IMEC update

A.M. Goethals

IMEC, Leuven, Belgium

Outline

- IMEC litho program overview
- ASML ADT status
  - 1st imaging
  - Tool description
- Resist projects
  - Screening using interference litho
  - K_{LUP} / Novel resist : polymer bound PAG

Advanced Litho Program '06-'08

Sub-program 1
Immersion Litho Extendibility

- Hyper NA imaging & OPC
- Alternative mask stacks
- High index liquids & res.
- Baseline processes
- XT:1700i assessment

Sub-program 2
Double Patterning Lithography

- Alternative process schemes
- Design split & OPC
- DP based integration
- DP manufacturability

Sub-program 3
Extreme UV Lithography

- *EUVL resists*
- EUVL reticles
- EUV Alpha Demo Tool Assessment

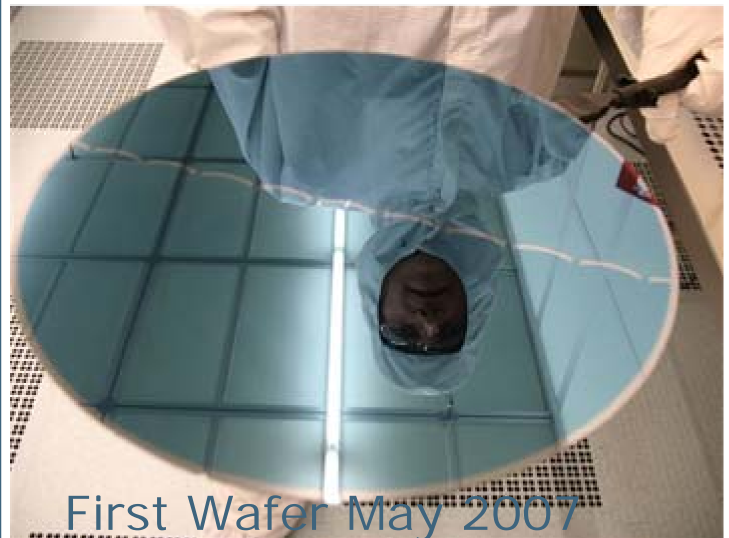
Sub-program 4 **Resist fundamentals**

K_{LUP} (LWR, resolution, sensitivity), alternative resists/development, defectivity.

ASML EUV Alpha Demo Tool (ADT) at IMEC

Arrival Aug 2006
installed by Dec 2006

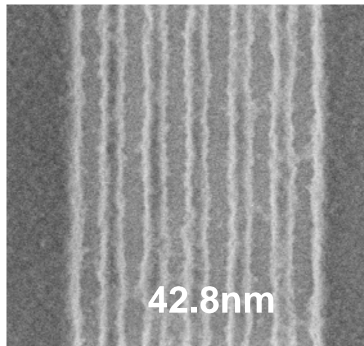
First Light Apr 2007

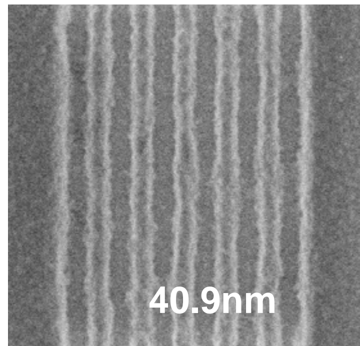

First Wafer May 2007

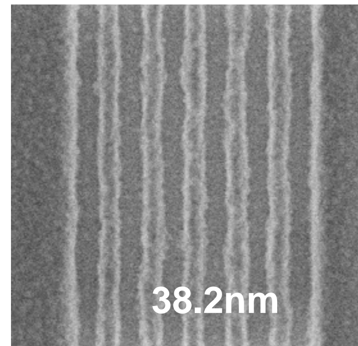
ADT imaging
40nm V and H lines through dose

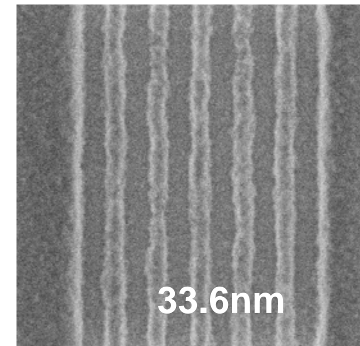
17.55 mJ	17.8mJ	18.05mJ	18.3mJ	18.55mJ

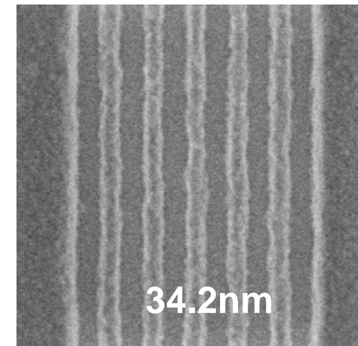
Vertical lines



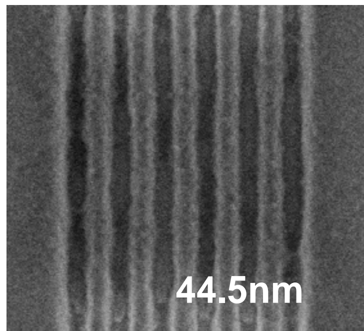


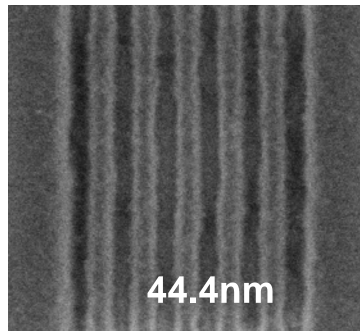


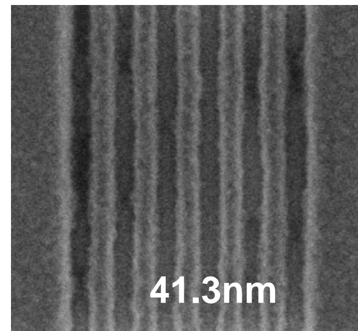


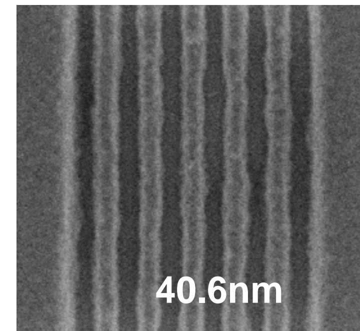


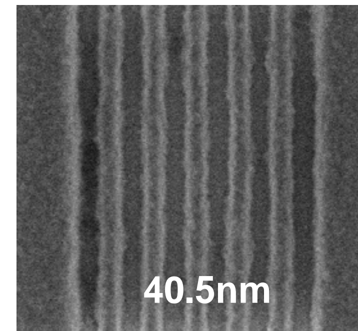
Horizontal lines









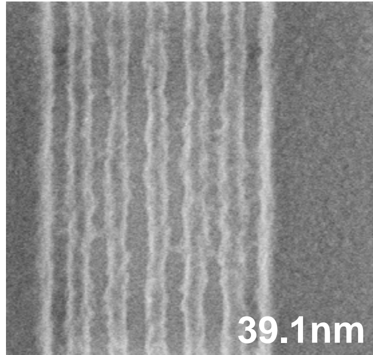


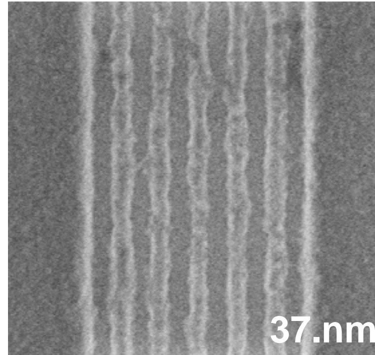
Resist: Rohm Haas MET-2D
Thickness 100nm
NA=0.25, σ=0.5
Lens aberration reduction not finalized yet

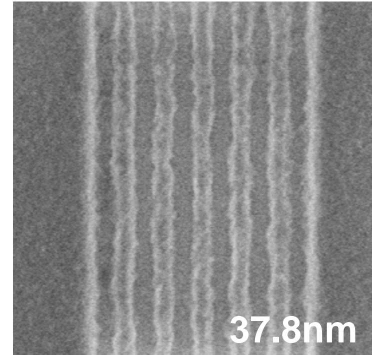
ADT imaging
35nm V and H lines through dose

18.05mJ/cm^2 | 18.3mJ/cm^2 | 18.55mJ/cm^2

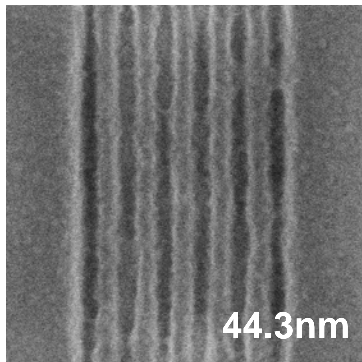
Vertical lines

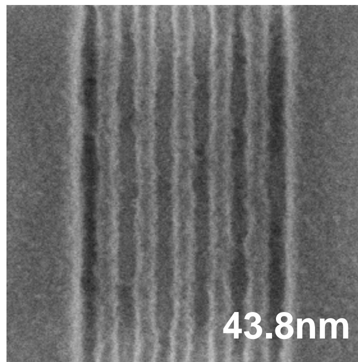


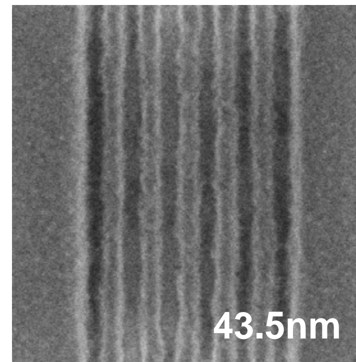


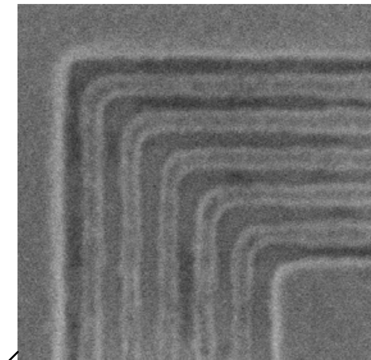


Horizontal lines









Resist: Rohm Haas MET-2D
Thickness 100nm
NA=0.25, σ=0.5
Lens aberration reduction not finalized yet

ASML EUV ADT

EUV Tool	SPECs
Lens flare	<16%
NA Range	0.15 to 0.25 step ≤ 0.01
Field Size	26 x 24; max X 16 x 27; max Y
Imaging - Dense Lines	40 nm
- Isolated Lines	30 nm
- iso/dense contacts	55 nm

- Wafer size : 300 mm
- Reduction ratio : 4X
- Interfaced to TEL ACT12
- 6 inch reticles (according to ADT specification)
- Illumination mode : Conventional, sigma=0.5

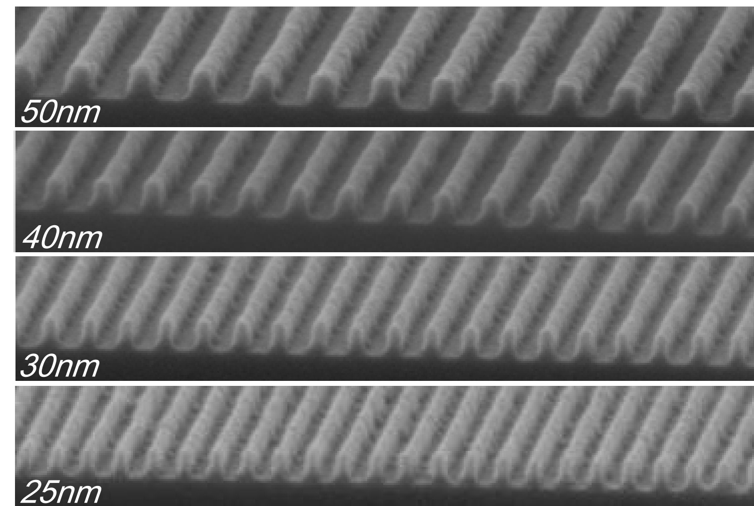
ASML EUV ADT

- Supporting equipment
  - **KLA-T eCD1, eCD2**
  - **Hitachi S-9380II and CG4000** CD-SEM
  - **KLA-T SCD100 & SCD XT100** scatterometry
  - **KLA-T 2351 and 2800** defect inspection (patterned wafers)
  - **KLA-T SP2** defect inspection (unpatterned wafers)
  - **KLA-T Archer AIM** overlay
- Access to ADT ?
  - Partners in the IMEC IIAP lithography program
  - If interested to join the program, please contact
    Kurt Ronse, Director lithography
    Kurt.Ronse@imec.be
- Outgassing specifications
  - Resist should pass the ASML witness plate protocol

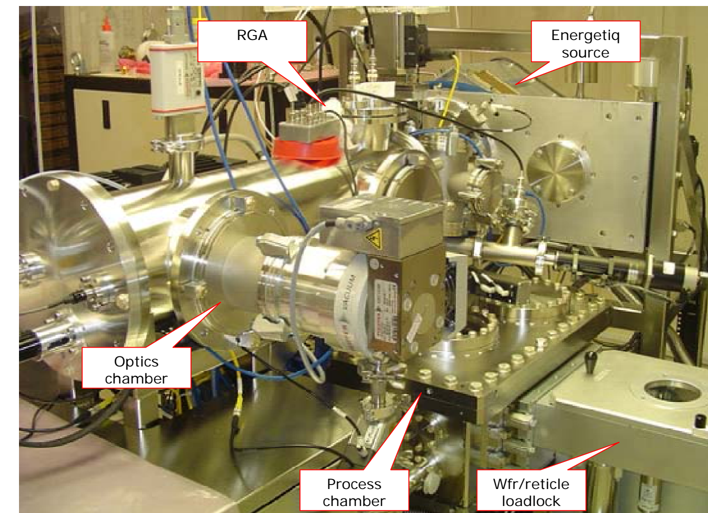
EUV resist project
Key objectives

- EUV resists
  - Benchmark EUV resist performance versus requirements
  - Drive EUV resist suppliers
  - Demonstrate EUVL ability for small electrically working circuits
  - Build fundamental understanding for EUV resist out-gassing requirements for EUVL high volume manufacturing

in close collaboration with all major resist suppliers worldwide

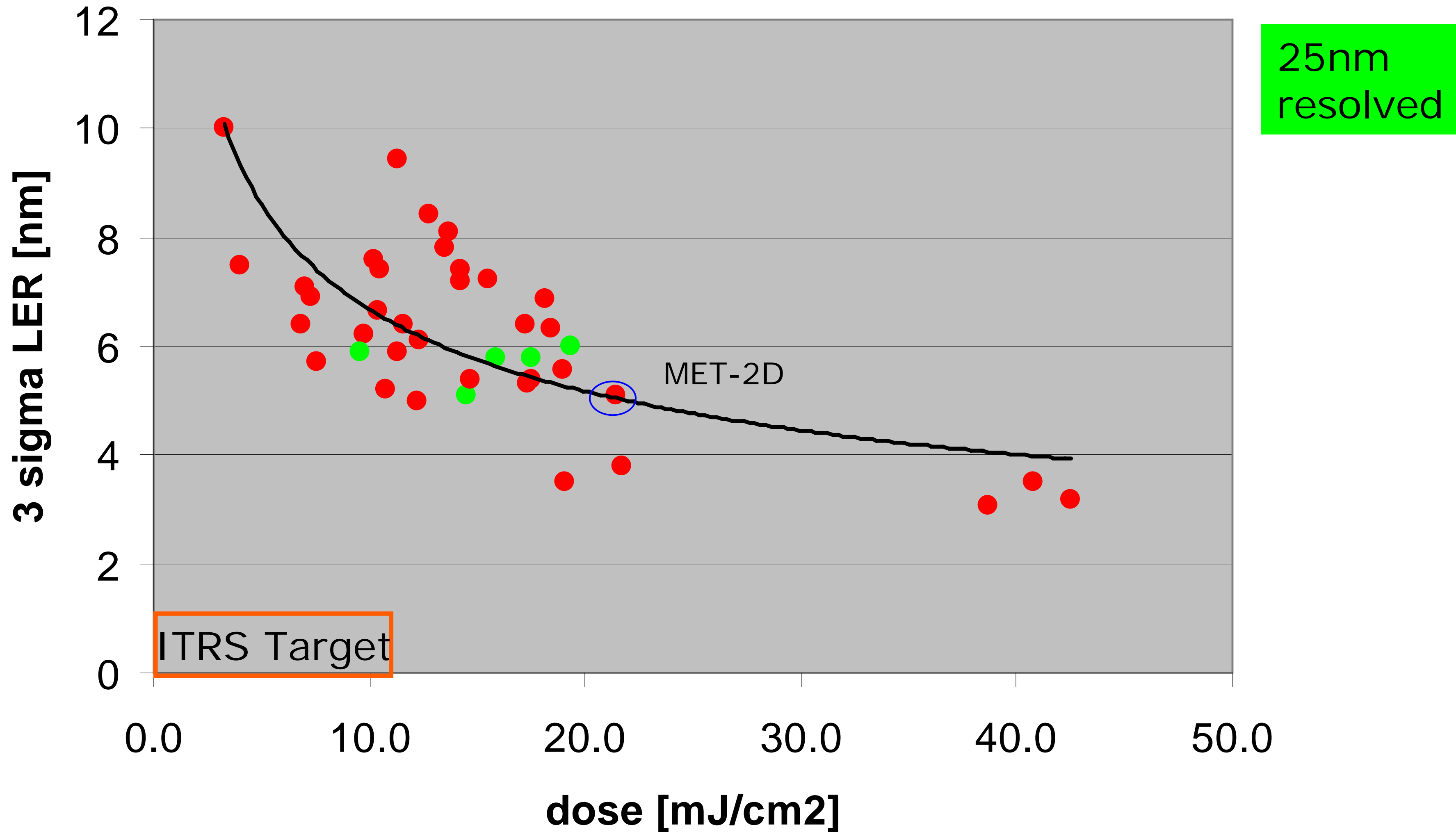


Resist Screening at PSI

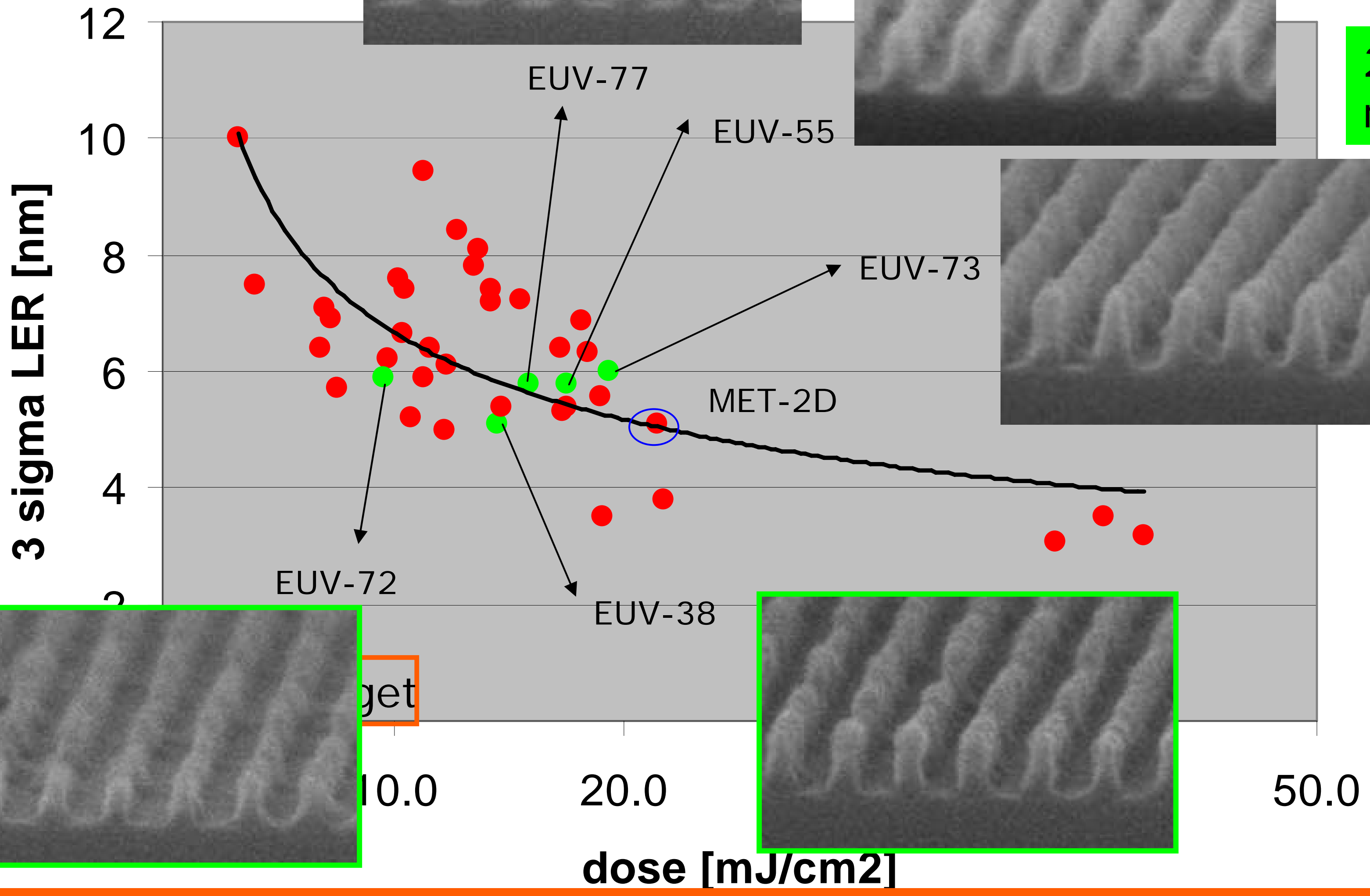


EUV Technology Outgassing Tool

Line Edge Roughness versus sensitivity
LER results on 50nm lines (Interference lithography)



Line Edge R... versus sensitivity
LER results o... (interference lithography)



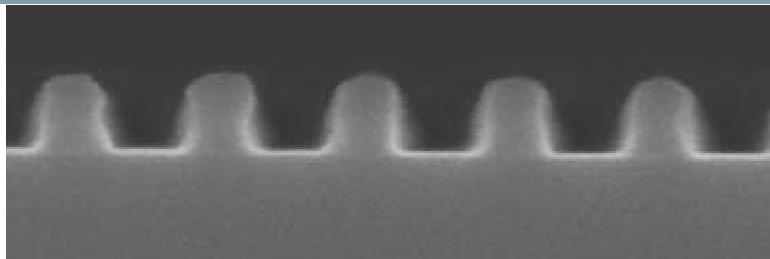
25nm resolved

Best overall performing resist is EUV-72 (high sensitivity with ~25nm resolution).

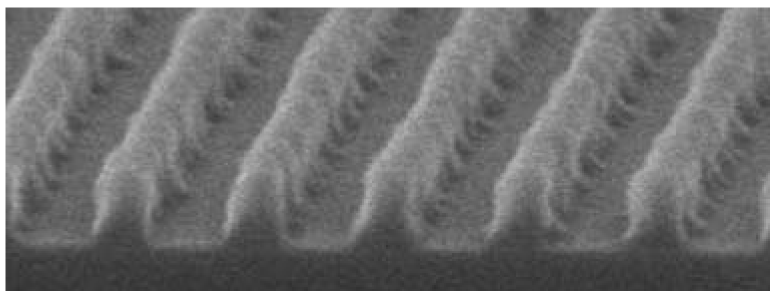
Overall best resist Q3 2007

EUV-72 resist

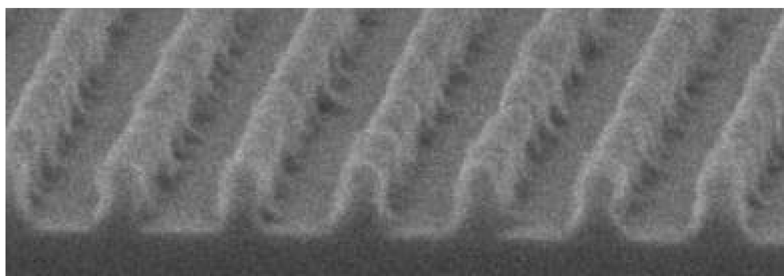
50 nm



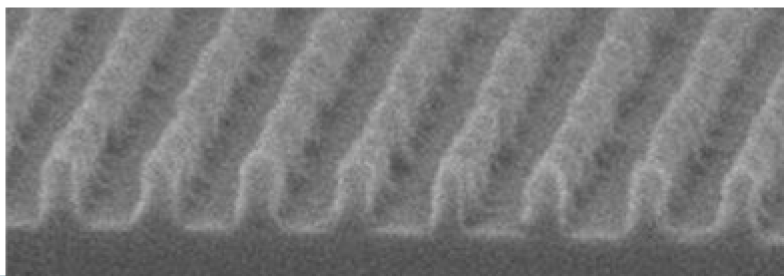
45 nm



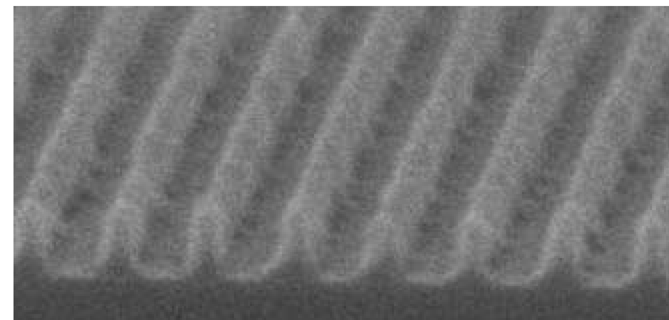
40 nm



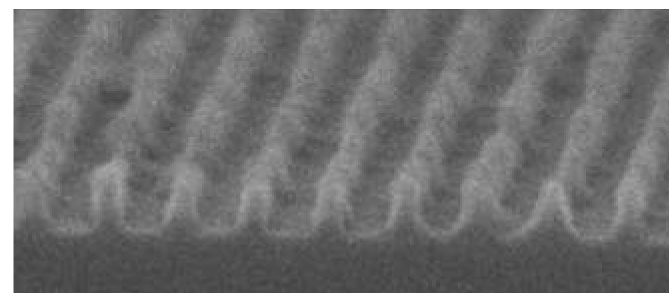
32.5 nm



30nm



25nm



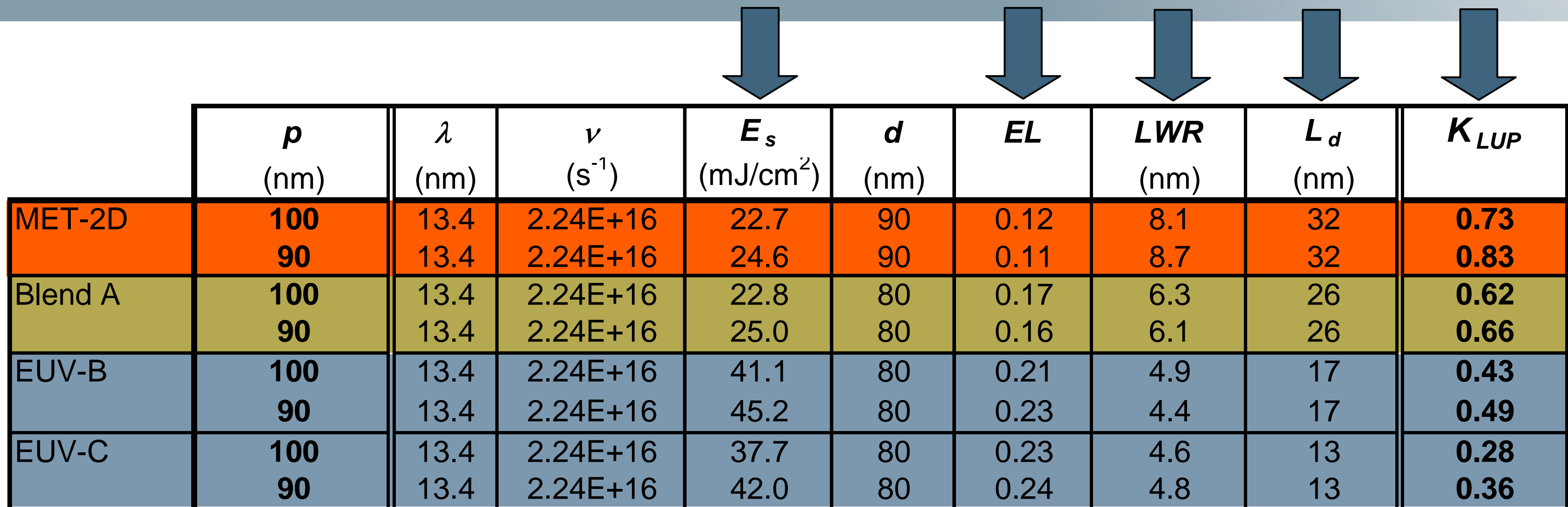
$Energy_{size}$	**9.6 mJ/cm²**
Exp. Lat. (50nm)	27%
LER (3σ) (50nm)	**5.9nm**
Resolution	**~25 nm**

Assessment of Polymer-Bound PAG resists

- K_{LUP} has been determined for three EUV resists using EUV interference lithography
  - Polymer-bound PAG + blended PAG
  - Polymer-bound PAG B
  - Polymer-bound PAG C
- Apart from the PAG the three formulations are similar: same backbone and same acid labile group
- Lithographic performance of three resists are compared to EUV reference resist MET-2D

RE-08 "Performance assessment of novel resist approaches for EUV lithography using a single figure of merit", D. Van Steenwinckel, R. Gronheid, F. Van Roey

Assessment of Polymer-Bound PAG resists



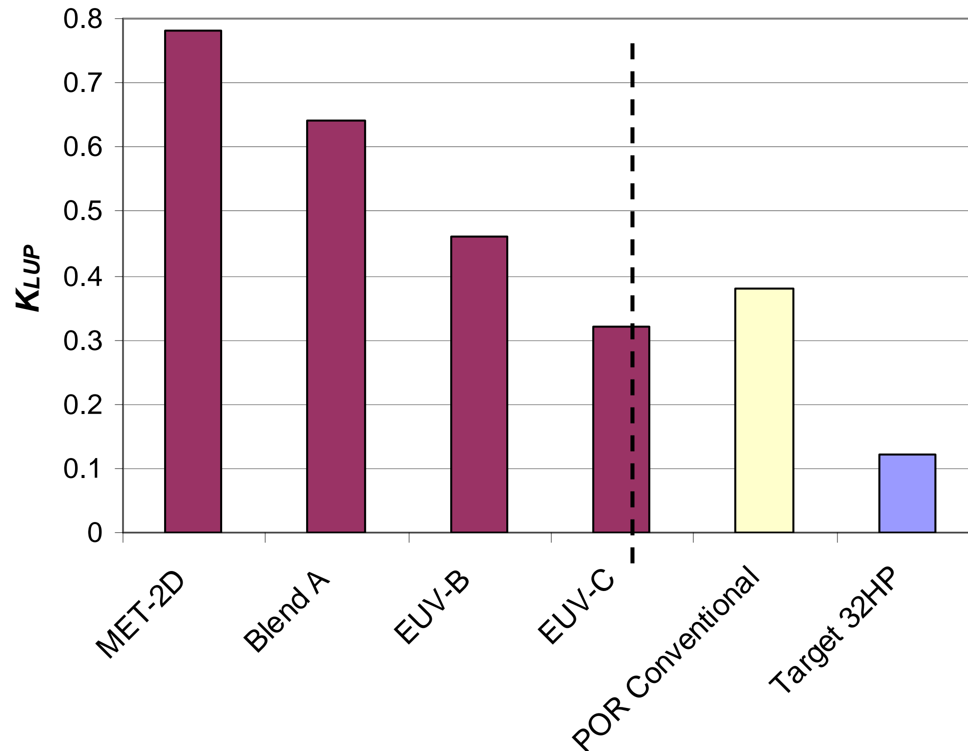
	p (nm)	λ (nm)	ν (s^{-1})	E_s (mJ/cm^2)	d (nm)	EL	LWR (nm)	L_d (nm)	K_{LUP}
MET-2D	**100**	13.4	2.24E+16	22.7	90	0.12	8.1	32	**0.73**
	90	13.4	2.24E+16	24.6	90	0.11	8.7	32	**0.83**
Blend A	**100**	13.4	2.24E+16	22.8	80	0.17	6.3	26	**0.62**
	90	13.4	2.24E+16	25.0	80	0.16	6.1	26	**0.66**
EUV-B	**100**	13.4	2.24E+16	41.1	80	0.21	4.9	17	**0.43**
	90	13.4	2.24E+16	45.2	80	0.23	4.4	17	**0.49**
EUV-C	**100**	13.4	2.24E+16	37.7	80	0.23	4.6	13	**0.28**
	90	13.4	2.24E+16	42.0	80	0.24	4.8	13	**0.36**

Observations:

- *LWR* of novel resist concepts is considerably improved
- Lower L_d gives larger *EL* as a bonus
- The novel materials B and C show substantially larger sizing doses
- Yet, novel materials exhibit significantly lower K_{LUP} values

RE-08 "Performance assessment of novel resist approaches for EUV lithography using a single figure of merit", D. Van Steenwinckel, R. Gronheid, F. Van Roey

Assessment of Polymer-Bound PAG resists



- Polymer-bound PAG resists show very promising results
  - EUV-C exhibits lowest K_{LUP} so far
  - Blend-A and EUV-B show intermediate results

RE-08 "Performance assessment of novel resist approaches for EUV lithography using a single figure of merit", D. Van Steenwinckel, R. Gronheid, F. Van Roey

aspire invent achieve