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Factors of Optical Proximity Correction in EUV Lithography

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Abstract

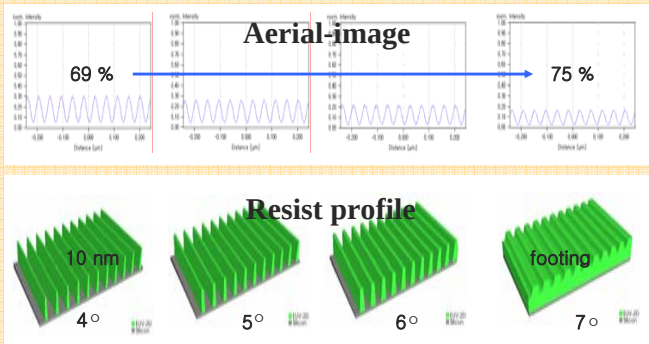
❖ Extreme UV that has 13.4 nm wavelength is assumed to be one of the best lithography candidates for making half pitches of 32 nm and below.

❖ One of the EUV issues is whether we need to use optical proximity correction (OPC), and how we do OPC if we need it.

❖ The line widths and positions for vertical and horizontal (including other directions) patterns are different due to shadow effect of EUV mask.

❖ We studied when OPC is needed and how OPC can be applied.

EUVL : Incident angle



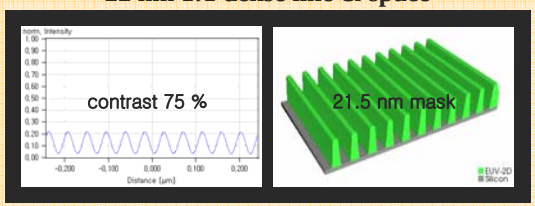
Aerial image and resist profile as a function of incident angle.

Incident angle	CD (nm)	Sidewall Angle
4	10	86
5	14	85
6	22	84
7	footing	

Patterning Analysis

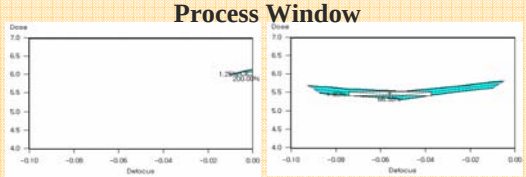
1. OPC

22 nm 1:1 dense line & space



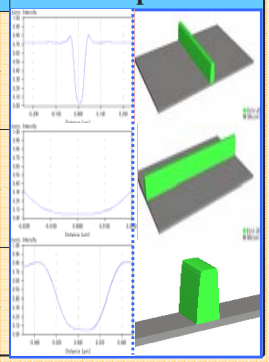
1:1 dense Line & space pattern	Mask OPC	dose
	5.29 mJ/cm^2 21.5 nm mask	5.579 mJ/cm^2 22 nm mask

Process Window



Over Dose Mask OPC

Direction	22 nm mask	Mask OPC	Resist profile
Vertical	18 nm	25.5 nm biased mask → 22 nm	
Horizontal	15 nm	29.5 nm biased mask → 22.2 nm	
45 degree	16 nm	28 nm biased mask → 22 nm	

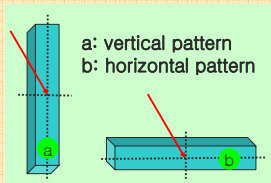


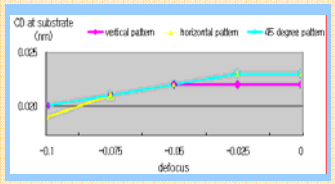
6 degree incident angle make a shadow effect.

Shadow effect makes several problems.

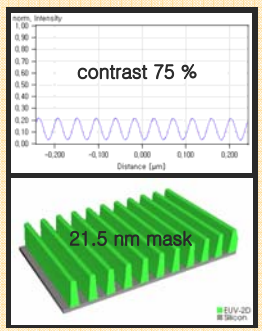
There is a difference in pattern direction; vertical, horizontal and 45 degree pattern.

We need different bias due to different direction.

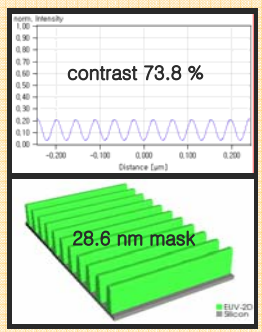




Vertical pattern



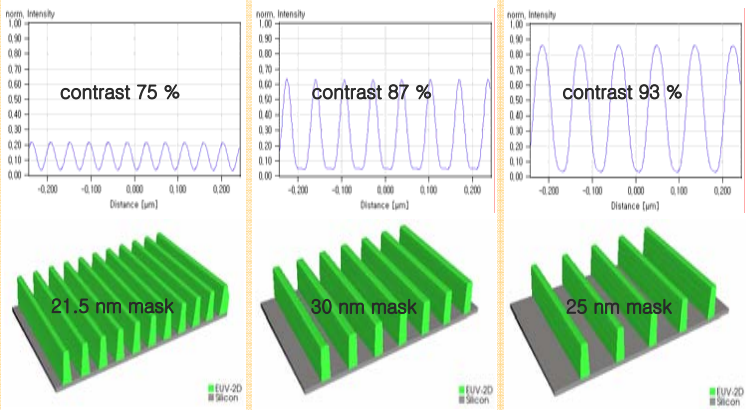
Horizontal pattern



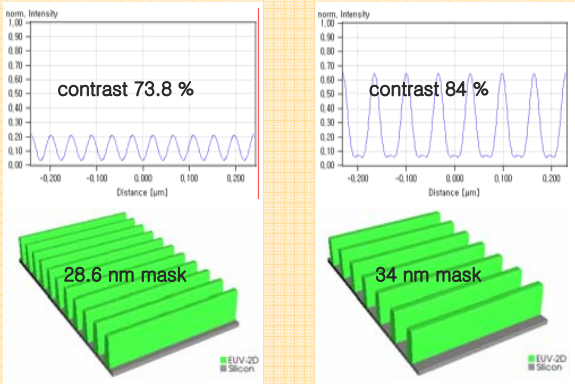
Patterning Analysis

2. Pitch

Circle Illumination = 1:1/1:2/1:3 “vertical pattern”



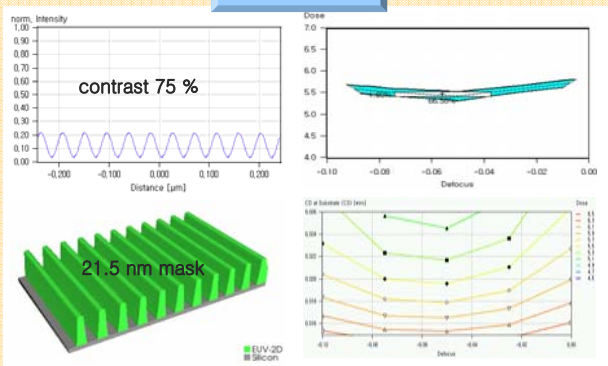
Circle Illumination = 1:1/1:2/1:3 “horizontal pattern”



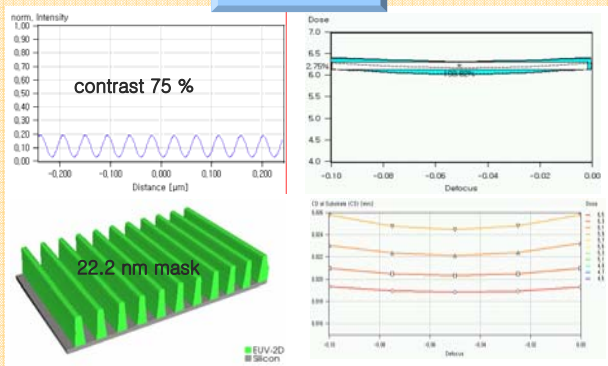
3. Pattern Profile : Circle & Annular

Incident angle (degree)	Multilayer Reflectivity (%)	Shadow Effect	Real Experiment (%)
6	73.10	⇩ Increase	66
...			?
12	57		

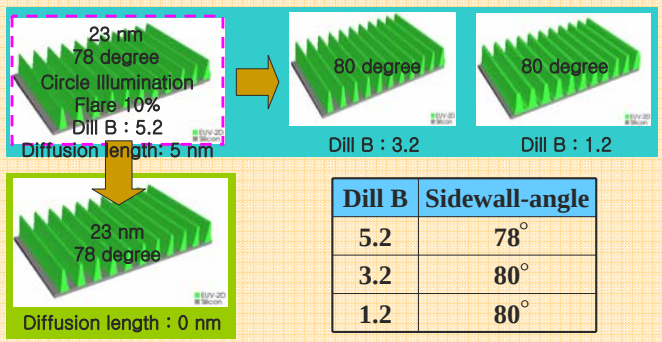
Circle



Annular

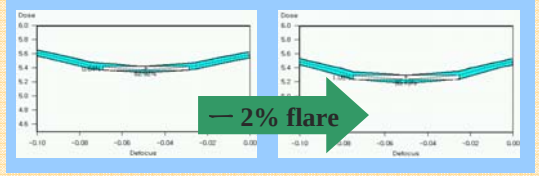


6. Flare Patterning : Dill B & Diffusion length



Dill B	Sidewall-angle
5.2	78°
3.2	80°
1.2	80°

Process Window



Less flare increase process window.

There is no difference between 5 and 0 nm of diffusion length.

Summary

- People thought OPC is not needed for EUV because EUV wavelength of 13.4 nm is much shorter than pattern size.
- OPC might be needed due to pattern direction and pitch.
- We compared circle illumination with annular illumination and confirmed the difference.

Acknowledgments

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