P-IM-01

EUV process establishment for NXE3300 and beyond

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Introduction

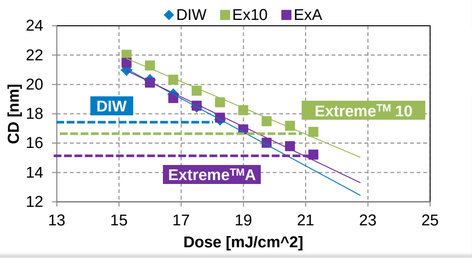
Advance EUV patterning on the ASML NXE:3300/ CLEAN TRACK™ LITHIUS Pro™ Z- EUV litho cluster is launched at imec, allowing for finer pitch patterns for L/S and CH. Tokyo Electron Limited (TEL™) and imec are continuously collaborating to develop manufacturing quality POR processes for EUV. TEL™ has new functionalities to enhance CD uniformity, defectivity and LWR/SWR. The patterning is characterized and optimized in both litho and etch for a more complete understanding standing of the final patterning performance.

Purpose

To establish the POR at imec for L/S and CH by using Extreme™A

Review of SPIE [9422-25, SPIE 2015]

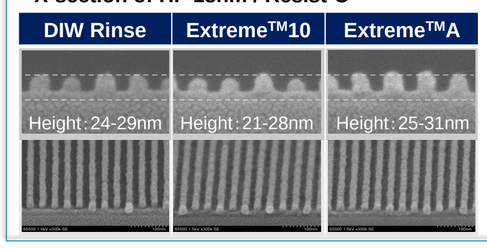
✓ **Surface tension reduction by introducing a New 'FIRM™ Material'**



※Extreme™ is a registered trademark of AZ Electronic Materials.

		smallest CD [nm]	⊿CD [nm]	LWR [nm]
HP 20nm / Resist-A	DIW	17.6	-	7.1
	Extreme™10	16.8	1.0	6.8
	Extreme™A	**15.2**	-0.2	7.2
HP 18nm / Resist-B	DIW	16.7	-	6.9
	Extreme™10	16.0	1.7	6.4
	Extreme™A	**14.9**	0.4	6.9
HP 17nm / Resist-C	DIW	16.2	-	8.5
	Extreme™10	17.6	1.2	8.0
	Extreme™A	**15.2**	0.1	8.2

X-section of HP 18nm / Resist-C

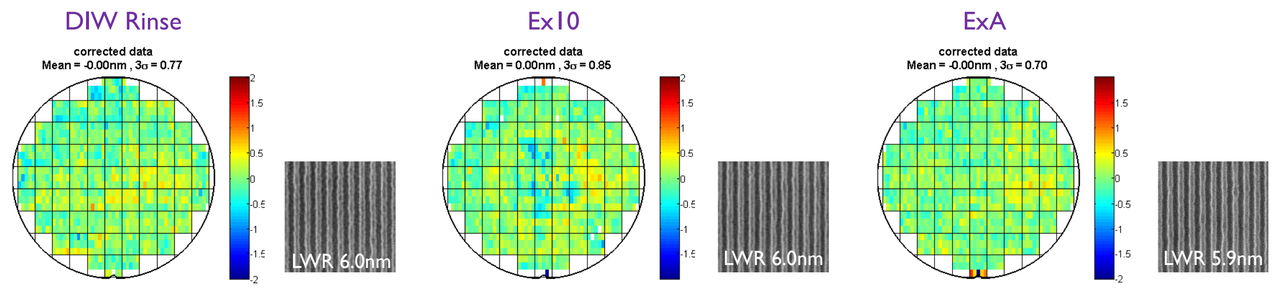


Extreme™A has
−best smallest CD without pattern collapse for several resist materials below 20nm
−Smaller CD change from DIW process than Extreme™ 10
−No negative impact to pattern profile and thickness

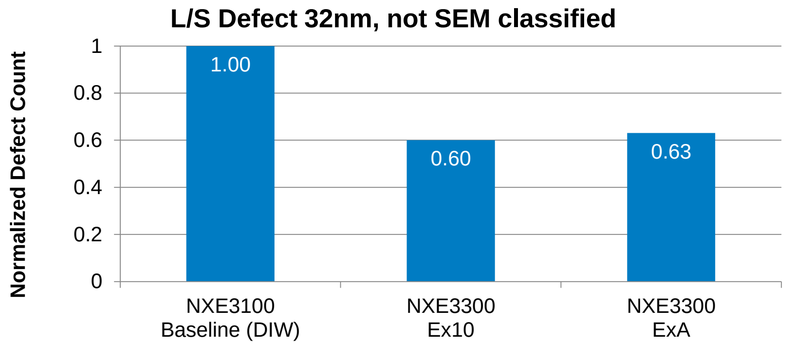
Experimental Condition
Coater/Developer
System : CLEAN TRACK™ LITHIUS Pro™ Z EUV (Tokyo Electron Ltd.)
Resist : EUV resist-A, Film thickness 40nm (L/S), 50nm (CH)
Developer : TMAH
Rinse solution : FIRM™ Extreme™10 and Extreme™A
EUV Scanner
System : NXE3300
Illumination : Conventional
Etch
Tactras™ T4 (Tokyo Electron Ltd.)
Measurement
SEM : Hitachi CG5000
Defectivity : KLA2835

CD Uniformity and Defectivity

L/S, CDU 22nm

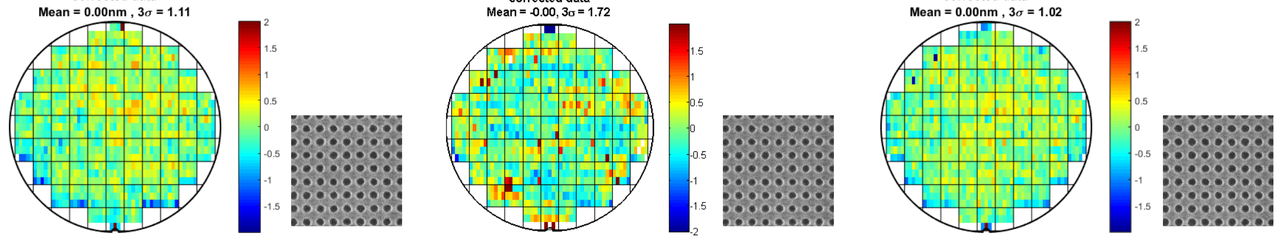


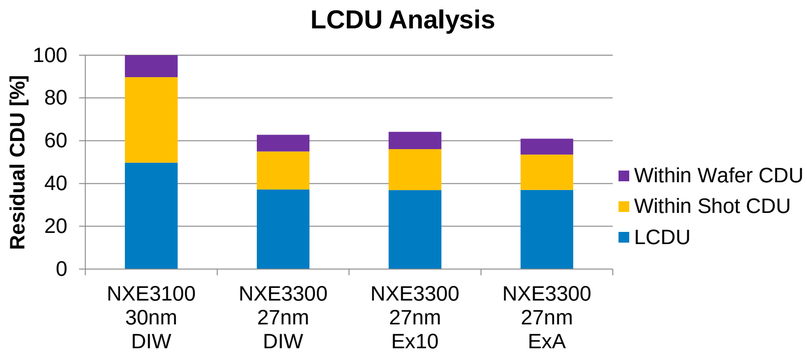
L/S, Defectivity 32nm



- ► Initial data with NXE3300.
- ► Extreme™A doesn't have any impact to CDU.
- ► NXE3300 defectivity is comparable with NXE3100, defect analysis is ongoing.

CH, CDU 27nm [Offline process between coater/developer at imec and scanner at ASML]



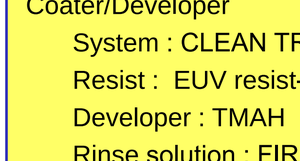


- ► Offline process data with NXE3300.
- ► NXE3300 improves within shot and local CD uniformity.
- ► Extreme™A doesn't have much impact to CDU.
- ► No rinse process budget for LCDU can be seen.

Project Overview

In comparison LE³ by ArF and EUV, EUV shows good pattern fidelity, but LWR/SWR is challenge.

193i LE³ vs EUV SP



	193i LE³ 13nm LE bias		EUV SP* 0nm LE bias	
	Litho	Etch	Litho	Etch
A (nm)	39.3(1.12)	27.7(2.53)	24.6(1.84)	25.1(2.25)
B (nm)	39.6(1.34)	26.8(2.41)	24.6(1.77)	25.3(1.89)
C (nm)	39.4(1.19)	27.4(2.68)	24.6(1.66)	25.2(1.96)
SWR	5.85	3.50	5.18	4.90

193i LE³ 13nm LE bias		EUV SP* 0nm LE bias	
Litho	Etch	Litho	Etch
51.9 (3.53)	27.2(4.31)	26.2 (3.61)	25.5(3.85)
-	27.0(3.00)	25.7(2.88)	24.9(3.02)
-	24.3(3.60)	25.2(3.67)	25.6(3.97)
11	8.6	-	-

* Edge dies removed

- Better CDU for EUV SP but slightly worse LWR/SWR
- In each case CDU and LWR can lead to open or bridging
- 193i LE³ route results in corner rounding
- EUV SP offers clearly better patterning fidelity than 193i LE³

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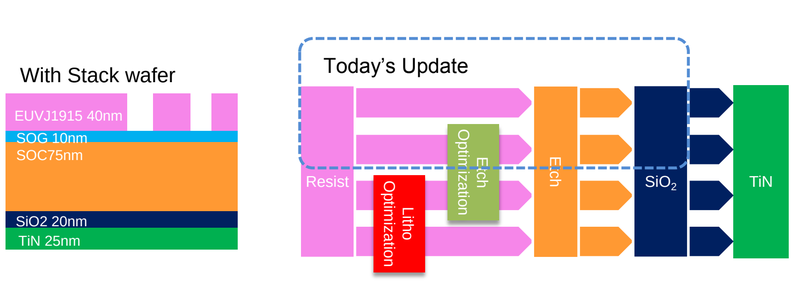
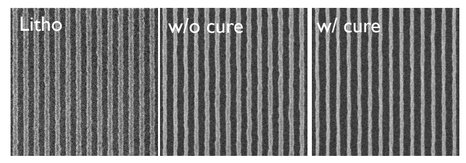
LWR/SWR

Test Plan
Etch and litho optimization will make line smoother.
Optimization for both treatments combined is underway.





24nm HP LS (trench CD)

	Litho	Etch w/o Cure	Etch w/ Cure
CD (nm)	26.9	28.2	32.4
SWR@ 24nm HP LS	5.85	5.84	**5.47**
SER@ 24nm HP LS	-	3.74	3.45

- ► SWR is slightly improved with etch cure
- ► Targeting correct CD with cure
- ► Test different cure
- ► Check the combination with etch and litho optimization

Conclusion

- **Initial data of L/S 22nm and CH 27nm with NXE3300 were taken.**
- **New FIRM™ material Extreme™A doesn't have any impact to CDU, but the pattern collapse prevention effect could be seen on 22nm L/S.**
- **Defect analysis such as L/S 22nm and CH 27nm are needed.**
- **Further studies towards better CDU, defectivity after litho/etch and LWR/SWR are ongoing.**

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