LithoVision | 2011

Advanced Binary Film for 193nm Lithography Extension to Sub-32nm Node

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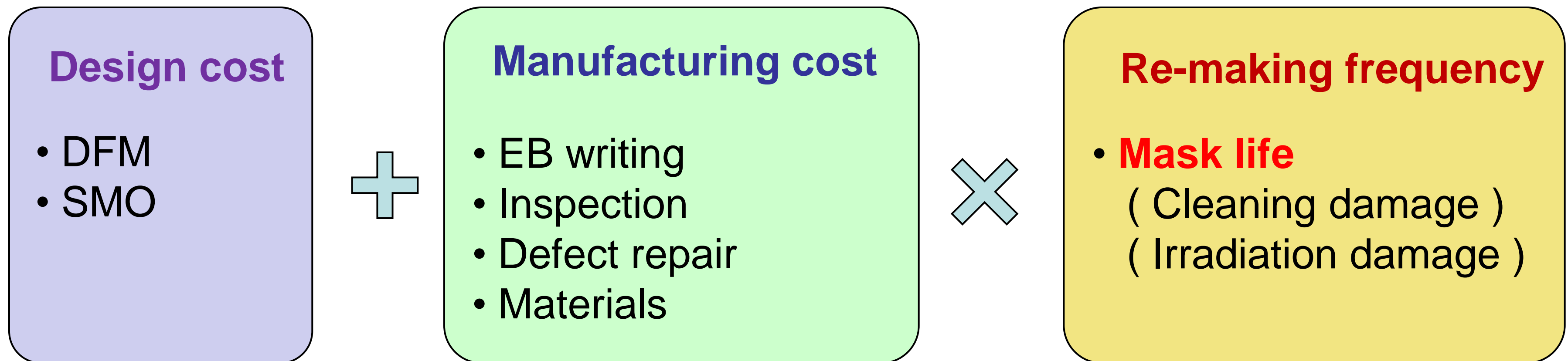
Consideration of Mask Cost



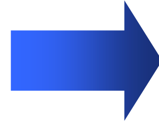
✓ **The mask cost increases by multiplication of mfg. cost x "frequency of re-making"**

✓ **It is critical for leading-edge masks to maximize their useful life, especially in the high volume production phase**

Motivation for New Film Development

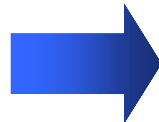
Challenges

- ✓ CD change
- ✓ Optical Density decrease



- Chemical durability

- ✓ CD growth
- ✓ Pattern degradation
- ✓ Light-shading degradation

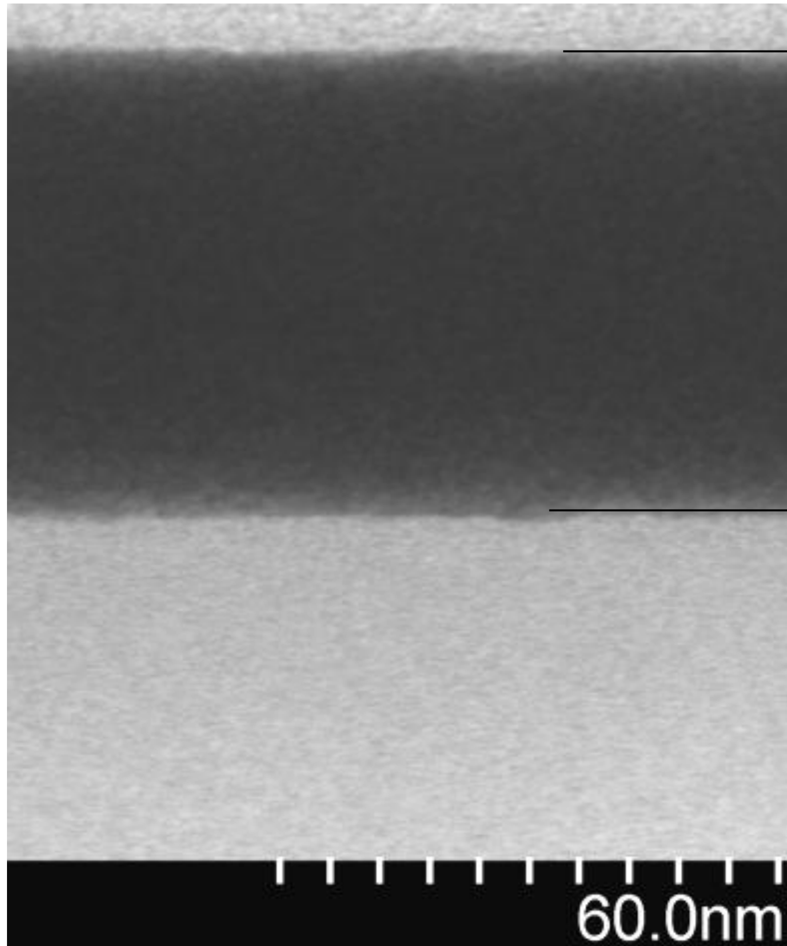


- 193nm irradiation durability

Can we develop a new film with significantly improved chemical & irradiation durability?

193nm Irradiation on MoSi Film

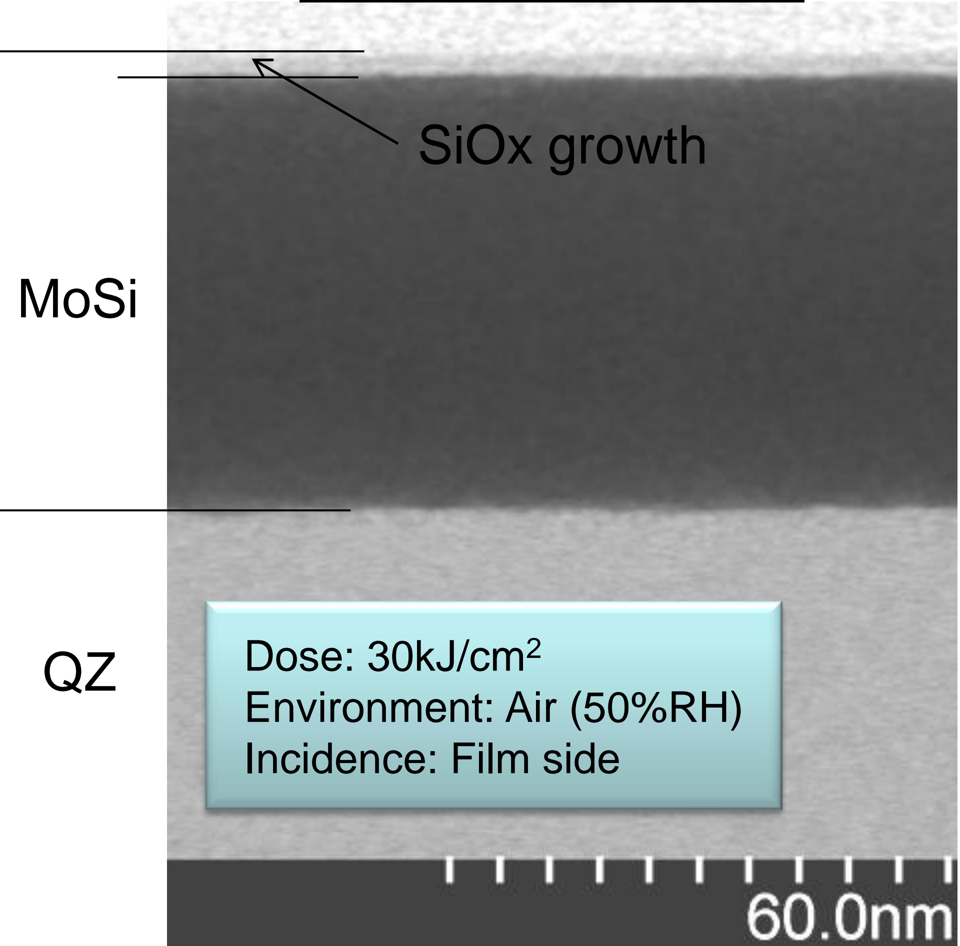
Before ArF irradiation



MoSi

QZ

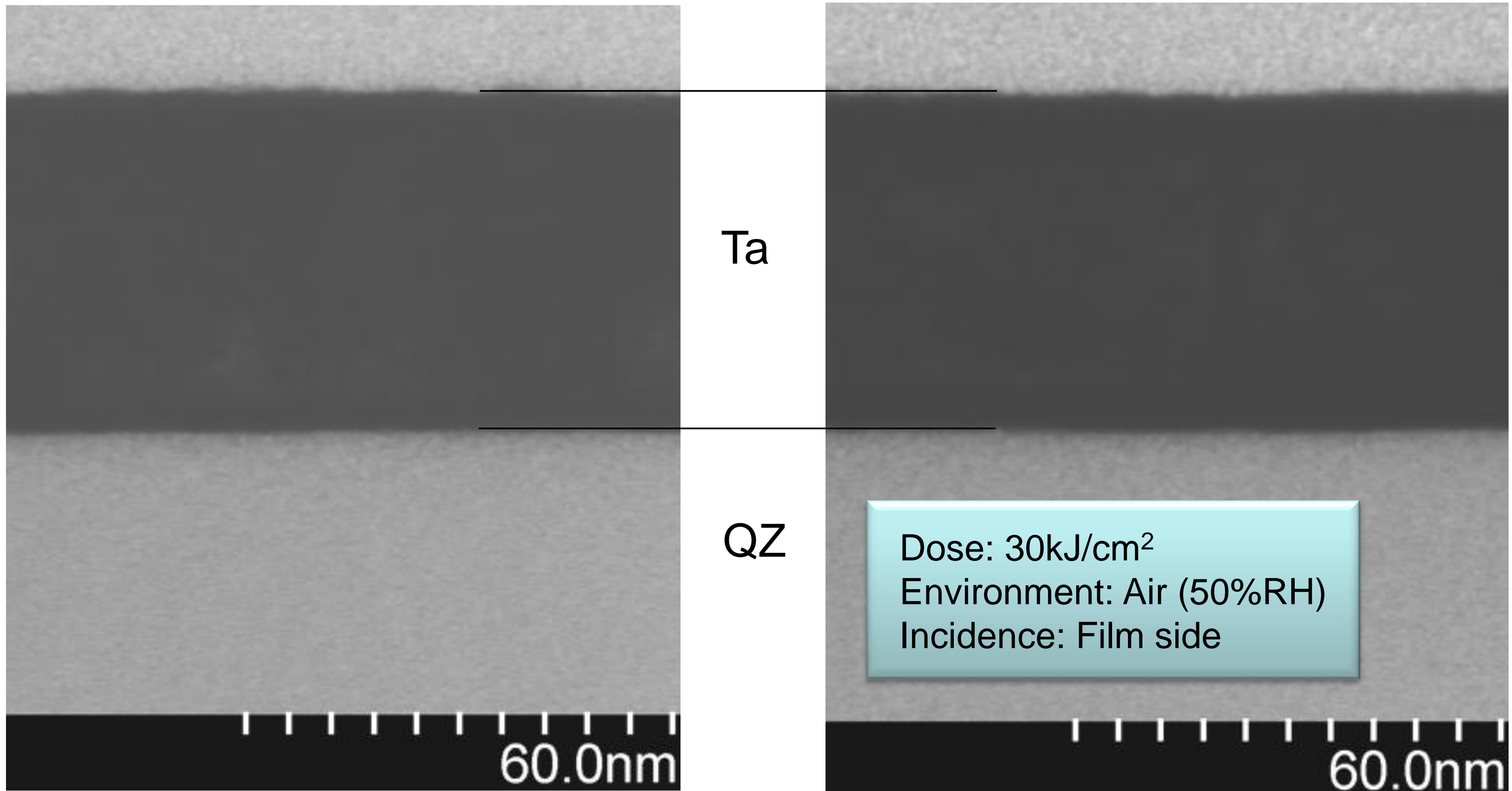
After ArF irradiation



Dose: 30kJ/cm^2
Environment: Air (50%RH)
Incidence: Film side

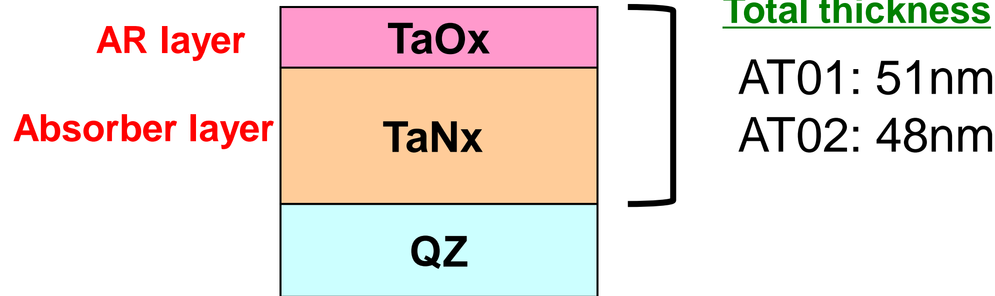
Oxidation layer on MoSi surface seems to grow

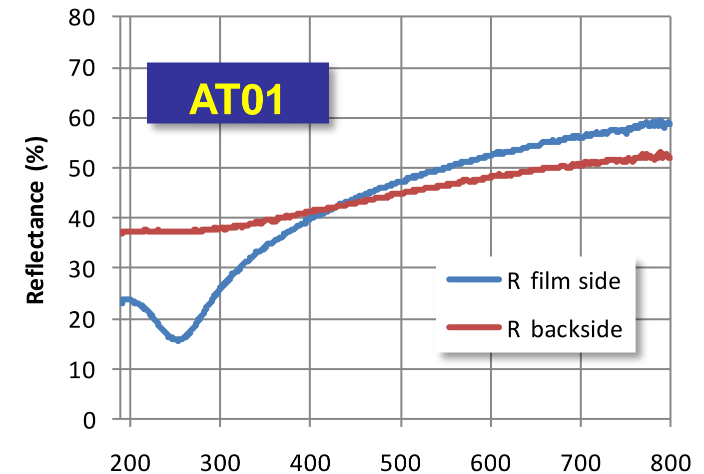
193nm Irradiation on Ta Film



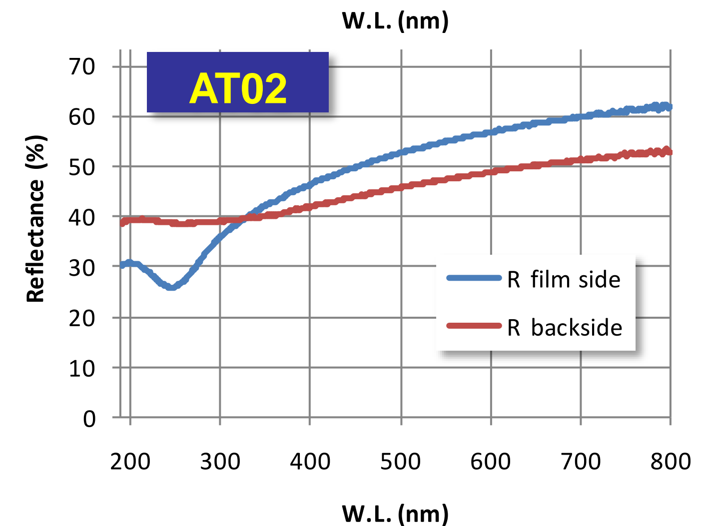
No change is observed on Ta surface after irradiation

Film Structure and Optical Property





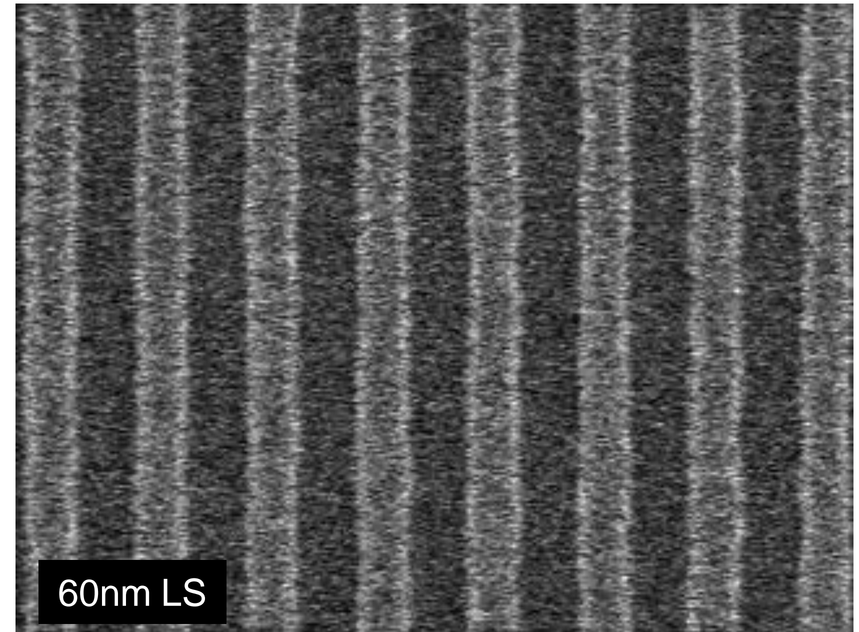
	AT01	AT02
Thickness of AR layer	9nm	5.5nm
Thickness of ABS layer	42nm	42.5nm
OD @193.4nm	3.06	3.02
Film side reflectivity @193nm	23.7 %	30.5 %
Backside reflectivity @193nm	37.2 %	38.8 %
Film side reflectivity @257nm	15.9 %	26.8 %



A thin film is achieved with sufficient OD and optimized reflectivity

Initial Patterning Result

Cross sectional SEM image of 60nm L/S



TOP view of 60nm L/S

✓ **Vertical profile obtained**

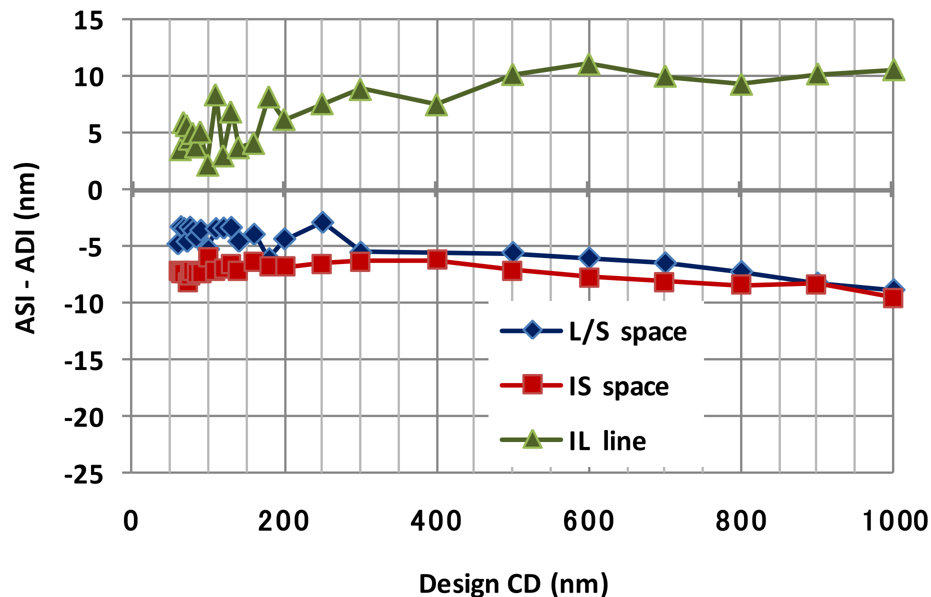
LER: 3.5nm (3 sigma)

Resist: PRL009 100nm w/o HM

Initial Patterning Performance

Film structure of test blanks

P-CAR (100nm)	
AT01	TaO (9nm)
	TaN (42nm)
Quartz sub.	



Category	Design Range	CD linearity	
		Range	3 sigma
L/S space	1000 - 60nm	6.0nm	4.9nm
IS space	1000 - 60nm	3.5nm	2.4nm
IL line	1000 - 64nm	8.8nm	8.1nm

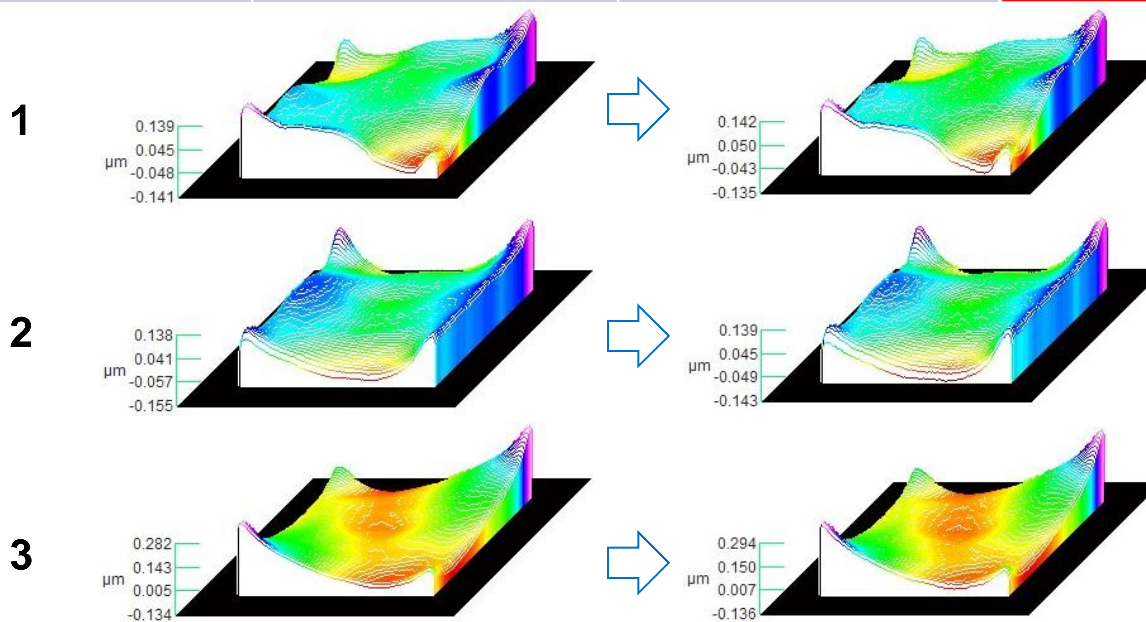
No correction of EB writing was performed.

AT01 can be patterned using 100nm resist

Film Stress

Flatness change between initial and after AT01 deposition

Plate	Sub TIR (nm)	AT01 TIR (nm)	Delta TIR (nm)
1	279	276	-3
2	293	281	-12
3	416	430	14

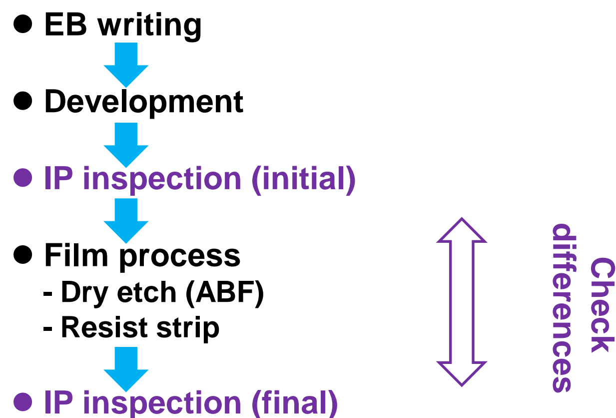


Low stress is observed on AT01

Image Placement Error

Reference: Proc. of SPIE Vol. 7823 78232W-9

Magnification change	
Layout Data	Memory device data (high density)
Writer	EBM-7000 (NFT)
Resist	PRL-009
Measurement	LMS-Ipro3 (KLA)

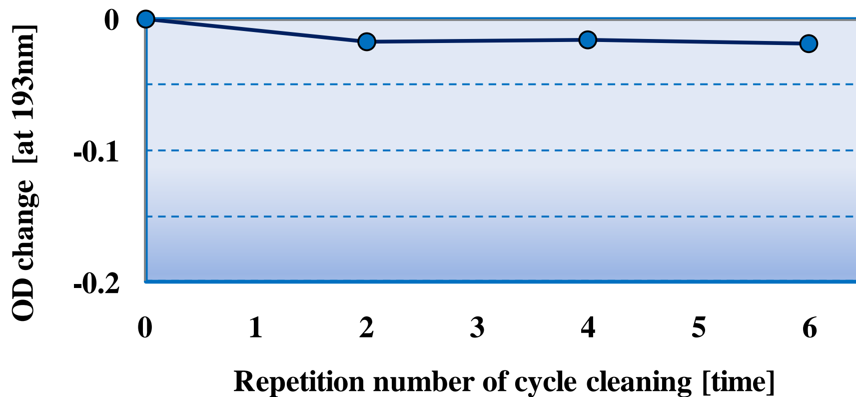


Magnification change is near zero (-0.1 ~0 ppm)

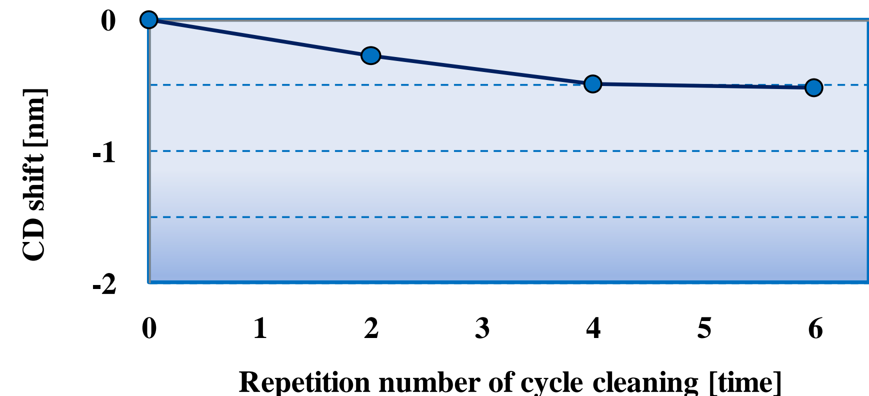
Chemical Cleaning Durability

Test condition per cleaning cycle

Process	Condition	Treatment time
O_3+DIW	O_3 = 50ppm, Room temp.	10 min
SC1	NH_4OH:H_2O_2:DIW=2:1:4, Room temp.	10 min
Hot DIW	85℃	10 min
Spin rinse	Room temp.	3 min



OD change is less than 0.02

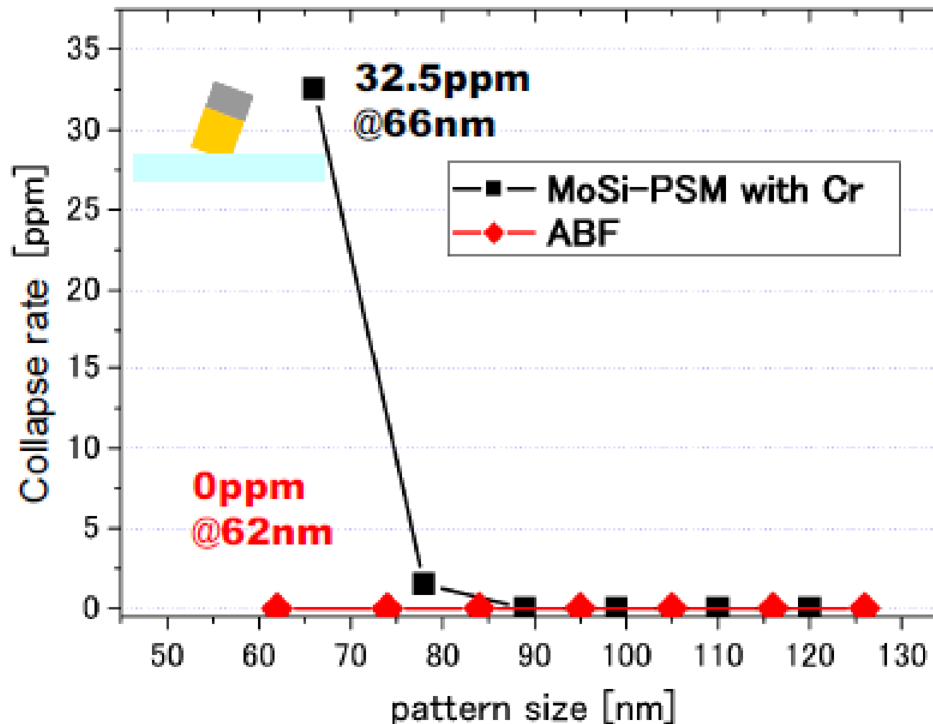


CD shift is very small

AT01 demonstrates excellent mask cleaning durability

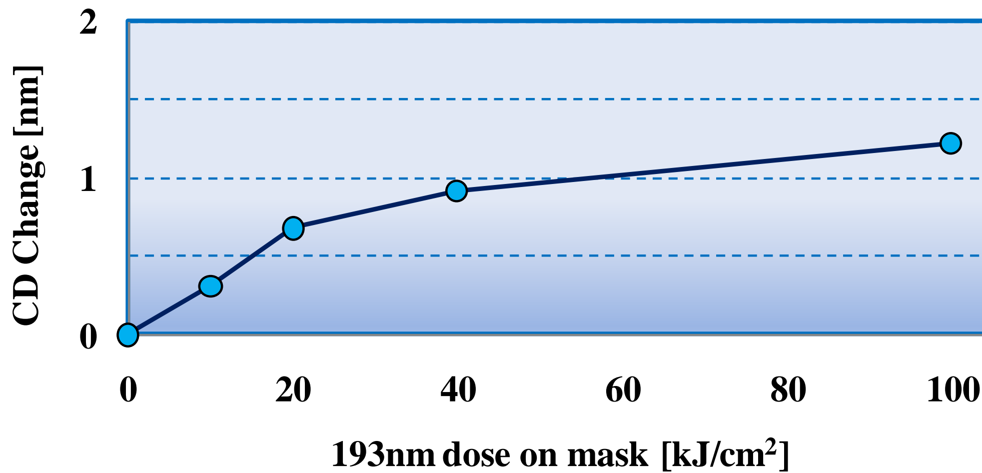
Physical Cleaning Durability

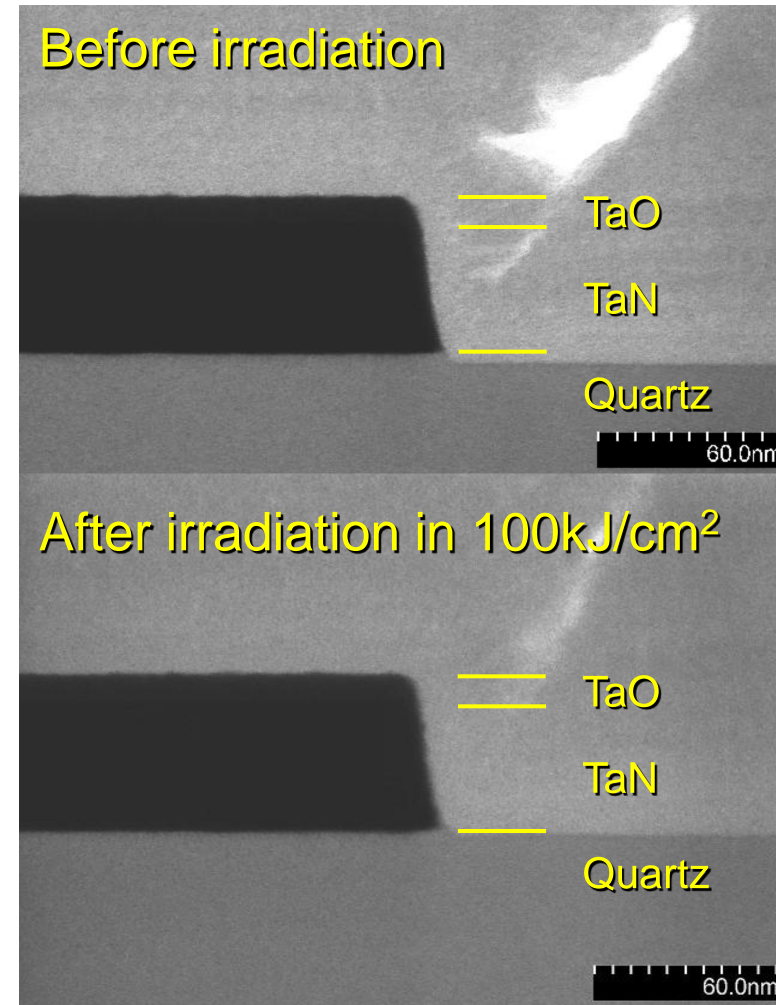
Reference: Proc. of SPIE Vol. 7823 78232W-9



No pattern collapse at 62nm patterns

Degradation Due to 193nm Irradiation





- ✓ **Minimal CD shift due to 193nm irradiation**
- ✓ **No pattern degradation observed**

Summary

- Ta was selected as the base material for its dry-etch capabilities and suitable thickness (to achieve satisfactory optical density), as well as its cleaning and irradiation durability
- Ta-based AT01 and AT02 are now fully developed
- AT01 successfully demonstrates high durability to both mask cleaning and 193nm irradiation
- AT01 and AT02 are expected to enhance mask life, resulting in significant long-term savings in total mask related cost in the lithography process