EUV Interference Lithography for 1X nm

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Outline

- Introduction
- Fabrication of the transmission diffraction grating
- Improvement of the EUV-IL exposure tool
- Resist patterning results

  hp 15 nm L/S and 28 nm hole patterns
- Conclusions

ITRS 2010 Update

Year of Production	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
DRAM 1/2 Pitch (nm) (contacted)	25	23	20	18	16	14	13	11	10	9
Flash 1/2 Pitch (nm) (un-contacted-poly)	17.9	15.9	14.2	12.6	11.3	10	8.9	8	7.1	6.3
MPU/ASIC Metal 1(M1) 1/2 Pitch (nm) (contacted)	21	19	17	15	13	12	11	9	8	8
MPU/physical gate length (nm) [after etch]	17	15	14	13	12	11	10	9	8	7
MPU gate in resist length (nm)	22	20	18	16	14	12	11	10	9	8
resist thickness (nm, single layer)	40-75	35-65	30-60	25-50	25-45	20-40	20-40	15-35	10-25	10-25
Low frequency LWR: (nm, 3σ) <8% of CD	1.8	1.6	1.4	1.3	1.1	1	0.9	0.8	0.7	0.6

The International Technology Roadmap for Semiconductors, 2010 Update

EUV interference lithography for the evaluation of 1X nm

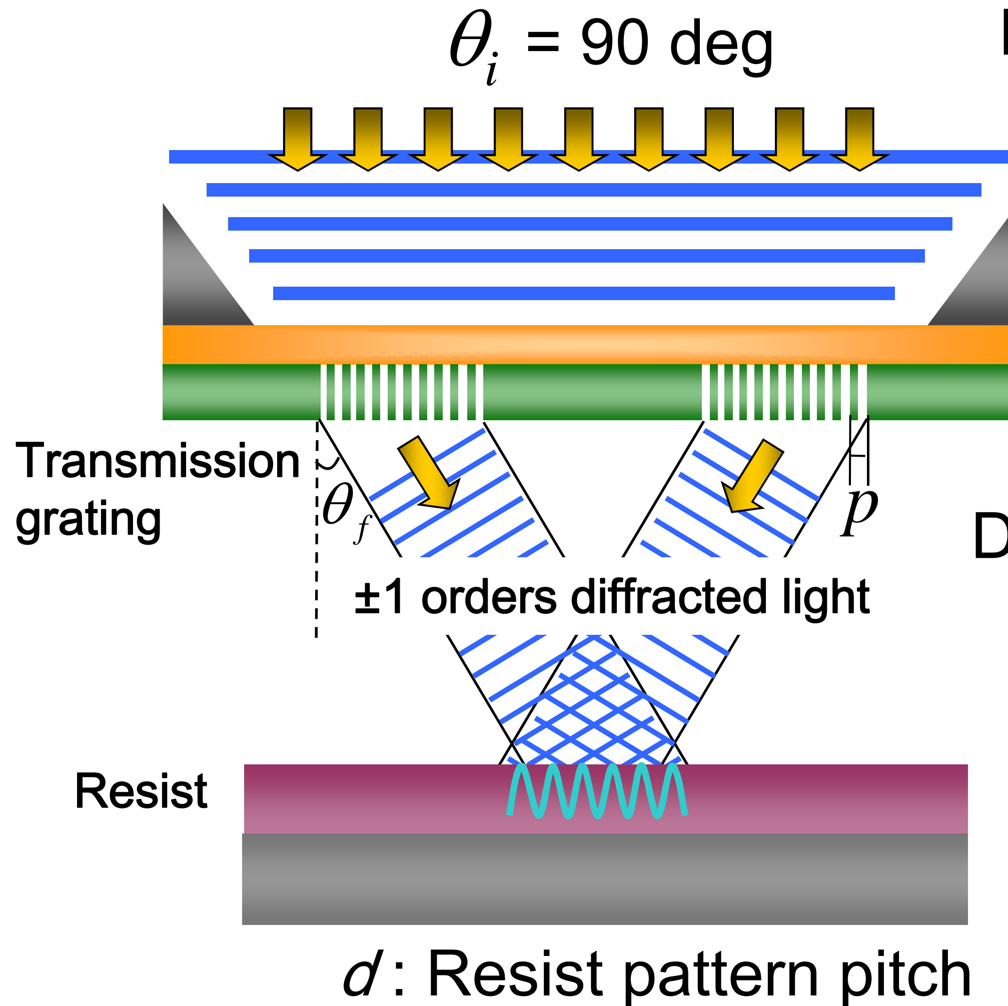
EUV-IL

Two luminous and four luminous EUV interference lithography exposure tool was installed at BL9 long undulator beamline.

The exposure characteristics of the resist itself can be obtained without mask error and optics aberration.

Transmission grating pattern pitch of 40 nm which corresponds to the resist pattern of 10 nm L/S is now fabricating.

Principle of the EUV-IL



d : Resist pattern pitch

Replicating resist pattern pitch

$$d = \lambda / (2 \sin \theta_f)$$

λ : Wavelength

d : Resist pattern pitch

θ_f : Diffraction angle

Diffraction angle θ_f (θ_i = 90 deg)

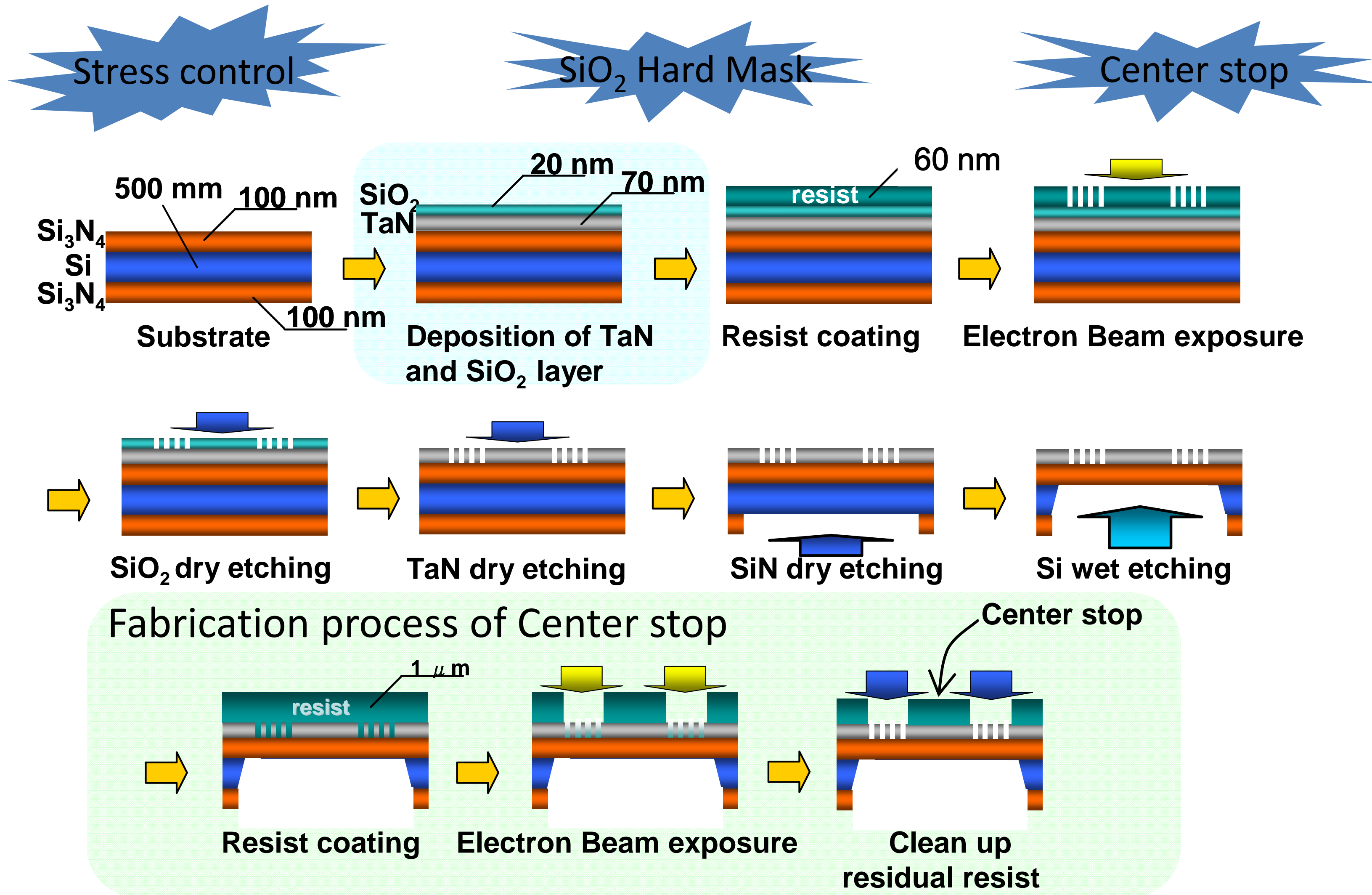
$$\sin \theta_f = \frac{n\lambda}{p}$$

p : Grating pattern pitch

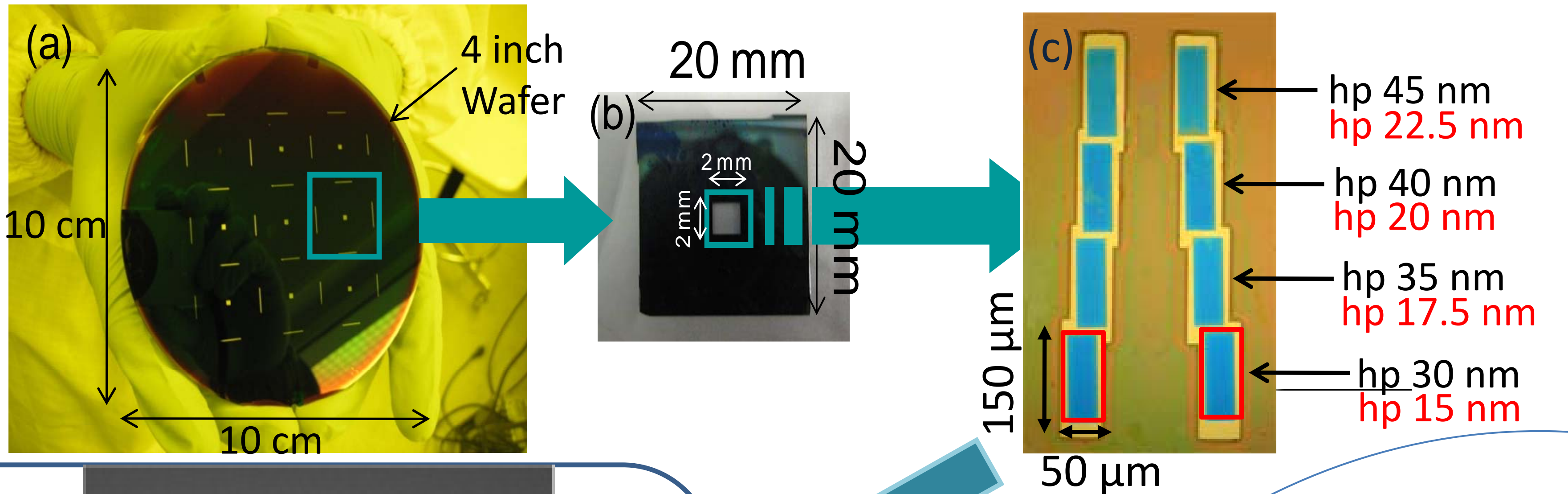
$$d = p / 2n$$

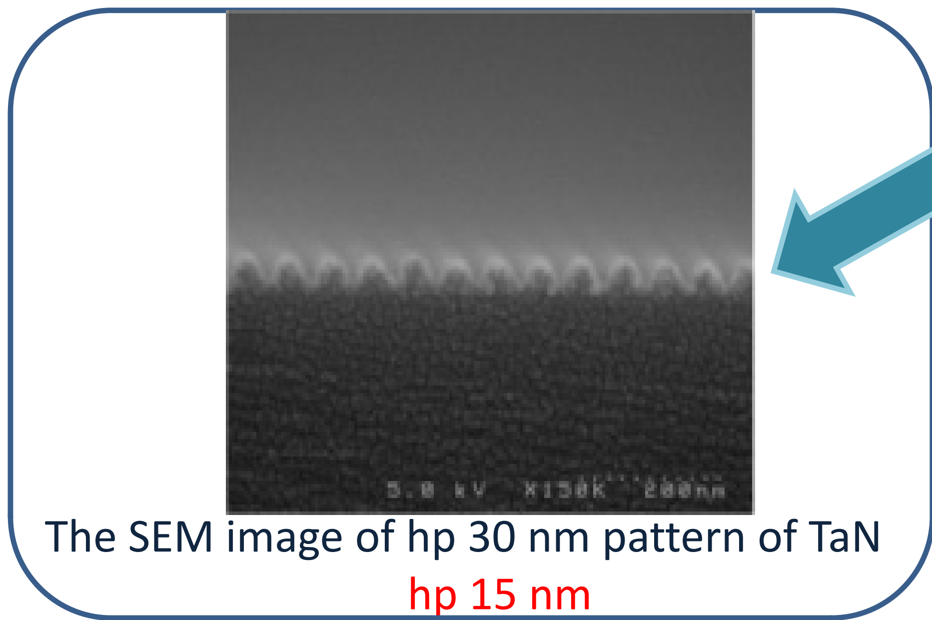
If n=1, the replicating resist pattern pitch is a half size of the grating pitch, not depending on the wavelentgh λ.

Fabrication Process of EUV-IL Transmission Grating

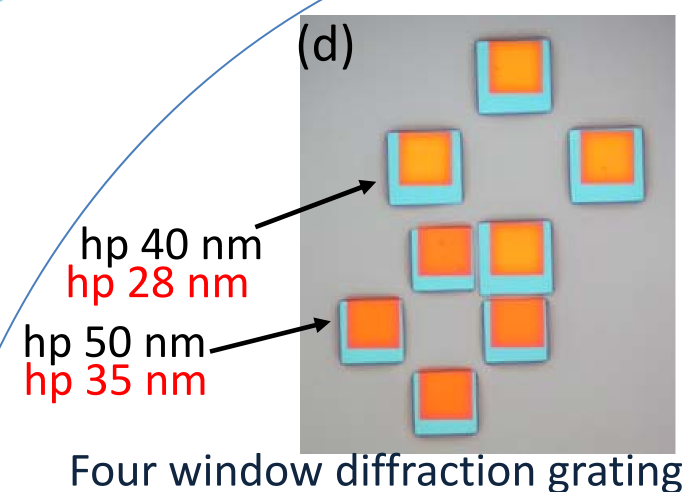


Two window transmission diffraction grating



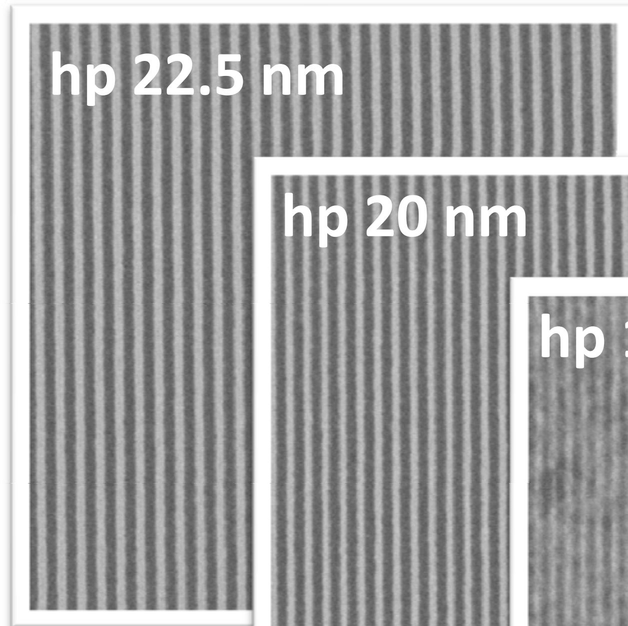


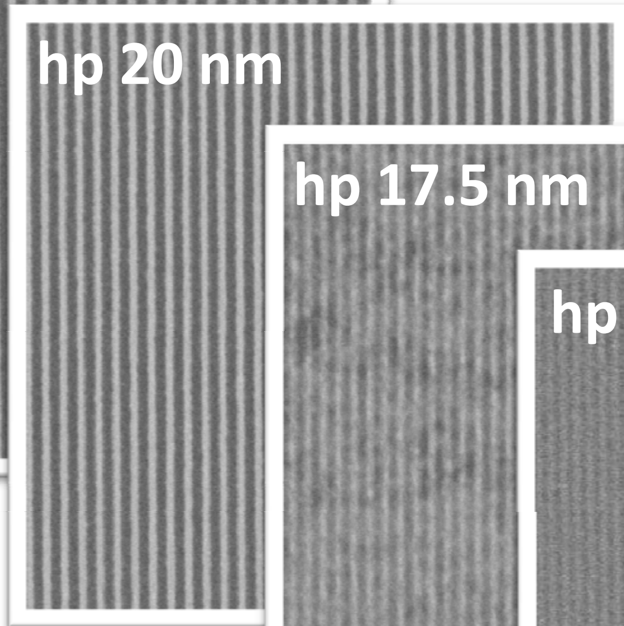
The SEM image of hp 30 nm pattern of TaN
hp 15 nm

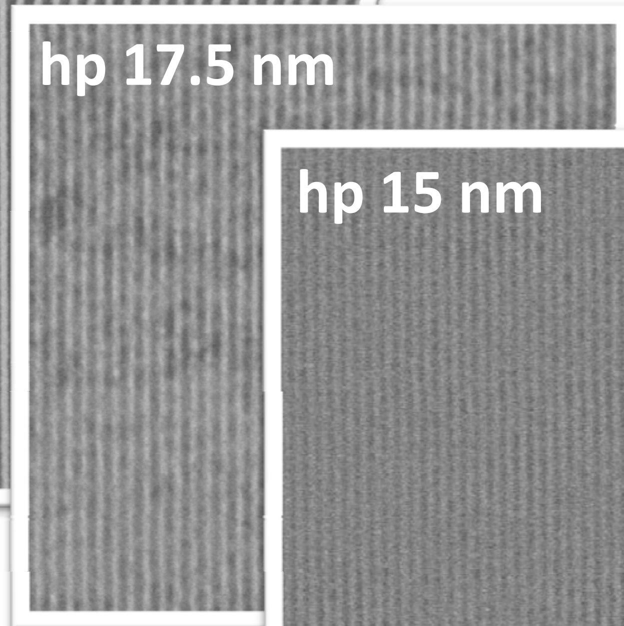


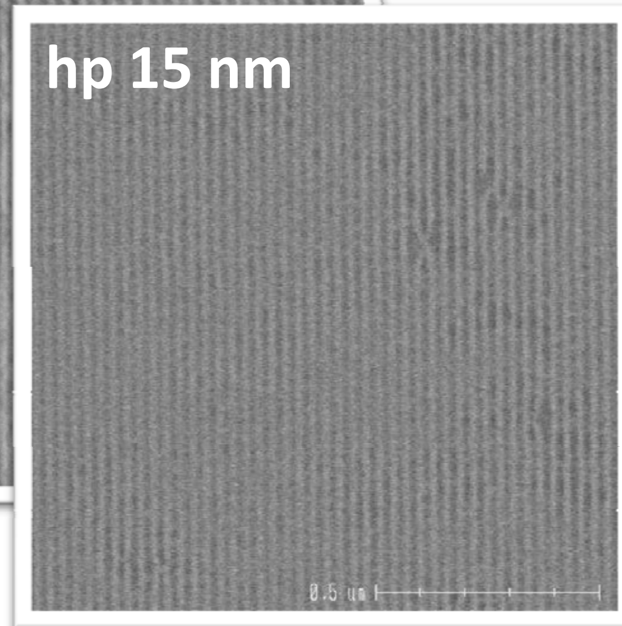
Four window diffraction grating

hp 22.5-15 nm patterning with negative-tone Inpria resist



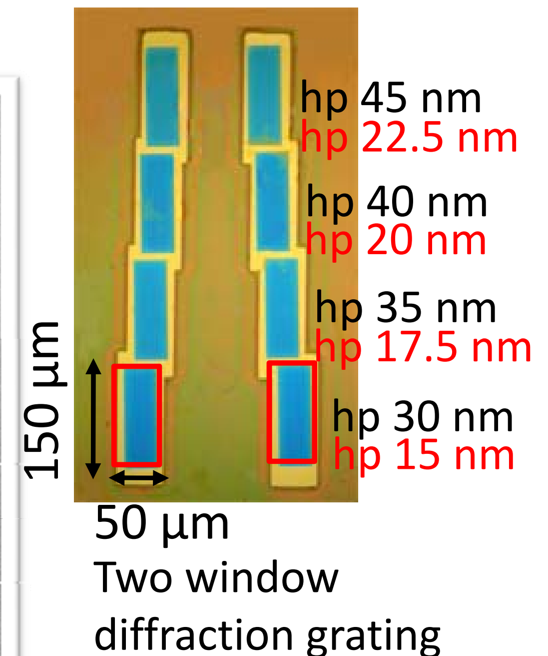






Negative-tone Inpria resist

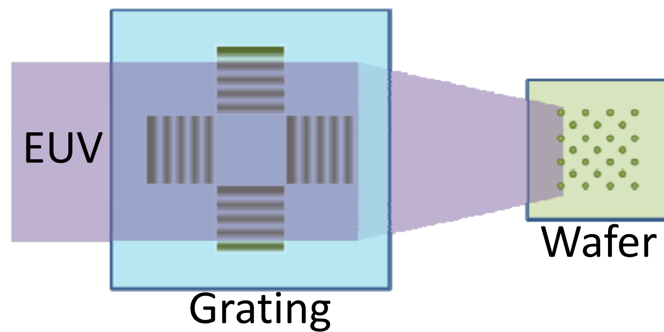
hp 15 nm L/S pattern was replicated.

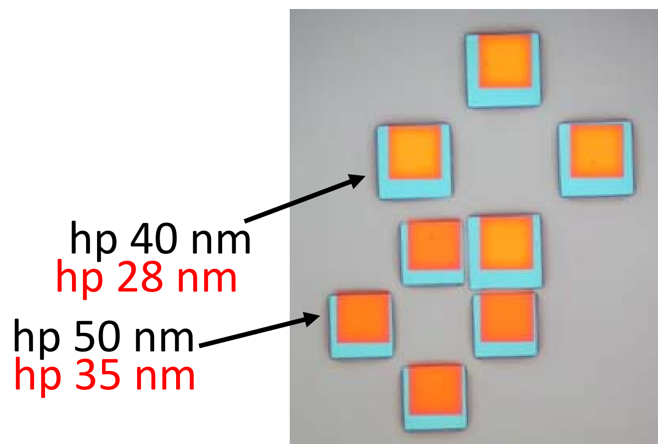


Two window diffraction grating

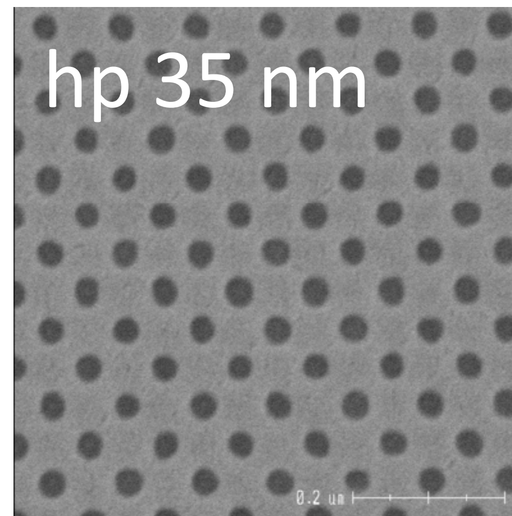
In the near future, we will realize evaluation of EUV resist for 11 nm.

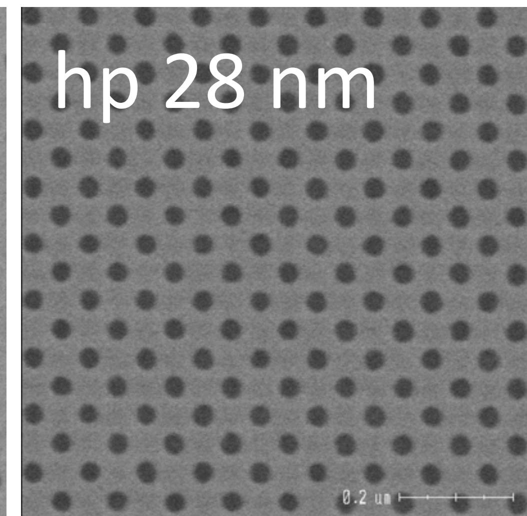
Four-luminous-flux interference exposure using the four window diffraction grating





Four window diffraction grating





hp 35, 28 nm hole patterns with high contrast was replicated.

Conclusions

1) The transmission grating with 30 nm L/S was succeeded with fabrication.
2) hp 15 nm L/S pattern and hp 28 nm hole pattern was replicated.
3) The EUV-IL is to open use for evaluation of resist for 1X nm in EUVL to accelerate resist development.

Near future plan

- In the near future, for hp 11 nm resist patterning, fabrication of the transmission gratings would be improved, and we will realize evaluation of EUV resist for 11 nm.

- We will evaluate various type of EUV resists.

Acknowledgments

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