157nm Reticle Handling Technology

Sematech Technical Data Review

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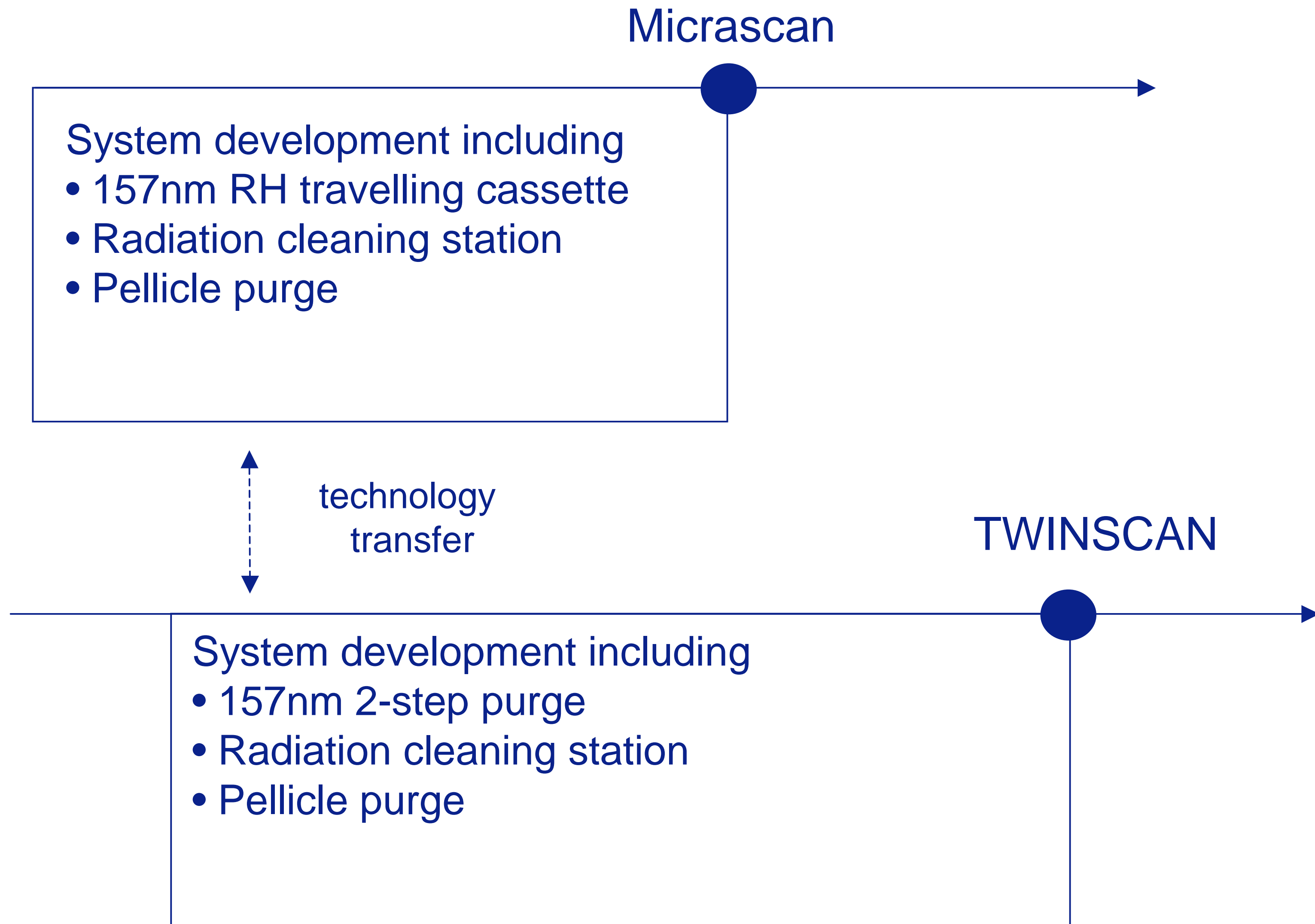
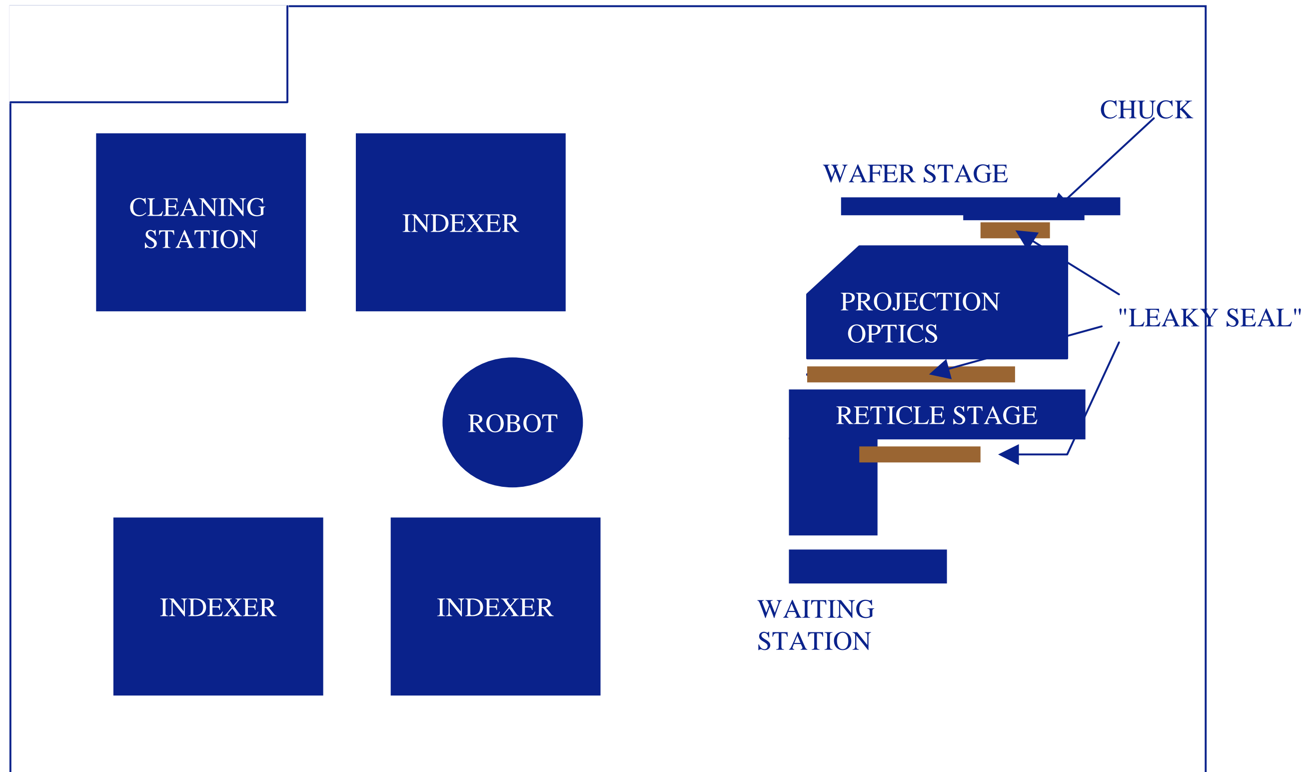
Outline

- Introduction
- Status on developments
  - RH building blocks
  - Experimental results cleaning and purge
  - Particle protection
- Conclusion

157nm mask related activities



Micrascan configuration



ENCLOSURE TOP VIEW

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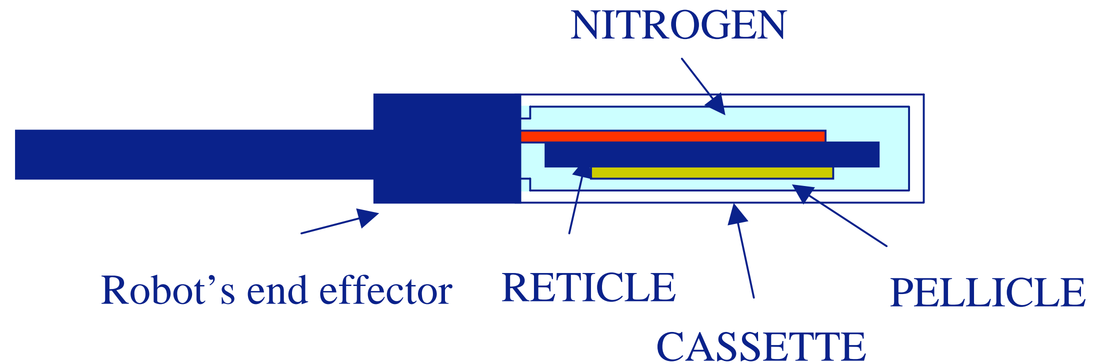
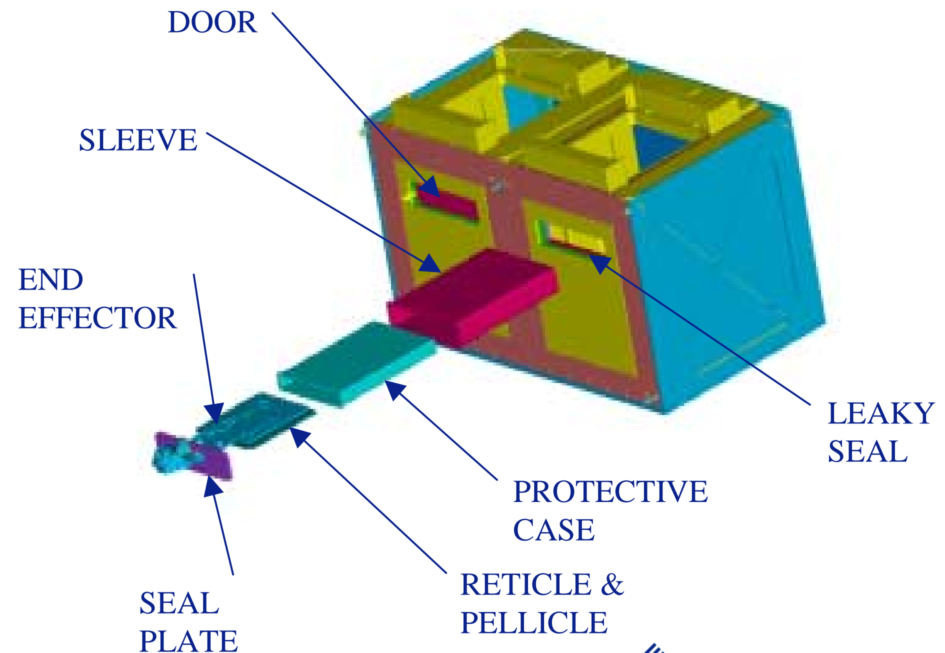
Micrascan: Travelling Cassette

- Protect the reticle with "Traveling Cassette"
  - provides small nitrogen atmosphere that surrounds the reticle and travels with it.
- Reticle storage in nitrogen
- particle contamination improved robot





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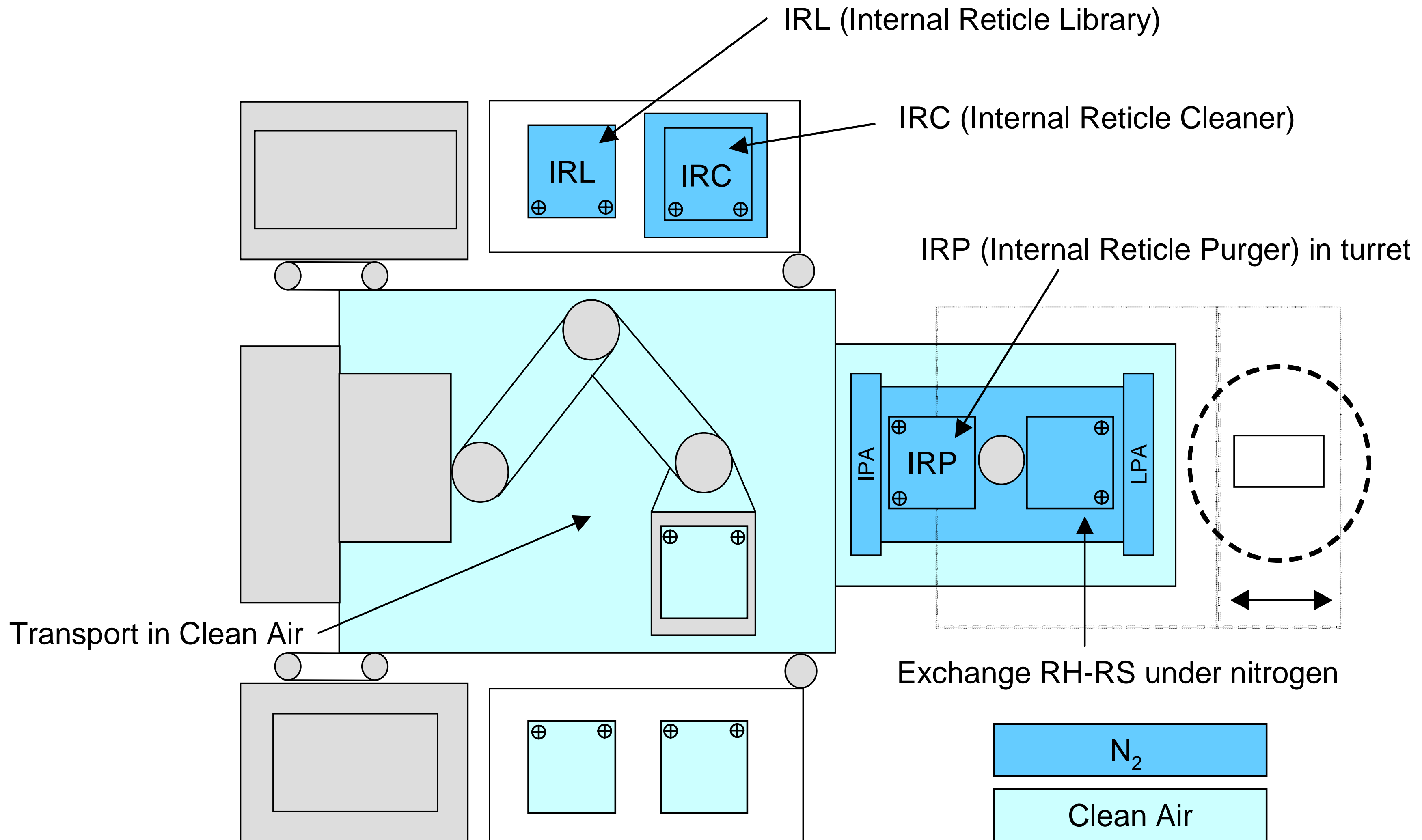
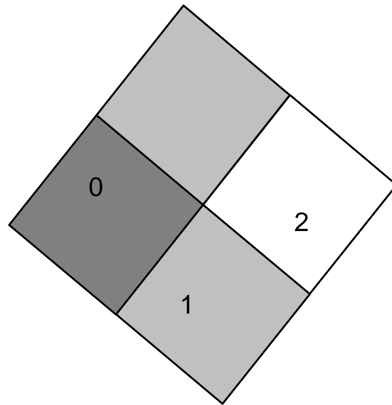
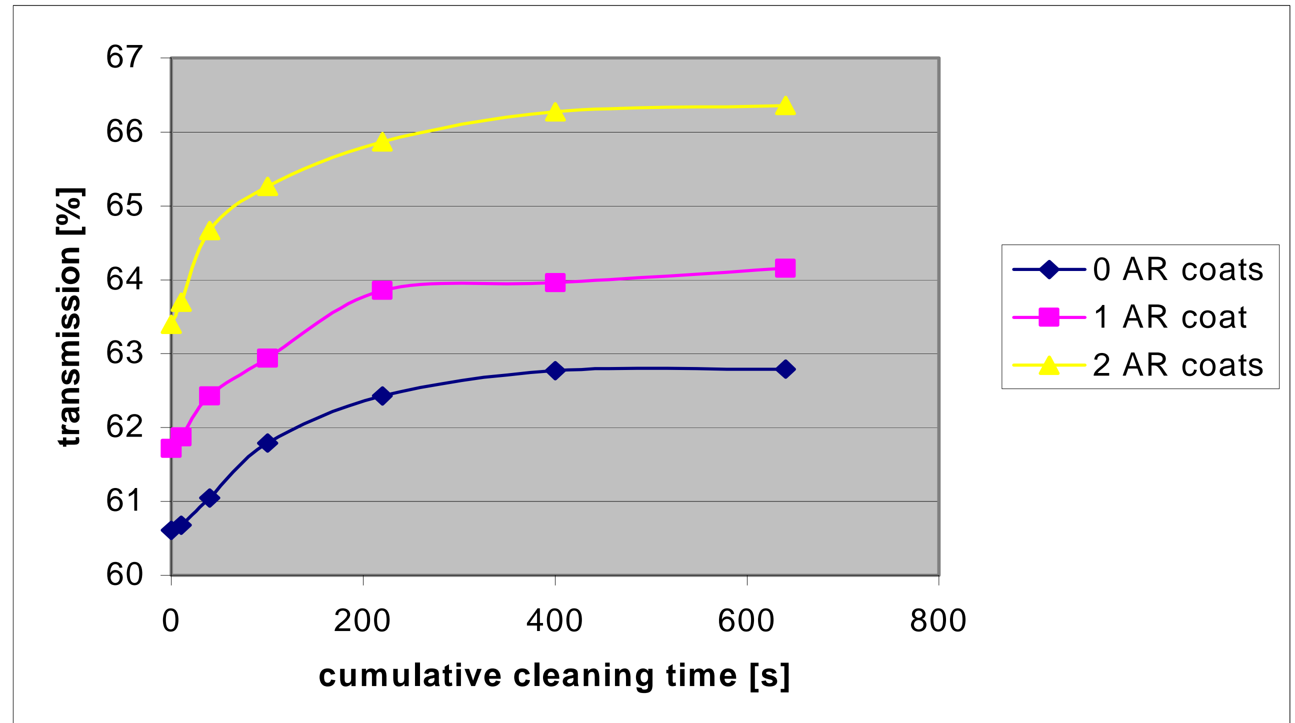
TWINSCAN RH configuration



Example: cleaning of coated substrate





- F-doped substrate with hard-pellicle type AR coatings
  - 0, 1, 2 layer coatings

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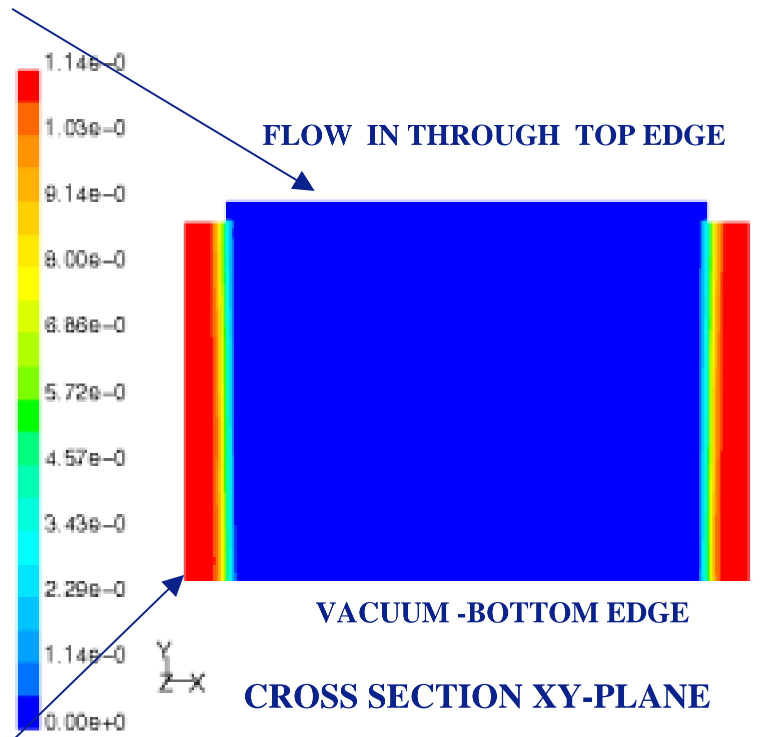
Porous Pellicle Frame Purging

- Requirement
  - Fast purge of pellicle space
    - proposed with porous frame
  - Flow Testing
    - empirical testing determined a less than 0.5 minute rate
  - Flow Modeling
    - modeling determined that side walls of frame must be non-porous to achieve homogenous steady state flow

Porous Pellicle Frame Purging

Side edges (Left & Right) = Impermeable (1.0E-16 m^2) (NOTE: Cant set to zero in Fluent Program Without changing model to wall)
Top and Bottom = 1.0E-08 m^2 (Highly Permeable)
Inlet flow – Pure N2 = 0.0148 psi = 0.4 IN H2O

BLUE – PURE N2 FROM PO SIDE



Contours of Mass fraction of o2 (Time=1.0000e-02) Dec 05, 2001
FLUENT 5.5 (3d, segregated, spe2, lam, unsteady)

NON-PERMEABLE SIDE EDGES

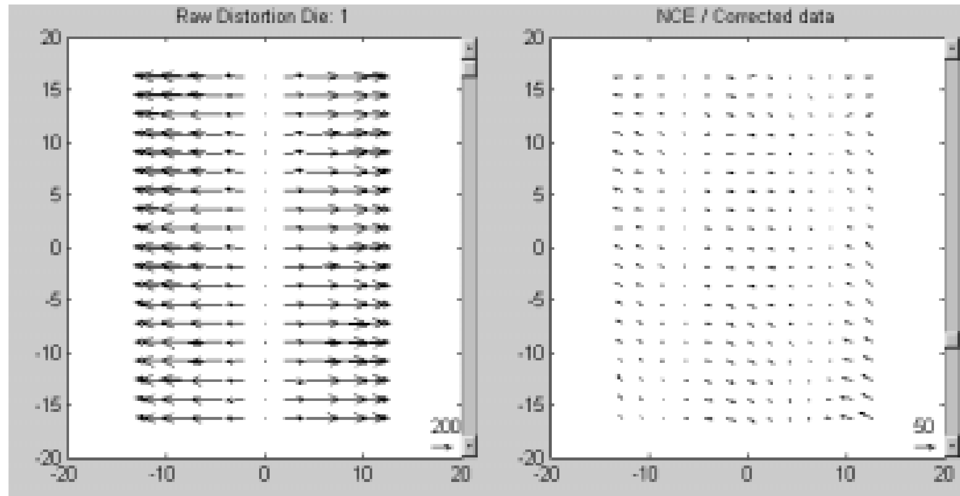
RED – 1000 ppm N2 (From Reticle Side – through Gap 0.003 inch)

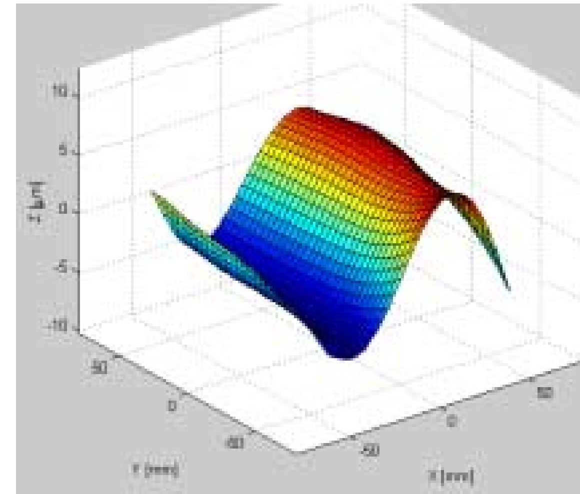
Thick pellicle approach

- ASML machines prepare for thick pellicle
  - Vertical stages MicraScan for 300 um thick pellicle
    - no gravity bending: current design can correct for optical effects
  - Horizontal stages TWINSCAN for 800 um thick pellicle
    - gravity bending, additional correction needed
    - switch to soft pellicle requires manual adjustments
- Experimental feasibility study work
  - Lithography testing in 248 nm scanners
    - data presented relative to distortion fingerprint no-pellicle

800um with fused silica frame

Raw data | NCE corrected | Non correctable plate bending





Maximum vector

dx = 435 nm

dy = 21 nm

Maximum NCE

dx = 33 nm

dy = 15 nm

Corrected for
- **translation**
- **rotation**
- **magnification**
- **3rd order distortion**
- **scan scaling**
- **scan skew**

Distortion summary

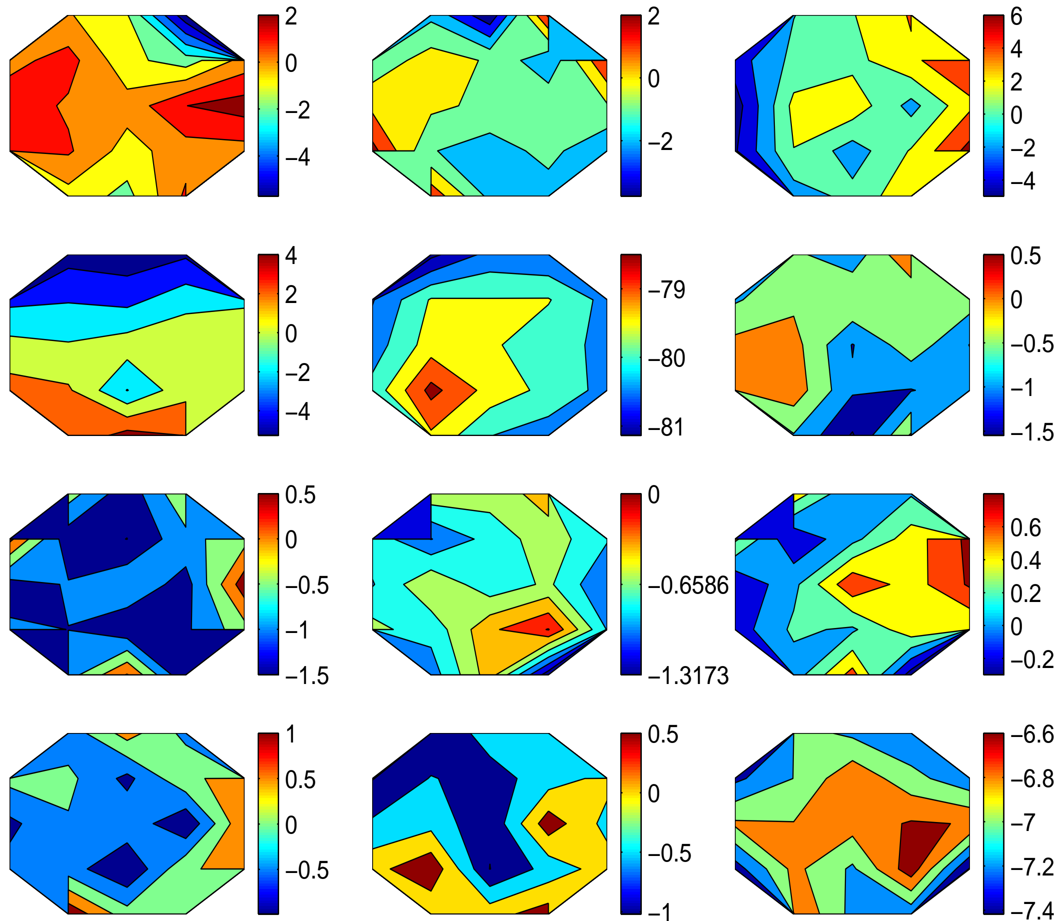
	800um quartz frame	800um aluminum frame	300um aluminum frame
raw data (x,y)	435nm, 21nm	510nm, 107nm	120nm, 25nm
NCE (x,y)	33nm, 15nm	55nm, 60nm	30nm,35nm
sigma (x/y)	6.3 / 7.0 nm	4.1 / 3.6 nm	14 / 12 nm

Fused silica frame better than aluminum frame

800um thick plate more stable than 300um thick plate

Further improvement needed

Field dependent aberrations
800um thick pellicle



- Z9 and Z16 Spherical dominant aberration
  - order of magnitude higher than lens specification
- Range spherical ok
  - good thickness control plate
- Coma (Z7/Z8) and AST (Z5/Z6) too high but not killing now

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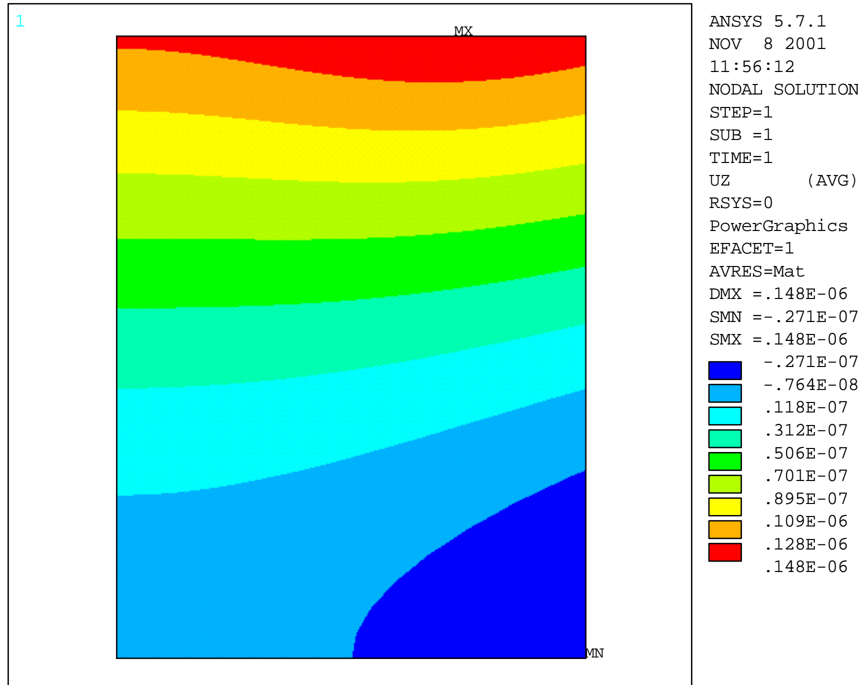
300um Porous Frame - Mechanical Modeling

- Independent numerical models from the University of Wisconsin and ASML have supported the same conclusions:
  - Out-of-plane pellicle distortion due to gravity: 5 nm
  - Reticle distortion due to attachment of pellicle with bowed (50 µm) porous frame:
    - Out-of-plane: 1.5 nm
    - In-plane: 0.1 nm
  - In-plane reticle distortion due to 0.1 °C uniform temperature increase: 5 nm

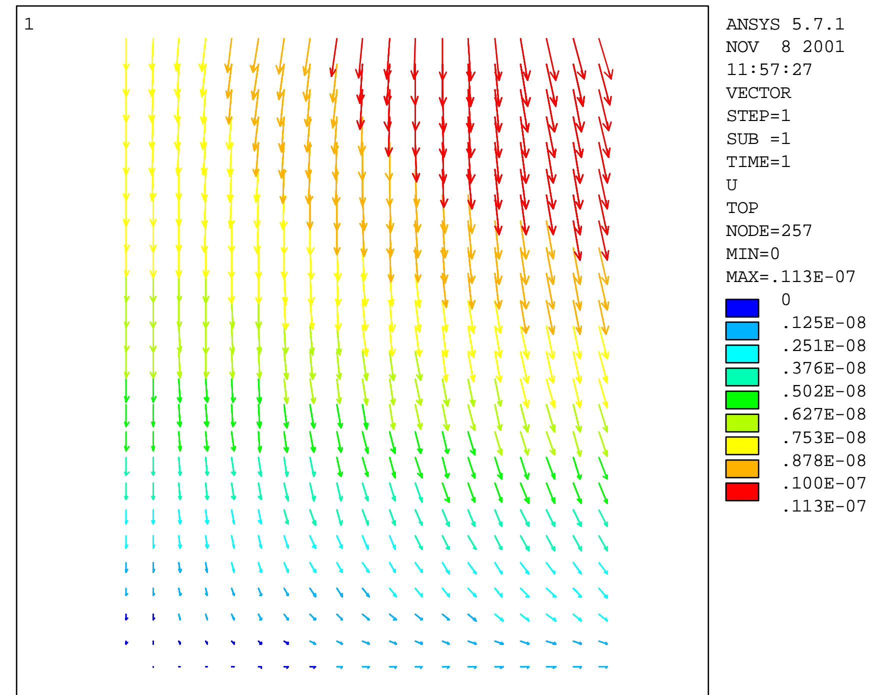
300um Porous Frame - Mechanical Modeling

Out-of-plane Distortion from Attachment



Quarter-symmetry result shown over filter footprint. Initial Frame bow was 50 µm. Maximum OPD is 1.5 nm.

In-plane Distortion from Attachment



Quarter-symmetry result. Initial frame bow was 50 µm. Maximum IPD is 0.1 nm.

Pellicle-less feasibility study

- **Feasibility study is done on active removal of particles on reticle**
  - assumed requirement on particulate environmental constraints
    - ~ 1 particle (≥ 40nm) per m^3, or equivalent Class 0.0002
  - relaxes cleanliness requirements in handling system

- **Investigate two *in-situ* reticle particulate cleaning methods**
  - electrostatic cleaning
    - ionized N2 stream eliminates electrostatic forces adhering particulates to reticle, N2 stream blows neutralized particulates away
  - laser assisted cleaning
    - direct intense (tens of mJ/cm^2) of laser energy on the particle to blow it away

1st Test electrostatic method

- **Initial Po^{210} Testing**
  - used blank reticle substrates
  - exposed in the 157nm miniscanner which includes an N2 air shower and particle filtration
  - particle “sniffer” measured environment as ~ Class 0.1 to 0.2 near scanning reticle stage
  - reticles (plus control) measured on KLA Starlight
- **Initial Results - first results unclear, more experiments needed**
  - 25cm² area, 2 hour exposure
    - “uncleaned” reticle: 5 “adders” > ~ 100nm
    - “cleaned” reticle: 36 “adders” > ~ 100nm
    - control reticle: 1 “adder” > ~ 100nm

Conclusion

- Cleaning and purging solved in principle
  - engineering work ongoing, maximize commonality MS and AT
- Pellicle remains a concern
  - thick pellicle shows progress, but feasibility still questionable
    - find root causes for overlay and imaging observations
  - engage more in active particle removal studie(s)
- Soft pellicle remains preferred solution

Acknowledgements

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  - ISMT, University Wisconsin, Intel, Asahi, Zeiss

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