Etched multilayer mask in EUV lithography for 22nm node and below

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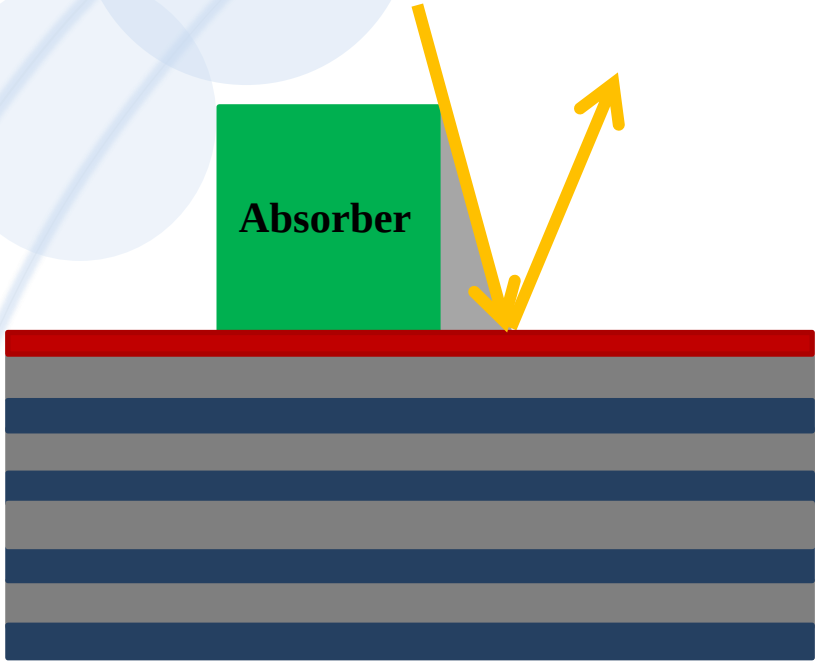
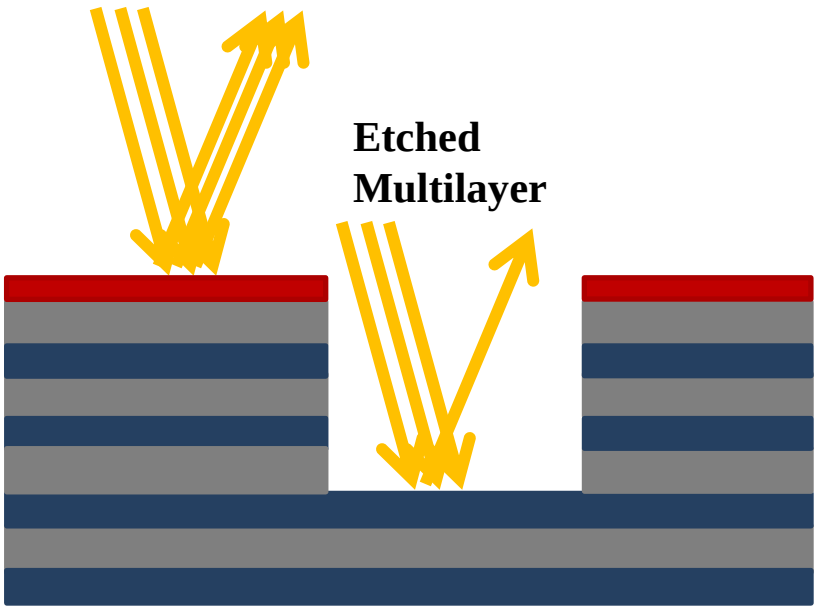
Introduction

- Binary absorber stack



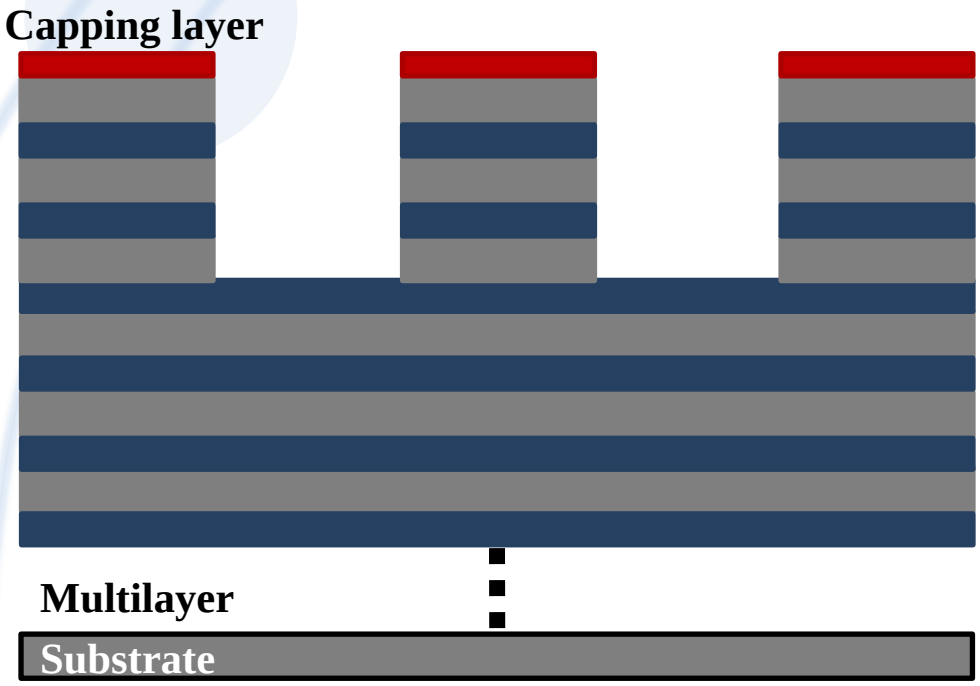
- Etched multilayer



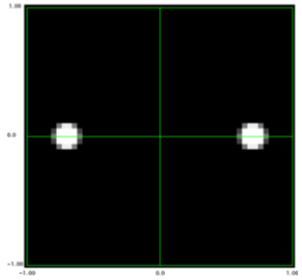
A conventional absorber stacked EUV mask is believed to be widely used for EUV mass production. However, we found that an etched multilayer type mask could give benefits to the smaller patterns of 16 nm node.

Simulation Condition

- **Mask structure (Line/Space Pattern)**



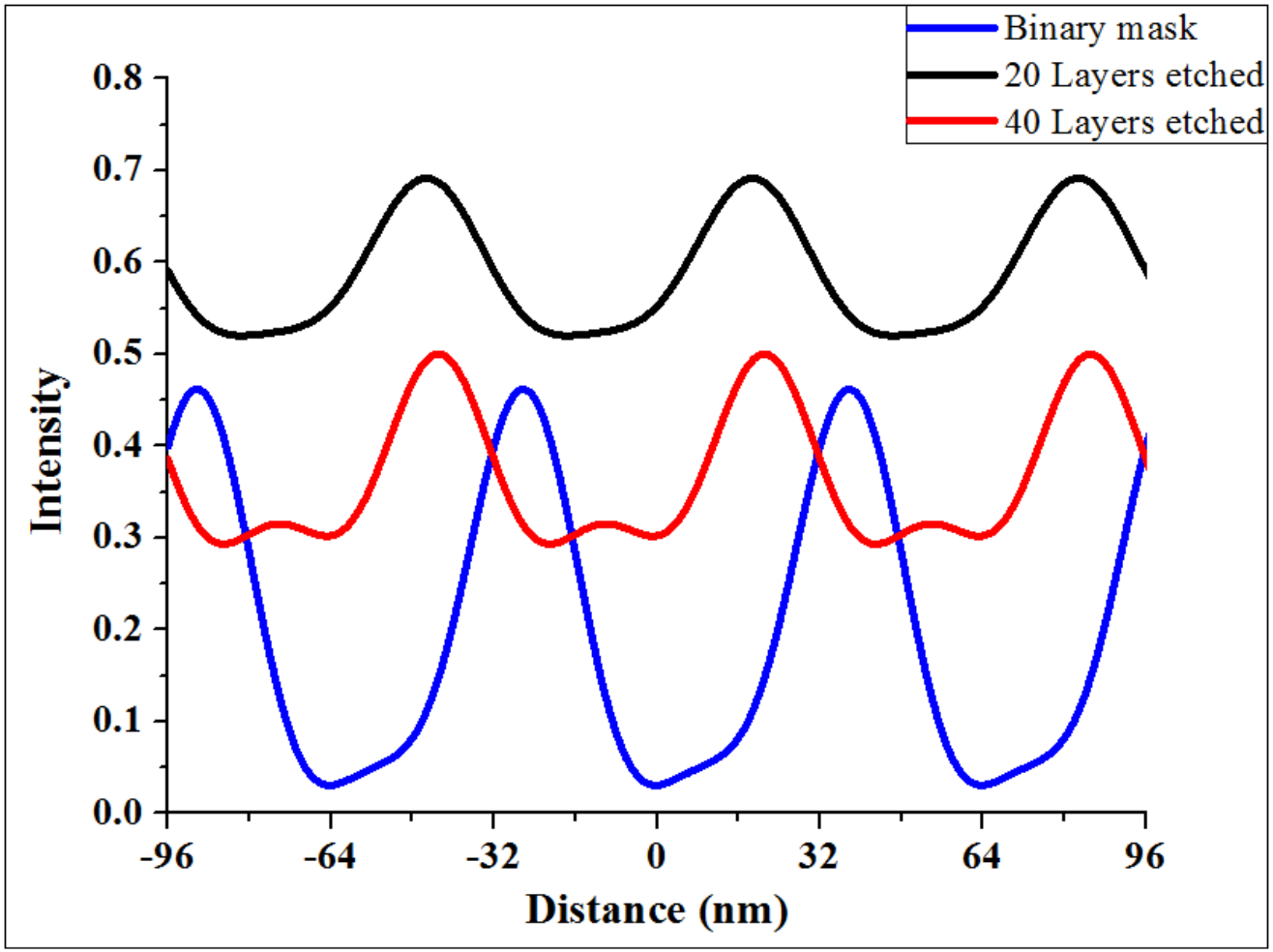
- **Exposure condition**

Illumination shape	 **<Dipole>**
Coherence (σ)	**0.1(σ_r)_0.7(σ_c)**
Wavelength (nm)	**13.5**
NA	**0.33**
Incident Angle	**6°**
Etching depth (layers)	**20, 40 (70, 140 nm)**

Sentaurus Lithography (synopsys)

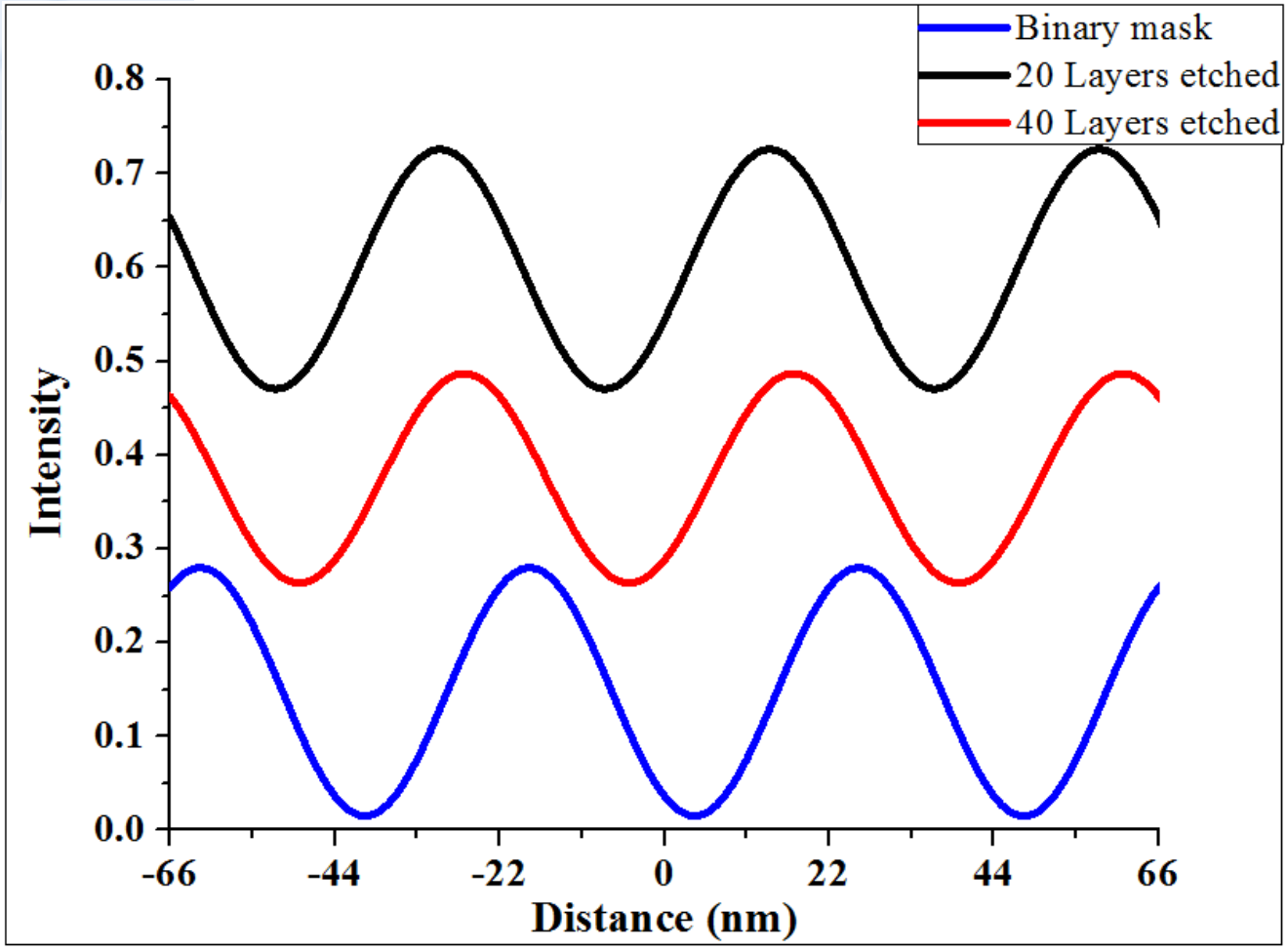
Simulation Results I

- **Aerial images for 32 nm node**



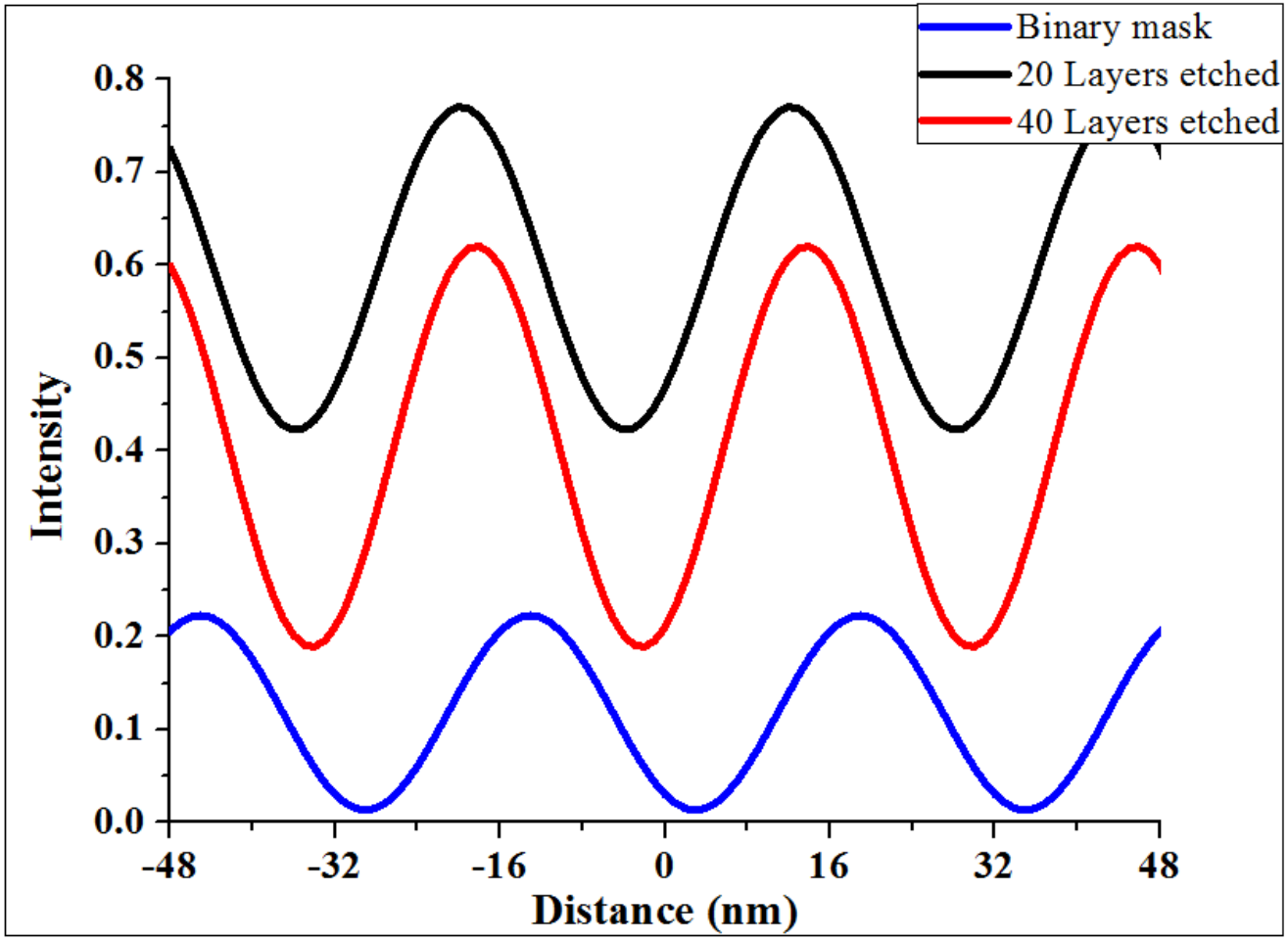
Simulation Results I

- **Aerial images for 22 nm node**



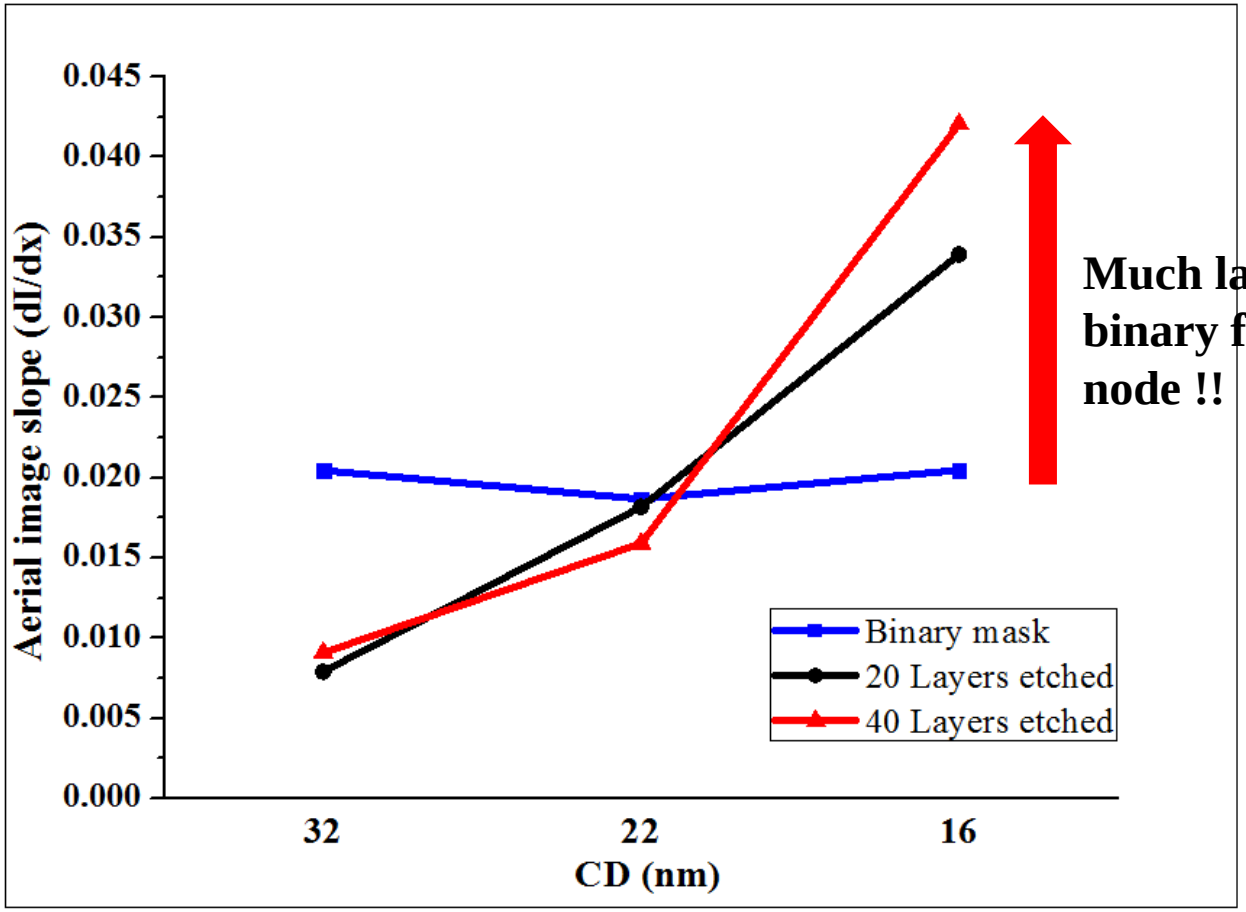
Simulation Results I

- **Aerial images for 16 nm node**



Simulation Results I

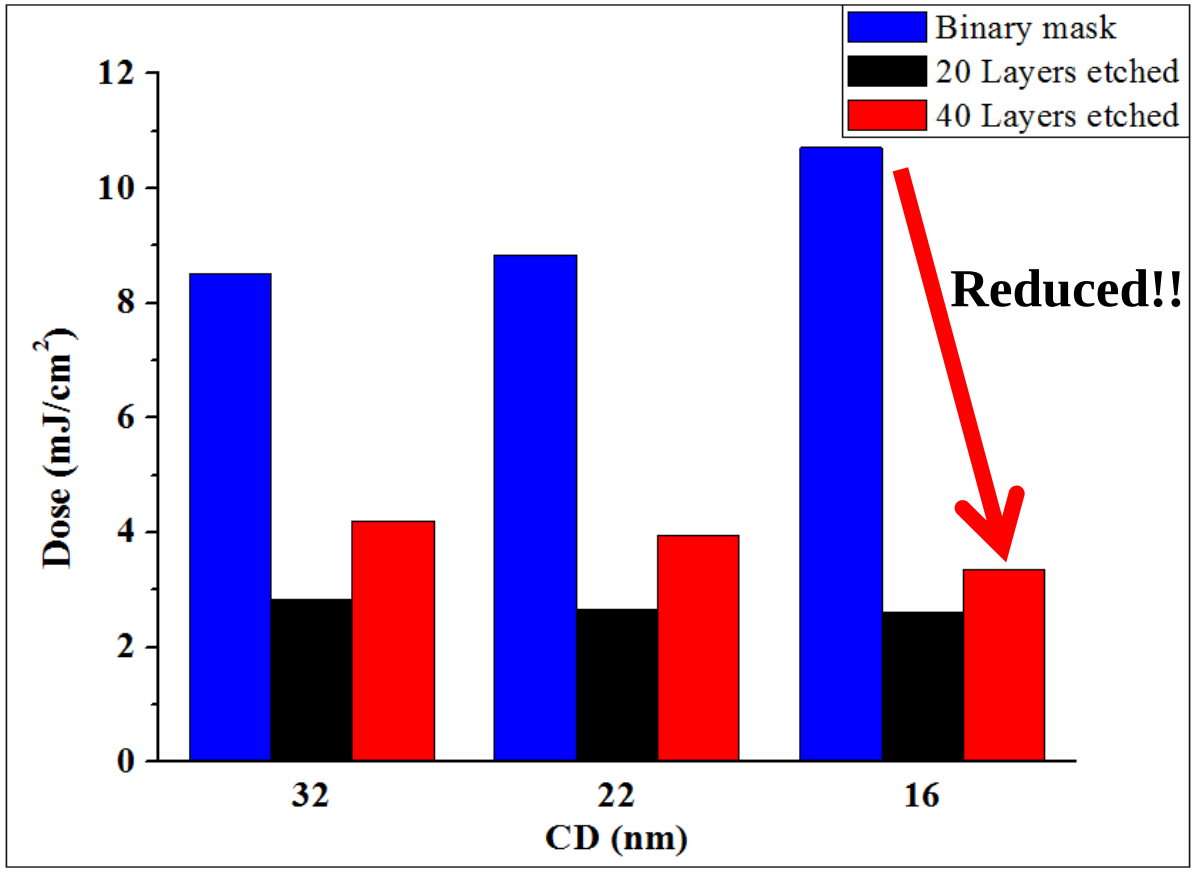
- **Aerial image slopes**



The aerial image slopes at the pattern edge is compared.

Simulation Results II

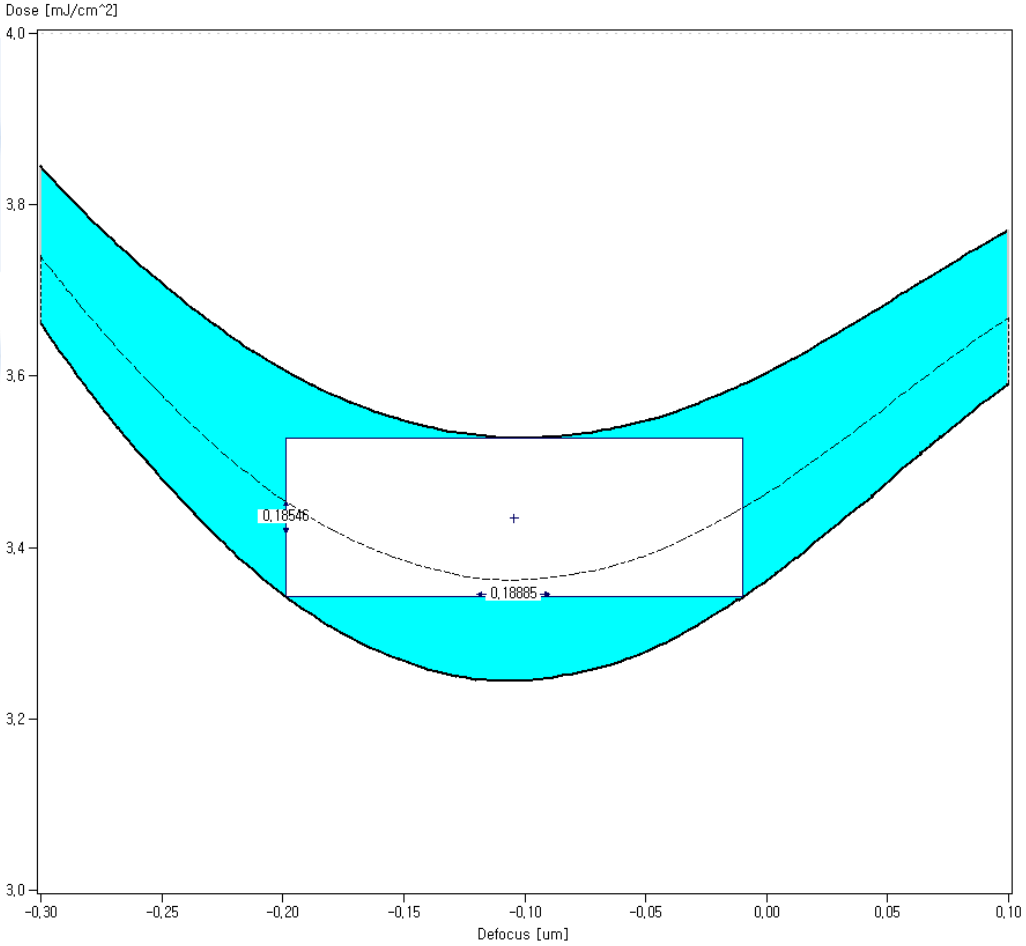
- **Dose-to-size**



The needed source power can be reduced down to ¼ of the suggested source power at 16 nm node.

Simulation Results II

- **Process window**



We checked the process window of the etched mask. For 16 nm node, it showed good process window of

DOF = 190 nm
EL = 8.4%

Conclusion

- We revisited an etched mask for 22 nm node and below for better EUV process.

- For 32 nm, the aerial image of conventional binary mask is better than those of the etched mask. However, for 16 nm, the aerial image of 40 Mo/Si multilayer etched mask is much better than that of the conventional binary mask.

- The slopes of etched masks are larger than those of absorber stacked masks so that line width control would be better for 16 nm node.

- More importantly, the dose to size of an etched mask is much smaller than that of an absorber stacked mask. This can be very good news since people are struggling to increase the source power.