EUV reticles: particle-free handling and storage in the pellicle-less era

Bas Mertens, Erik Ham, Gert-Jan Heerens, Rob Snel, Rob Lansbergen, Hans Meiling, Roel Moors, Henk Meijer, Brian Blum

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Overview

- Introduction
  - Issue and objectives
  - Life of a reticle
  - Sources of particle contamination
- Strategy for particle contamination control
- Development strategy for reticle handler
- ASML AD-tool reticle handling hardware
- Life of a reticle: workshop conclusions / extendibility
- Conclusions and outlook

Issue and objectives

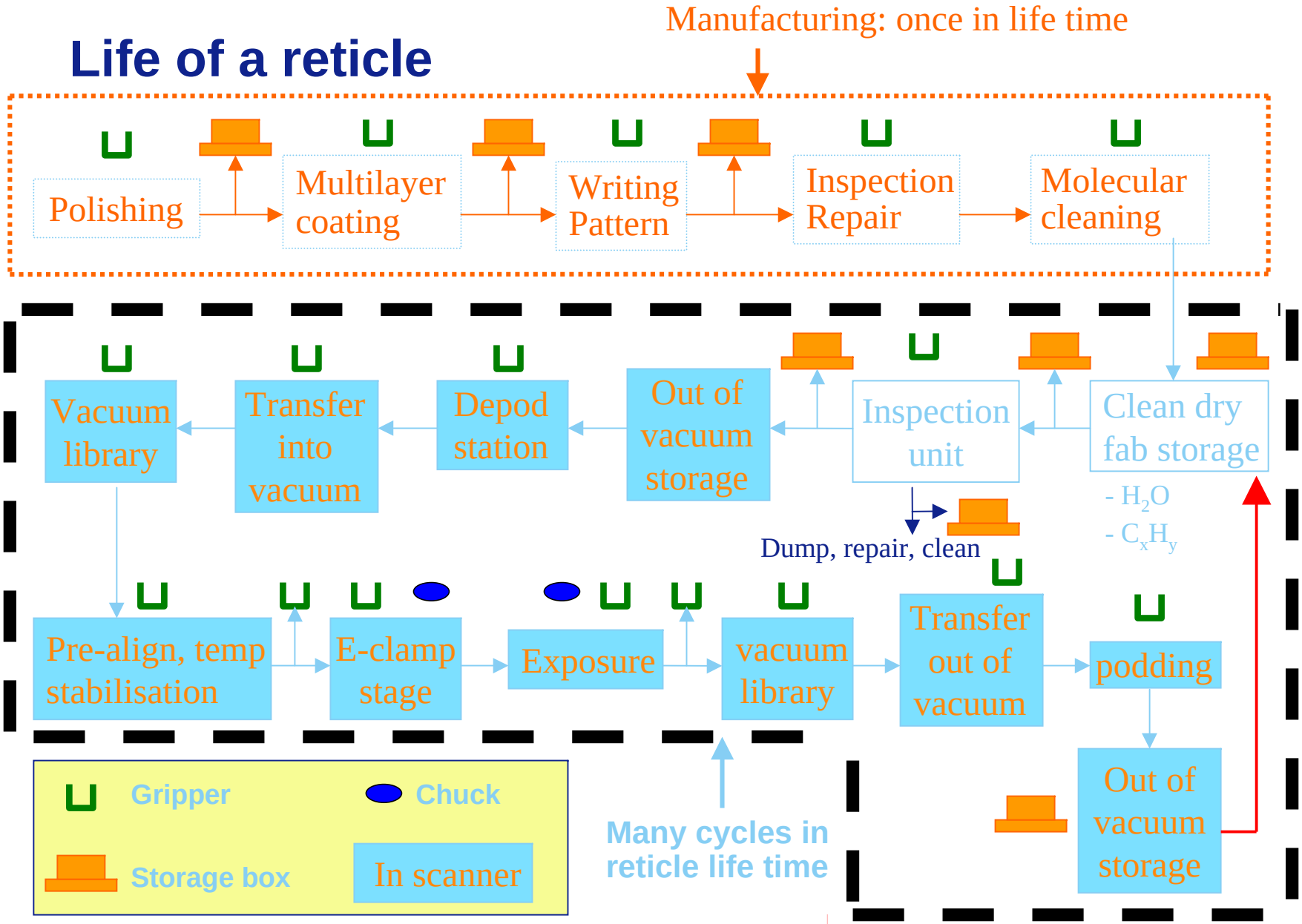
- Contrary to current technologies, EUV reticles have no pellicles =>

  Particle-free reticle production, storage and handling is a challenge for EUVL

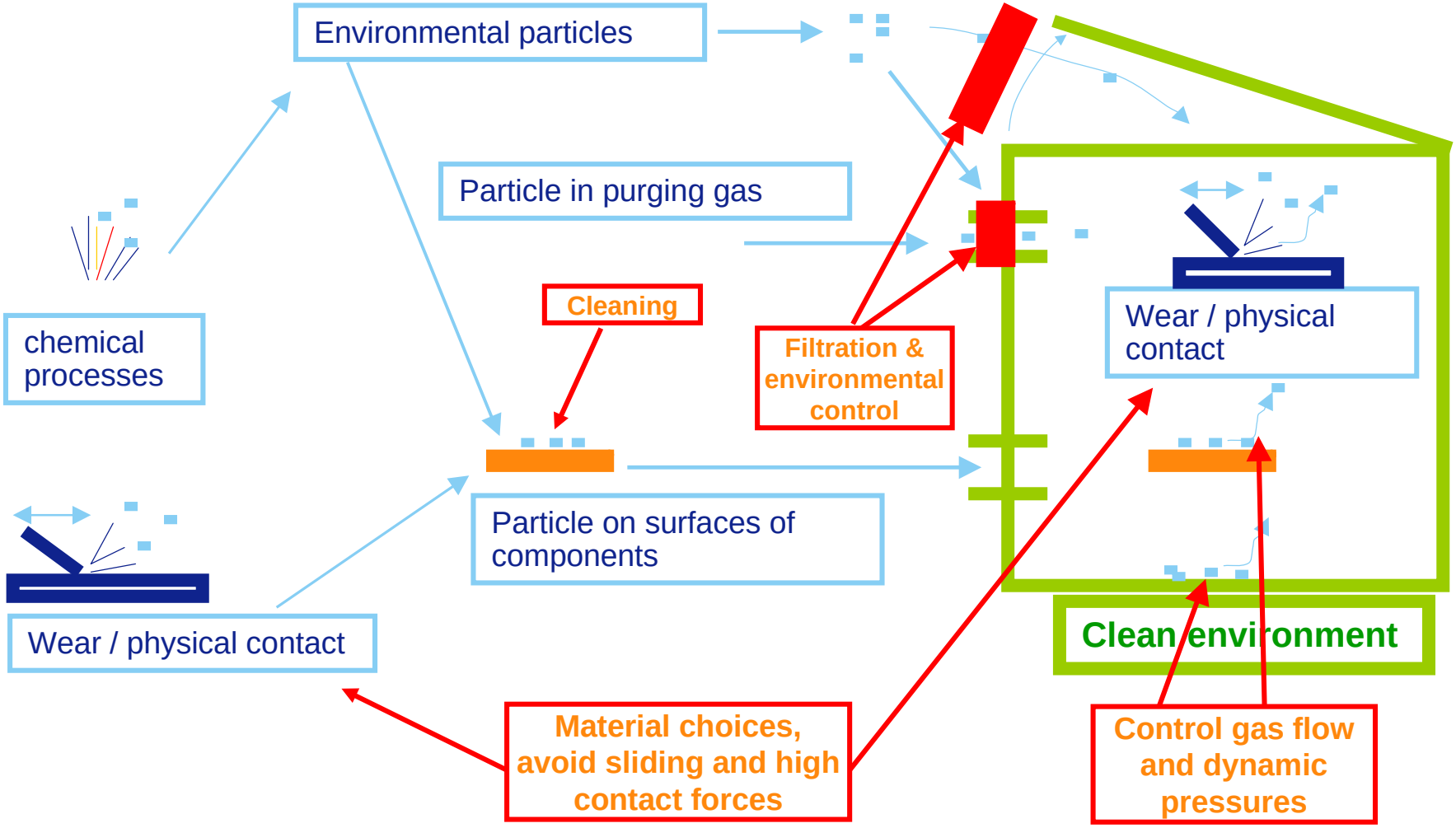
Objectives of the work:

- Acquire basic knowledge on particle generation processes and migration of particles
- Apply this knowledge in viable solutions to prevent particle contamination on reticles in EUV Lithographic tools

Life of a reticle



Sources of particle contamination



Strategy for particle contamination control

- Minimize particle generation:
  - Minimize number of contacts (by design)
  - Choose materials that produce low numbers of particles through contact (get knowledge through basic experiments)
- Prevent particle migration
  - By design
  - Proper pumping / venting sequences (develop through experiments)

Use reticle handling frame

Loose particles dislodge, particles generated through contact do not dislodge

Suitable materials combinations for practicle designs have been found

Development strategy for reticle handler

Basic idea: iterative design cycles

- Build load lock (LL) concept
- Particle qualification of LL to validate design
- Build FuMo reticle handler (RH) with improved LL
- Particle qualification of FuMo to validate design

Summarize all acquired knowledge

- Final design and build actual RH

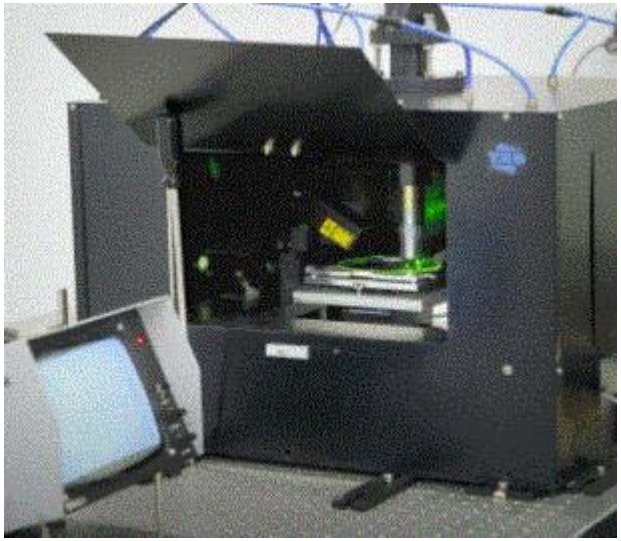
Intermezzo: atmospheric particle qualification

Actions:

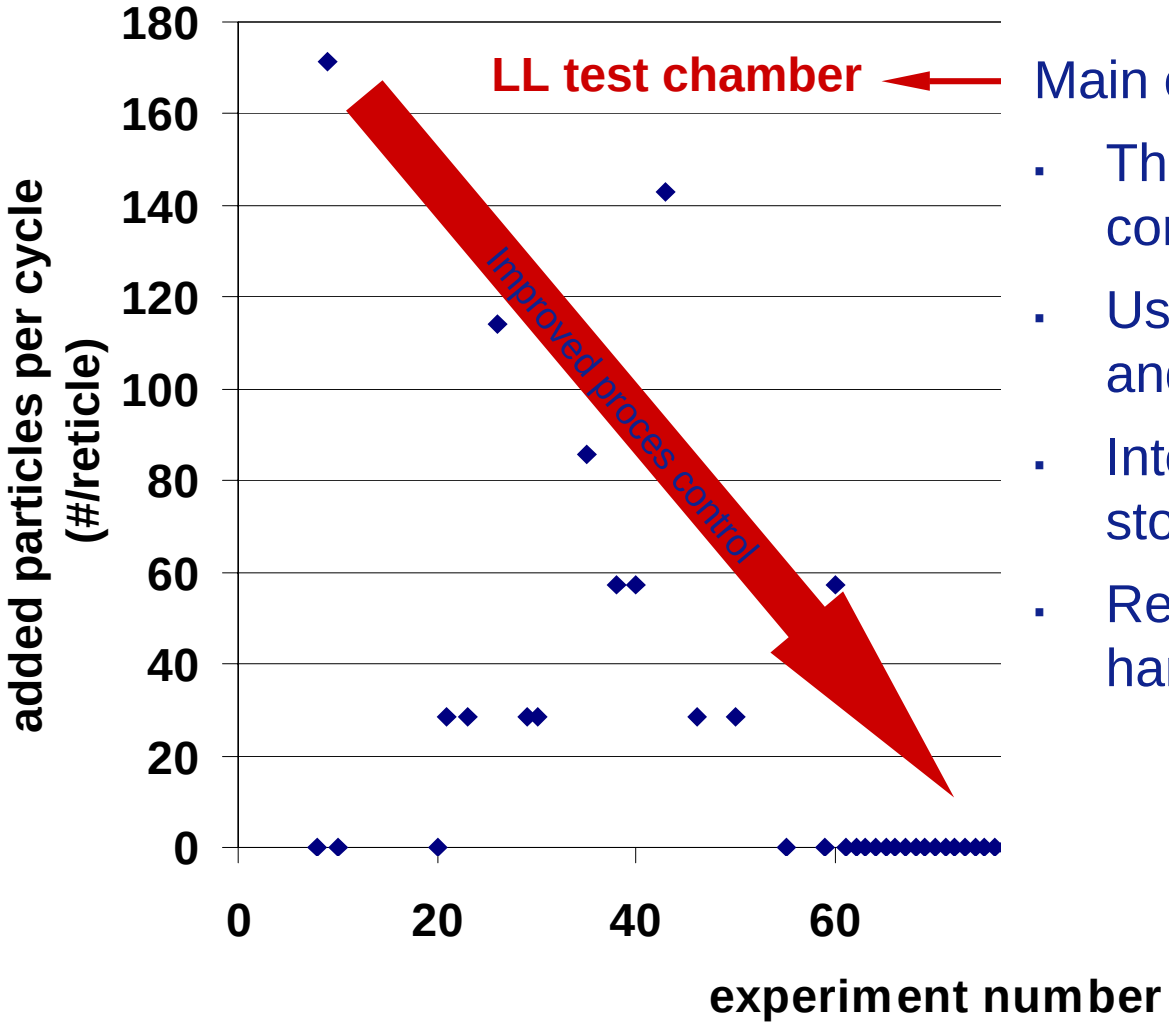
- put “reticle” inside metrology box for scanner
- scan number of particles on “reticle” in particle scanner
- remove from metrology box and put in storage box with frame
- perform “reticle” handling activity (e.g., loading - to RS - unloading)
- re-scan the number of particles
- image processing to determine added particles

Particle scanner:

- based on optical scattering (flat surfaces, used wafer)
- protective cover integrated
- scan area upto 100 cm^2
- scan speed: 10 cm^2 per hour
- upgrade: ~100 cm^2 per hour (ongoing)



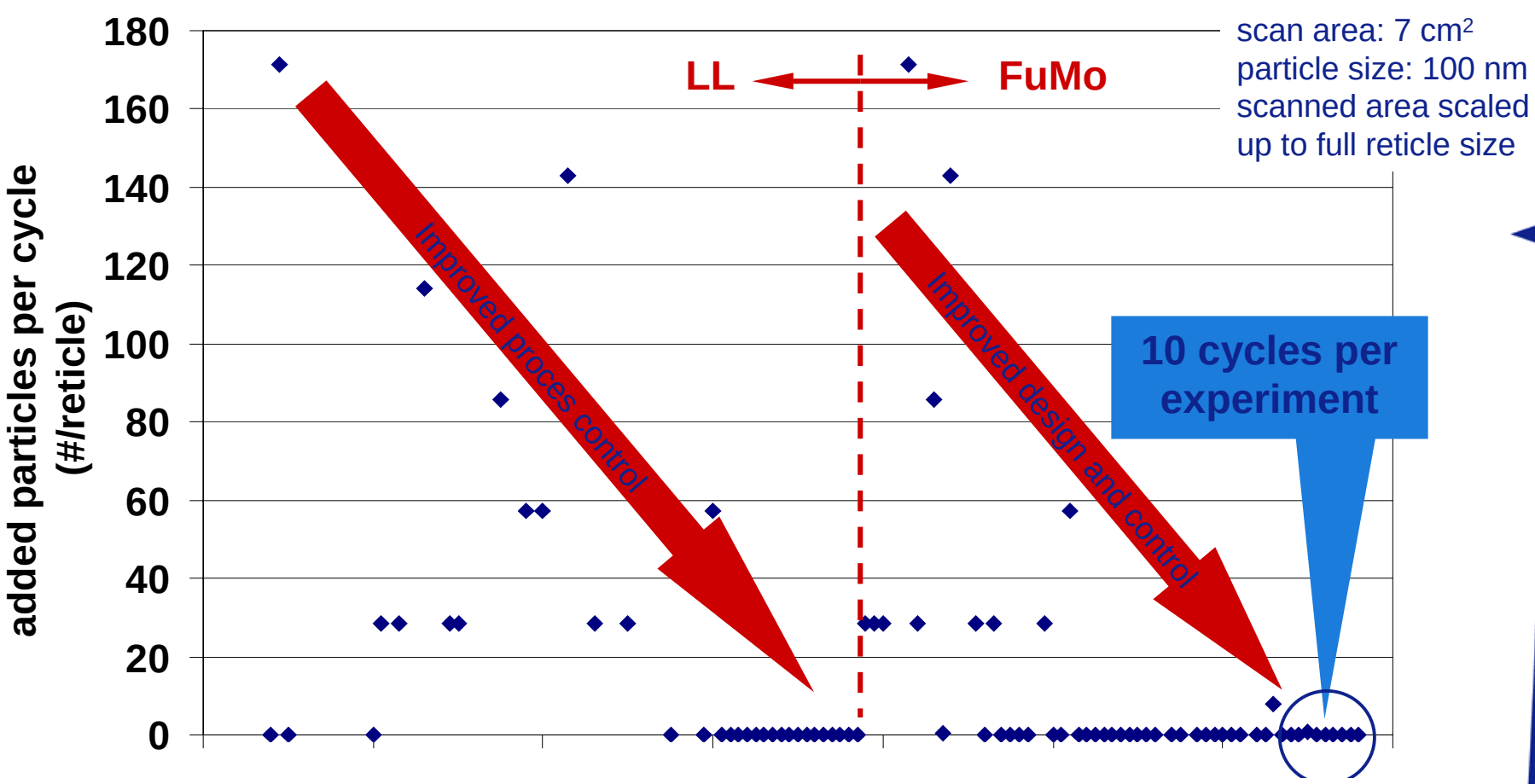
Load Lock Test Set-up & Particle scanner
- results (particles > 100 nm) -



Main conclusions:

- Thorough cleaning of all components
- Use proper particle filters and vacuum valves
- Integration of reticle storage box with LL
- Reticle movement and handling only in vacuum

Particle testseries for FuMo RH



Conclusion

- ***0 added defects are routinely achieved in reticle handling (FuMo setup)***

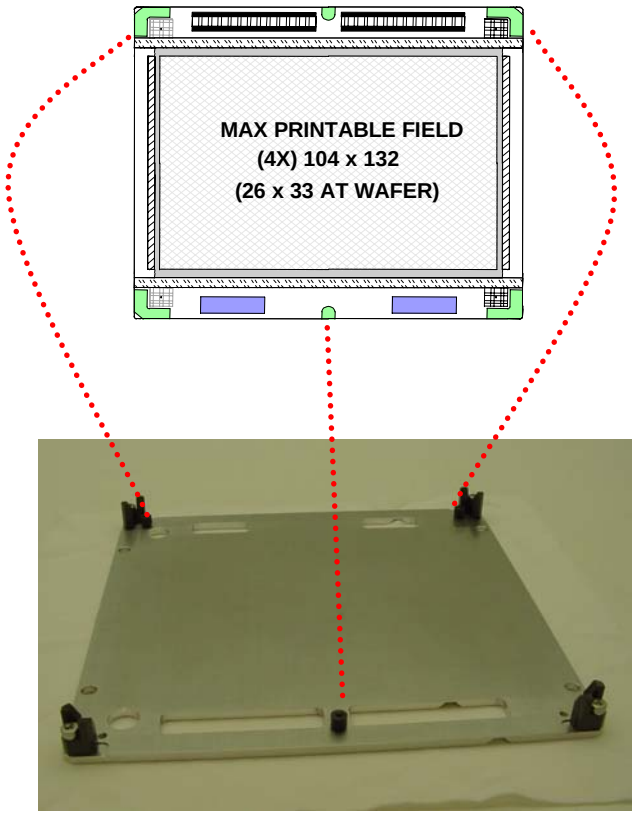
Overall conclusions from LL/FuMo test series

- Minimize number of contacts:
  - Use reticle frame
  - Integration of reticle storage box with LL
- Prevent particle migration:
  - Thorough cleaning of all components
  - Proper particle filters and vacuum valves
  - Exposure tool reticle movement and handling only in vacuum
  - Develop dedicated mechanics to avoid particle production (reticle release mechanism)
  - Unidirectional gasflow during pumping and venting

RH design: reticle frame

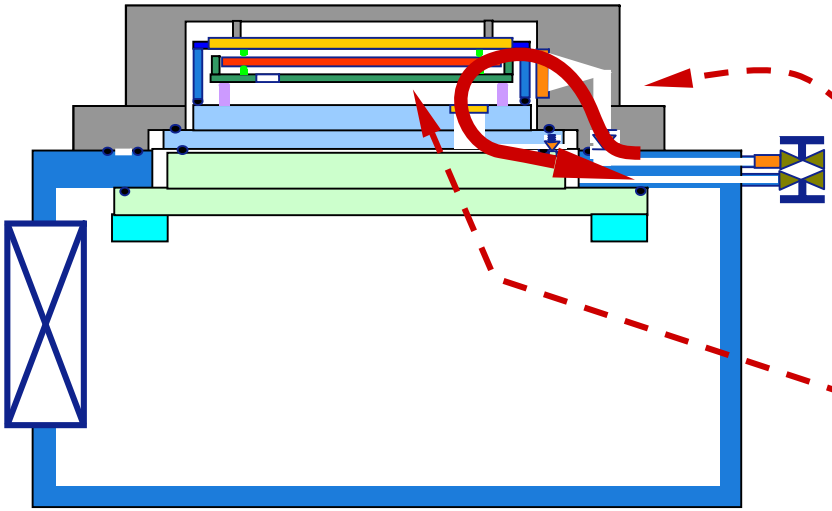
- Handling of reticle limited to:
  - take-over from mask-shop box to reticle storage box
  - release to reticle stage / take from reticle stage
- In all other cases, the reticle frame is handled

proposed handling areas
(green areas)

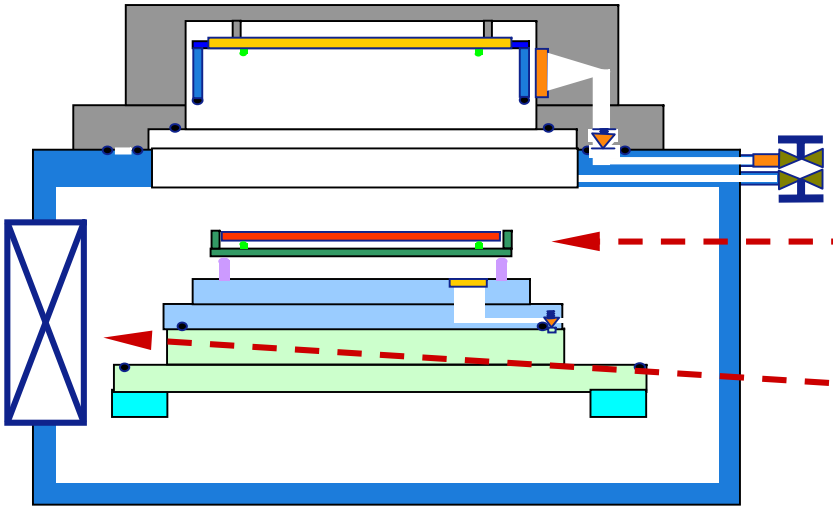


RH frame

RH design: storage box and LL



- Gasflow directed away from pattern area
- Gasflow through filters in same direction during pumping and venting
- During pumping / venting a protective cover keeps reticle clean by making gasflow diffuse



- Movement of reticle only under vacuum conditions
- Use particle-free valve towards robot chamber and RS area

Life of a reticle

Manufacturing: once in life time

open

Workshop: needs to be added

Covered area within current work

Gripper

Chuck

Storage box

In scanner

Many cycles in reticle life time

Extendibility of AD tool reticle handling solution

- Current solution:
  - Qualified design at zero adders in cluding the metrology step (atmospheric)
  - Designed for “R&D type” transportation
- ASML storage box is based upon current standard (RSP150) but optimised for EUV:
  - Pump down / venting
  - Vacuum compatibility of materials
  - Constructions needs to withstand force due to vacuum
  - Mechanics to avoid particle production (bottom release mechanism)
- Extendibility:
  - Test for normal shipping conditions (if needed, optimise)
  - Interfacing to mask shop (metrology) and fab infrastructure (storage, environmental control)

Conclusions and outlook

- Conclusions
  - Experimental solutions for particle control in Lithographic tools translated into LL and RH FuMo systems
  - Zero added particles are routinely achieved in FuMo through improved designs and process control
  - Solutions implemented in actual RH for AD-tools

- Outlook:
  - Full field, 50 nm particle qualification of complete reticle flow on AD-tools
  - Work on extendibility in field of interfacing towards infrastructure for reticle storage, transport, inspection and cleaning