



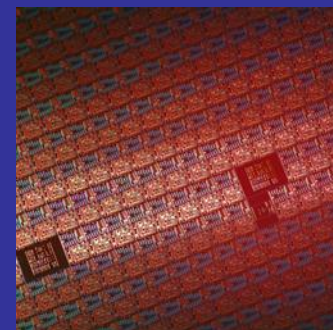
Accelerating the next technology revolution

Sept 2013 Resist TWG Survey Results

Karen Petrillo – SEMATECH/IBM

Serge Tedesco – CEA-LETI

Kyoungyong Cho – SEMATECH/Samsung

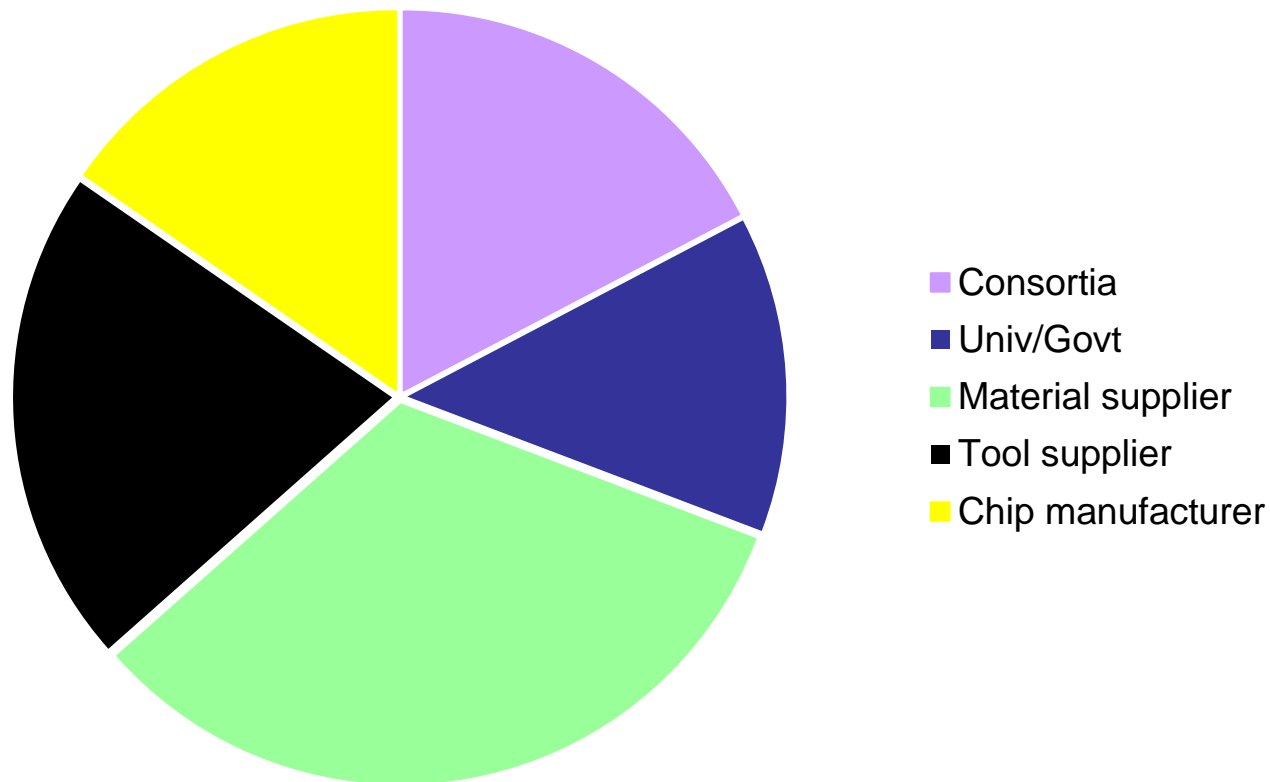


SEMATECH

IEUVI Resist TWG Attendance



52 people attended



- **Outgas testing**
 - Major issue limiting materials research and development. Focusing on this issue for the past several meetings
 - Testing availability is improving
 - Ability to research topics related to outgassing is becoming available
- **Interest in DSA as a means to compliment traditional lithography**

Agenda



Welcome and Introductions

K. Petrillo, SEMATECH

NIST Outgas Testing Update

S. Hill, NIST

EIDEC Outgas Test Results

T. Takahashi, EIDEC

ROX Outgas Testing Update

G. Denbeaux, CNSE

IMEC Outgas Testing Update

I. Pollentier, IMEC

Break

EUVT Outgas Testing Update

R. Perera, EUV Technology

DSA as a Mean for EUV Contact Rectification

R. Gronheid, IMEC

**DSA as Complementary Lithography:
Guiding Pattern Requirements for Contact
Shrink and Contact Multiplication**

R. Tiron, CEA-Leti

Summary

S. Tedesco, CEA-Leti

NIST update, Shannon Hill



- 21 customer samples tested to date, 100 % passing
- Focusing on metrology

Some facilities are having problems exposing high E0 materials in the 1 hour window.

Expose for longer time

Expose a smaller area in an hour

Need to make sure you are working in the contamination limited zone

High partial pressures during outgassing can result in non-mass-limited CG and hence *underestimates* for outgas-testing CG for either EUV or e-beam exposures.

•Mass-limited growth should be verified for high-outgassing resists (e.g., check that CG thickness profile does NOT follow intensity profile of beam.)

EIDEC update, Eishi Shiobara



- 60 customer samples tested, 80% passing
- Studied the effect of formulation and process parameters on contamination growth, and recommended ways to reduce testing
 - Considering protecting unit ratio and PAG loading;
clear correlation with contamination thickness was obtained for both parameters. However, this correlation was not the same for dose.
 - Considering quencher loading and PEB temperature;
clear correlation with contamination thickness was obtained for both parameters. For these parameters, a clear correlation with dose was also observed.
 - **Guidelines on resist outgas test sample reduction** were suggested.
(based on evaluated data)

ROX Update, Greg Denbeaux



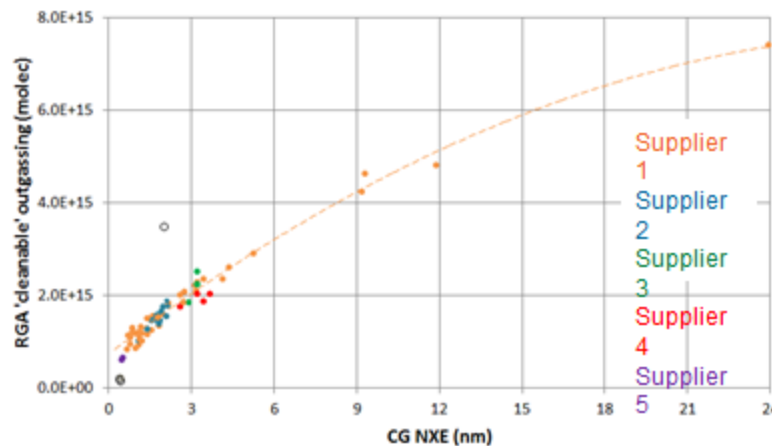
- 81 customer samples tested, 55% passing
- Residual contamination from stray electrons discussed
- Residual contamination in the chamber
 - 2 hour delay between samples is the current methodology to deal with chamber outgassing
- High E0 samples
 - No correlation between high E0 samples and CG

IMEC update, Ivan Pollentier



- 69 customer samples tested, 70% passing
- Good correlation of RGA to CG on witness sample
 - Suggestion from audience to use RGA as a screening method, and only do WS testing for samples that are on the pass/fail borderline

Check of correlation in 72 resist tests so far



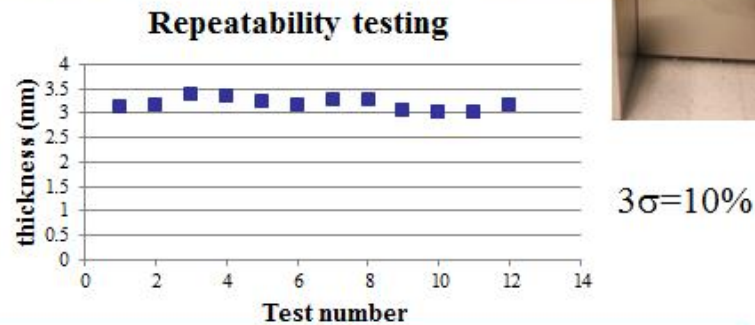
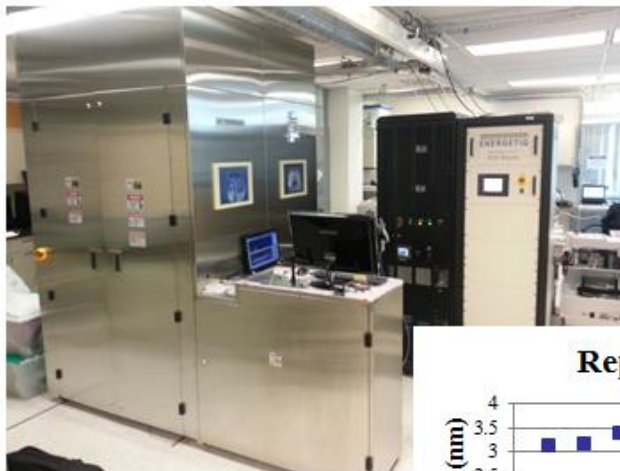
Resist materials from 5 suppliers follow correlation fairly well.

So far only one TC is significantly away from the curve.

EUVT update, Rupert Perera



- 3 customer samples tested, tool is currently undergoing maintenance
- Showed good repeatability testing
- Residual contamination from stray electrons is an issue
 - Oxygen plasma cleaning is not the answer



High throughput tool – plan for over 1000 materials/year

DSA for EUV contact rectification, Roel Gronheid



- Grapho-epitaxy based on homo-polymer blends works, but only to maintain the relative CDU performance in combination with shrink
- Grapho-epitaxy based on BCP requires very large initial hole CD and may not be attractive path for dense hole patterns
- Chemo-epitaxy DSA flow with BCP looks promising, but does not yet meet requirements
 - Repair is not perfect
 - Some pitches and geometries don't work well

GRAPHO-EPITAXY WITH BCP

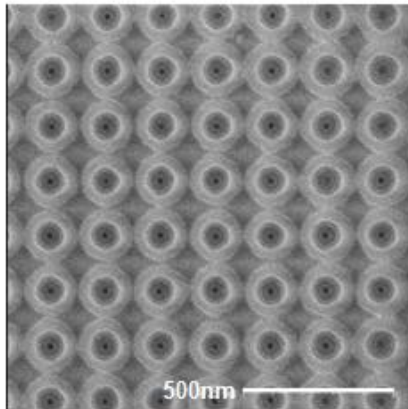
193nm pre-pattern

	1 Pst-Litho	2 Pst-HardBake	3 Pst-DSA + Wet Dev
SEM image			
CD (nm)	53.8	58.9	14.5
Change (nm, %)	--	+5.1, +9.5%	-44.4, -75.4%
Net Shrink (nm, %)	--	--	-39.3, -73.0%
CD Range (nm)	3.4	3.3	0.5

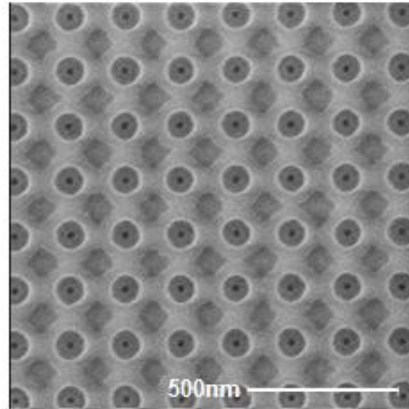
- DSA is a complementary lithography technique that could be inserted as early as the 14nm node
 - In a first step by using PS-*b*-PMMA like materials (lowest CD after etching 10nm)
 - In a second step by using high χ materials (CD < 10nm)

Contact shrink vs. BCP morphology

A/ Cylindrical PS-*b*-PMMA

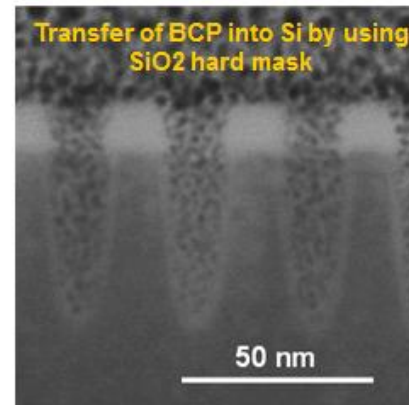


B/ Lamellar PS-*b*-PMMA

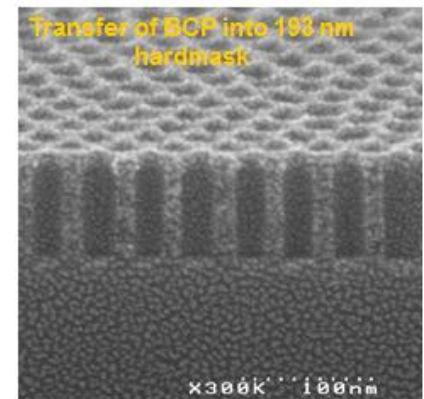


BCP Etching: capabilities demonstration on small samples

Transfer of BCP into Si by using SiO₂ hard mask



Transfer of BCP into 193 nm hardmask



Feb 2013 Outgas tool status & capacity



	Status	Tested as of Oct 2012	Tested to date	Current Throughput (samples per month)
ROX	Up and running	53	81	8 → 24
EUVT	August delivery, working towards Q4 certification & customer availability	0	3	40 - 80
NIST	Certified Aug/Sept 2011	9	21	6
EIDEC (LTJ)	Certification complete, ready to start	0	60	30 - 40
IMEC	Recently certified	10	69	~20
LTJ – 3 private	Certified		no data	no data
Total number of Customer samples tested		62	234	~70
Projected Total Capacity				145

Industry request: 250 per month, same as MET tools

Tool status



	Total	Total passing	% passing
NIST	21	21	100%
EIDEC	60	48	80%
ROX	80	45	55%
IMEC	69	48	70%
EUVT	3	3	

Summary



- Comparison between outgas tools: Some samples passing at one site but failing at another
 - Request failing sample testing at multiple sites
 - Follow up by e-mail with material suppliers and consortium testing facilities
- Non-cleanables
 - 100% passing
 - Is this useful?
- RGA comparison
 - Is there a way to implement
 - Suggestion: screen with RGA, and only witness test samples that are on the borderline