EUV resist outgassing activity at Selete

Semiconductor Leading Edge Technologies, Inc.

Toshiro Itani

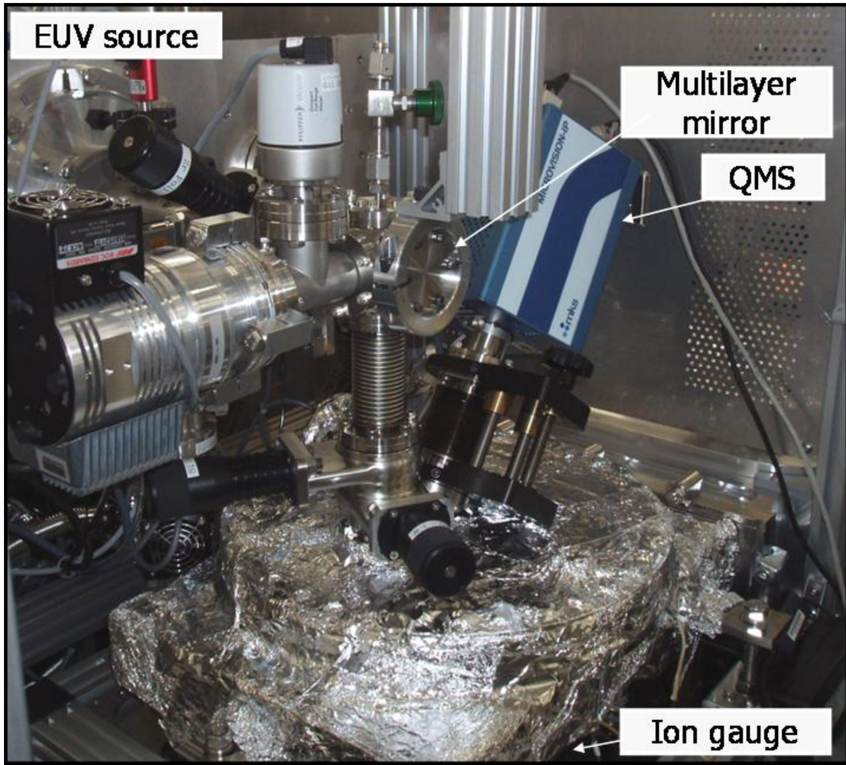
Outline

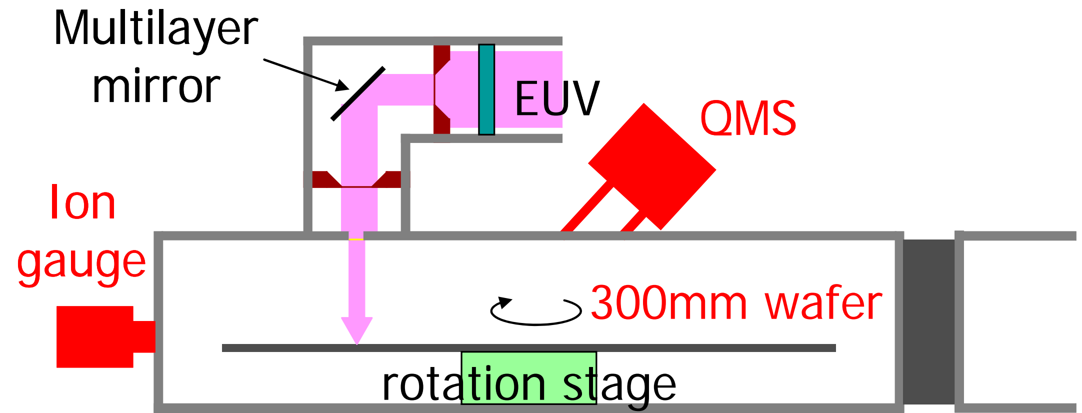
- Evaluation tools and methods
- Present activities and results
- Summary
- Future Plans
- Acknowledgement

Evaluation tool 1

Pressure rise method

QMS analysis





EUV Source	: EQ-10MR
Power on Wafer	: 0.03mW/cm^2
Exposure area	: 1.43 cm^2
Base pressure	**: 8x10^{-7} Pa**

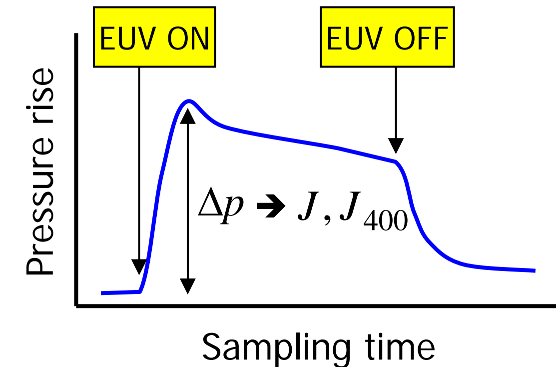
Pressure rise method (equations)

Resist outgassing ‘RATE’ [unit : molecules·cm-2·s-1]

Maximum rate during exposure → indicator for exposure tool management

$$J = \frac{\Delta p S_e}{RTA} N_A$$ (evaluated EUV intensity)

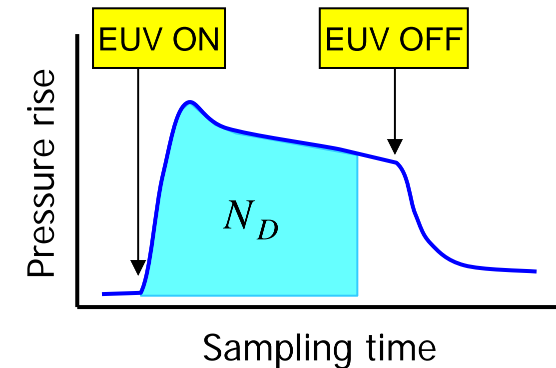
$$J_{400} = \frac{\Delta p S_e}{RTA} N_A \frac{400}{I}$$ (400mW·cm-2 assumed)



Resist outgassing ‘AMOUNT’ [unit : molecules·cm-2]

AMOUNT dependence on exposure dose → indicator for resist improvement

$$N_D = \sum_{i=0}^{t} \frac{\Delta P_i S_e}{RTA} (t_{i+1} - t_i) N_A$$

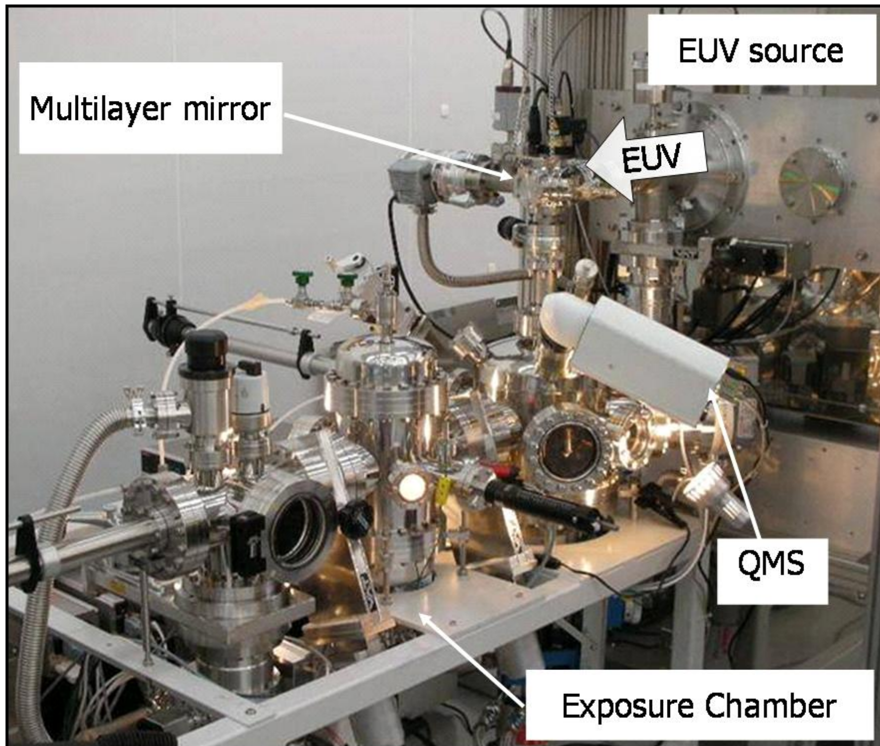


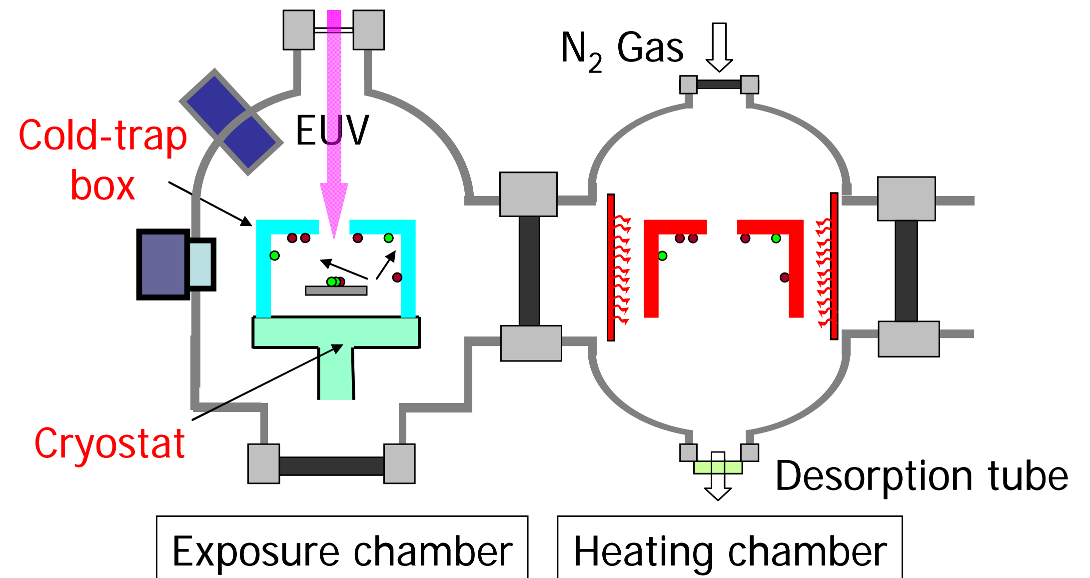
Δp : pressure rise	N_A : avogadro's number
S_e : effective pumping speed	I : EUV intensity
R : Gas constant	
T : temperature	(subscript)
A : area of exposure	i : time
	D : established dose

Rate and amount calculations based on the pressure variations.

Evaluation tool 2

GC-MS method





EUV Source	: EQ-10MR
Power on Wafer	: 0.014mW/cm^2
Exposure area	: 1.69 cm^2
Base pressure	**: 1x10^{-7} Pa**

Resist outgassing evaluation method

Methods	Description	Evaluation time	Selete
Pressure rise	□ Simple and quick for quantitative analysis. ■ Component identification not possible.	2 hours/sample	○
GC-MS	□ Component identification possible. ■ CO_2 cannot be detected. ■ Low throughput.	1 day/sample	○
QMS	□ In-situ qualitative analysis possible ■ Quantitative analysis not possible. ■ Qualitative analysis inaccuracy due to fragmentation effect.	2 hours/sample	○
Witness mirror	□ Contamination level directly observed. ■ Low throughput and high cost.	A few days/sample	△

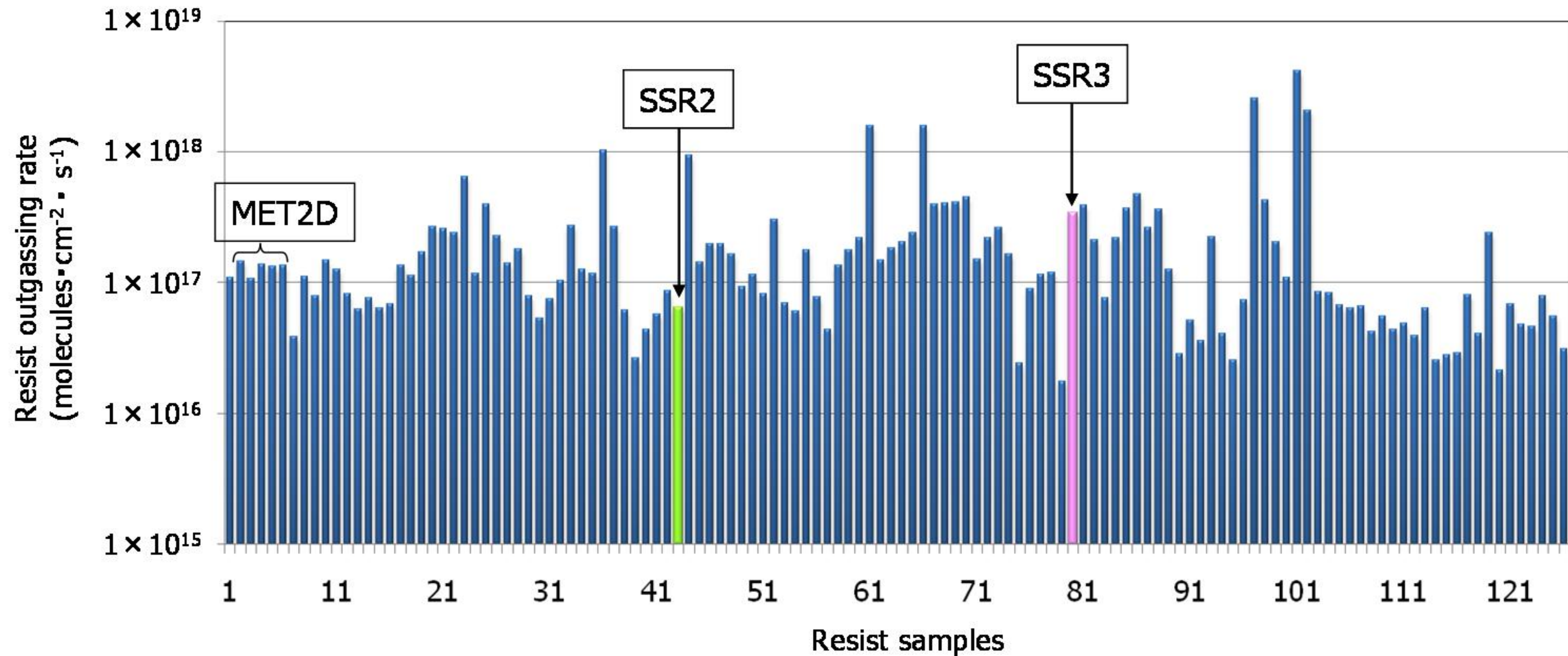
Pressure rise, GC-MS and QMS methods are applied for resist outgassing evaluations.

Outline

- Evaluation tools and methods
- Present activities and results
- Summary
- Future Plans
- Acknowledgement

Quantification 1

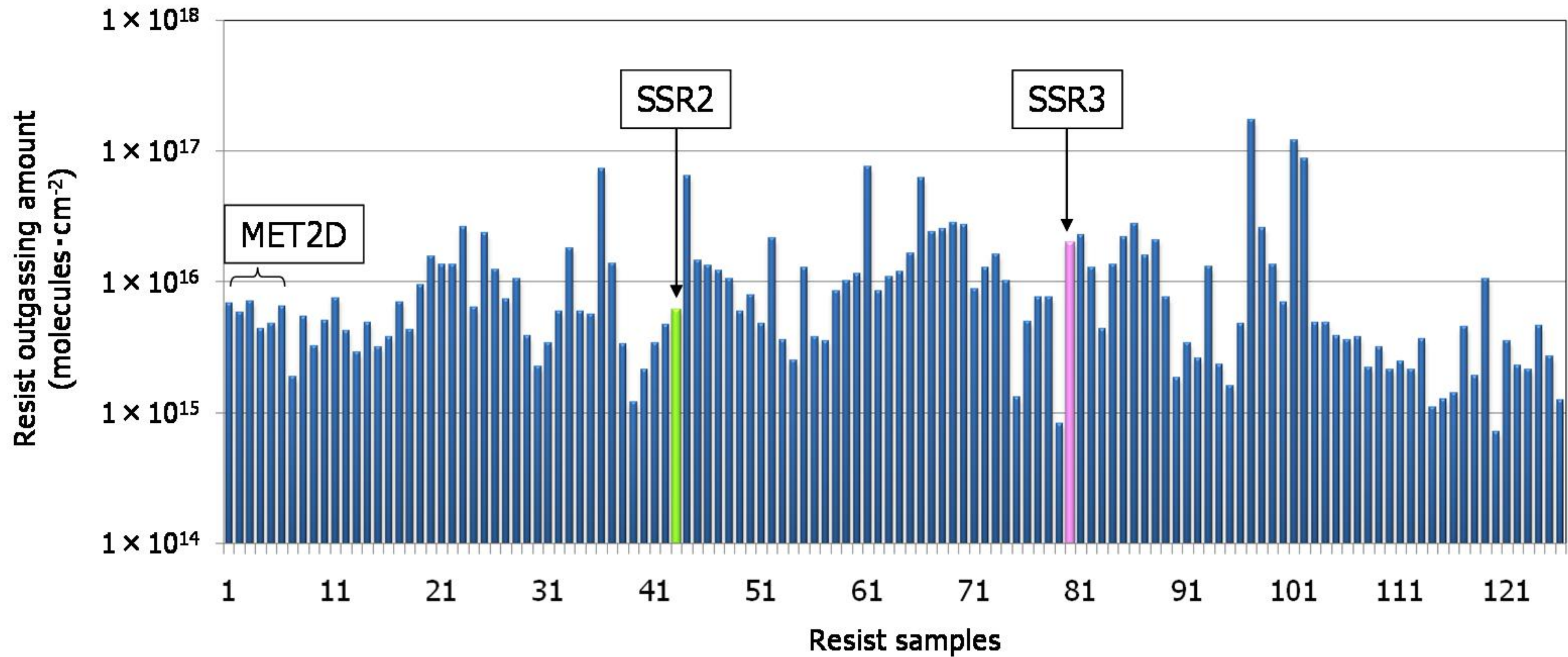
Pressure rise method for Quantification by **RATE**



More than 120 samples analyzed for resist outgassing rate.

Quantification 2

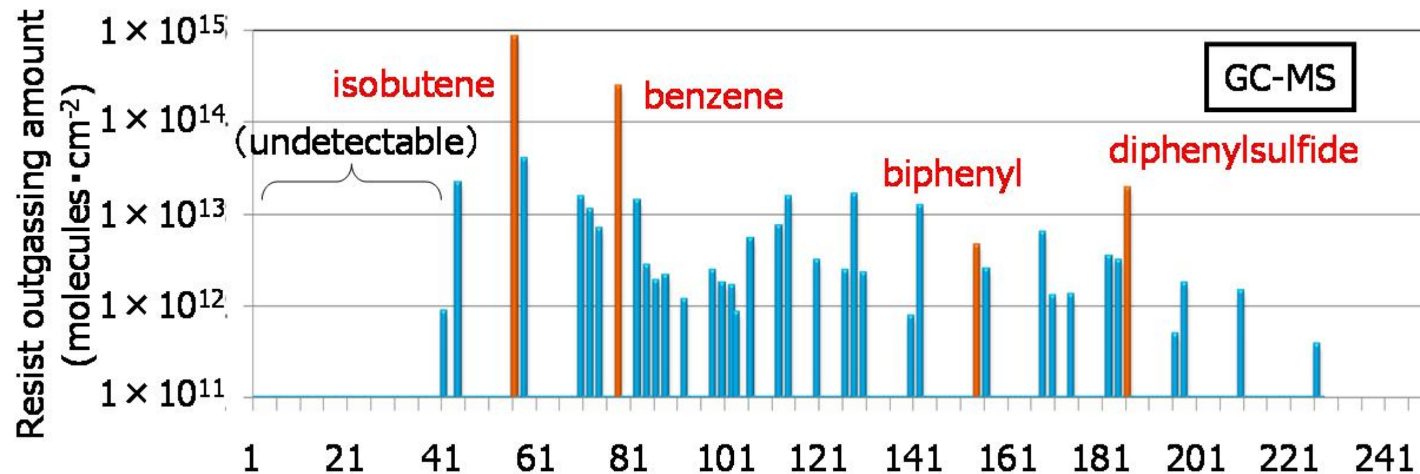
Pressure rise method for Quantification by **AMOUNT**

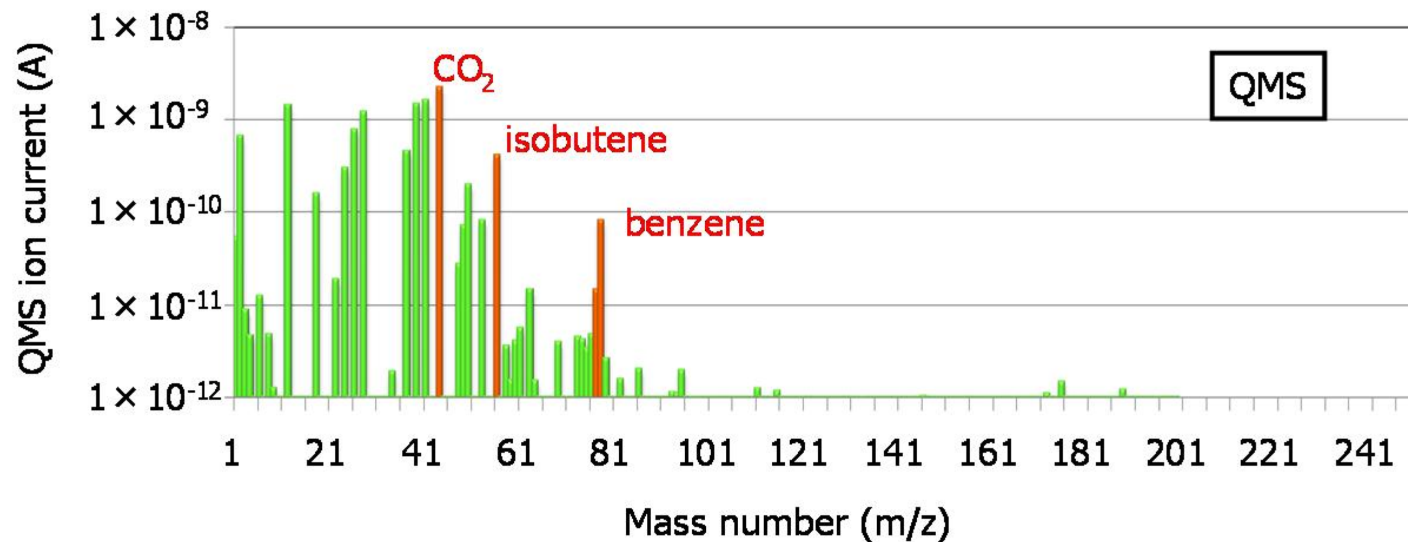


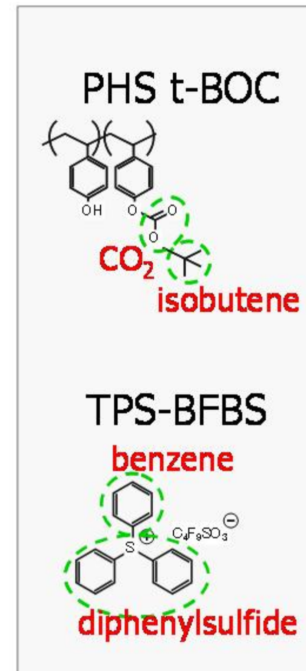
More than 120 samples analyzed for resist outgassing amount.

Component analysis

GC-MS method & **QMS analysis** for Qualitative analysis



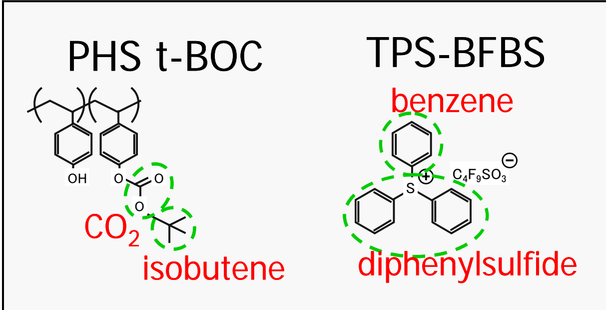


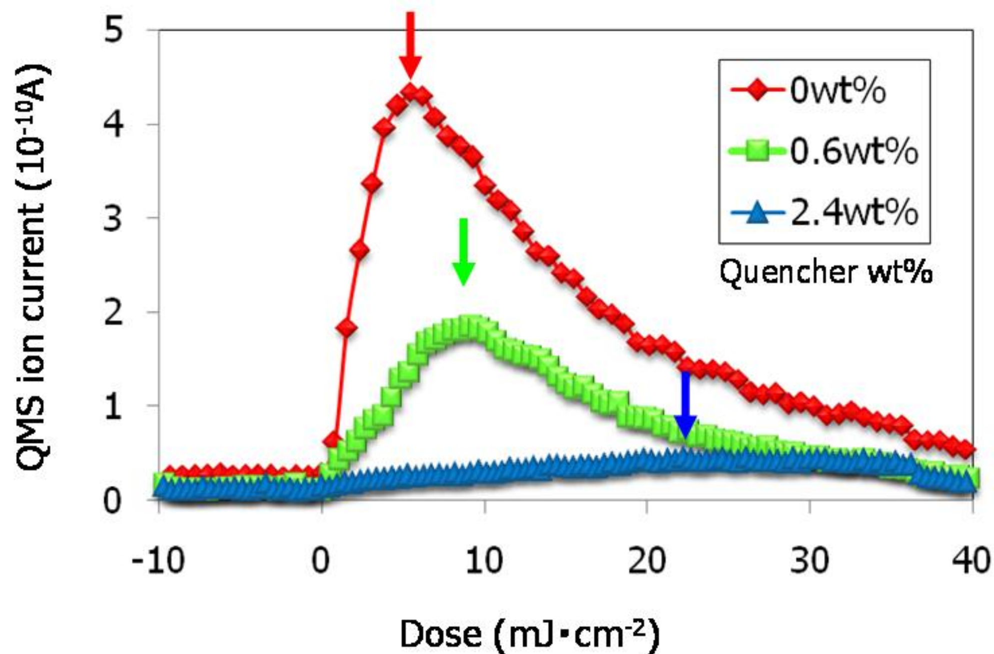


- GC-MS effective for component analysis. CO_2 cannot be detected.
- Fragmentation in QMS cause large difference in detected spectra.

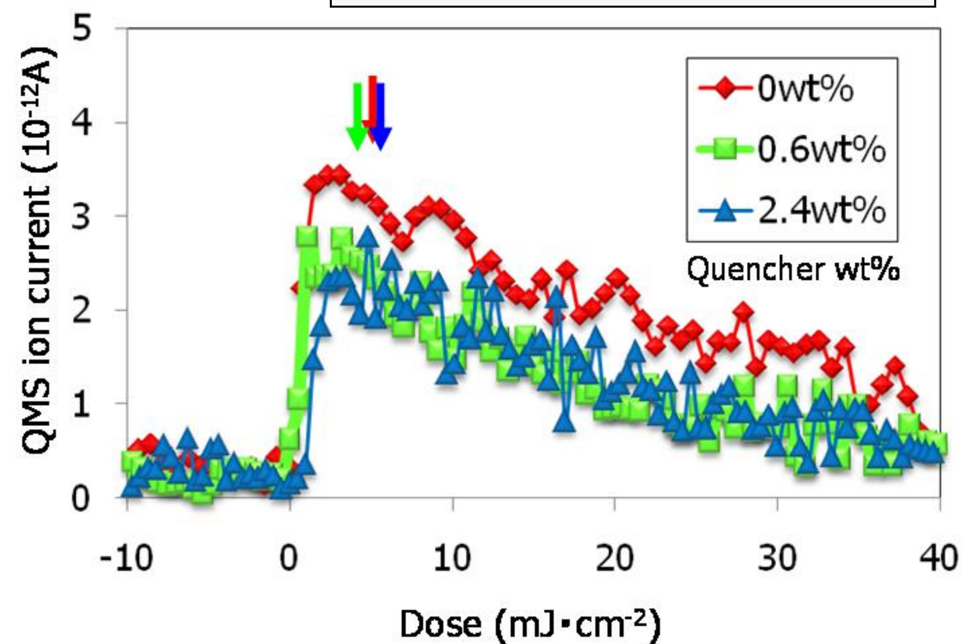
Mechanism analysis

QMS analysis for Reaction mechanisms





CO_2 (m/z=44) QMS spectra



C_6H_5 (m/z=77) QMS spectra

Dependence of component peak positions observed.
CO_2 (m/z=44) dependent, C_6H_5 (m/z=77) not dependent.

Selete resist outgassing evaluation procedure

Quantification (Quick Screening)	Pressure rise method Screening of resist samples received prior to exposure.
Component analysis	GC-MS method Improvement of resist samples based on new resist components.
Mechanism analysis	QMS analysis GC-MS method Basic study to improve tools and control methods.

Summary

- Quantification (Quick Screening)
  Resist outgassing rate and amount evaluations were performed for more than120 samples using the pressure rise method, prior to exposure.

- Component analysis
  GC-MS effective and accurate in the analysis of resist outgassing components. (CO_2 cannot be detected).

- Mechanism analysis
  QMS is highly recommended for component reaction mechanism analysis during exposure.
  GC-MS method is also applied to provide more accurate component identification for mechanism analysis.

Selete applies resist outgassing methods depending on the analysis objectives.

IRAI

Future plans

Selete

- Further improvement of analysis result accuracy.
- Discussion with exposure tool makers (Nikon and Canon) underway.
- Establish specific resist outgassing limits for pre-production level.
- Collaboration with other research consortiums, tool and material suppliers, universities and research groups.

Acknowledgement

- A part of this work is supported by New Energy and Industrial Technology Development Organization (NEDO).
- Selete member companies (EUV Lithomask program).