

Evaluation of pattern fidelity in EUVL using the high-numerical-aperture small-field EUV exposure tool (HiNA)

Yuusuke Tanaka, Hiroaki Oizumi, Takeo Hashimoto
Fumiaki Kumasaka, Iwao Nishiyama,
Tsukasa Abe*, Hiroshi Mohri*, and Naoya Hayashi*

ASET EUV Process Technology Laboratory
** Dai Nippon Printing Co. Ltd.*



Background

For 45-nm node, EUVL has large k_1 factor.

$$k_1 = \frac{R \cdot NA}{\lambda} = \frac{45 \times 0.3}{13.5} = 1.0$$

This should provide better pattern fidelity compared to optical lithography.

In this study, we evaluated the fidelity of the resist patterns printed with the latest version of the hina set small-field EUV exposure tool (HiNA).



EUVL mask fabrication process



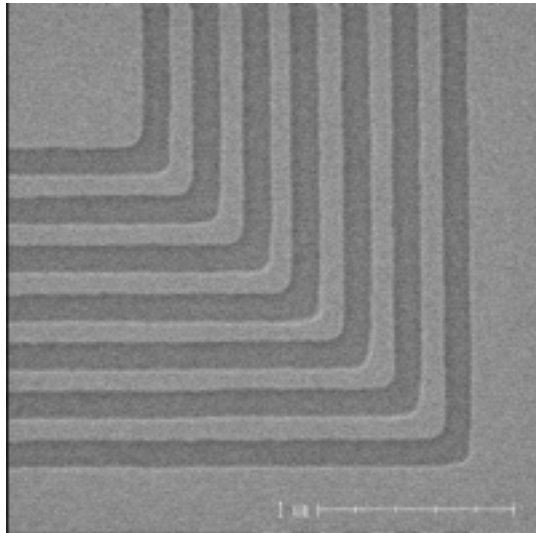
EUVL masks were fabricated using the mask blanks developed by ASET and the existing process tools for photomasks in DNP.

An EUVL mask for HiNA

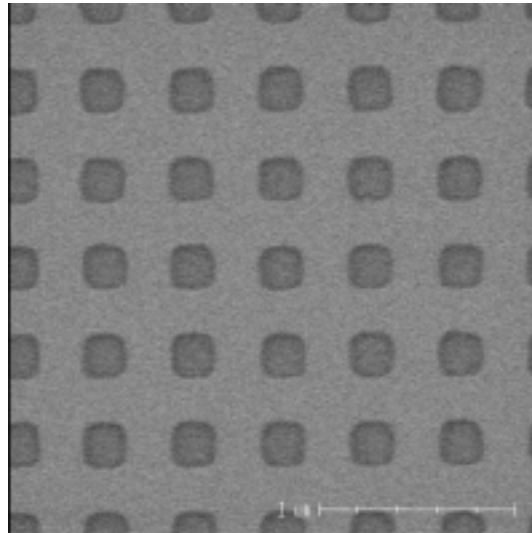


6 inch (6025)

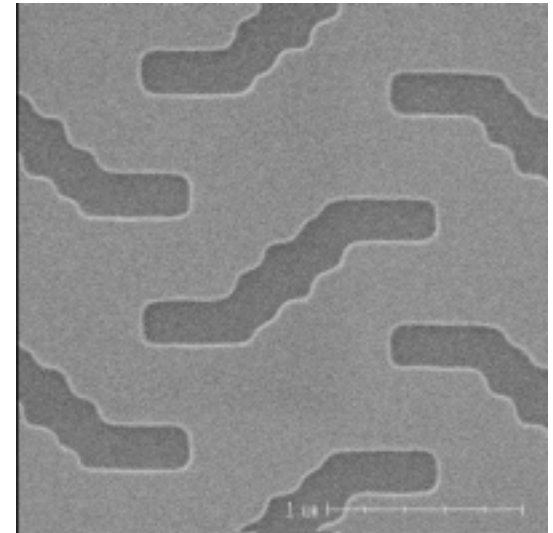
Fine patterns in the EUVL mask



(1) 125-nm L/S
(for 25-nm node)



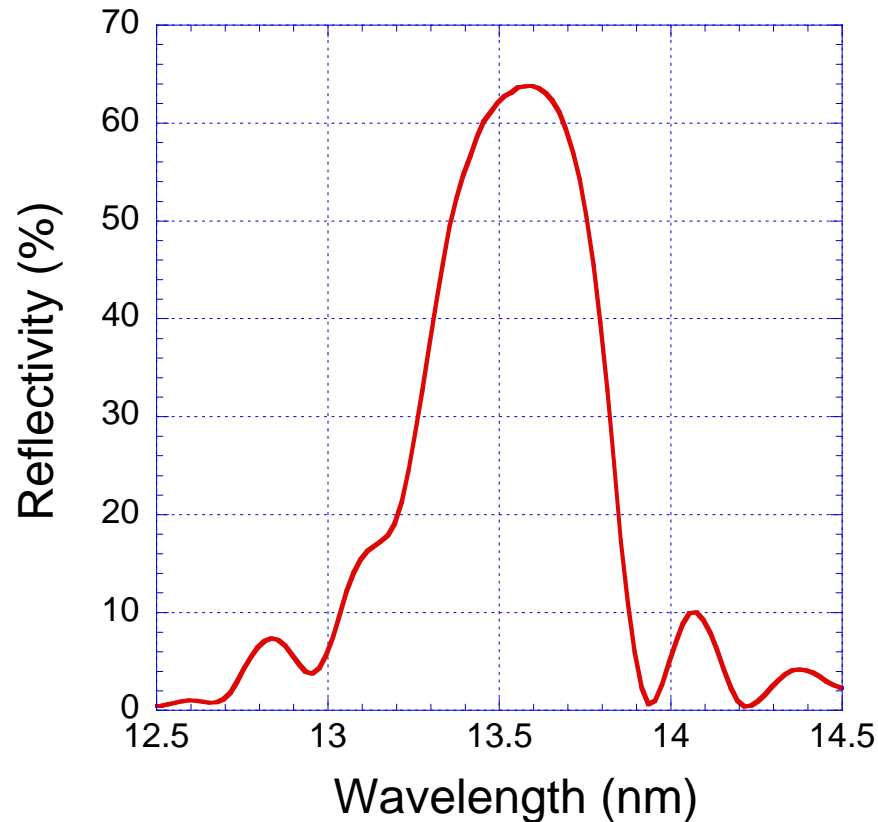
(2) 225-nm hole
(for 45-nm node)



(3) 225-nm S shape
(for 45-nm node)

Magnification of the HiNA is 1/5.

EUV reflectivity of a finished EUVL mask

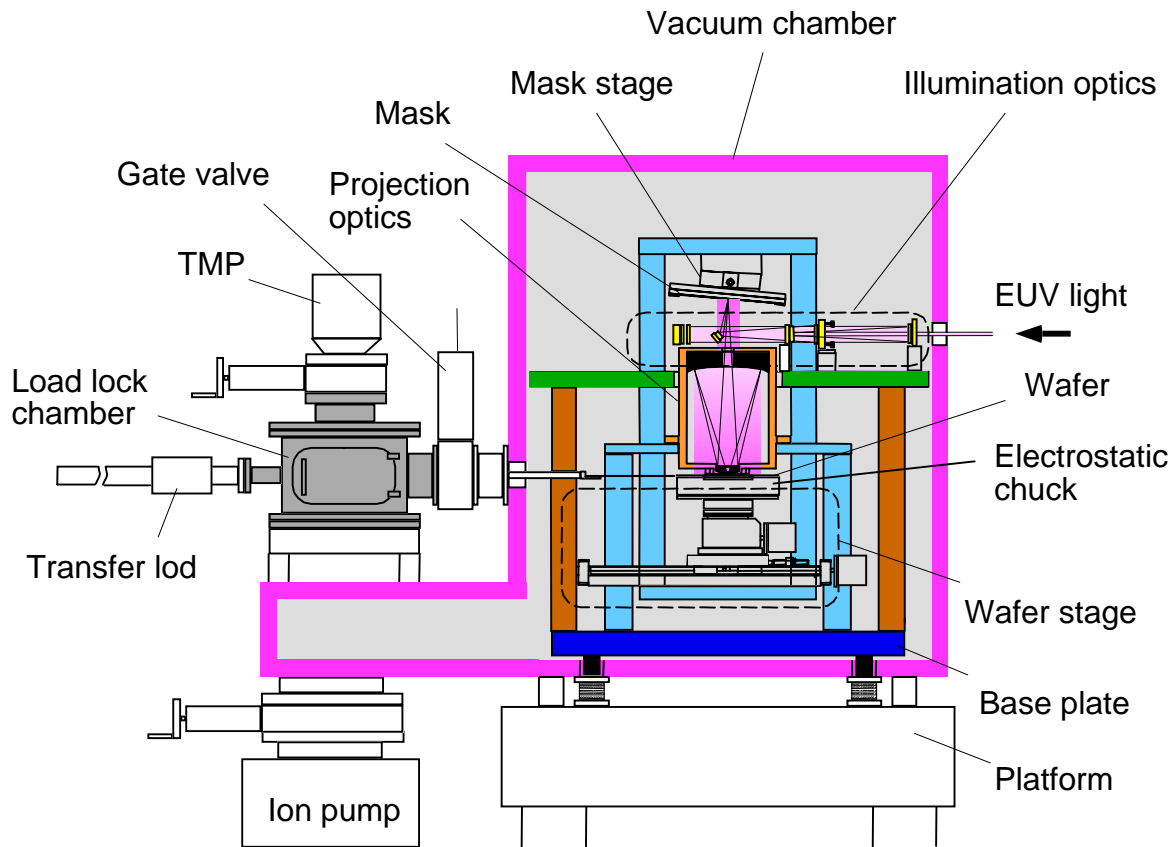


Peak reflectivity: 63.8%

Centroid wavelength: 13.54 nm



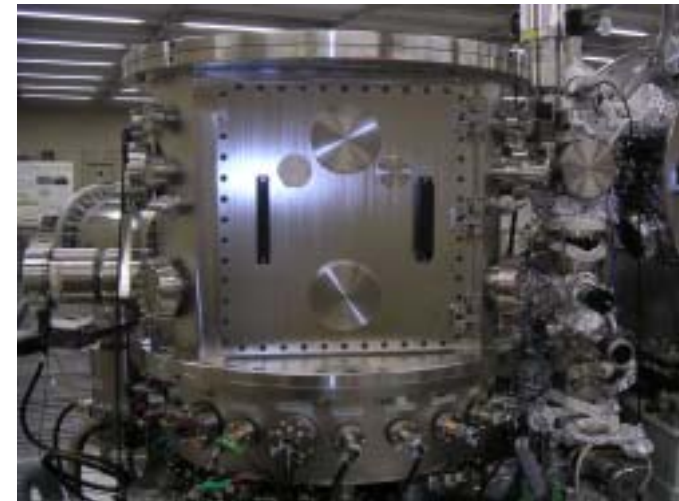
EUV exposure tool HiNA



- Magnification: 1/5
- NA: 0.3
- σ : 0 or 0.8 (selectable)
- Field size: 300 × 500 μm
- Light source: SR

<Set-3 projection optics>

- WFE: 0.9 nm
- Flare: 13%



HiNA was developed by Nikon Corporation.



Experimental condition

< Exposure >

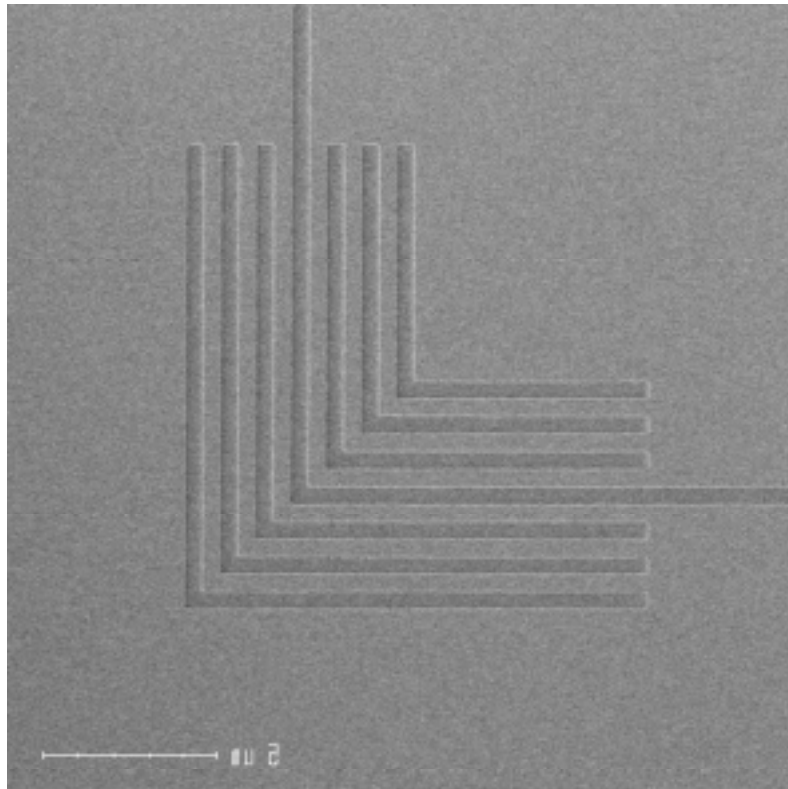
- σ : 0.8
- Dose: Roughly optimized
- Focus: Roughly optimized

< Resist Process >

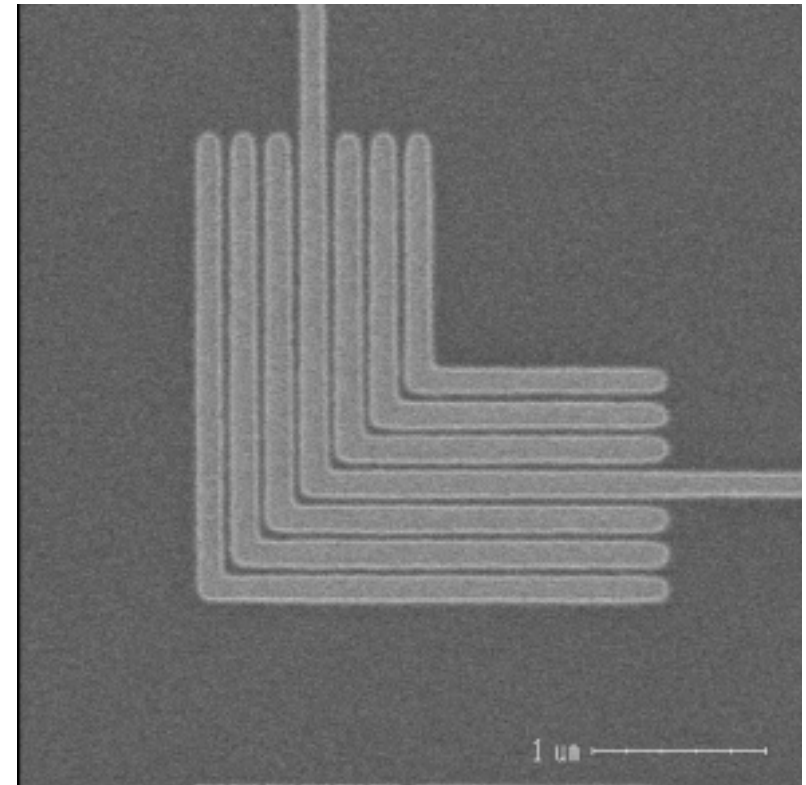
- Resist: ZEP520A (100 nm^t)
- Prebake: 180 120sec
- Development: n-amyl acetate 30sec
- Rinse: MIBK 7sec



100-nm L/S patterns



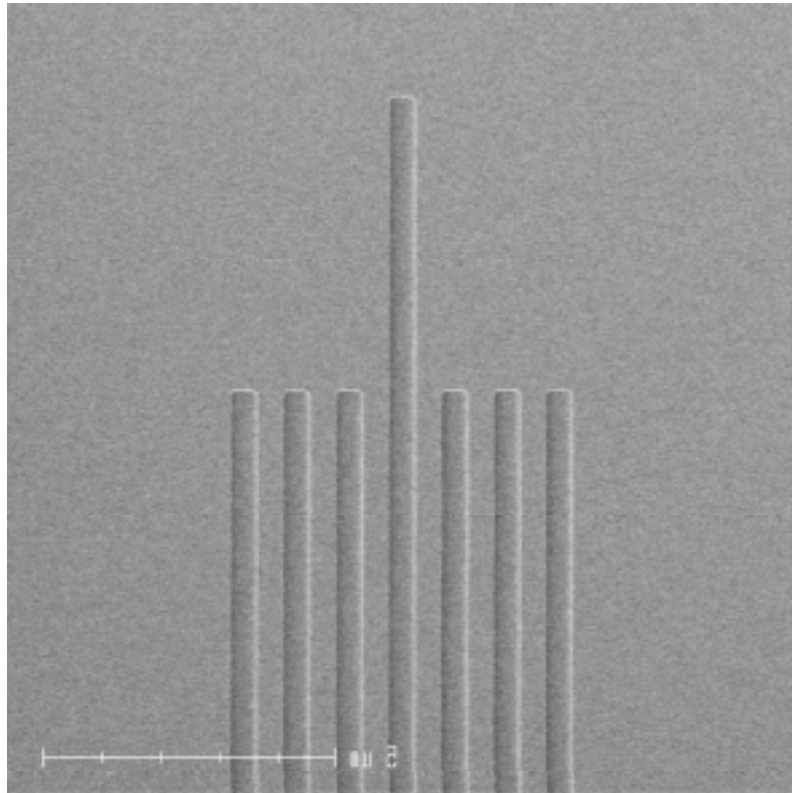
(1) Mask pattern



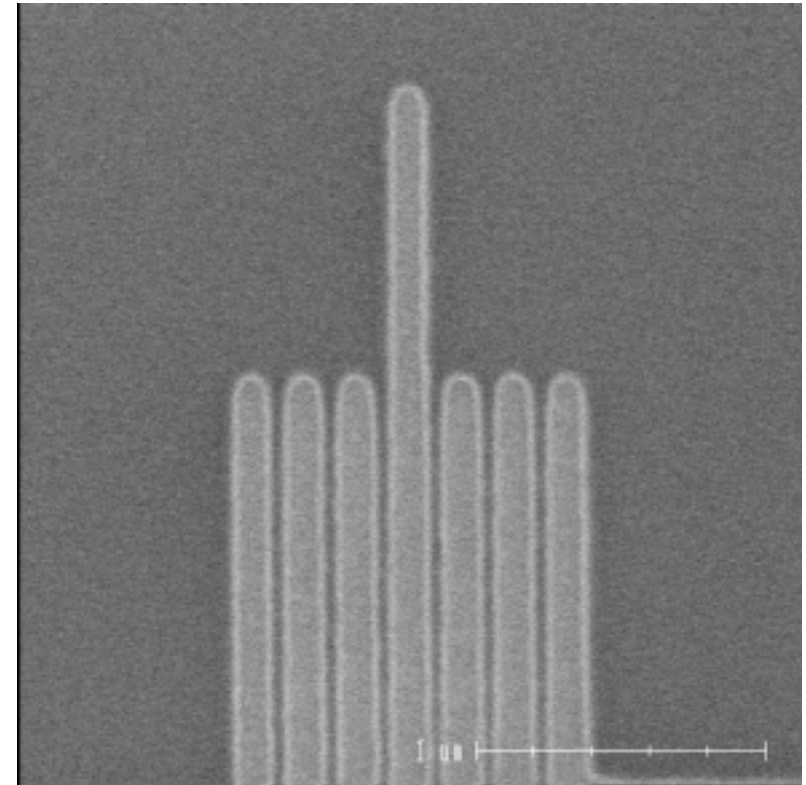
(2) Wafer pattern

Dose & focus conditions were not precisely optimized.

90-nm L/S patterns



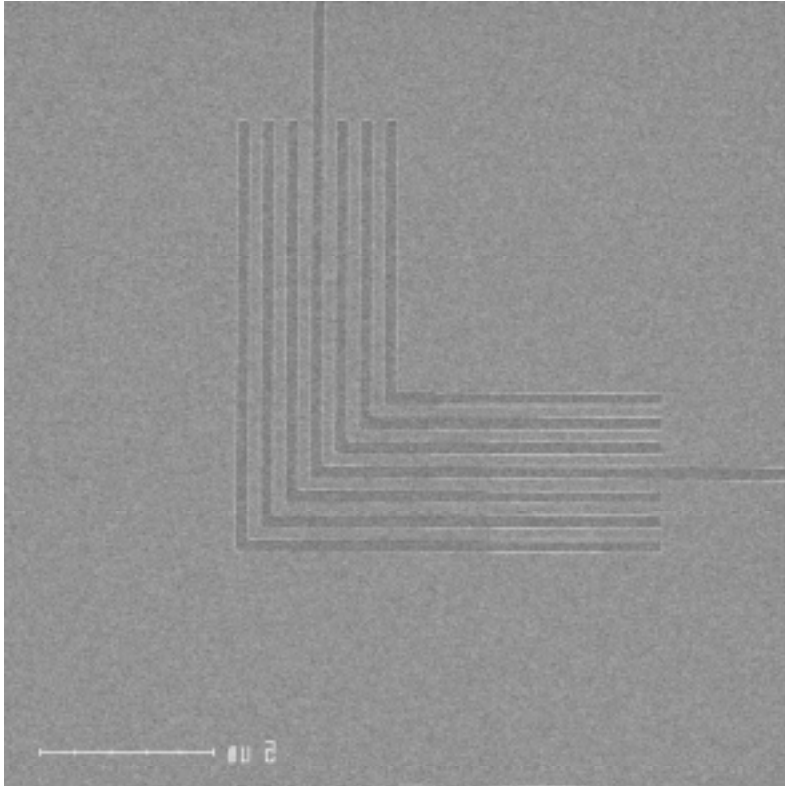
(1) Mask pattern



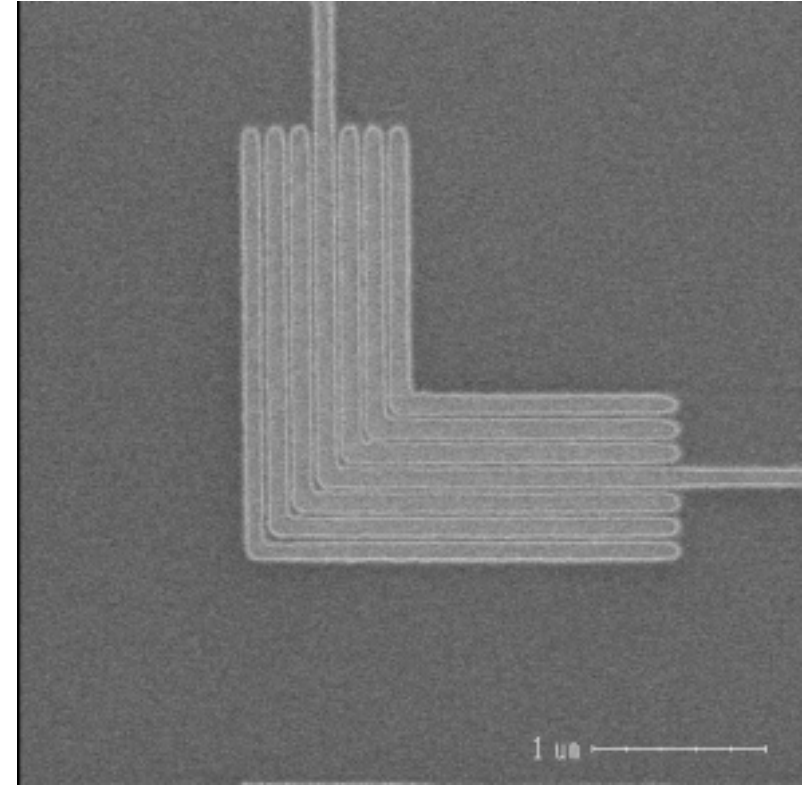
(2) Wafer pattern

Dose & focus conditions were not precisely optimized.

70-nm L/S patterns



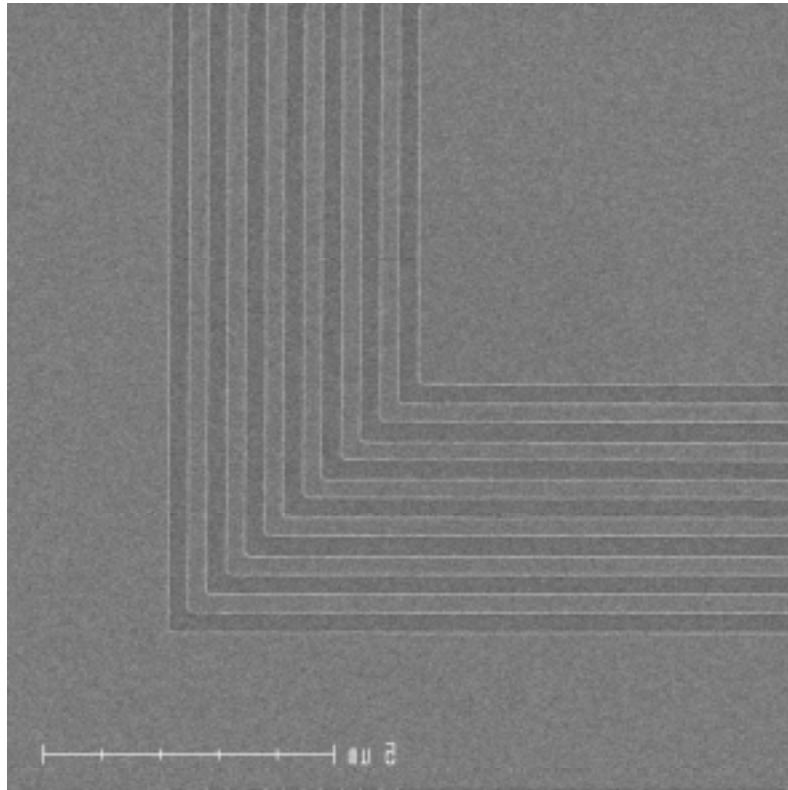
(1) Mask pattern



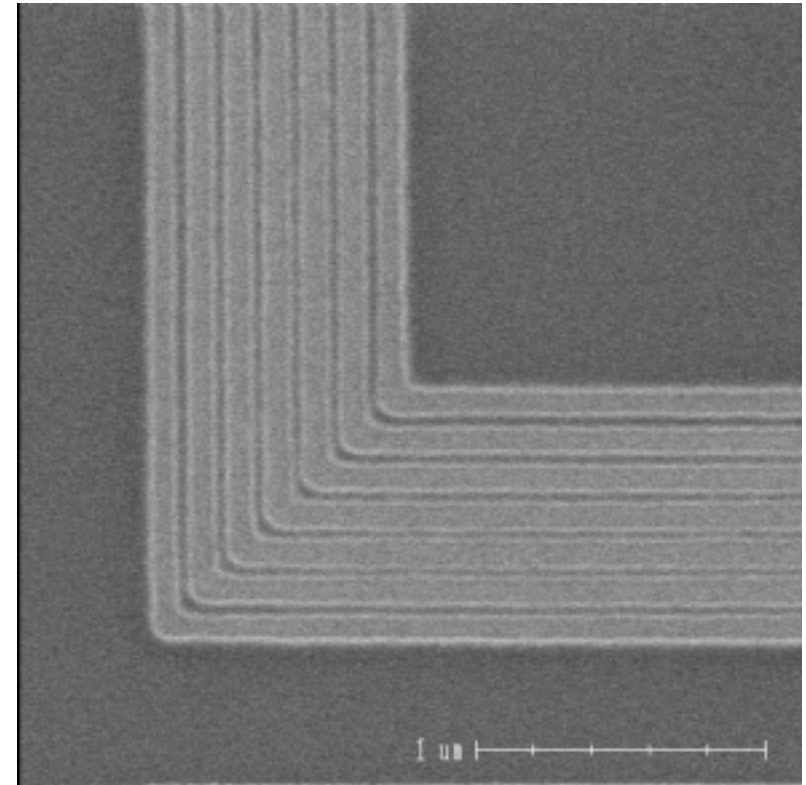
(2) Wafer pattern

Dose & focus conditions were not precisely optimized.

65-nm L/S patterns



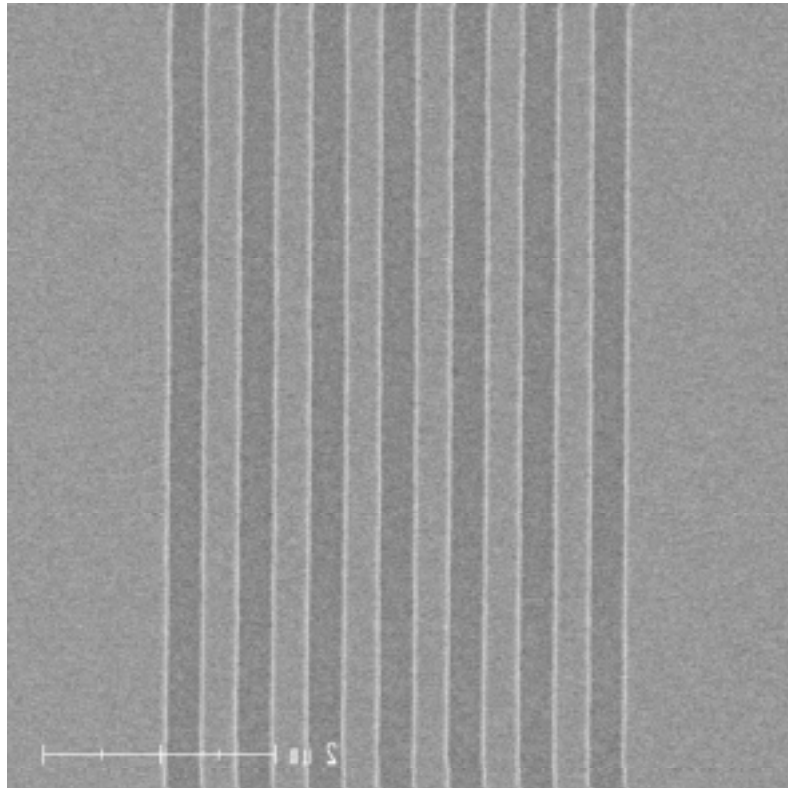
(1) Mask pattern



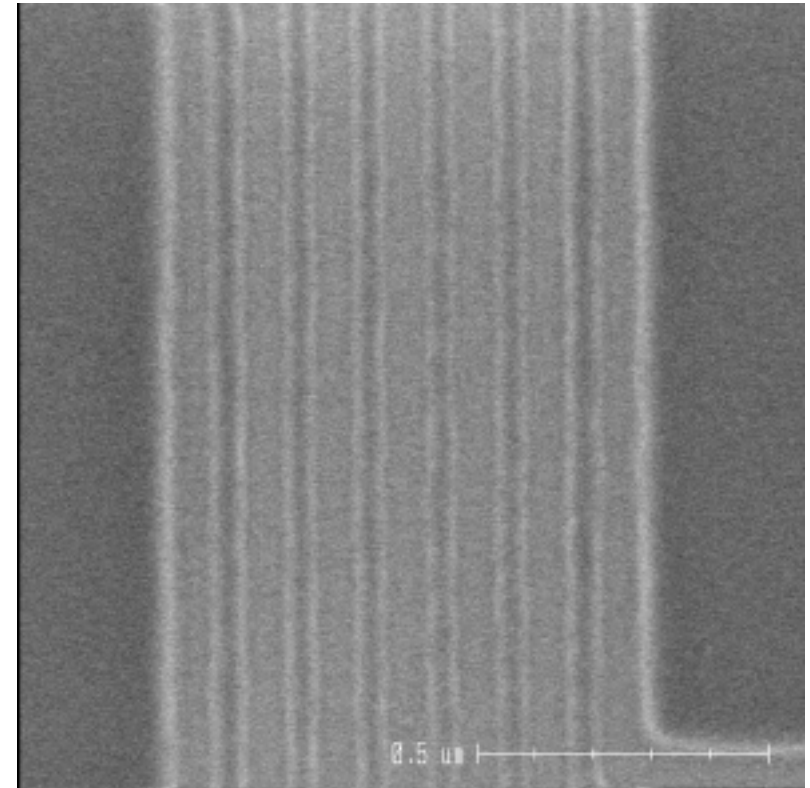
(2) Wafer pattern

Dose & focus conditions were not precisely optimized.

60-nm L/S patterns



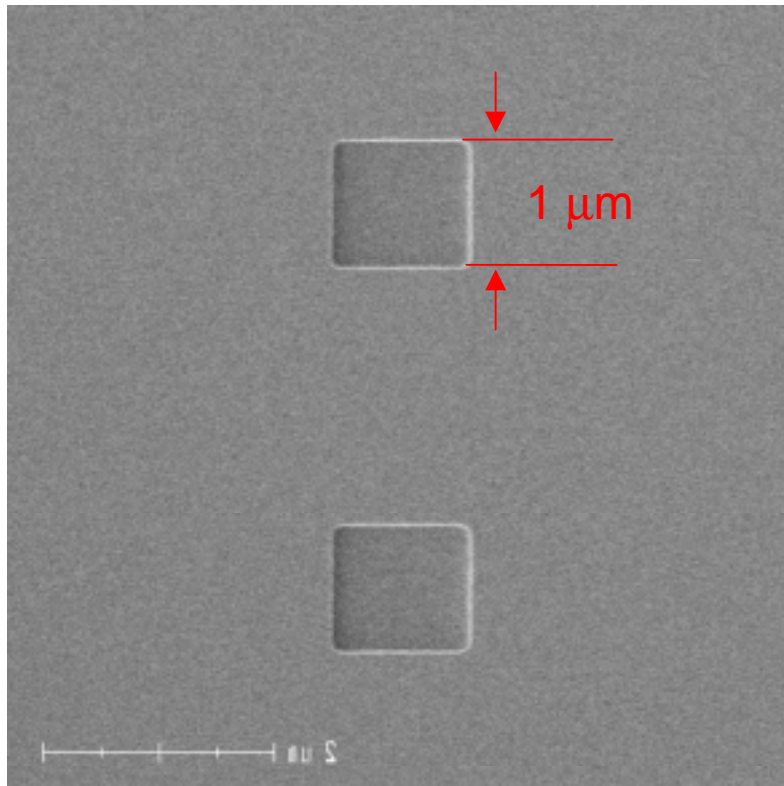
(1) Mask pattern



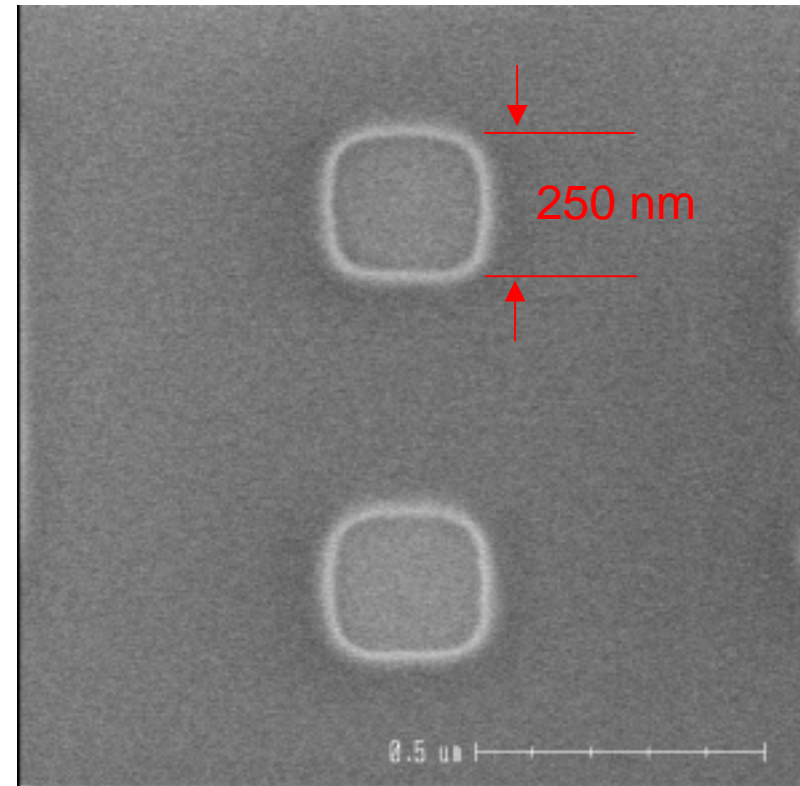
(2) Wafer pattern

Dose & focus conditions were not precisely optimized.

250-nm hole patterns



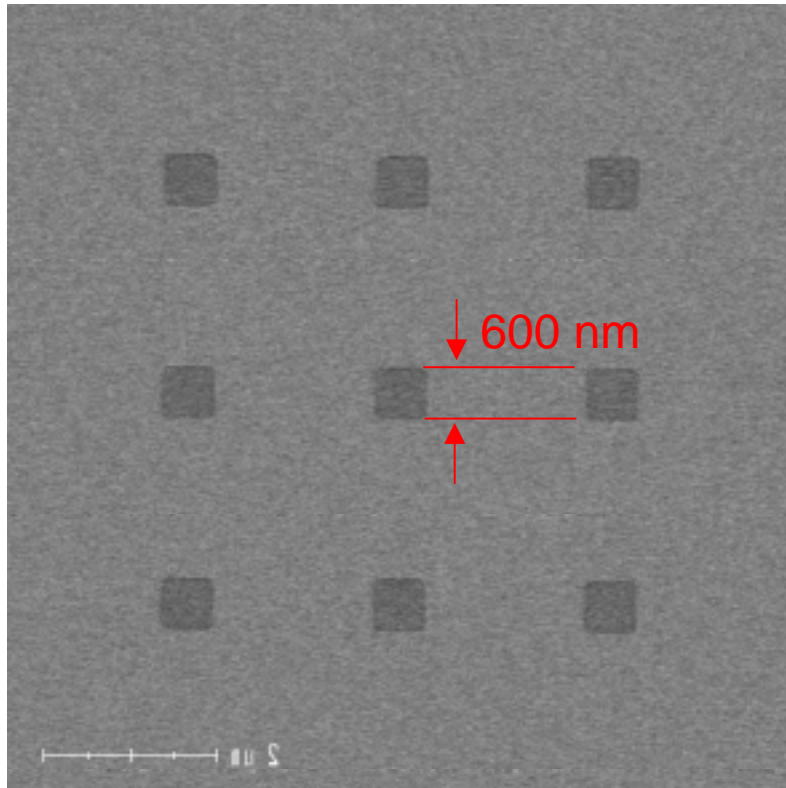
(1) Mask pattern



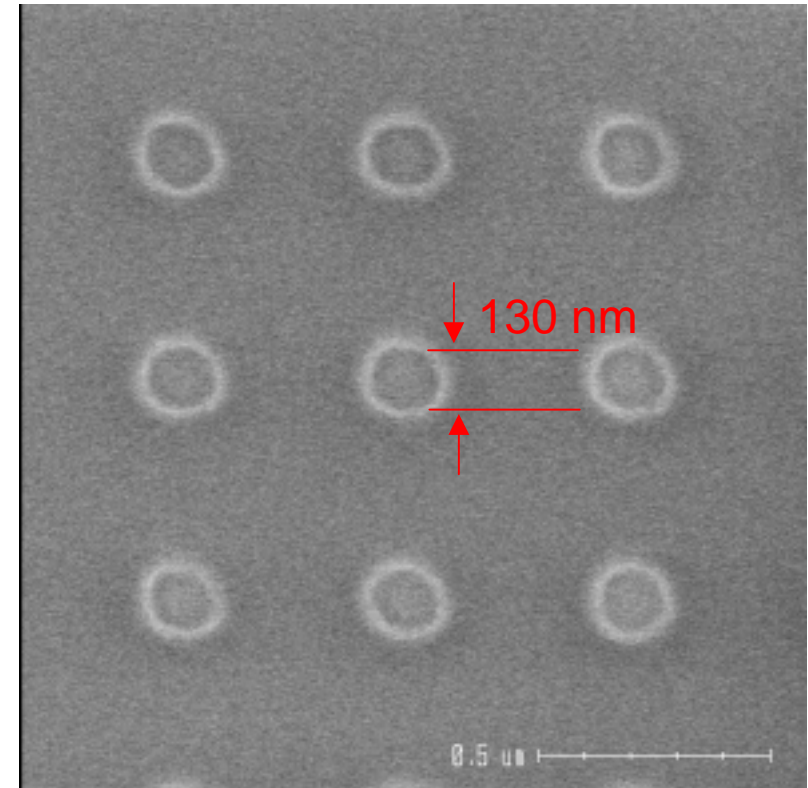
(2) Wafer pattern

Dose & focus conditions were not precisely optimized.

130-nm hole patterns



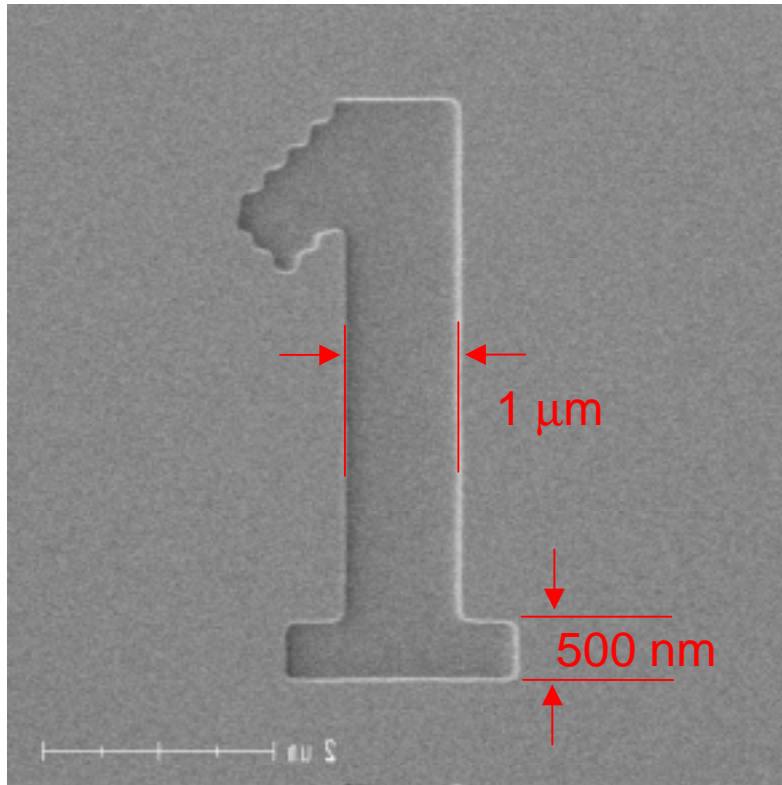
(1) Mask pattern



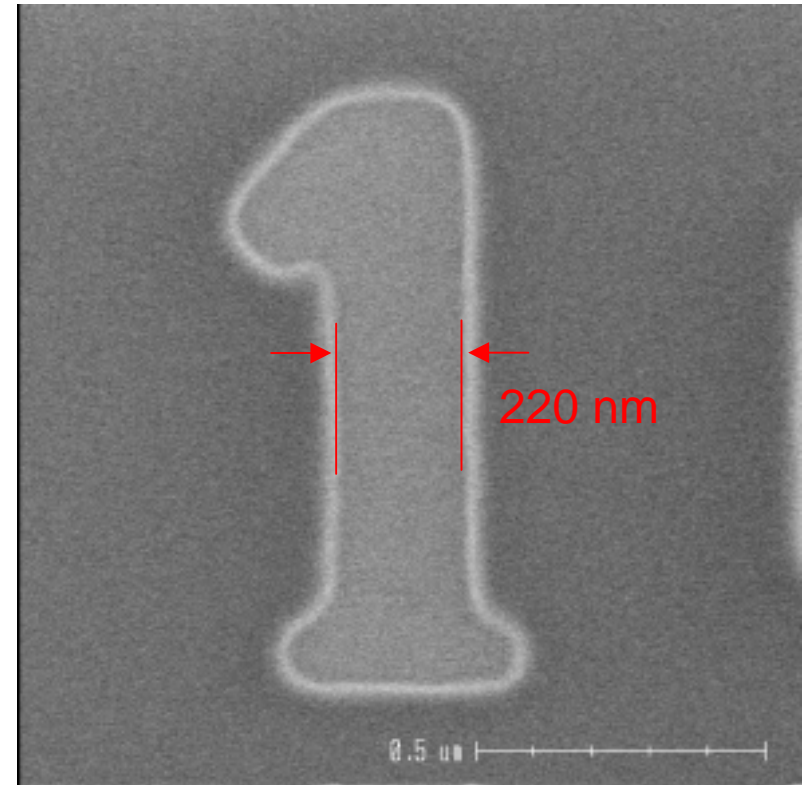
(2) Wafer pattern

Dose & focus conditions were not precisely optimized.

Character pattern



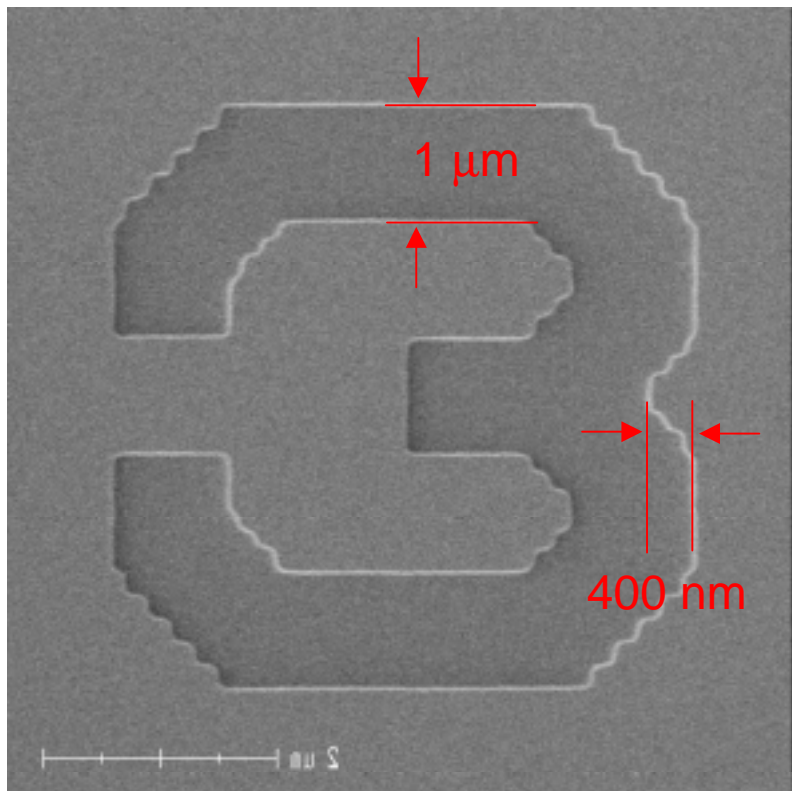
(1) Mask pattern



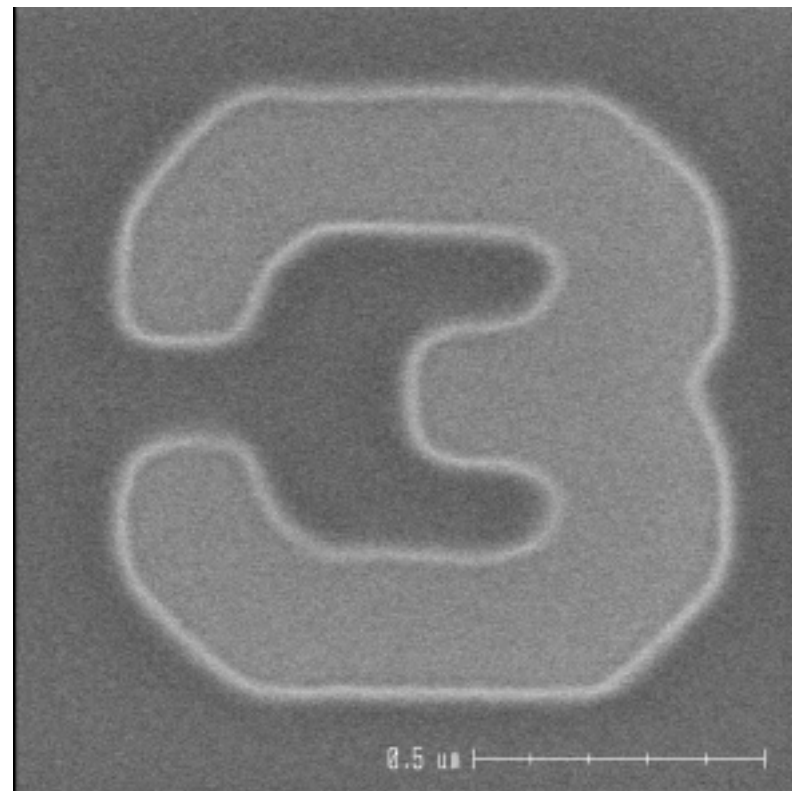
(2) Wafer pattern

Dose & focus conditions were not precisely optimized.

Character pattern



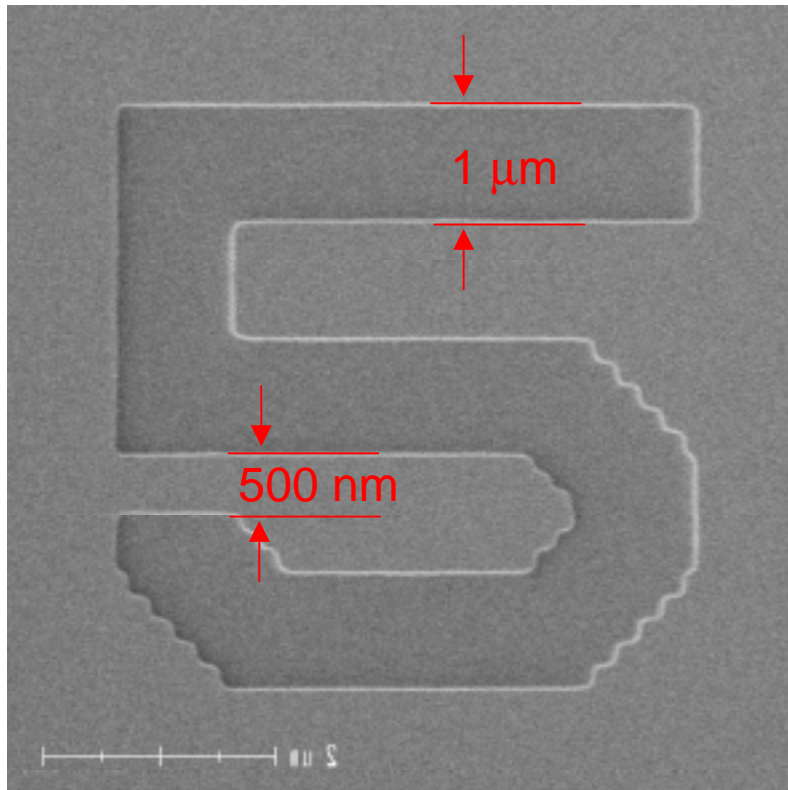
(1) Mask pattern



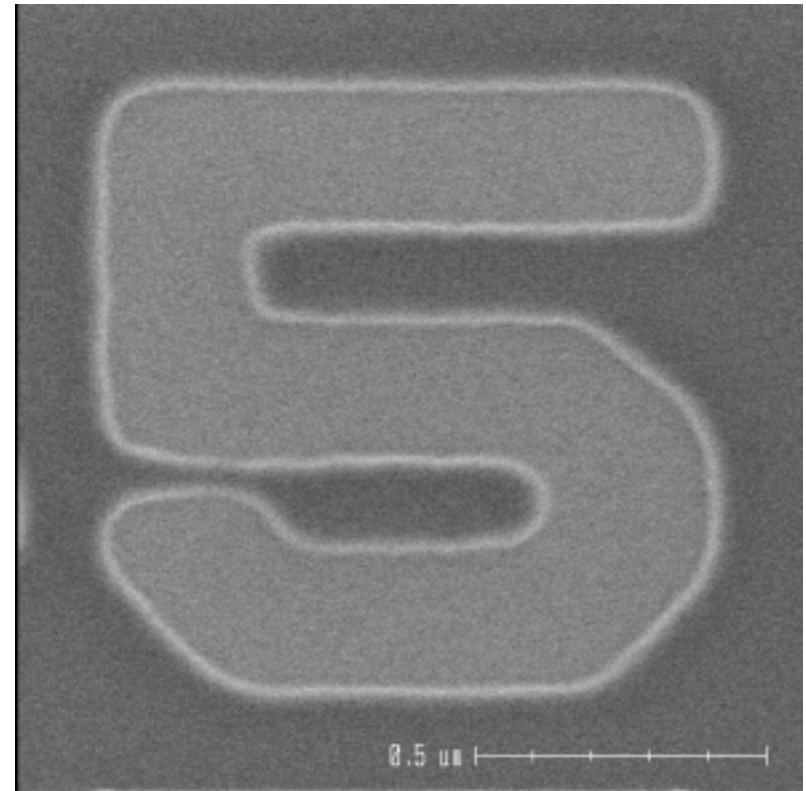
(2) Wafer pattern

Dose & focus conditions were not precisely optimized.

Character pattern



(1) Mask pattern



(2) Wafer pattern

Dose & focus conditions were not precisely optimized.

Conclusions

- Although dose and focus conditions were not precisely optimized, the EUV exposure tool HiNA with set-3 projection optics showed high resolution and good pattern fidelity.
- There were no serious problems in the EUVL masks with TaGeN(90 nm)/Cr(10nm)/ML structure for EUV exposure experiments.
- In EUVL, the required optical proximity correction (OPC) seems to be much easier than optical lithography.



Acknowledgements

HiNA set-3 projection optics were developed and provided by Nikon Corporation.

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