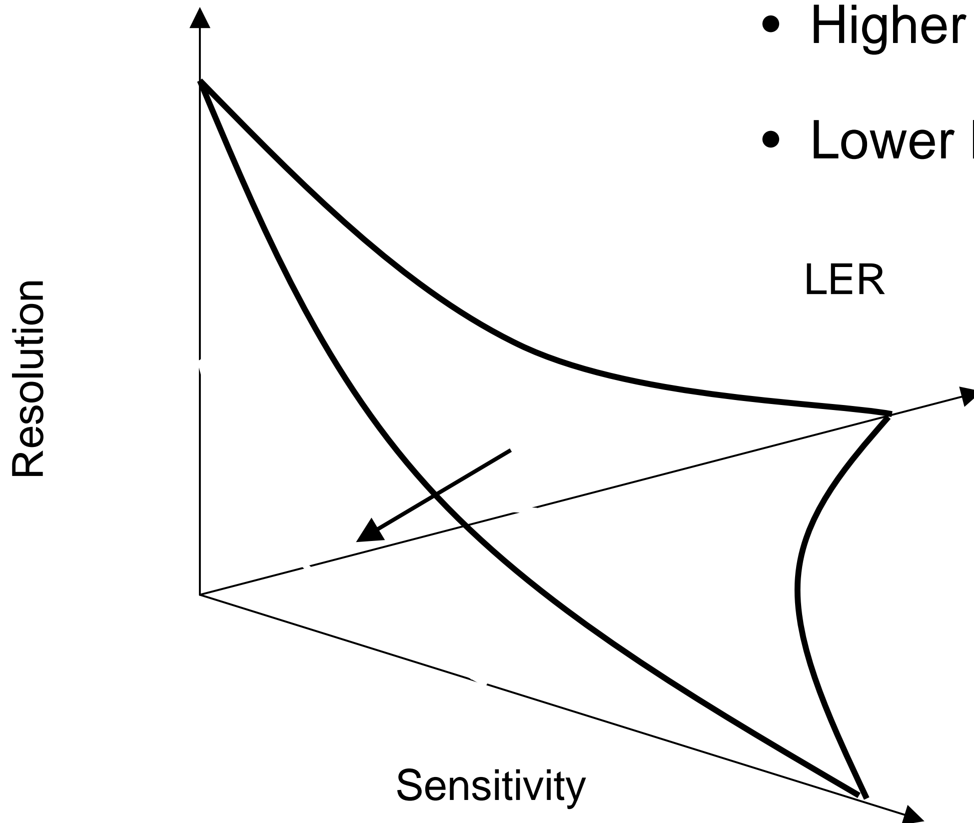
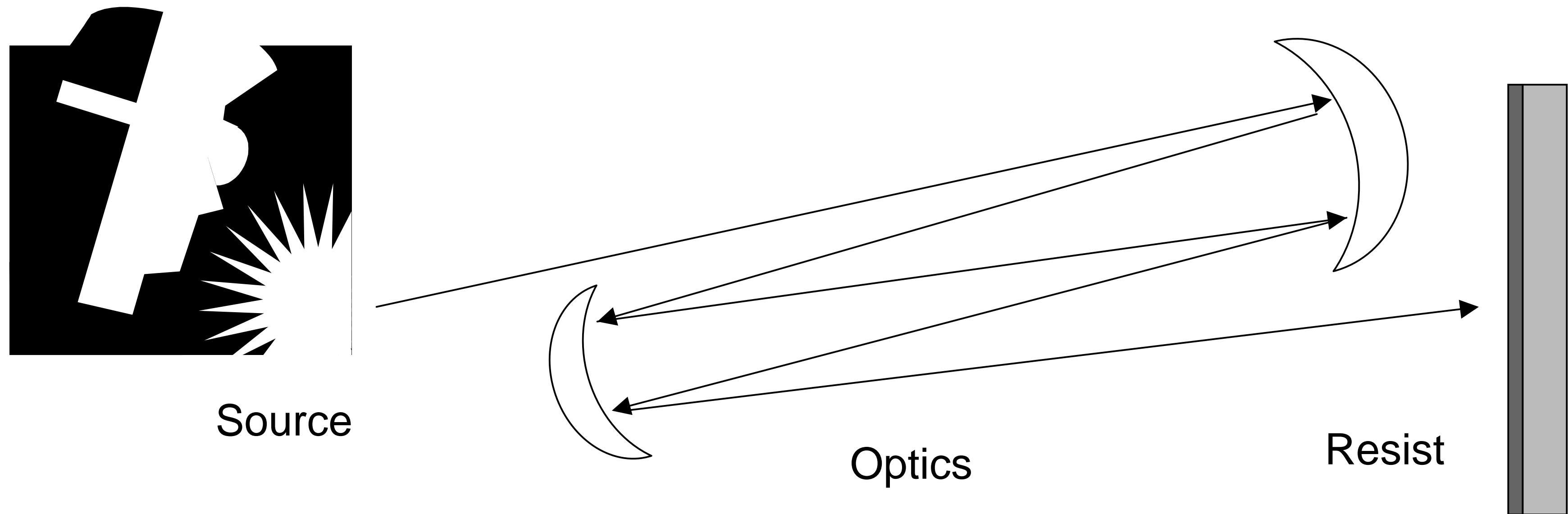
I. Introduction
Technical Goals

New EUV Resists Must Have:

- Improved sensitivity
- Higher resolution
- Lower line edge roughness (LER)



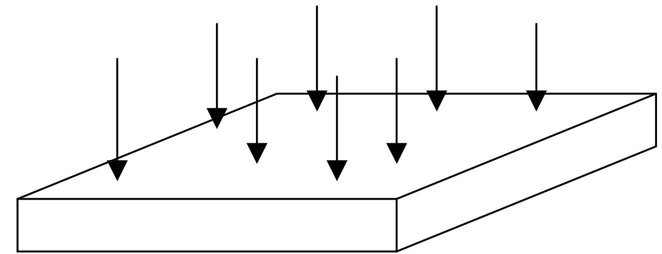
How Many Photons Are Needed?

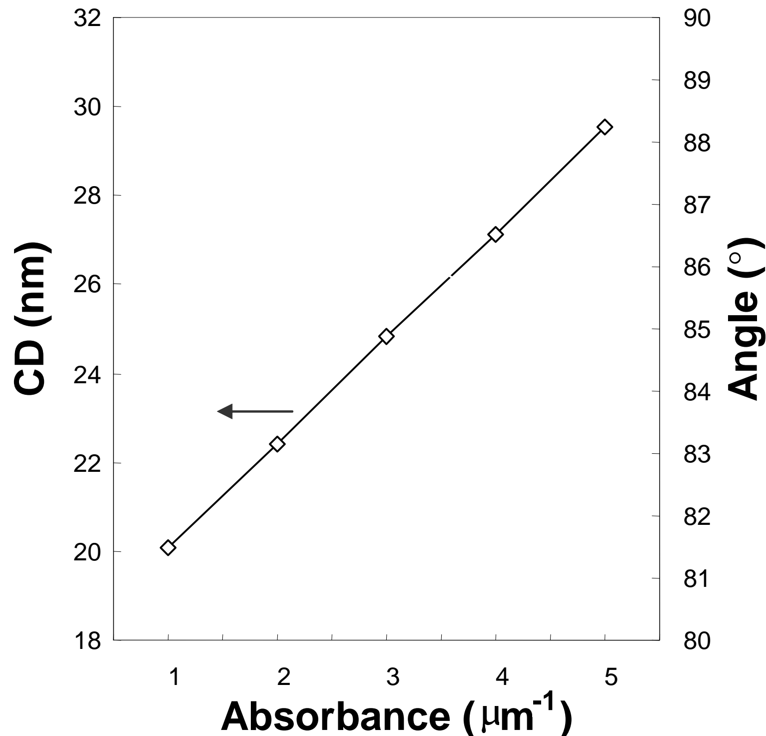


How Much Dose is Required to Print Resist Images with:

- High Resolution
- Low LER?

II. Absorption of Photons





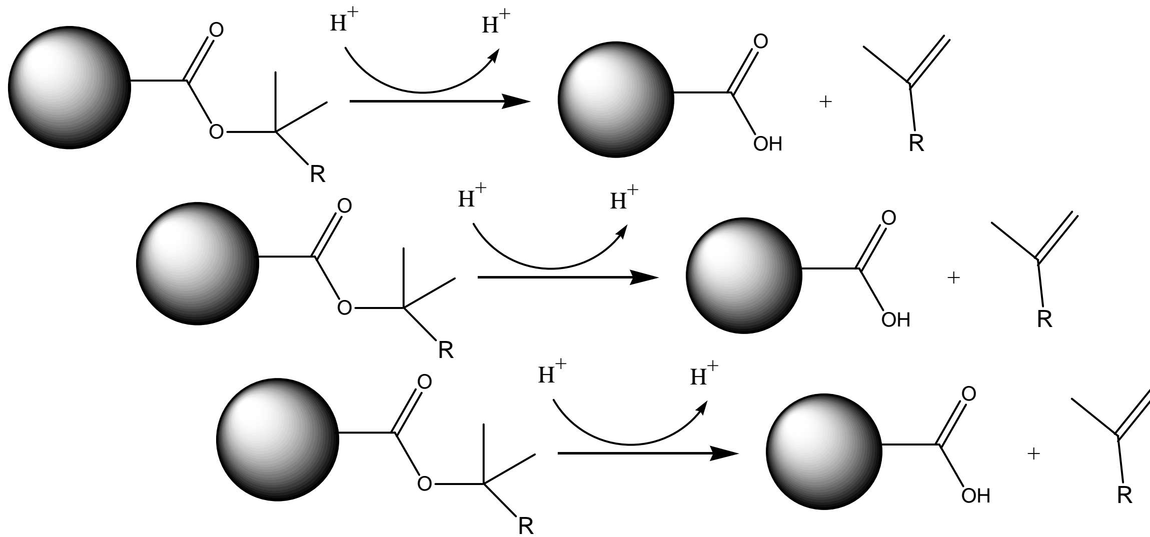
Increasing Absorption will help

resist sensitivity,

but hurt profile and resolution

Chandhok, et. al. SPIE **2004** 5374-102

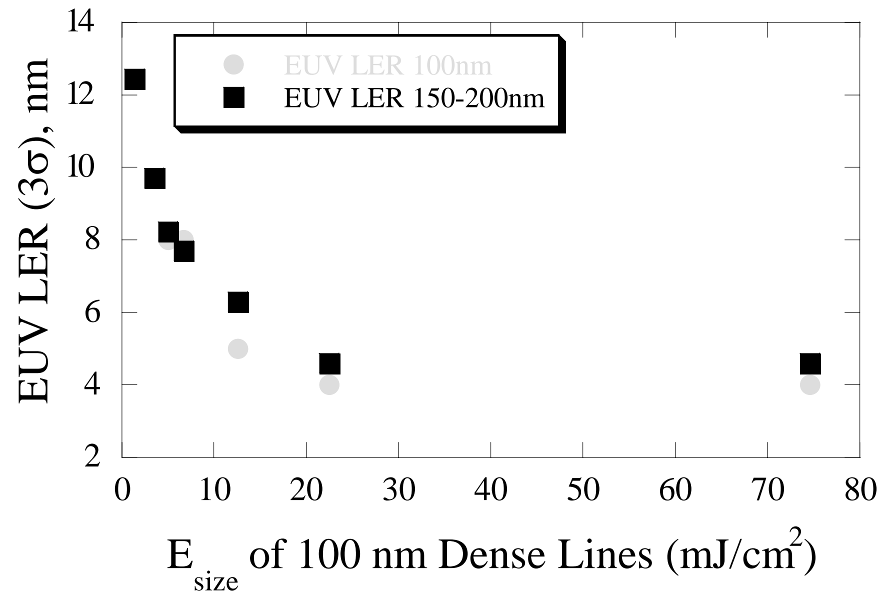
III. Turn Over Numbers



How many times is the same acid molecule catalyze this reaction?

Estimate = 30-200 times.

The more work a single acid does, the more sensitive the resist.



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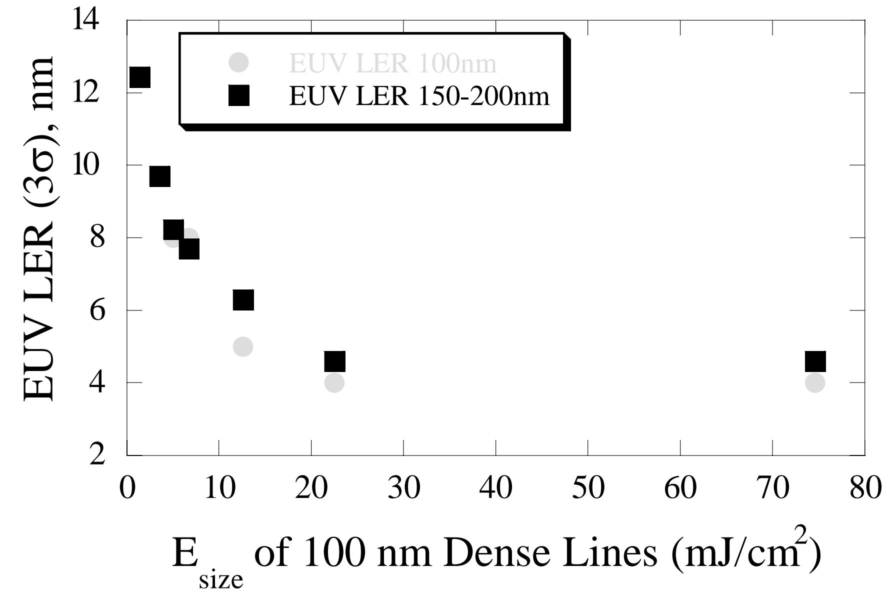
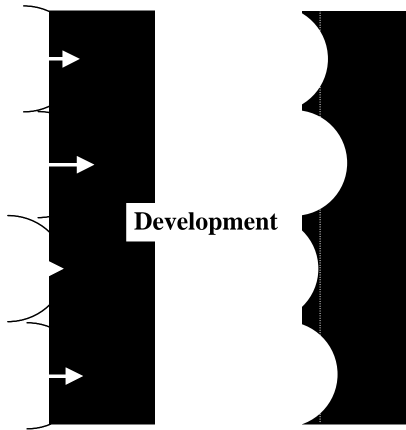
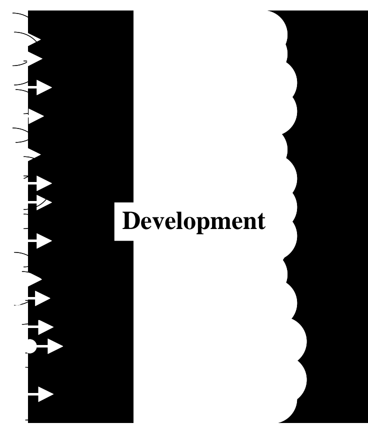


Low Dose,
High Turnover Number



High Dose,
Low Turnover Number



A resist needs to de-block a finite concentration of esters to dissolve.

Lots of Acid with low T.O. Numbers will give better LER, but be slower.

IV. EUV Resist Roadmap*

Specifications						
Resolution 1:1	45nm	35nm/45nm (C/S)	32nm		32nm	
Resolution contacts	55nm	TBD	45nm		45nm	
Resolution Isolated Lines	32nm	30nm/40nm (C/S)	22nm		22nm	
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)	$<5mJ/cm^2$	$21mJ/cm^2$ E-size @ 50-nm 1:1	$< 4mJ/cm^2$	Assuming ~30 wph	$< 3mJ/cm^2$	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		< 1.6 nm	LWR < 8% etched gate length; gate length = 20 nm
Wall Profile Angle	$>85^0$	80^0 @ 50-nm 1:1	$> 85^0$	Measure cross-sections	$> 85^0$	Measure cross-sections
Outgassing	Similar to ESCAP@ EUV	TBD	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	

* Source: IEUVI resist technical working group.

**Measured top down values for Rohm & Haas resist MET-1K.
C/S = cross section **Green** = spec is met, = spec is not met

Resist Supplier Access to Berkeley Micoexposure Tool in 2004 (NA = 0.3)

- 13 of shifts were used by resist suppliers in 2004 (SEMATECH-sponsored project)
- Most of the exposure time was used by SEMATECH member companies; some of that was donated to resist suppliers
- Resist suppliers will have access to Albany MET in March, 2005

Conclusion: We are in the very early stages of resist development using high NA tools

IV. Conclusions

Three critical EUV resist responses (LER, resolution and sensitivity) demonstrate performance trade-offs.

- Increasing optical density improves sensitivity, but at a cost in profile and resolution.
- Increasing turn-over numbers improves sensitivity, but at a cost to LER.

EUV resist roadmap shows:

- Current resist (MET-1K) is much slower than 2005 targets for sensitivity.
- Close or slightly behind in other measured properties.
- Big improvement in sensitivity required.
- Many properties yet to be determined.

More time is needed for resist suppliers to learn how to balance the 3 critical responses.

- Only 13 shifts of time on the MET @ ALS has been used by resist suppliers.
- Resist suppliers will have access to the MET in Albany in March.