EUV Optics Contamination and Lifetime Working Group 03/04/05

Meeting Organizer: Giang Dao, Intel/ SEMATECH
Chair: Ginger Edwards, Freescale/ SEMATECH

Membership:

Dick Anderson, Sandia
Fred Bijkerk, FOM
Hartmut Enkisch, Zeiss
Gregg Gallatin, IBM
Anthony Keen, BOC Edwards
Christian Laubis, PTB
Tom Lucatorto, NIST
Bas Mertens, TNO-TPD
Iwao Nisiyama, ASET
David Ruzic, University of Illinois
John Taylor, Lawrence Livermore
Cyril Vannuffel, CEA/ LETI
Stefan Wurm, Infineon/ SEMATECH
Kakutani Yukinobu, Univ. Hyogo
Takashi Aoki, Nikon
Manish Chandhok, Intel
Yasuaki Fukuda, EUVA
Yoshio Gomei, Canon
Kevin Kemp, Freescale/SEMATECH
Eric Louis, FOM
Hans Meiling, ASML
Niibe Masahito, Univ. Hyogo
Hiroaki Oizumi, ASET
Michael Sogard, Nikon
Hiromitsu Takase, Canon
Obert Wood, AMD/ SEMATECH

Invited; not present: Ted Madey, Rutgers; Siegfried Schwarzl, Infineon; Bruno Lafontaine, AMD; Thomas Stein, Zeiss

Proposed Joint Tasks: November 2005

1. Share data on scaling laws; divide parameter space; use consortia to benchmark testing capabilities
2. Perform testing in all three regions on a known, neutral ML
3. Share general data on fundamental understanding; have European, Japanese and American surface science experts unite to share data, expertise
4. Toolmakers to develop list of contaminant materials to be studied (coming from the source and resist).
5. Consortia to work together to develop scaling laws for oxidation of broad classes of materials (i.e. work together and share data).
6. White paper on one of the top three critical tasks.

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Agenda was designed to make progress in these tasks

IEUVI Optics TWG Meeting March 2, 2005 San Jose, California

5:00 10 min	On site registration Buffet Dinner is Served	
10 min	Introduction: Review of Areas of Possible Cooperation and Discussion of Desired Meeting Output	Ginger Edwards
10 min	EUV Optics Contamination and Lifetime: IBM Perspective & Expectations	Gregg Gallatin
10 min	EUV Optics Contamination and Lifetime:Intel Perspective & Expectations	Manish Chandhok
10 min	Origins of Contamination from EUV Sources	Dick Anderson, Sandia
10 min	Resist Outgassing Summary	Kim Dean, SEMATECH
10 min	Hydrocarbon Contamination Monitoring Update	Anthony Kean, BOC Edwards
10 min	Intel Resist Outgassing Metrology and Specs	Heidi Cao, Intel
10 min	Optics Lifetime Testing Update	Tom Lucatorto, NIST
10 min	Update on Ru Oxidation Modeling	Yoshio Gomei, Canon

(6:40 pm)

(Continued….)

IEUVI Optics TWG Meeting March 2, 2005 (continued)

10 min	E-beam Based Lifetime Testing Update	Dick Anderson, Sandia
10 min	Update from ASET	Iwao Nisiyama, ASET
10 min	Update from EUVA	Yasuaki Fukuda and Takashi Aoki, EUVA
10 min	Update from PTB	Christian Laubis, PTB
10 min	Update from TNO TPD	Bas Mertens, TNO TPD
10 min	Update from CEA-LETI	Cyril Vanneuffl, CEA-LETI
10 min	Update from Lawrence Livermore National Laboratory	John Taylor, LLNL
10 min	Discussion	
30 min	Group 1 Compiles Cooperation Topics; Group 2 Summarizes Key Results from Updates	All
10 min	Present Compilation of Key Results	Leader of Group 2
10 min	Present Compilation of Cooperation Topics	Leader of Group 1
10 min	Wrap-Up and Plans for Next Meeting	Ginger Edwards, SEMATECH
9:00	Adjourn	

IC Manufacturer Point of View:

IBM:

- No surprises are allowed
- Science is nice, but we are here to make money. In the name of esoteric knowledge, do not handicap the EUV exposure tool with any variety of metrology, processes or sensors that will slow down the the chip making process or increase COO.

Intel:

- Impact of contamination: Intel is more concerned about CD uniformity than a small decrease in throughput
- Prevention is better than cure
  - Reduce contaminants to zero
  - Thermally stable MLs
  - "Intelligent" capping layers* ***(editorial note: this will be a problem; see only small effort in this direction worldwide)***
- In-situ cleaning, only if necessary
  - Need to see credible data before implementation

Sources of Contamination: Summary I, EUV Sources

Conclusions

- The source target material, any support matrix (and its decomposition products), and any gases (with their contaminants) used for fast ion mitigation, should be considered as potential contaminants in the P. O. chamber.
- This is especially true in the absence of a spectral density filter or other structure to prevent inter-chamber diffusion.

We request an update from Source TWG member on this topic at our next Optics TWG

Sources of Contamination: Summary II, Resist

Conclusions

- Extensive efforts in this area worldwide; standardization of units, degree of inter-community communication is promising

- Huge variation (3 orders of magnitude) in tool specifications for “tolerable” resist outgassing AND in the range of experimental results is troubling; danger of over-specification or under-specification?

- Metrology progress is badly needed. For RGA along, questions exist:
  - Resolution vs. sensitivity trade-off’
  - Method of measurement can impact results (need standardization)
  - Data analysis issues (deconvolution, etc).

  What is the best way to measure contamination/ outgassing?

- No good methodology currently exists for assessing the mirror contamination from outgassing ;
  - good ideas exist, but development is needed
  - Resist and Optics TWGs will work together to share ideas

World-wide capability matrix for projection optics lifetime testing

updated

	Current	Planned
EUV photon exposures		
EUV photons, high radiative flux		
EUV photons, high contaminant gas partial pressures		
e-beam exposures (short & long term)		
Pulsed source testing		
Resist outgassing studies		
Novel cleaning/mitigation		
Multilayer coating development		
Extensive materials/ analytical characterization effort		
Complementary surface science investigations		

Summary of Progress: United States

Type of Work Performed:

- Electron beam and EUV exposures on Ru-capped ML from LLNL (standard benchmarking sample)
- Scaling laws were determined with water vapor pressure, radiative flux as scaled parameters; time dependent measurements done as well

Main Finding:

- Scaling results were counter-intuitive. Damage scaled as expected with time and radiative flux, but actually decreased with increasing water vapor pressure
- Indicated that hydrocarbons present can dictate the surface chemistry of mirror degradation out of proportion to their numbers (~10^{-10} Torr H_xC_y vs. ~10^{-7} water, for example)
- Contamination control is critical in optics lifetime testing chambers

Main Questions:

Do tool specifications need to be revised to account for specific hydrocarbon levels? Which hydrocarbons are benign? Which are bad actors? What are acceptable levels and how do we measure them?

Summary of Progress: Japan

Type of Work Performed:

- Electron beam and EUV exposures on Ru- and Si-capped MLs
- Scaling laws were determined with water vapor pressure, radiative flux as scaled parameters; time dependent measurements also
- High radiative flux measurements possible
- A general contamination model is being developed; includes pulsed vs. synchrotron scaling

Main Finding:

- First public reporting of accelerated lifetime test:
  - **Tests at Hyogo University, Y. Kakutani group**
  - **Performed test on Si-terminated ML. For same damage:**
    - **Power densities differed by a factor of ~30**
    - **Time to perform tests differed by a factor of ~30**

→I.e. test with power density that was lower by a factor of 30 took 30 times longer to perform (28 hours vs. 1 hour)

Main Question:

Will same relations hold for capped multilayers? Is testing with high radiative flux the best way to develop an accelerated lifetime test, or will there be irrelevant effects at high fluxes and test times?

Summary of Progress: Europe

Type of Work Performed:

- Environmental chamber with surface science analytical chambers connected under vacuum will be operational by Q2 2005
- Additional test chambers using actual EUV exposure tool system hardware is being assembled
- Both facilities use commercial EUV sources (pulsed operation)
- Analytical model of pulsed vs. synchrotron operation has been developed and experimentally verified (preliminary)
- Extensive confidential e-beam and EUV scaling tests have been performed on proprietary samples

Main Issues Under Investigation:

How do the data obtained during extensive scaling tests in synchrotron and test facility compare to the conditions in the actual tool?

On-going Cooperation

1. Share data on scaling laws; divide parameter space; use consortia to benchmark testing capabilities
2. Perform testing in all three regions on a known, neutral ML (see next slide)
3. Share general data on fundamental understanding; have European, Japanese and American surface science experts unite to share data, expertise
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"Surface Chemistry Processes Relevant to the Degradation of EUV Mirrors, " Ted Madey, Rutgers, as part of SEMATECH LITH160 deliverables.

Additional Areas of Cooperation

I. Calibration of Synchrotron Test Facilities ***(short term timescale)***

- Compare test facilities by performing tests on standardized samples under identical conditions; metrology performed at standard facility (SEMATECH to provide samples & analysis)
- Hydrocarbon levels to be below a certain level, to be negotiated
- Sample fiducials, test conditions, shipping protocols, and background gas metrology under negotiation

II. Develop Pulsed vs. Synchrotron Scaling Relationship ***(medium term timescale)***

- Effort will be experimental and theoretical; already underway
- Testing will occur in US, Japan, and Europe to validate models
- Will address the impact of pulsed frequency rate, currently not addressed in European and Japanese models

III. Cooperate on Accelerated Protocol Development ***(long term timescale)***

- What is best way to accelerate lifetime testing to insure that optics last the required 30,000 hours?

Areas of Cooperation: Risks

- Concerns about testing schedules were expressed; aggressive goals have been set in Europe and Japan and volunteer testing may prove burdensome. Possibly as late as September for testing start date. Under negotiation.
- Europe has moved completely to pulsed testing; to participate in the first experiment (synchrotron test facility calibration), they will have to finance experiments that are not in their critical path.
- Lifetime testing itself is expensive, as is post-test analytical characterization. Samples are costly. Having a small budget to help in this endeavor would dramatically increase IEUVI leverage.

Next Meeting

- August 9, after the VNL Quarterly Review in Berkeley, CA. Teleconferencing will be available for off-site attendees.
- Entire group will meet again in conjunction with the November EUVL Symposium