Electron Beam Mask Writer EBM-9500PLUS for logic 7nm+ node generation

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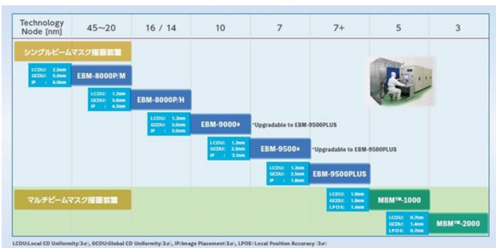
NuFlare's EB mask writer roadmap

- *Full production lineup is ready for sales.*



Motivation for development

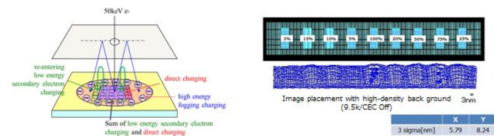
- Target technology Node: 7 nm+
- Key development: Improvement of Image Placement error

	EBM-8000P/M	EBM-8000P/H	EBM-9000	EBM-9500	EBM-9500PLUS
Technology node	45-20nm	14/16nm	10nm	7nm	7nm+
Current density [A/cm^2] (Total current[nA])	400 (1000)	400 (490)	800 (500)	1200 (750)	1200 (750)
Max shot size [nm]	500	350	250	250	250
LCD* [3σ]	2.5nm	1.3nm	1.3nm	1.3nm	1.3nm
IP [3σ]	6nm	4.3nm	3.0nm	2.1nm	*1.8nm***
Writing time[H]***	12.0	12.0	6.5	6.0	6.0

**Shot noise (resist sensitivity) is dominant.*
***NFT high density layout*
***Full mask writing time*

Problem statement for Image Placement error

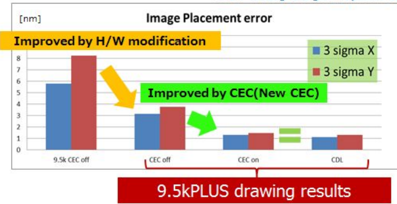
- Resist charging is dominant error source for image placement error.
  - NuFlare's mask writer use Charging Effect Correction (CEC) S/W to compensate resist charging error.
    - Correction residual error is error source for position accuracy. (Especially for complex patterns)
- Components of resist surface charging
  - Direct charging
  - Fogging charging
  - Re-entering low-energy secondary electron charging



Charging Effect Reduction (CER)

- CER technology was developed for EBM-9500PLUS.
  - H/W modification : To reduce fogging charging
  - New CEC model : To compensate re-entering low-energy secondary electron charging

CER achieves image placement performance equivalent to CDL results.
**CDL : Coating Charge Dissipation Layer*



Global image placement with low-density layout

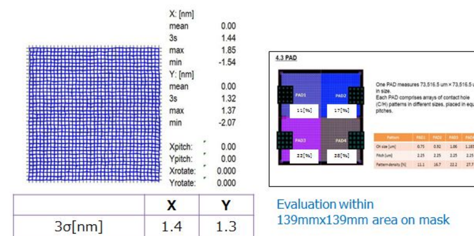
- Achieved EBM-9500PLUS standard specification. (1.8[nm])

Image placement	#1		#2		#3	
	X	Y	X	Y	X	Y
3σ[nm]	1.4	1.2	1.3	1.3	1.4	1.1

Mask to Mask Overlay	#1 - #2		#2 - #3		#3 - #1	
	X	Y	X	Y	X	Y
3σ[nm]	1.2	1.1	1.2	1.2	1.1	1.1

Global position with high-density layout

- 4 different density pads are placed in global.
- Achieved EBM-9500PLUS standard specification (1.8[nm])

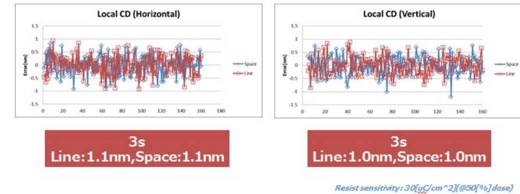


	X	Y
3σ[nm]	1.4	1.3

Evaluation within 139mmx139mm area on mask

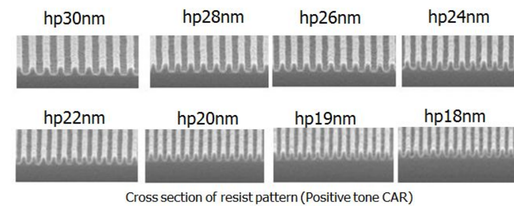
Local CD accuracy

- Evaluation by 120nm width space in local area on mask.
- Line : measurement between exposed lines.
- Space : measurement on exposed line.
- Achieved EBM-9500PLUS standard specification. (1.3[nm])



Patterning resolution

- ***Less than 30[nm] were resolved.***



Cross section of resist pattern (Positive tone CAR)

Conclusion

- **We developed EBM-9500PLUS for 7nm+ tn generation.**
  - **Charging Effect Reduction (CER) technology is newly introduced to improve Image Placement error with high-density layouts.**
    - **CER achieves image placement performance equivalent to CDL performance.**
- **Nuflare confirmed performance of EBM-9500PLUS.**
  - **EBM-9500PLUS meets standard specification.**
    - **Local CD : 1.3[nm]**
    - **Global IP with high-density layouts : 1.8[nm]**
- **Released for sale on Oct, 2018.**

NuFlare Technology,Inc.