Limitation of the Acid Diffusion Length in Extreme Ultraviolet Lithography

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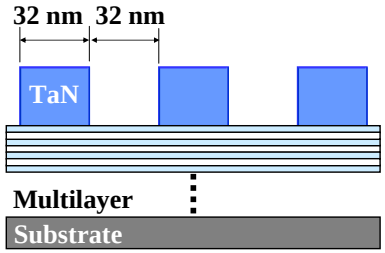
Introduction

- ❖ EUV resist is one of the biggest problems in EUV process.
- ❖ The acid diffusion length is a very important factor to make desired line width and control.
- ❖ The desired small line width roughness and line edge roughness can not be made without proper control of the acid diffusion length.
- ❖ The diffusion length should be smaller than 12 nm in order to make 1:1 32 nm half pitch.
- ❖ The influence of the flare in EUV system is known to be very serious.
- ❖ Flare must be less than 10% to make 32 nm patterns.
- ❖ We compared the effect of flare and diffusion length for line width control and found the diffusion length control is more important than the reduction of the flare.

Simulation Condition



32 nm L/S pattern

▪ Material information (at 13.4 nm)

	Material	Thickness (nm)	*n*	*k*
Mo/Si (40 pair)	Mo	2.8	0.925356	0.0062201
	Si	4.2	0.9820859	0.0144074
Absorber	TaN	50	0.9272114	0.0429262
Resist	EUV-2D	80	-	-

▪ Resist Dill parameter

Refractive Index *n*	0.9765
Dill parameter A (1/㎛)	0
Dill parameter B (1/㎛)	5.1851
Dill parameter C (cm^2/mJ)	0.195

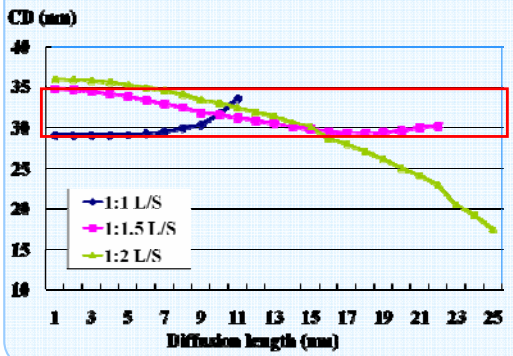
▪ Develop parameter

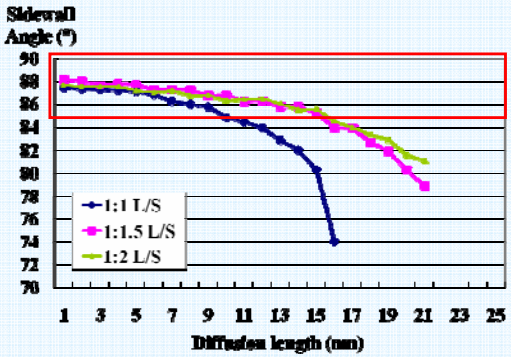
R_{max}	451.2 nm/s
R_{min}	0.15 nm/s
M_{th}	0.55
N	9.2

Diffusion Length

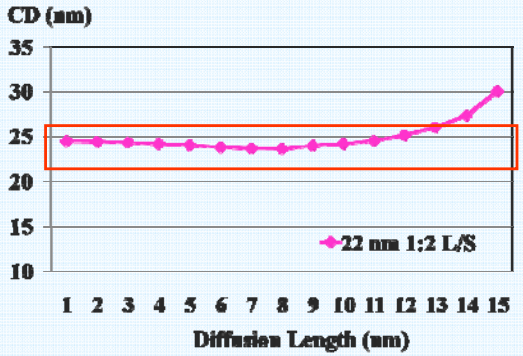
▶ Diffusion Length vs. Pitch

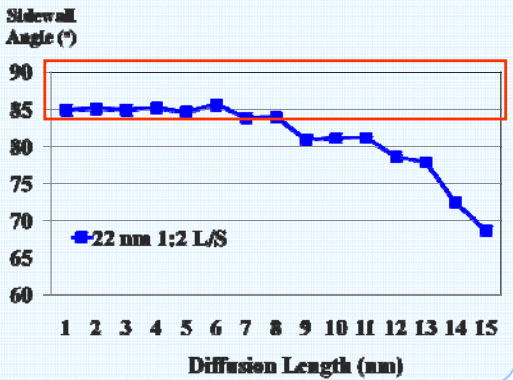
32 nm Line & Space





22 nm Line & Space

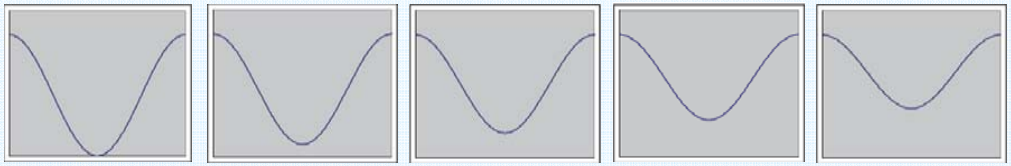




Flare

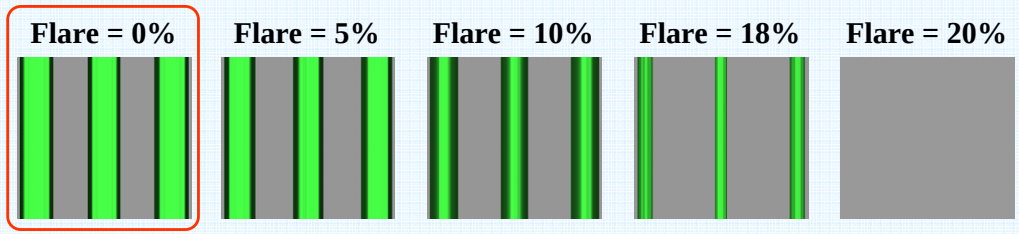
❖ Aerial image

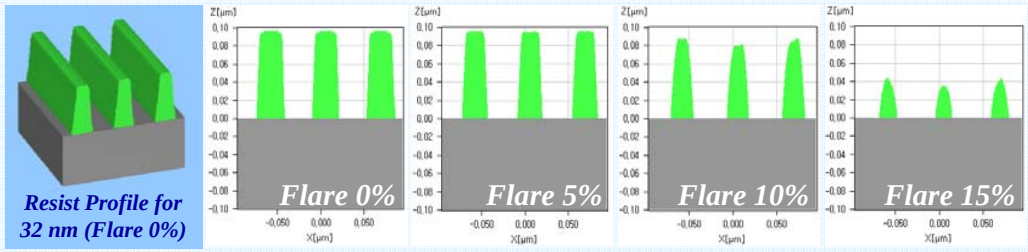
"EUV Resist Performance under High Stray Light Levels: an Interference Lithography Study", StudyRoel Gronheid, 2006 EUVL Symposium 2RE05



Flare = 0%, NILS = 3.1	Flare = 10%, NILS = 2.6	Flare = 20%, NILS = 2.1	Flare = 30%, NILS = 1.7	Flare = 40%, NILS = 1.3

❖ Photoresist top-view

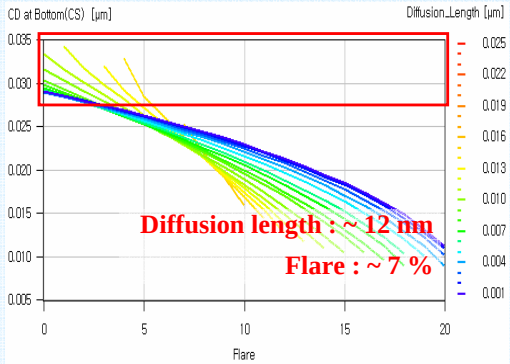




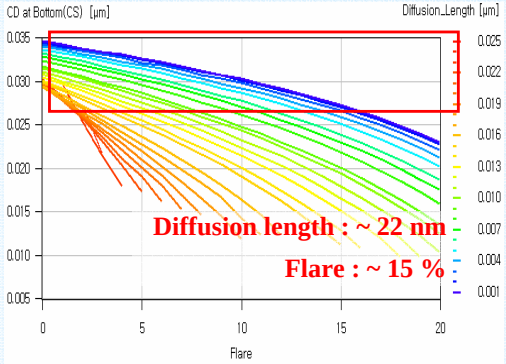
- When the flare increases, the contrast goes down.
- Flare affects the resist profile (Increased top-loss, footing and LER).
- Flare must be under 10 % for the 32 nm and 22 nm pattern.

Diffusion Length vs. Flare

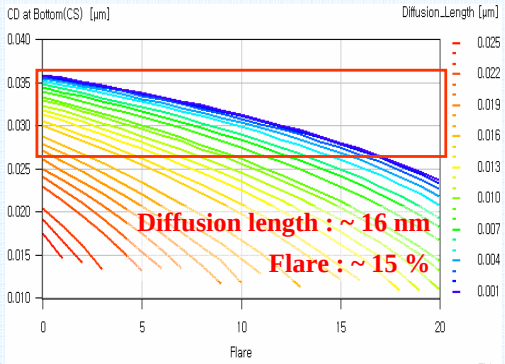
- 1:1 LS pattern



- 1:1.5 LS pattern



- 1:2 LS pattern



- If the diffusion length is under 10 nm, the pitch and flare dependency can be minimized
- Maximum allowable diffusion length:
  - 32 nm LS : 1:1 LS (~ 12 nm)
    1:1.5 LS (~22 nm)
    1:2 LS (~16 nm)
  - 22 nm LS : 1:2 LS (~ 8 nm)

Conclusion

❖ The typical diffusion length (under 20 nm) of currently available CAR makes it difficult to pattern 32 nm LS.

❖ Maximum allowable diffusion length is different by the pitch.

❖Decrease of the diffusion length is more important than the flare reduction.

❖ We need to make EUV resist which has smaller diffusion length.

Acknowledgment

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