LWR Improvement on EUV Track System

Masahiko Harumoto,
****Harold Stokes, *Yan Thouroude, Yuji Tanaka,***
Koji Kaneyama, Charles Pieczulewski and Masaya Asai

SCREEN Semiconductor Solutions CO., LTD.
**** SCREEN SPE Germany GmbH***

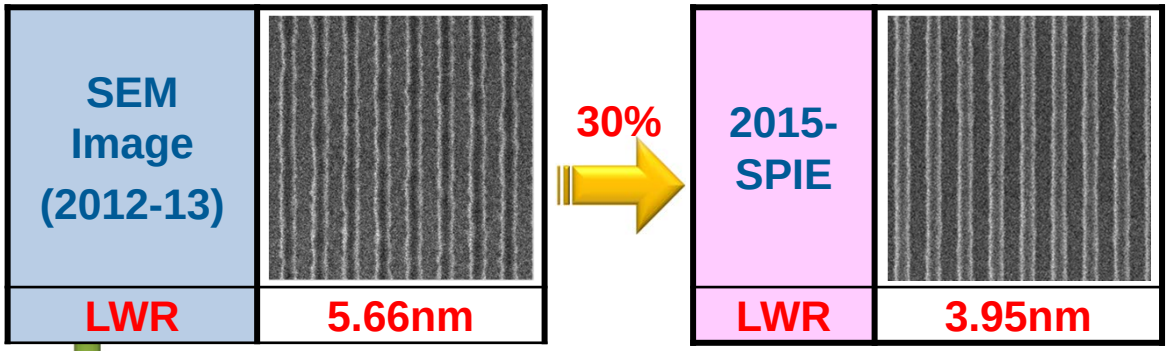
Poster Session : P-IM-02
International Symposium on Extreme Ultraviolet Lithography 2015
Monday, October 5, 2015
Maastricht, The Netherlands

SCREEN

Outline

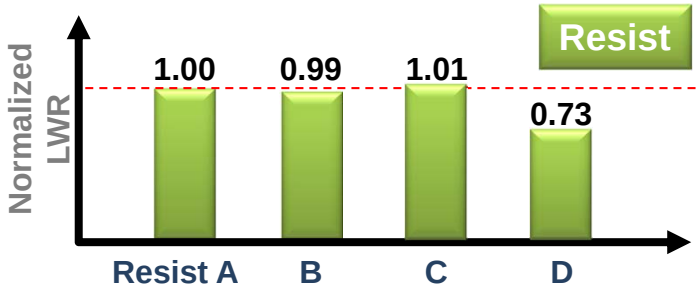
- **Background ~Previous improvements~**
- **Goal**
- **Experimental**
- **Results and Discussions**
  - ✓ Baseline LWR with NA 0.33
  - ✓ LWR for each pattern pitch
  - ✓ Chemical cure effect with 22nm-hp
  - ✓ Chemical cure effect with 32nm-hp
  - ✓ Progress of LWR improvements
- **Summary**

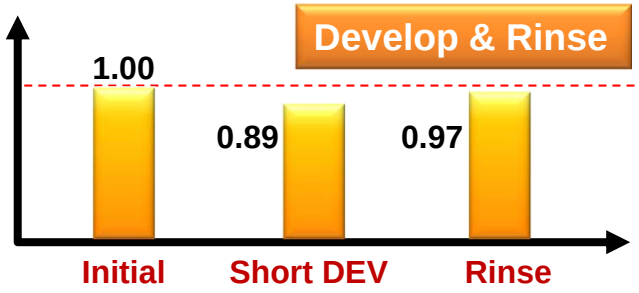
Background ~Improvement Learning~

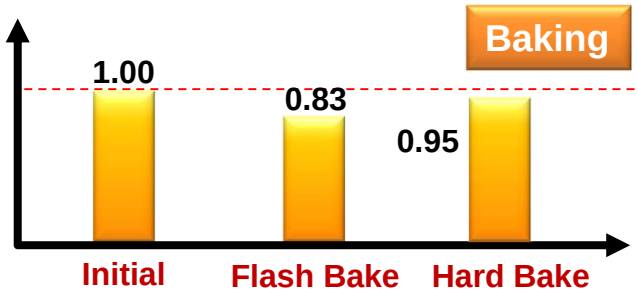


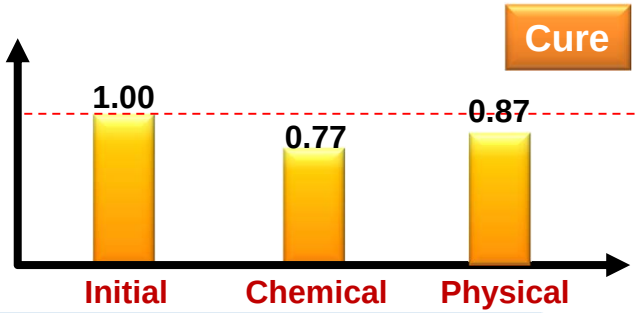
- ✓ Materials → Resist
- ✓ Process → Develop & Rinse
- Process → Baking
- Process → Cure

Resist : A@50nm-FT (Left)
B@50nm-FT(Right)
Target CD : 32nm L/S
Exposure : Conv. NA 0.25
Dose : A 10.8mJ/cm² B 27.0mJ/cm²









- **30% LWR improvement compared with 2013.**
- **Chemical and Physical Cure was effective in some cases.**

Goal

- **LWR Improvement for manifold EUV Track Processes**
  - ✓ Baseline LWR with NA 0.33
  - ✓ Multiple pattern pitches
  - ✓ Single or combined approach

Experimental

♦ Tools

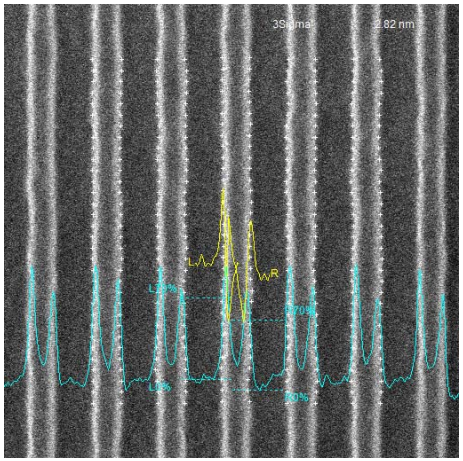
- ✓ Exposure tool: NXE:3100 / NXE:3300
- ✓ Track : SOKUDO DUO
- ✓ CD-SEM : CG5000 (Hitachi High-Tech.)

♦ Materials

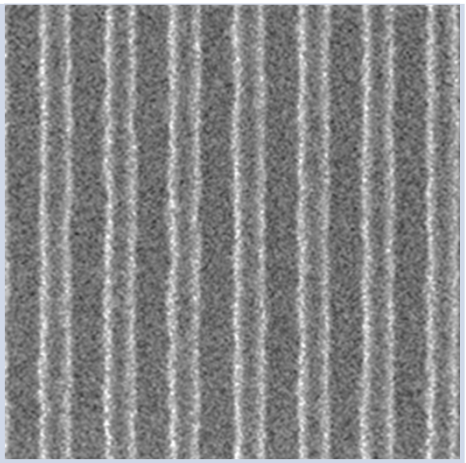
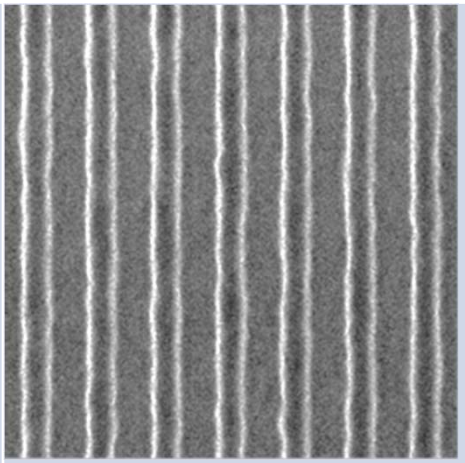
Under Layer	**EUV Under Layer A @20nm-FT**
Resist	**EUV Resist A @ 50nm-FT (32nm-L/S)** **EUV Resist B @ 50nm-FT (32nm-L/S)** **@ 40nm-FT for NXE:3300 (22nm-L/S, 32nm-L/S)**
Developer	**TMAH 2.38wt%**

♦ Measurement Condition

- ✓ Magnification : 300k
- ✓ FOV : 450nm x 450nm
- ✓ Measurement Point : 32
- ✓ Sum Lines / Point : 16
- ✓ Method : Threshold
- ✓ Smoothing : 7
- ✓ Differential : 5
- ✓ Search Area : 400

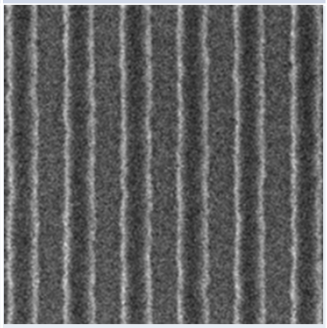
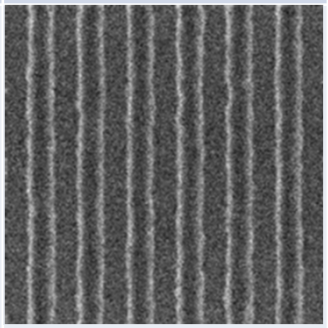
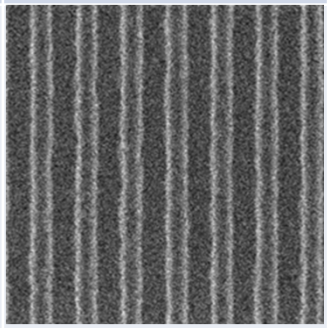
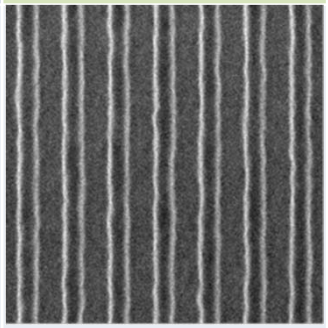
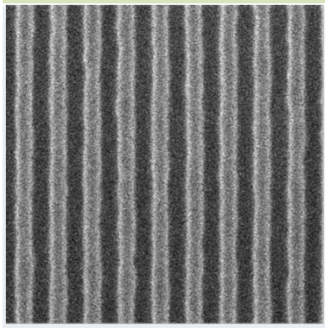


Baseline LWR with NA 0.33

Exp. Tool	NXE:3100	NXE:3300
SEM Image		
LWR (nm)	4.20	3.26
CD (nm)	33.70	30.32

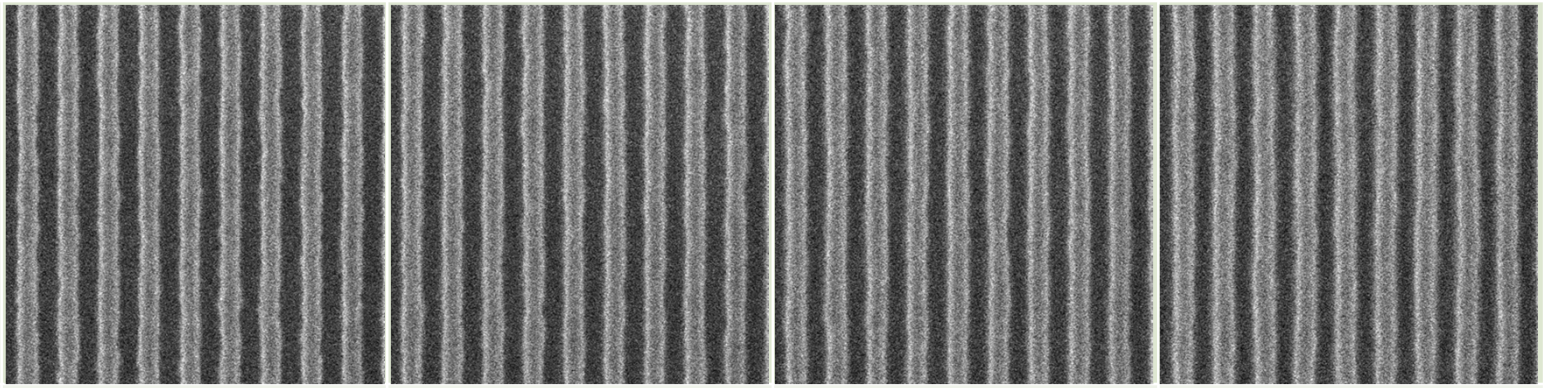
- **LWR was improved about 20% by NA 0.33, even though the resist film thickness and the reticle were different.**

Multiple pattern pitches

Exp. Tool	NXE:3100			NXE:3300	
Half pitch	**40nm**	**35nm**	**32nm**	**32nm**	**22nm**
SEM Image					
LWR (nm)	4.01	4.16	4.20	3.26	3.17
CD (nm)	41.17	37.52	33.70	30.32	22.91

- **LWR for each pattern pitch was almost all the same, slightly better with larger pitch.**
- **LWR was significantly improved about 20% with NXE:3300, even 22nm-hp.**

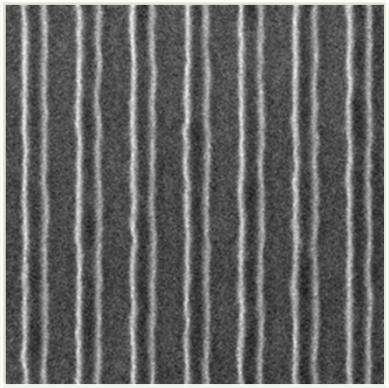
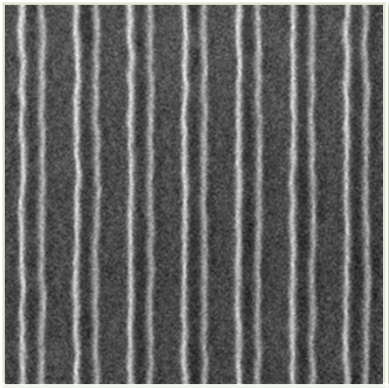
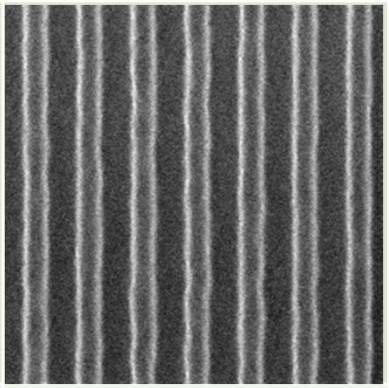
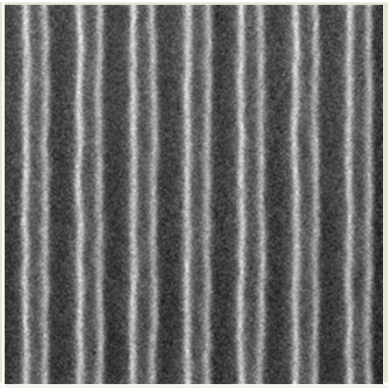
Chemical Cure Improvement – 22nm HP

Process	Initial	Condition 1 (soft)	Condition 2 (middle)	Condition 3 (strong)
SEM Image				
LWR (nm)	3.17*	2.91	2.91	2.80
Improvement rate	--	7.8%	8.2%	11.6%
CD (nm)	22.91*	22.94	23.28	24.28

*Mean value of 6 wafers.

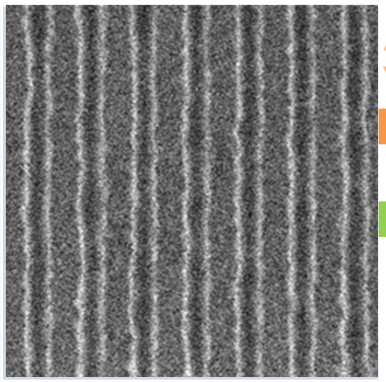
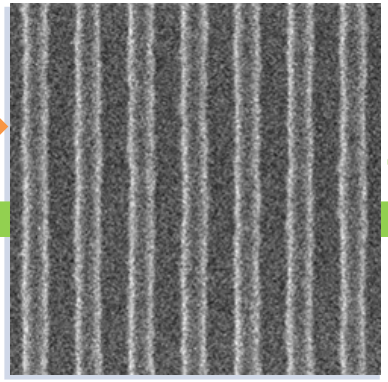
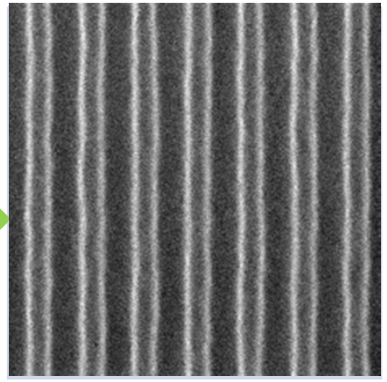
- **Chemical cure process was effective for LWR improvement, about 11%.**
- **Stronger conditions for chemical cure resulted in better LWR.**

Chemical Cure Improvement – 32nm HP

Process	Initial	Condition 1 (soft)	Condition 2 (middle)	Condition 3 (strong)
SEM Image				
LWR (nm)	3.26	3.21	3.03	2.90
Improvement rate	--	1.7%	7.3%	11.0%
CD (nm)	30.32	30.67	30.91	33.48

- **Chemical cure process was still effective for LWR improvement, about 11%, with the larger pattern pitch.**
- **Stronger conditions for chemical cure resulted in better LWR.**

LWR Improvement Timeline

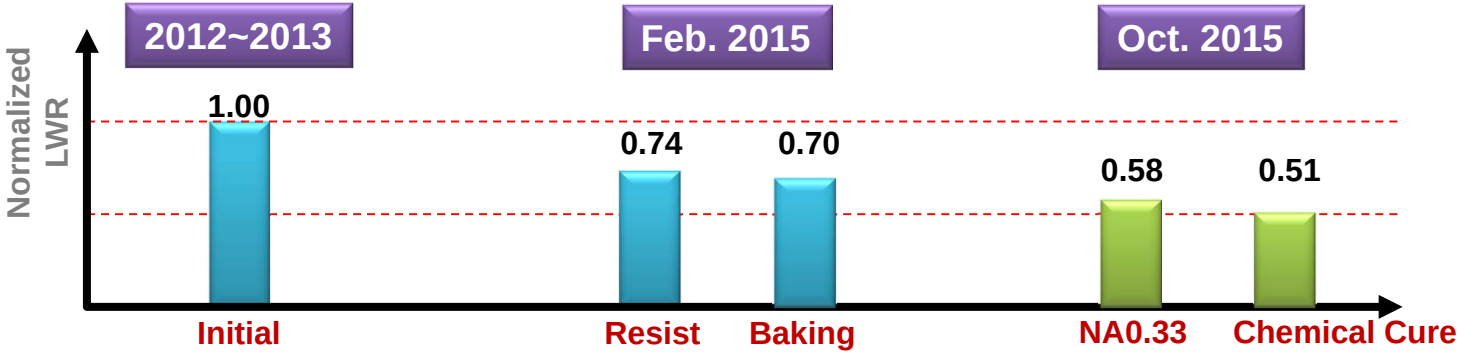
Date	2012~13	Feb. 2015	Oct. 2015
Sample SEM Image			
LWR (nm)	5.66	3.95	2.90

30%

49%

✓ Materials
✓ Baking

✓ NA 0.33
✓ Cure process



◆ **About 50% improvement compared with 2012. Materials and Exposure tool were big improvement. Also better LWR was obtained by EUV Track process.**

SCREEN

Summary

- ***50% improvement (5.7nm → 2.8nm) compared with 2012.***
- ***Baseline LWR with NA 0.33***
  - ✓ LWR was improved about 20% by NA 0.33, even though the resist film thickness and the reticle were different.
- ***LWR for each pattern pitch.***
  - ✓ LWR for each pattern pitch was almost all the same, slightly better with larger pitch.
- ***Effect of Chemical cure process.***
  - ✓ Chemical cure process was effective for LWR improvement, about 11%.
  - ✓ Stronger condition of Chemical cure process had better LWR.
- **Next Test**
  - ✓ LWR analysis of high and low frequency
  - ✓ Physical cure for 22nm


SCREEN