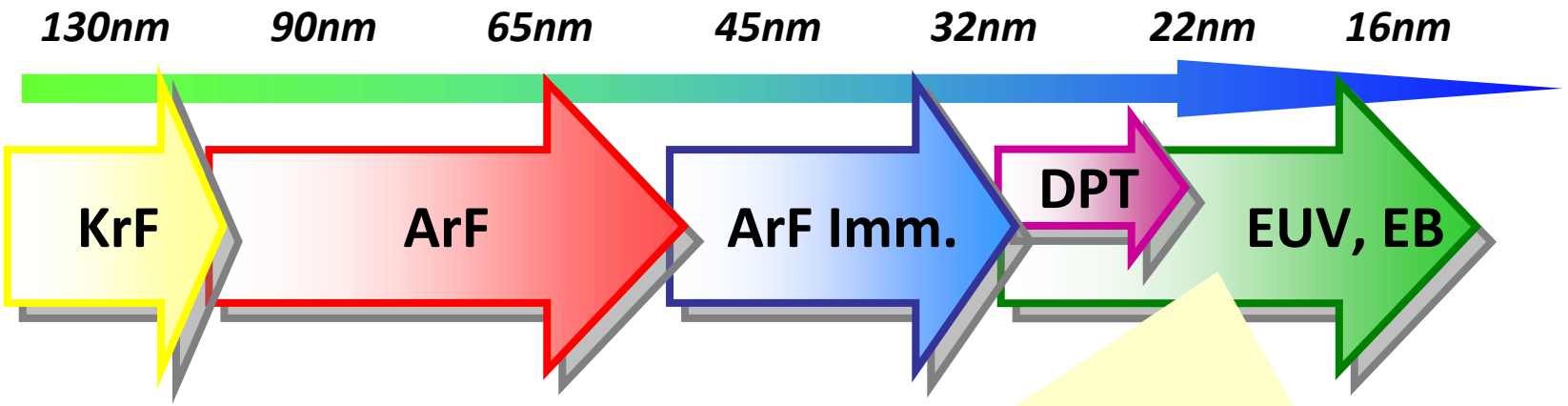
# P42

## *New approach for reducing the Out of Band effect and outgassing by applying top coat materials (Outgassing and Out-of Band Protection Layer: OBPL)*

**Nissan Chemical Industries, LTD.**

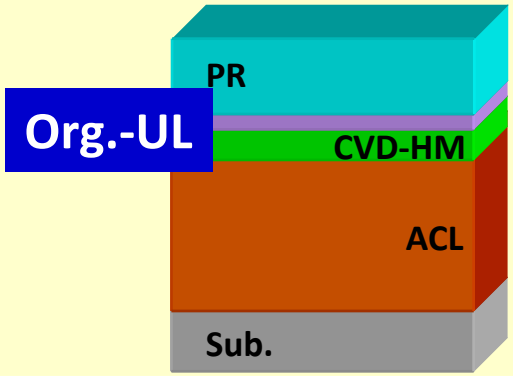
# Outline

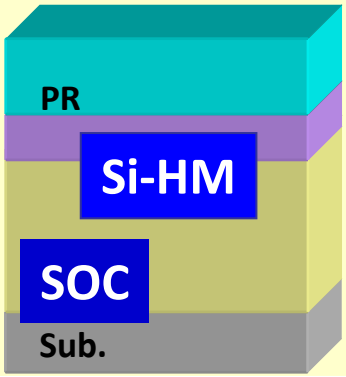
***Lithography Technology***

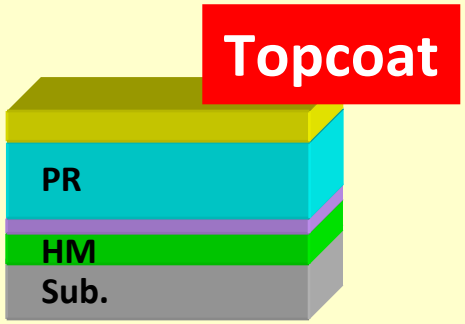



***Nissan Chemical's activity for EUVL***

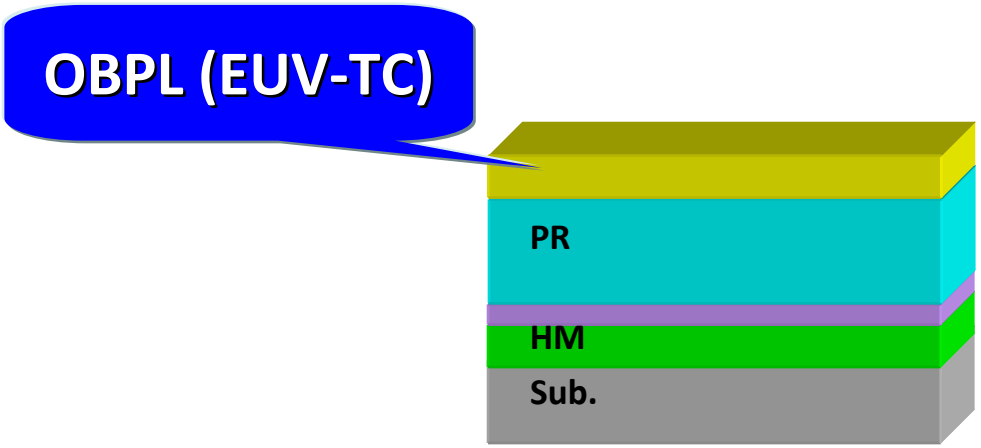
**Today's talk**



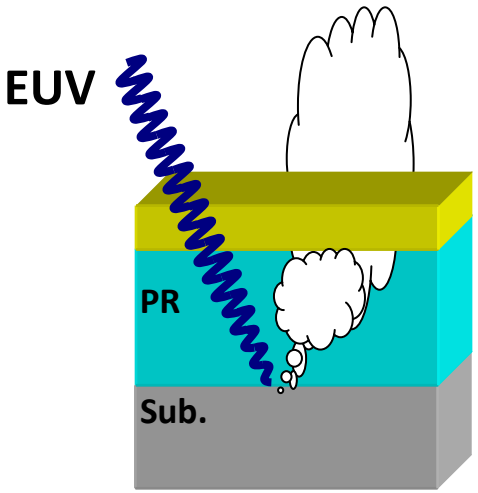



# *Nisan OBPL*

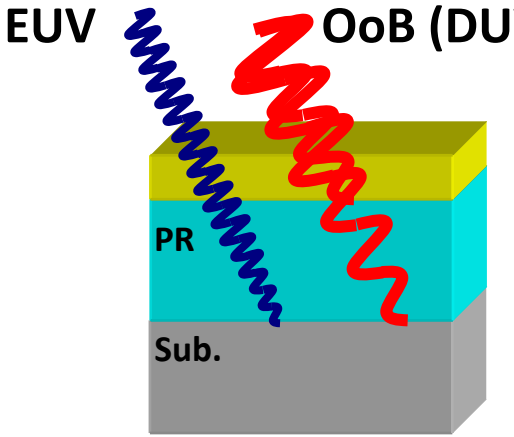


**OBPL**

# Outgassing & Out-of-Band Protection Layer

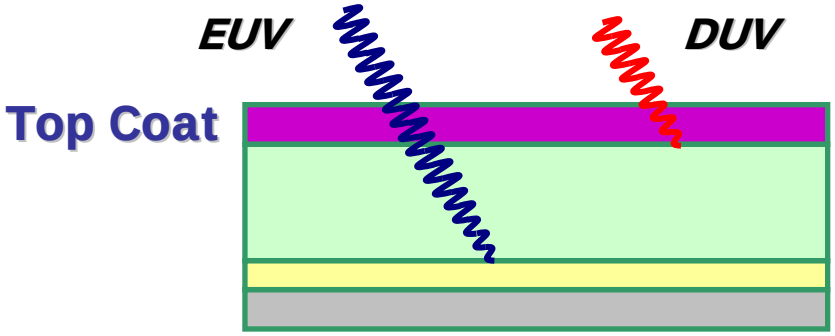



**Outgassing barrier**




**Out-of-Band filter**

# Concept of Top Coat material




**Outgassing and OoB Protection Layer (OBPL)**

**Resist**

**Under layer**

***Characteristic of OBPL :***

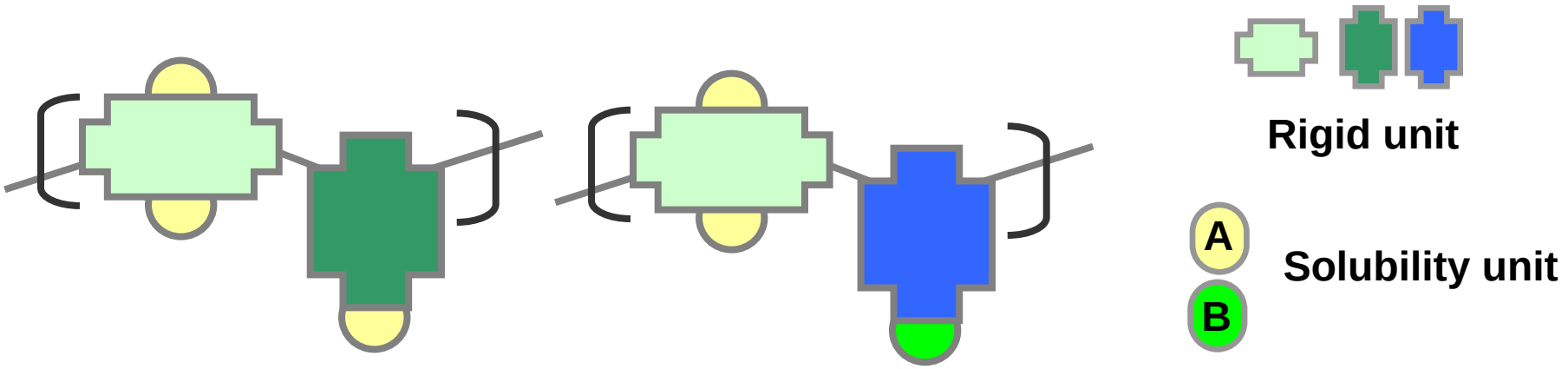
1. Low transmittance for OoB light
2. High transmittance for EUV light
3. Prevention of outgassing from resist

} **Specific property for EUVL**

4. No mixing with resist film
5. Removable by development and rinse process

} **Common property with TARC and imm. TC**

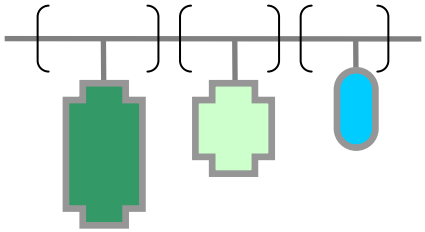
# Material design Concept




- **Ridged unit :** high outgassing barrier property and DUV abs.
- **Solubility unit A:** Developable unit into TMAH/DIW (For PTI)
- **Solubility unit B:** Solubility unit for OBPL Solvent (org.Solvent) and NBA (For NTI)

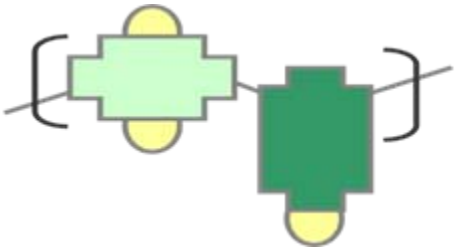
# Development road map

## 1st Generation



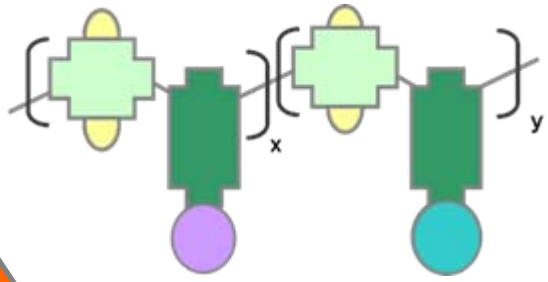
| Polymer platform | A |
|---|---|
| OoB absorption | ☺ |
| Outgassing barrier | ☹ |
| Litho improvement | ☹ |
| Applicable for resist | Pure methacryl |
| Applicable for Dev. process | PTD |

## 2nd Generation



| Polymer platform | B |
|---|---|
| OoB absorption | ☺ |
| Outgassing barrier | ☺ |
| Litho improvement | ☺ |
| Applicable for resist | Pure methacryl |
| Applicable for Dev. process | PTD |

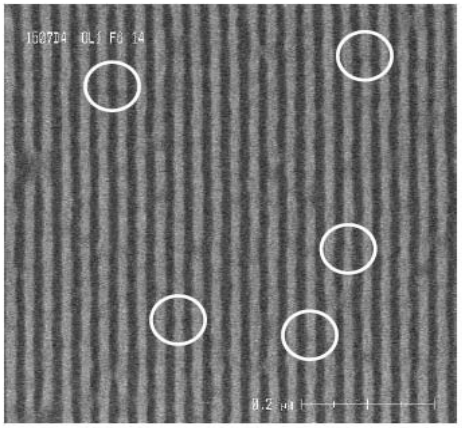
## 3rd Generation (Current R&D)




| Polymer platform | B |
|---|---|
| OoB absorption | ☺ |
| Outgassing barrier | ☺ |
| Litho improvement | ☺ |
| Applicable for resist | All resist type |
| Applicable for Dev. process | PTD & NTD |

# Outgassing

14 nm HP



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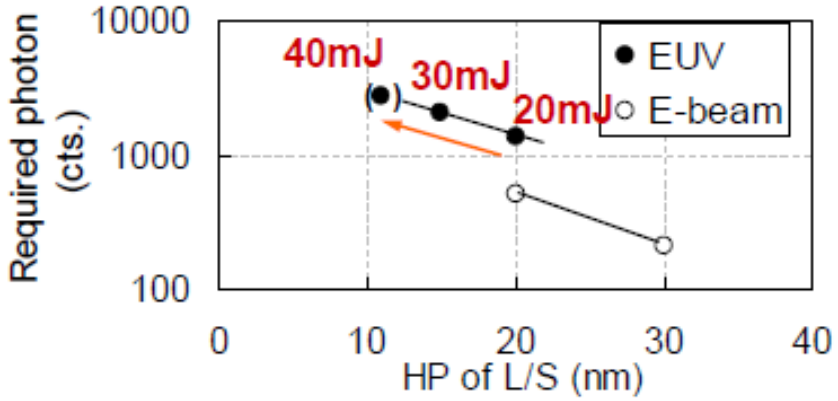
# PSN in EUVL

| | Required photon cts. for resolution (pinching cts. < 10) | |
|---|---|---|
| HP of L/S | EUV (LBNL MET) | EB (50 keV) |
| 30 nm | -- | 205 |
| 20 nm | 1360 | 500 |
| 15 nm | 2040 | -- |
| 11 nm | 2720 (estimated) | -- |




**20 mJ/cm² for 20 nm, 30 mJ/cm² for 15 nm are required**

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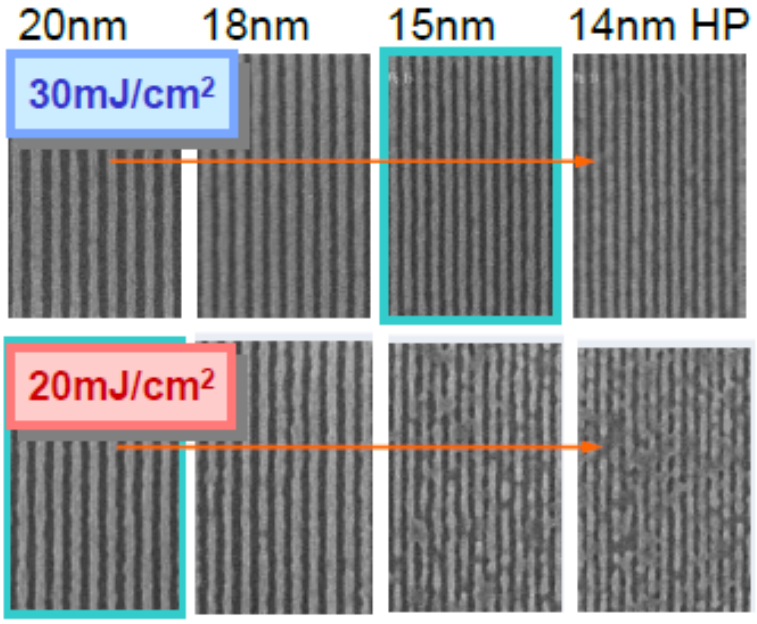
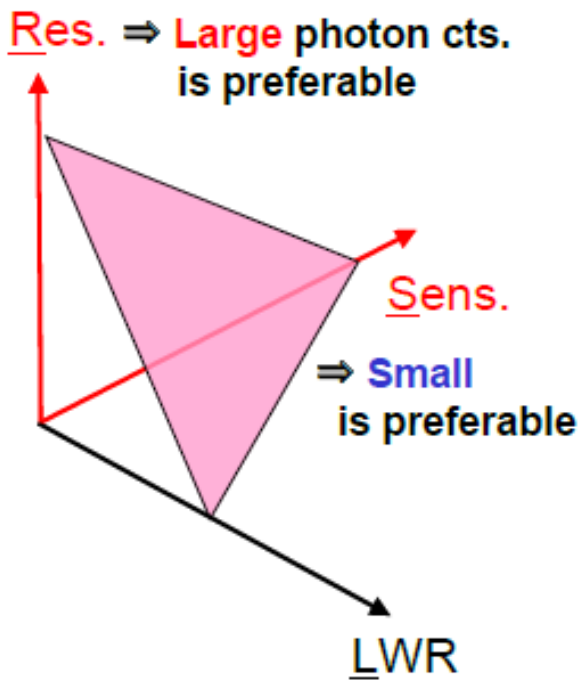
# Resolution – sensitivity tradeoff




## PSN statistics causes res. – sens. tradeoff

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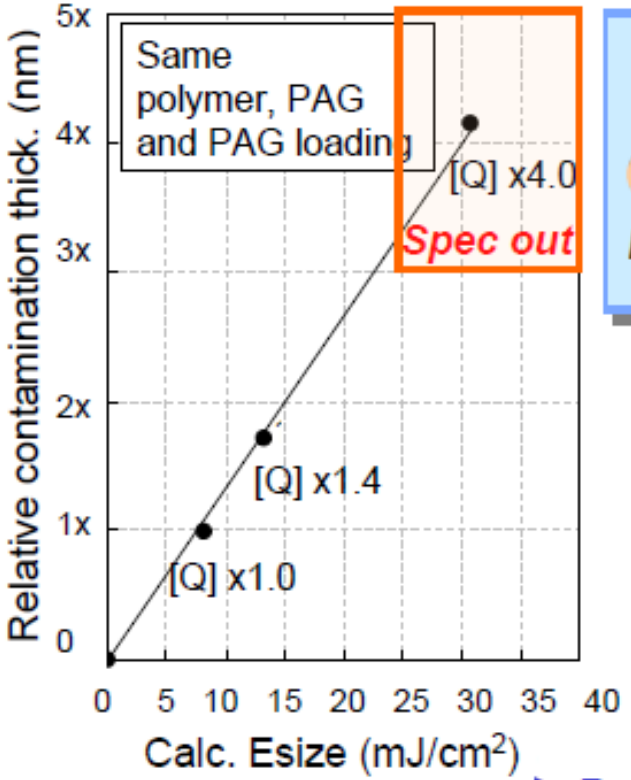
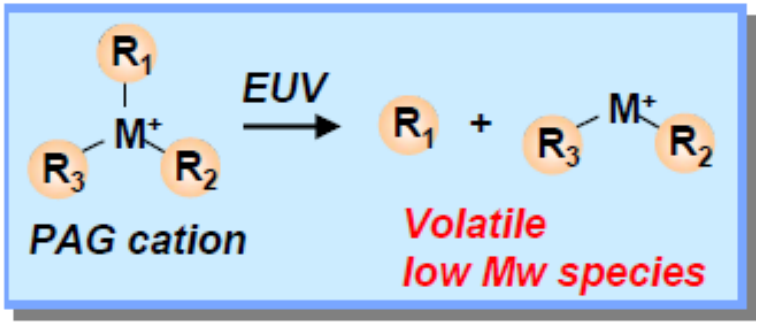
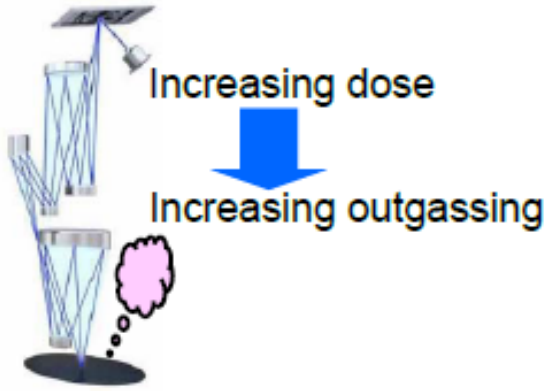
# Resolution – outgassing tradeoff




**Slow Esize. for high res (1x nm). caused outgassing**

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# *Important message*

**Below Hp15 Generation.**

**More than 2000 photon will be required to get**

**The enough Resolution and imaging quality.**

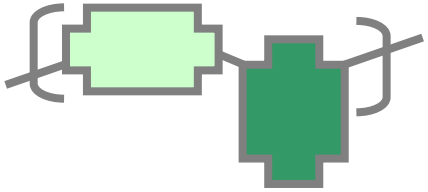
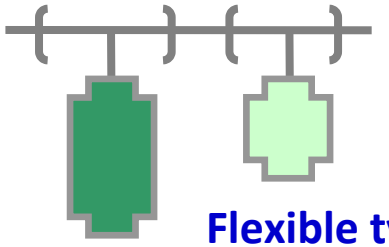
**→High dose (>30mJ) will be exposed to PR.**

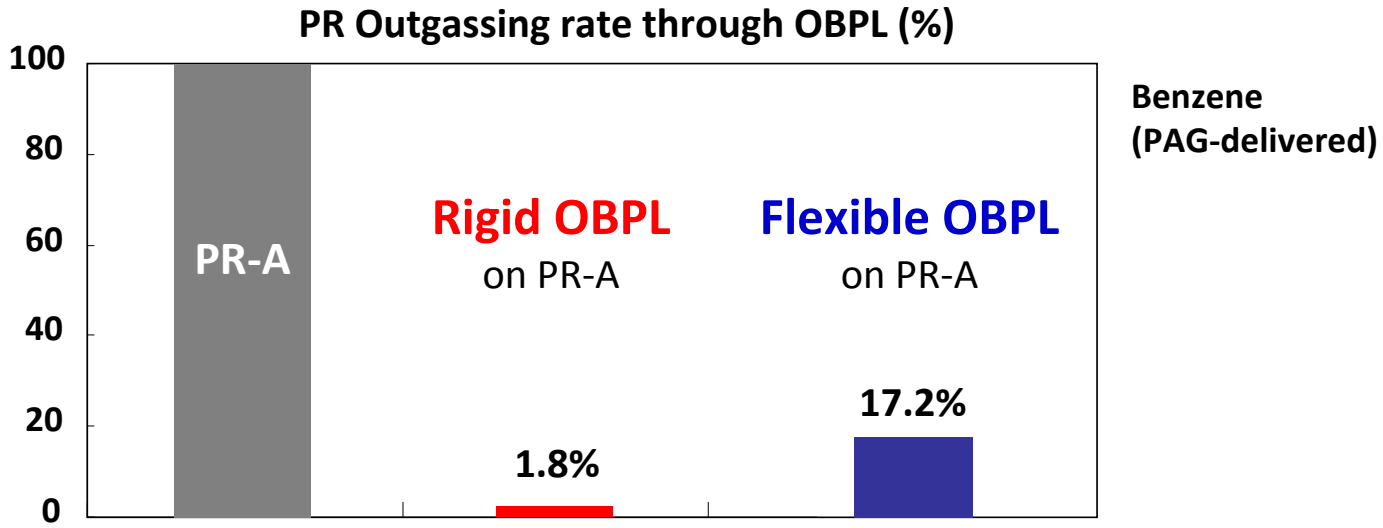
**→→ Outgass must be higher and higher.**

**Because of trade off between Res. & Outgass.**

**EUV-TC will be required for Hp15 and beyond**

# Previous study by RGA

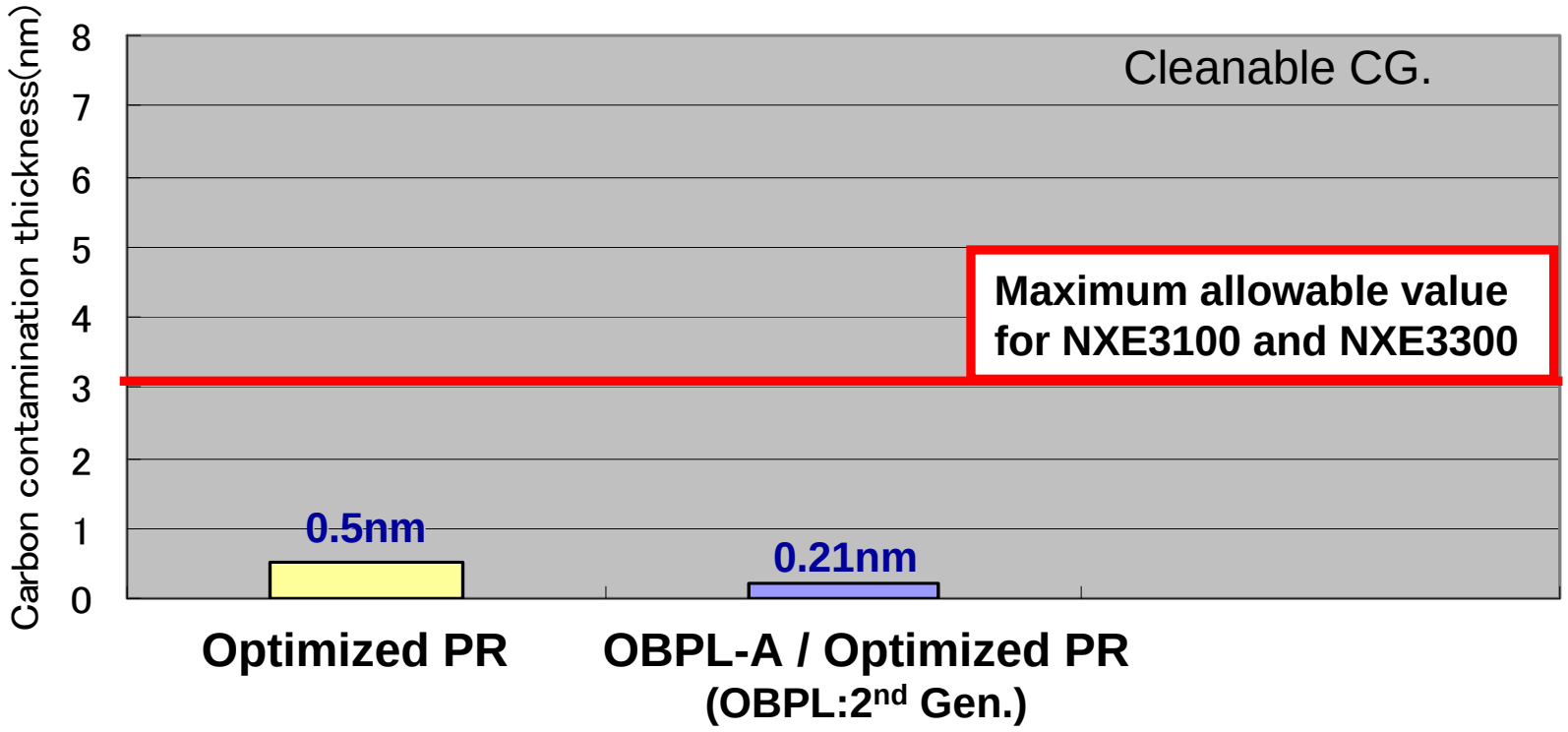
| | OBPL-1 | OBPL-2 |
|---|---|---|
| Polymer platform |  Rigid type |  Flexible type |
| Film density (g/cm$^3$) | 1.21 | 1.15 |




**Chemistry dependency for outgass barrier was confirmed, But appling OBPL could reduce the outgassing significantly.**

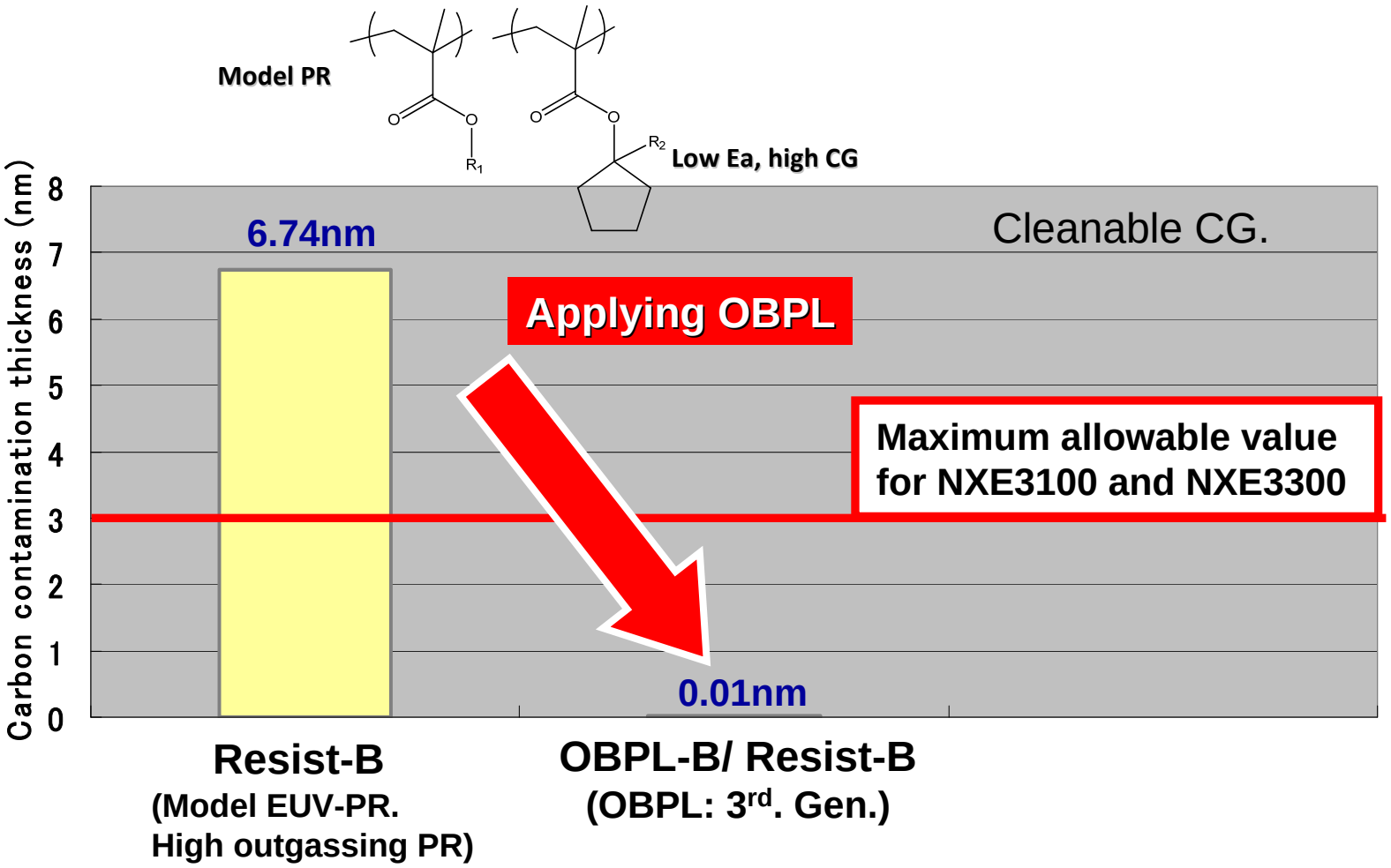
# Outgassing barrier test by WS

**Tester / location: CNSE ROX (Witness)**
**OBPL-A (FT: 30nm)**



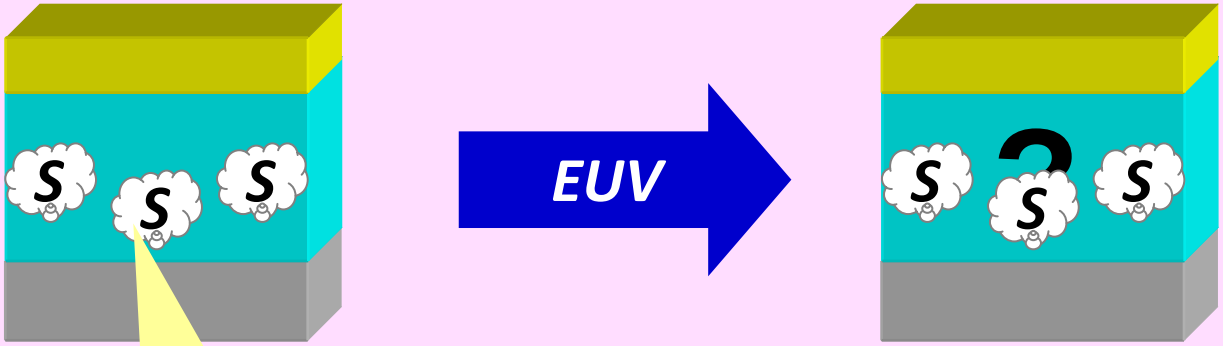

**There is no significant difference in outgassing level By using OBPL for optimized PR.**

# Outgassing barrier test

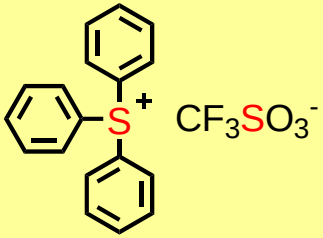



**Perfect outgassing prevention by OBPL was confirmed.**
**→ SPEC-OUT PR could be SPEC-IN by Applying OBPL.**

# Contamination distributional analysis



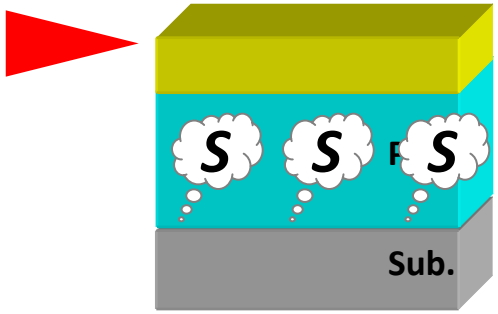

**PAG-delivered**

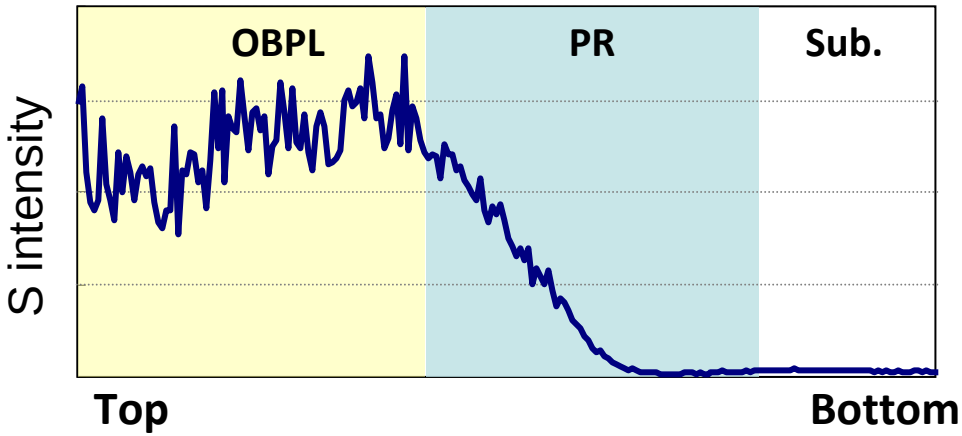



| | | |
|---|---|---|
| **Analysis method** | **:** | **Depth profile** |
| **Tool** | **:** | **TOF-SIMS** |
| **Detection atom** | **:** | **Sulfur** |

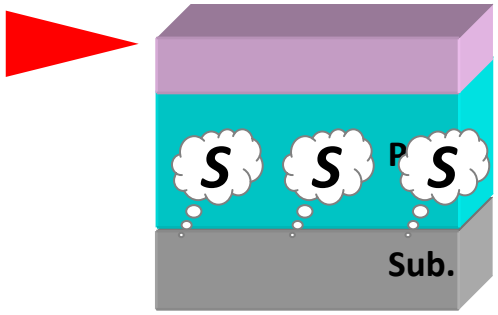
# Variation concentration of Sulfur atom

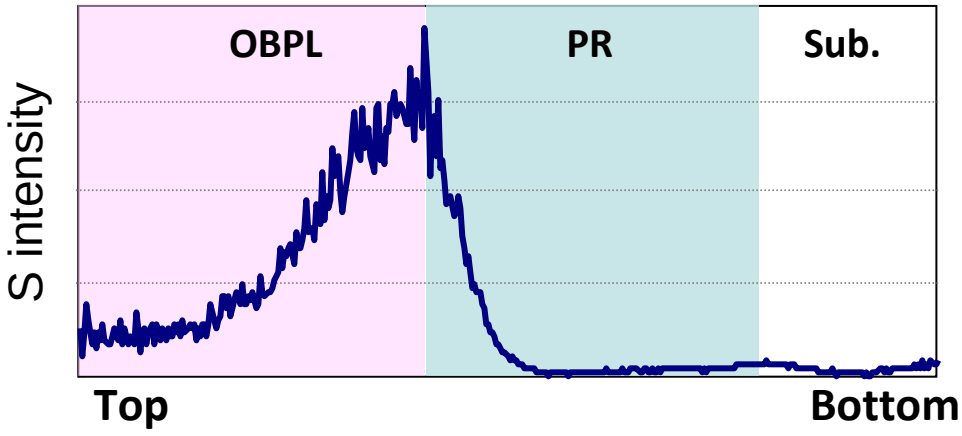
**Flexible OBPL**




**Rigid OBPL**

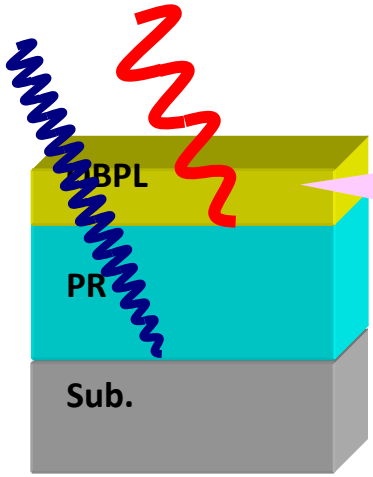



**Rigid OBPL blocks PR outgassing at interface.**

# OoB study

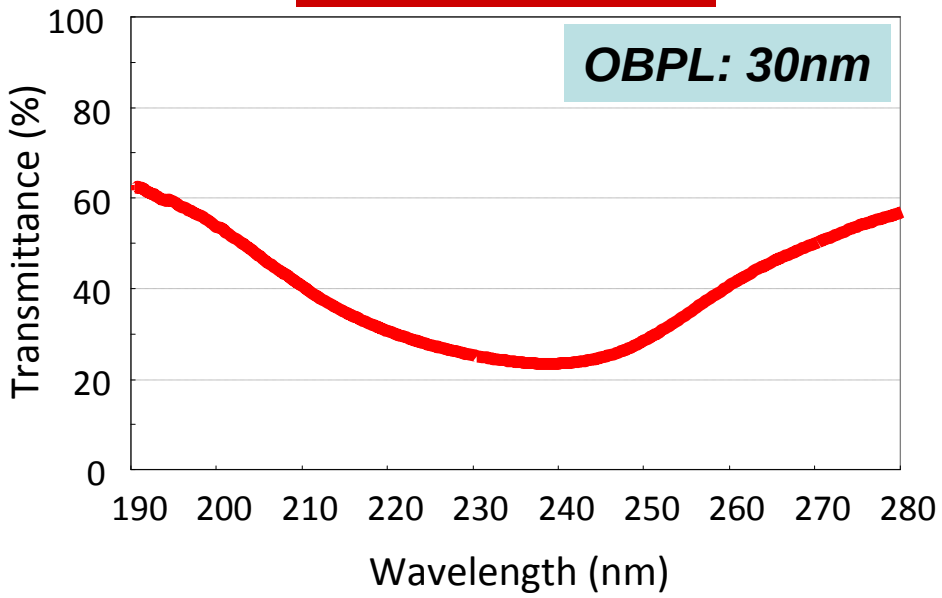
# Requirement of OBPL



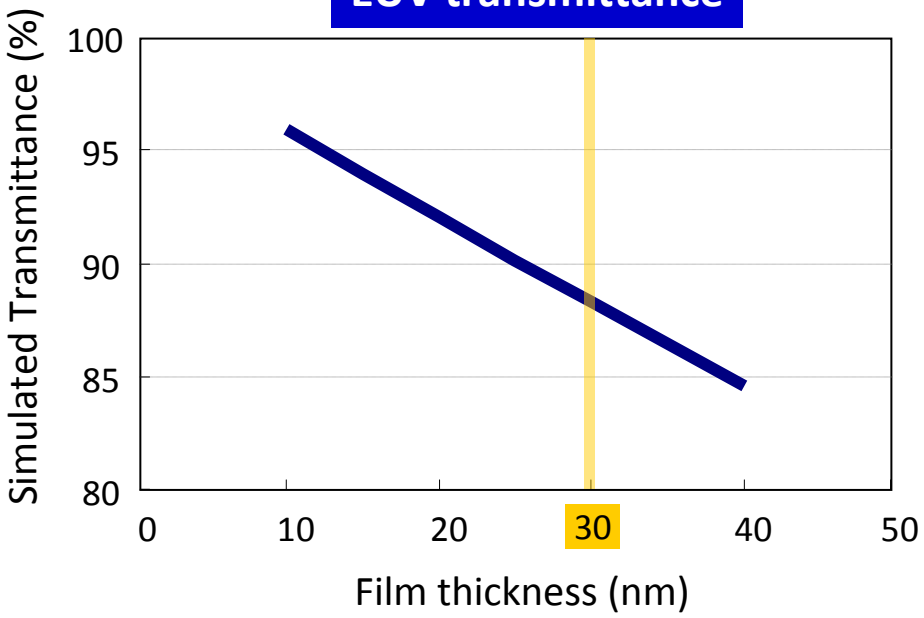

***Requirement of OBPL***

- Low DUV transmittance **20~30%@min.**
- High EUV transmittance **~90%**

**DUV transmittance**

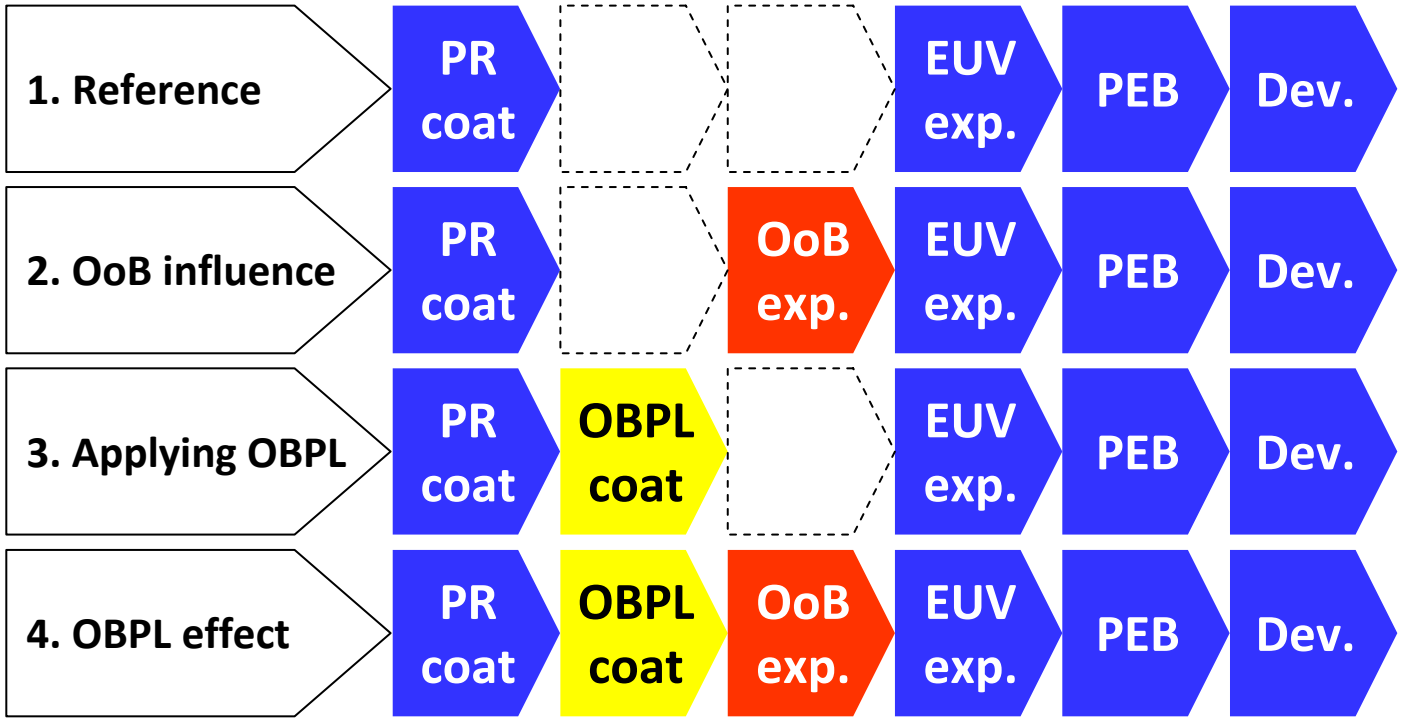



**EUV transmittance**



# Investigation of OBPL effect

*S.A.George al., SPIE (2011)*



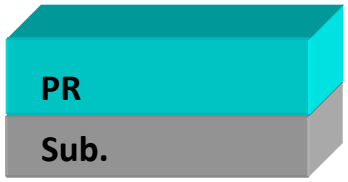

SEMATECH

***OoB exposure condition***

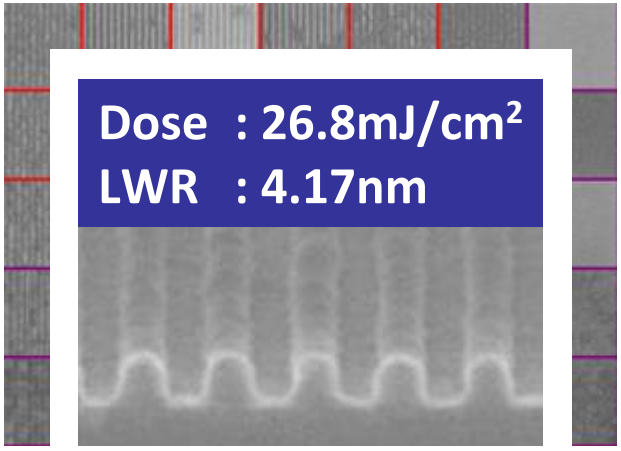
**Wavelength: 160~300nm (broad band)**

**Dose: 5.0mJ/cm$^2$ (20% of EUV)**

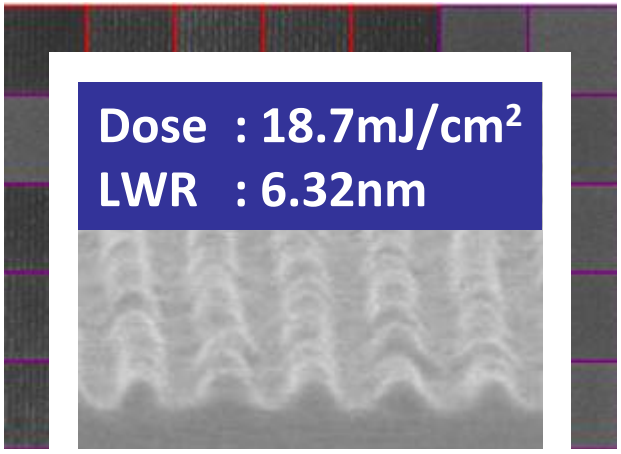
# OBPL effect results



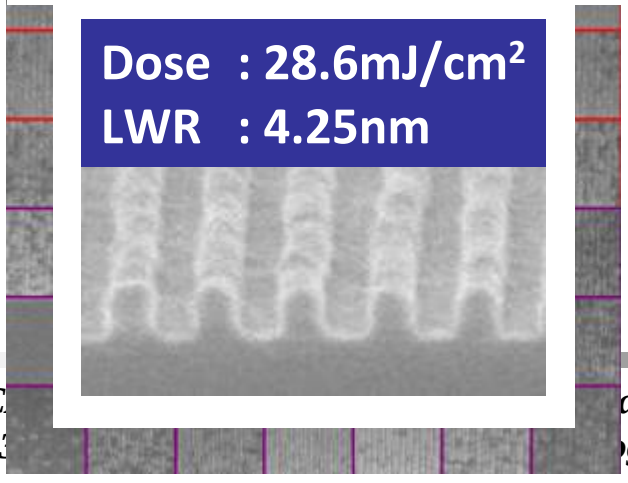

**EUV**

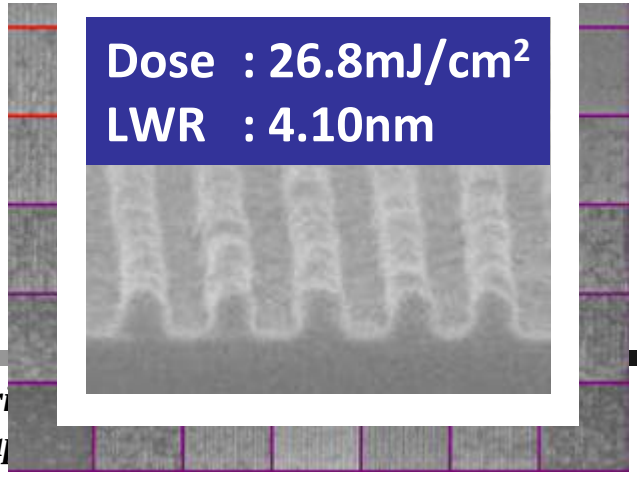



**EUV + OoB**




**OBPL behaves extremely well as OoB filter.**

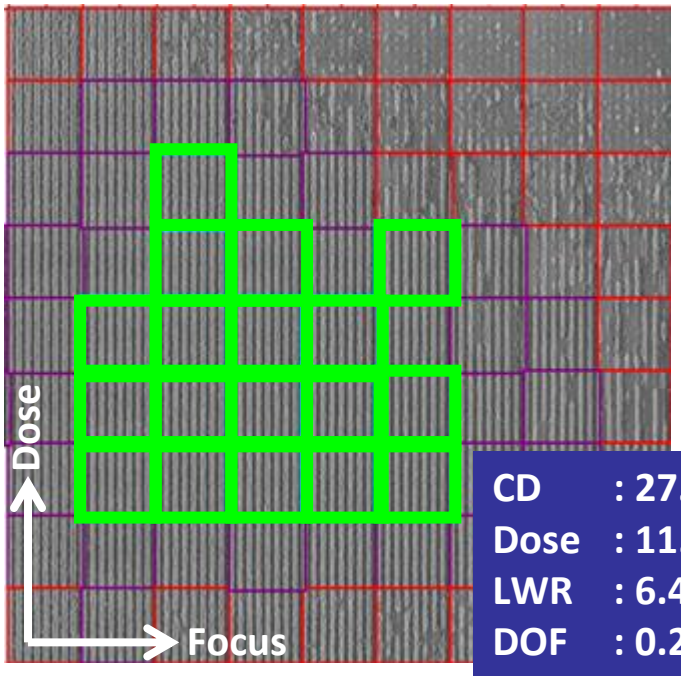
# 3rd Generation (Current R&D)

## Concept: Universal TC for PR and process

| | |
|---|---|
| Polymer platform | Rigid type |
| OoB absorption |  |
| Outgassing barrier |  |
| Litho improvement |  |
| Applicable for resist | All resist type |
| Applicable for Dev. process | PTD & NTD |

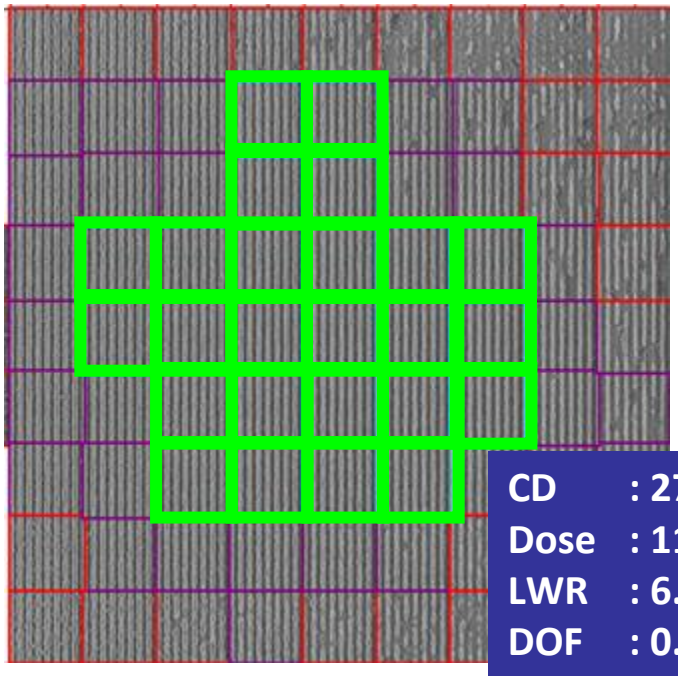
# Lithographic performance with NXE:3100

**without OBPL**

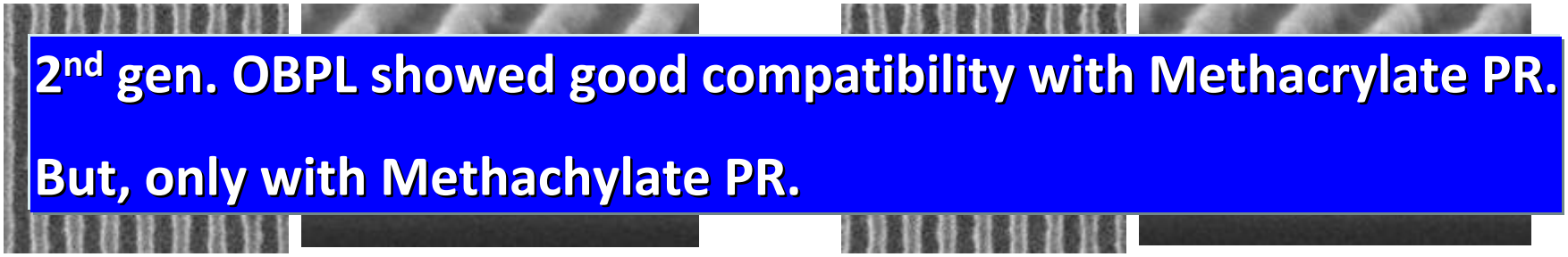



CD : 27.7nm
Dose : 11.2mJ/cm$^2$
LWR : 6.4nm
DOF : 0.20um

**with OBPL**



CD : 27.4nm
Dose : 11.5mJ/cm$^2$
LWR : 6.6nm
DOF : 0.22um



**2nd gen. OBPL showed good compatibility with Methacrylate PR.**

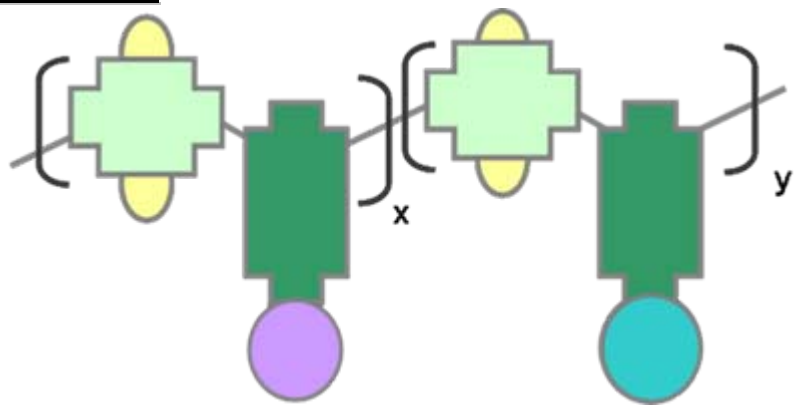
**But, only with Methachylate PR.**

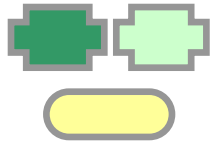
# 3rd Generation OBPL

***Target:***

**Universal compatibility for PR (Methacrylate & PHS) and Dev. Process (PTD&NTD).**

## Material design

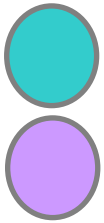


Rigid unit
Outgassing barrier

Hydrophilic unit

x+y = 100%



Solubility unit for solvent

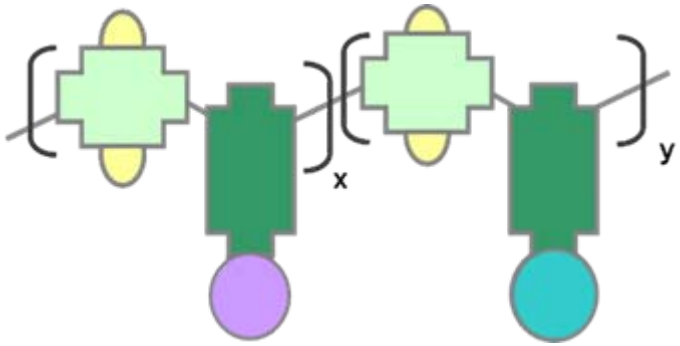


Functional unit

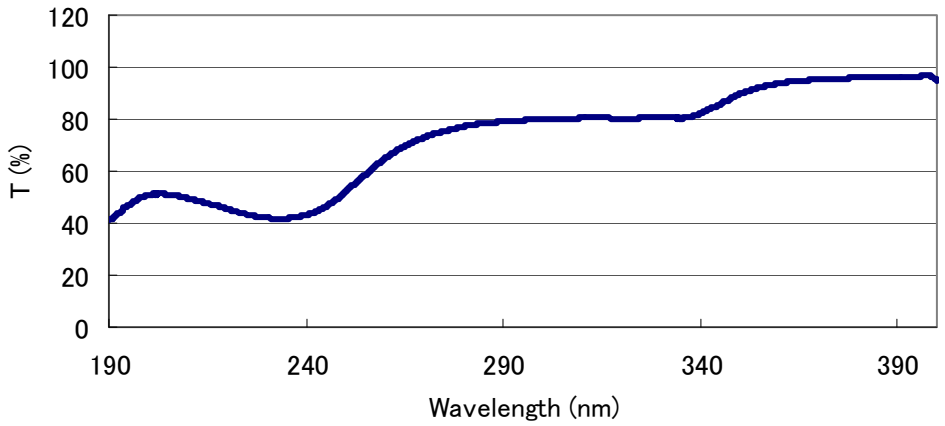
| | | |
|---|---|---|
| Sample design | Basis of materials | High rigidity resin |
| | Solvent | Org. Solvent (non-mixing with Methacryl and PHS type PR) |
| Process | Applicable for resist | All resist type |
| | Applicable for process | PTD (TMAH aq) & NTD (NBA) |

# Proposal sample (3rd Generation )

## Material design




**DUV transmittance of 30nm OBPL**




## Sample property (NCX2088)

| Sample name | Polymer platform | R unit | Outgassing qualification | | Transmittance | |
|---|---|---|---|---|---|---|
| | | Type | Qualification | Barrier test | 13.5nm | 240nm |
| NCX2088 | B | High hydrophilic | Pass | | 81% | 43% |

**High DUV abs. and good outgass barrier property**

# Methacrylate type PR

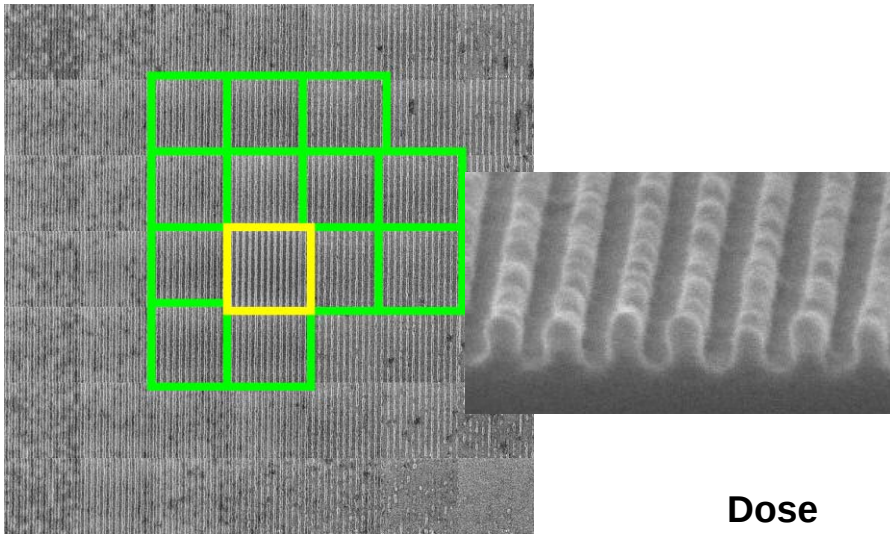
**Tester / location: Sematech (AMET)**

**Best shot** **Pattern standing**

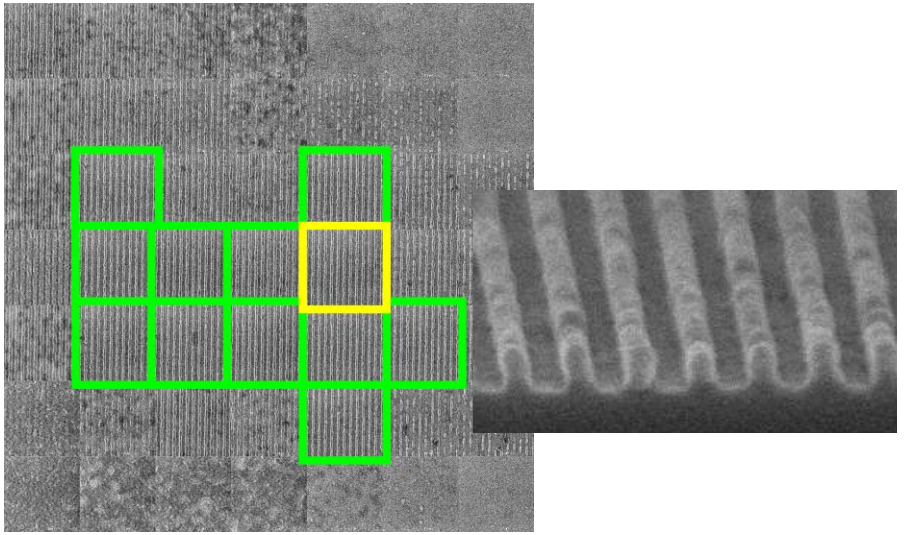
Focus

Dose

**Resist-C**



**NCX2088 / Resist-C**



| | |
|---|---|
| CD (nm) | 27.3 |
| Dose (mJ/cm$^2$) | 11.5 |
| LWR (nm) | 4.3 |
| Max EL (%) | 13.0 |
| Max DOF (um) | 0.20 |

| | |
|---|---|
| CD | 28.1 |
| Dose | 14.0 |
| LWR | 4.5 |
| Max EL | 10.7 |
| Max DOF | 0.20 |

**Appling OBPL keep good process margin and LWR.**

# HS/Methacrylate hybrid type

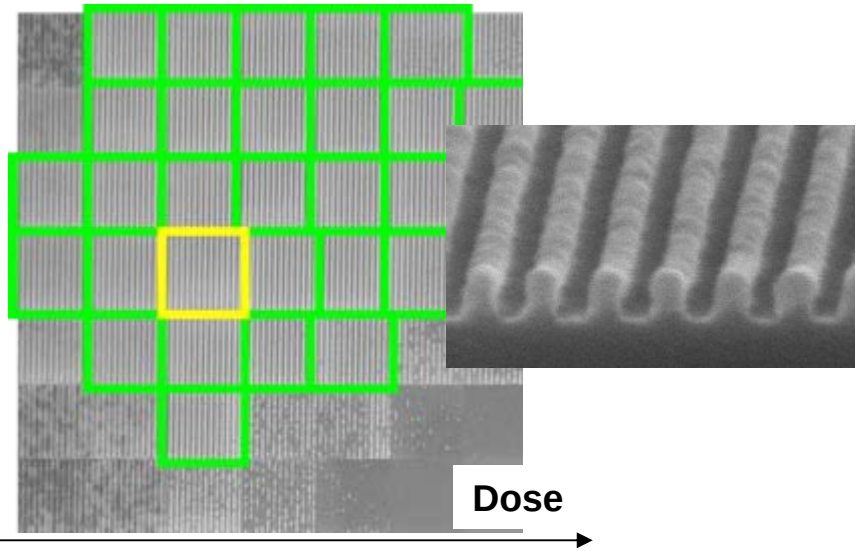
**Tester / location: Sematech (AMET)**

Best shot  Pattern standing

Focus

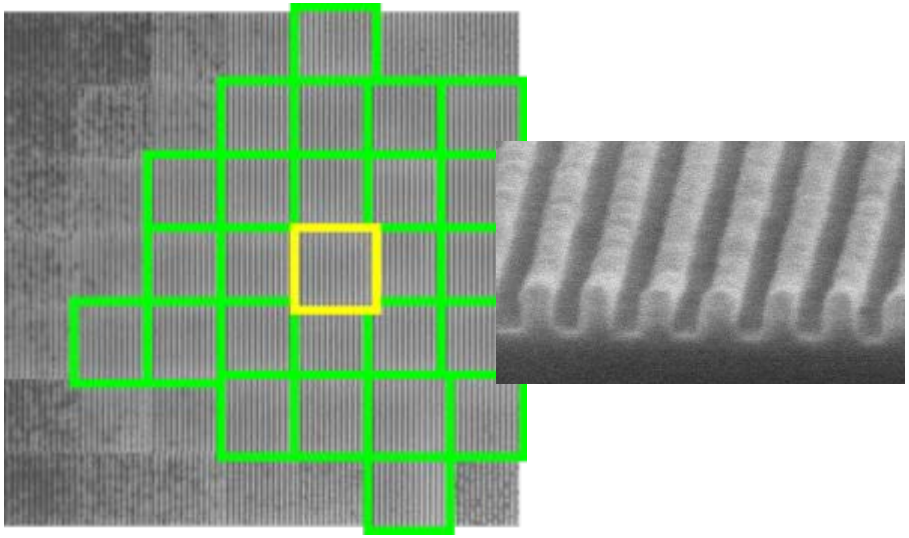
Dose

**Resist-D**



| | |
|---|---|
| CD (nm) | 26.1 |
| Dose(mJ/cm$^2$) | 24.0 |
| LWR (nm) | 4.0 |
| Max EL (%) | > 29.2 |
| Max DOF (um) | > 0.30 |

**NCX2088 / Resist-D**

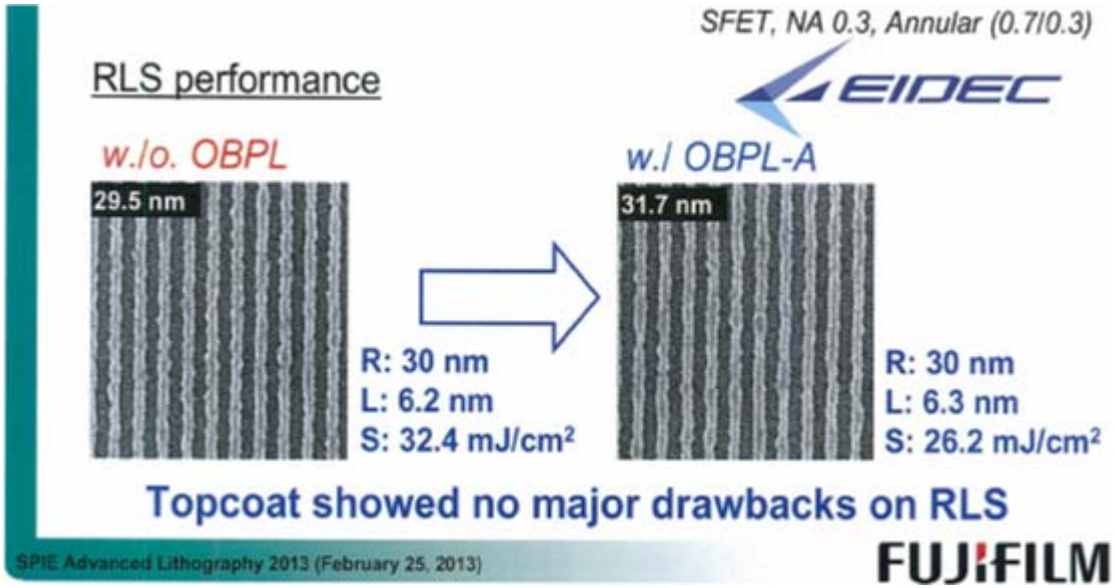


| | |
|---|---|
| CD | 25.7 |
| Dose | 27.0 |
| LWR | 4.1 |
| Max EL | > 18.5 |
| Max DOF | > 0.30 |

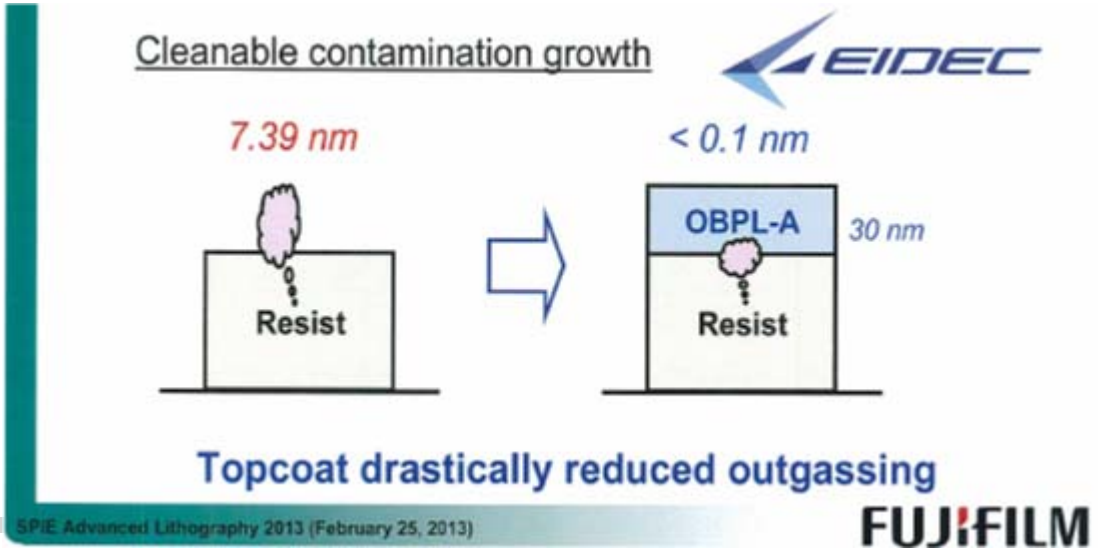
**Appling OBPL keep good process margin and LWR.**

# Performance for NTI

**Lithography performance**




**Outgassing barrier performance**




**H. tsubaki, SPIE 2013**

# Summary

## Outgassing

Perfect barrier property was confirmed.
ROX qualification of Staked (PR/OBPL),
**SPEC-OUT PR could be SPEC-IN by OBPL!!**

3rd Gen. OBPL

**NCX2088**

## Universality
PR kinds and Process

Methacrylate type PR(PTI)

PHS hybrid type PR (PTI)

PHS hybrid type PR(NTI)

## OoB

High DUV abs. could prevent
OoB irradiation effect.

# Conclusion

- Nissan Chemical has successfully developed OBPL for EUVL.
- OBPL has PR outgassing barrier property and Out-of-Band filter effect.
- 3rd Gen. OBPL showed good PR universality and process compatibility.
- OBPL can be the key material for high volume manufacturing by EUVL.