EUV Process improvements on Track system

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Outline

- **Goal**
- **Experimental**
  - Process conditions and metrology
- **Results and Discussions**
  - Coating Stability for Ultra-thin UL
  - CD Uniformity for L/S
  - CD Unifromity for C/H
  - Defectivity : 'Bridge' types defect improving
  - Defect Classification
  - LWR Improvement : Hard Baking and Surfactant Rinse
  - LWR Improvement : for C/H
- **Conclusions**

Goal

- **Baseline for EUV Track Process**
  - ✓ Coating uniformity and defectivity for Ultra-thin Under Layer.
  - ✓ CD uniformity for L/S and C/H.
  - ✓ Defect review with full field exposure.
  - ✓ LWR improvement.

Experimental

◆ Target thickness and CD

- ✓ Film Coating : 10nm and 20nm (UL)
  50nm (Resist) for L/S and 60nm (Resist) for C/H
- ✓ CD Uniformity for L/S : 27nm L/S
- ✓ Defectivity : 32nm L/S
- ✓ Local CD Uniformity for C/H : 30nm-Hole / 60nm-Pitch (Bias 20%)
- ✓ LWR improvement : 32nm L/S

◆ Materials

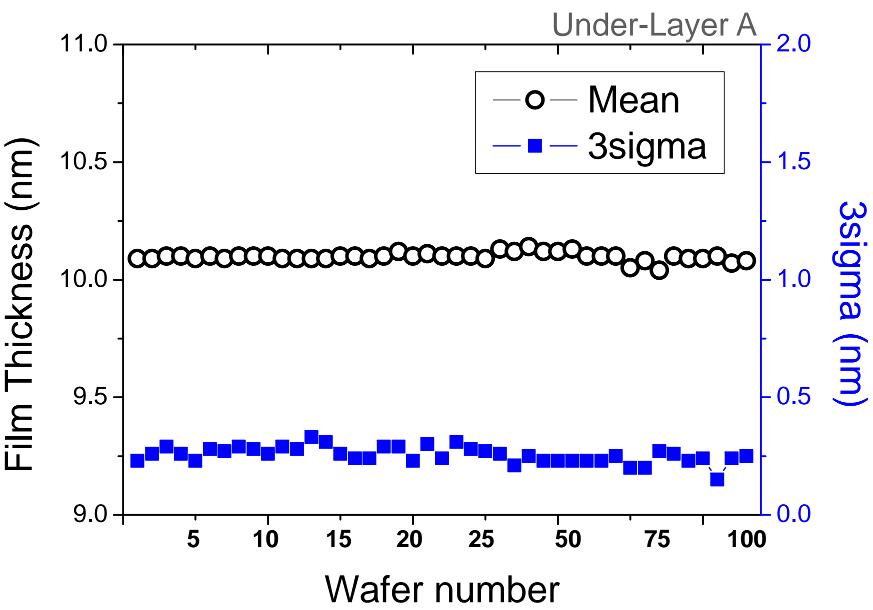
Under Layer	**Under Layer A @10nm-FT** **Under Layer B @ 10nm-FT** **Under Layer C @ 20nm-FT**
Resist	**Resist A @ 50nm-FT (L/S)** **Resist B @ 50nm-FT (L/S), 60nm-FT (C/H)** **Resist C @ 50nm-FT (L/S), 60nm-FT (C/H)** **Resist D @ 50nm-FT (L/S)**
Developer	**TMAH 2.38wt%**

◆ Metrology

- ✓ Film thickness : SCD-100 (KLA-Tencor)
- ✓ CD Measurement : CG-4000, CG-5000 (Hitachi High-Tech)
- ✓ Defect inspection : SP3 (KLA-Tencor)
  KLA2835 (KLA-Tencor)
- ✓ Defect Review : RS-6000 (Hitachi High-Tech)

Coating Stability for Ultra-thin UL

Film Thickness Stability



Film Thickness :10.10nm
3sigma mean : 0.25nm

*100 wafers were coated. FT of all wafers were measured in Lot-1. Selected 6 wafers were measured in Lot2, 3 and 4.

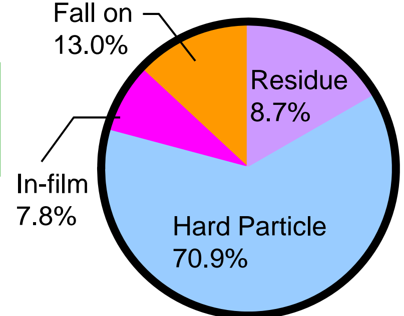
Coating Defectivity

Under-Layer A

Defect type	Residue	Hard particle	In-film	Fall on
SEM image	FOV:675nm			
Ratio	8.7%	70.9%	7.8%	13.0%

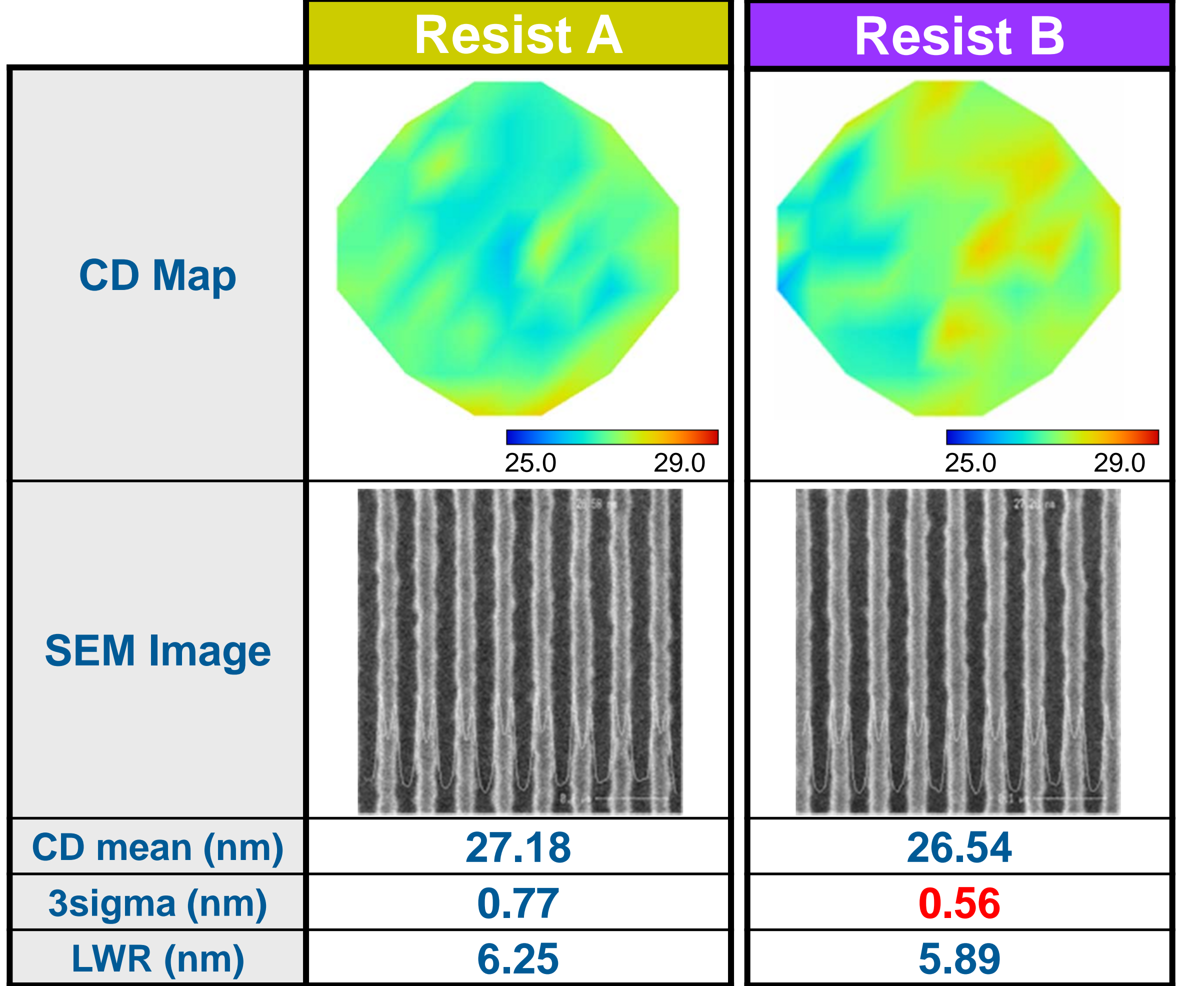
Defect Density : 0.01/cm²
Major Defect : Hard Particle

*Defect inspection : SP3 @42nm-up



◆ **Excellent long term stability and lower defectivity.**

CD Uniformity for LS



	Resist A	Resist B
CD Map	25.0 – 29.0	25.0 – 29.0
SEM Image		
CD mean (nm)	27.18	26.54
3sigma (nm)	0.77	0.56
LWR (nm)	6.25	5.89

Under-Layer : Under-Layer C @20nm-FT
Resist : Resist A @50nm-FT
Resist B @50nm-FT

Target CD : 27nm half pitch
Exposure : Conventional, NA 0.25
Dose : 12.7mJ/cm^2 (Resist A)
13.1mJ/cm^2 (Resist B)

Die size : 26x33mm (71 Dies)

Measurement : 213 points (3points / Die)

- **Resist-B was better than Resist-A.**
- **3sigma 0.56nm was achieved.**

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CD Uniformity for CH

	Resist C / Under Layer B	Resist C / Under Layer C
CD Map	28.0 – 31.0	29.0 – 32.0
SEM Image		
CD mean (nm)	29.53	30.73
3sigma (nm)	0.91	0.99
3σ-LCDU (nm)	3.74	3.12

Under-Layer : Under-Layer B @10nm-FT
Under-Layer C @20nm-FT
Resist : Resist C @ 60nm-FT

Target CD : 30nm-CH / 60nm-pitch
(Mask bias 20%)

Exposure : Conventional, NA0.25
Dose : 17.0mJ/cm^2 (Under-Layer B)
17.7mJ/cm^2 (Under-Layer C)

Die size : 27x34mm (87 Dies)

Measurement : 87 points (1point / Die)
(25 holes / point)

◆ **3sigma <1.0nm was achieved.**

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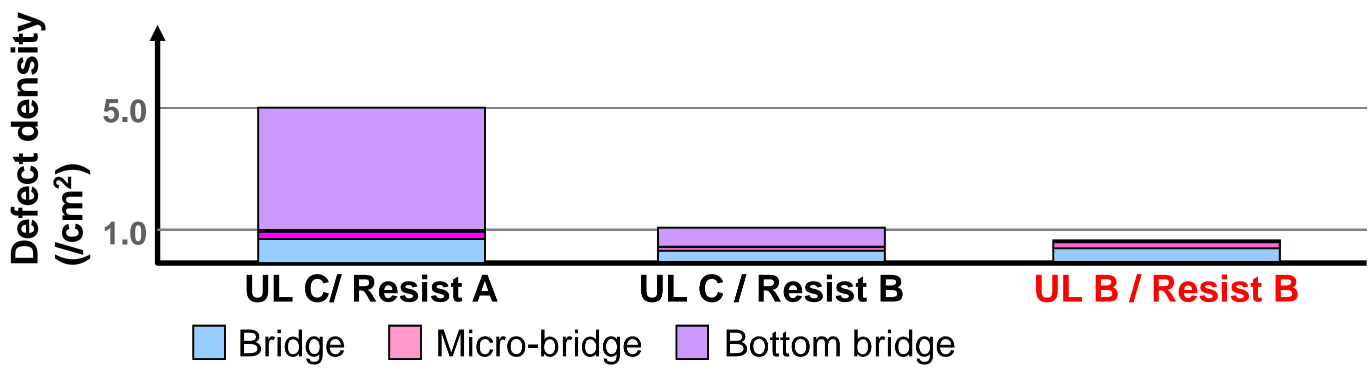
Defectivity : 'Bridge' types defect improving

	Resist A	Resist B	
	Under Layer C		Under Layer B
Defect Map			
Total D.D. (/cm^2)	4.99	1.18	0.74 (259 ea.)
Bottom-bridge	4.03	0.67	0.03 (9 ea.)

Under-Layer : B @10nm-FT
: C @20nm-FT
Resist : A @50nm-FT
B @50nm-FT

Target CD : 32nm-hp
Exposure : Conv. NA 0.25
Dose : A 10.8mJ/cm^2
B 12.1mJ/cm^2

Die size : 26x33mm
(71 Dies)
Inspection : 55 Dies



◆ "Bottom-bridge" ; 0.03/cm^2 defect density was achieved.

Defect Classification

	Resist A	Resist B	
	Under Layer C		Under Layer B
Bridge	FOV : 337.5nm	FOV : 337.5nm	FOV : 337.5nm
D.D. (/cm²)	0.93	0.38	0.54
Micro-bridge			
D.D. (/cm²)	0.03	0.13	0.17
Bottom-bridge			
D.D. (/cm²)	4.02	0.67	0.03

Under-Layer : B @10nm-FT
: C @20nm-FT
Resist : A @50nm-FT
B @50nm-FT

Target CD : 32nm-hp
Exposure : Conv. NA 0.25
Dose : A 10.8mJ/cm^2
B 12.1mJ/cm^2

Die size : 26x33mm
(71 Dies)
Inspection : 55 Dies
SEM Review : Random 200defects

- "Bottom-bridge" was reduced by Resist B.
- "Bottom-bridge" was significantly reduced by Under Layer B.

LWR : Hard Baking and Surfactant Rinse

Process	POR	Hard Baking	Surfactant Rinse	Surfactant Rinse / Hard Baking
SEM Image				
LWR (nm)	4.16	3.95	4.06	3.98
Improvement rate	--	5.09%	2.44%	4.34%
CD (nm)	33.16	33.29	34.23	34.28

Under-Layer : C @20nm-FT
Resist : D @50nm-FT

Target CD : 32nm-hp
Exposure : Conv. NA 0.25
Dose : 27.0mJ/cm^2

Die size : 26x33mm (71 Dies)
Measurement : 284points (4points/Die)

- **Hard baking process has a small impact for LWR improvement.**
- **Surfactant rinse process has also a small impact for LWR.**

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LWR : Additional Annealing Process

Resist	Resist C		Resist B	
Process	Initial	Additional	Initial	Additional
SEM Image				
LWR (nm)	5.70	4.37	5.62	5.25
Improvement rate	--	23.33%	--	6.58%
CD (nm)	35.88	37.17	35.32	35.70

- Additional annealing process has a big impact for LWR, 23% improvement on Resist C.
- Additional annealing process has a different effect depended on resist types.

Under-Layer : C @20nm-FT
Resist : B @50nm-FT
C @50nm-FT

Target CD : 32nm-hp
Exposure : Conv. NA 0.25
Dose : B 12.1mJ/cm^2
C 13.1mJ/cm^2

Die size : 26x33mm (71 Dies)
Measurement : 284points (4points/Die)

Conclusions

- **Coating stability**
  - ✓ Excellent stability was confirmed.
- **CD uniformity**
  - ✓ L/S 27nm :3sigma 0.56nm was achieved.
  - ✓ C/H 30nm :3sigma 0.91nm was achieved.
- **Defectivity**
  - ✓ "Bottom-bridge" was significantly improved by Under-Layer B.
  - ✓ "Bottom-bridge" Defect density of 0.03/cm^2 was achieved.
- **LWR improvement**
  - ✓ Hard baking and Surfactant rinse process have a small impact for LWR improvement.
  - ✓ Additional annealing process has a big impact for LWR, 23% improvement on Resist C.
- **Future**
  - ✓ "Bridge" reduction
  - ✓ LWR improvement using Additional annealing process on Resist D.

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