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Study on Photo-chemical Analysis System for EUV Lithography

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Outline

1. Introduction
2. The construction of the system
3. Experiment and result
4. Simulation
5. Conclusion

Introduction

A system for photo-chemical analysis of EUV lithography processes has been developed. This system has consists of 3 units: (1) an exposure that uses the Z-Pinch discharge-excitation plasma EUV Light source (Energetiq Technology Inc.) to carry out a flood exposure, (2) a measurement unit for the development rate (RDA) of photo-resists (LTJ), and (3) a simulation unit that utilizes PROLITH (KLA-Tencor) to calculate the resist profiles and process latitude using the measured development rate data. With this system, preliminary evaluation of the performance of EUV lithography can be performed without any lithography tool that is capable of imaging and alignment.

Profiles for 32 nm lines are simulated for the Posi-2 resist. Those resist that has sensitivity 8.75mJ/cm^2 (Eth_{60}) at the 13.5nm wavelength.

The simulation successfully predicts the resist behavior. Thus it is confirmed that the system enables efficient evaluation of the performance of EUV lithography processes.

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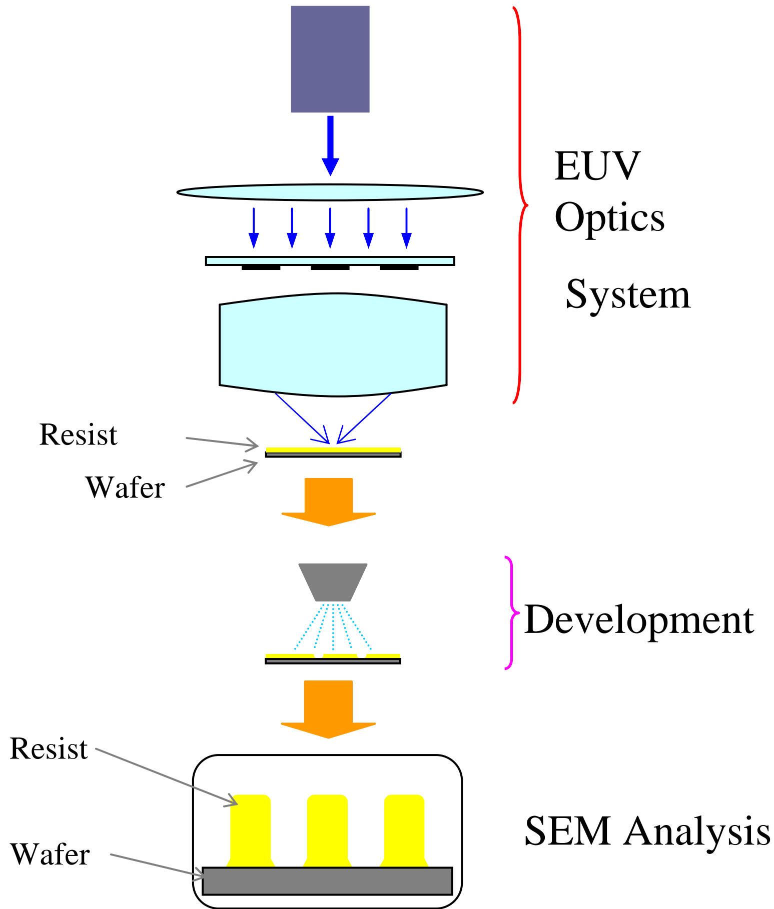
The construction of the system



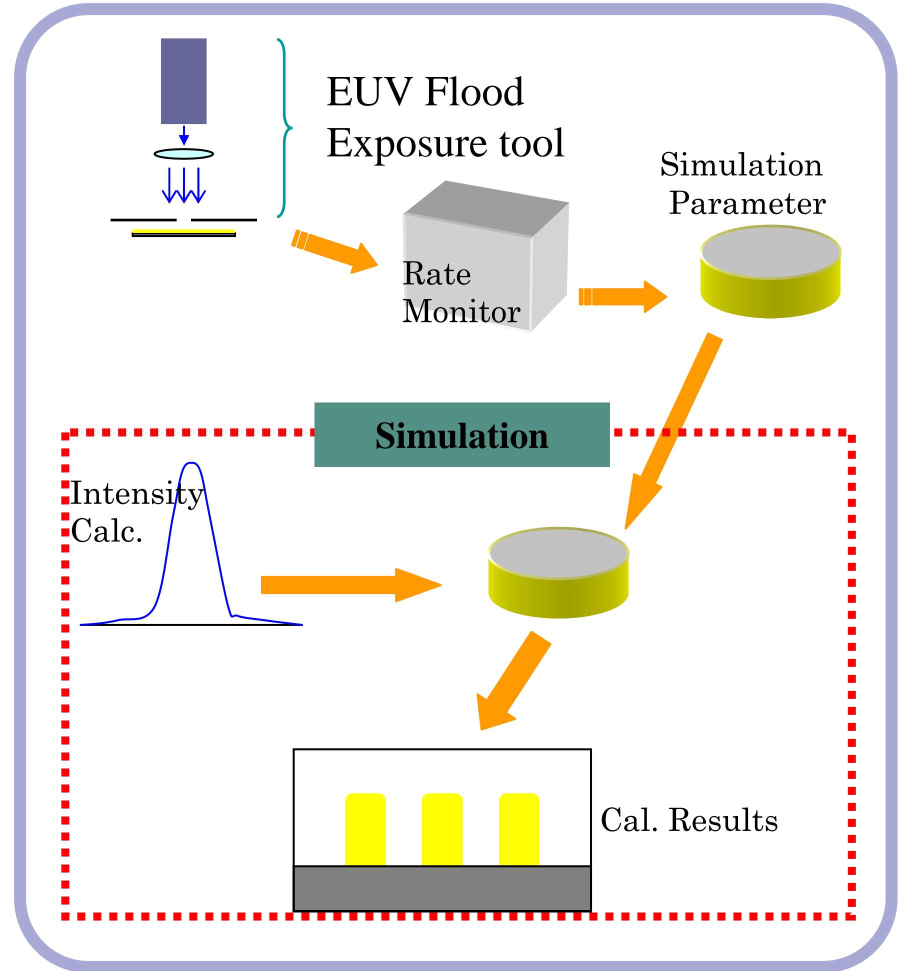
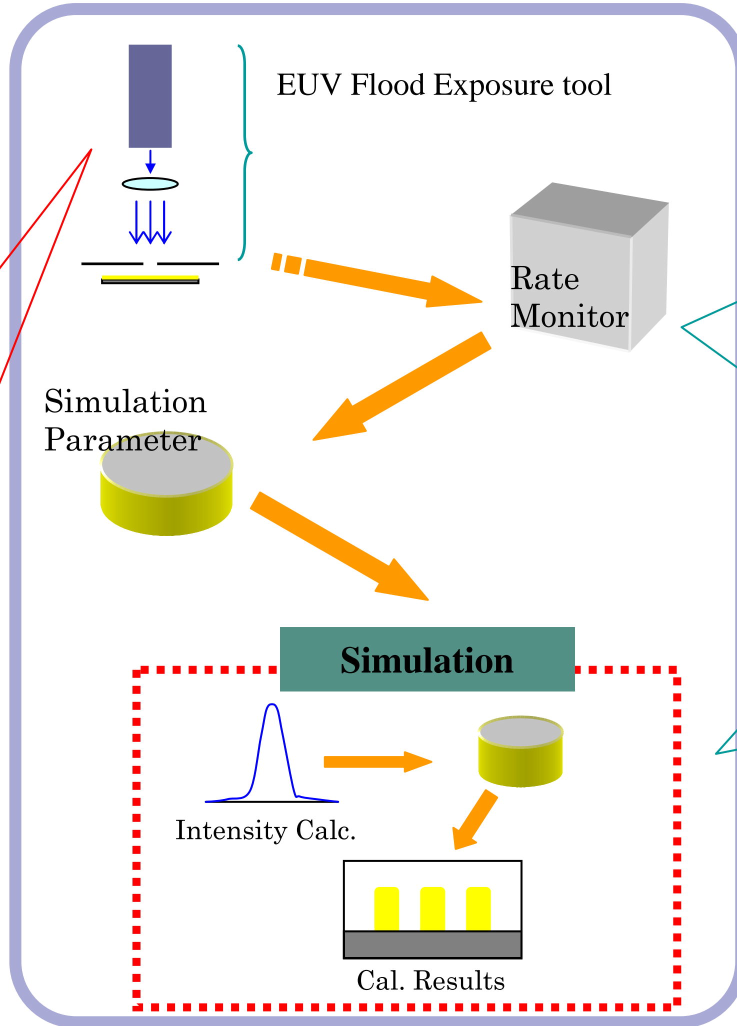


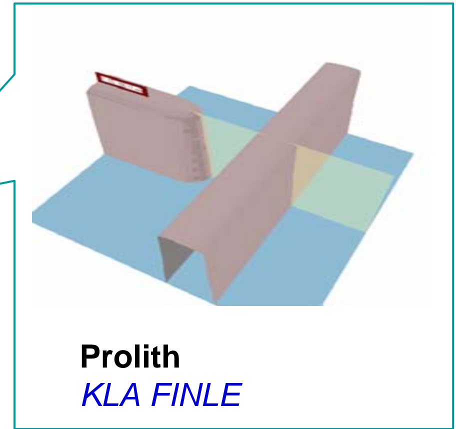
Photo-chemical Analysis System for EUV Lithography

The virtual lithography evaluation system (VLES)

EUVES-7000



RDA-800_EUV


Prolith
KLA FINLE

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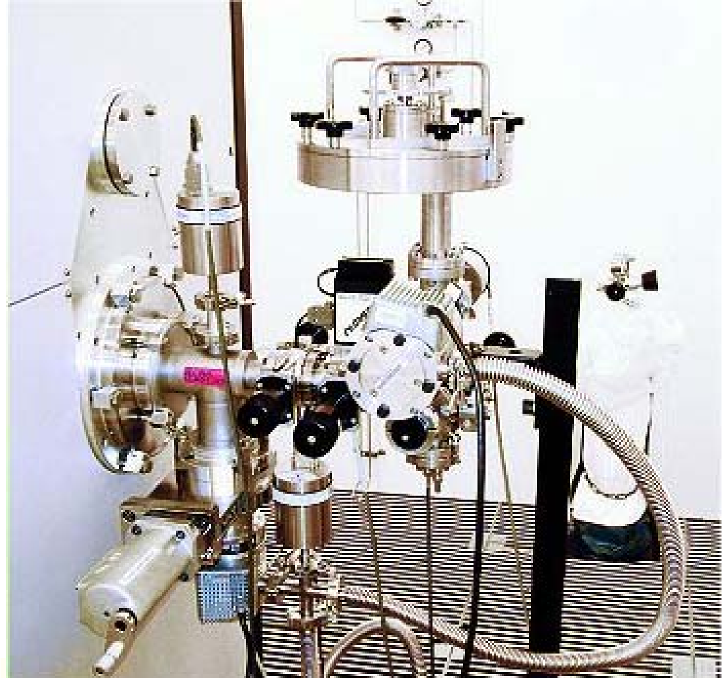
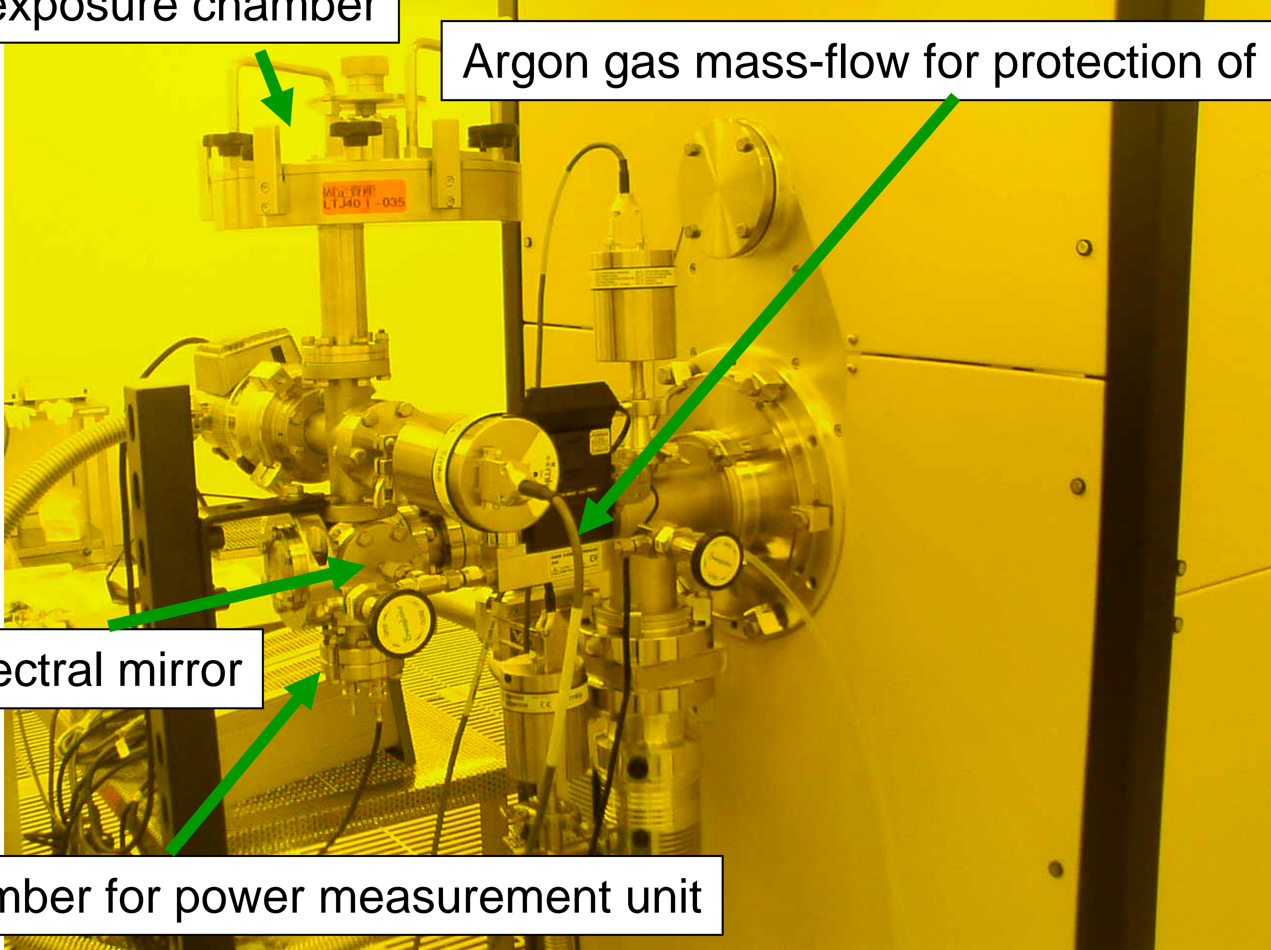
EUV open frame exposure system EUVES-7000



EUV open frame exposure system EUVES-7000



Experiment and result

Negative-type						
Resist	maker	Pre-bake		PEB		Thickness
		Temp.	Time	Temp.	Time	
Nega-1	Rohm & Haas E.	105	60	115	60	100
Nega-2	Nippon Kayaku	90	90	95	100	100

Positive-type						
Resist	maker	Pre-bake		PEB		Thickness
		Temp.	Time	Temp.	Time	
Posi-1	TOK	120	90	120	90	100
Posi-2	TOK	100	90	110	90	100
Posi-3	TOK	110	90	100	90	100
Posi-4	Nippon Zeon	90	90	95	100	100

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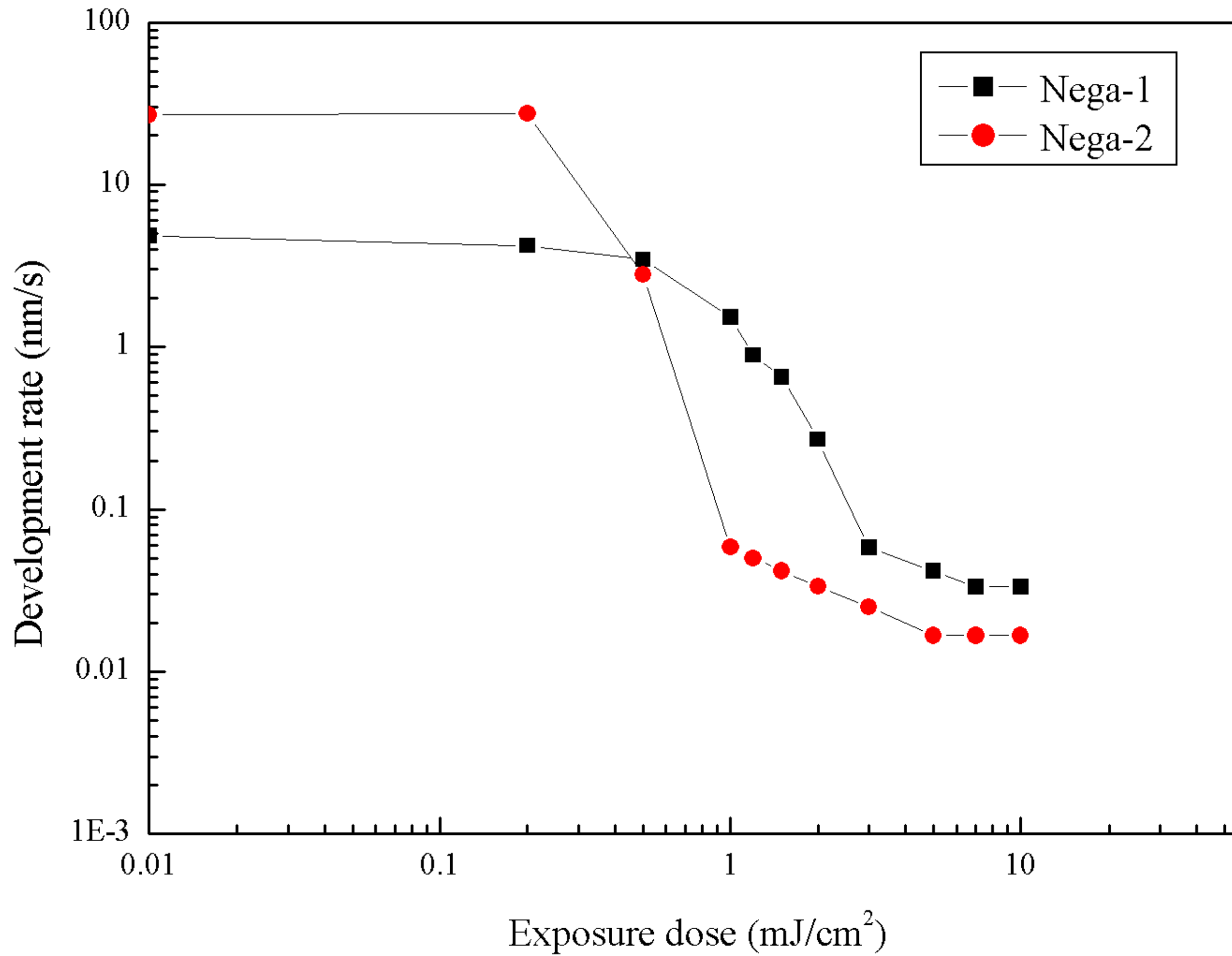
Experiment and result



Discrimination curve for Nega-type resist

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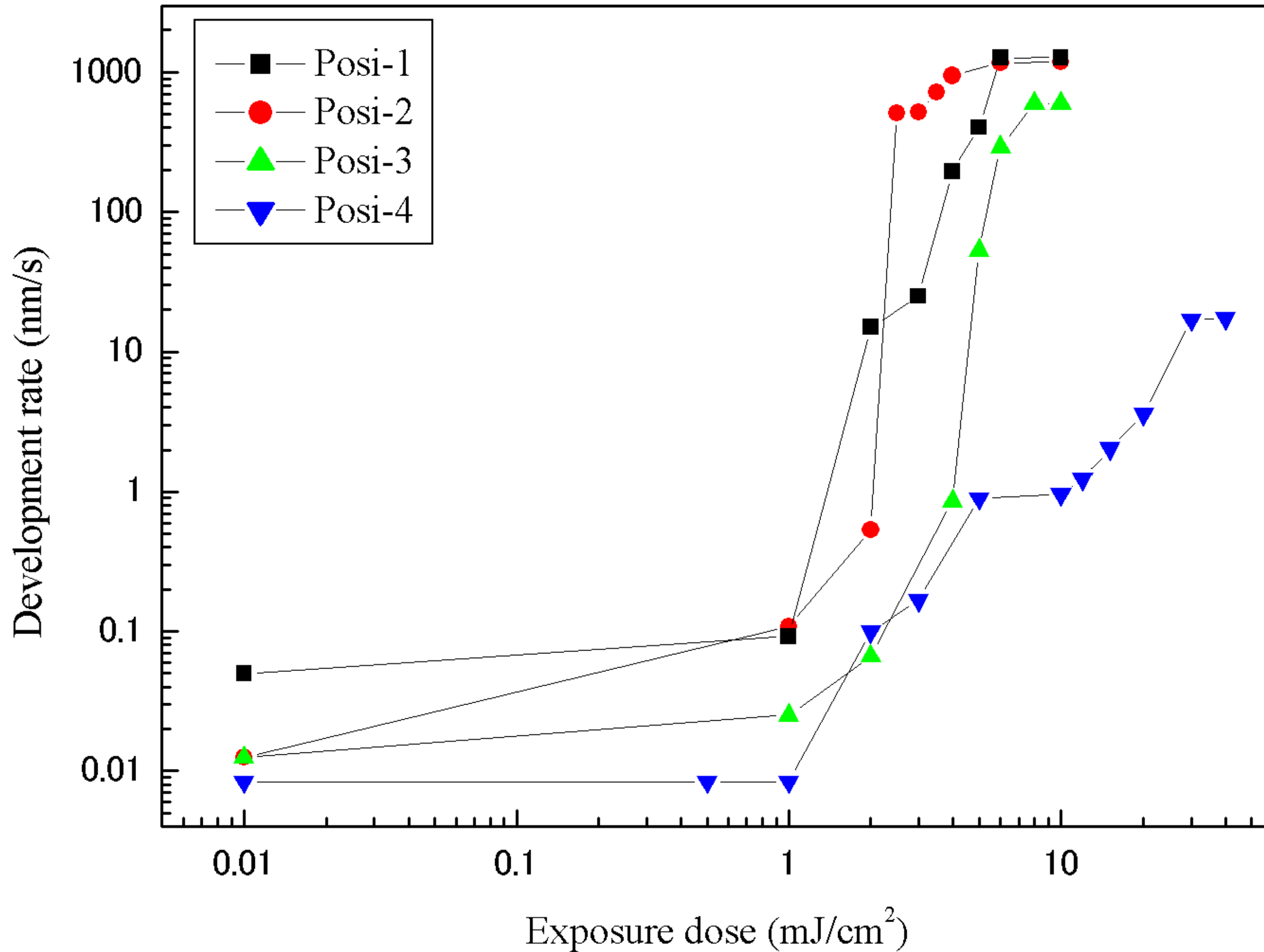
Experiment and result



Discrimination curve for Posi-type resist

Simulation

Simulation condition (Estimate for NIKON/HiNA-3)

Wavelength=13.5nm

NA=0.30

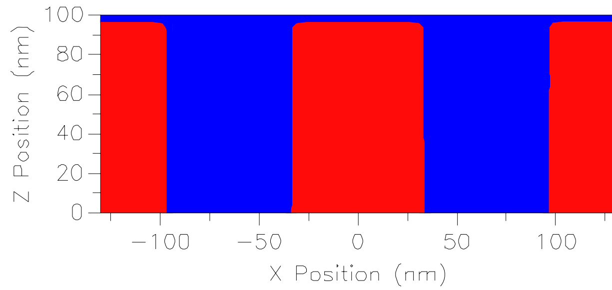
Sigma=0.8

Reduction=1/5

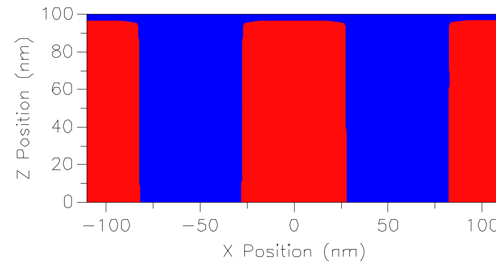
Line and space=66, 55, 45, 32, 22nm

Resist=Posi-2

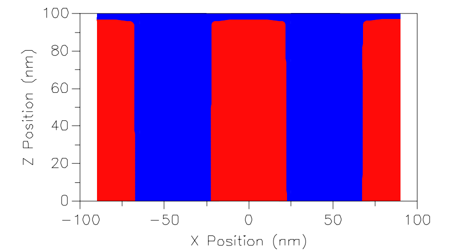
Simulation



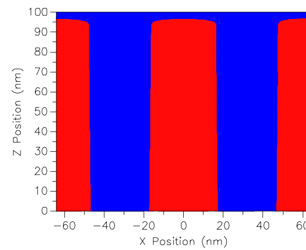
65nm



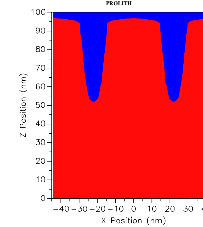
55nm



45nm



32nm



22nm

L&S Pattern simulation, Exposure dose= 17.2mJ/cm^2

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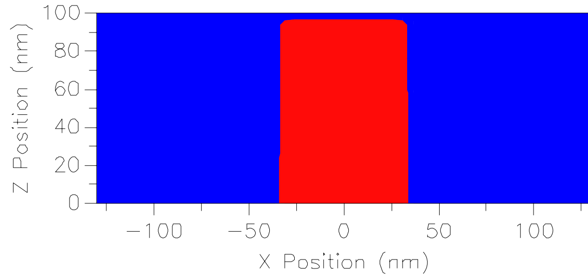
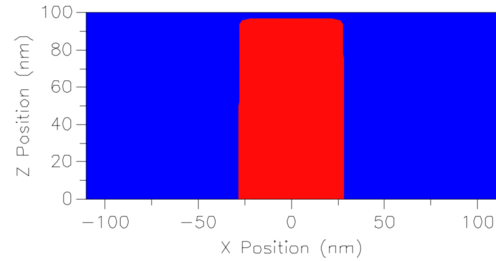
Simulation

PROLITH



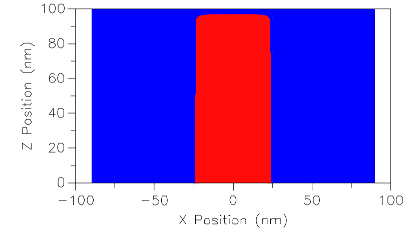
65nm

PROLITH



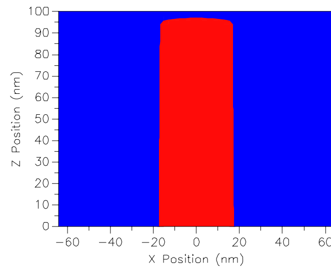
55nm

PROLITH

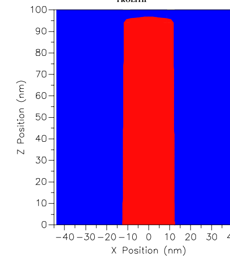


45nm

PROLITH



32nm



22nm

Iso Pattern simulation, Exposure dose= $17.2 mJ/cm^2$

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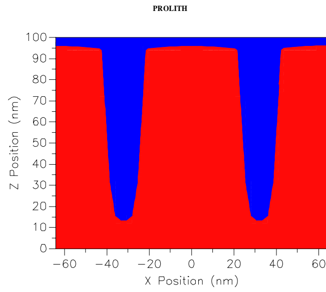
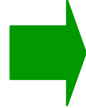
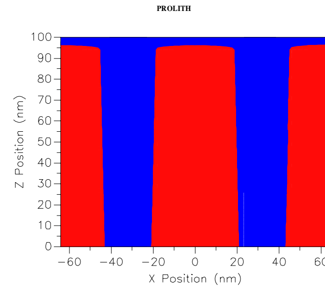
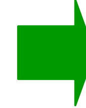
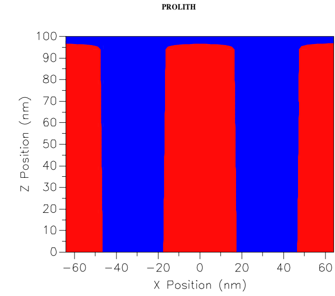
Simulation









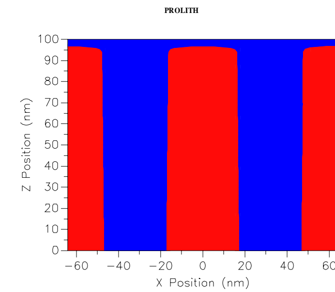


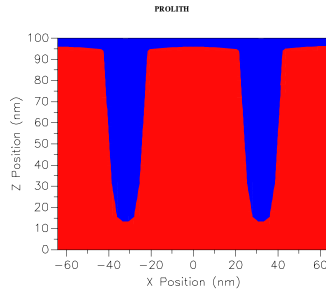
-0.13μm

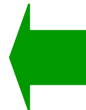
-0.10μm

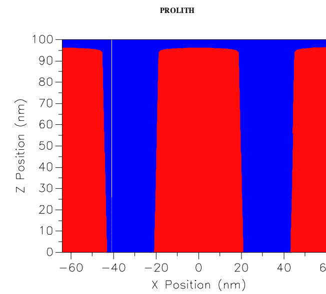
-0.05μm

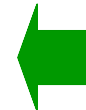
±0μm

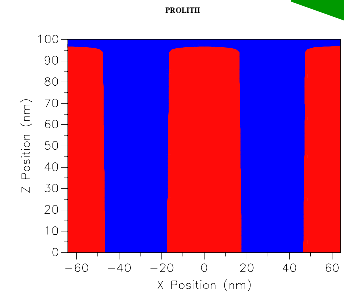












+0.13μm

+0.10μm

+0.05μm

Defocus simulation / L&S=32nm /Exposure dose=17.2mJ/cm^2

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Conclusion

We used the VLES to compare the sensitivity and development contrast of negative-type and positive-type resists with EUV exposure. We also simulated EUV exposure using development rate data for the Posi-2, which showed the highest development contrast of all resists tested. The results of the experiment indicated a resolution of 32 nm with L&S patterns and a resolution of 22 nm with isolated patterns from simulation result. We also calculated defocus characteristics with a 32 nm L&S pattern. According to calculations, we estimate a focus margin of approximately
0.2 μm in DOF. We believe that using the system as described in this paper will permit the development of photoresist materials for EUV and expedite process development without requiring the purchase of costly EUV exposure equipment.

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Acknowledgement

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