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TOK Resist Development Status for EUV Lithography

February 23, 2006

EUV Resist Specification Roadmap

Specifications	Alpha (2005)		Beta (2007)		Gamma (2009)	
	Spec	Current**	Spec	Comment	Spec	Comment
Resolution 1:1	45nm	35nm/45nm (C/S)	32nm		32nm	
Resolution contacts	55nm	TBD	45nm		40nm	
Resolution Isolated Lines	32nm	30nm/40nm (C/S)	22nm		18nm	
Depth of Focus	200nm	100nm for 35-nm 1:1 200nm for 50-nm 1:1	225nm	Dense and isolated; DOF at 10% exposure latitude	225nm	Dense and isolated; DOF at 10% exposure latitude
Photospeed (mJ/cm ²)	10 mJ/cm ²	21mJ/cm ² E-size @ 50-nm 1:1	7mJ/cm ²	Assuming ~30 wph	5mJ/cm ²	Assuming > 100 wph if 5 mJ/cm ² , 115W intermediate focus
Line Edge Roughness (3 σ)	< 4 nm	~4 nm @ 50-nm 1:1 ~7 nm @ 35-nm 1:1	< 3nm		< 1.4 nm	LWR < 8% etched gate length; gate length = 18 nm
Wall Profile Angle	>85°	80° @ 50-nm 1:1	> 85°	Measure cross-sections	> 85°	Measure cross-sections
Outgassing	4.7E13 molecules/cm ² -sec	1.60E+13	TBD		TBD	
Pattern Collapse	>3	None observed	>3	Aspect ratio 3:1 for all structures	>3	Aspect ratio 3:1 for all structures
Unexposed Film Thickness Loss	< 10%	10nm	< 5%		< 5%	
PEB Sensitivity	< 2.5 nm/deg C	TBD	<1.5 nm/deg C		< 1 nm/deg C	
Delay Stability @ < 1ppb amine	30min	TBD	30 min	a) pre-exposure, b) under vacuum, c) post-exposure	30 min	a) pre-exposure, b) under vacuum, c) post-exposure
Etch Resistance	Similar to novolak	TBD	Similar to novolak		Similar to novolak	

**Measured top down values for Rohm and Haas resist MET-1K.

C/S=cross section **Green** = spec is met, **Orange** = spec is not met

EUV Resist Screening Results

Specifications	2007 Spec	Resist A	Resist B	Resist C
Resolution 1:1	32nm	40nm	40nm	30nm
Resolution contacts	45nm	-	-	-
Resolution Isolated Lines	22nm	30nm	35nm	-
Depth of Focus	225nm	150nm	200nm	-
Photospeed (mJ/cm ²)	7mJ/cm ²	15mJ/cm ²	8mJ/cm ²	12mJ/cm ²
Line Edge Roughness (3 σ)	< 3nm	-	-	5nm
Wall Profile Angle	> 85°	> 85°	-	-
Outgassing	TBD	-	-	-
Resist Thickness		50nm	50nm	70nm
Exposure Condition		1/2 annular	1/2 annular	Y-monopole

Resist Platforms

Resist A: Current polymer

Resist B: Small Mw and low dispersion polymer

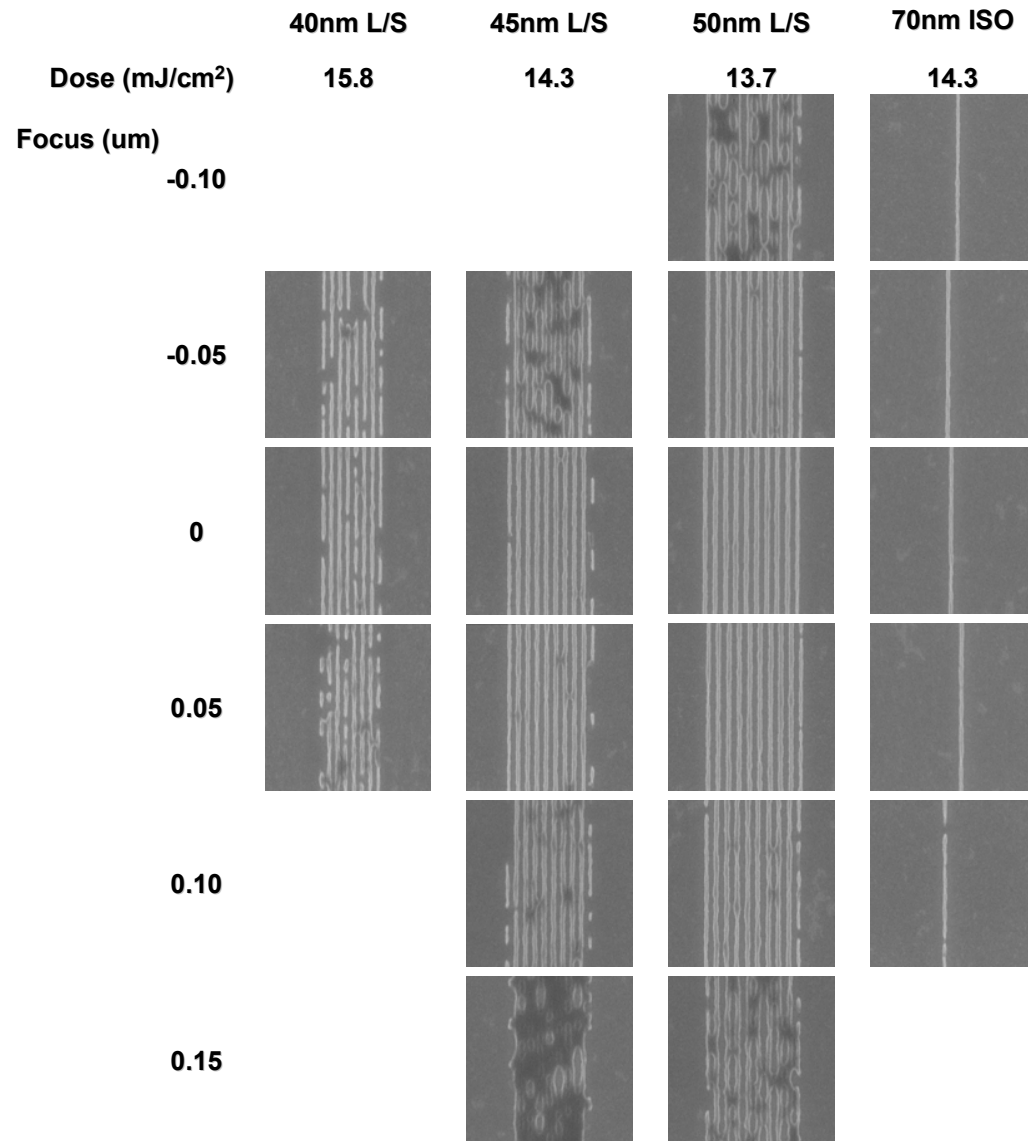
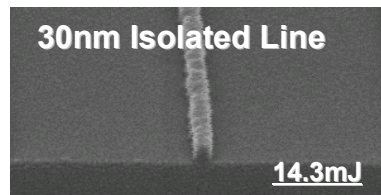
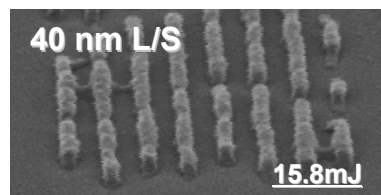
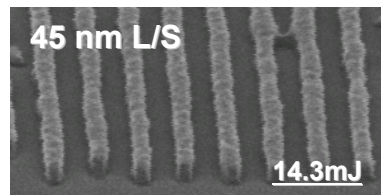
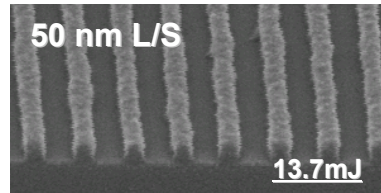
Resist C: Higher efficiency polymer

*** All platforms have been selected by EB patterning result. (EB Acc. 50KeV)**

EUV Resist Screening Results

SEM Data (top down and cross-section)

Resist A

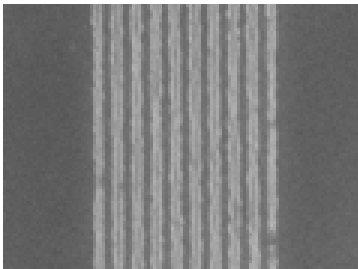


EUV Resist Screening Results

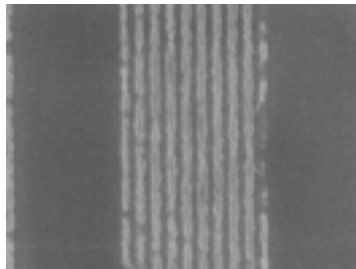
SEM Data (top down and cross-section)

Resist B

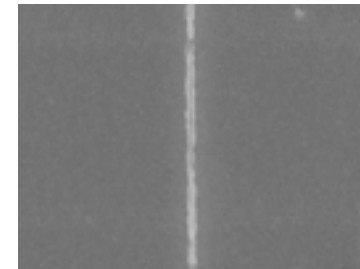
45 nm 1:1



40 nm 1:1

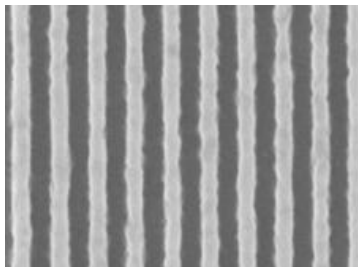


35 nm isolated line

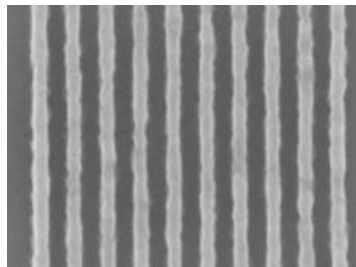


Resist C

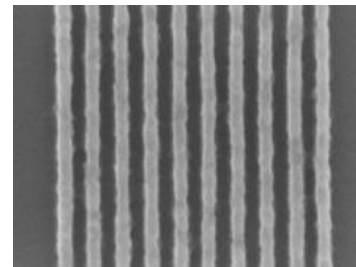
45 nm 1:1



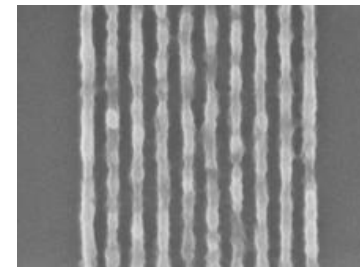
40 nm 1:1



35 nm 1:1

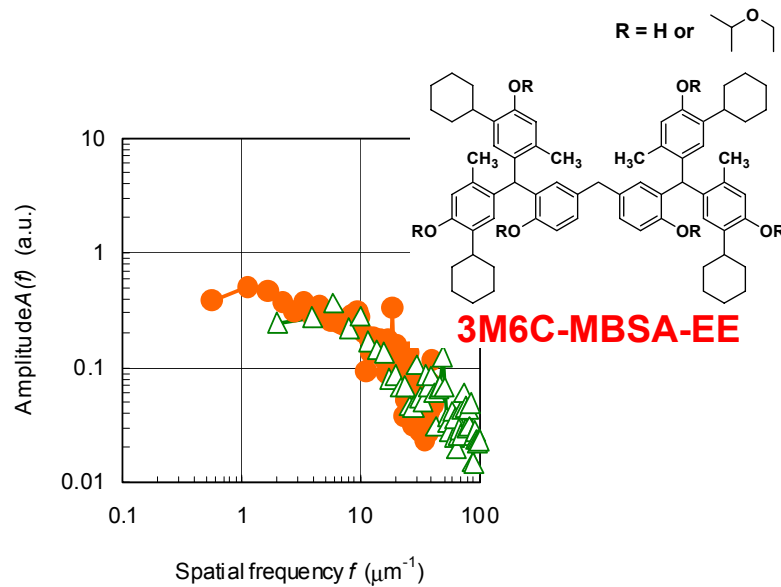


30 nm 1:1

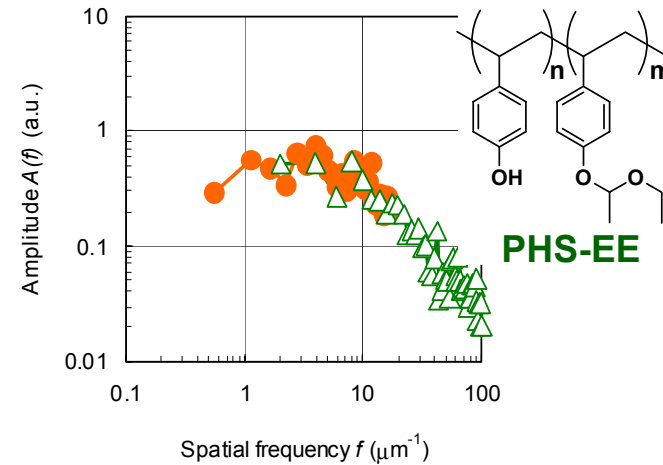
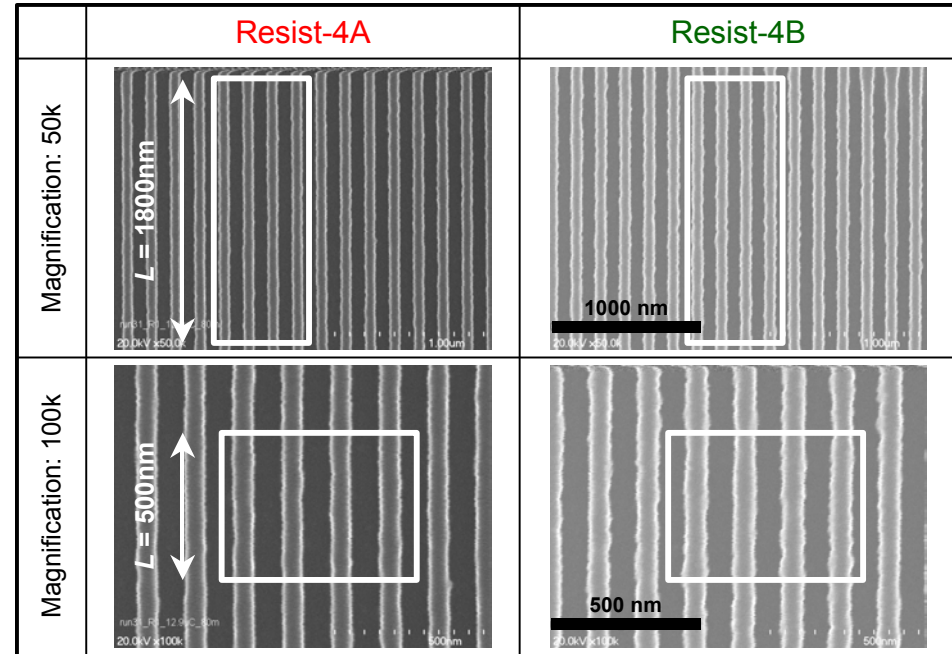


Molecular Resist-1 (EB)¹⁾

80 nmL/S patterning with EB exposure and LER analysis of **Molecular Resist** (Resist-4A) were performed as compared with **polymeric resist** (Resist-4B).



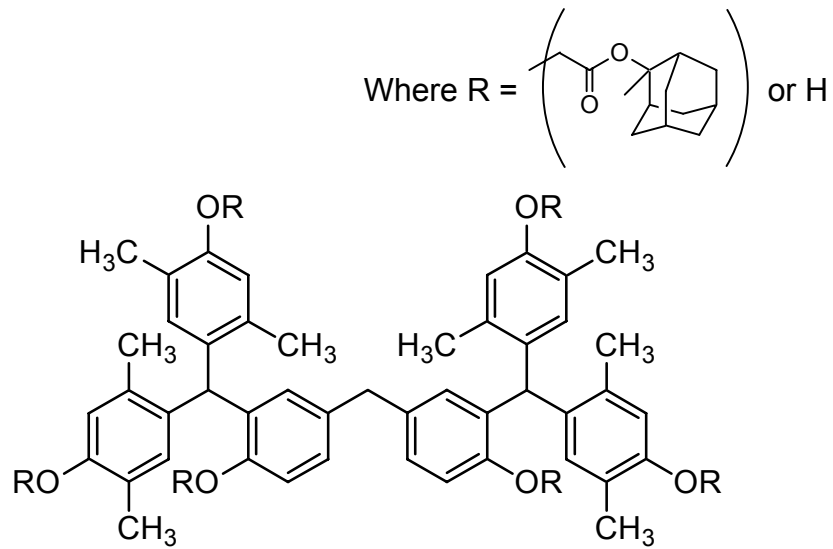
Molecular resist (Resist-4A)
LER (3sigma, $L=1800\text{nm}$) = 5.1 nm



Polymer resist (Resist-4B)
LER (3sigma, $L=1800\text{nm}$) = 7.4 nm

Figure The Fourier amplitude spectra and the LER²⁾ of resist-4A and 4B.

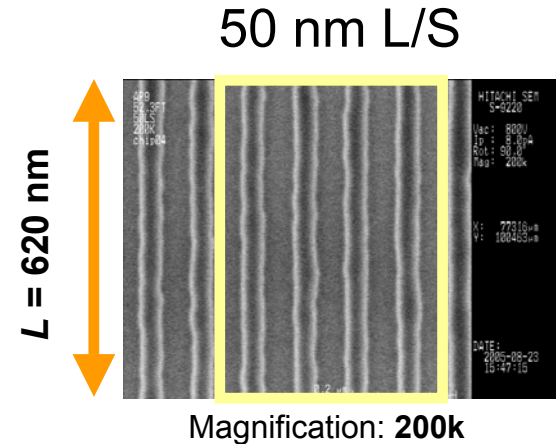
EUV Exposure Results and LER analysis (50 nm L/S) with Molecular Resist



**Partially protected 25X-MBSA
(25X-MBSA-P)**

4,4'-methylenebis[2-[di(2,5-dimethyl-4-hydroxyphenyl)]methyl] phenol

SEM Image



Fourier amplitude spectra
of the LER

