Development status of patterning enhancement materials for EUVL

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IEUVI Resist TWG

Agenda

01 Rinse material

1.1 Benefit of using rinse material

1.2 Latest update

02 Smoothing material

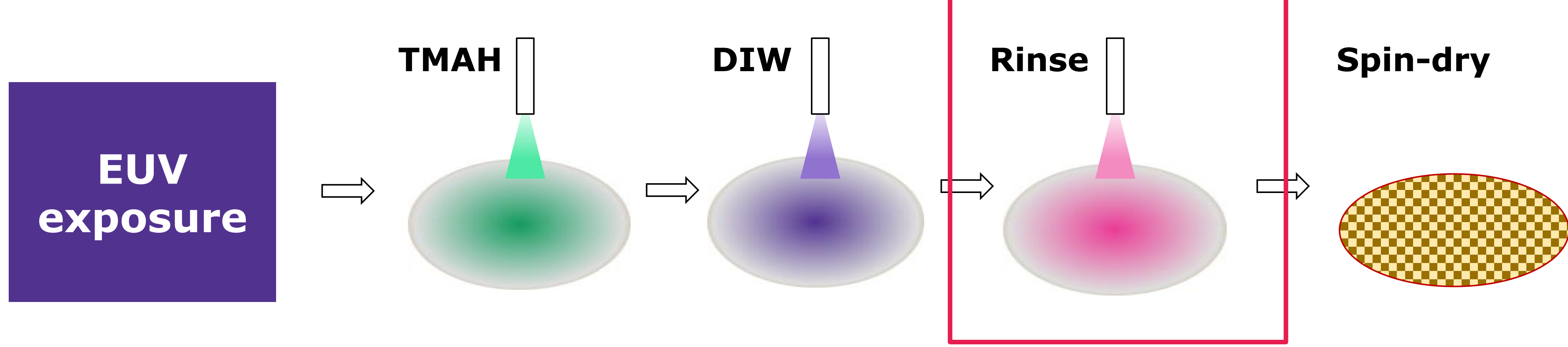
2.1 Concept to improve LWR

2.2 Test result

03 Summary

Rinse material

Rinse material
Benefit of using rinse material



Benefit of rinse process

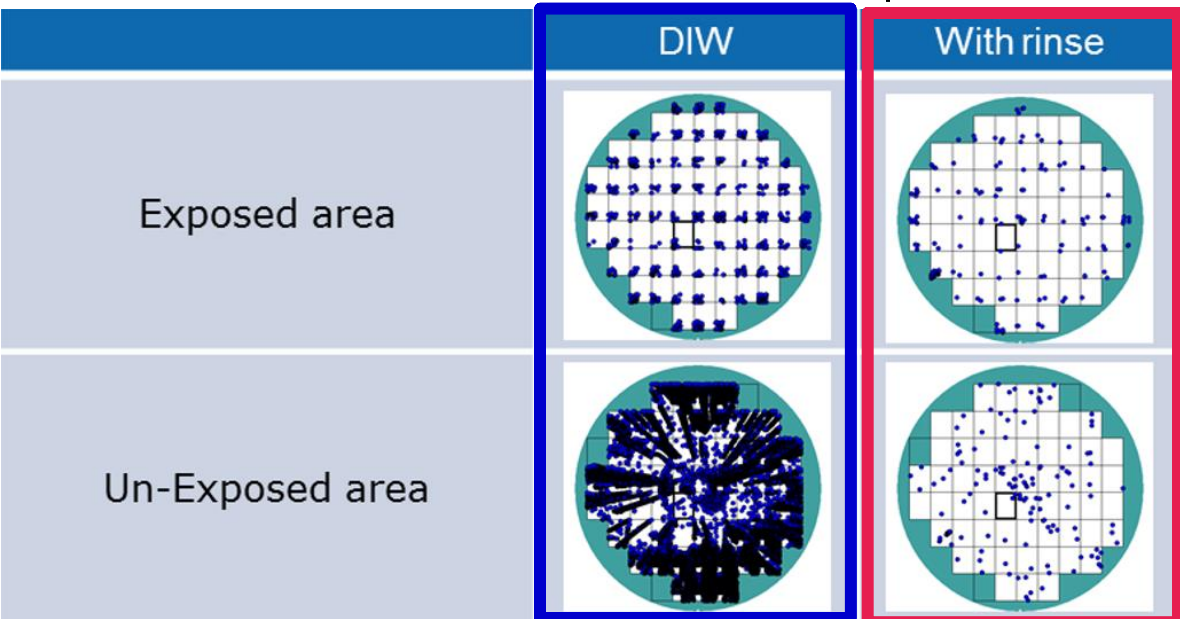
- ✓ **Better defectivity**
- ✓ **Wider process window**
- ✓ **Sensitivity improvement**

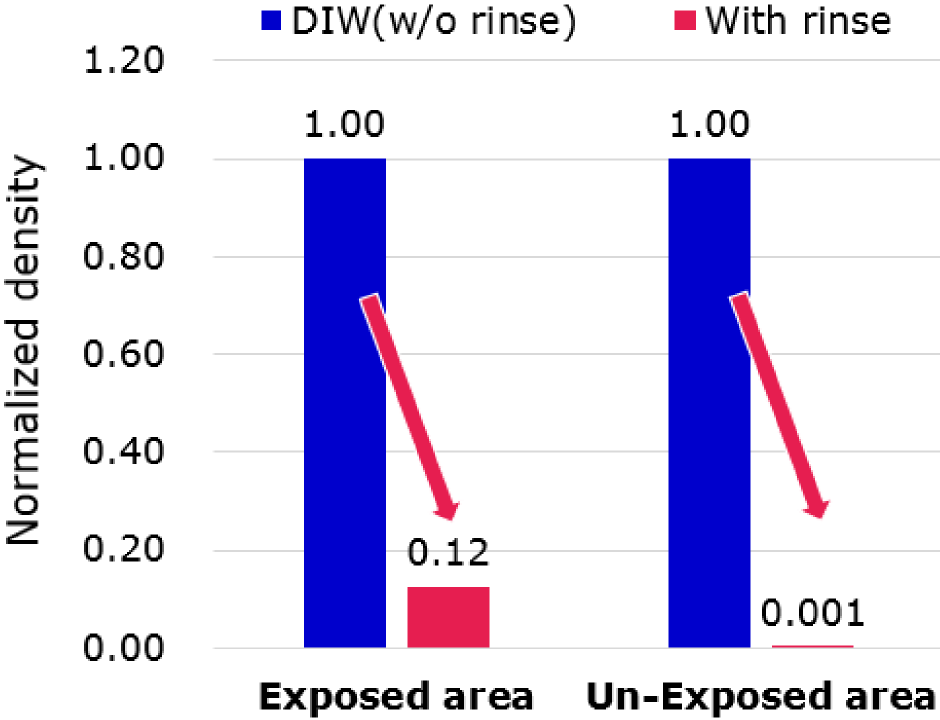
Rinse material
Better defectivity

Process condition
Exposure tool: NXE:3100
Resist: Resist-A / 50nm thick
Process: 2.38%TMAH ➔ DIW ➔ Rinse

Inspection area
Exposed area: 70.3cm^2/wafer
Un-Exposed area: 451.3cm^2/wafer

Evaluation with NXE:3100 at 28nmhp





✓ Rinse reduces PR defectivity significantly.

*T.Nagahara, IEUVI Resist TWG Feb 21, 2016

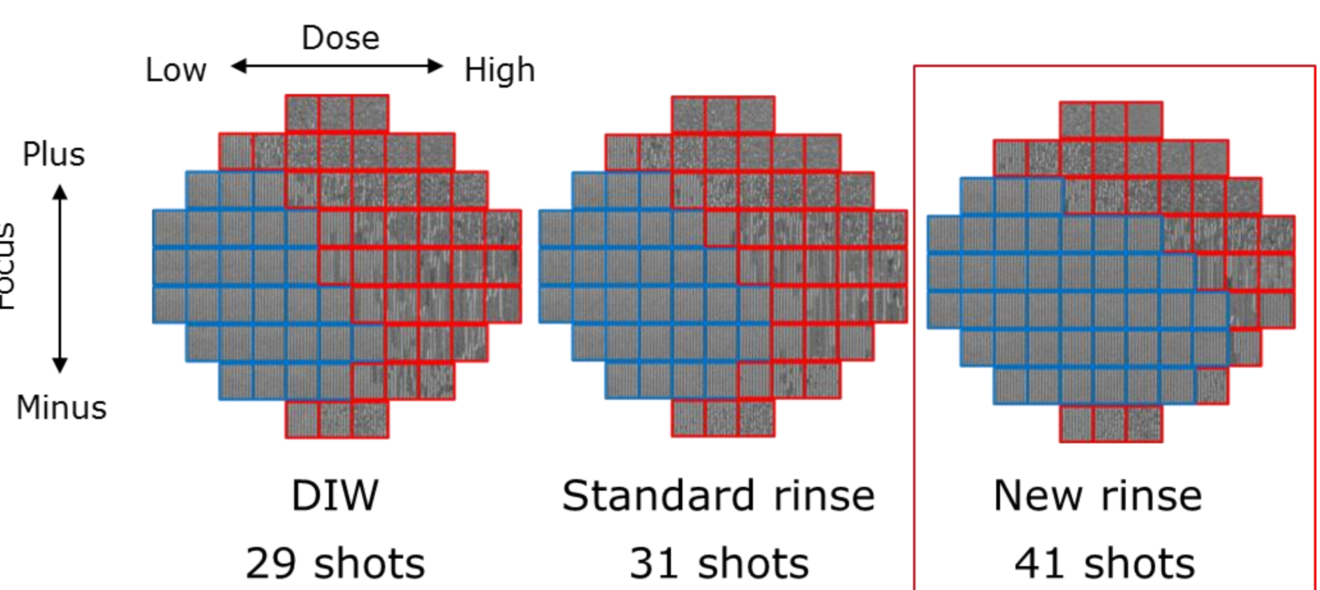
Rinse material
Wide process window

Process condition
Exposure tool: NXE:3100
Resist: Resist-B / 50nm thick
Process: 2.38%TMAH ➔ DIW ➔ Rinse

Dose: 40.0mJ/cm2 center, 2mJ/cm2 step
Focus: -0.06um center / 0.06um step

Evaluation at 22nm hp

	DIW	Standard rinse	New rinse
Minimum CD (nm)	21.7	20.2	17.5
Sensitivity (mJ/cm^2) Dose to 22nm	39.3	38.7	37.5



✓ New rinse achieved wide process margin and improved resist sensitivity.

*Kazuma Yamamoto, ICPST-33, 2016

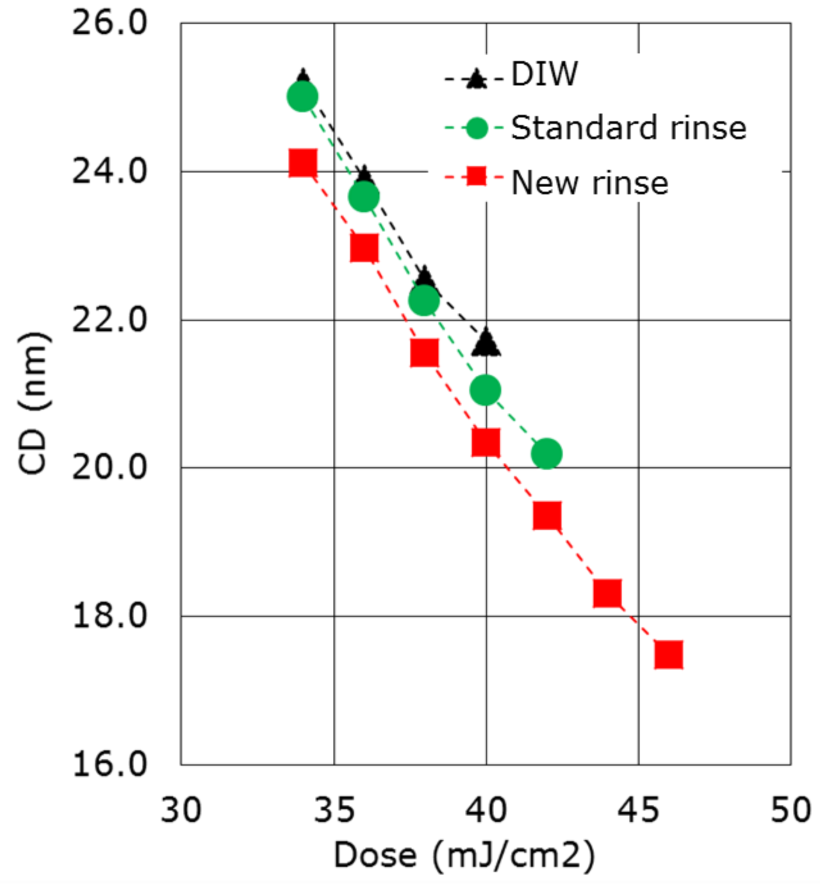
Rinse material

No resist top loss with new rinse material

Process condition
Exposure tool: NXE:3100
Resist: Resist-B / 50nm thick
Process: 2.38%TMAH ➔ DIW ➔ Rinse

Observation at 22nm hp

DIW	Standard rinse	New rinse



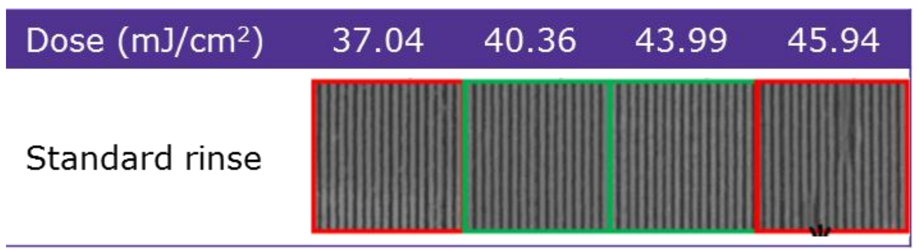
✓ No resist top loss was seen with rinse process.

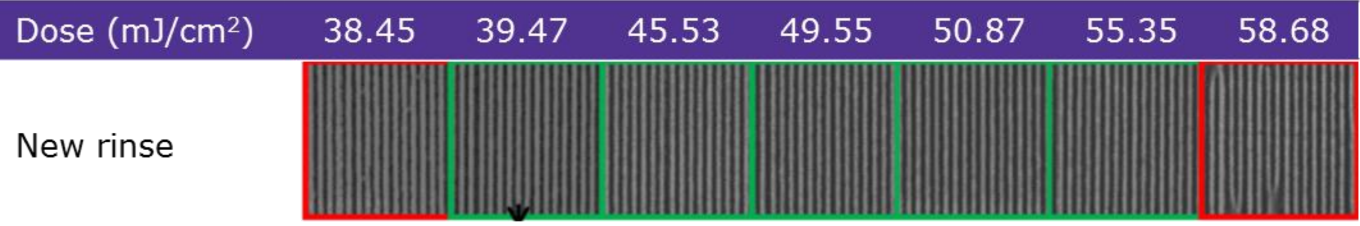
*Kazuma Yamamoto, ICPST-33, 2016

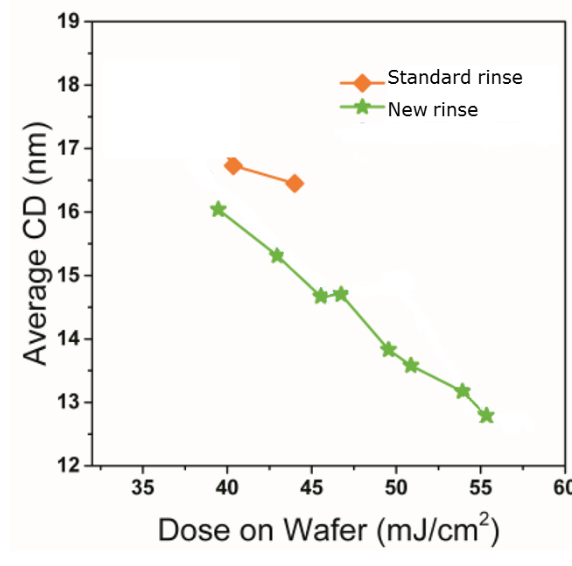
Rinse material
Applicability for 16nm hp at PSI

Process condition
Exposure tool: EUV-IL tool at PSI
Resist: Resist-C / 35nm thick
Rinse Process: TMAH => DIW => Rinse

Observation at 16nm hp







	Standard rinse	New rinse
Minimum CD (nm)	16.5	12.7
Sensitivity (mJ/cm2) Dose to 16nm	45.5	40.0

- ✓ New rinse was applicable for 16nm hp.
- ✓ Minimum 12.7nm CD was achieved with over dose by new rinse.
- ✓ Resist sensitivity was improved by new rinse.

Smoothing material

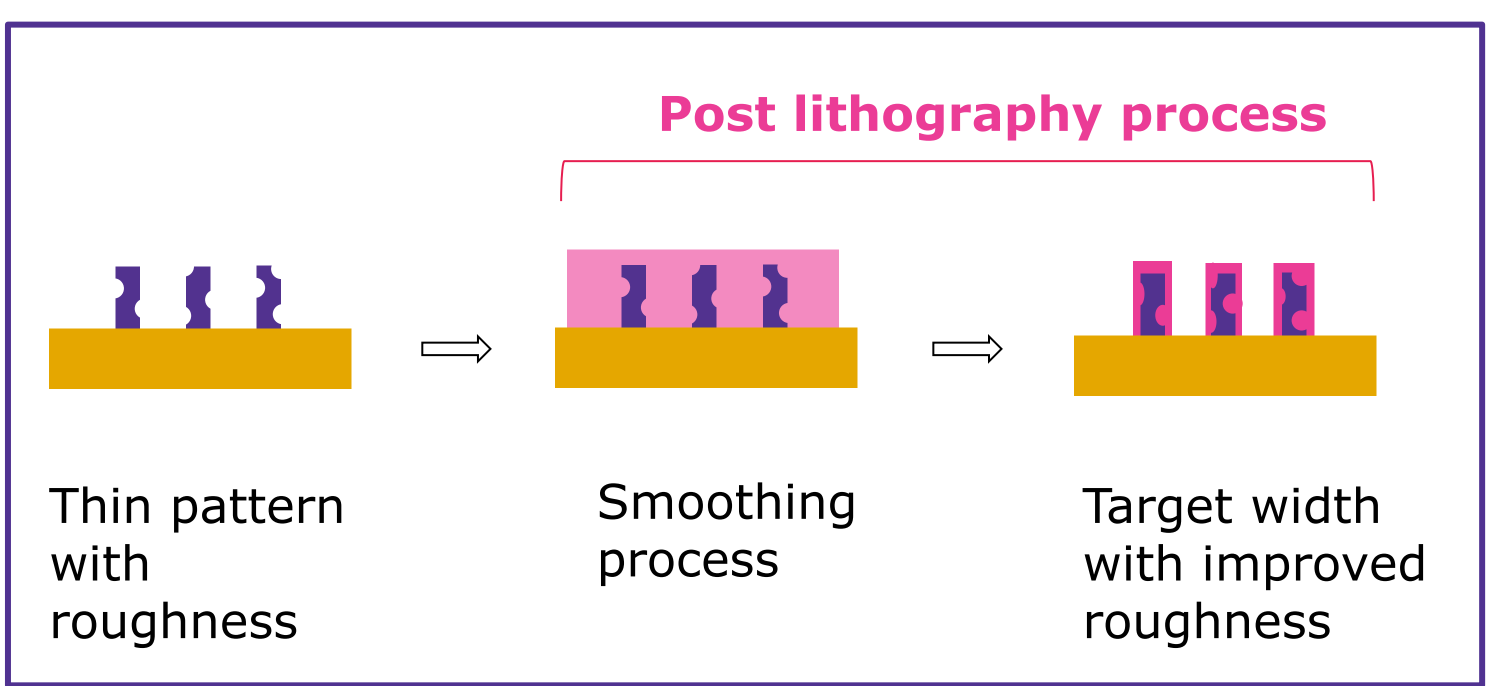
Smoothing material
New concept of roughness improvement

LWR

Sensitivity

Resolution

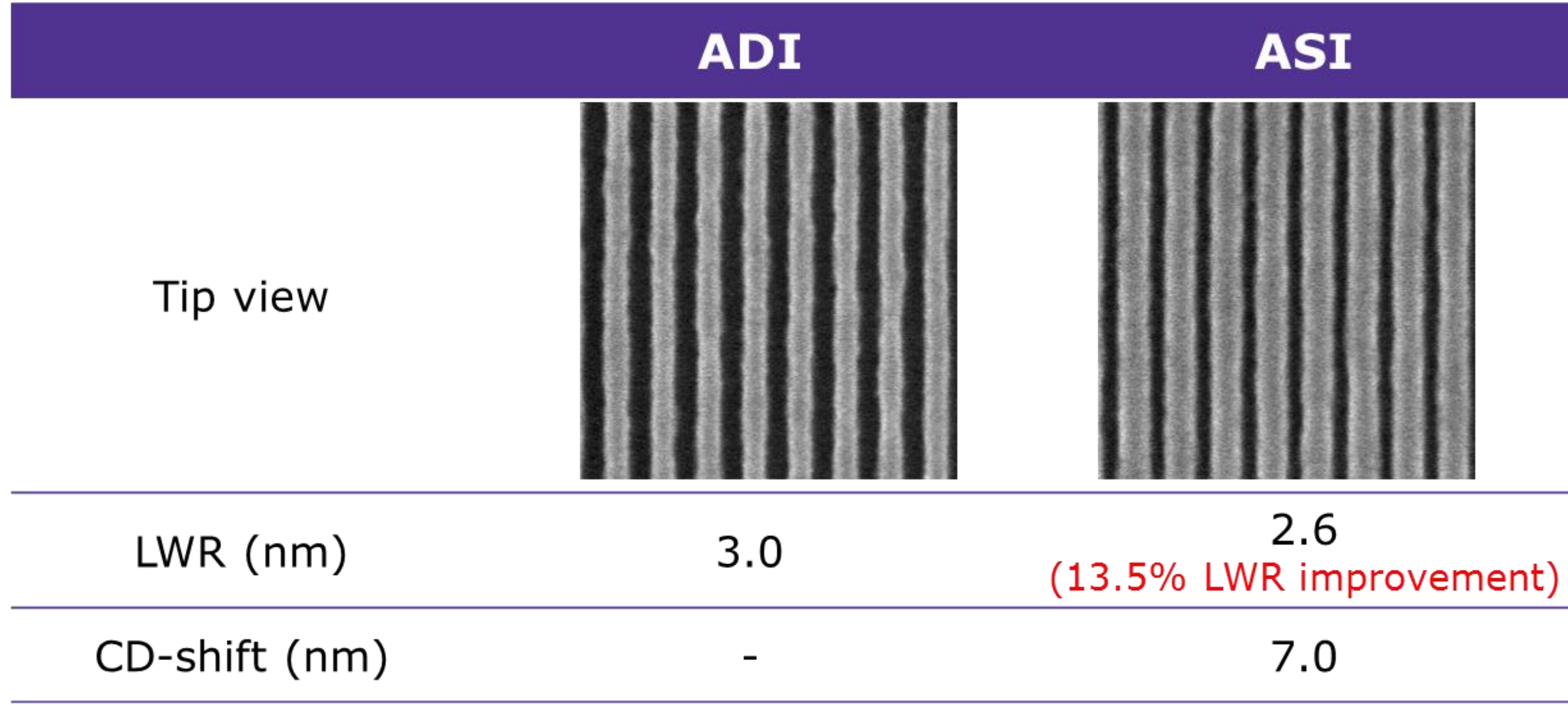
“Smoothing process"



✓ Post lithography process to improve roughness of resist pattern.

Smoothing material
New concept of roughness improvement

Process condition
Exposure tool: NXE:3300
Resist: Resist-D
Smoothing: Smoothing-A
Bake: 130C/60s
Development: DIW



Evaluation at 22nm hp

	ADI	ASI
Tip view		
LWR (nm)	3.0	2.6 (13.5% LWR improvement)
CD-shift (nm)	-	7.0

✓ The new concept to improve roughness was proven.
✓ Reduction of CD shift will be studied.

Summary

1. Rinse material
    - Significant defect reduction was confirmed
    - Minimum CD of 12.7nm was achieved at PSI
    - Sensitivity improvement of 12.1% against standard rinse was observed at PSI

2. Smoothing material
    - New concept to improve roughness was proven
    - Reduction of CD shift will be studied

Acknowledgement

[Rinse material]

ASML:

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PSI:

The authors thank Elizabeth Buitrago, Michael Vockenhuber and Yasin Ekinci for preparation of EUV patterned wafer and evaluation of rinse material.

[Smoothing material]

Screen:

The authors thank Masahiko Harumoto for preparation of EUV patterned wafer and discussions for evaluation of smoothing material.