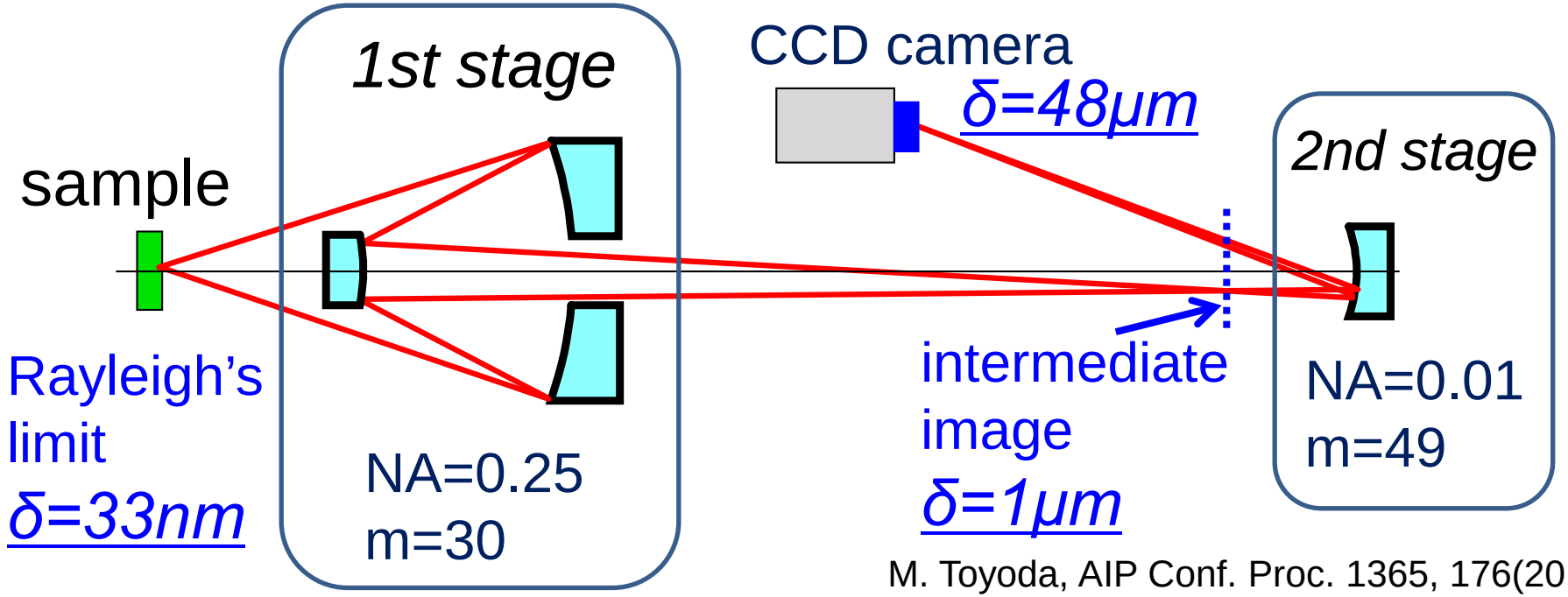
Innovative EUV imaging facility realizing both

✓**high spatial resolution for 22-nm node mask,**

✓**wider field of view for practical inspection time**.

2. Experimental

Two-stage imaging system for high magnification



M. Toyoda, AIP Conf. Proc. 1365, 176(2011).
M. Toyoda, Japan Patent 2010-79257.

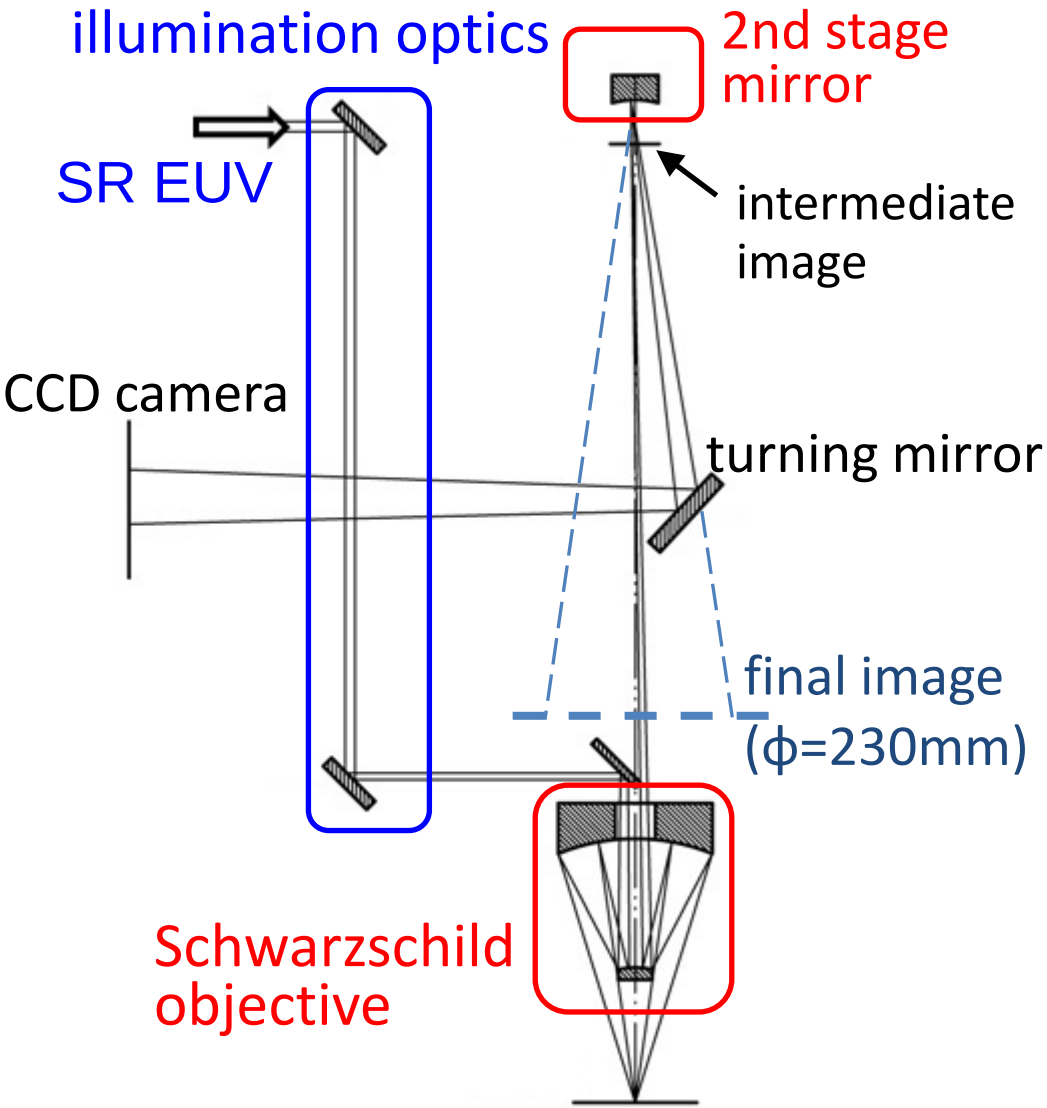
✓Higher magnification (m=1460)

⇒ ***Resolution of 30nm with EUV-CCD camera***

✓Good *correction of off-axis aberrations*

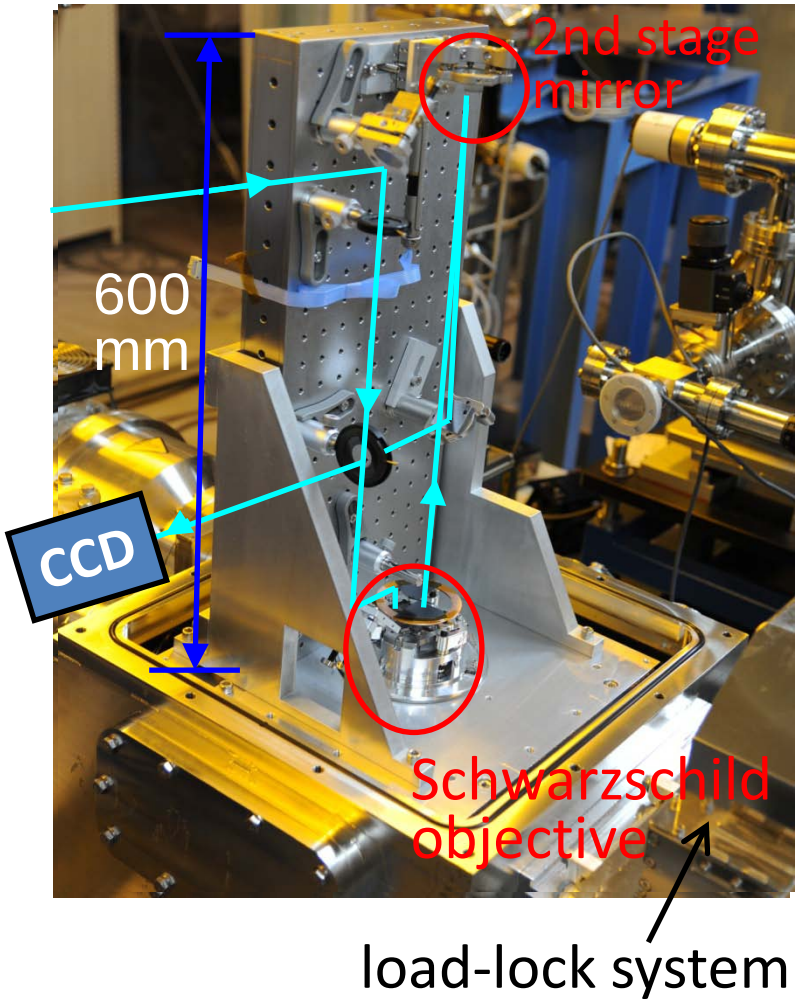
⇒ ***Large field of view over Φ>160μm***

Experimental setup of the novel facility



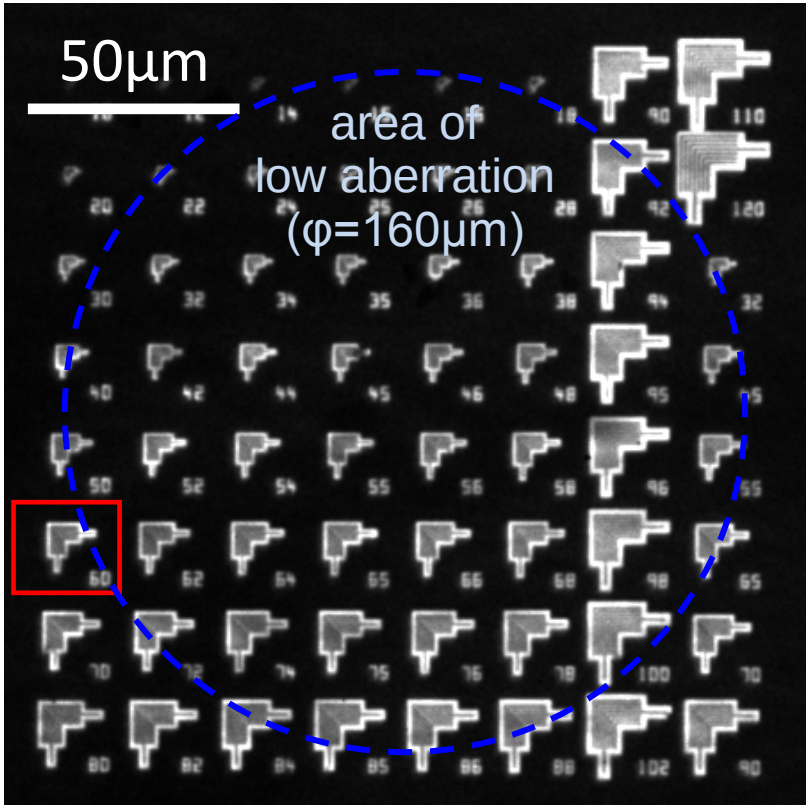
EUVL mask (F.O.V.: ϕ=160μm)

NewSUBARU BL3



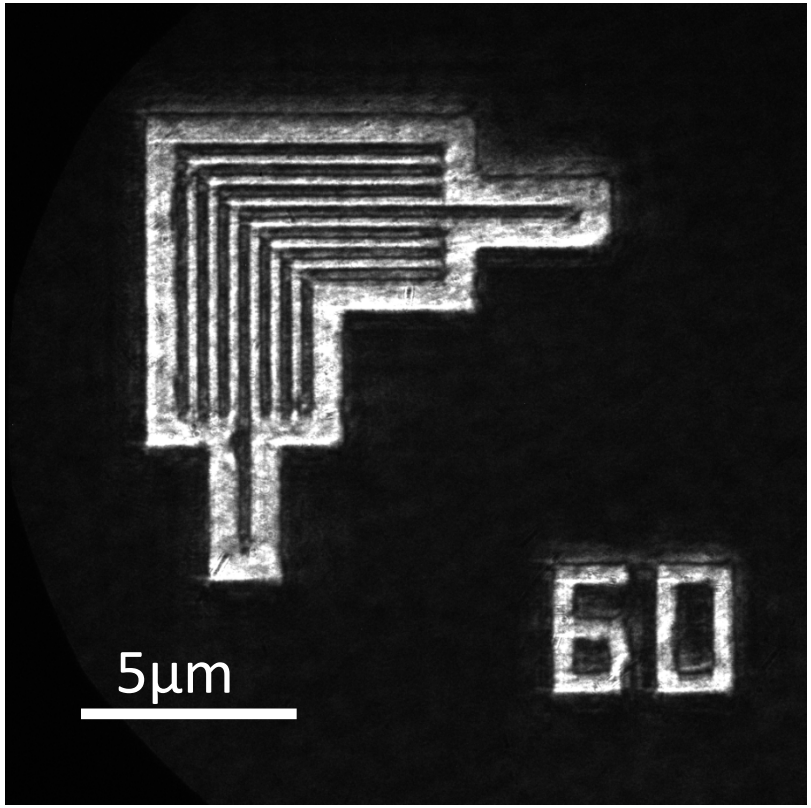
3. Highlight data

Confirmation of the magnification enhancement



Intermediate image (m=30)

Exp. time: 0.25 sec.



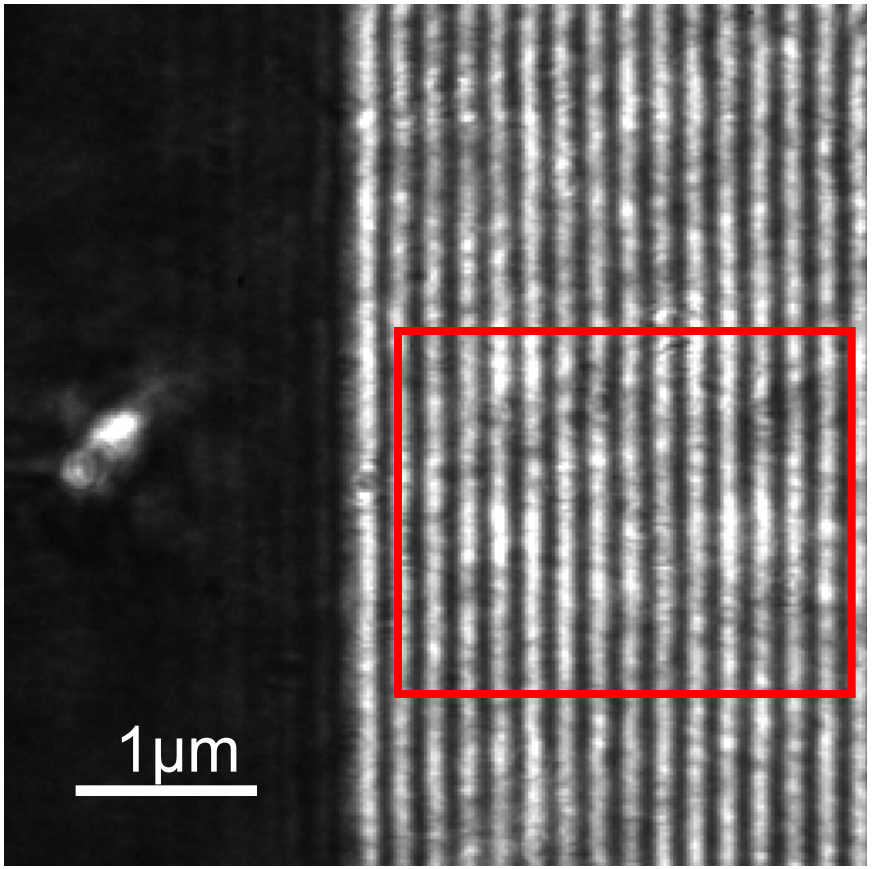
Final image (m=1460)

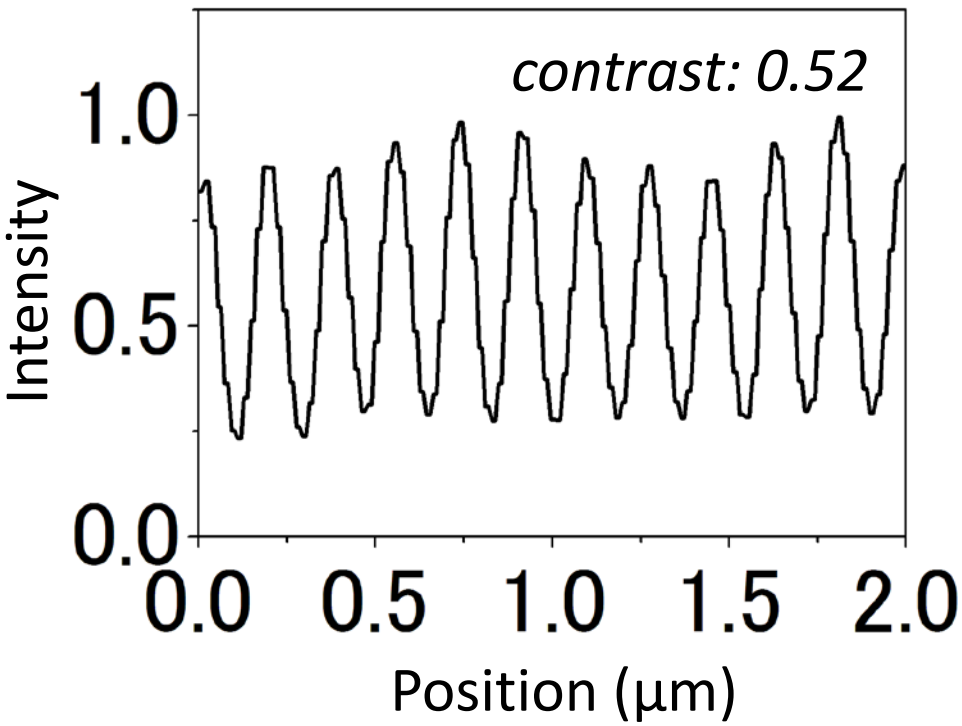
Line width: 240nm (60nm)

Exp. time: 36 sec.

EUV-CCD camera: pixel size 13.5μm, 2048 × 2048 pixels

Resolution measurement with L/S patterns





✓88nm-width pattern was resolved with good contrast

⇒The capability of inspecting 22nm-node masks.

4. Summary

✓A high magnification EUV microscope based on all-reflective objective is proposed.

✓The objective is expected to have a large field of view of 160 μm.

✓A 88-nm wide L/S patterns is resolved with good contrast.

Future plans

✓Detailed estimation of the resolution

✓Upgrade of the facility

An illumination optics with uniform intensity, coherence control

A large scale EUV-CCD camera for practical application

✓Lab-scale inspection tool with a plasma light source

Special thanks to

- ***Optical shop and machine shop of IMRAM***
- ***T. Terasawa and T. Amano of EIDEC***

This work is suported by

- ***Japan Science and Technology Agency (JST)***
- ***New Energy and Industrial Technology Development Organization (NEDO)***

Thank you for your attention.