An Integrated Demonstration of EUVL Reticle Defect Control

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INTRODUCTION

- No pellicle exists that will work with EUV photon energies
- Critical defect size on the mask will be around 30nm
  - Particles as small as 30nm could result in catastrophic yield losses
- Contamination of the reticle is perceived as a possible showstopper for EUVL

10/2003 SEMATECH Ranking of Critical EUVL Issues

- Source power and lifetime including condenser optics lifetime
- Availability of defect free masks
- Reticle protection during storage, handling, and use
- Projection and illuminator optics lifetime and contamination
- Resist resolution, sensitivity, and LWR
- Optics quality for 32nm node

- Intel and SEMATECH are working together to develop the technologies necessary to demonstrate a path to high volume manufacturing.
  - An integrated demonstration of particle defect control is planned for 1H'05

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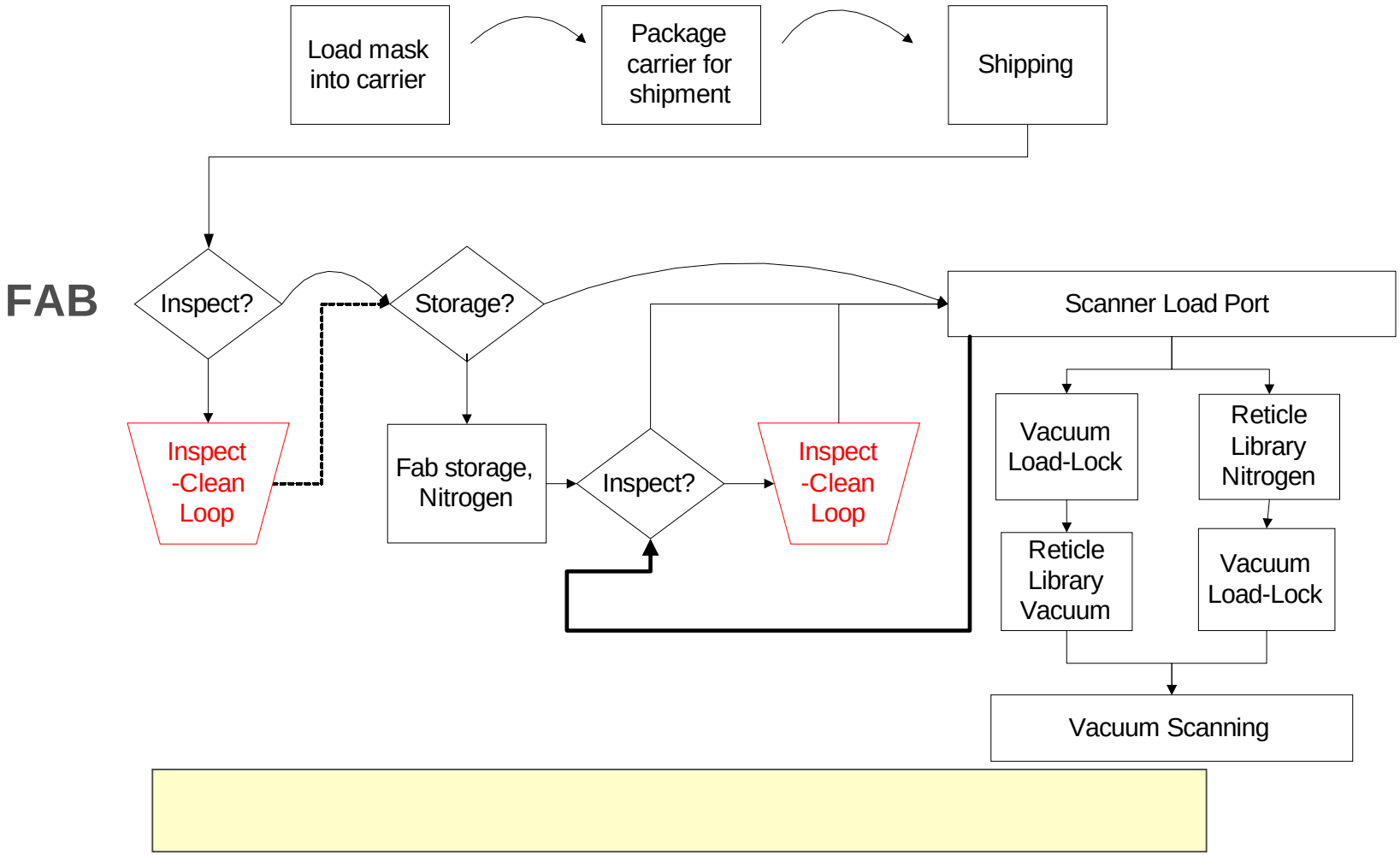
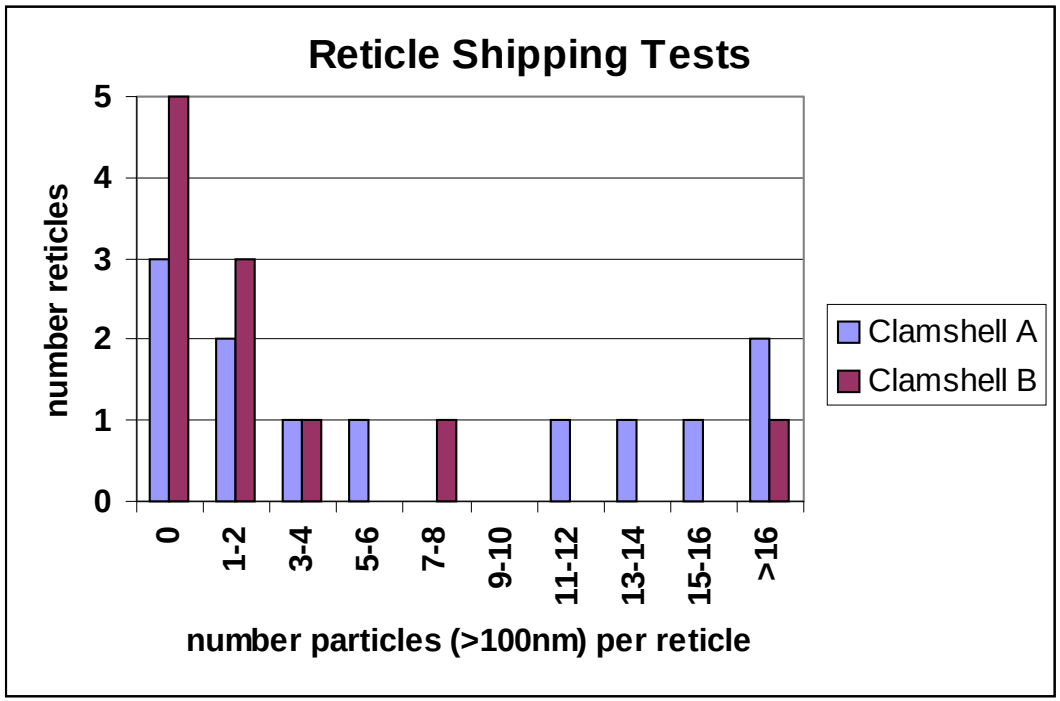
Mask Flow Post-Build

- Several handling steps are involved after mask final clean and inspection till it reaches the point of use



Current Baseline for Shipping

- SEMATECH data on shipping (IBM testing)

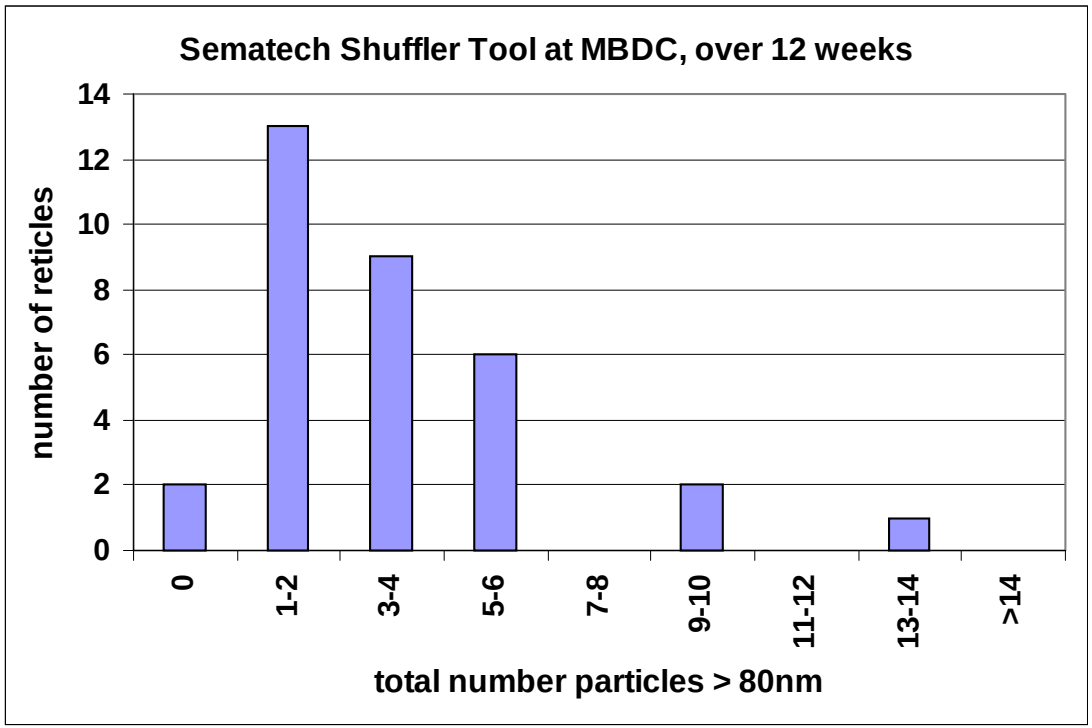


To reduce particle adders during shipping we need

- Clean carrier
- Clean shipping methodology (packaging/handling)

Current Baseline for Handling

- SEMATECH MBDC reticle transfer tool

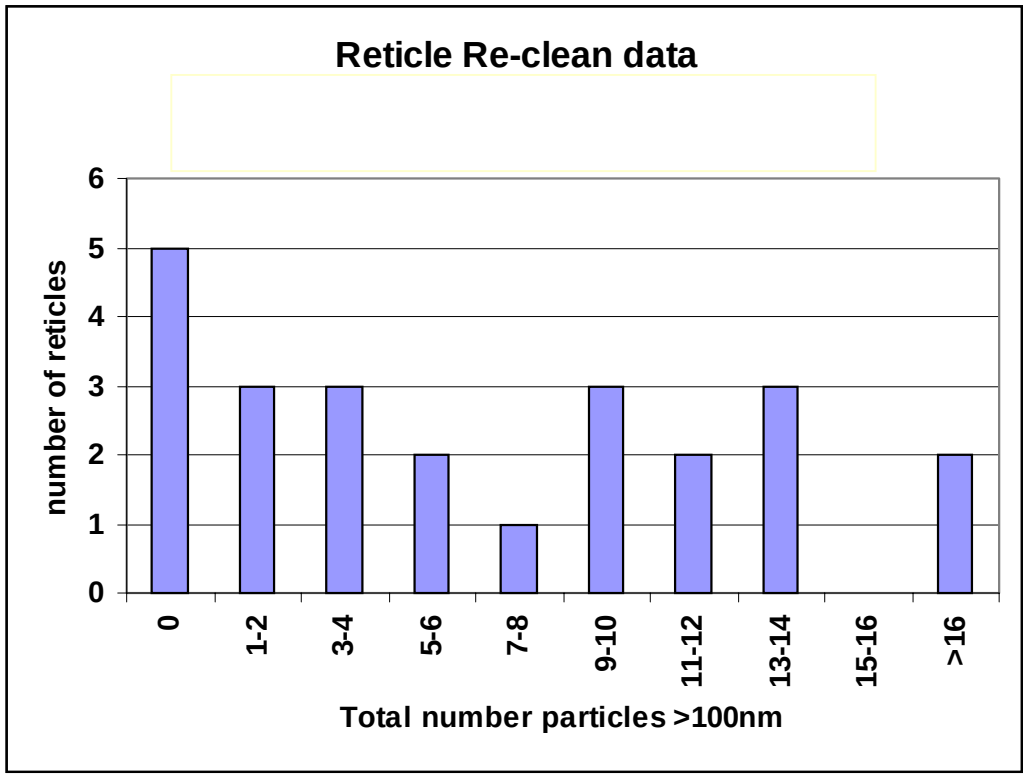


Reduction in handling adders is needed

- More particles are expected at <80nm sizes
- Long distribution tail

So…why can't we clean in the fab?

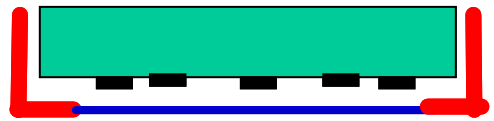
- Cleaning data from SEMATECH (IBM test)



- Significant development is required on nanoparticle removal
- Multiple cleans could damage the EUVL mask films

Defect Control for 2005 Demonstration

- Protect the mask with a removable pellicle
  - A “Bracket” will secure the removable pellicle near the surface (3mm) of the reticle
  - Reticle will be face down in the Bracket
  - Reticle stays protected during handling, shipping, and vacuum pumpdown/purge
  - Removable pellicle is removed during scanning



- Use thermophoretic protection to protect the reticle in vacuum during scanning.
- Testing will be conducted at the Intel EUV Pilot line and the SEMATECH Pilot line in Albany, NY
  - Handling, storage, shipping and scanning tests will be conducted

  - Determine feasibility of reticle protection and establish a path to high volume manufacturing

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Research Projects on Particle Control

- Removable pellicle studies
  - Evaluation of the concept of removable pellicle protection during handling, shipping and vacuum pumpdown
  - Modeling simple removable pellicle in carrier – **LLNL/SNL**
  - Experimental verification
    - Protection due to a removable pellicle in a carrier – **U of Minnesota**
    - Protection due to a removable pellicle in the loadlock - **U of Minnesota**

- Thermophoretic studies
  - Evaluation of thermophoretic protection during scanning
  - Experiments and modeling in vacuum - **U of Minnesota**
    - Map out parameter space related to temperature, pressure
  - Implement in “mock” scanning system “Defect Control Tool”

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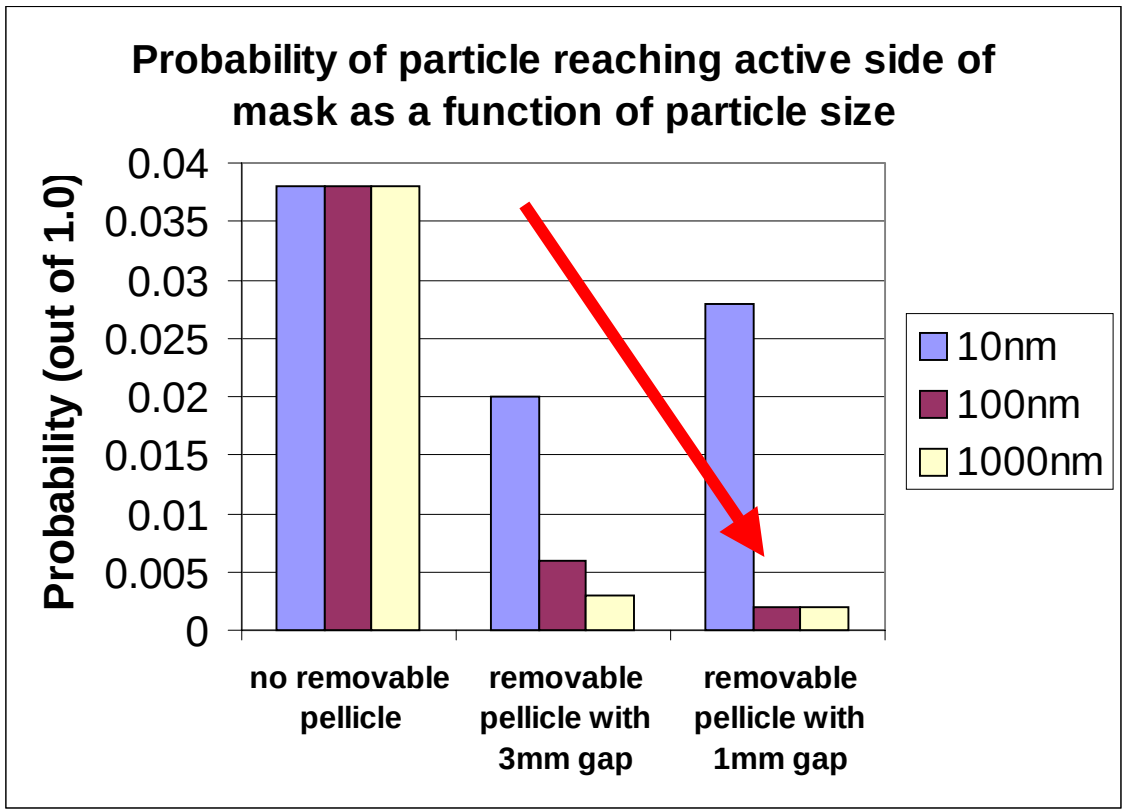
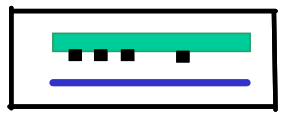
Modeling of removable pellicle

- Simple removable pellicle modeled by LLNL and SNL
  - No side protection



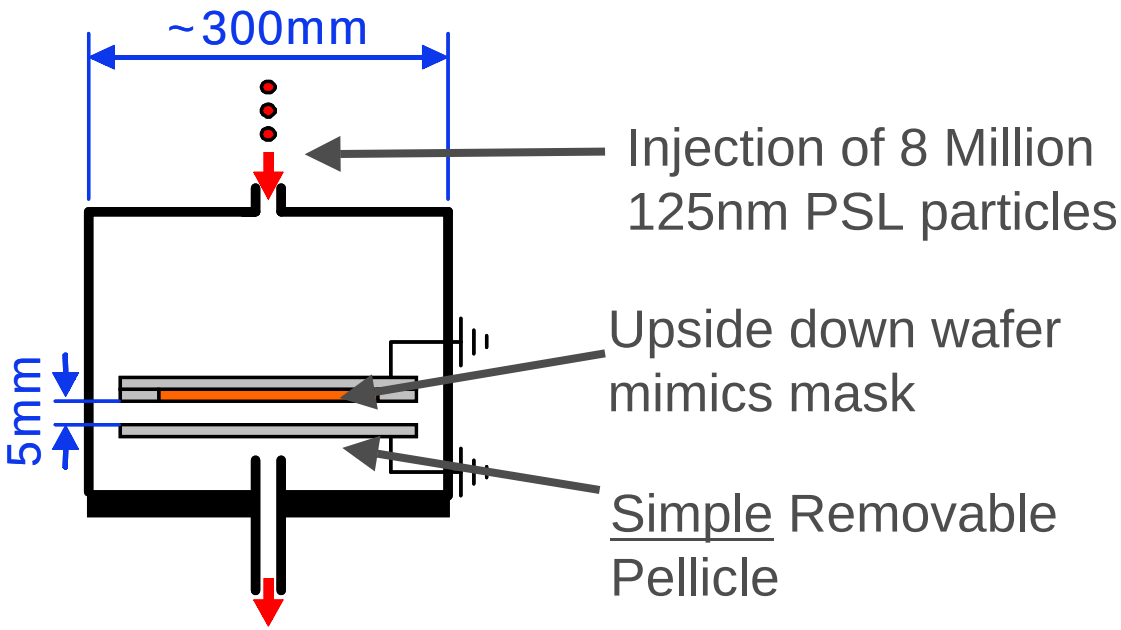


POSTER: Improved Reticle Carrier Design through Simulation – A.S. Geller and C.C. Walton

Removable pellicle – In a Carrier

- Experiments conducted at U of Minnesota
  - Removable pellicle tested at atmosphere

atmospheric 'carrier'



Particles added:

No Removable Pellicle: 13,064

With Removable Pellicle: 1

- POSTER: Design and Preliminary Results of an Atmospheric Chamber to Evaluate Nanoparticle Protection Schemes for EUVL Carrier System

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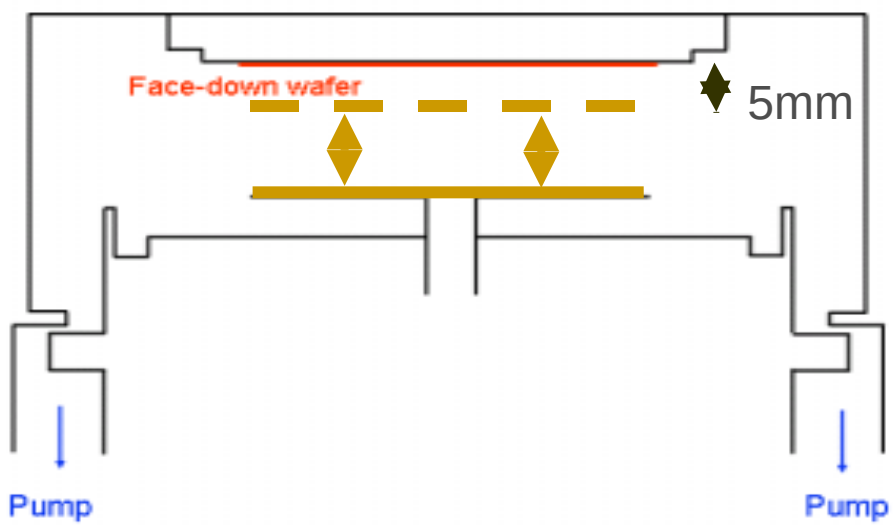
Removable pellicle – In Loadlock

- Experiments conducted at U of Minnesota
  - Removable pellicle tested at low pressure (30mTorr)



Ten Cycles Pump-down & Purge with fast 'dirty' pump speeds

- Without removable pellicle: 32 particles total (= 100nm)
- With removable pellicle: 3 particles total

PRESENTATION: Design and Preliminary Results of a Vacuum Chamber to Evaluate Nanoparticle Protection Schemes for EUVL Vacuum System

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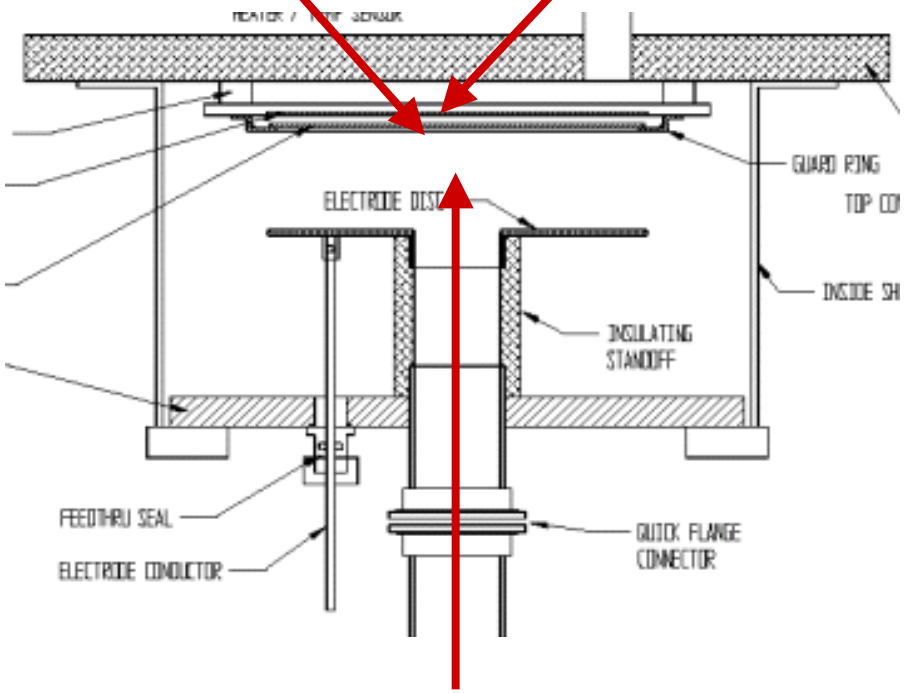
Thermophoretic Studies

- U of Minnesota vacuum chamber experiments

Upside-down wafer mimic mask

Heater element for thermophoresis



PSL particle injection

30 mTorr
80m/sec particles
∇T 1.5K/cm : 2175 particles
∇T 11K/cm : 487 particles
Thermophoresis not sufficient

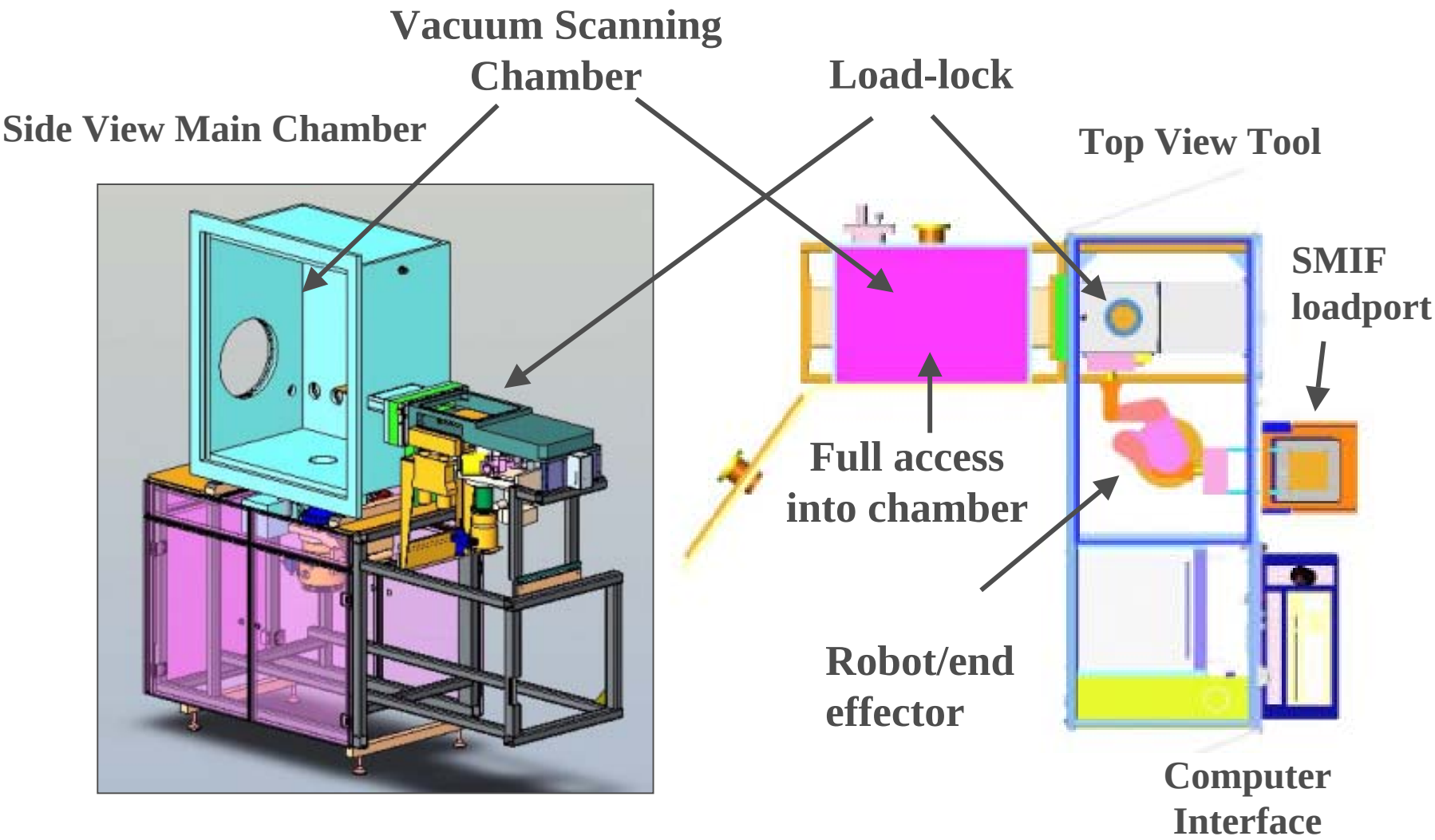
400 mTorr
4.8m/sec particles
No heat: 298 particles
∇T 4K/cm : 18 particles *
Thermophoresis works

Parameter space mapping underway
Results will be used to define thermophoretic domain for implementation in Defect Control Tool

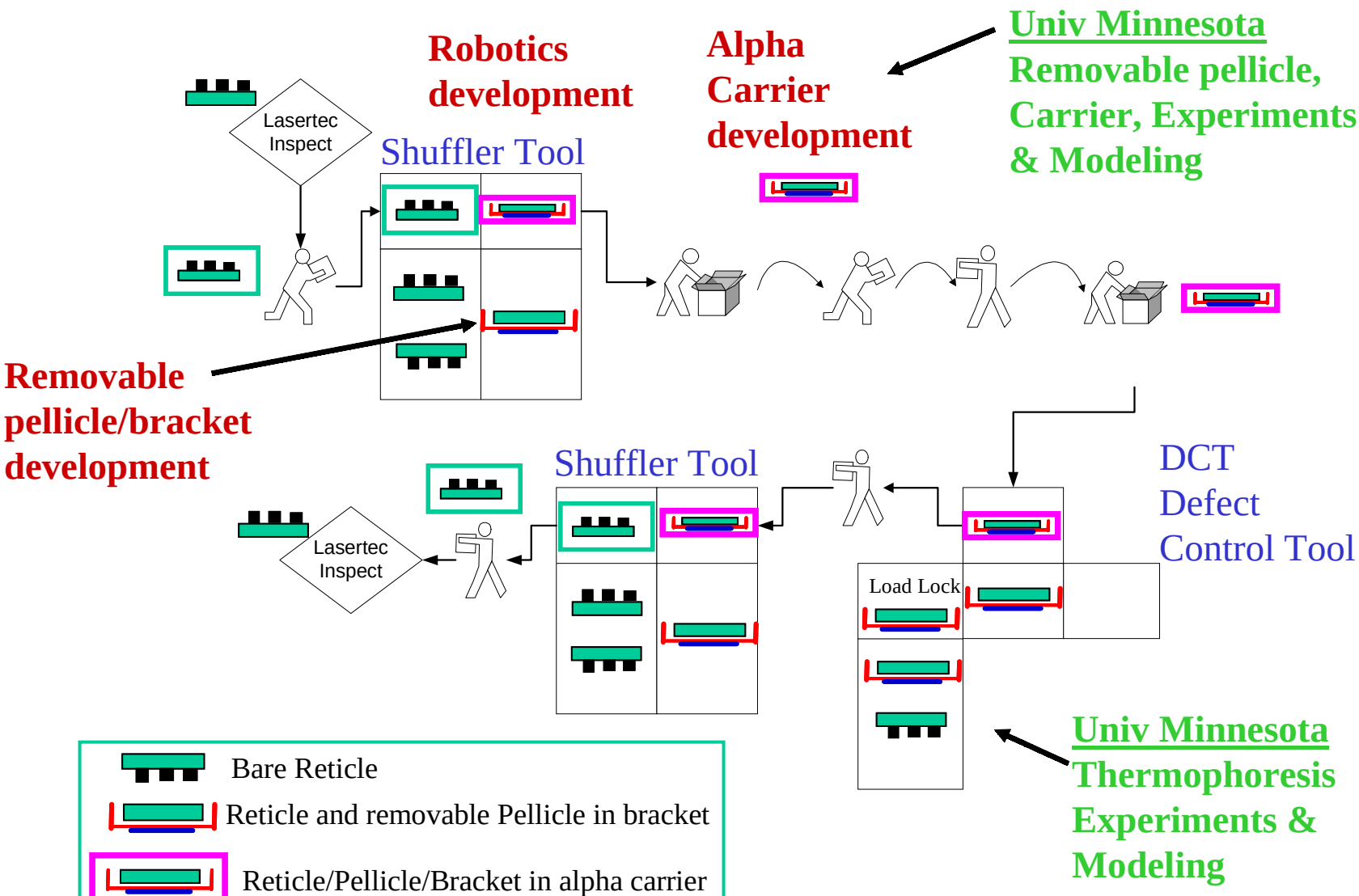
Defect Control Tool

- "Mock" Scanning System
  - Will be located at MBDC, Albany. Delivery early Dec 2004
- Features
  - SMIF interface
  - Vacuum loadlock with vacuum main chamber (1mTorr-100mTorr)
    - Reticle face down on scanning stage
    - Thermophoretic apparatus
  - Automated handling of the reticle

Defect Control Tool Schematic

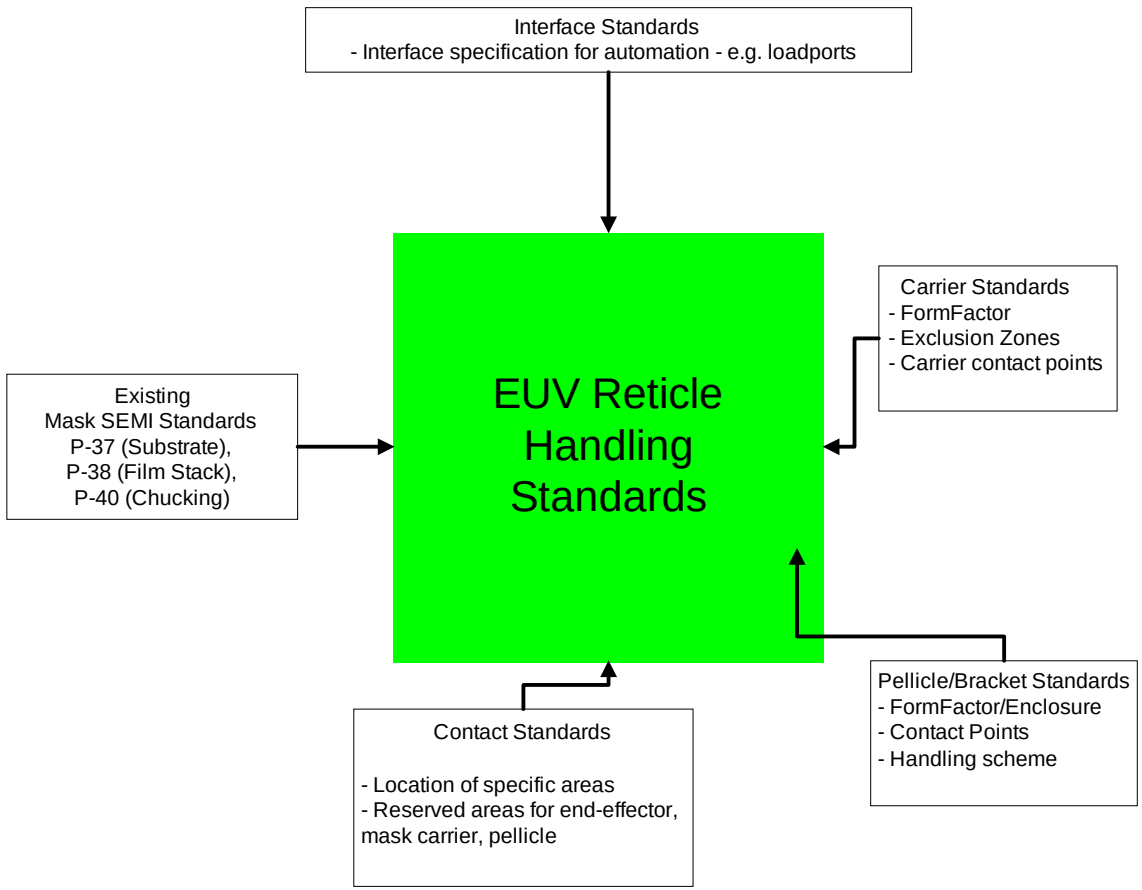


Integrated Demonstration Flow



EUV Reticle Handling Standards

- Standards are needed for carrier, interface, pellicle, and contacts
  - To enable development of high volume manufacturing tools, standards development for reticle handling need to be accelerated.



SUMMARY

- Good progress has been made on identifying key challenges in EUV reticle handling
  - Programs have been defined to address the risks
- Modeling and Experiments to date confirm importance of a simple removable pellicle to protect the reticle front side
  - No protection from sides in these tests
- Intel and SEMATECH are working towards a joint, integrated demonstration of reticle handling in 2005 to establish path to high volume manufacturing
- Standards are needed to ensure tool interoperability
  - Lengthy standards process means that we need to start the standards development effort now

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QUESTIONS?