Particle free EUV reticle handling

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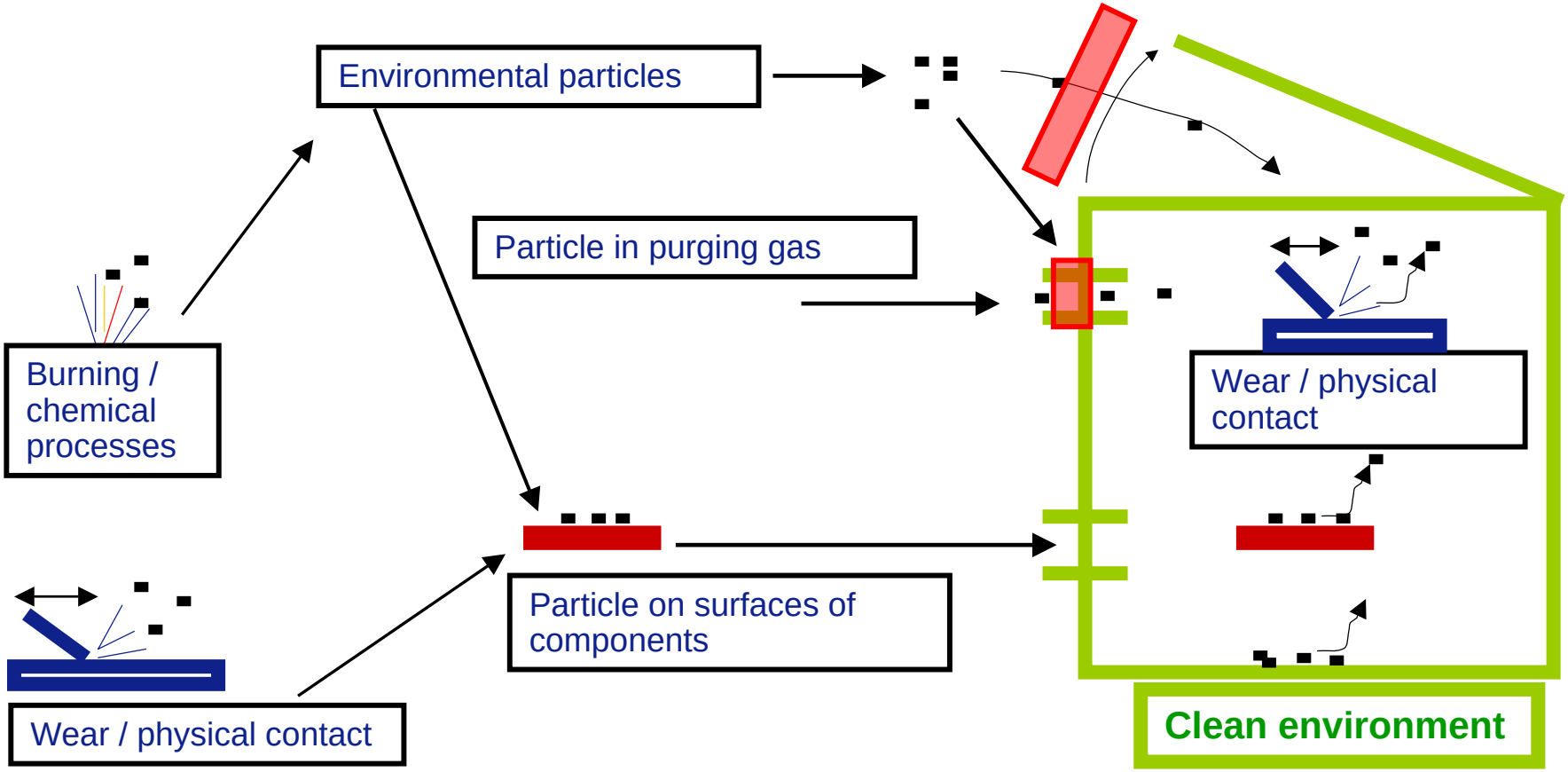
Outline

- Objectives
- Reticle process flow
- Risk assessment
- Contact experiments
- Surface scanner (intermezzo)
- Pump/venting experiments
- Status reticle handler
- Summary

Objective

Demonstrate that we can keep the reticle free of printable defects during its entire life, i.e. including storage, handling and presence in-tool.

Sources of reticle contamination



Priorities

- **Risk during reticle handling:**
  - Mechanical contact (hit, slide, release)
  - Pump down and gas flows
  - Interface to “dirty” outside world
  - Many different environments with moving components
- **Risk during stay on reticle stage:**
  - Moving components in neighborhood
  - Low pressure gas flows (may carry small particles)
  - Electrical fields
- **This talk focuses on reticle handler issues**

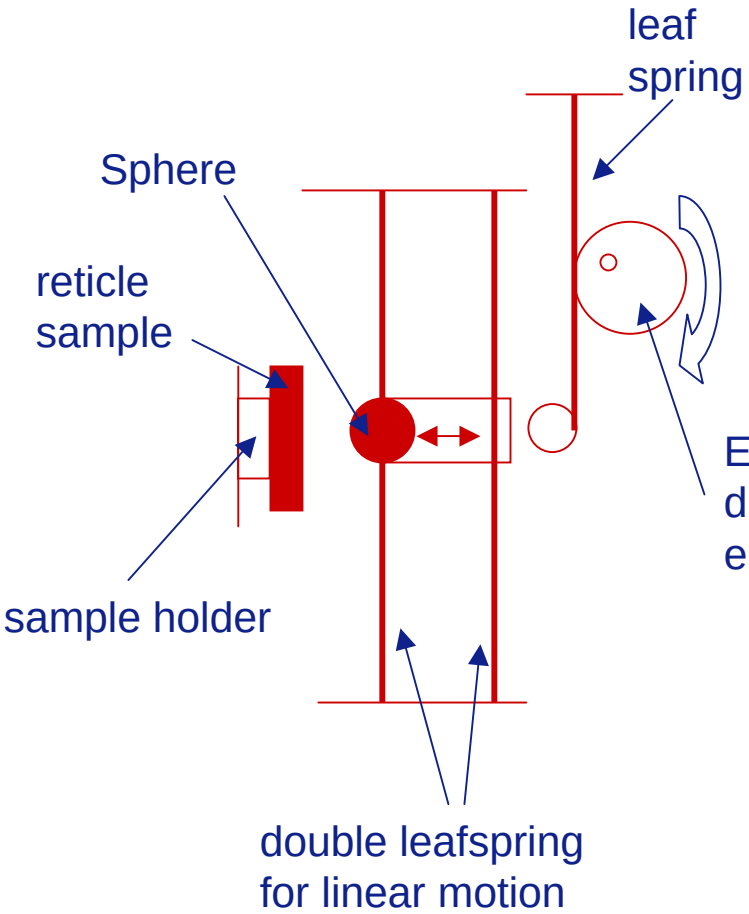
Particle generation due to mechanical contact

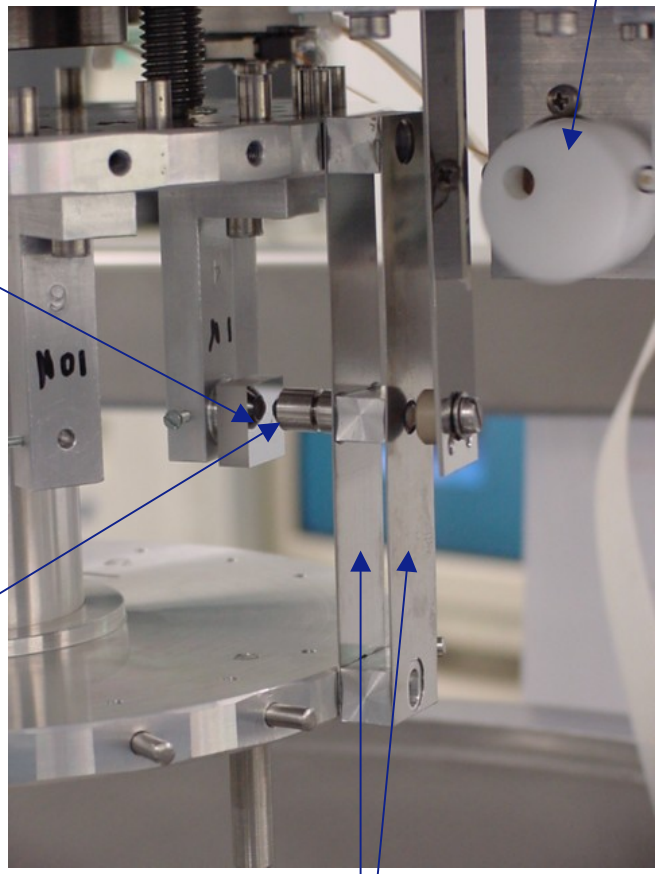
Select low-particle generating materials

Important parameters

- (Combination of) materials
- Contact pressure
- Relative movement
- Environment (air/vacuum)
- Number of events

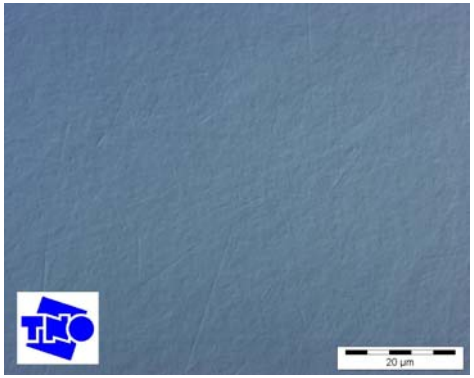
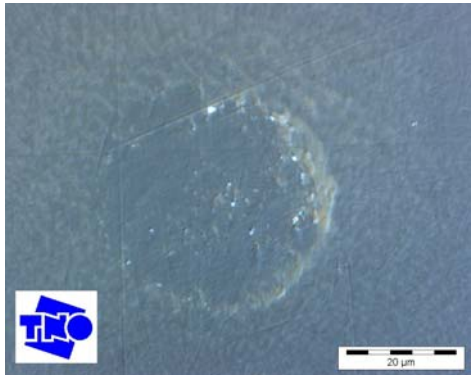
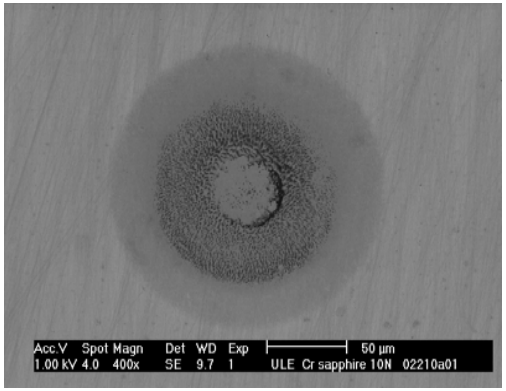
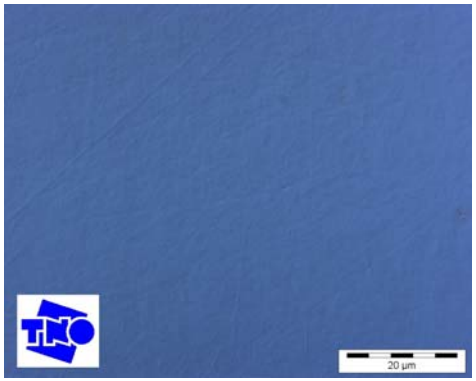
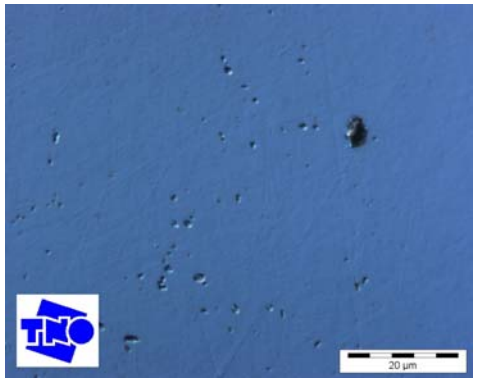
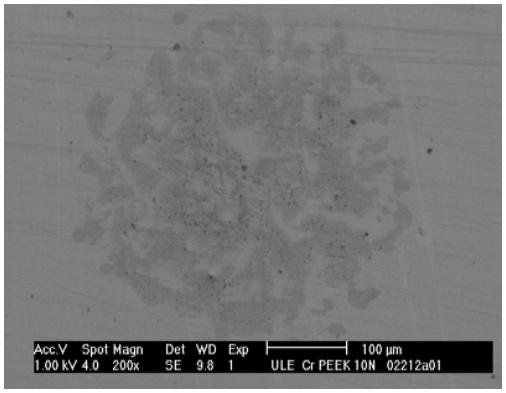
Material investigation method





Influence of material

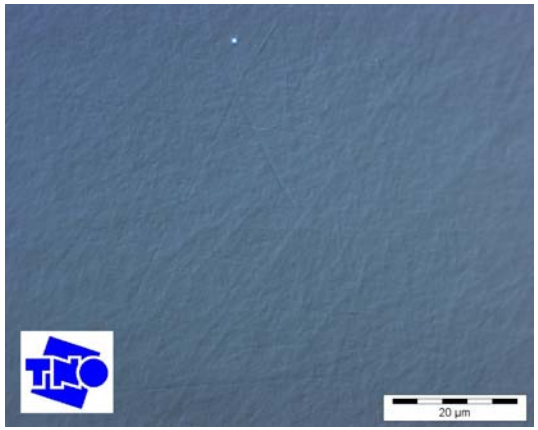
- Conditions: 10N, 100 contacts, ULE / Cr sample, air

	before	after	after
A			
B			

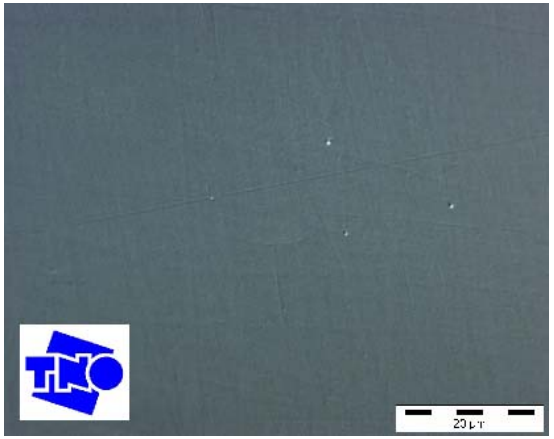
Influence of pressure

- Conditions: 100 contacts, ULE / Cr sample, air

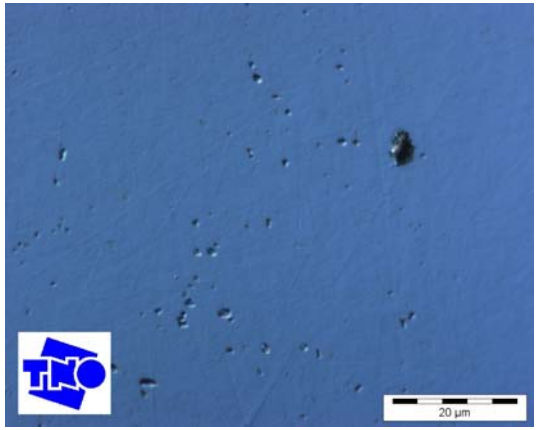
before



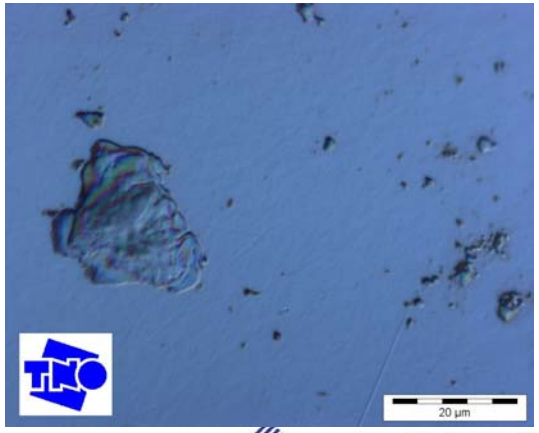
1 N



10 N



20 N



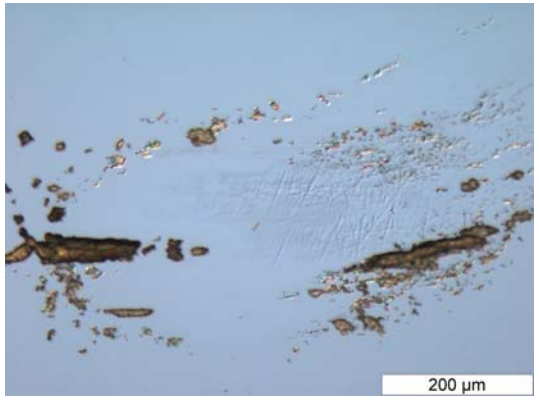
Influence of environment

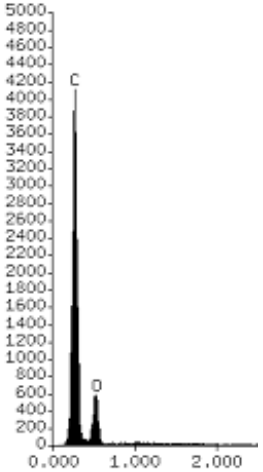
- Conditions: 5N; 10,000 contacts, ML-coated ULE w/ Cr

before | after

Vacuum

Air





Materials testing results

- Found two materials that have produced few particles and no damage
- Found gripper materials compatible with bare and Cr-plated ULE

Particle migration during pressure transitions

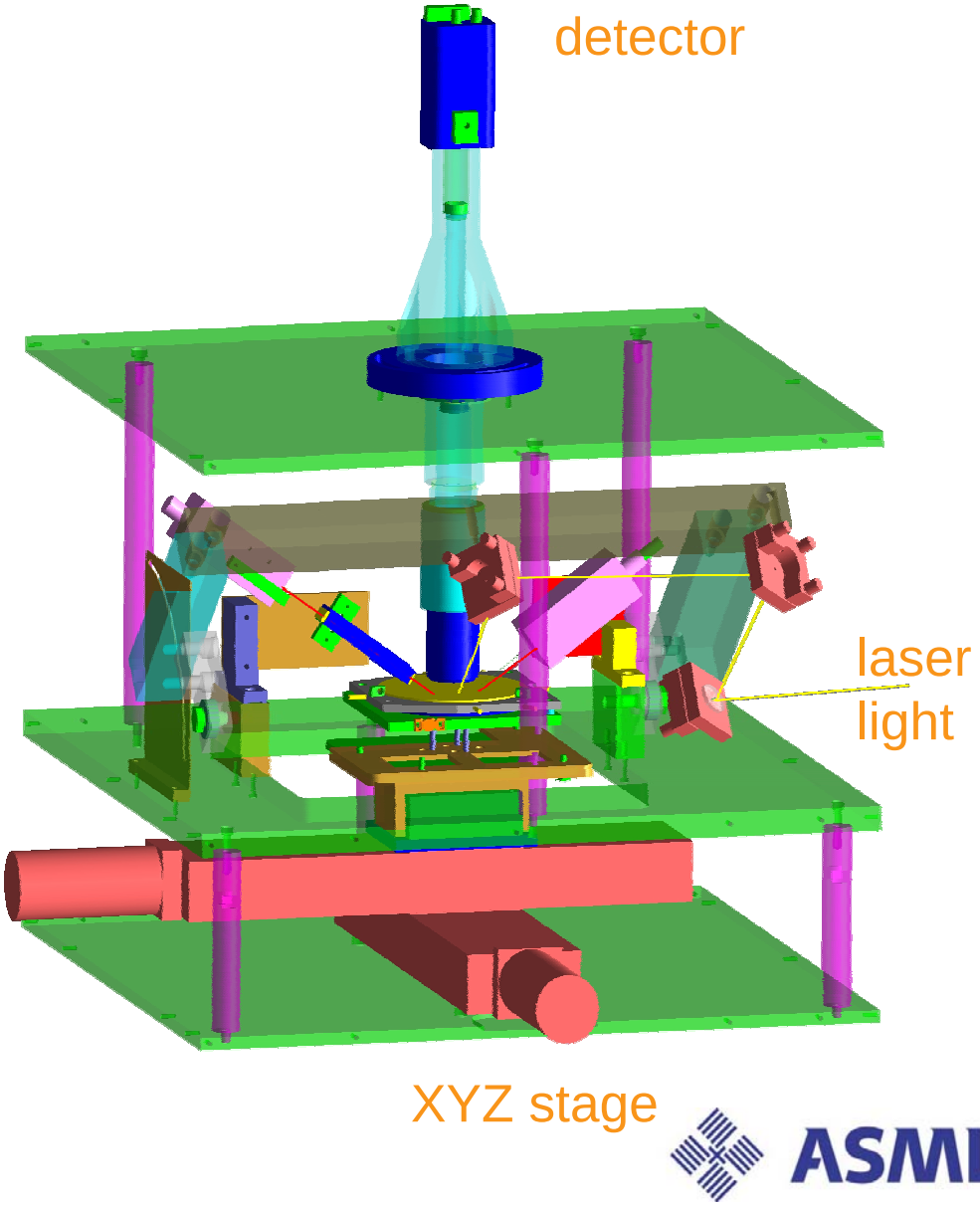
- **Problem:** Particles can be dislodged from surfaces by gas flow such as occurring during pressure transitions
- **Goal:** Prevent particle settling on patterned areas

Qualification of cleanliness (intermezzo)

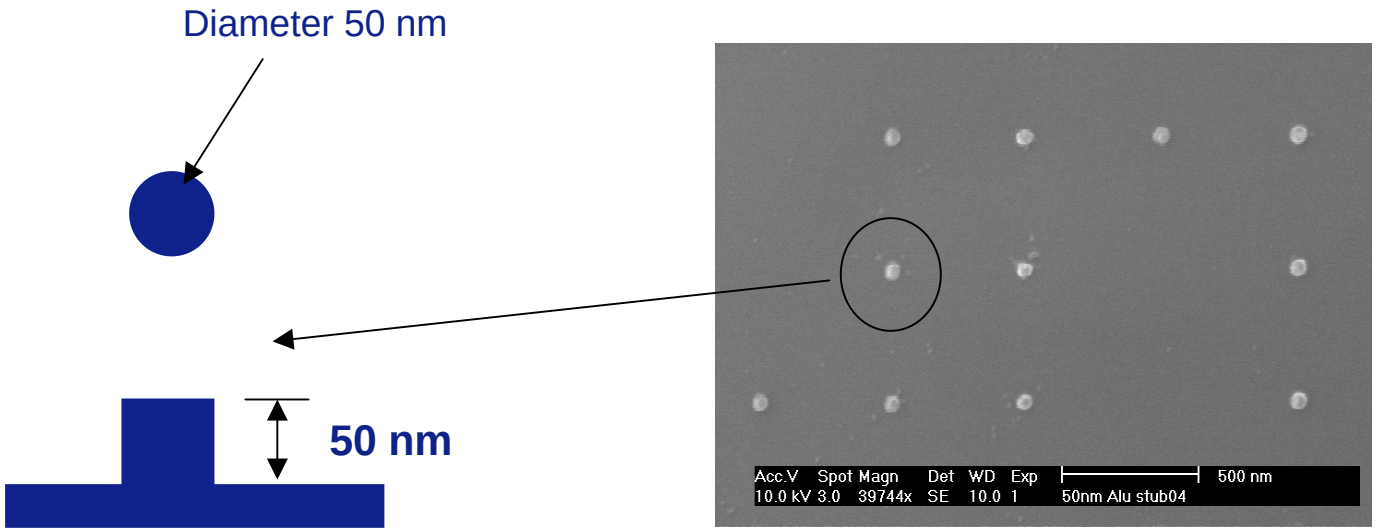
- Assessment of handling-induced particle contamination for EUVL requires detection method capable of detecting particles < 50 nm.
- Approach:
  - Develop surface scanner that can detect particles of 50 nm on unpatterned surface (test wafers)

Surface scanner

- Automatic inspection of flat surfaces
- Particle size:
  - > 50 nm manual
  - > 100 nm automatic
- Scan speed:
  - 10 cm²/hr currently
  - 100 cm²/hr planned

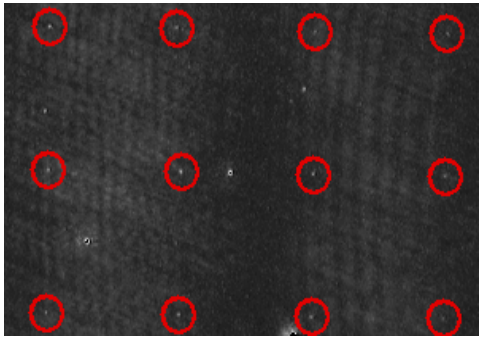


Qualification of surface scanner



SEM

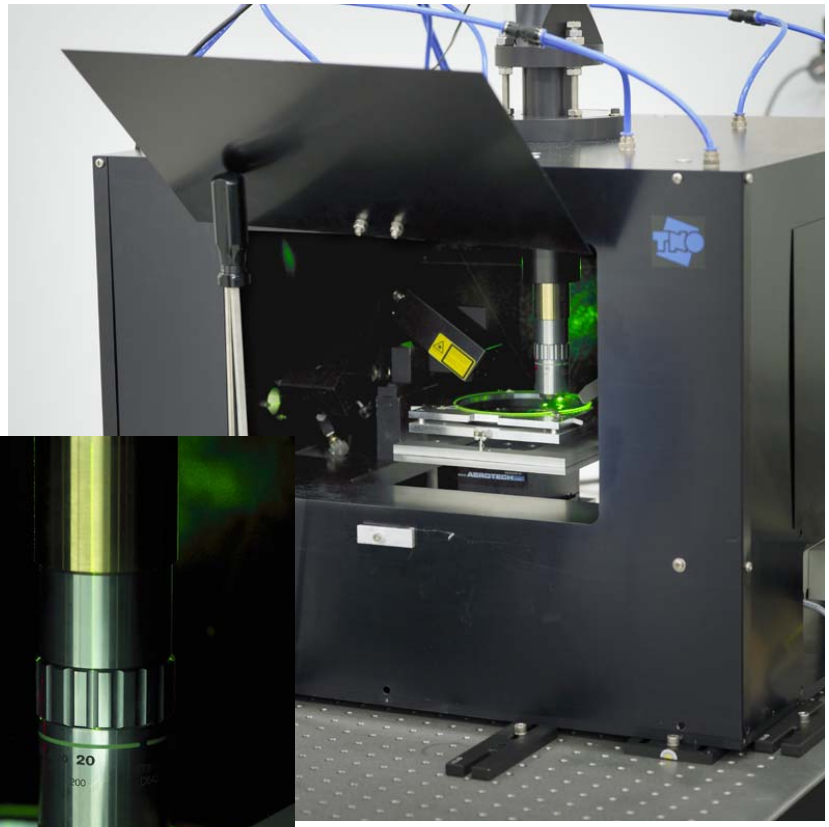
Lithographic structures used for qualification

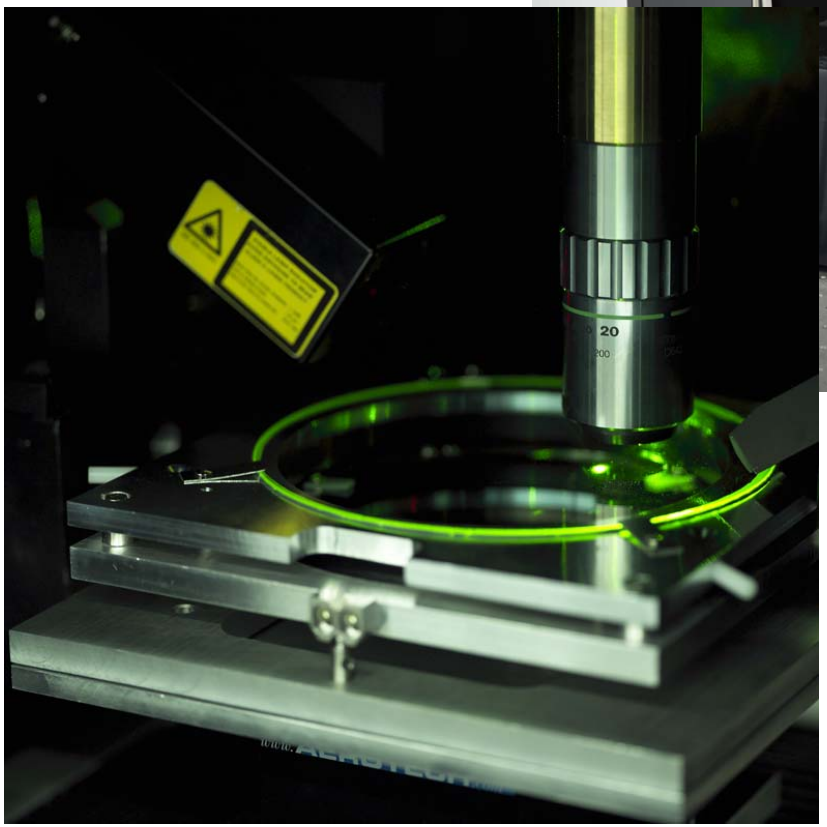


Surface scanner

Surface scanner

No additional sample contamination due to transparent cover





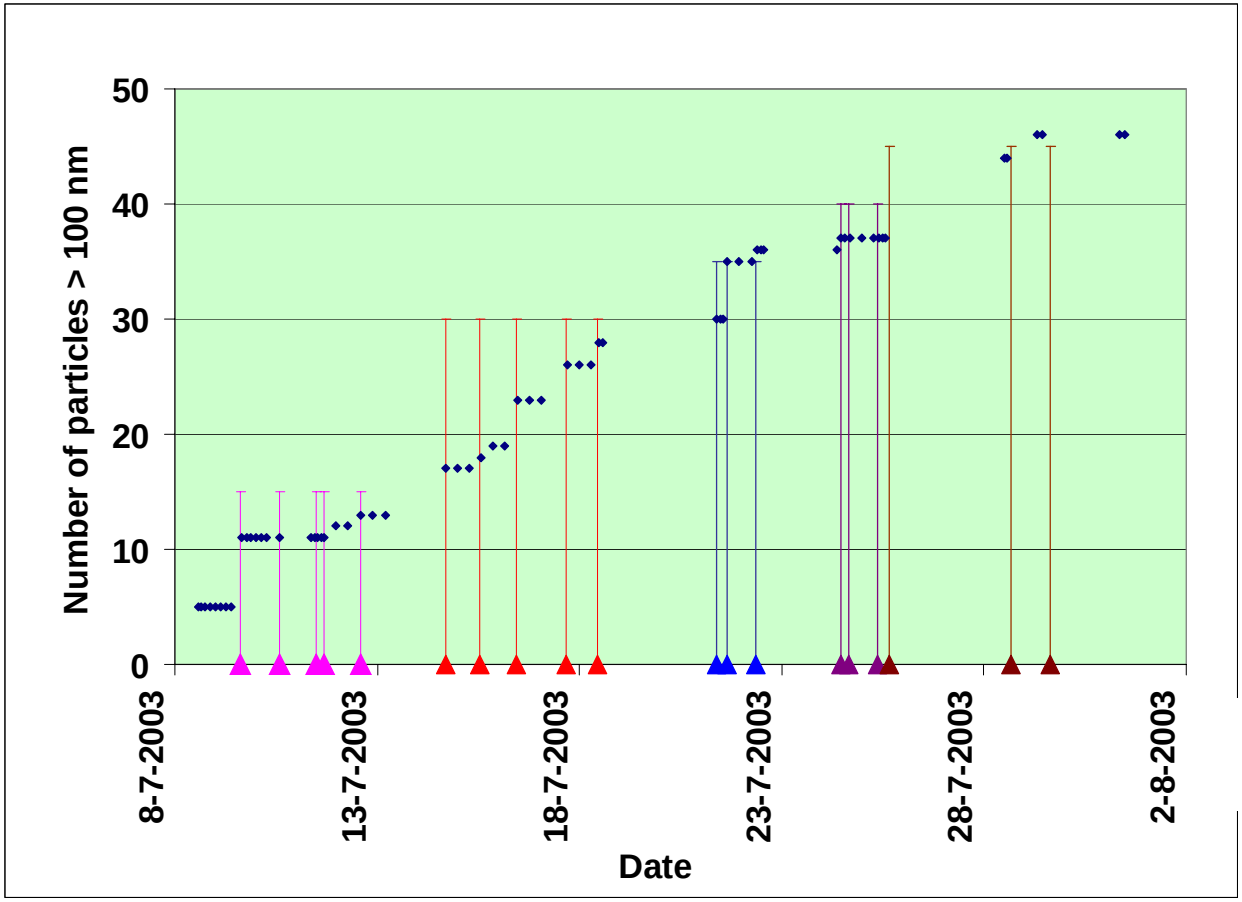
Particle Migration during pressure transitions

- **Problem:** Can we cycle loadlock between 1 bar and vacuum without depositing particles on reticle ?

- **Experimental setup:**
  - Vacuum test chamber (loadlock)
  - Test wafers: 7 cm^2 quality area (inspected using home-built surface scanner)

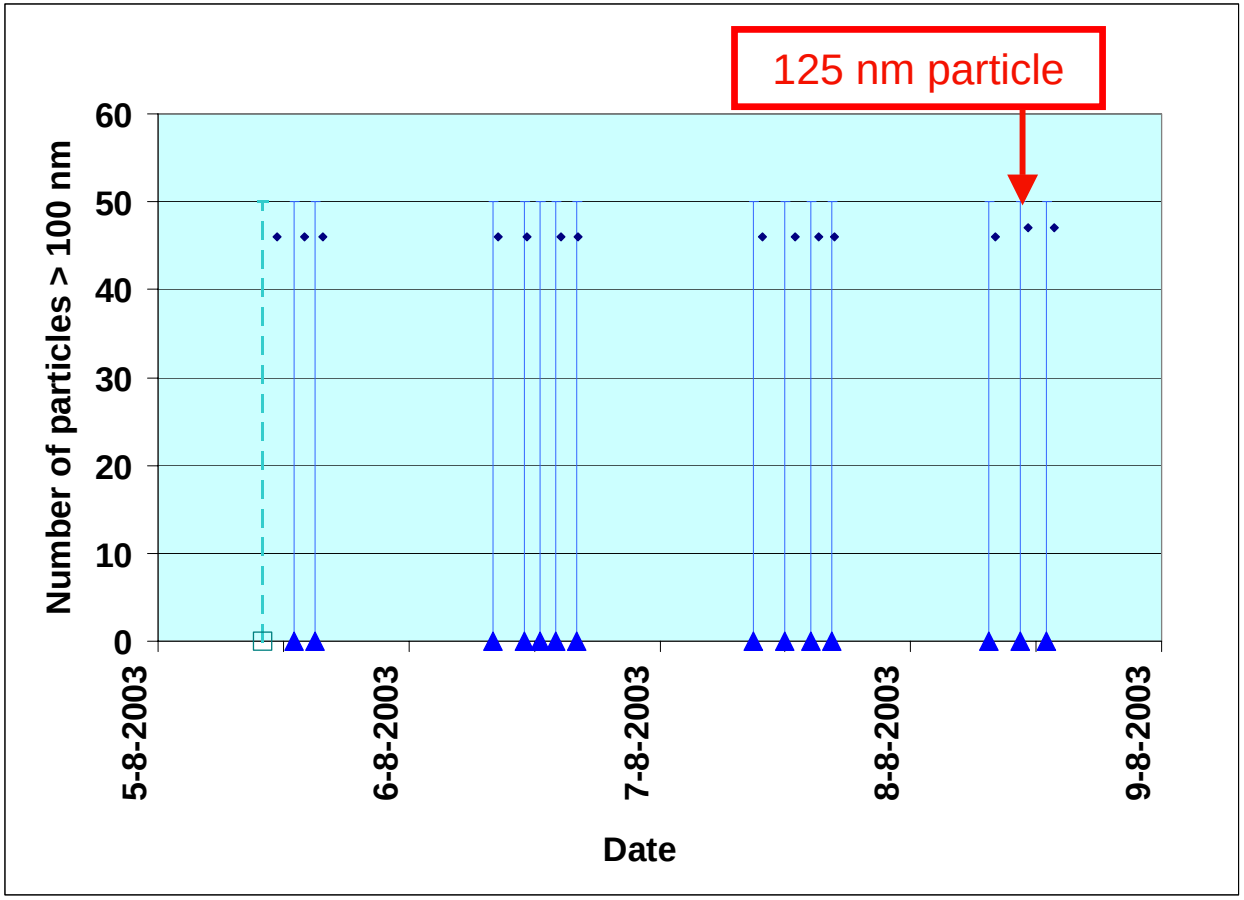
Pump/vent cycle: Early experiments

- Continuous build-up of particulate contamination



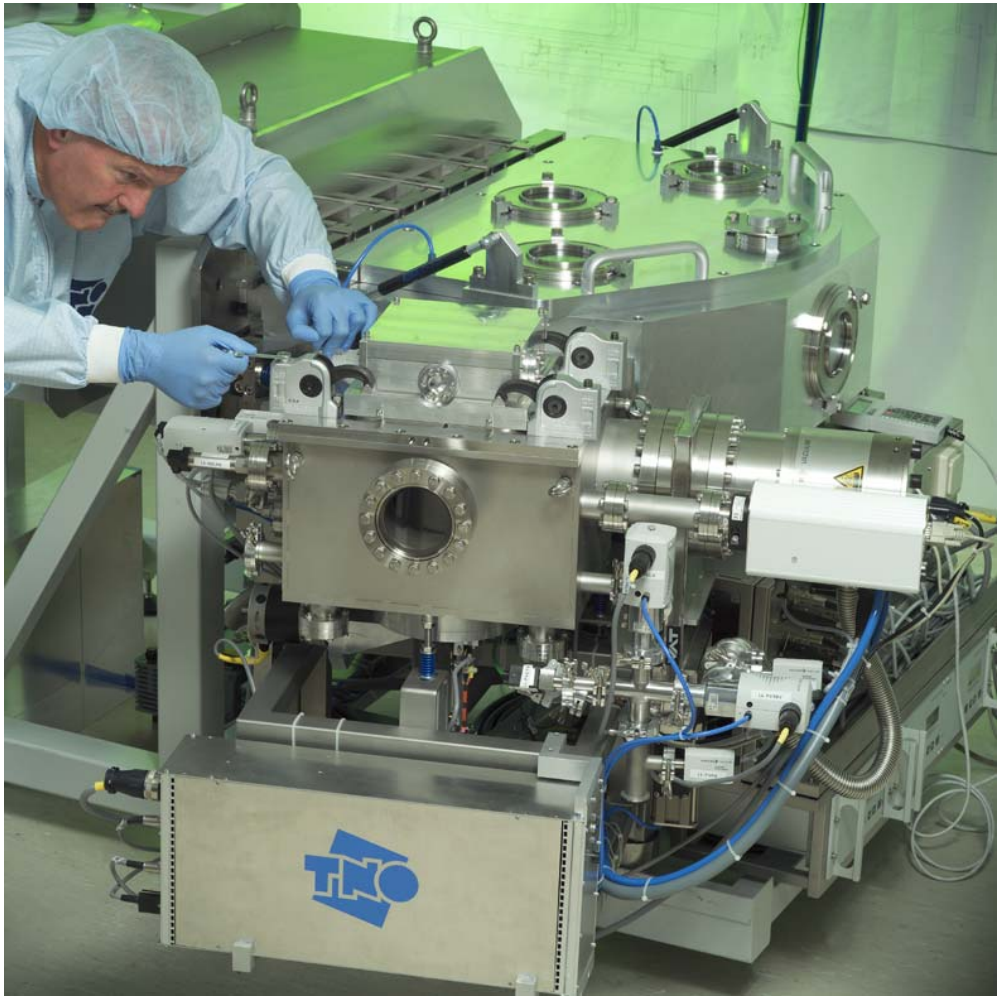
Pump/vent cycle: Improved loadlock

- Repeated cycling without adding particles > 100 nm



Reticle handler realization

- Vacuum qualification done
- Software and electronics have been validated
- Particle contamination experiments on full reticle handling cycle will start soon.



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Summary

- Particle generation at reticle minimized by:
  - Minimizing direct contact events (gripper with RH frame)
  - Selecting low-particle generating materials
- Particle migration minimized by:
  - Improved load lock design
  - Suitable operating procedures
- Functional model of reticle handler w/ load lock realized and tested.
- Reticle handler w/ load lock for EUV α-tool nearly finished; full cycle particle contamination experiments pending.

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Thank you for your attention !