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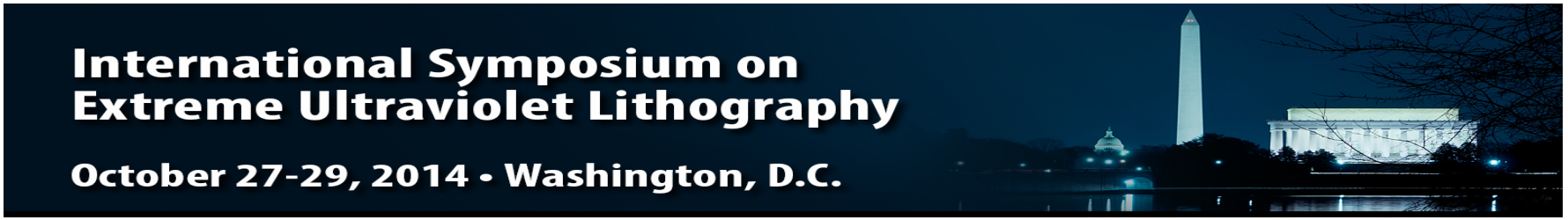


# Study of Dill's B parameter measurement of EUV resist

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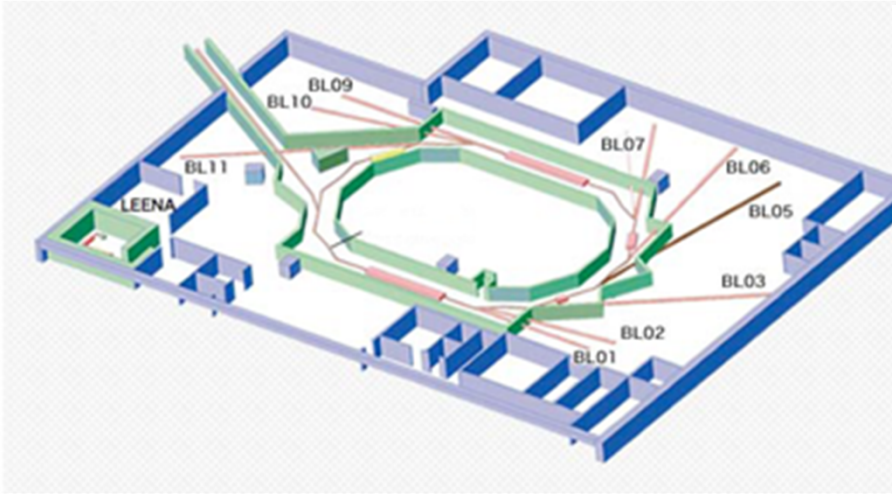
# Outline

1. Introduction
2. Overview of the measuring equipment
3. Evaluation and result
4. Influence of the addition of $HfO_2$ material
5. Conclusion

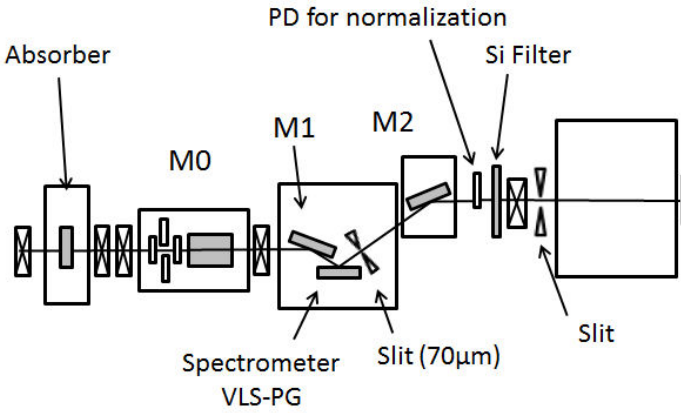
# 1. Introduction

・Transmission is one of the key parameter to increase EUV resist sensitivity.
・EUV resist was coated on the SiN membrane substrate, and the transmittance was measured directly.
・The sensitivity enhancement method in adding $HfO_2$ was evaluated.

# 2. Overview of the measuring equipment

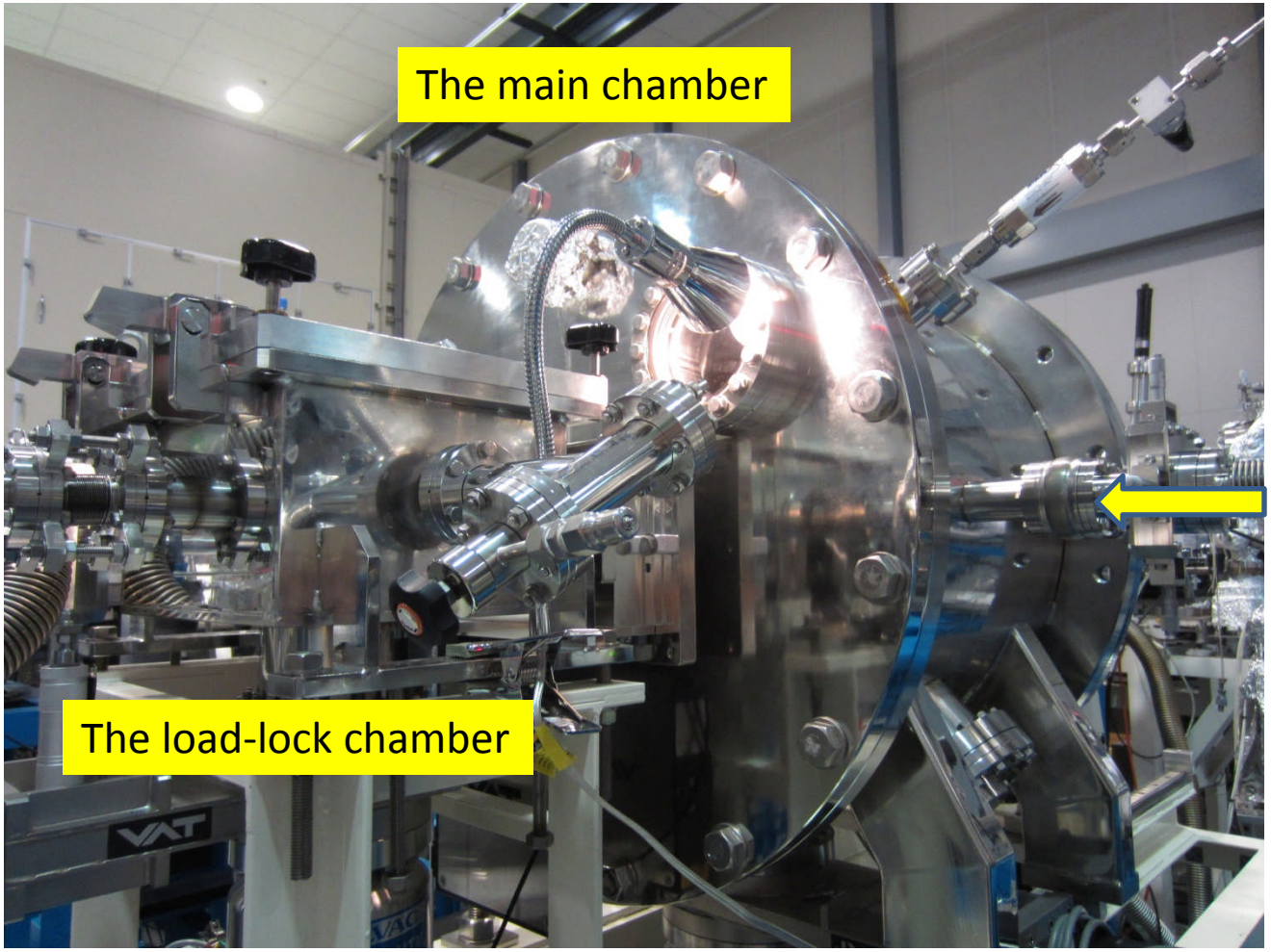



(a)NewSUBARU

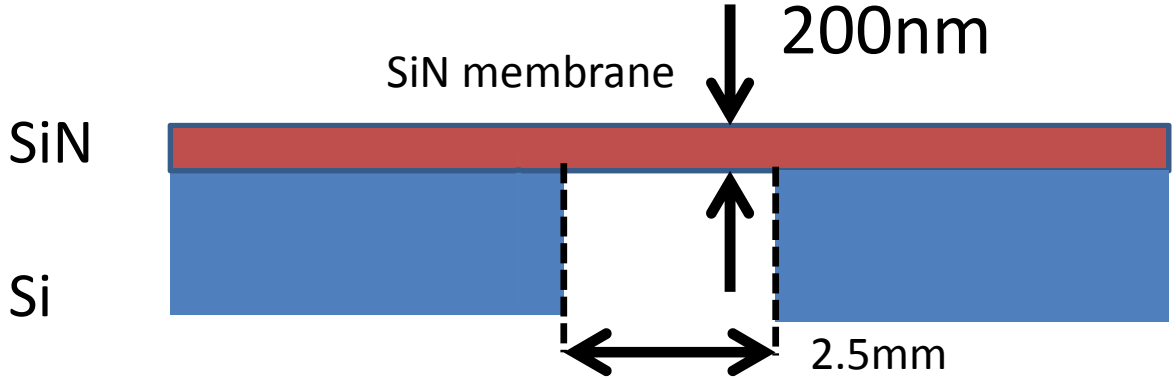


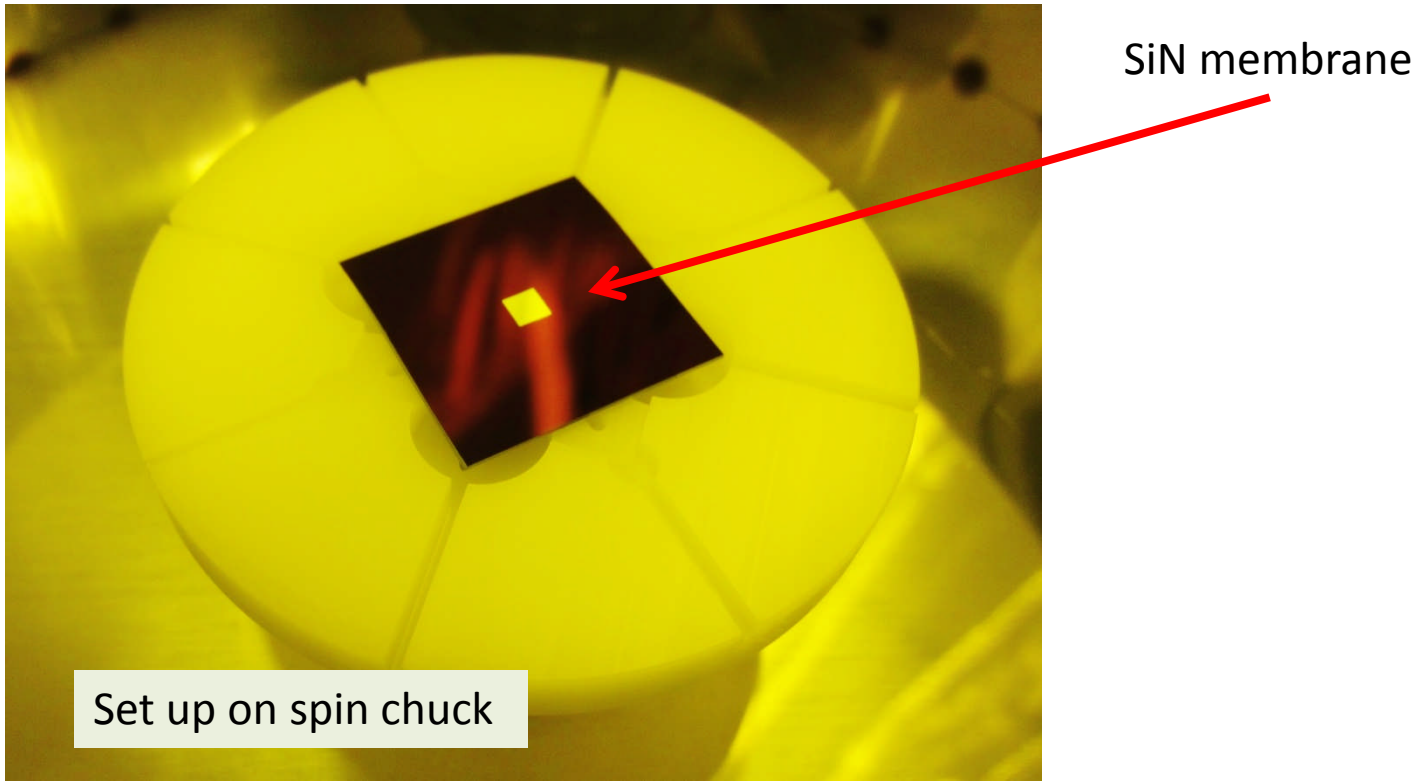

(b)Measurement system

Structure of EUV transmittance measurement system at NewSUBARU BL10 beamline.



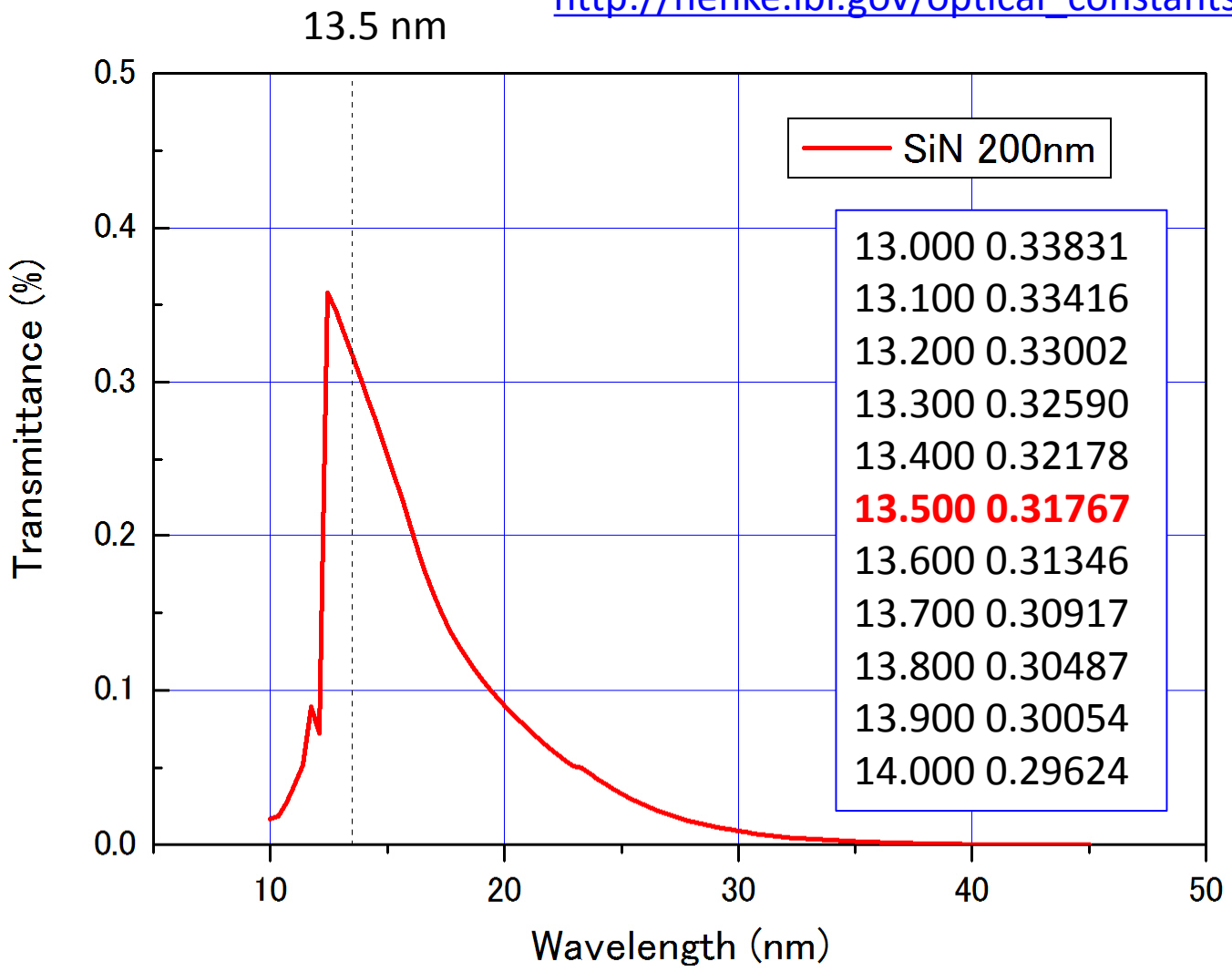

EUV transmittance measurement tool



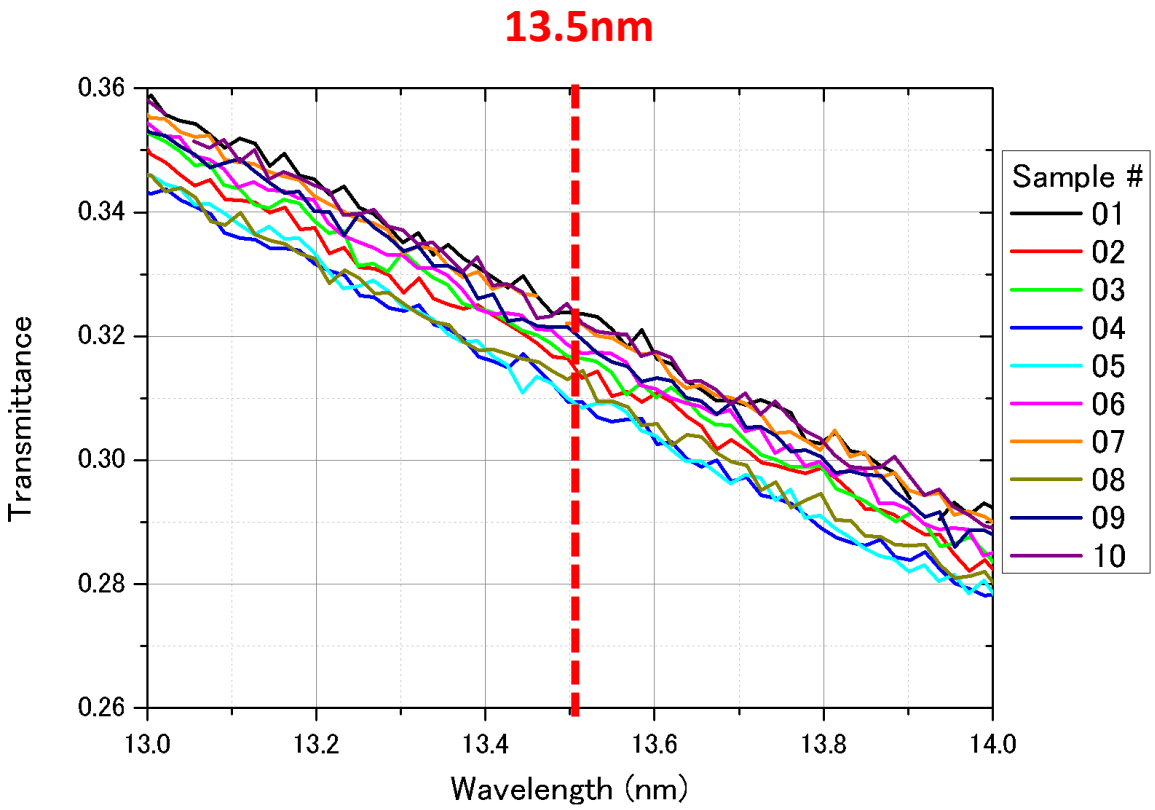

Ultra thin SiN membrane substrate

http://henke.lbl.gov/optical_constants/filter2.html




Calculated transmittance of 200 nm$^{t}$ SiN membrane

# Transmittance measurement result of 10 substrates




| Substrate # | Transmittance |
|---|---|
| 1 | 0.3239 |
| 2 | 0.3164 |
| 3 | 0.3168 |
| 4 | 0.3094 |
| 5 | 0.3102 |
| 6 | 0.3188 |
| 7 | 0.322 |
| 8 | 0.313 |
| 9 | 0.3215 |
| 10 | 0.3253 |
| Average | 0.31773 |
| σ | 0.005578 |
| max | 0.3253 |
| min | 0.3094 |
| R | 0.0159 |

# 3. The resist sample employed in this study

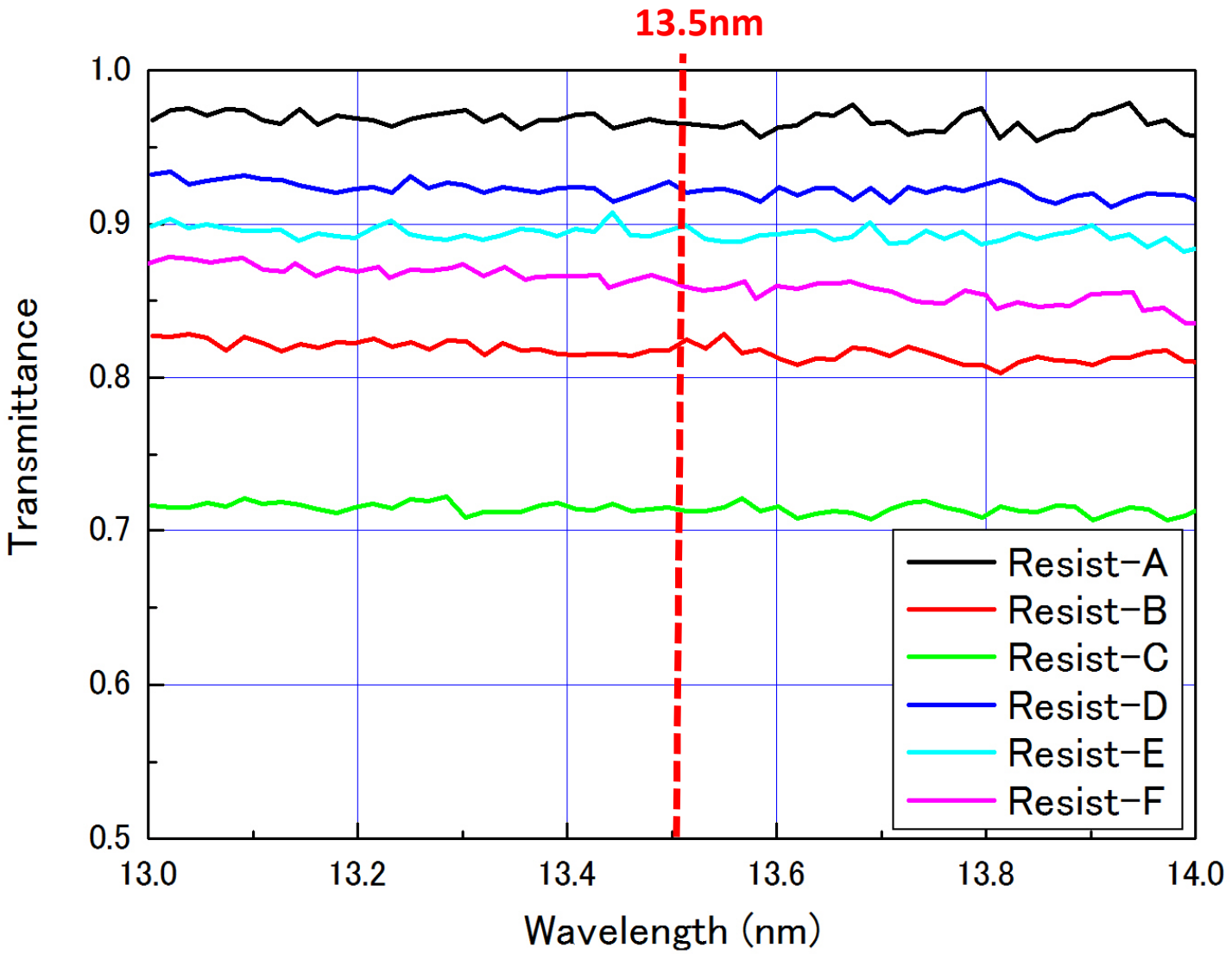
## Sample condition

| Resist | Chemical formula | Thickness (nm) | PAB temp (deg. C) | PAB time (s) | Calculated Abs. |
|---|---|---|---|---|---|
| A | $C_{58}H_{41}O_{1}$ | 50.5 | 105 | 60 | 3.83 |
| B | SEVR-140 | 49.1 | 105 | 60 | 5.91 |
| C | $C_{43}H_{31}O_{4}F_{23}$ | 51.2 | 105 | 60 | 8.80 |
| D | $C_{49}H_{76}O_{11}$ | 55.7 | 130 | 90 | 4.00 |
| E | $C_{46}H_{62}N_{1}F_{5}O_{10}$ | 56.7 | 130 | 90 | 4.80 |
| F | $C_{20}H_{28}O_{5}$ | 38.7 | 100 | 90 | 5.70 |

**Resist B: SEVR-140 (Shinetsu)**

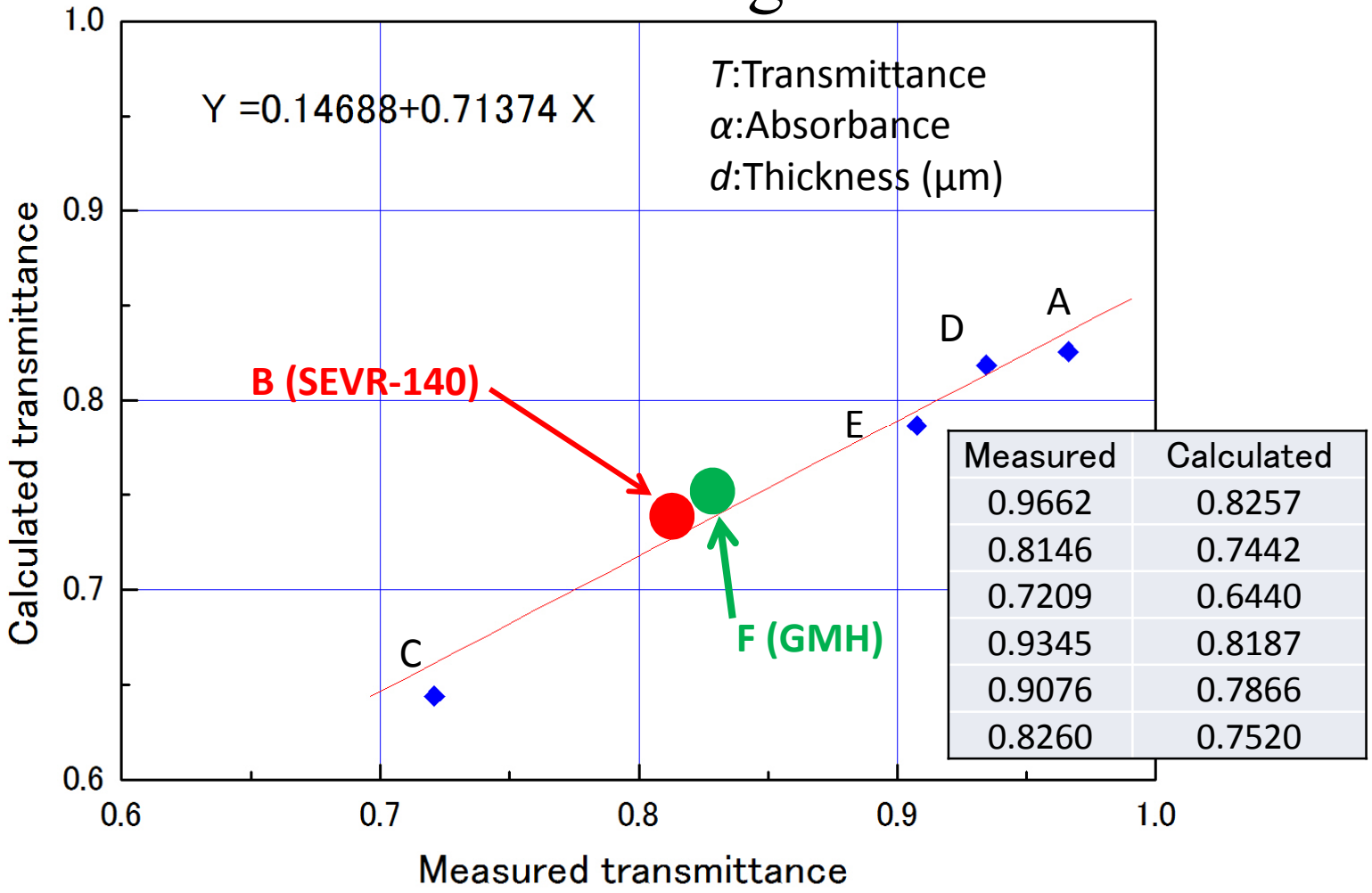
**Resist F: GMH (GBLMA/MAdMA/HAdMA 40/40/20 (mol%))**

# Transmittance measurement results



# Comparison of the measured and calculated transmittance

$$\log T = -\alpha d$$




| Measured | Calculated |
|---|---|
| 0.9662 | 0.8257 |
| 0.8146 | 0.7442 |
| 0.7209 | 0.6440 |
| 0.9345 | 0.8187 |
| 0.9076 | 0.7866 |
| 0.8260 | 0.7520 |

# Result of B-parameters measurement

| Resist | B ($\mu m^{-1}$) |
|---|---|
| A | 0.69 |
| **B** | **4.10** |
| C | 6.54 |
| D | 1.35 |
| E | 1.94 |
| **F** | **3.81** |

**Resist B: SEVR-140**

**Resist F: GMH**

$$B = -\frac{1}{d}\log(T)$$

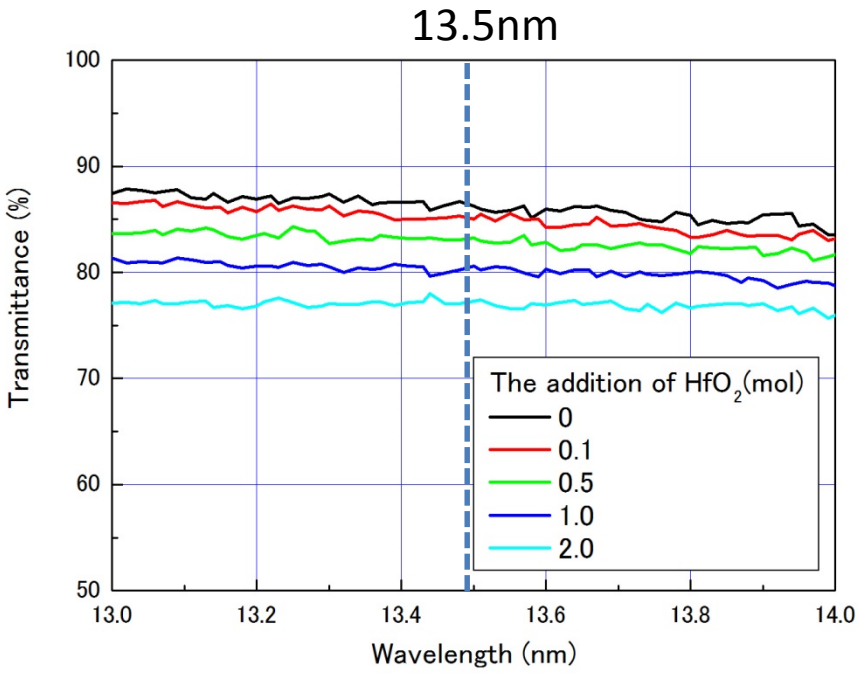
$B$:B parameter ($\mu m^{-1}$)

$D$: Thickness ($\mu m$)

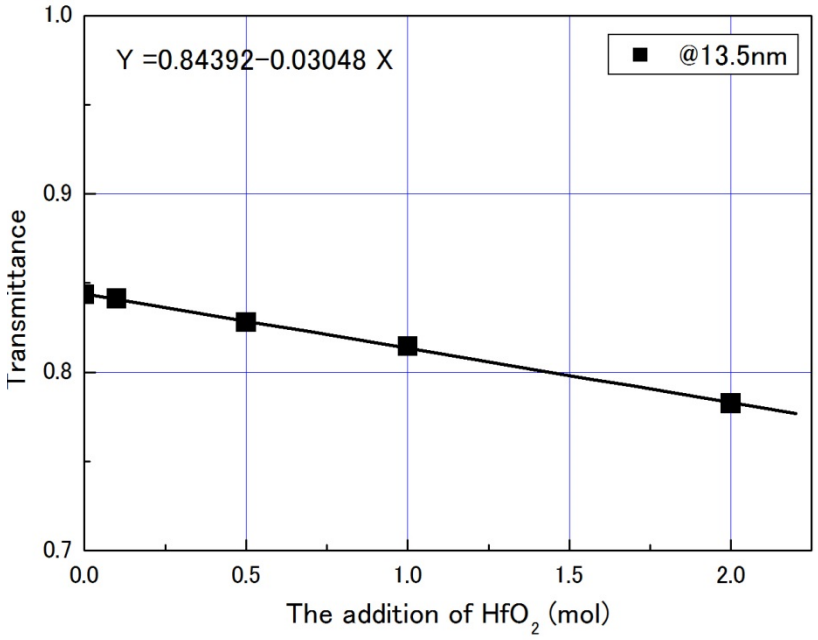
$T$: Transmittance

# 4. The influence of the addition of $HfO_2$ material

## Resist :F（PAG TPS-TF 4%)+ $HfO_2$ material




(a) Transmittance and wavelength by addition of $HfO_2$



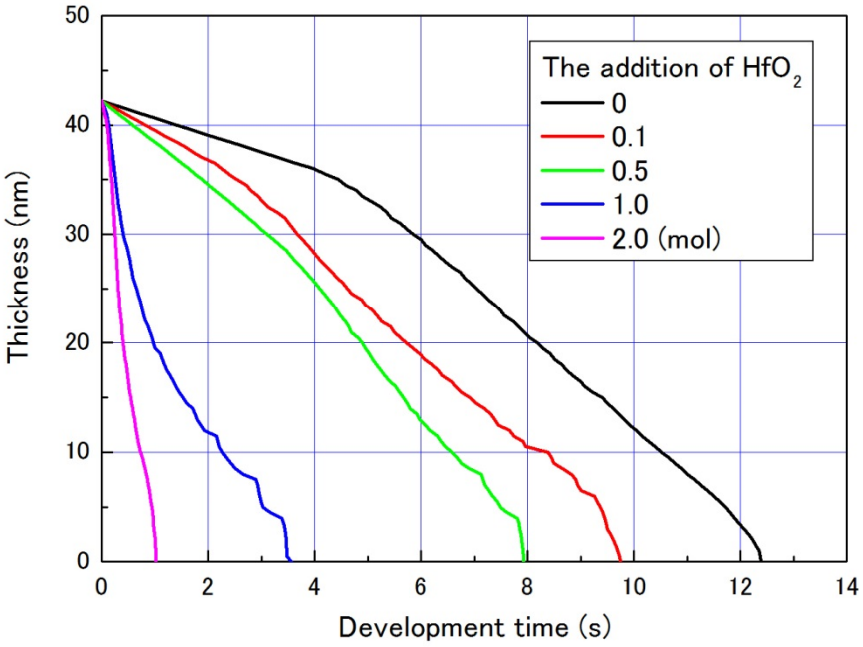

(b) Transmittance and addition of $HfO_2$ at 13.5nm (t=50nm)

## Transmittance in adding $HfO_2$

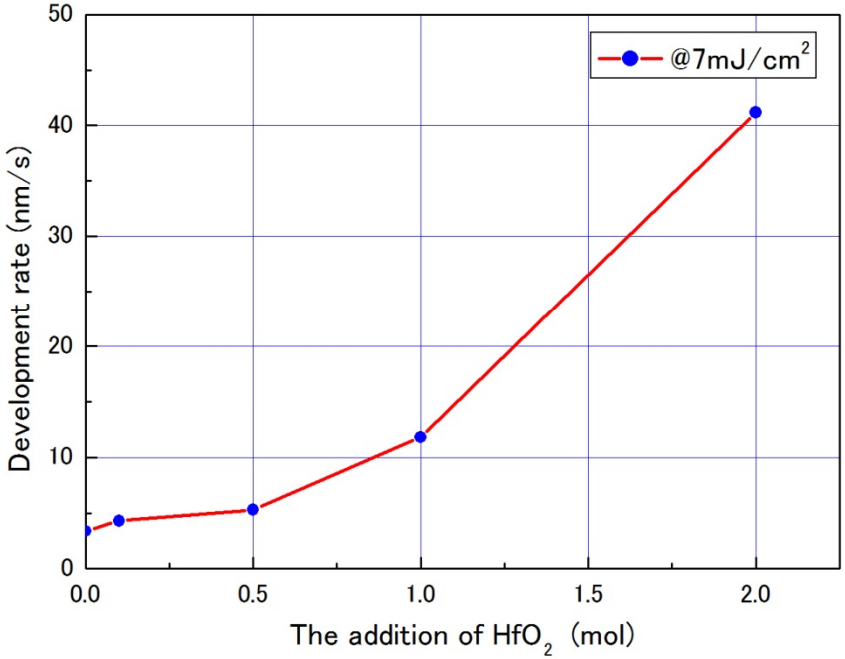
# Result of development measurement in adding $HfO_2$

Exposure: NewSUBARU BL3
Wavelength: 13.5nm at 0.33mW/cm$^2$
Exposure dose: 7mJ/cm$^2$
Rate measurement: RDA-800 (LTJ)

Resist: Resist F + PAG (TPS-TF) 4% + $HfO_2$
Pre-bake: 100deg.C/60s
PEB: 120deg.C/60s

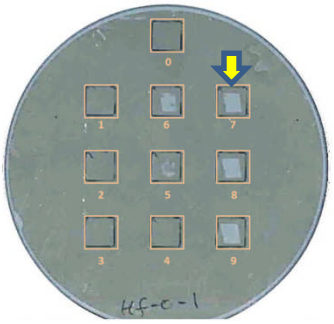
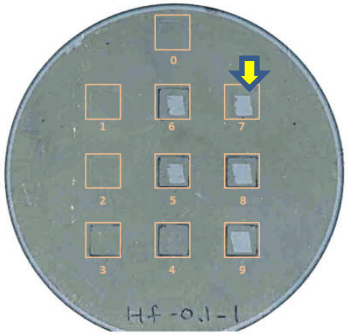
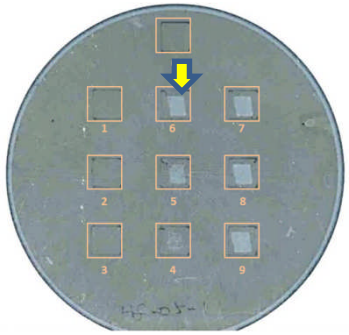
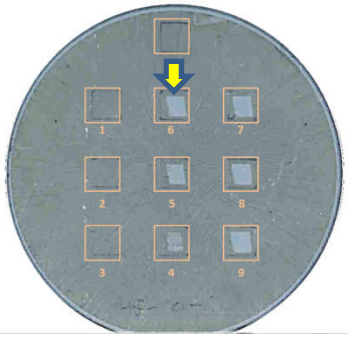
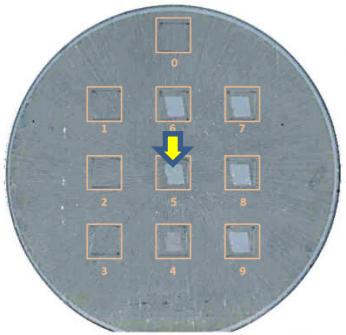


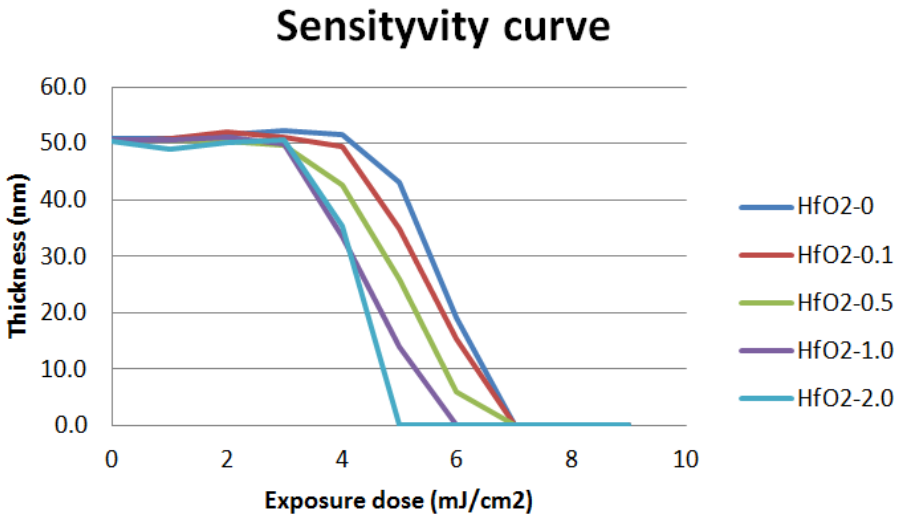

(a) Thickness and development time by addition of $HfO_2$

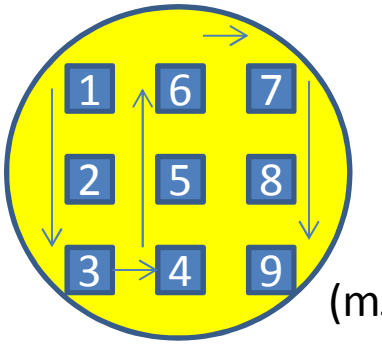



(b) Development rate and addition of $HfO_2$

# Result of Eth measurement in adding $HfO_2$

| $HfO_2$ (mol) | 0 | 0.1 | 0.5 | 1.0 | 2.0 |
|---|---|---|---|---|---|
| |  |  |  |  |  |
| $Eth_{60}$ | 7.3 | 7.0 | 6.4 | 6.0 | 5.1 ($mJ/cm^2$) |




($mJ/cm^2$)

The order and the exposure dose of the exposure

## 5. Conclusions

- We studied the transmittance measuring method of the EUV resist coated on the SiN membrane substrate. The transmittance measurement for 6 different resists were carried out.
- As a result, the calculated and measured transmittance -values were consistent.
- Using this measuring method, it is possible to obtain the B parameters of the EUV resist.
- It is found that the sensitivity improved by 30 % in adding $HfO_2$ material.

**ACKNOWLEDGEMENTS**

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