

Report to the IEUVI

5th International EUV Initiative Resist Technical Working Group Meeting

San Jose, California

Kim Dean, SEMATECH
Serge Tedesco, CEA/LETI
Wolf-Dieter Domke, Infineon



March 4, 2005

Accelerating the next technology revolution.

Goals and Objectives of Resist TWG

- **Goal—increased cooperation among EUV resist community world wide**
 - Develop resist specification roadmap
 - Coordinate efforts to address top 3 issues
- **Objectives—share data and information to speed development of EUV resist**



Attendees (31)

Current Members

- ASET: Hiroaki Oizumi
- AMD: Adam Powloski
- CEA/LETI: Serge Tedesco
- IBM: Greg Wallraff
- Infineon: Wolf-Dieter Domke
Klaus Lowack
- IMEC: Mieke Goethals
- Intel: Wang Yueh, Heidi Cao
- SEMATECH: Kim Dean
- Philips: Peter Zandbergen
- Freescale: Richie Peters

New Members

- Rohm and Haas: Robert Brainard
- Sumitomo: Nobuo Ando
- TOK: Mitsuru Sato
- Fujifilm: Seiya Masuda
- AMSL: Koen van Ingen Schenau
- Nikon: Katsuhiko Murakami
- Canon: Phil Ware

Others

- Osaka U: Seiichi Tagawa, Minoru Toriumi
- CEA/LETI: Cyril Vannuffel, Amandine Jouve
- SEMATECH: Jan Makos-Brotherton
- ASET: Iwao Nisiyama
- Samsung: Juan Hwan Hah



Top Three Issues for TWG Cooperation (July, 2004)

- 1. What is a safe level of resist outgassing?**
 - Work together to determine specifications, include tool and resist suppliers
- 2. Understanding the resolution limits of chemically amplified resists**
 - Provide enough tool time for cycles of learning
- 3. How to optimize photospeed, LWR, shot noise, resolution?**
 - Design experiments to investigate these parameters



IEUVI Resist TWG Meeting March 3, 2004 San Jose, California

8:30	Welcome and Introductions Review of Charter and Goals for Resist TWG	Kim Dean , SEMATECH
8:40	Feedback from 1st European on Resist Limitations	Wolf-Dieter Domke , Infineon
8:55	Feedback from SEMATECH LER and Resist Limitation Workshops	Kim Dean
9:10	Brief Description of Outgassing Methods (5 min each)	Cao , Domke , Watanabe , Keen , Vannuffel , Nishiyama , Dean
9:40	Resist Outgassing; compare methods and explore areas of cooperation	Wolf-Dieter Domke
10:20	Break	
10:30	Resist Specification Roadmap; Review, Edit	Kim Dean
10:40	Update Japan/ASET	Iwao Nishiyama , ASET
10:55	Update from More Moore	Serge Tedesco , CEA/LETI
11:10	Update from MEADEA/EXCITE	Wolf-Dieter Domke
11:25	Update from US/SEMATECH	Kim Dean
11:40	Three Topics for TWG Cooperation	Serge Tedesco
11:50	Wrap up, Plans for Next Meeting	Kim Dean
12:00	Adjourn	All

Resist Outgassing Researchers (7)

- **Intel**
 - Synchrotron source, desorption tubes, ongoing
- **Infineon**
 - Synchrotron source, mass spec, ongoing
- **SEMATECH**
 - Synchrotron source, desorption tubes, ongoing
- **ASET**
 - Synchrotron source, mass spec, ready mid-2005
- **CEA/LET**
 - Stand alone source, mass spec, controlled contamination studies, ready mid-2005
- **BOC Edwards**
 - Stand alone source (borrowed), mass spec, could be ready soon
- **University of Hyogo**
 - Synchrotron source, mass spec, ongoing



Resist Outgassing Discussion

- Round robin test
 - Use model resist
 - Low and high outgassing resists? Use just one to start with.
 - Agreement from TOK, R&H, Sumitomo, Fujifilm to supply model resists
 - All researchers agrees to round robin.
- Several outgassing researchers gave presentations at the optics and contamination TWG
 - Good collaboration started between groups



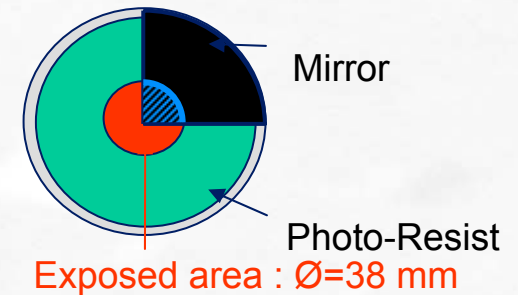
University of Wisconsin



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Resist Outgassing Discussion

- Experimental Details
 - Start with ASML spec for 2005, C_xH_y (integr. > 44 AMU) $4.7E13$ molecules/cm²-sec
 - Dose? Esize for 50nm 1:1, record clearing dose for model compound, if possible, test model compound at various doses?
 - Record time in vacuum, vacuum level at start of exposure (time in vacuum: 5 hours, 20 minutes, 15 minutes)
 - 125nm thickness
 - For mass spec, record time how long it takes to detect a certain mass
 - Use same internal standard?



Outgassing Discussion

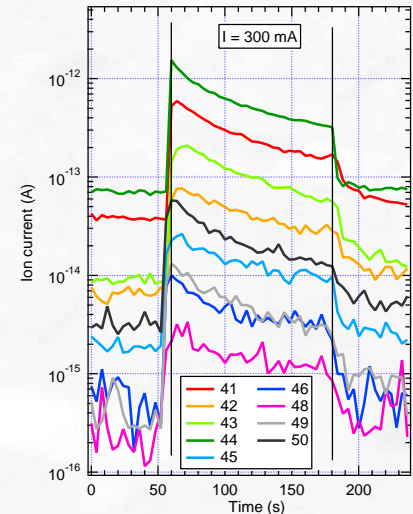
- Solvent outgassing

- MET: wafers sit for 20min in load load, production tools 2 min in load lock
- ASML can share some data about solvent outgassing, might not be a problem
- Difficult to measure outgassing on short time scale

- When to start?

- 2 systems will start mid-year (LETI, ASET)
- Intel, SMT, Infineon ready now
- BOC Edwards ready soon

- Report results at November Symposium



EUV Resist Specification Roadmap

Specifications	Alpha (2005)		Beta (2007)		Spec	Gamma (2009)
	Spec	Current**	Spec	Comment		
Resolution 1:1	45nm	35nm/45nm (C/S)	32nm		32nm	
Resolution contacts	55nm	TBD	45nm		45nm (40)	
Resolution Isolated Lines	32nm	30nm/40nm (C/S)	22nm		22nm (18)	
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)	< 5 mJ/cm^2 (10)	21 mJ/cm^2 E-size @ 50-nm 1:1	< 4 mJ/cm^2 (7)	Assuming ~30 wph	< 3 mJ/cm^2 (5)	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 (1.4)	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	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	30m in	TBD	30 m in	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 & Haas resist MET-1K.

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

EUV Resist Specification Roadmap

- Changes and discussion
 - Made 2009 targets consistent with ITRS 32hp (resolution and LWR)
 - Relaxed photospeed for 2005 and 2007, but spec is still $5\text{mJ}/\text{cm}^2$ for production tools in 2009
 - Added ASML spec for resist outgassing
 - Discussed adding resist thickness, out of band sensitivity, defectivity
 - Should add assumptions (NA and flare)



Top Three Issues for TWG Cooperation

1. **What is a safe level of resist outgassing?**
 - Work together to determine specifications, include tool and resist suppliers
2. **Understanding the resolution limits of chemically amplified resists**
 - Provide enough tool time for cycles of learning
3. **How to optimize photospeed, LWR, shot noise, resolution?**
 - Provide enough tool time for cycles of learning



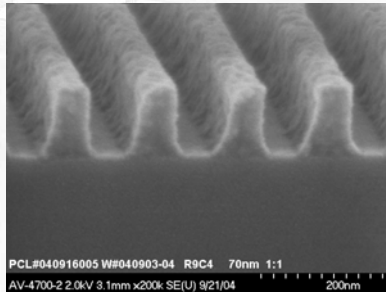
Exposure tool availability

- **MET at ALS Berkeley:** operations scheduled to stop 06-05; limited access, AMD offered to share time with resist suppliers
- **Exitech Intel:** operational; for Intel development
- **HiNA3 ASET:** operational; available, but limited through put (2 wafers per day)
- **PSI Zurich interferometer:** operational; available for others, pay per shift
- **Exitech Albany:** scheduled operational 04-05; open to all with established priority
- **ASML alpha tool:** scheduled operational mid-2006; tool for IMEC and their programs

Plans for NEXT TWG Meetings

- **Mid-year teleconference**
- **Topics for mid-year:**
 - Outgassing update
 - LER standardization
- **November EUVL Symposium (San Diego)**

Bonus Slides!



Comparison of resist performance at LBNL microstepper and PSI interference setup

Roel Gronheid; Frieda Van Roey; Mieke Goethals; Koen van Ingen Schenau (ASML); Cyril Vannuffel (CEA-Leti)



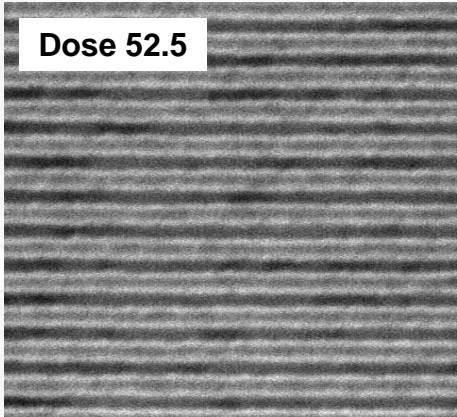
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Resist A 40 nm through dose

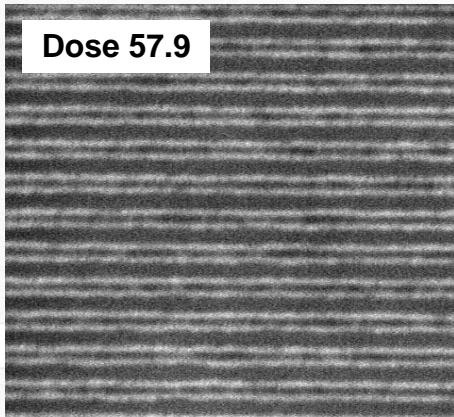
PSI

Aerial image and
flare differences?
Photospeeds different.

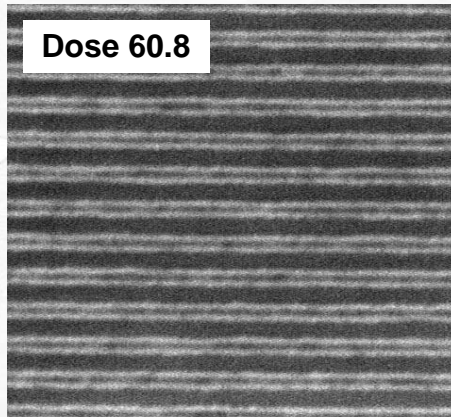
Dose 52.5



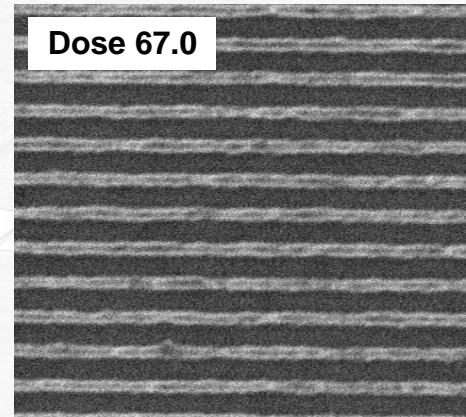
Dose 57.9



Dose 60.8

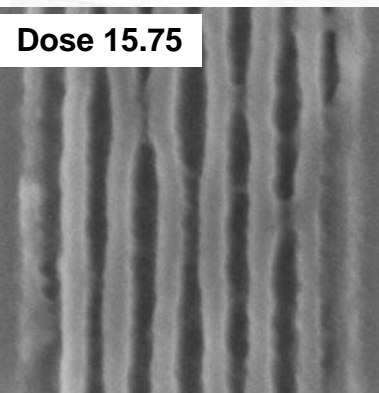


Dose 67.0

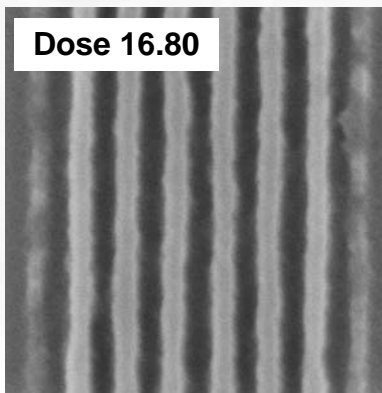


LBNL Brightfield

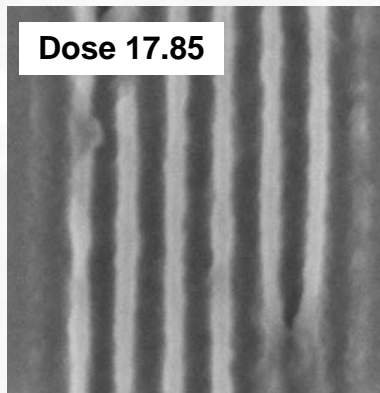
Dose 15.75



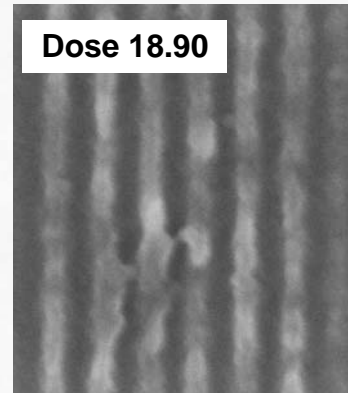
Dose 16.80



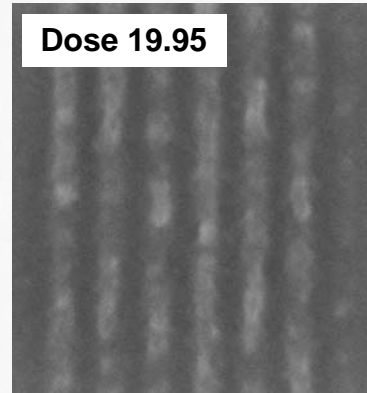
Dose 17.85



Dose 18.90



Dose 19.95



Resist A @ LBNL

50 nm through dose

Darkfield

