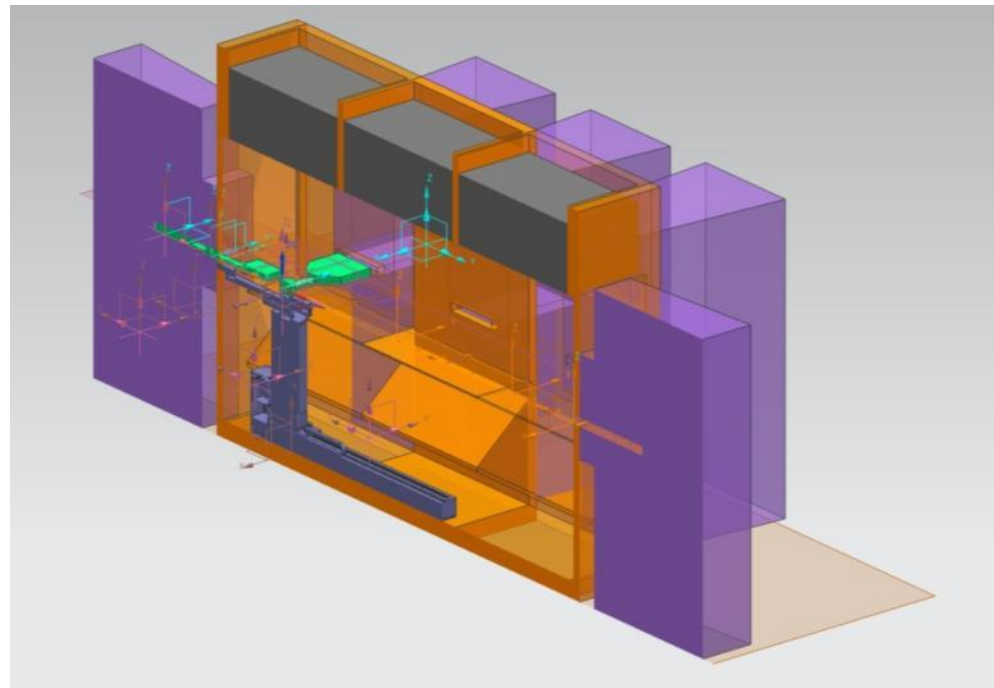




## Shared Development Platform for Particle-Free Reticle Handling

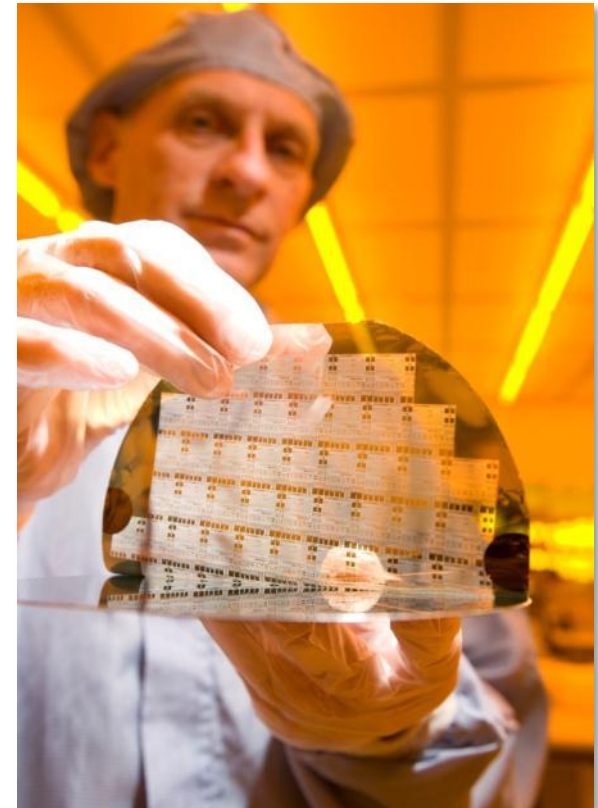
- › Roland van Vliet – Program Director Semicon
- › September 30, 2012 - MASK TWG Brussels





## TNO for High Tech Industry

- › TNO uses a number of expertise (e.g. mechatronics, optics, contamination control, materials science, nanofabrication, system architecture) to develop new production technologies, enhance quality, reduce costs and improve efficiency.
- › TNO focusses on
  - › Productivity, Performance, and Lifetime of equipment for the semicon industry
- › One of the grand challenges 2005-2015:
- › Handling and storage of reticles for EUVL





# The life cycle of an EUVL reticle: TNO contributions

blank production

patterning

pattern repair

pattern inspection

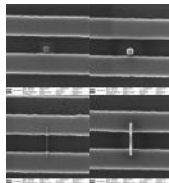
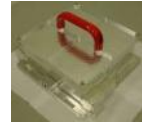
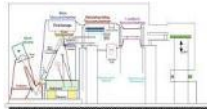
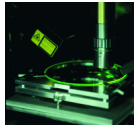
cleaning

transport

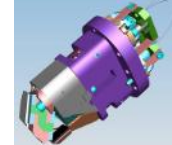
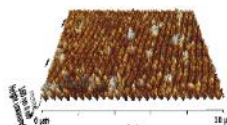
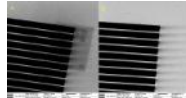
handling

clamping

conditioning in  
stepper



(SPIE 2011)





# A history in reticle handling at TNO

**EUVL 2005** **ASML**

Erik Ham, Jacqun van der Duuck, Ben Mervas, Rob Soel, Michiel Olorenoff, Rob Luchberger, Hans van den Berg, Hans Melting, Henk Meijer, Ton Nabben, Roel Moort, Brian Blum

### Progress in particle-free handling of reticles in the ASML EUV program

**Introduction**  
Controlling particle contamination of reticles is one of the major challenges for EUV lithography. Within the ASML EUV program, TNO and ASML have developed strategies to prevent particle contamination on reticles during handling and storage near the tool and during reticle loading inside the tool. This poster presents a status overview.

**Strategy to develop particle contamination control in the ASML EUV tool**

- Minimize particle generation:
  - Choose materials that produce low numbers of particles through contact (get knowledge through basic experiments)
  - Prevent particle migration by design
  - Proper pumping / venting sequences (service through experiments)
  - Ball lead ring and rollers before using the float hardware

**Reticle Handler for ASML EUV tool**  
Experimental results are tuned into hardware

**Particle contamination control experiments results**

**Procedure:**

- Measure # of particles on reticle (particle scanner)
- Transfer reticle from particle scanner tool to storage box (manual action)
- Load/unload reticle in EUV tool
  - open storage box & LL rampdown
  - robot transfer from LL to HV chamber
  - move to AD Mesh Chamber R3 load position
  - change to AD R3 & close
  - return to LL & close storage box
  - wait LL to atmospheric
- Transfer reticle from storage box to particle scanner tool (manual action)
- Measure # of particles on reticle

**Particle Scanner**  
A particle scanner is developed to detect particle contamination at a reticle. The scanner detects particles of 75 nm and larger. Imaging software determines number, size and location.

**Future work**

- Collect more data for static loading of reticle.
- Use real reticle blanks
- Improve particle scanner
- Install clean particles on a reticle and handle it in a cleanroom

**TNO Science and Innovation**

**SOSS** **microlitec** **HAMATECH** **HOPE**

O. Brus, P. van der Walter, J.C.J. van der Duuck\*, P. Drees  
HamaTech GmbH & Co. KG, Ferdinand-Hörner-Str. 10, 73447 Nottulm, Germany  
\*TNO, P.O. Box 195, 3600 AD Ede, The Netherlands

### Investigating the intrinsic cleanliness of automated handling designed for EUV mask pod-in-pod systems

**Introduction**

- Extreme Ultraviolet Lithography (EUV) is emerging as the promising solution for sub-10nm half-pitch technology nodes.
- The successful implementation of EUV, critical aspects like float and substrate particle contamination control, organic and inorganic contamination, copper deposition and vacuum compatibility in respect to the EUV exposure.
- Substrate cleanliness must be controlled in respect to the EUV exposure.
- Prevention of re-contamination after final cleaning in the mask shop and prior to exposure becomes very critical.
- Transportation, shipping and (manual) handling are recognized as main root causes for contamination.
- Dual Pod system is defined as new industry standard to protect the EUV mask during transport and storage.

**MaskTrack Pro InSync**

- MaskTrack the 300mm (200 x 180/250 cm) as interface for Dual Pod System between MaskTrack Pro Cleaner and other EUV hardware.
- EMMS as Dual-Pod drive system.
- Purpose of MT Pro InSync is to facilitate the linear and (EP) surface load/unload and make the full system available for transfer to the MT Pro cleaning system in a fully automatic and protected way avoiding any contamination and damage of the equipment.
- MT Pro InSync consists of a Dual Pod load port, ESP transfer station, handling unit and a full range ESP library for ESP storage while the EUV mask is in use.
- Additional features like ESP cleaning functionality to avoid re-into re-contamination and include Particle detection for verification of EUV reticle cleaning processes.

**Results & Discussion**

**Intrinsic Cleanliness Qualification**

- Intrinsic cleanliness experiments have been performed by measuring the defect map as the EUV mask surface before and after running a number of load cycles.
- Most of the tested mappings shows a PFD value of 0.02 or lower, which is sufficient level to allow the specified PFD value of <math>0.018</math> for the total process flow in the MT Pro InSync tool.
- Higher particle counts with particle size >1µm during a flow test experiment can be assigned to mechanical stress after manual load/unload tests and manual analysis. Tool related root causes are selected.

Parameter	Unit	Specification	Result
Particle Count	1/cm²	<math>10^4</math>	<math>10^3</math>
Particle Size	µm	<math>0.1</math>	<math>0.1</math>
Particle Size	µm	<math>0.2</math>	<math>0.2</math>
Particle Size	µm	<math>0.5</math>	<math>0.5</math>
Particle Size	µm	<math>1.0</math>	<math>1.0</math>
Particle Size	µm	<math>2.0</math>	<math>2.0</math>
Particle Size	µm	<math>5.0</math>	<math>5.0</math>
Particle Size	µm	<math>10.0</math>	<math>10.0</math>
Particle Size	µm	<math>20.0</math>	<math>20.0</math>
Particle Size	µm	<math>50.0</math>	<math>50.0</math>
Particle Size	µm	<math>100.0</math>	<math>100.0</math>

**Root Cause Analysis for Particle Added**

**Particle A, Particle B, Particle C**

- For external analysis, a water vehicle (flow jet) is used for particle collection inside the exchange port.
- In total 20 particles (>1µm) were added to an area of 40 cm².
- 7 particles were found on an SEM and the composition was determined by EDX analysis.
- Three particles contained nickel, Li and Cu.
- SEM source of particles A and B also showed on peak for particles and composition.
- No particles can be assigned to the EP as this material is used only for purging of the EP.

**Particle D, Particle E, Particle F**

Visual inspection of the EP showed wear on the side of the bottom plate where the touches the bottom plate.

**Co**

- The intrinsic cleanliness performance of the EP and the EUV is proven.
- The target specification of <math>10^4</math> PFD is achieved.
- No particle generation has been detected after multiple opening and closing cycles (> 4000).
- Detected 4 particles must be either origin point between ESP station and EP or air in.
- Design changes to the Exchange Flat loading.
- Particle generation caused by friction on the must be addressed by the Dual Pod supplier.

**Acknowledgement**

Thanks goes to the participants: the customers (ASML) and the staff of EP (particle cleanliness) who have supported the development (European Government Strategic Investments).

EUVL 2005

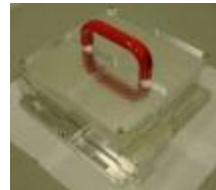
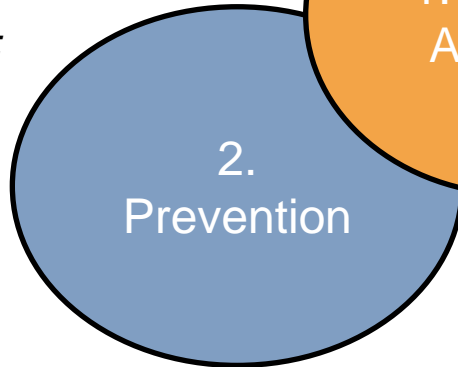
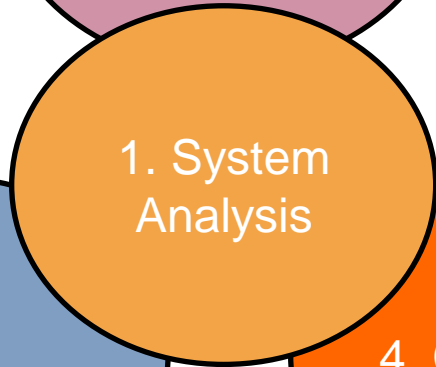
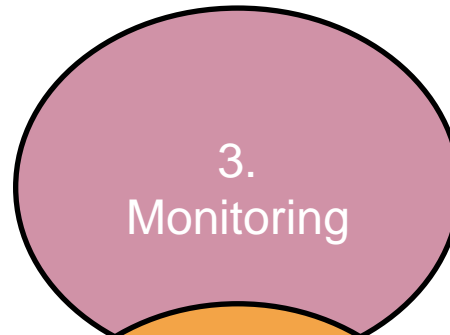
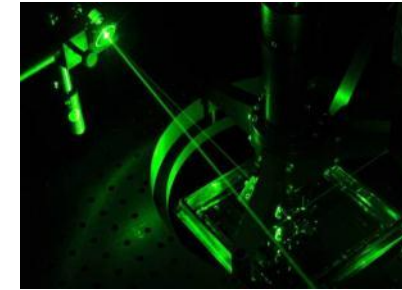
→ SPIE 2011



# Our experience...

## Particle Detection:

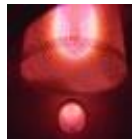
- *RapidNano*



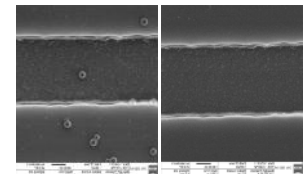
Storage boxes

## Reticle handlers:

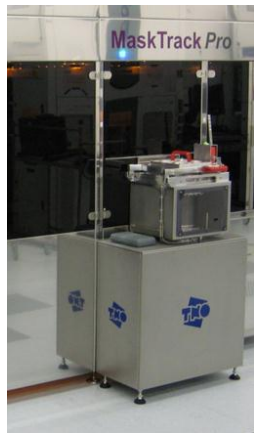
- *ADT*
- *Hamatech InSync*



- (Miniature) plasma heads, CO<sub>2</sub> snow



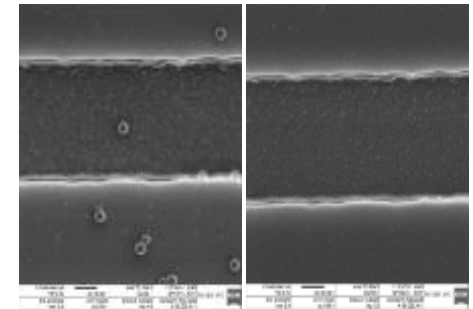
Critical components have a cleanliness level of PRP = 0.02





## ...and feedback from industry..

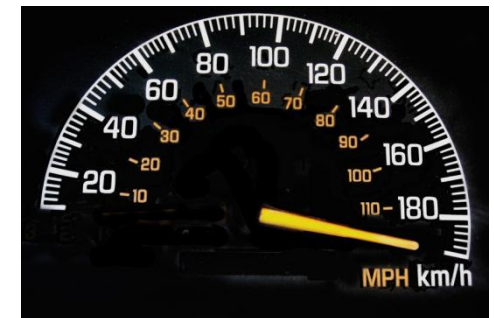
- › No standard in handling equipment
- › No qualified atmospheric robot
- › No qualified vacuum robot (only proprietary)
- › No generic knowledge on particle-free design
- › No generic knowledge on material selection
- › No generic solution for contamination-free storage
- › No independent qualification facilities





## ...lead to a TNO initiative

- › Set an open standard in reticle handling and storage
  
- › Open for partners to join
  - › in development and application
  - › in qualification of their equipment and processes
  
- › Leading to
  - › Shorter time to market
  - › Reduced risk
  - › Reduced development cost
  - › Increased independent expertise/knowledge

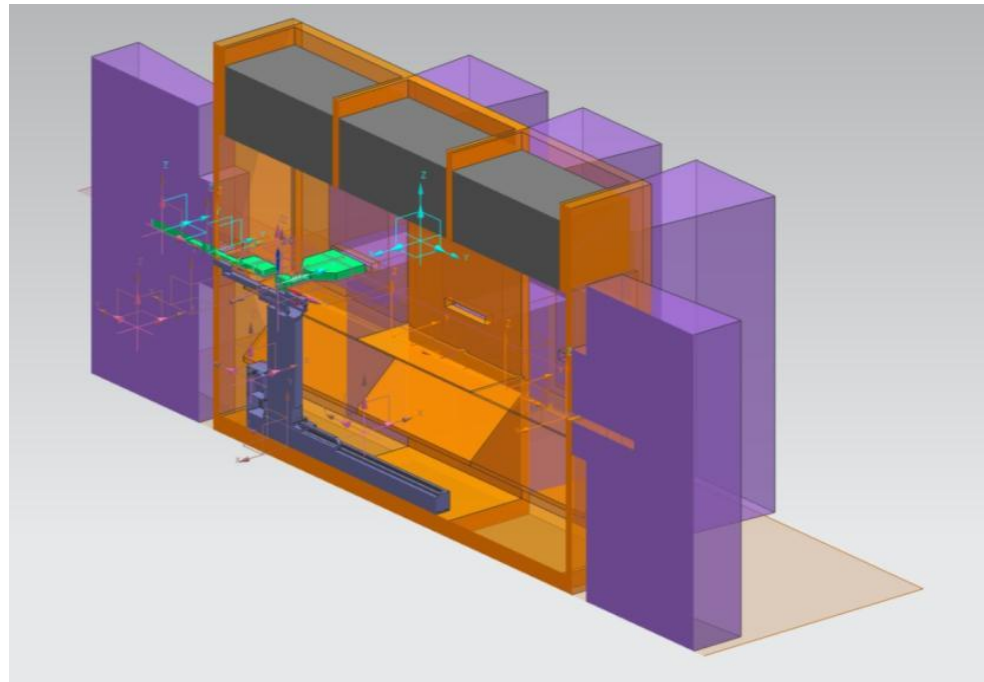




## To kick-start this

TNO invests in the development of a generic EUV reticle handler which

- › can transfer an EUVL reticle from Single Pod or Dual Pod to processing unit and vice versa
- › can in the near future easily be combined with other equipment for R&D and qualification (cleaners, load locks, vacuum robots, particle scanner...)



*Concept design Particle-Free Reticle Handler*





# Design/Integration Activities

**INTEGRATE** – Chamber,  
 - Robot  
 - Sensors  
 - Conditioning Units  
 - Electrical Hardware

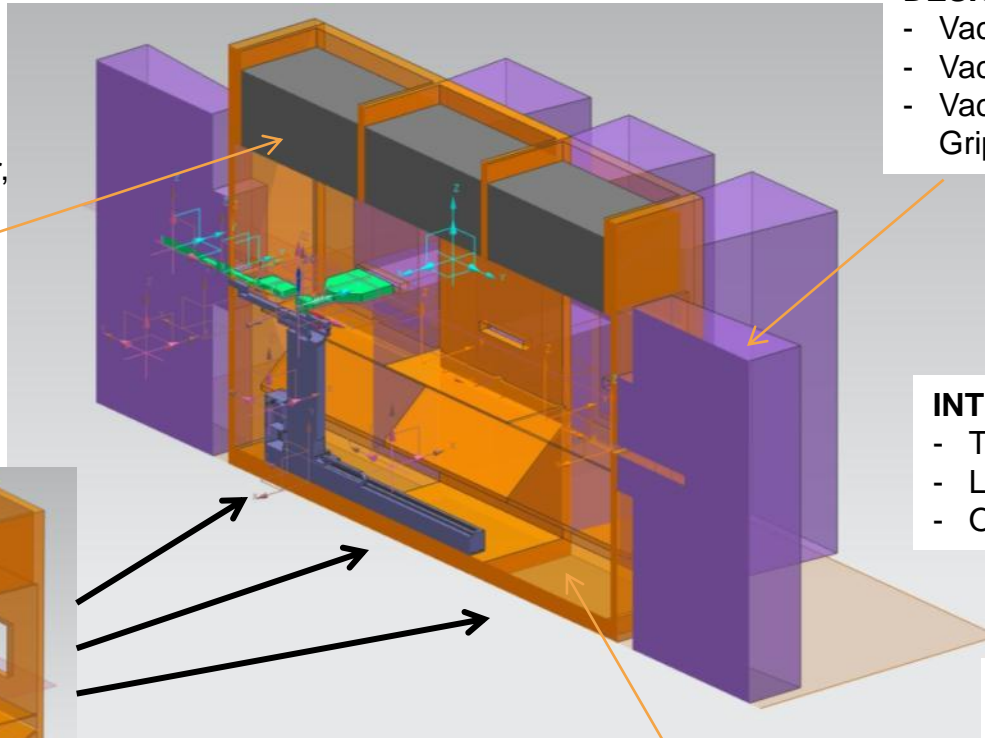
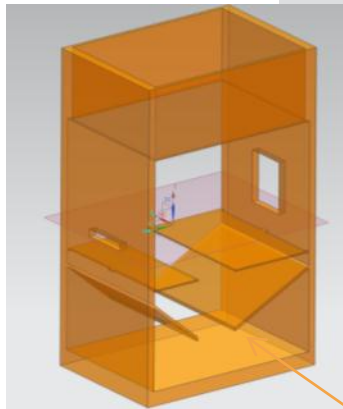
**DESIGN** – External Systems,  
 - Vacuum Load Lock (Phase 5)  
 - Vacuum Chamber (Phase 6)  
 - Vacuum Robot (Phase 7) +  
 Grippers

**INTEGRATE** – External Systems,  
 - TNO particle Scanner (Phase 2)  
 - Load Port (Phase 2)  
 - Other

**DESIGN** – Internal Systems,  
 - Exchange Port (Phase 2)  
 - Library (Phase 3)

**DESIGN** – Handling Unit,  
 - Grippers  
 - Chamber  
 - Doors  
 - Flip Tool

**DESIGN** - Modular  
 chamber, allowing the  
 chamber to be easily scaled.



Phase 1 to be completed end Q1, 2013



# Setting a standard on particle-free handling

- › Translate general knowledge to practical design rules

## 1 System Analysis

- Performing a system analysis
- Contamination Error Budgeting
- Qualification
- COTS Equipment knowledge

## 2 Prevention

- Sources / Transport / Deposition
- Material Selection
- Wear, Making/Breaking Contacts, Sliding, Pressure
- Mechanisms, Bearings, hinges, actuators, Seals
- Environment (shock, velocity)
- Flow, Diffusion, Gravity

## 3 Monitoring

- Monitoring/Detection Techniques
- Designing for monitoring

## 4 Cleaning

- Molecular Cleaning Techniques
- Particle Cleaning Techniques
- Designing for cleanliness



## Summary

- › An open standard on particle-free reticle handling & storage is needed
  - › Shorter time to market
  - › Reduced risk
  - › Reduced development cost
  - › Increased independent expertise/knowledge
  
- › Therefore TNO initiated a shared development program
  - › generic EUV reticle handler which meets demands of 2016
    - › first phase completed end Q1, 2013
  - › Co-create and qualify equipment and processes
  
- › You are invited to join this program!