MS-13 EUV Microstepper

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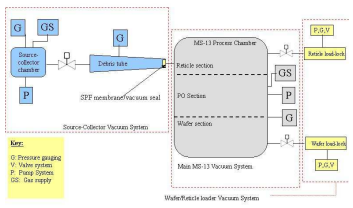
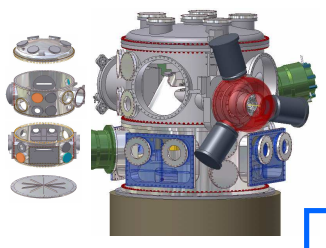
Vacuum System

- Hydrocarbon free pump system
  - Scroll pumps
  - 3x 3000 l/s Mag-Lev turbo pumps
    - High HC compression ratio
    - Low noise, high reliability
  - Base pressure 10^{-6} mbar
  - HC's < 10^{-10} mbar
    - HC's are an optics risk, to minimise:
    - UHV compatible materials used
    - Extensive outgas testing
- Differential pumping
  - Main chamber has 3 zones (PO, reticle, wafer)
    - One 3000 l/s TMP per zone
  - Source isolated by SPF filter
    - 3 x 1300 l/s TMP's on source for low Xe pressure
- Modelling
  - FEA analysis for chamber modal response, stiffness, safety, pump-down distortion
  - TransCalc (BOC-E), VacTran, StarD and Monte Carlo codes used to model aspects of vacuum system





Tool Core

- Function
  - Supports projection optics, reticle & wafer stages, chuck stacks & metrology systems
- Requirements:
  - Stiff, light, stable, very low expansion
  - UHV compatible, high gas conductance,
  - manufacturability
- Design
  - Range of shell & space frames studied –fig.1
  - Conic shell chosen, two halves – fig.2
  - INVAR – low expansion
  - FEA to guide & refine design for high stiffness

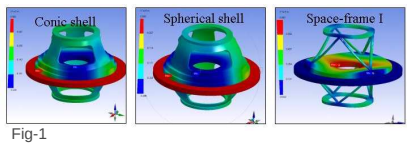
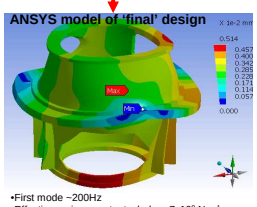


Fig-1

Fig-2

Concept conic' structure

Very stiff – f_1 ~ 277Hz, INVAR, support points for stages and optics, large pumping access.

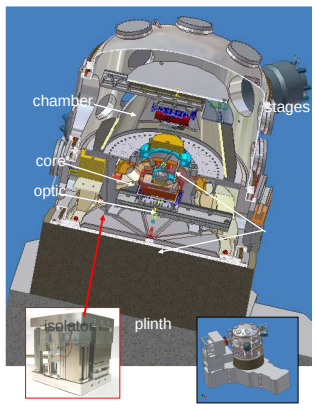


- First mode ~200Hz
- Effective spring constants, k_x, k_y ~ 7×10^8 Nm^{-1}
- < 7nm static deflection for max stage impulse.
- Expansion <1 μmK^{-1}

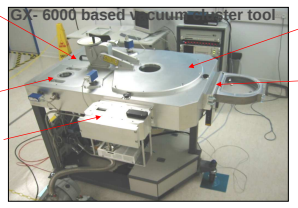
Vibration Control

Concept:

- Common base (tool, source, loaders)
- Massive chamber plinth
  - Polymer concrete
  - Low Q, high stiffness & damping
- Very stiff core structure
  - Supports 'passive' tool system
- 3 IDE active isolators (6 DOF total)
  - Core 'floats' in-vacuum
  - Attenuation –30dB @ 10 Hz
  - Air-spring & linear forcers
- Quiet tool system
  - Mag-lev pumps, very stiff chamber, low stage forces, long settle times…
- Finite element analysis
  - Detailed modelling to engineer structural modes & dynamics.

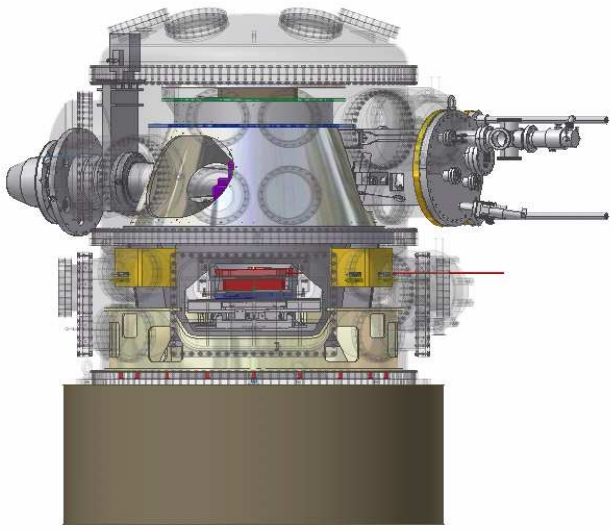


Brooks-PRI Wafer Loader



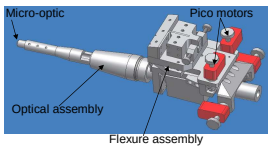
MagnTran™ 7 Vacuum Robot

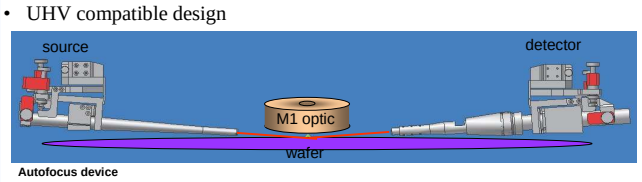
- Handles 200mm or 300mm wafers
- Interface to resist track (TEL ACT 12) & MS-13 tool
- State-of-art vacuum robot
- Modified to provide additional "manual" load lock
- In vacuum wafer aligner
- Oil free pumping system (BOC-E Mag-Lev turbo + 2 x XDS10 scroll pumps)



Autofocus system

- Optical non contact sensor
- Measurement at exposure site
- ~10nm resolution, ~100 μm range
- Fibre coupled laser source
- 2-D position sensitive detector
- Pico-motor in vacuum alignment
- UHV compatible design



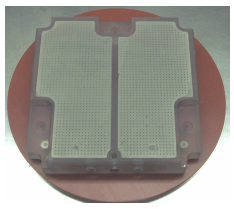


Autofocus device

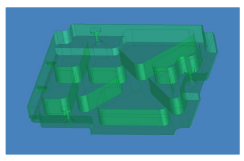
- Mounted between the projection optics and the wafer
- Angle of incidence 4º, spot size ~ 600 μm, 10nm resolution, 100 micron range

Electrostatic Chuck

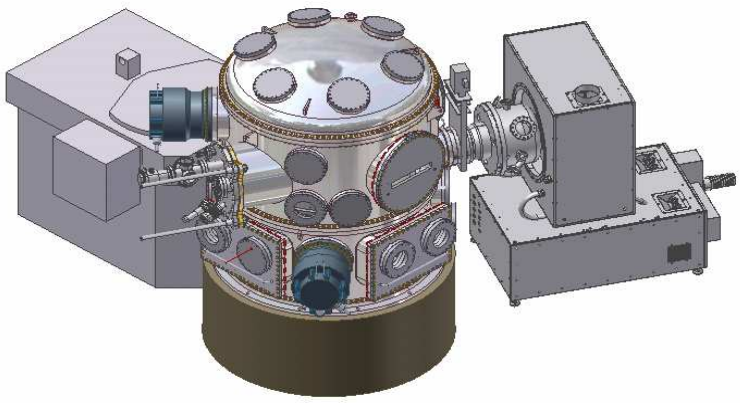
- Electrogrip
- Bipolar wafer and reticle chucks
- Advanced "sensing" electronics:
  - Monitor substrate proximity to chuck surface
  - Optimise grip voltage
  - Facilitate release by cancelling residual charge
- Light-weighted ULE structure
  - optimised for stiffness by FEA
  - replaceable quartz surface
  - best option, thermally
- Surface flatness 250nm over any 40mm
- Kinematic mounting



Electrostatic reticle chuck (bipolar)

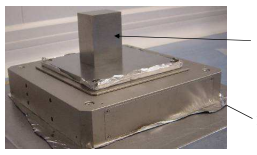


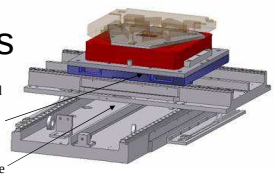
Lightweighted, FEA-optimised design

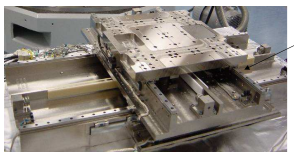


- World's first commercial EUV Microstepper
- Built for the 35nm node
- 13.5 nm z-pinch plasma source
- 0.3NA 5× lens
- 0.6mm field size
- 200 and 300mm wafers
- Exchangeable 5×3 field Reticle
- High Vacuum system
- Wafer loader interfacing TEL ACT 12
- SEMI standard compliant

Stages



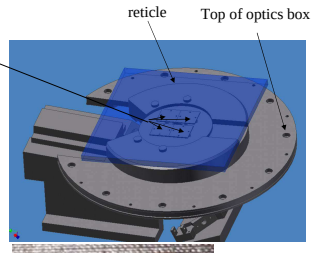


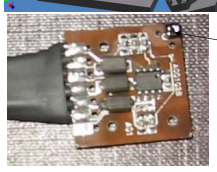


- Both reticle and wafer have similar stage pairs
- Combination of linear "piezo walker" and piezo flexure stage
- Long range with high resolution
  - Range > 450 mm
  - Resolution < 5 nm
- Stiff design
  - Vibration < 3nm (3σ)
- Inherent brake at standstill
- 6-axes of movement

Dose control

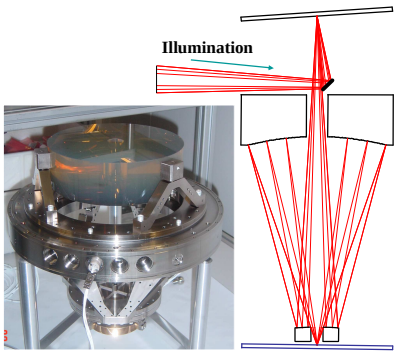
- 4 detectors mounted on PO box below reticle
  - Dose control + beam shape monitoring
  - As close to wafer as practicable
- Custom photodiode and electronics from IRD
  - Rad-hard SXUV diode with direct-deposited Zr filter
  - AlN circuit board to sink heat effectively
  - low-power preamp with second, line driver, board. Minimise heat dumped into PO
  - Sample and hold board outside vacuum
- Microstar DAP PCI card interfaces detectors to control computer
- Versatile
  - Same detector design used for all EUV detection purposes in tool





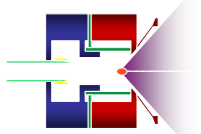
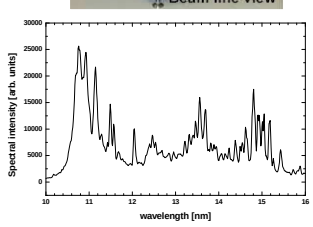
Projection Optics

- Zeiss implementation of well-documented LLNL (Hudyma/Hale) MET design
- Stiff PO box based on hexapods and flexures
- ~2Å surface roughness
- DoF (30nm lines) > 80nm
- < 1nm wavefront error
- 0.3 NA
- ×5 magnification
- For illuminator please see Zeiss poster



EUV Source

- Xtreme Technologies
- Repetitive Z-pinch plasma (Xe gas)
- ~2 kW into 2π (whole spectrum)
- 35W into 2 π (13.5 nm, 2% BW)
- 1 kHz repetition rate @ 10% duty cycle
- Effective debris reduction system
- 4000 l/s pumping
- See Xtreme poster for further details



- pre-ionised Xe stream
- z-pinch electrode