ASML Program on Extreme UV lithography

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2nd International EUV Workshop

San Francisco, USA, October 17–19, 2000

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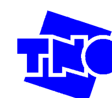
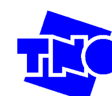


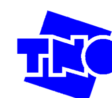
Contents

- Introduction
  - when is EUVL required?
  - approach towards production tools
  - international technology network
- Summary EUCLIDES results
  - optics & multilayer coatings
  - EUV testbench
  - system architecture / system budgets
- Source benchmarking / Flying Circus

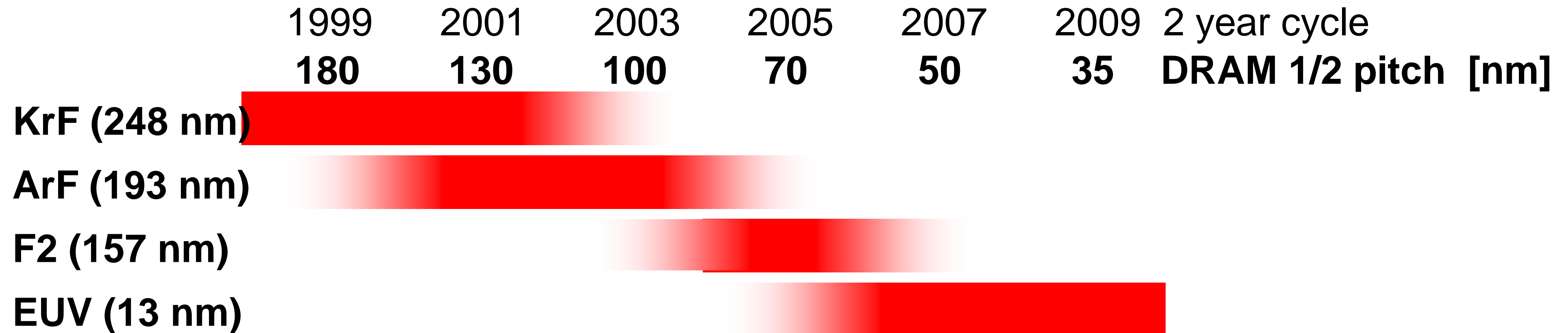


Contents (cont'd)

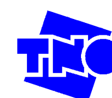
- The alpha research tool
  - timing, specs
  - present status (optics, system design, sensors, environment control, ...)
- Summary and conclusions



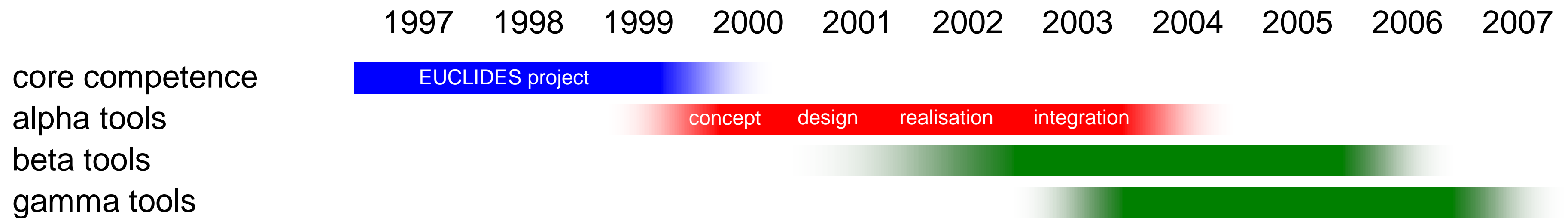
When is EUVL required?



ASML pursues "photons forever" scenario.
Best guess today: 157 nm will be extended to 70 nm node,
and EUV will insert in mass volume production at 50 nm node.



Phased approach EUV tools

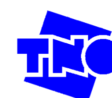


Status Sept 2000:

- Core competence phase (EUCLIDES) succesfully completed
- Alpha tool project ongoing:

  fully staffed

  concept phase almost completed



International technology network

EUV consortium
Intel/AMD/Motorola/
Micron/Infineon

Mask patterning
consortium
members

ASET

EUV-LLC

Tool development
Lawrence Berkley NL
Lawrence Livermore NL
Sandia NL

Nikon

Canon

International EUV
coordination
group

TRW: lasers
AES: nozzle
ISI (Ultratech): stages
Tinsley (SVG): optics
Osmic, Veeco: coatings

USAL

SVGL

ASML

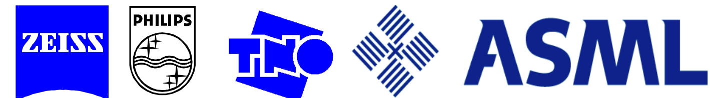
Main partner

Main contractors

ZEISS

TNO

PHILIPS



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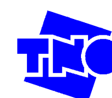
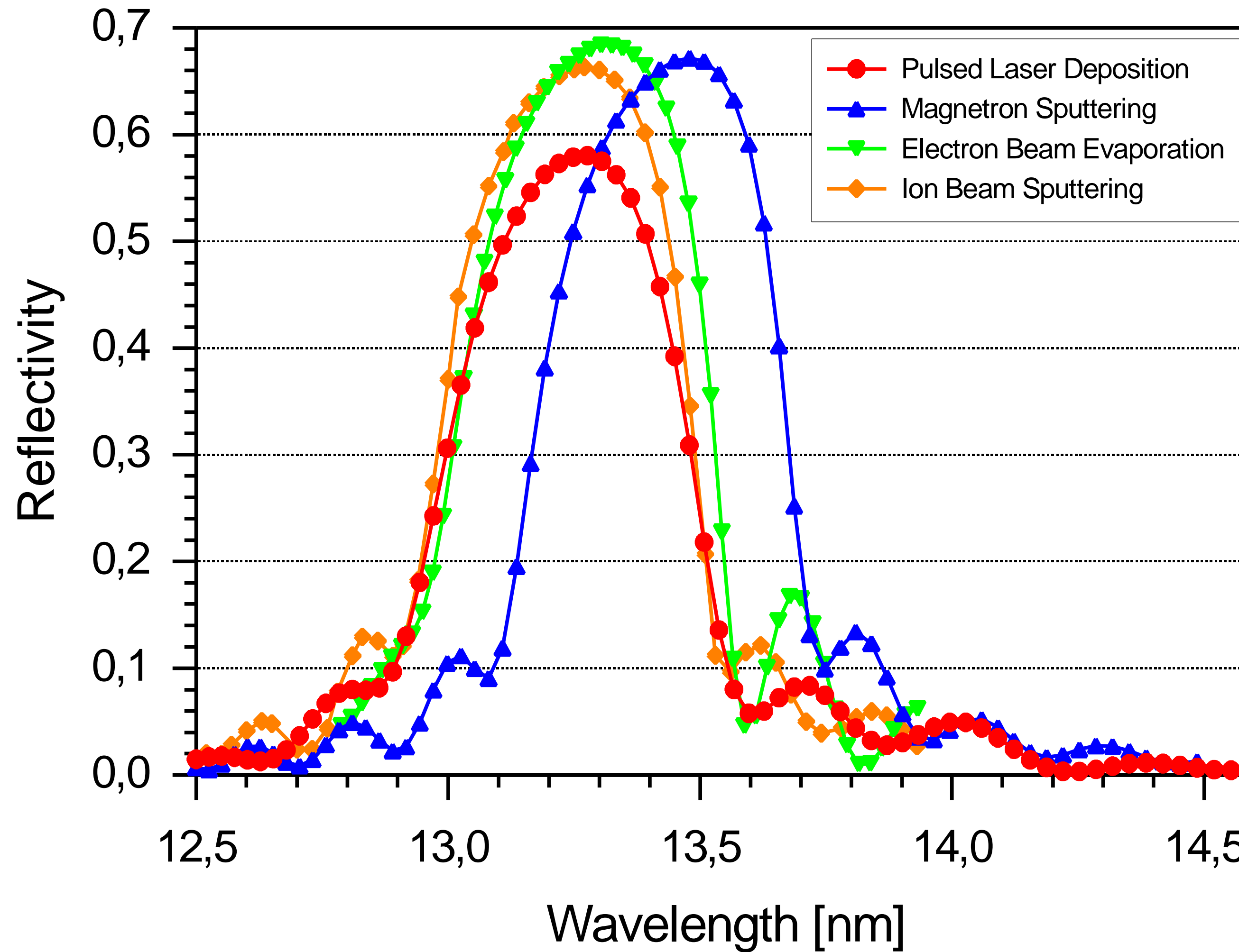


Multilayer coating technology*



*F. Bijkerk et al., this Workshop.

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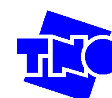
System architecture: budgets

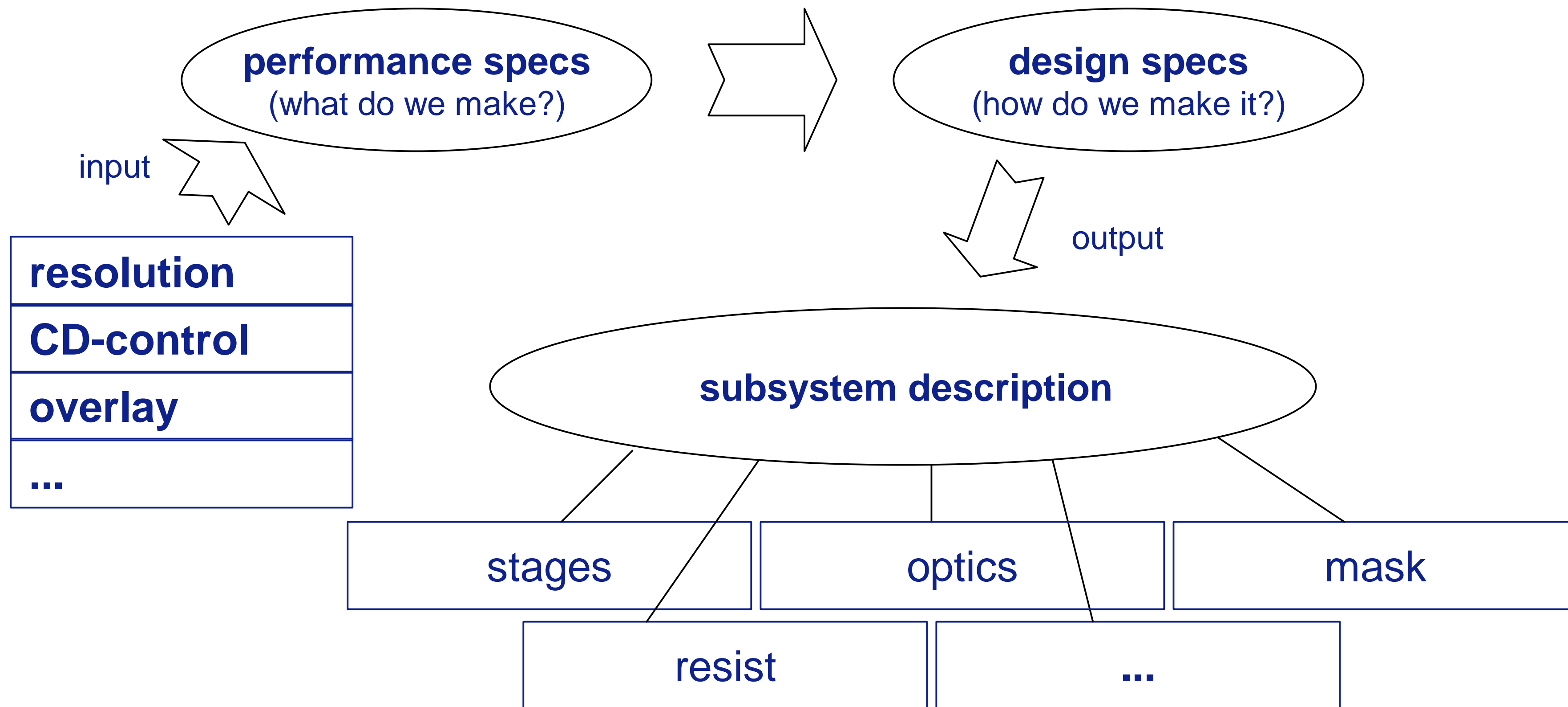
- Based on ITRS 50-nm-node compliant imaging, design budgets* were setup for
  - Throughput
  - CD-control
  - Overlay
- These budgets drive the overall system design.

**H. Meiling et al., 44th EIPBN, to be published in J. Vac. Sci. Techn. B (Nov/Dec 2000).*



How to design a lithography production system?

system = scanner + reticle + process



budgets are distributed such, that a total system solution is available!

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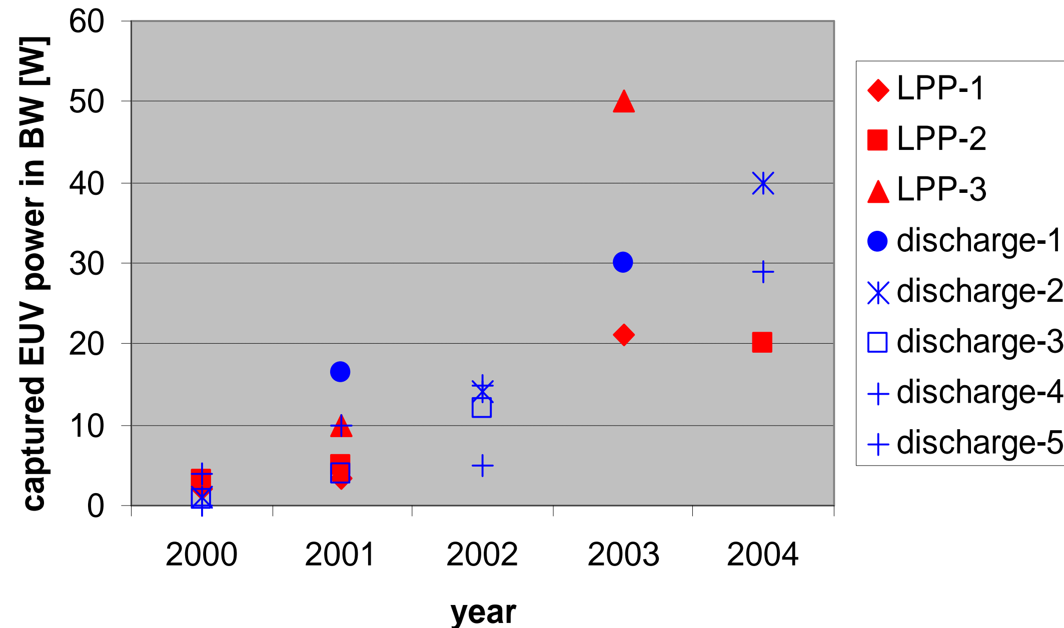
Throughput: results

- Under the present assumptions for optical design, resist sensitivity, etc., a source is needed with 40 W in-band collected EUV for a 80-w/h tool (6 W for 10 w/h).



Several commercial suppliers execute roadmaps that will lead to >40 Watt EUV sources around 2004.

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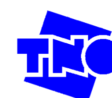
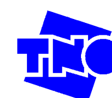


WW source benchmarking: Flying circus (FC)

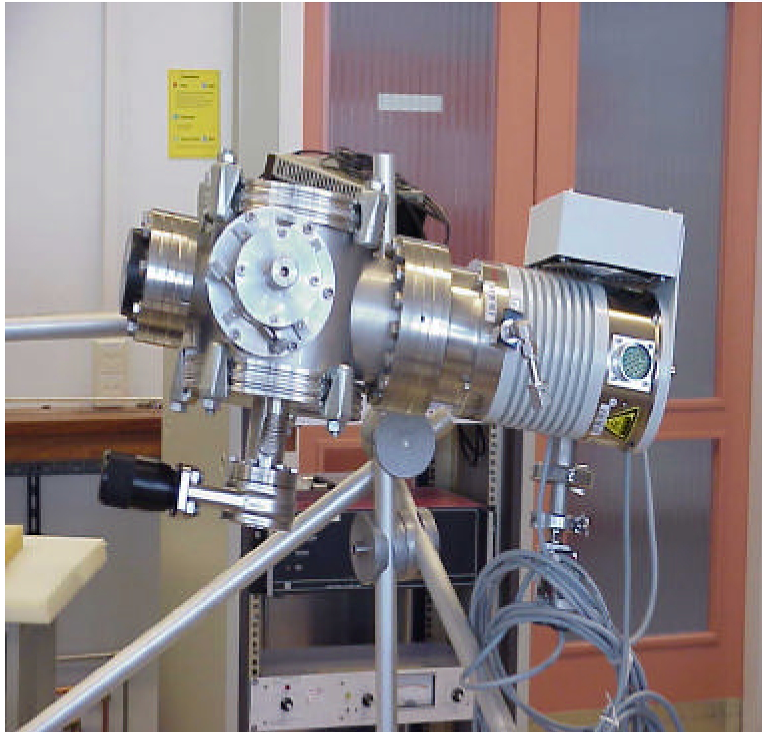
- A set of portable tools has been constructed
- Used for EUV source characterization at the most promising EUV sources at different locations
  - 3 Laser produced plasma sources
    SNL, Philips, FOM-Rijnhuizen
  - 4 Discharge sources
    SNL, Plex, Cymer, Fraunhofer-Aachen
- Source characteristics being measured
  - absolute intensity & average power
  - source size & shape
  - positional stability
  - size/shape pulse-to-pulse fluctuations
  - spectral measurements
  - pulse-to-pulse intensity stability
  - contamination

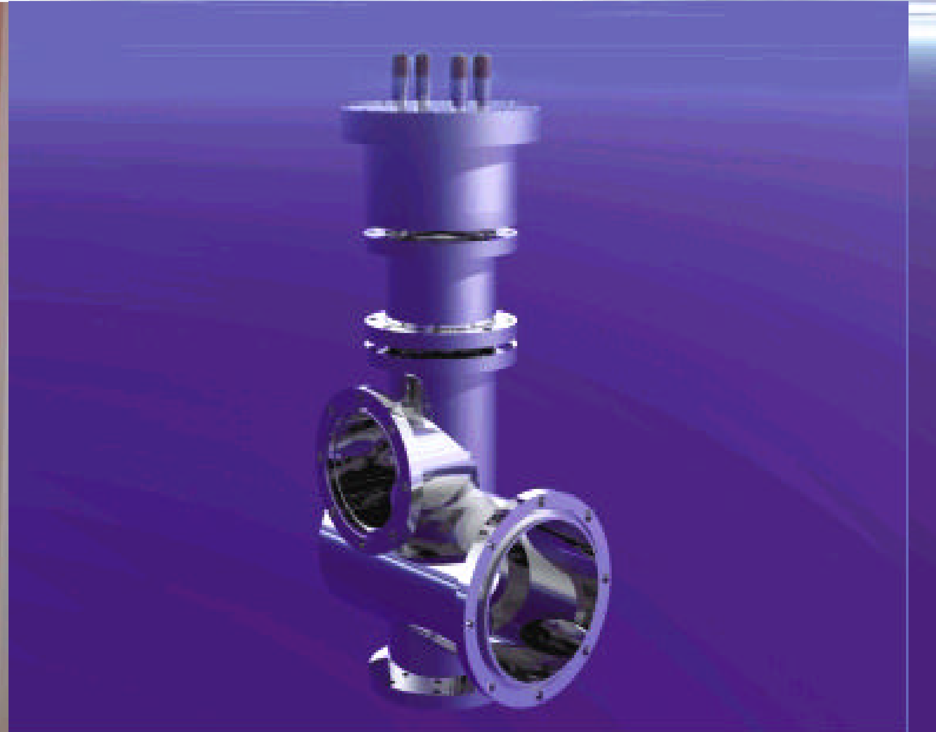


Flying circus (FC)

Pinhole camera
and spectrometer unit

Unit for absolute EUV measurements





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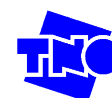


Goal alpha research tool (α-RT)

- prove EUVL viability for $\leq$50 nm nodes

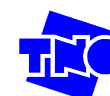
- reduce risk for γ-tool development

- source
- optics / multilayer coatings
- contamination control
- synchronized vacuum scanning stages
- 50nm node compliant imaging performance
  - resolution, overlay, CD-control
- basic ‘EUV’ ICs (= step to γ-tools)

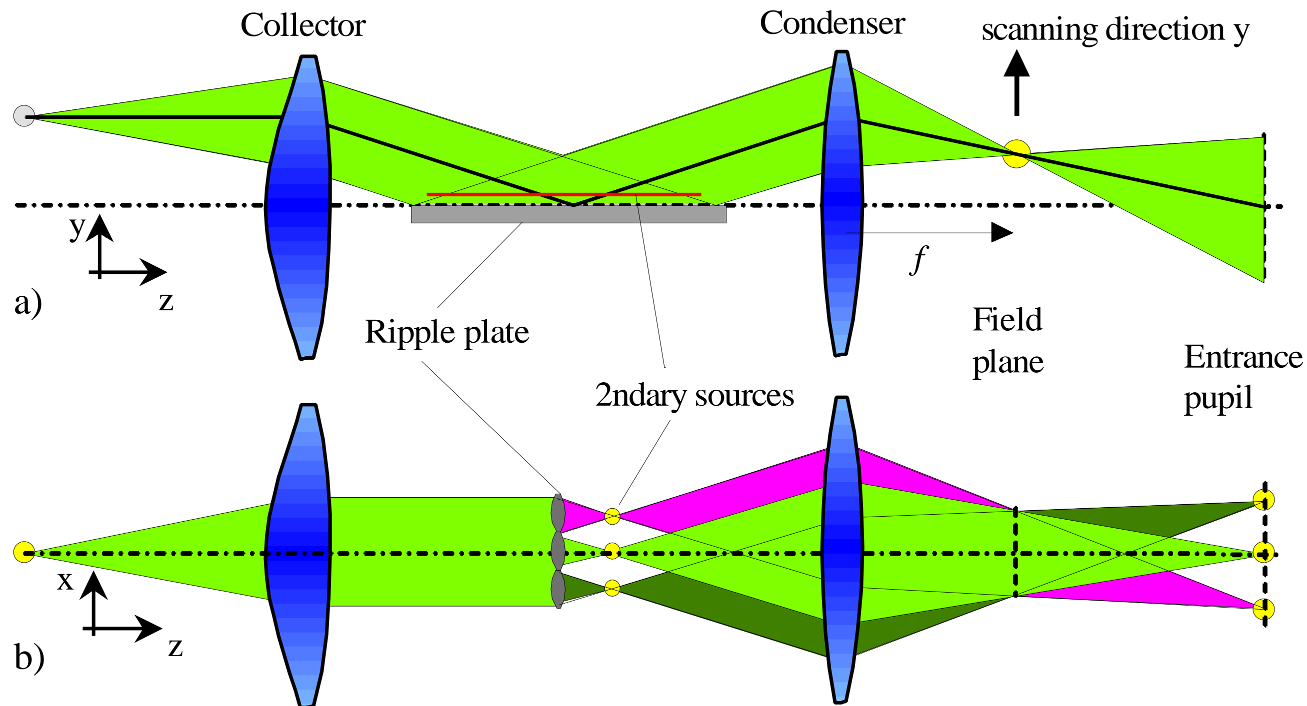
Project organisation

EUV α-tool

- **ASML**
  - project definition
  - system engineering
  - alignment sensor
  - source trade-off/choice
- **Carl Zeiss**
  - projection optics
  - illuminator
  - multilayer coating
  - EUV metrology
- **Philips**
  - stages
  - frames
  - software
  - electronics
  - handling
  - tool assembly
  - EUV testbench
  - TIS
  - reticle level sensor
- **TNO-TPD**
  - wafer level sensor
  - electrostatic chuck
  - reticle clamping
  - contamination control
  - system engineering



Optical design: illuminator

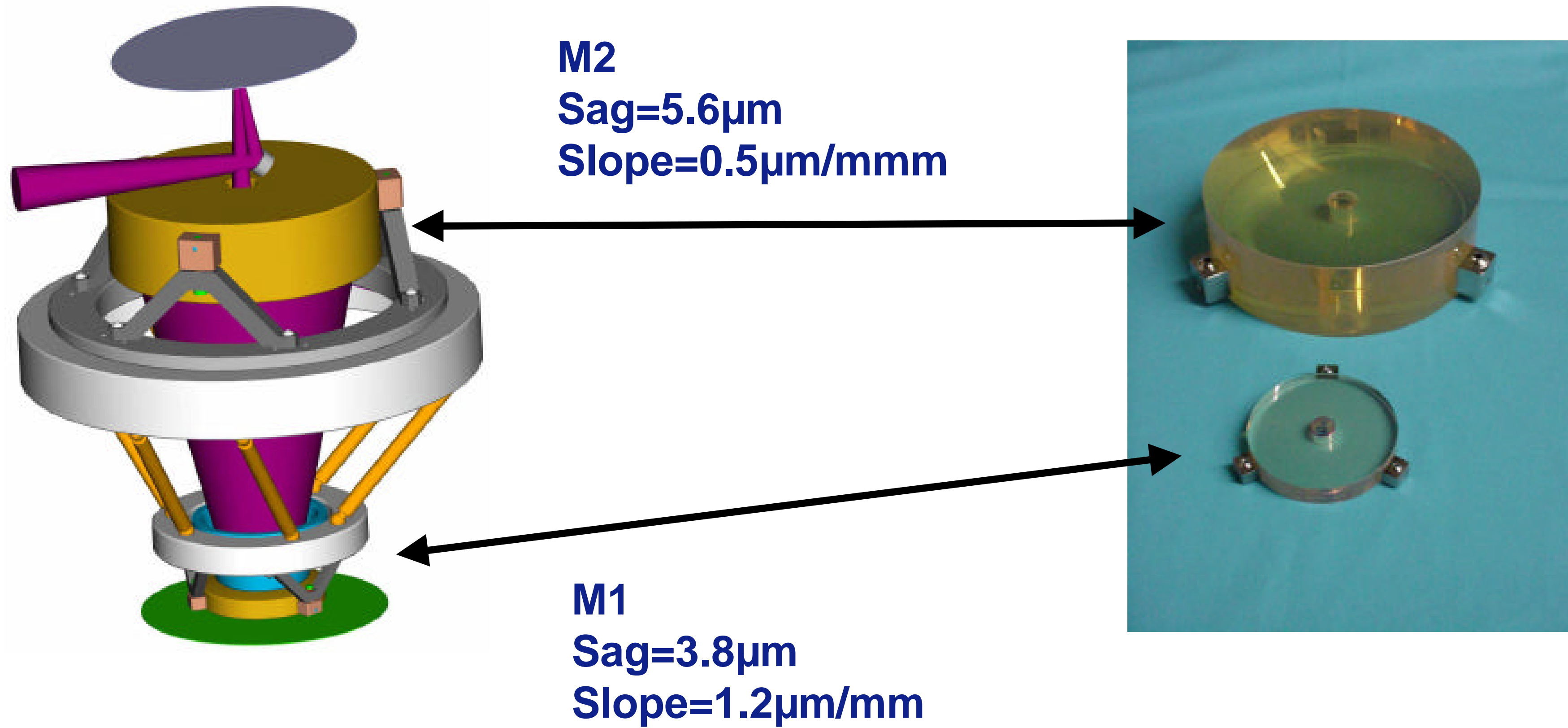


Ripple concept

- Illumination type CRITICAL (scan)
  & KOEHLER (^ scan)
- Field Formation by conical reflection

M. Antoni et al., SPIE 2000.
P. Kürz et al., this Workshop.

Optics fabrication (MET)



U. Dinger et al., SPIE 2000.

Contamination issues

- **Mirror reflection reduction due to carbon growth and/or oxidation**

- ***Carbon growth*** due to cracking of hydrocarbons under EUV irradiation

- ***Oxidation*** due to
  - H_2O and EUV
  - O_2 and EUV
  - mirror cleaning with
    - UV/O_3
    - O_2 rf plasma
    - ...

prevent or remove

avoid
at all times

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Contamination: requirements

- 1% $\Delta R/R$ per mirror results in ~10% transmission loss of optical train.

➔ therefore: 1–3 nm C growth per mirror can be tolerated before cleaning is required.

➔ or, a 0.5–1 nm additional oxide growth per mirror (after that, replace!)

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Summary and conclusions

- ASML will pursue “photons forever” scenario
- ASML believes EUV will be inserted at 50 nm node
- ASML and partners have successfully completed core competence build-up phase (the EUCLIDES program) early 2000.
  Results on optical substrate, multilayer coatings and at-wavelength interferometer were presented.
- ASML and partners have started the EUV alpha tool project Q4 1999.
- Currently alpha tool project almost completed concept phase: throughput, overlay and CD budgets have been finalized, system architecture nearly frozen, source assessment concluded.
- The alpha tool project will lead to a first high NA full field scanner end 2003
- **ASML plans to deliver 50 nm node compatible, full field EUV scanners to customers by 2004 / 2005**