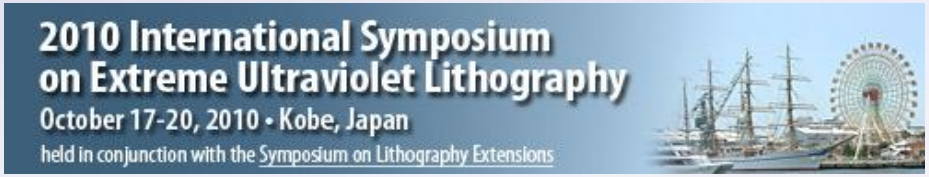

EUV Contact Hole Resist Progress for High Photosensitivity and Improved Local CD uniformity

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Outline

- Introduction
  - ✓ Challenges for EUV Contact Hole Resist
- Resist Dependency on Improvement of Dose and Local CD Uniformity
  - ✓ PAG and Quencher Optimization
  - ✓ Molecular Weight Effect
  - ✓ Resist Platform Dependence
- Mask Dependency on Improvement of Dose and Local CD Uniformity
  - ✓ Mask Bias Effect
  - ✓ Mask CD Uniformity Effect
- Summary
- Acknowledgement

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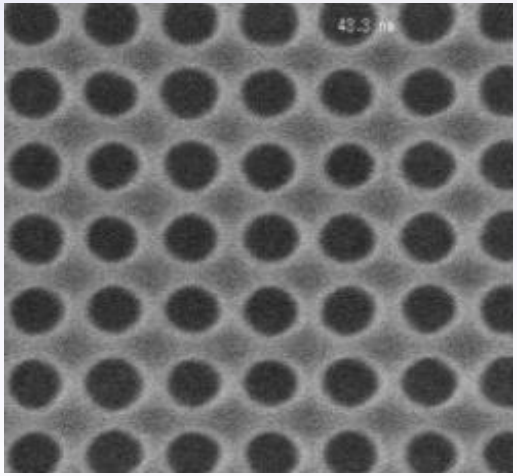
Challenges in EUV Contact Hole Resist for Pilot-line Implementation

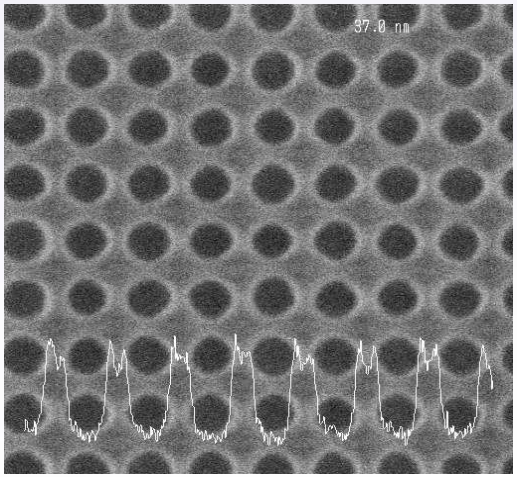
- ADT, 0.25 NA, 0.5 sigma
- Dose : 35mJ/cm^2

35nm HP



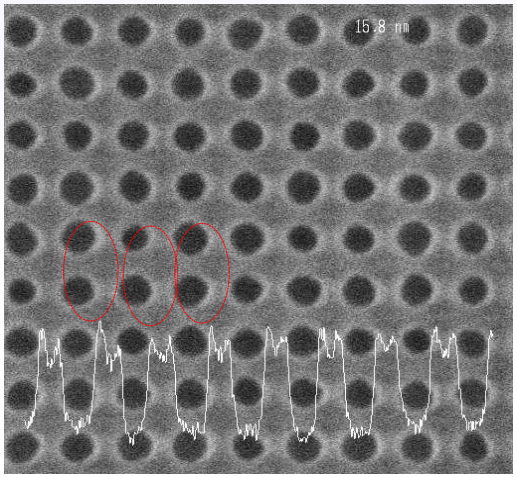
Local CD Uniformity: 4.5nm

33nm HP



Local CD Uniformity: 4.8nm

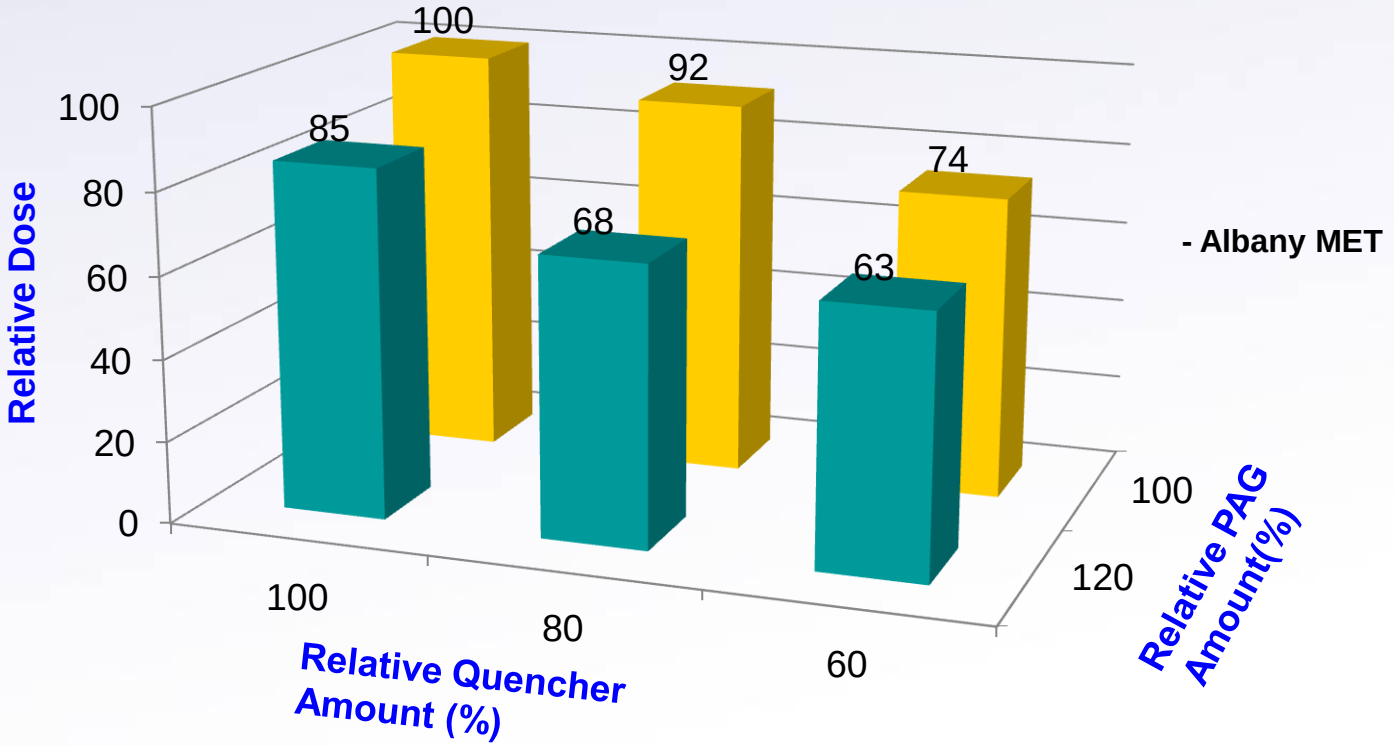
30nm HP



Local CD Uniformity: 5.2nm

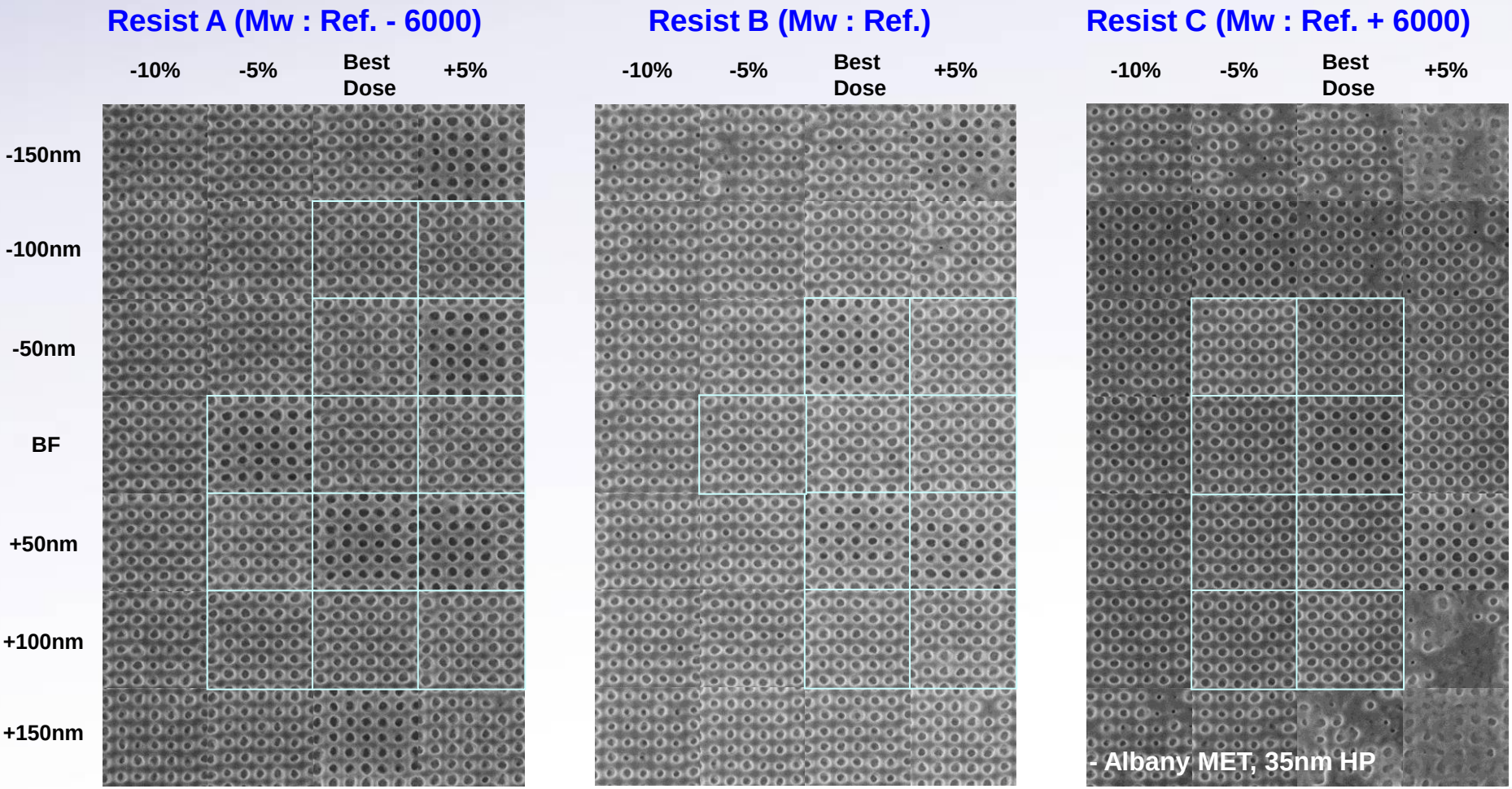
- **Issue 1 : High dose (Dose : 35mJ/cm^2 , Target : 15mJ/cm^2)**
- **Issue 2 : Bad local CD uniformity (5.2nm @ 30nm HP, Target : 3.5nm)**

Photosensitivity Dependency on the Loading Amount of PAG and Quencher



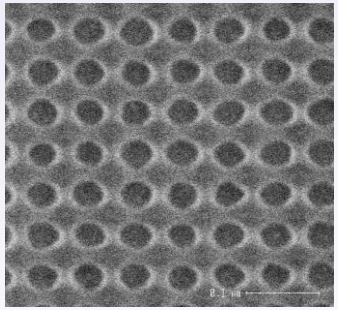
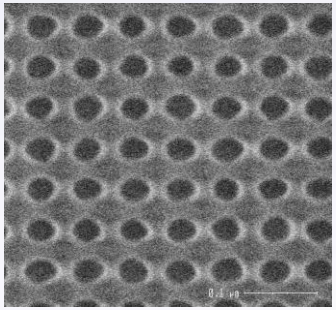
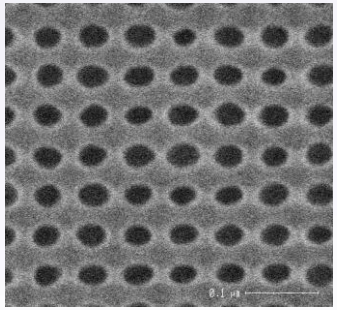
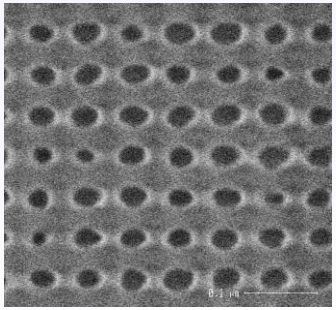
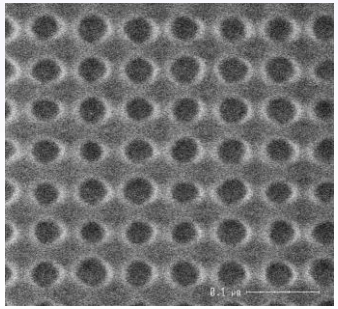
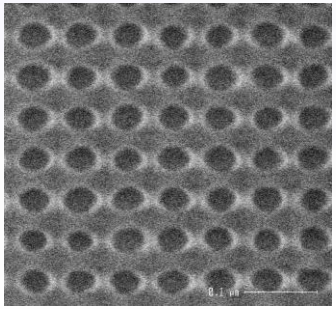
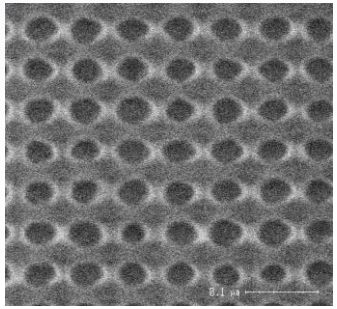
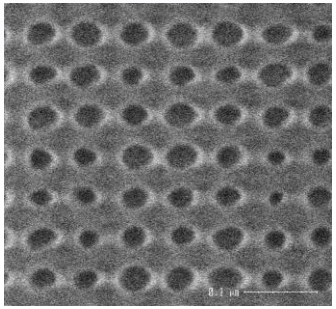
- **Dose was improved by the amount of 17% with an increase of 20% PAG loading amount, and improved by the amount of 12% with a decrease of 20% quencher loading amount.**

Molecular Weight Effect on Contact Hole Performance



- DOF can be increased with lower molecular weight of polymer.
- Improvement of local CD uniformity need to be studied in detail at ADT.

Resist Platform Dependency on Local CD uniformity : Champion Resist of Each Resist Platform at ADT

	-50nm	Best Focus	+50nm	+100nm
Polymer Bound PAG Resist **Dose : 18mJ/cm^2** **FoV LCDU : 7.1nm**				
Methacrylate Blend Resist **Dose : 16mJ/cm^2** **FoV LCDU : 7.9nm**				

•FoV LCDU (3σ) : Field-of-View Local CD uniformity (3σ of all contact holes in a field-of-view at the magnification of 300K)

- **Polymer bound PAG resist platform looks more promising than other resist platforms in terms of local CD uniformity.**

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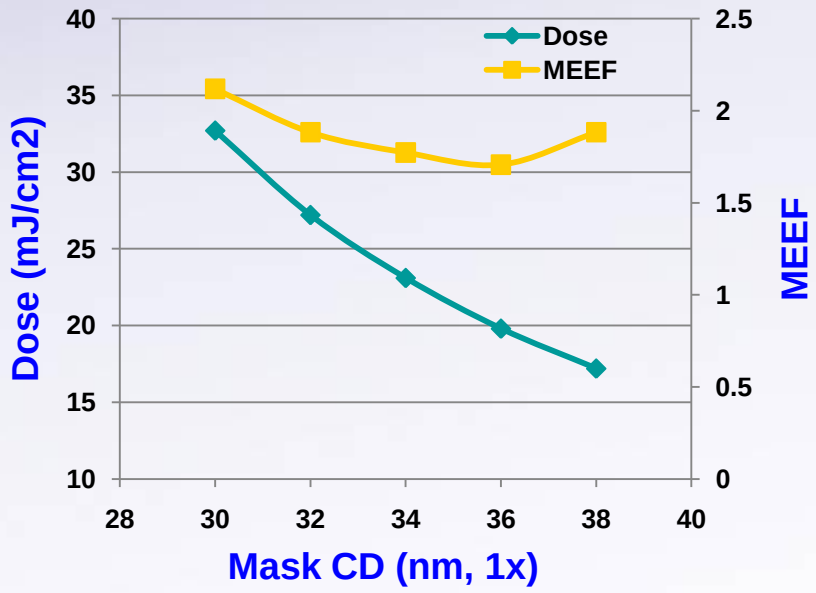
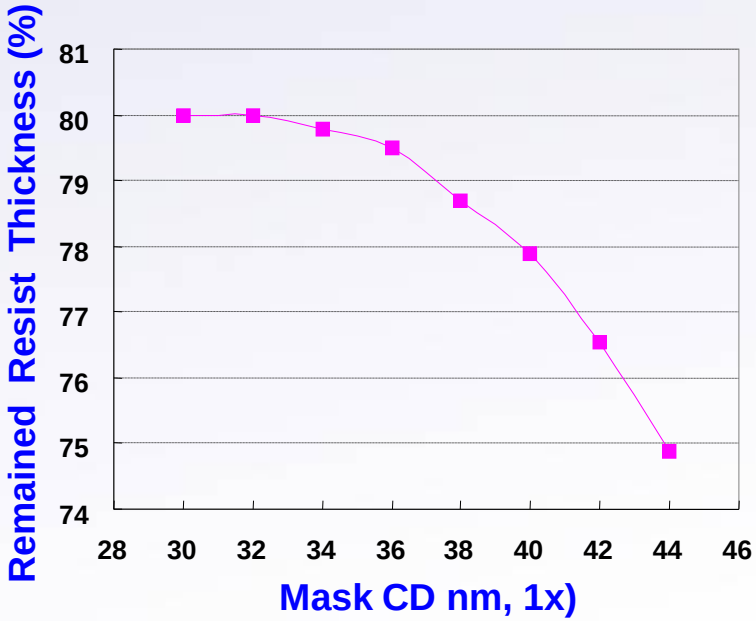
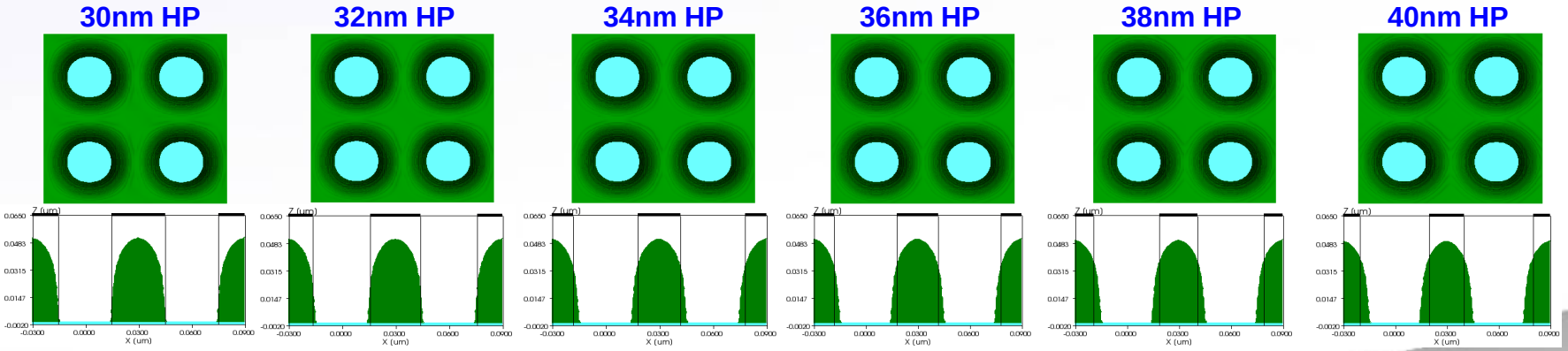
Mask Bias Effect for Contact Hole Patterning

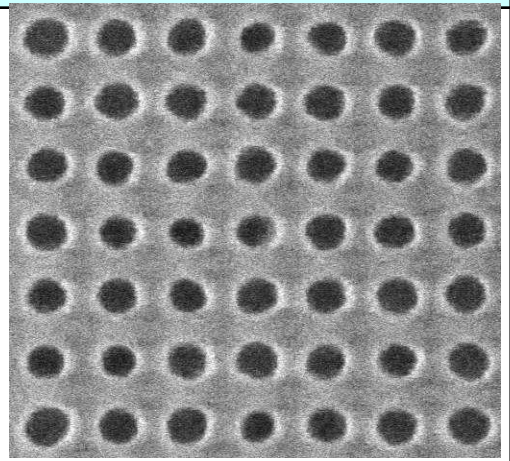
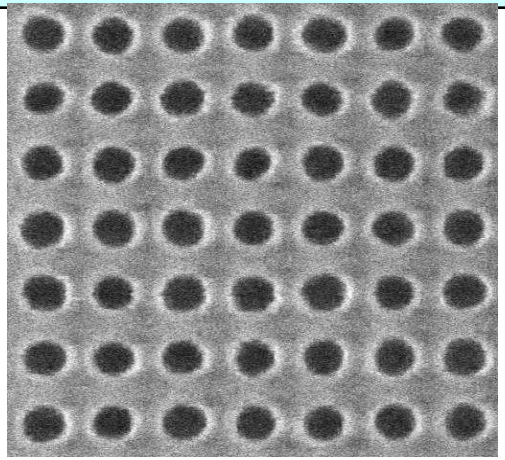
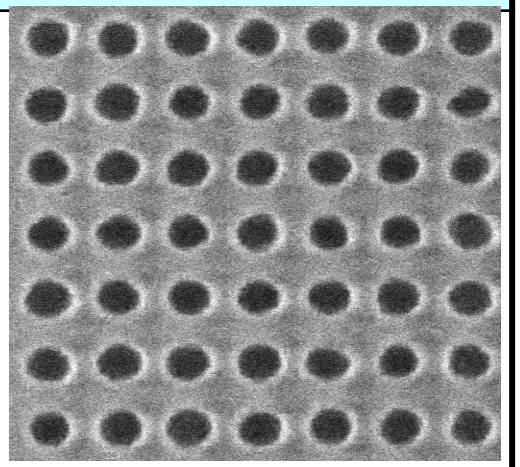






- **Not only dose but also FoV local CD uniformity can be improved with mask bias optimization.**

Dose and Local CD Uniformity Improvement with Mask Bias Optimization

ADT	Mask Bias : +2nm	Mask Bias : +4nm	Mask Bias : +6nm
Dose @ Target CD	25.7mJ/cm^2	21.4mJ/cm^2	19.3mJ/cm^2
FoV LCDU (3 sigma)	6.0	4.6	4.9
350K Mag.			

* FoV Local CD Uniformity(3σ) : 3 sigma of all contact holes in a field-of-view.

- **Both dose and FoV local CD uniformity were improved with mask bias optimization.**

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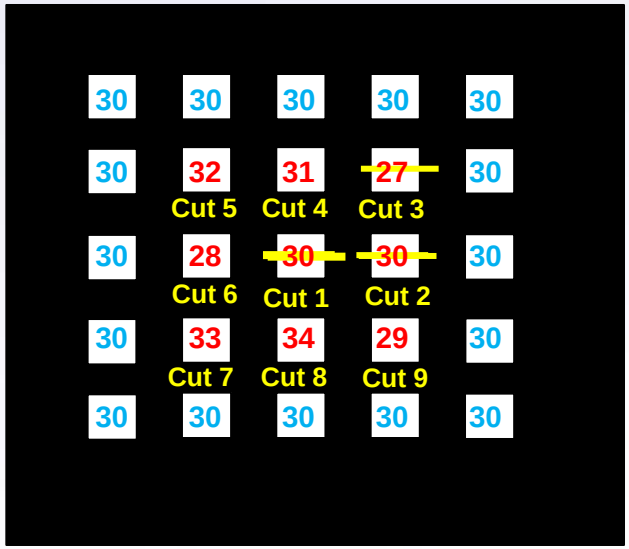
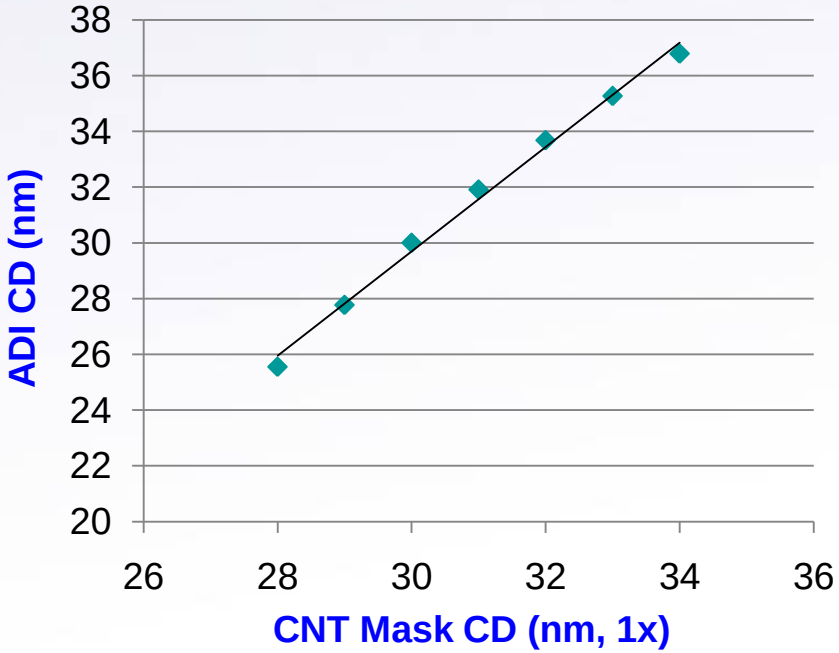
Contact Hole CD Correlation with Mask CD Uniformity

Simulation : SLITHO_EUV (3D mask)

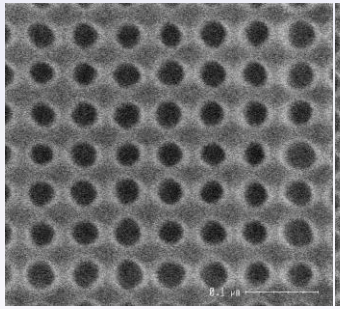
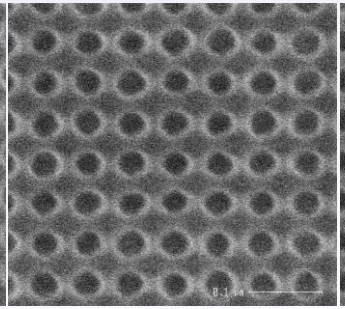
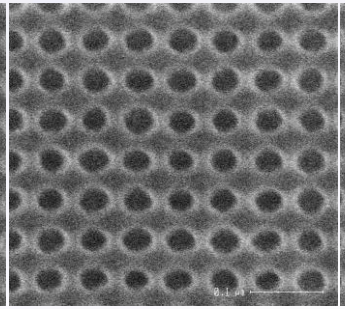
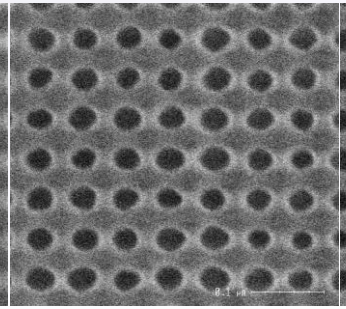
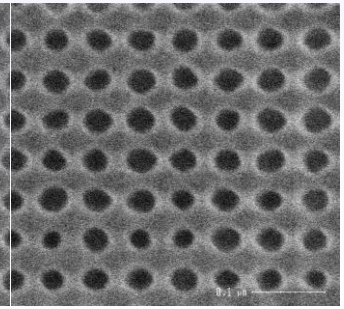
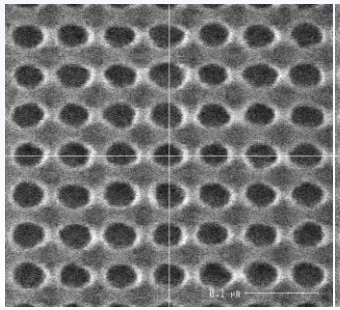
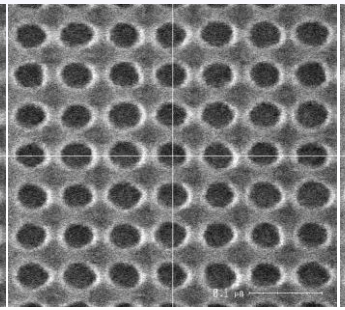
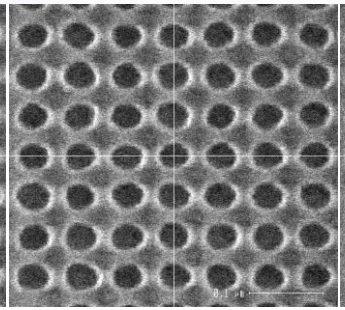
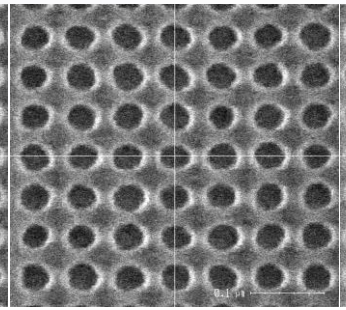
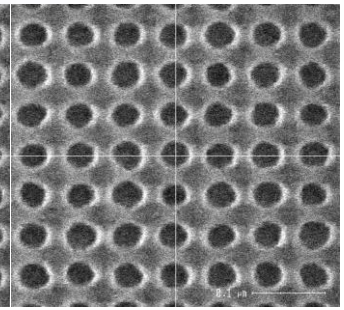


MEEF : 1.9 at 30nm HP



- **Local CD uniformity is largely dependent on mask CD uniformity according to aerial image simulation.**

Improvement of Local CD Uniformity with a New EUV Mask having Improved Mask Uniformity

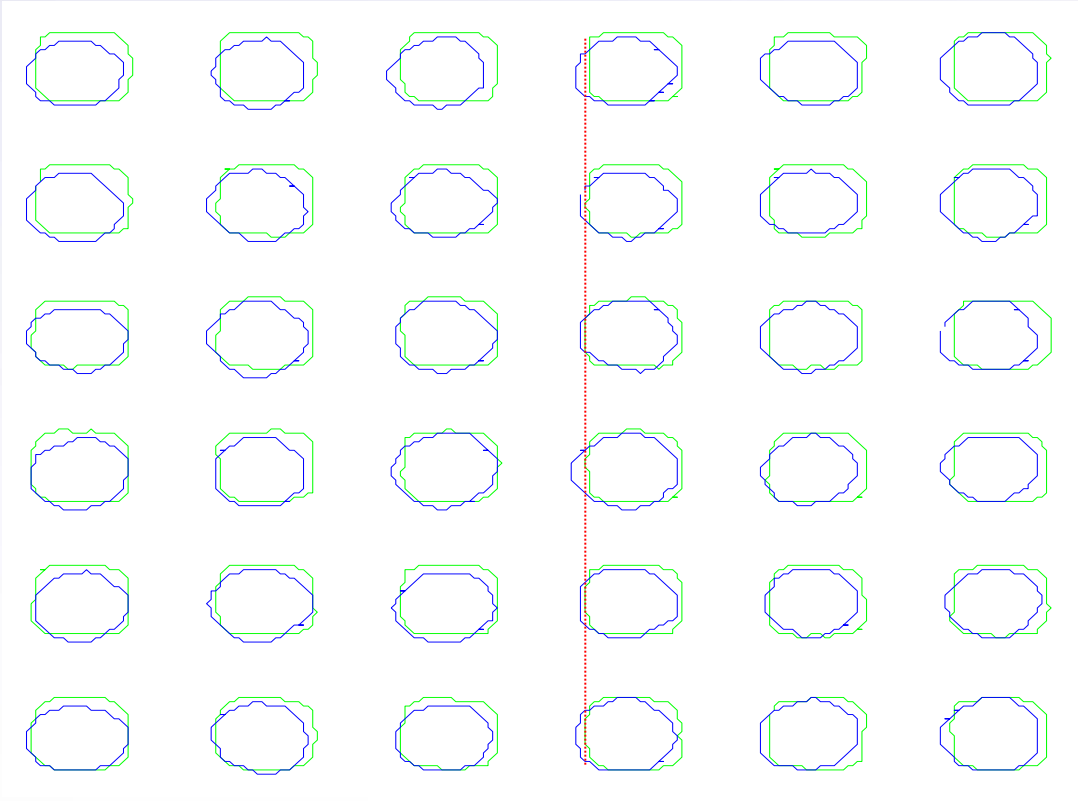
	-100nm	-50nm	Best Focus	+50nm	+100nm
Mask A FoV LCDU:8.8nm					
Mask B FoV LCDU:5.5nm					

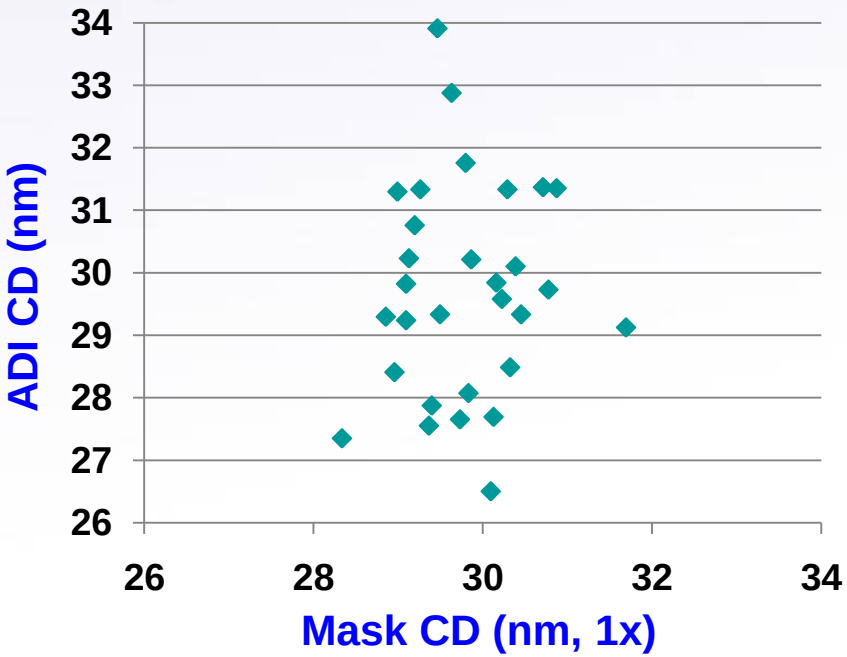
•FoV LCDU(3σ) : Field-of-View Local CD Uniformity.
•The same resist was used at ADT.

- **FoV Local CD uniformity was improved by the amount of 37% with using a new mask having better mask CD uniformity.**

Correlation of Image Contour of Contact Hole Between Mask and Wafer

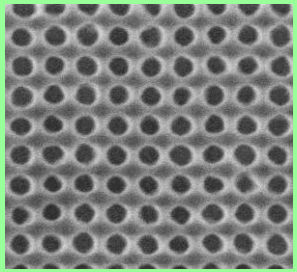
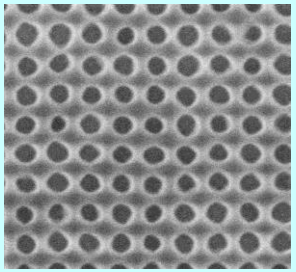
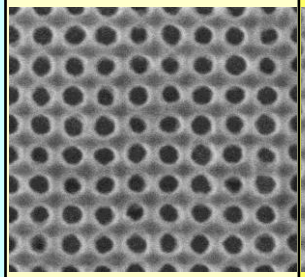
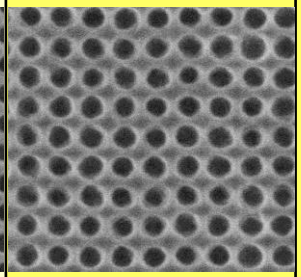
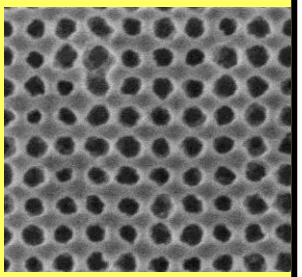
- Green color : Contour of contact hole on mask
- Blue color : Contour of contact hole image on wafer at ADT





- The correlation between contact hole CD on the wafer and contact hole size on the mask was poor because of CD non-uniformity caused by resist.

Performance of Champion Contact Hole Resist of EUV Resist Suppliers at Albany MET

Resist Supplier	Target	A	B	C	D	E
Resist Design Strategy		Polymer Bound PAG Resist	Methacrylate Blend Resist	PHS Hybrid Resist	Polymer Bound PAG Resist	Polymer Bound PAG Resist
Top View (30nm HP) @ Albany MET						
Converted Dose @ ADT	15.0mJ/cm^2	19.0mJ/cm^2	14.6mJ/cm^2	27.5mJ/cm^2	25.0mJ/cm^2	20.0mJ/cm^2
DOF @ 30nm HP	150nm	150nm	100nm	120nm	50nm	0nm

- Albany MET, 80nm Resist Thickness

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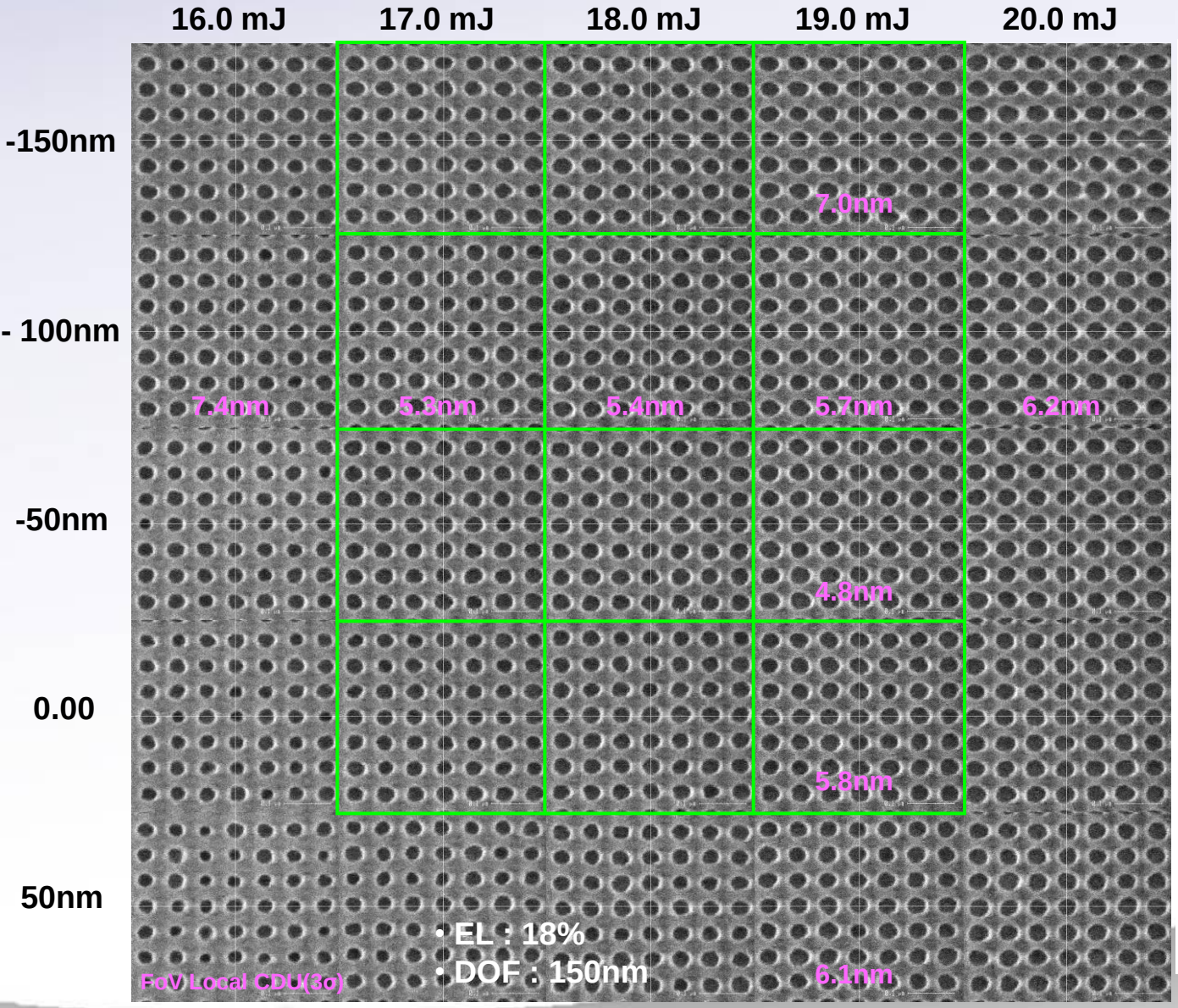
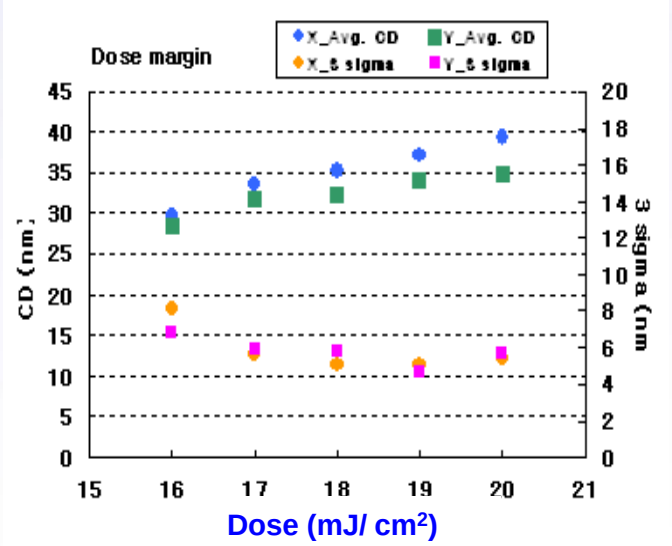
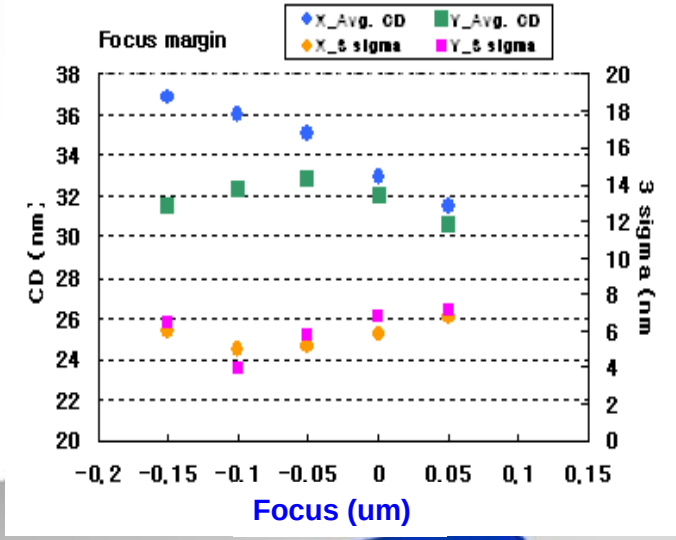
Contact Hole Performance of 30nm HP at ADT : Local CD uniformity needs to be improved more for EUVL implementation (5.5nm → 3.5nm)







Summary

- Contact hole resist having higher photosensitivity and improved local CD uniformity is required for EUVL pilot-line implementation of sub 32nm HP.
- Dose for contact hole patterning can be improved by the amount of more than 40% with mask bias optimization and PAG/ quencher optimization for 30nm HP patterning.
- Contact hole CD Uniformity was largely dependent on mask CD uniformity, and the study to get improved mask CD uniformity is further required.
- The correlation between contact hole CD on wafer and contact hole size on the mask was poor at 30nm HP contact hole because of CD non-uniformity caused by resist. The resist study to improve local CD uniformity is important for EUVL implementation for 30nm HP patterning.
  - ✓ Polymer bound PAG resist showed better local CD uniformity because it has more uniform PAG distribution in resist. Polymer bound PAG resist platform looks more promising and needs to be studied more intensively for better local CD uniformity considering mass production.
- The study of an additional process to improve local CD uniformity is required for pilot-line implementation of sub 30nm HP contact hole with EUVL.

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