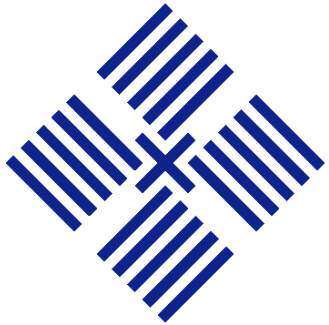

ASML

ASML's EUVL Program Progress Update

Noreen Harned

2nd International EUVL Symposium

October 1, 2003

Content

- ASML's EUV Roadmap
- Key Technical Items for EUVL
  - Source (power, lifetime)
  - Optics (fabrication, lifetime)
  - Defect-free mask handling
  - Vacuum technology / α-demo system realization
- Summary and Conclusions

Revised EUV Roadmap

- Market drivers:
  - EUV insertion has been delayed to the 32 nm node, with high volume in 2009
  - Given the uniqueness of the technology, customers have asked for “early” access to tools (2 yrs in advance) in their fabs
  - Even earlier access to the technology is desired to build the EUV infrastructure
- ASML program has been adapted accordingly:
  - Alpha Demo (10) tool imaging specs tightened to support early research learning for a different node
  - A process development tool, EUV(30), will be available in 2007 and 2008
  - The volume production tool, EUV(80) is targeted to ship January 2009

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ASML is Working on Key Risk Areas

- **Source**
  - More than a 10x increase in power is required over the current capability to get to >100 wph (needed for acceptable CoO)
  - Source operational lifetime today is measured in months, not years
- **Pellicle-less reticles**
  - Handling and particulate contamination for volume production with no added particles > 50 nm
- **Optics development**
  - Imaging: improving mirror surface quality to support sub 50 nm resolution
  - Impact of molecular contamination on lifetime to get to >5 year life
- **Vacuum technology**
  - Stages, sensors
  - Realization of lithography for customers: the α-tool

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Commercial EUVL Source Requirements*

Attribute	2009 Commercial Tool
Central wavelength (nm)	13.5
Clean EUV power in 2% BW (W)[1] delivered to intermediate focus	125 w
Source-induced condenser lifetime at full power and 6 kHz	>30,000 hrs
Etendue of source output (mm^2sr)	1 – 3.3 (max.)
Max. solid angle to illuminator (sr)	0.03 – 0.2
Repetition Rate (Hz)	7-10 kHz
Integrated energy stability at 6 kHz and nom. scan speed	±0.3% 3s, 50 pulses

* Based on consensus of ASML, Canon, Nikon modified Feb. 2003

[1] Corresponding to 100 wafers/hr (300 mm) with 5 mJ/cm^2 resist

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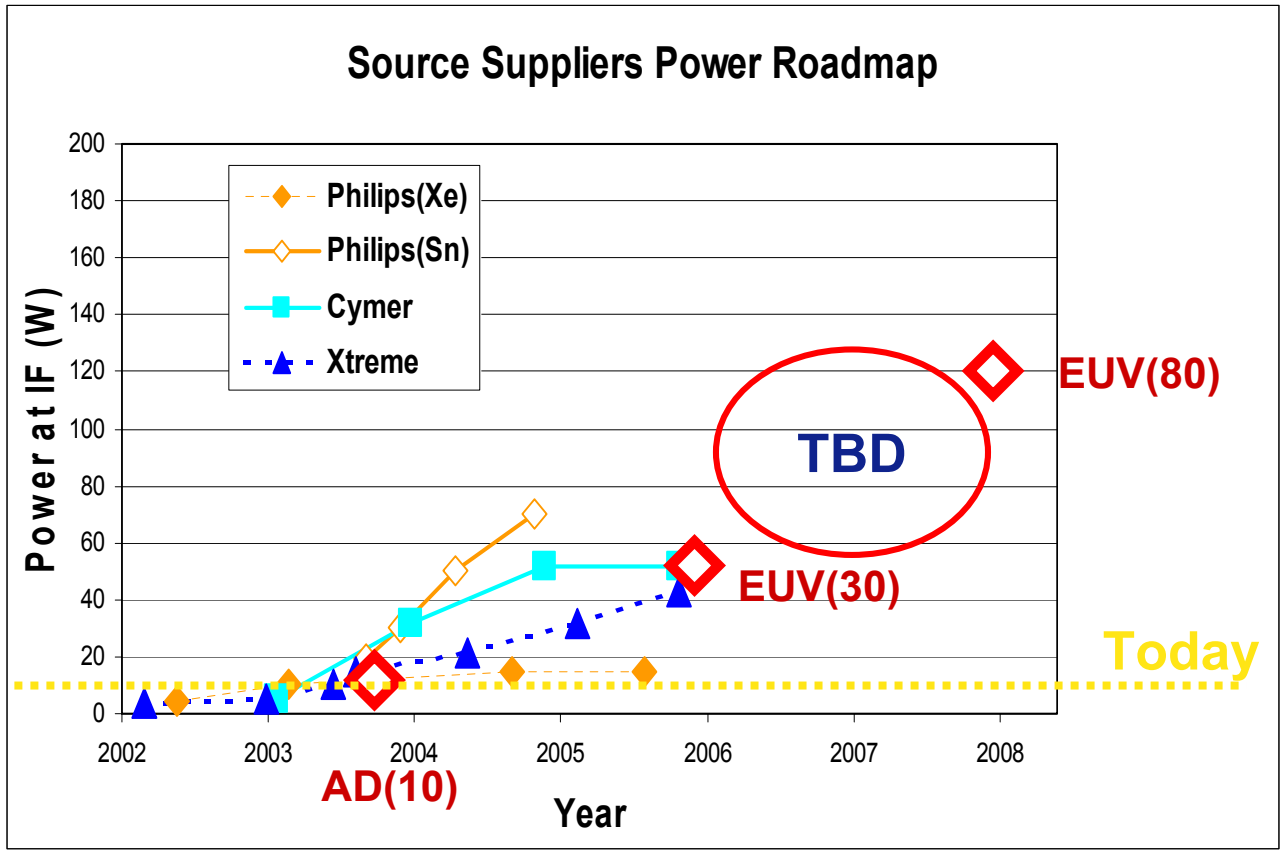
Source Roadmap

Note: If spectral purity filter is needed, achieved power should be reduced 50%



Conclusion: Today's EUV source options are adequate for EUV Alpha Demo tool and there is an improvement roadmap for EUV(30). The path for EUV(80) tools needs significant research and development.

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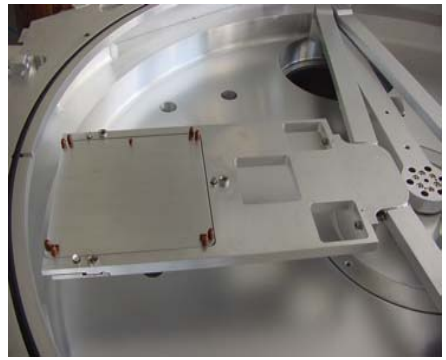
EUV Mask Protection

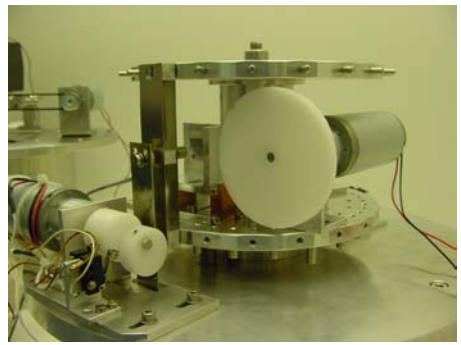
- Problem: Direct contact with the mask (reticle) creates particles and pellicles can not be used, since virtually all materials absorb EUV.
- Two-part solution approach:

1.Minimize the number of direct contact events by using reticle handling frame



Robot arm with RH Frame

2. Find low-particle generating material combinations and the conditions under which they can be used



Material Contact Test Set-up

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Material Contact Test Investigation

- Goal: Find combinations of materials that are low particle generators and determine the “process window” for which they are acceptable
- Parameters:
  - materials
  - contact pressure
  - relative movement
  - environment
  - number of contact events

Summary of Material Contact Tests to Date:

- **Unacceptable Results/Combinations**
  - Several different extremely hard materials found to cause damage on samples
    - e.g - Sapphire, Steel
  - Bare ULE:
    - difficult to clean & keep particle free; should always be coated
- **Acceptable Results/Combinations**
  - Two different polyimides were found to be be good candidates for contact points
    - both performed well in Vacuum environment
    - one required very low contact force to avoid particles
    - the other had only limited trials
  - One extremely hard material was found to be a good candidate for inderct cotnact points
- **Mixed Results - need more testing**
  - Still have not found acceptable material that is also conductive

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Material Contact Tests - Conclusions(cont'd)

- Next Steps:
  - Continue search for acceptable process window with a conductive material to provide a ground to the reticle during handling
  - Build prototype gripper and handling frame using one of the acceptable materials for the mask contact points and the docking pins, and test particle performance on the Alpha Demo Reticle Handler Functional Model

ASML is Working on Key Risk Areas

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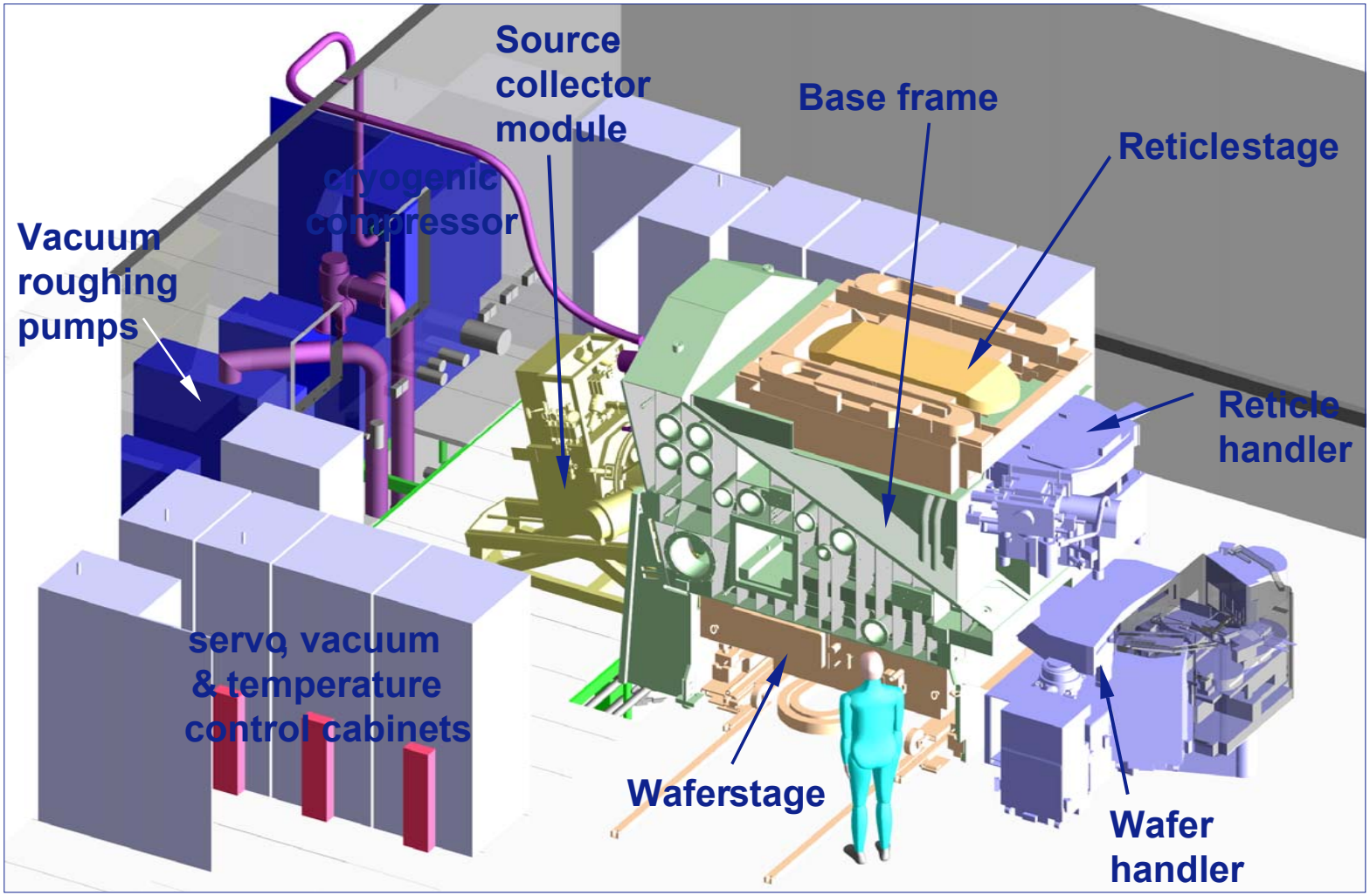
Alpha Demo Tool in Building 9



α-Demo Tool Realization

Focus for the next six months:

- In process activities:

√ assembly of frames & test for vacuum qualification

√ functional testing in air of modules

√ vacuum outgas testing of components

√ functional testing of modules in vacuum

- Next Phase:

  integration of major modules

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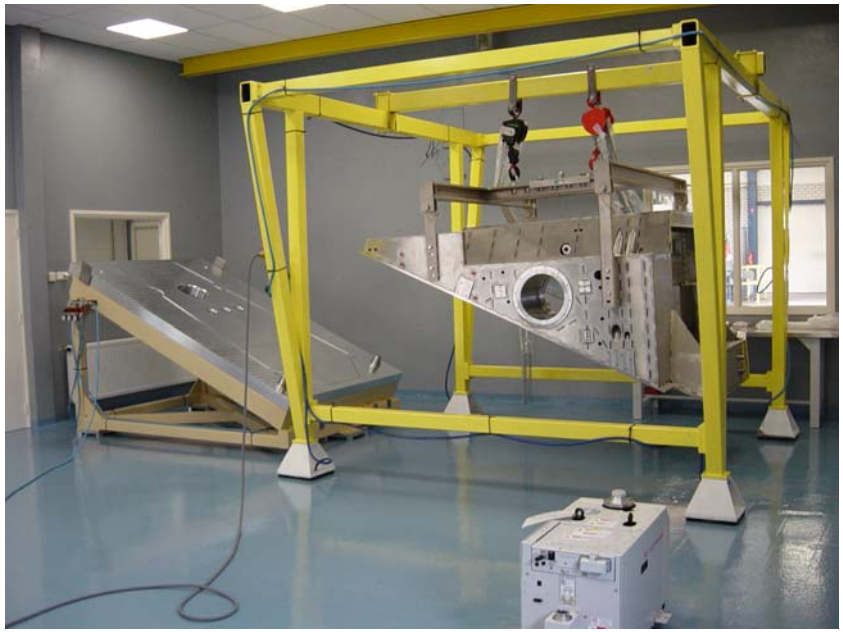
α-Demo Tool Realization: Frames Status

- Baseframe Assembly
  - Machining qualified
  - Vacuum qualification, including bake-out in process:
- Metroframe Bottom
  - Machining ready
  - Cleaning & vacuum qualification in process
- Metroframe Top
  - Assembly ready
  - Assembly vacuum qualification: preliminary results OK

α-Demo Tool Realization: Qualification Testing of Frames



Reticle Stage Support Frame, part of the Baseframe, installed on vacuum qualification test rig

Baseframe Mainbody, during Coordinate Measurement Machine qualification.

α-Demo Tool Realization: Stages Status

- Wafer Stage:
  - Air tests complete
  - Vacuum qualification in process:
    - stand alone servo control of short-stroke in vacuum demonstrated;full vacuum qualification started
    - long stroke has been vacuum qualified
- Reticle Stage:
  - Air tests complete
  - Long stroke functional tests with Al dummy slider complete
  - Re-qualification in vacuum of long stroke to start after Al slider is changed to SiC

α-Demo Tool Realization: Handlers Status

- WH:
  - FuMo assembly complete
  - Partial vacuum testing is ongoing
    - Robot drive has been vacuum qualified
- RH:
  - Baseline air tests complete
  - Vacuum qualification started (no ears design)
    - Loadlock now vacuum qualified
    - Vacuum qualification of loadlock + dummy robot chamber is next
  - Contamination tests in process
    - FuMo Loadlock undergoing particle test

Conclusions

- Source (power, lifetime):
  - ✓ confident that alpha demo technology will be secured
  - production tool solutions are proposed, but not demonstrated
- Optics (fabrication, lifetime):
  - ✓ confident that alpha demo technology & lifetime will be secured
  - production tool polishing specifications are being approached, lifetime solutions identified, but not demonstrated
- Defect-free mask fabrication and -handling
  - good progress on material selection and handling schemes/design, data shows some promising material candidates, no added particles during handling on FuMo with reticle frame prototype
- Vacuum technology (frames, stages, handlers):
  - ✓ using proper design and procedures, confident that specs will be met

α-demo tool system realization: well under way!

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- …and many others