Lithographic Performance of High-Numerical-Aperture (NA=0.3) Small-Field Exposure Tool (HINA) for EUV Lithography

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Progress of ASET Exposure tools

2000/2：Principle proof

Micro-field exposure tool (20x Schwarzschild optics)

Resolution:50nm L/S @coherent illumination ($\sigma \approx 0$)

To accelerate the development of masks, resist processes, and materials for EUV lithography

High-NA small-field exposure tool (NA=0.3)

2001/3 HINA1: $\lambda/2$ →Improvement of WFE

2002/5 HINA2: $\lambda/7$

Flare effect

Minimum Resolution:70nm L/S (dark field mask)

2004/7 HINA3: $\lambda/15$

Exposure imaging experiment has just started.

Design of High-NA small-field exposure tool

(1) Exposure wavelength: 13.5nm.

(2) Magnification: 1/5

(3) Two-aspherical-mirror projection optics

NA：0.3

resolution: 50nm

field size: 500 x 300 μm

(4) Two illumination systems

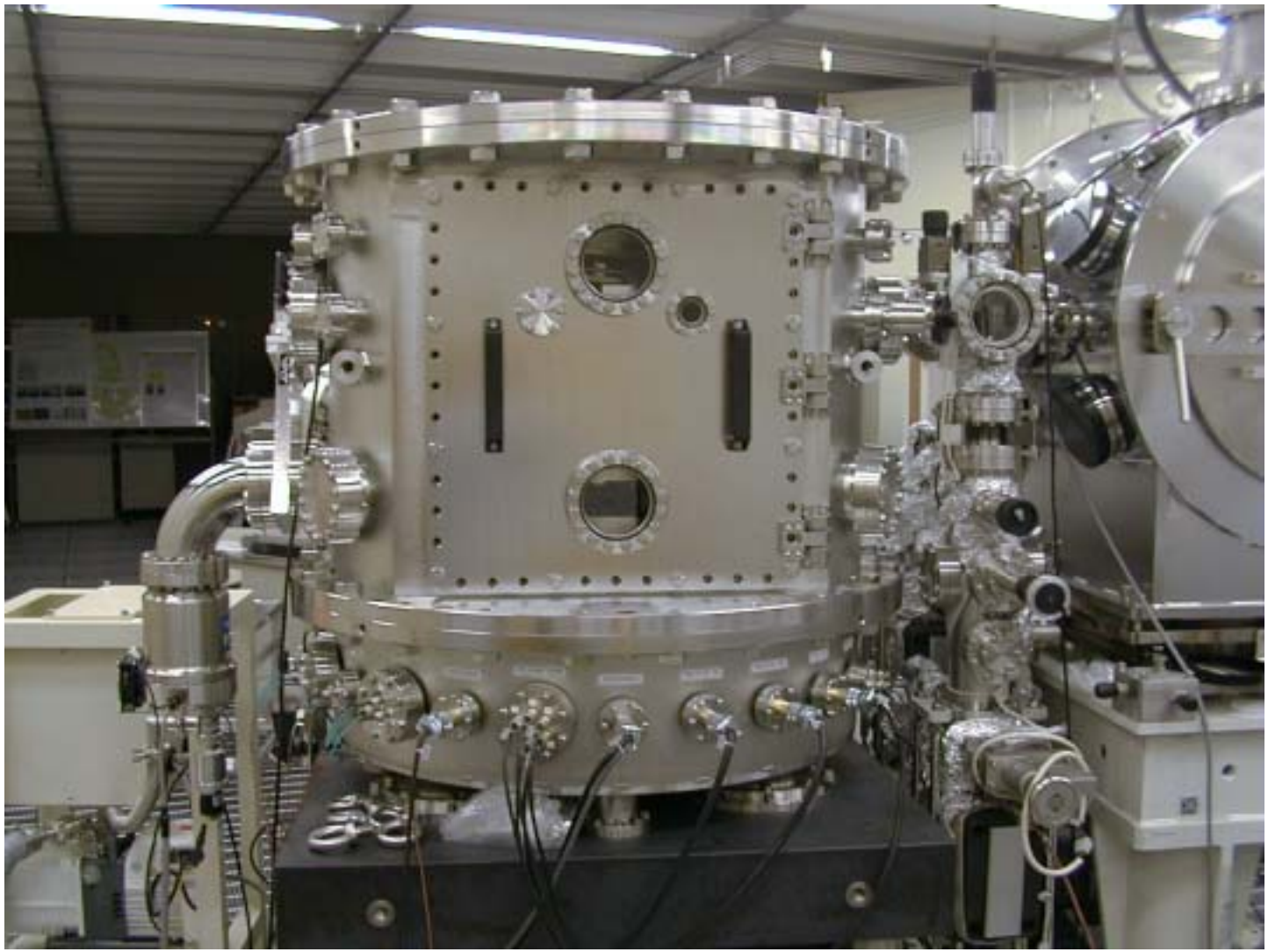
Koehler illumination with $\sigma \approx 0.8$ (Normal)

coherent illumination with $\sigma \approx 0$

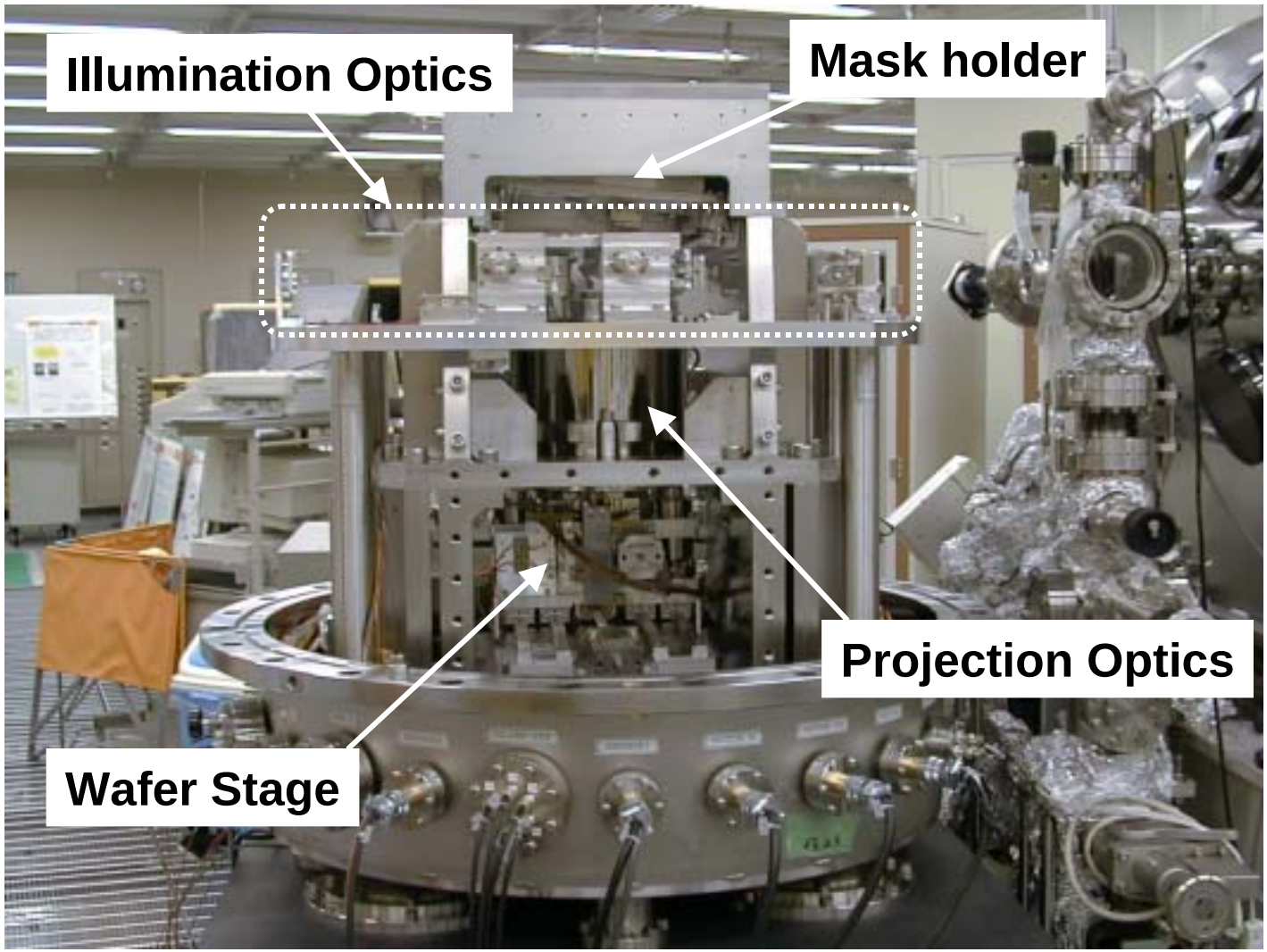
(5) Mask size: 6025 reticle or 8”ϕ.

(6) Wafer size: 8”ϕ.

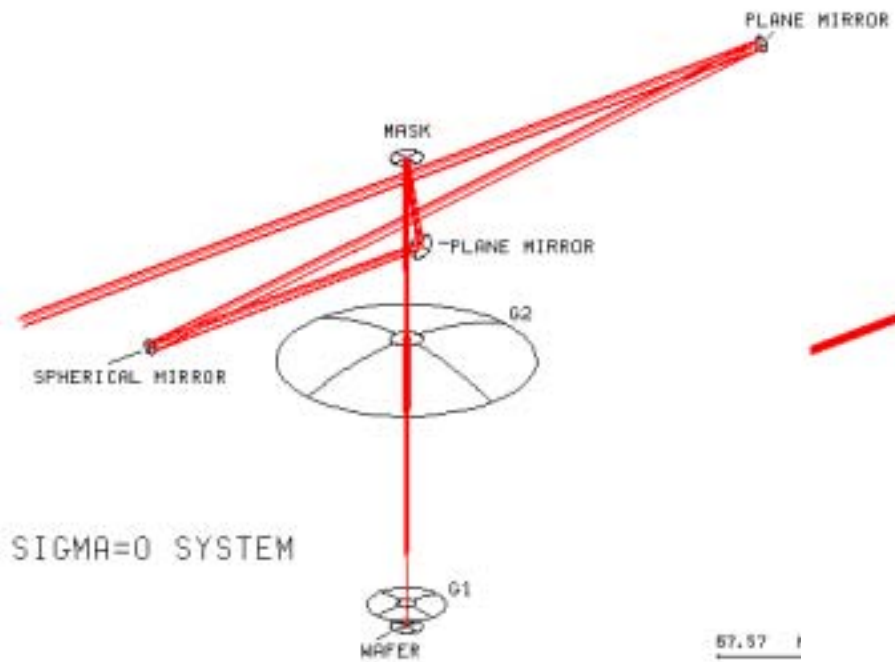
High-NA Small-Field Exposure Tool

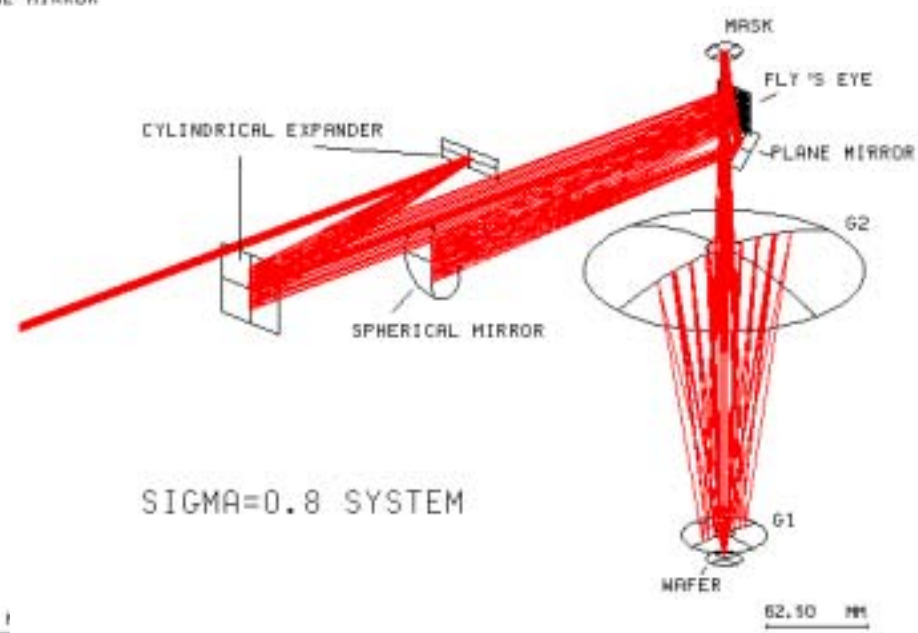


Inner structure of High-NA Small-Field Exposure Tool



Illumination optics of High-NA exposure tool (σ≈0.0, 0.8)

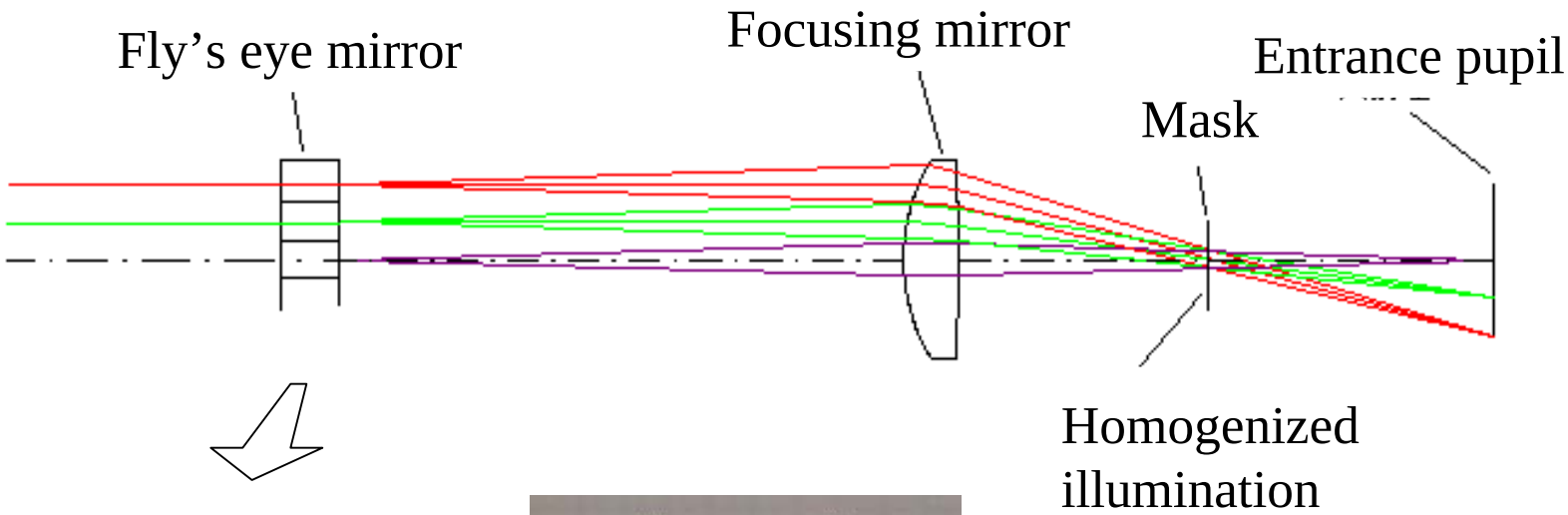


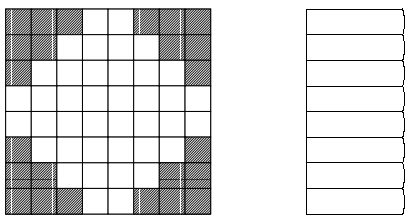


σ ≈ 0

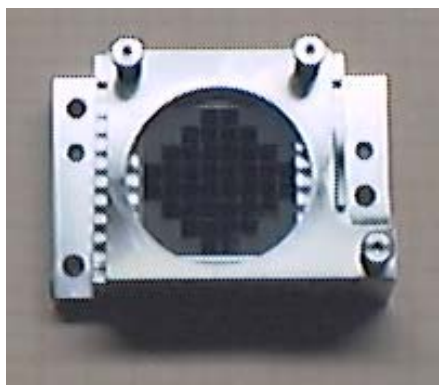
σ ≈ 0.8

Illumination optics of High-NA exposure tool (σ≈0.8)





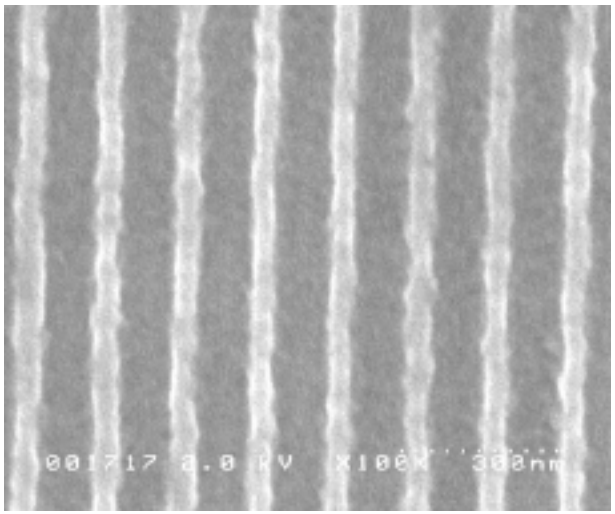
8x8 Fly's eye



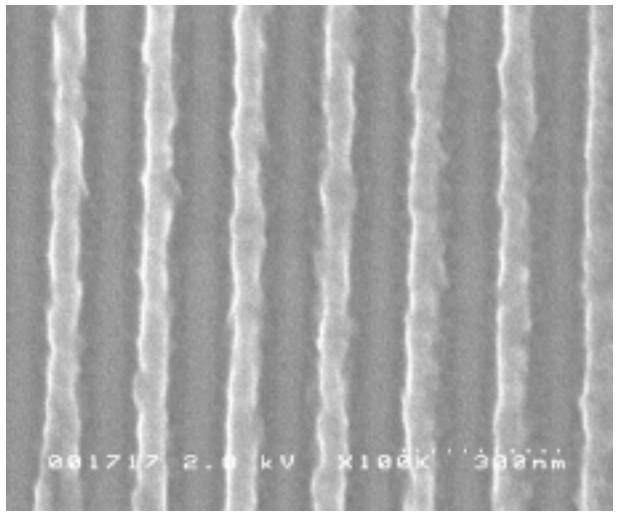
Lithographic Performance of HINA2

HINA2:Pattern delineation of bright-field mask ($\sigma \approx 0.8$)

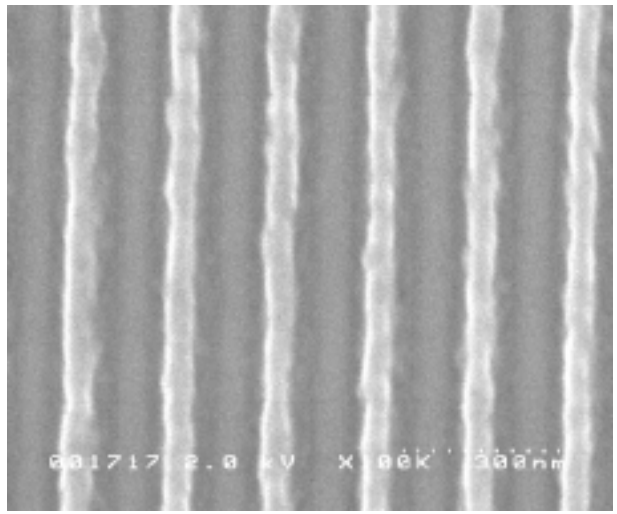
Non-chemically amplified resist: ZEP520A 105nm^t



80nm L/S
(not resolved)



90nm L/S

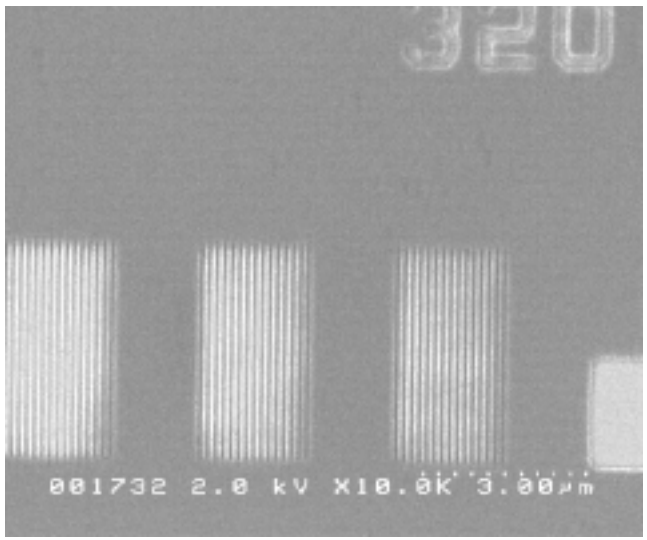


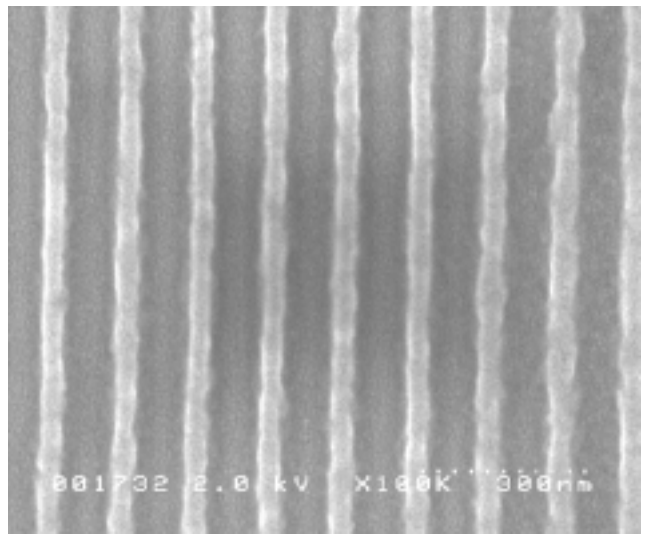
100nm L/S

HINA2: Pattern delineation of dark-field mask: ($\sigma \approx 0.8$)

70nm L/S

ZEP520A (105 nm^t)





HINA2 → HINA3

Mirror specifications and Measured wave front error of HINA

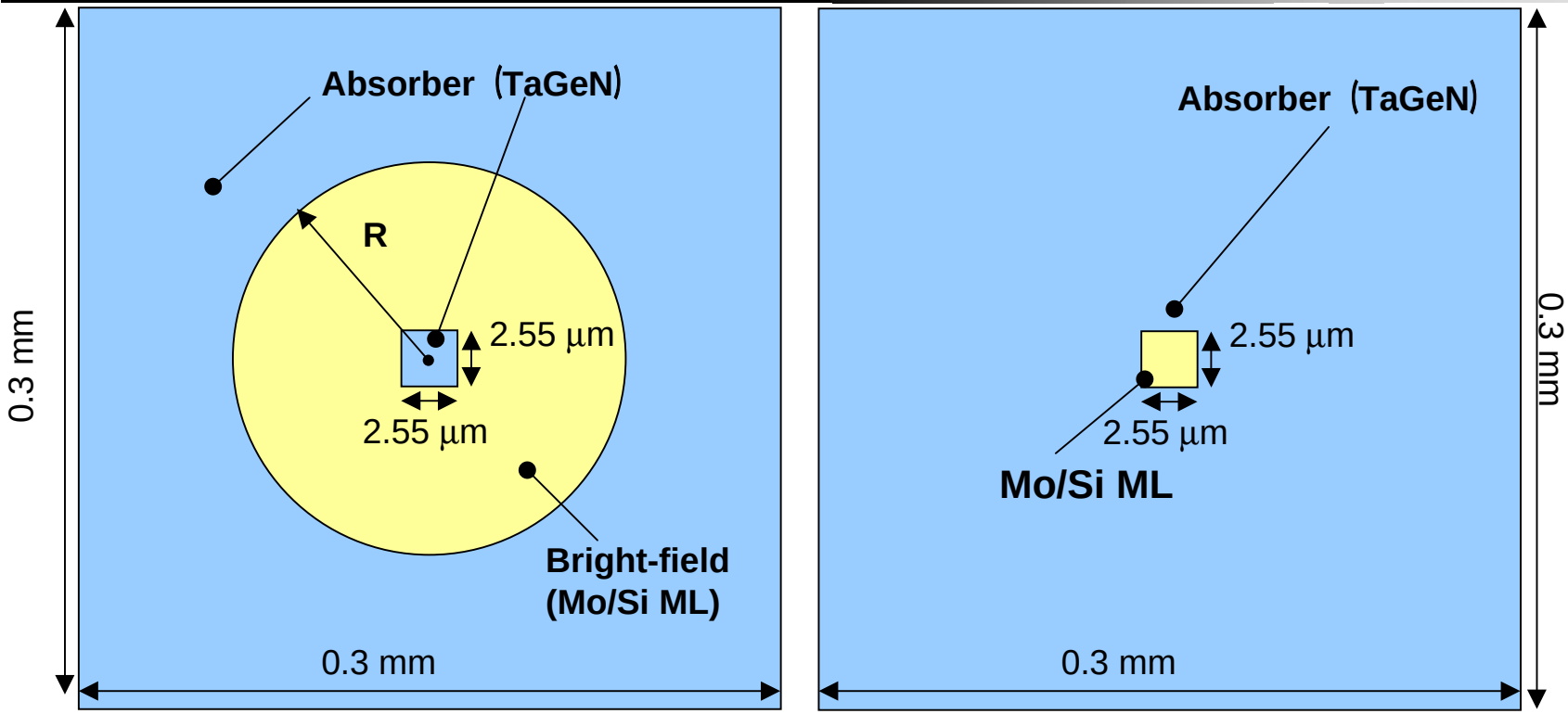
		LSFR			MSFR			HSFR		
			Raw	Z36		ϕ1mm	0.1mm		10μm	1μm
HINA2	M1	0.52	0.55	0.22	0.34	0.34	0.25		0.13	
	M2	0.66	0.66	0.40	0.32	0.33	0.23			
HINA3	M1	0.25	0.28	0.14	0.17	0.17	0.13	0.10	0.10	0.09
	M2	0.25	0.25	0.20	0.20	0.18	0.11			

T. Ohino et al.: Proc. SPIE, Vol. 5374 (2004) 897.

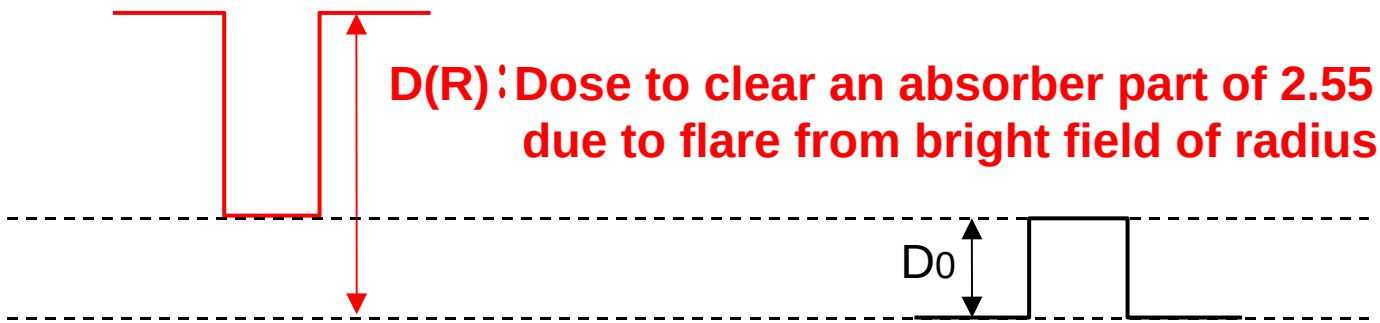
Measured wave front error (nm RMS)

HINA2: 1.9 nm (λ/7) **HINA3: 0.91 nm (λ/15)**

Mask patterns for Flare evaluation



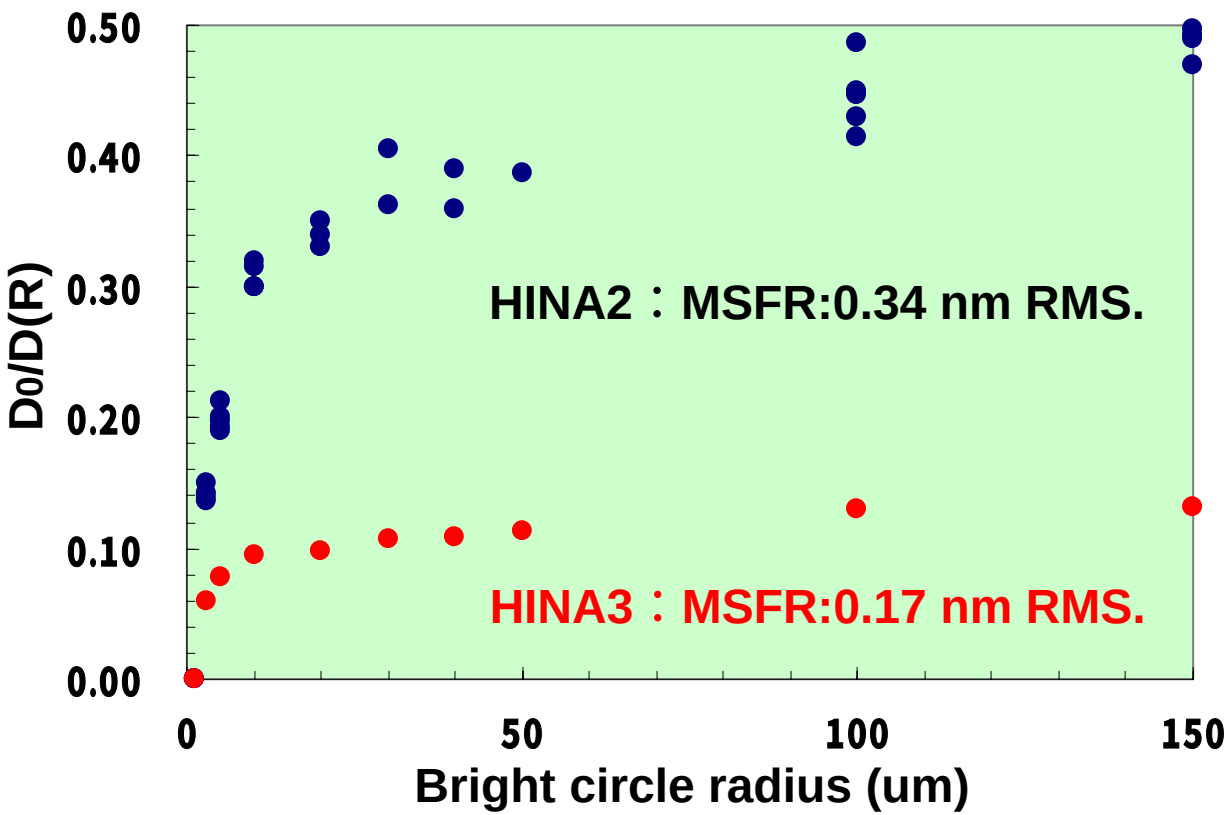
Dose to Clear method: $D_0/D(R)$

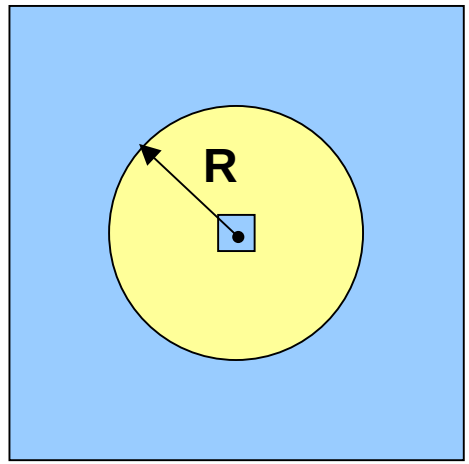


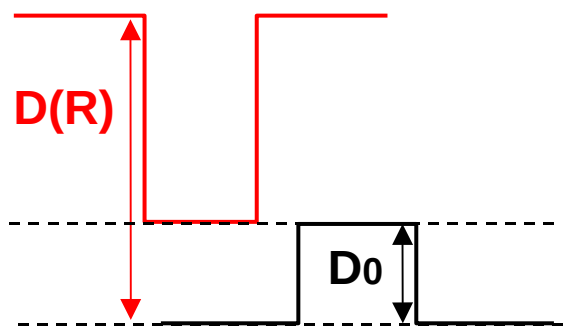
D(R)：Dose to clear an absorber part of 2.55 um sq. due to flare from bright field of radius R.

D0：Dose to clear dark field of 2.55 um sq.

Flare evaluation: HINA3



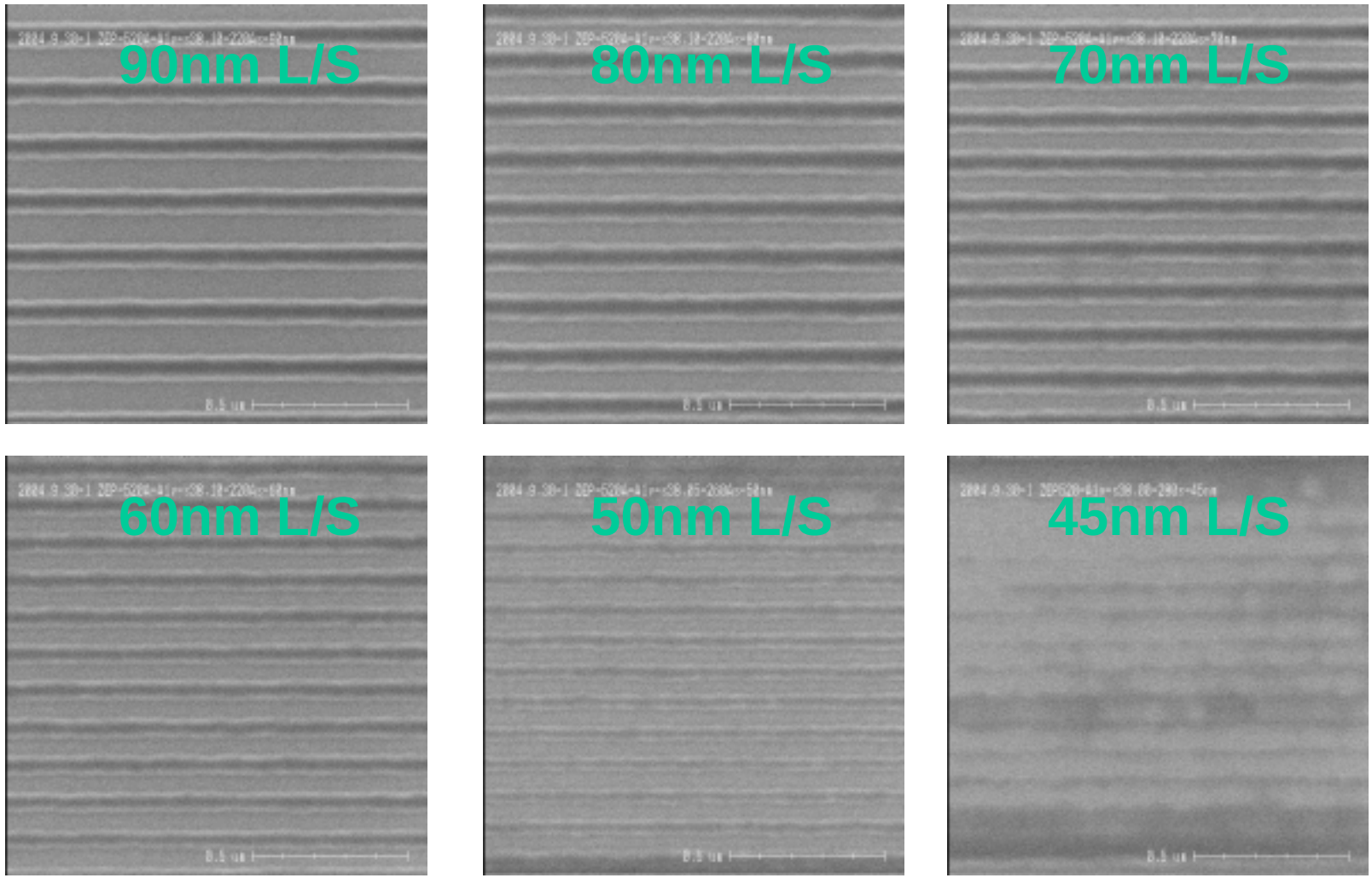




Lithographic Performance of HINA3

HINA3: Pattern delineation of dark-field mask ($\sigma \approx 0.8$)

Non-chemically amplified resist: ZEP520A 90nm^t



Summary

High NA small field exposure tool (HINA) was developed for the research of resist process and mask fabrication for 45nm node.

HINA2 → HINA3

WFE : 1.9 nm RMS → 0.91 nm RMS

MSFR : 0.34 nm RMS → 0.17 nm RMS

Flare evaluation (Resist) : 50 % → 13 %

$\sigma \approx 0.8$

L/S Resolution (non-CAR) : 70 nm → 50 nm

L/S Resolution (CAR) : 80 nm → 60 nm

Hole Resolution (non-CAR) : 100 nm → 60 nm

Hole Resolution (CAR) : 100 nm → 70 nm

$\sigma \approx 0.0$

L/S Resolution (non-CAR) : 35 nm → 30 nm

L/S Resolution (CAR) : 45 nm → 35 nm

We will accelerate the development of masks and resist processes.

Acknowledgements

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