EUV Lithography Research and Development Activities at University of Hyogo

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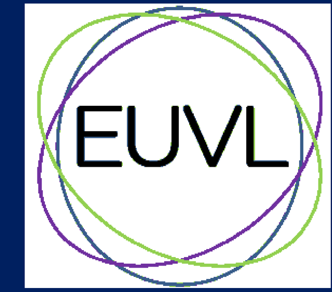


Introduction

EUV lithography is the most promising lithographic technology for electronic semiconductor device HVM in 7 nm node and beyond. The technical issues of EUV lithography for HVM are the achievement of 1) high power EUV light source, 2) EUV resist which satisfy high resolution, high sensitivity, low LER, and low outgassing, simultaneously, 3) pellicle for EUV mask, 4) defect free of EUV mask.

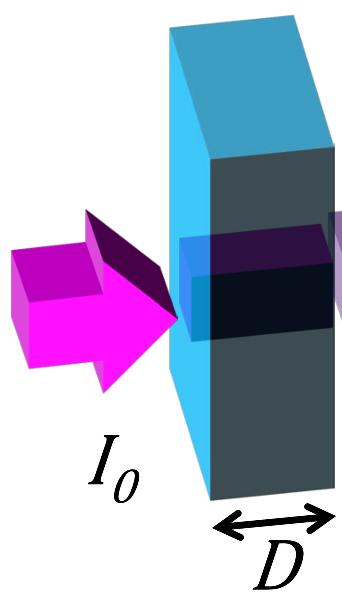
At NewSUBARU synchrotron light source of University of Hyogo, it is prepared that 1) large reflectometer for large collector mirror to achieve high EUV light power at the intermediate focus position, 2) the resist absorption coefficient measurement in high precision using photodiode, 3) EUV resist chemical reaction analysis using total electron yield method, 4) EUV interference lithography for the evaluation of 1X nm patterning, 5) resist outgassing evaluation tool using in-situ ellipsometry, and 6) 1st principle calculation method applied for the chemical structure analysis of the polymer resist material, 7) EUV mask inspection using EUV coherent scatterometry.

Using these tools, we can contribute to resolve the EUV technical issues toward electronic semiconductor device HVM using EUV lithography.

Resist absorption coefficient measurement in high precision using photodiode

Absorption coefficient

In order to evaluae the effect of the high EUV absorption resist material, the absorption coefficient was computed.



Absorption coefficient

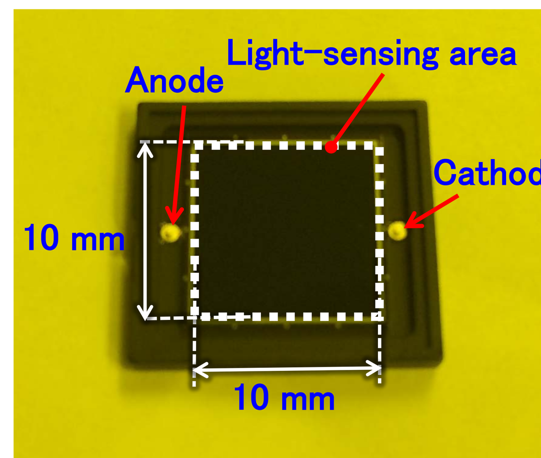
$$\mu = \frac{1}{D}\ln\left(\frac{1}{T}\right),\ \mu_m\rho = \mu$$

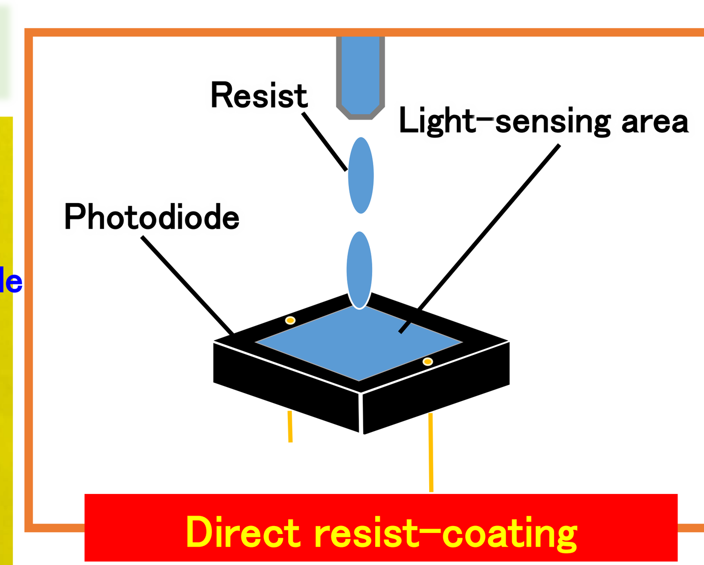
μ = Absorption coefficient
D = Resist thickness
$T = I/I_0$ = Transmittance
I_0 = Intensity of incident light
I = Intensity of transmission light
μ_m = Mass absorption coefficient

Benefit of novel method using direct-resist coating on a photodiode

In novel method, sample resist was directly coated on a light-sensing area of the photodiode by spin-coating.

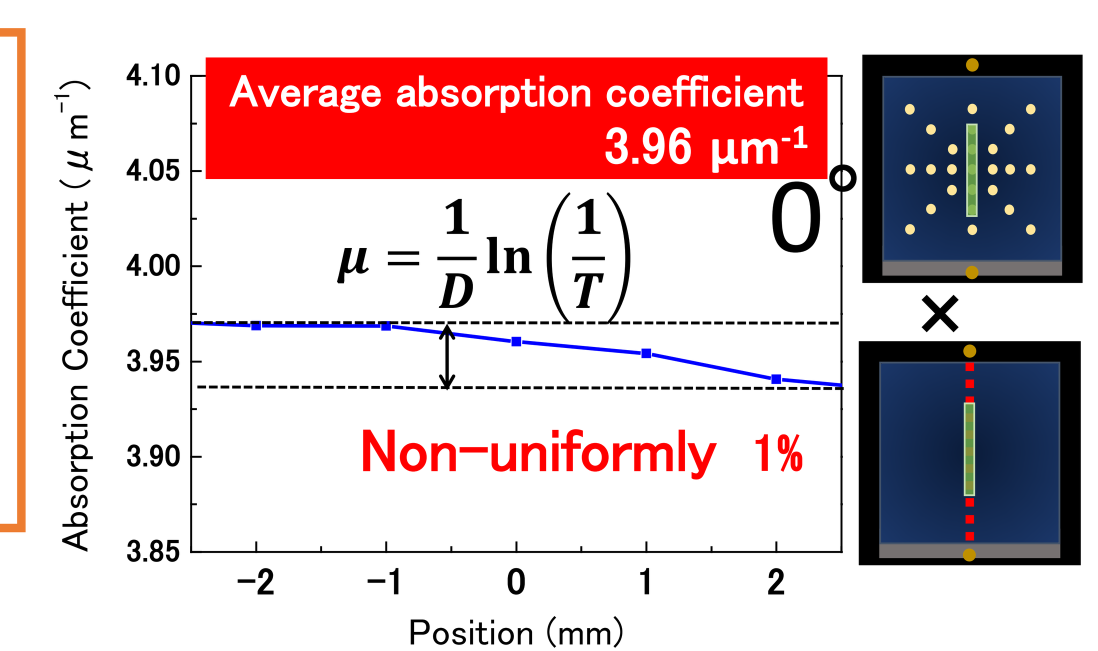
EUV sensitive photodiode
SXUV-100（Opto Diode Corp.）





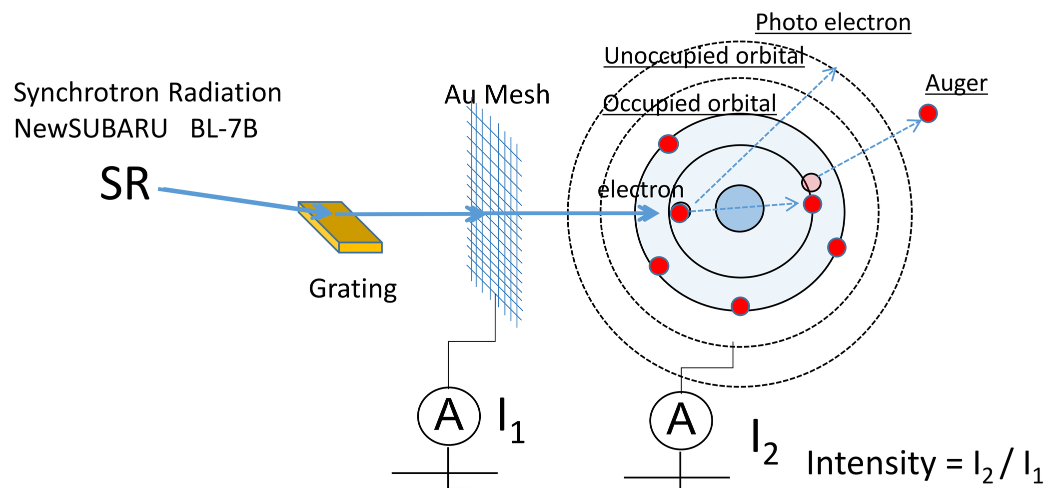
Computed result of absorption coefficient on the photodiode

Absorption coefficient were computed by mesurement results of the resist thickness in 90° and EUV transmittance.



EUV resist chemical reaction analysis using total electron yield method

The soft x-ray absorption spectroscopy

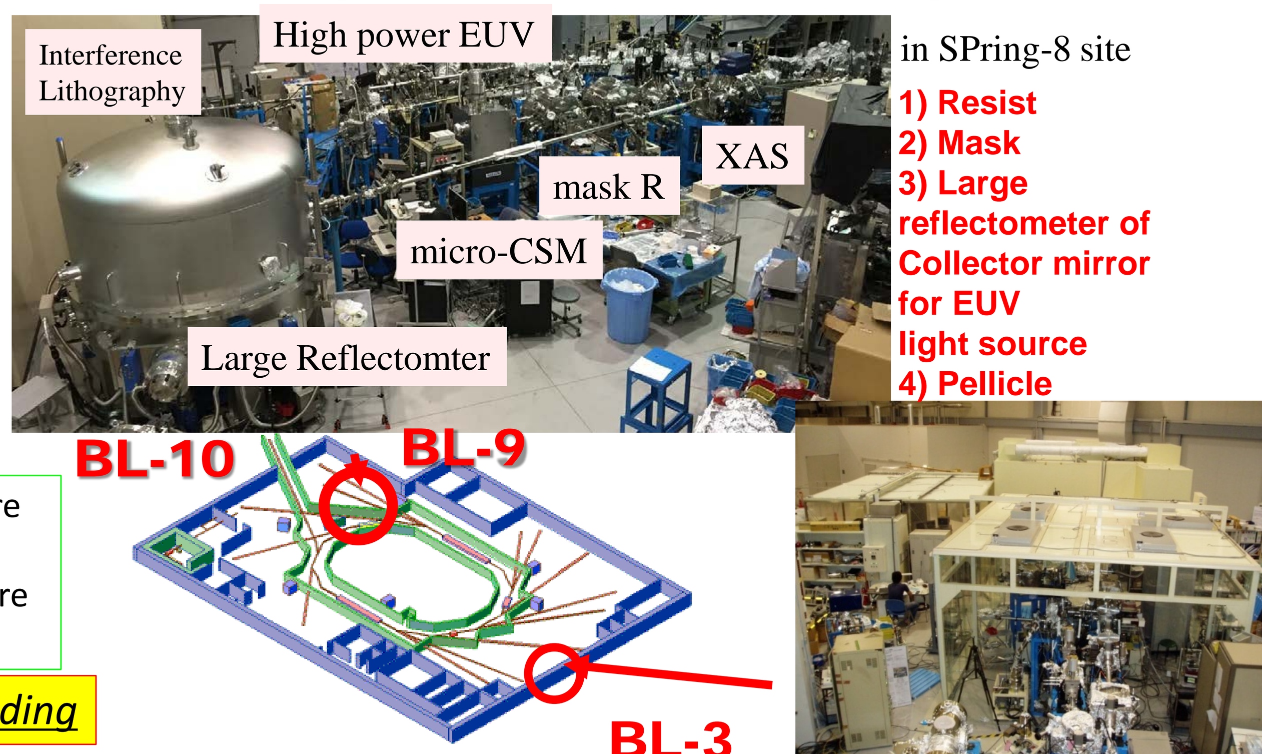


To measure the change of the chemical bonding, specific energy of the incident energy required for the measurement.

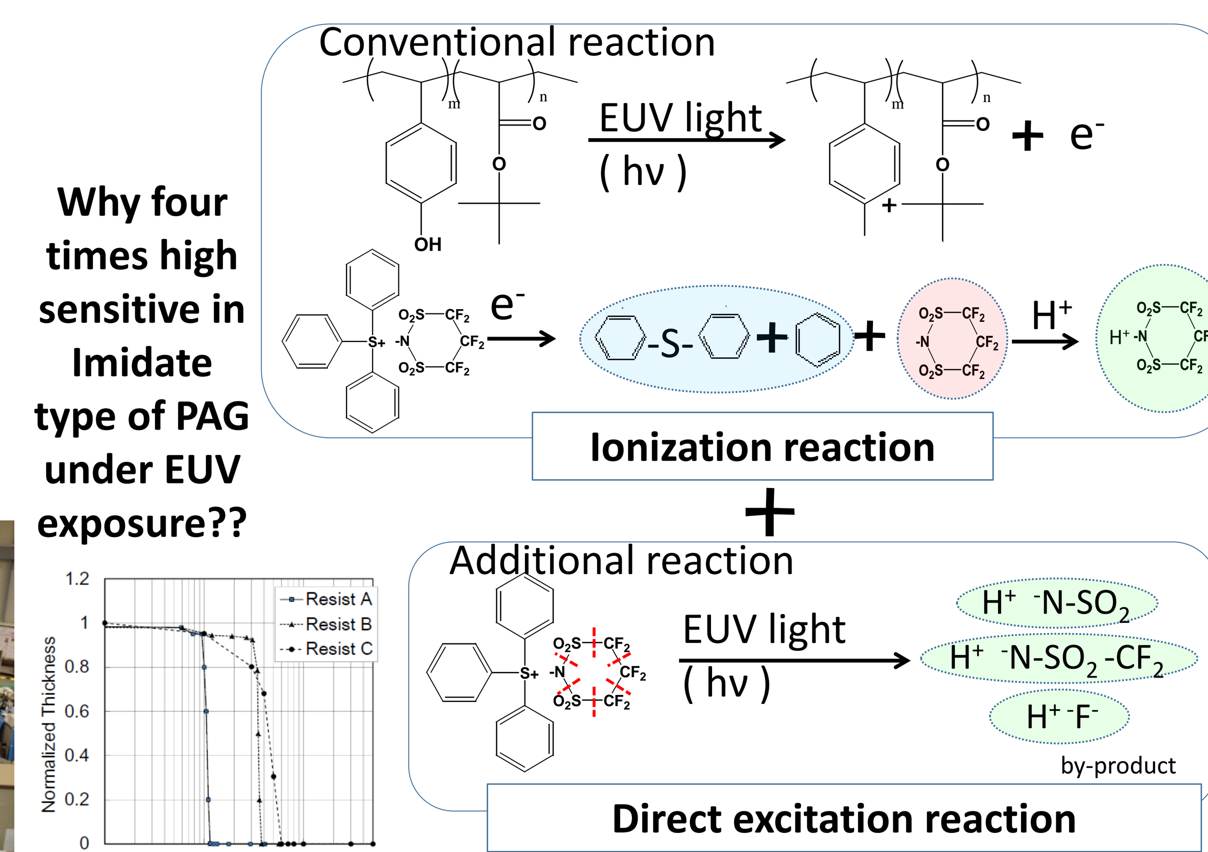
Carbon 1s core
280~330 eV
Fluorine 1s core
690~730 eV

Powerful tool for evaluating the change of the chemical bonding

Center for EUV Lithography
NewSUBARU Synchrotron Radiation Facility

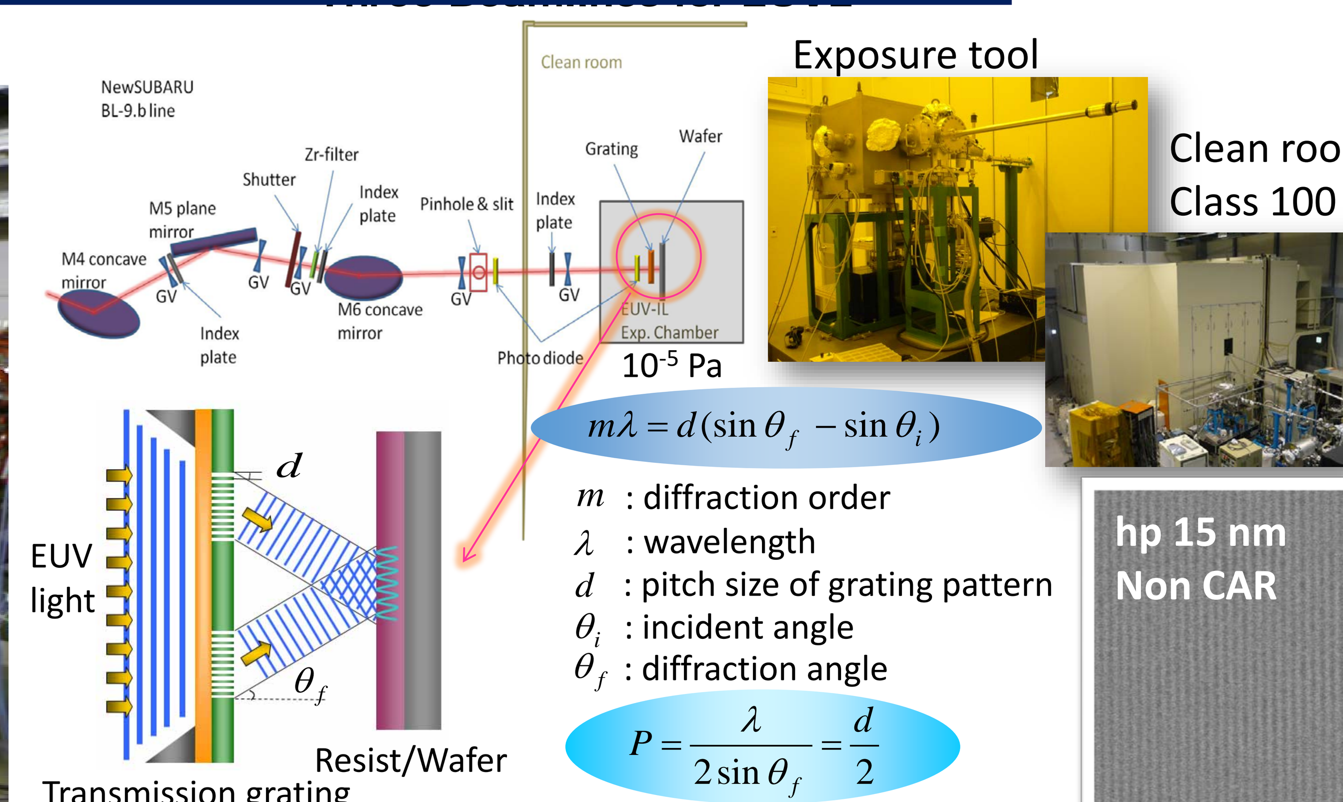


Why four times high sensitive in Imidate type of PAG under EUV exposure??



EUV interference lithography for the evaluation of 1X nm patterning

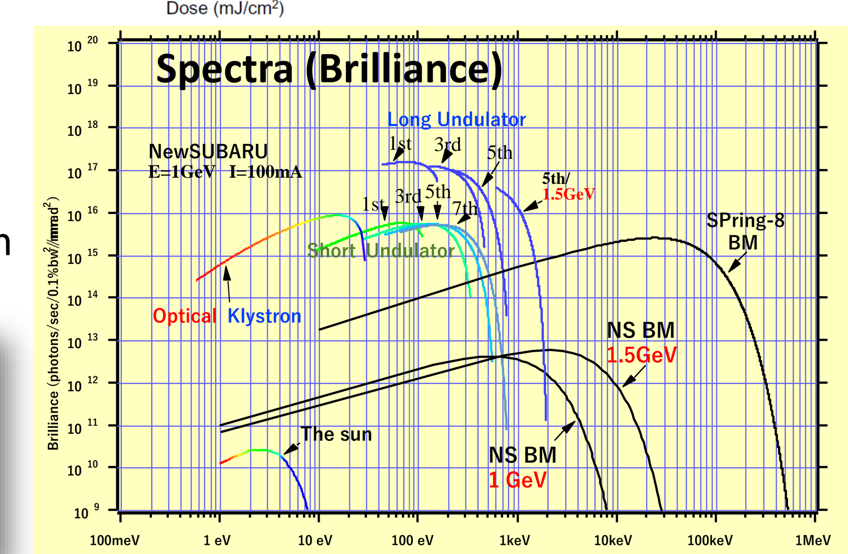
10.8 m Long Undulator



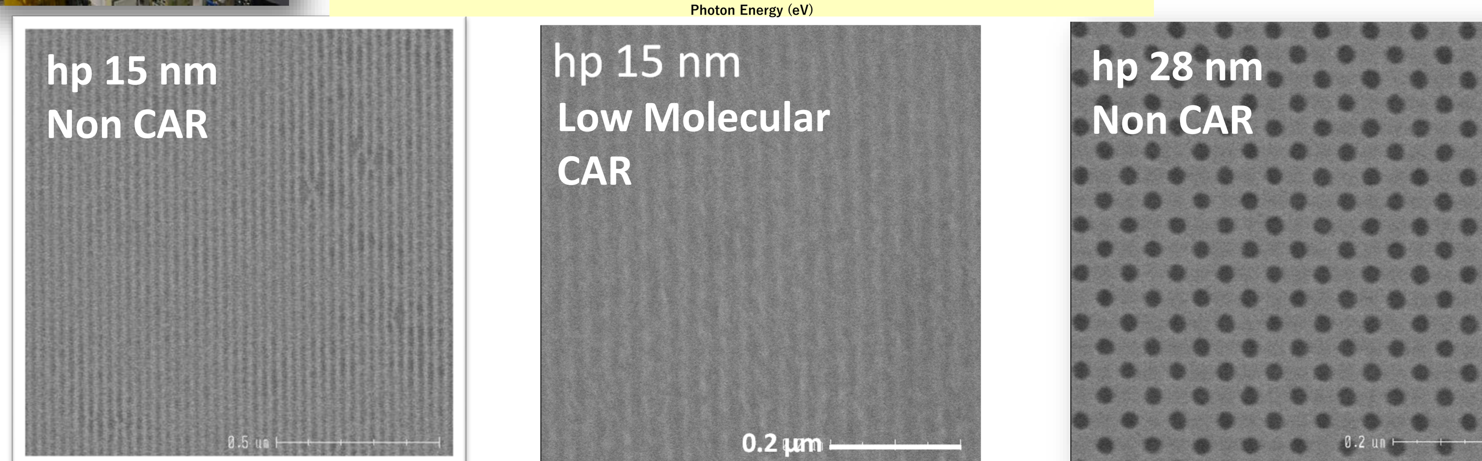
$$m\lambda = d(\sin\theta_f - \sin\theta_i)$$

m : diffraction order
λ : wavelength
d : pitch size of grating pattern
θ_i : incident angle
θ_f : diffraction angle

$$P = \frac{\lambda}{2\sin\theta_f} = \frac{d}{2}$$



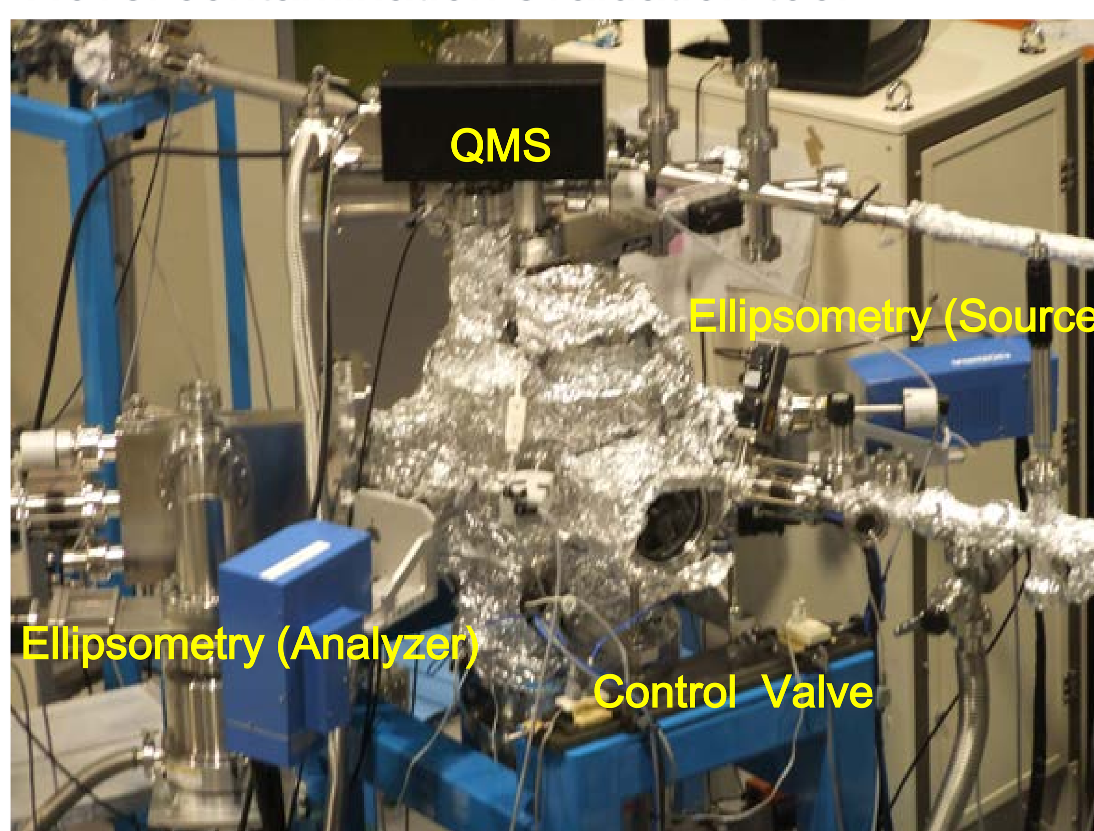
10.8 m long Undulator has high EUV Brilliance at 91.8 eV (13.5 nm). It is benefit for EUV interference Lithography.

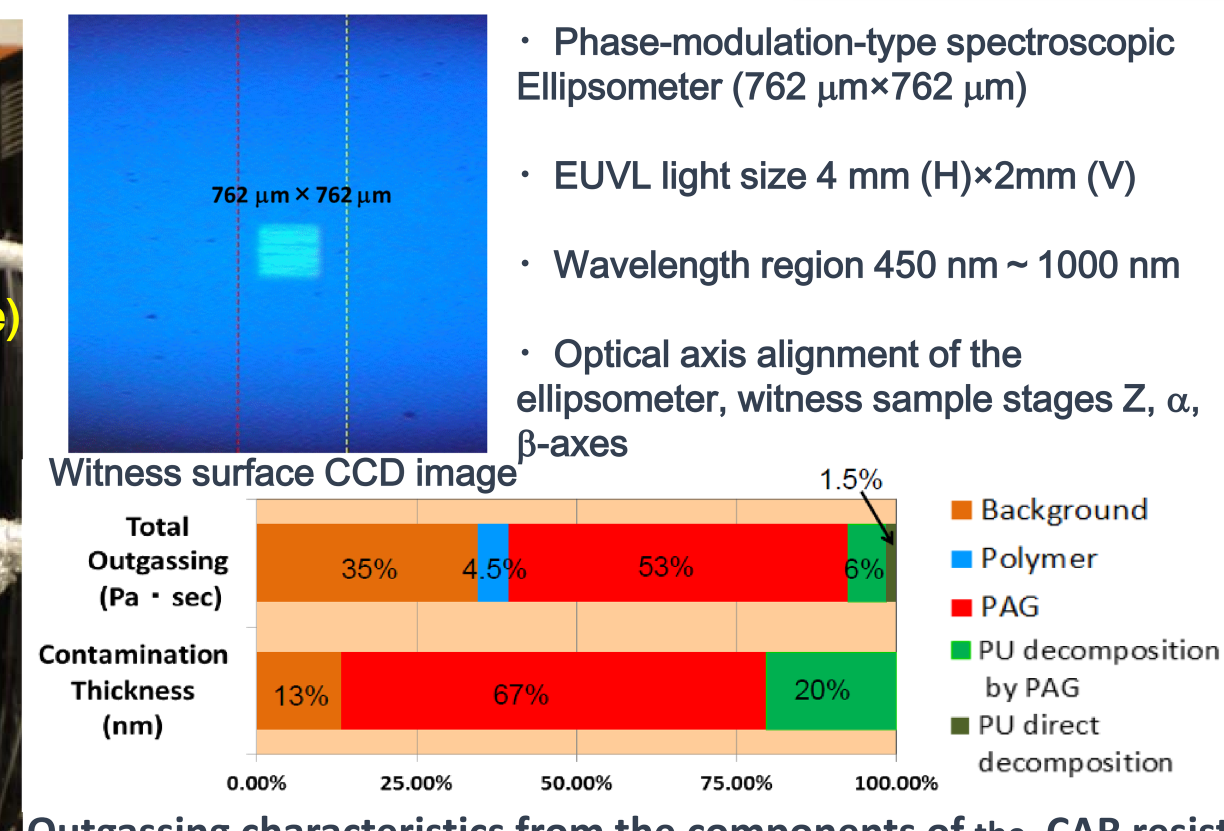


Resist outgassing evaluation tool using in-situ ellipsometry

	EUV - HERC+ -	Electron Beam - EUVOM-9000 -
Tool Geometry	Undulator Light, @ NewSUBARU BL9c, Resist, 120mW/cm², 320mW/cm², WS	E-gun 5keV, E-gun 0.9keV, Resist, WS
Vacuum Conditions	Base Pressure : 2~4 x 10-6 Pa Pressure during Exposure : 1~2 x 10-5 Pa	
Resist Thickness	60 nm	
Dose for Contamination Growth	2.5 x E0 E0 is measured on each tool, respectively.	≒2.5 x E0
Witness Sample (WS)	Ru 5 nm Mo/Si ML Si-sub.	Ru 50 nm Si-sub.

Novel contamination evaluation tool





・ Phase-modulation-type spectroscopic Ellipsometer (762 μm×762 μm)

・ EUVL light size 4 mm (H)×2mm (V)

・ Wavelength region 450 nm ~ 1000 nm

・ Optical axis alignment of the ellipsometer, witness sample stages Z, α, β-axes

Outgassing characteristics from the components of the CAR resist

Summary

1) Resist absorption coefficient measurement in high precision using photodiode was demonstrated.
2) Total electron yield method which is one of the method in soft x-ray absorption spectroscopy is very effective method to analyze the EUV resist chemical reaction analysis.
3) EUV interference lithography employed long undulator as a light source has a capability to evaluate EUV resist for 1x nm.
4) The outgassing characteristics from the components of CAR resist was obtained by outgassing evaluation tool using in-situ ellipsometry.

Acknowledgement

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