Status and Path to Particle-Free EUV Reticle Protection and Handling

EUVL Symposium 2006

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Outline

- SEMI standardization status
- EUV carrier
  - Options
  - Selected data highlights
  - Mapping
  - Robotic handling
- Protection during vacuum exposure
- Future work
- Summary

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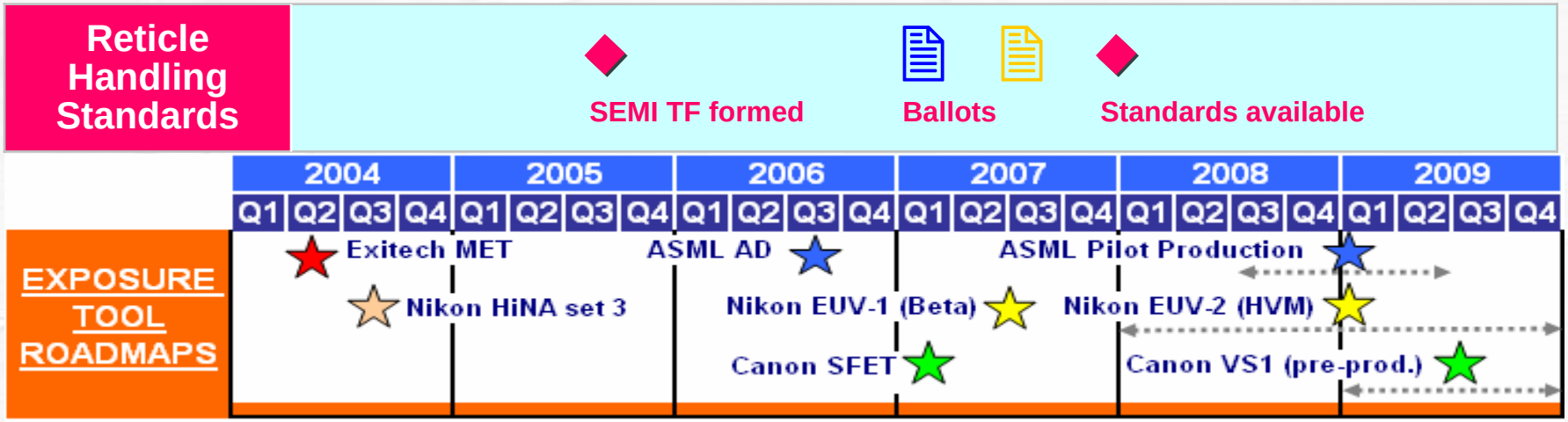
Status of SEMI EUV Reticle Handling Standardization



- **Carrier - Most stakeholders, especially the users want one carrier solution for all.**
  - Some leading EUV carriers may be emerging to meet this requirement.
- **Robotic handling - The industry is making good progress.**
  - Various suppliers are now addressing the robotic handling issues of leading carriers in exposure, metrology, and engineering vacuum tools.
- **The industry may be converging…**
  - Exposure tool suppliers are considering dual pod as a unified carrier solution.

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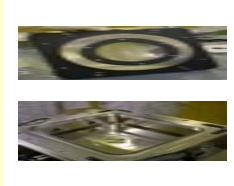
EUV Reticle Carrier Options

"Single-pod" Carriers

Entegris/Intel Alpha

Alcatel bottom-opening FOUP

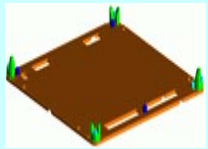


TDK vacuum Pod

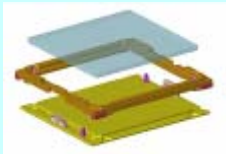
Removable Pellicles

Outer Pods/Carriers

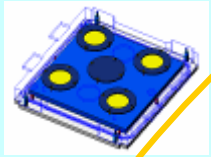
ASML Frame



Fala/Intel Bracket

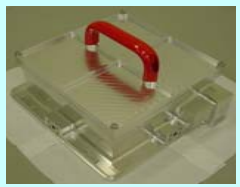


Nikon Inner Pod



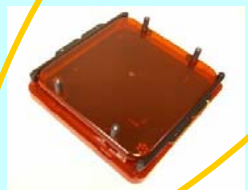
Entegris Inner Pod

?



ASML Storage Box

"Mod" Entegris/ Intel Alpha



Mod RSP200

Bottom-opening FOUP

Any reference to dual pod in the presentation means Entegris/Nikon/Canon EUV carrier unless explicitly indicated otherwise

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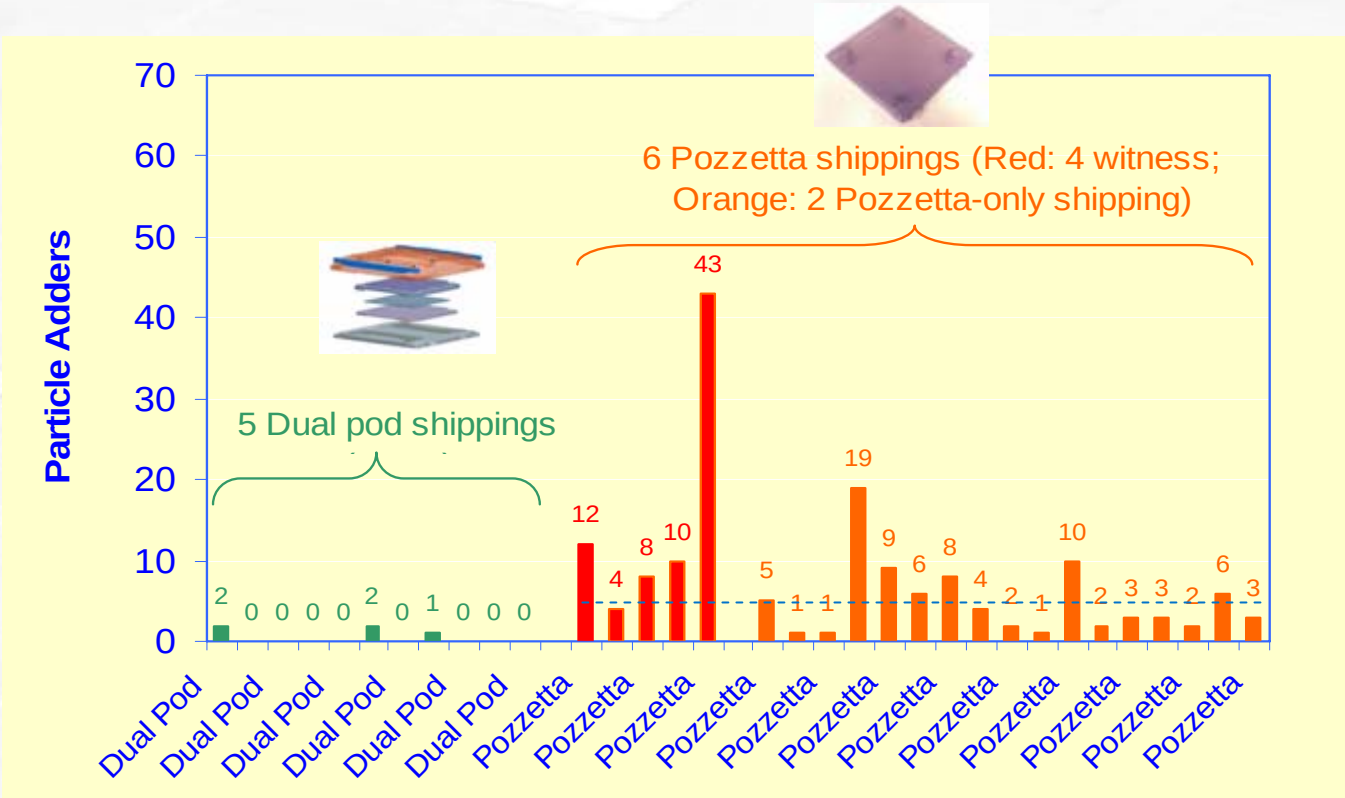
SEMATECH Test/Evaluation Results On Dual Pod for Shipping Use



Roundtrip shipping data: EUV dual pod carrier (Green) v. the new Pozzatta box (Red and Orange)

- The shipping results are at test noise level (of manual handling and metrology).
  - Data @54 nm sensitivity

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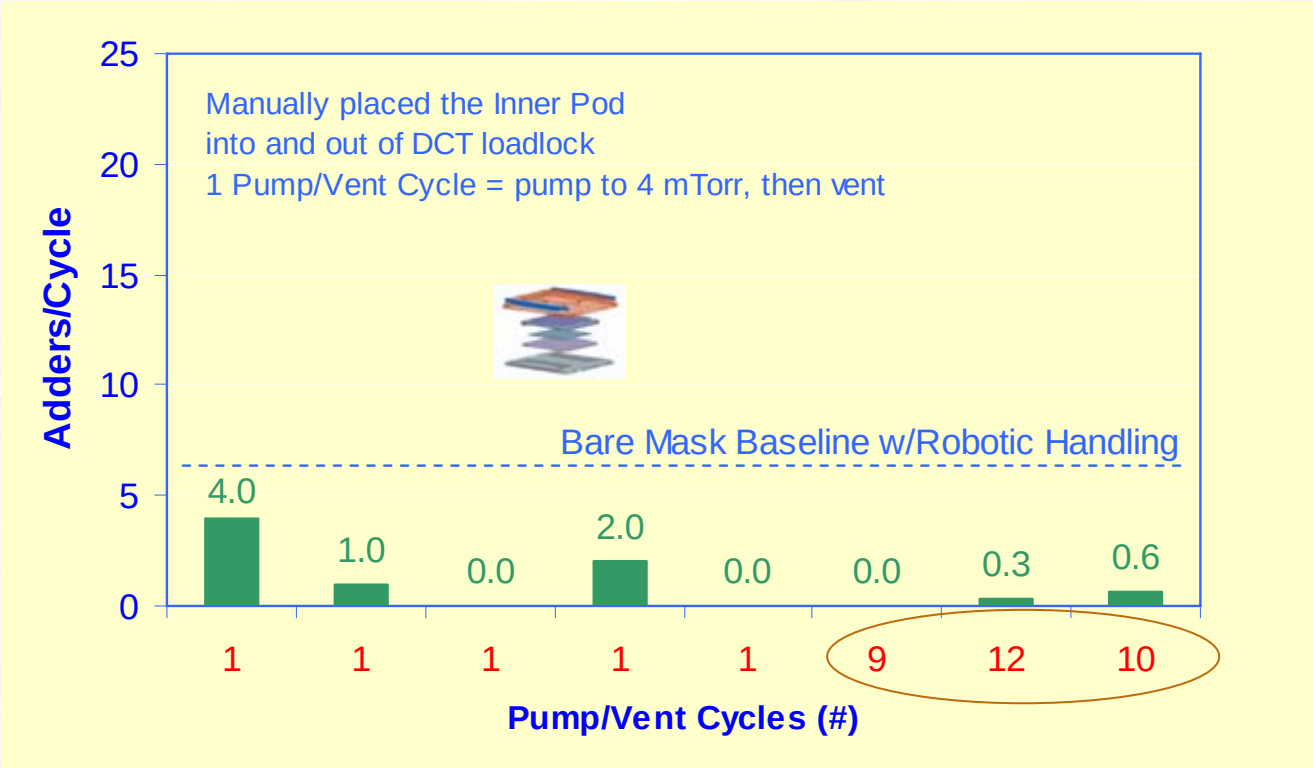
SEMATECH Test/Evaluation Results On Dual Pod For Vacuum Use



Vacuum test data: pumped to 4 mTorr, then vented to atmosphere. The inner pod was manually transferred into and out of the vacuum loadlock

- Both the shipping and vacuum results are at test noise level (of manual handling and metrology).
  - Data @54 nm sensitivity
- **More data needed for standardization!**
  - Especially, at 25, 30, 40 nm sensitivities
  - M7360 installed at SEMATECH

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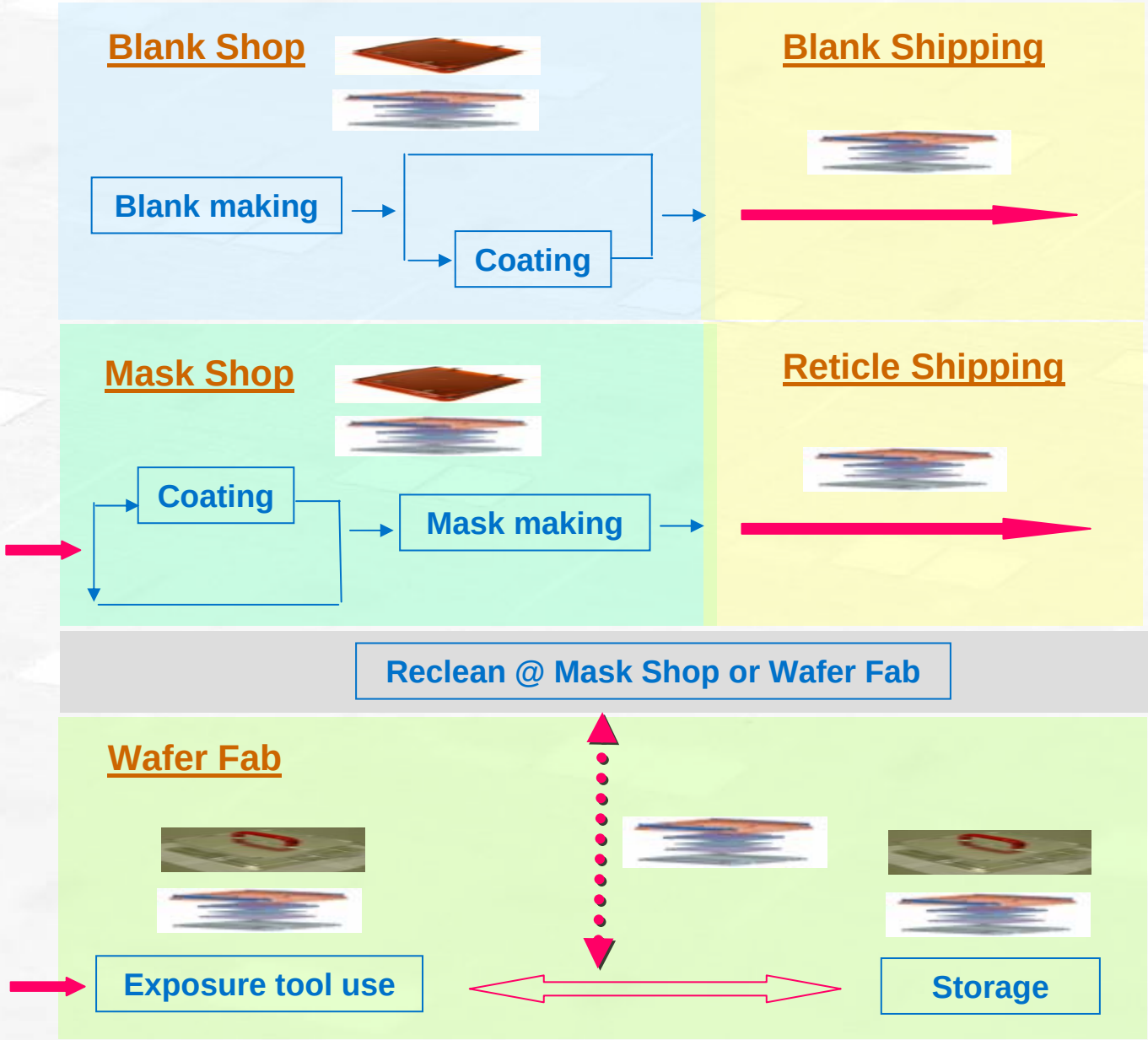
Mapping of Carrier Options to Life Stages



Legends:

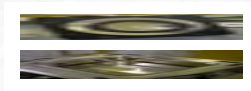
ASML storage-frame:

Dual Pod:

Other EUV single carriers:

BO FOUP:

TDK Vac Pod



Any non-EUV carriers:

- Dual pod could be used at all steps, supported by *limited data*.
- BO FOUP may be used in all places that dual pod can, but *need supporting data!*

Details such as where to inspect and reclean reticles and where to coat resist should not impact this mapping.

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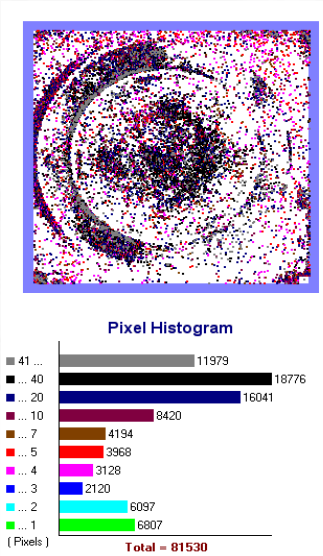
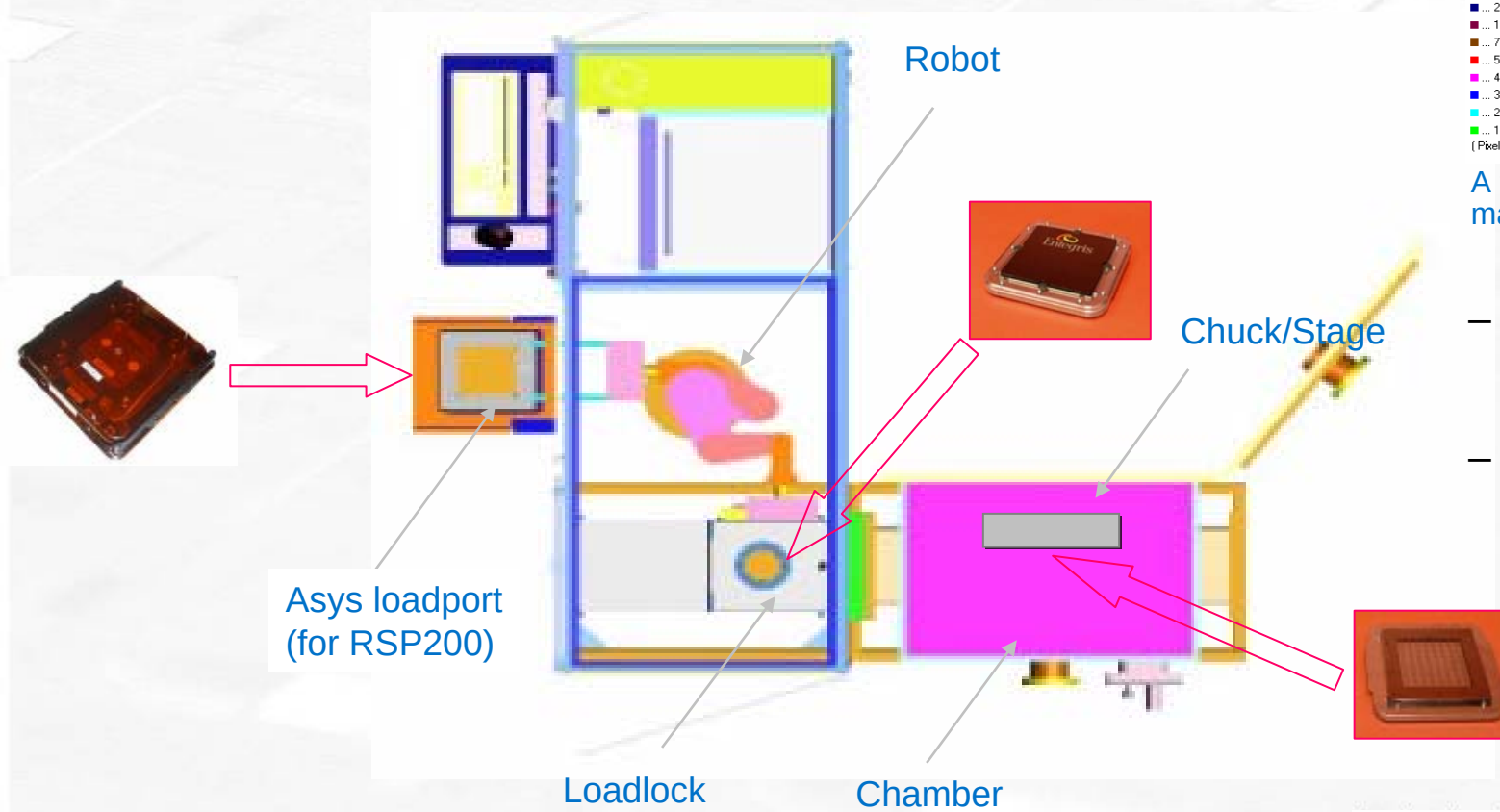
SEMATECH Upgrades DCT To Study Dual Pod, Robotic Handling, and e-Chuck Contamination

- **Main Goals:**
  - Vacuum data for carrier and automation standardization
  - Study e-chucking particle contamination
  - Learning for early implementation in development line
- **Targeted completion: 1/07**



A typical backside particle map after e-chucked



- Inner pod opens only in loadlock vacuum
- e-chuck mask in vacuum chamber

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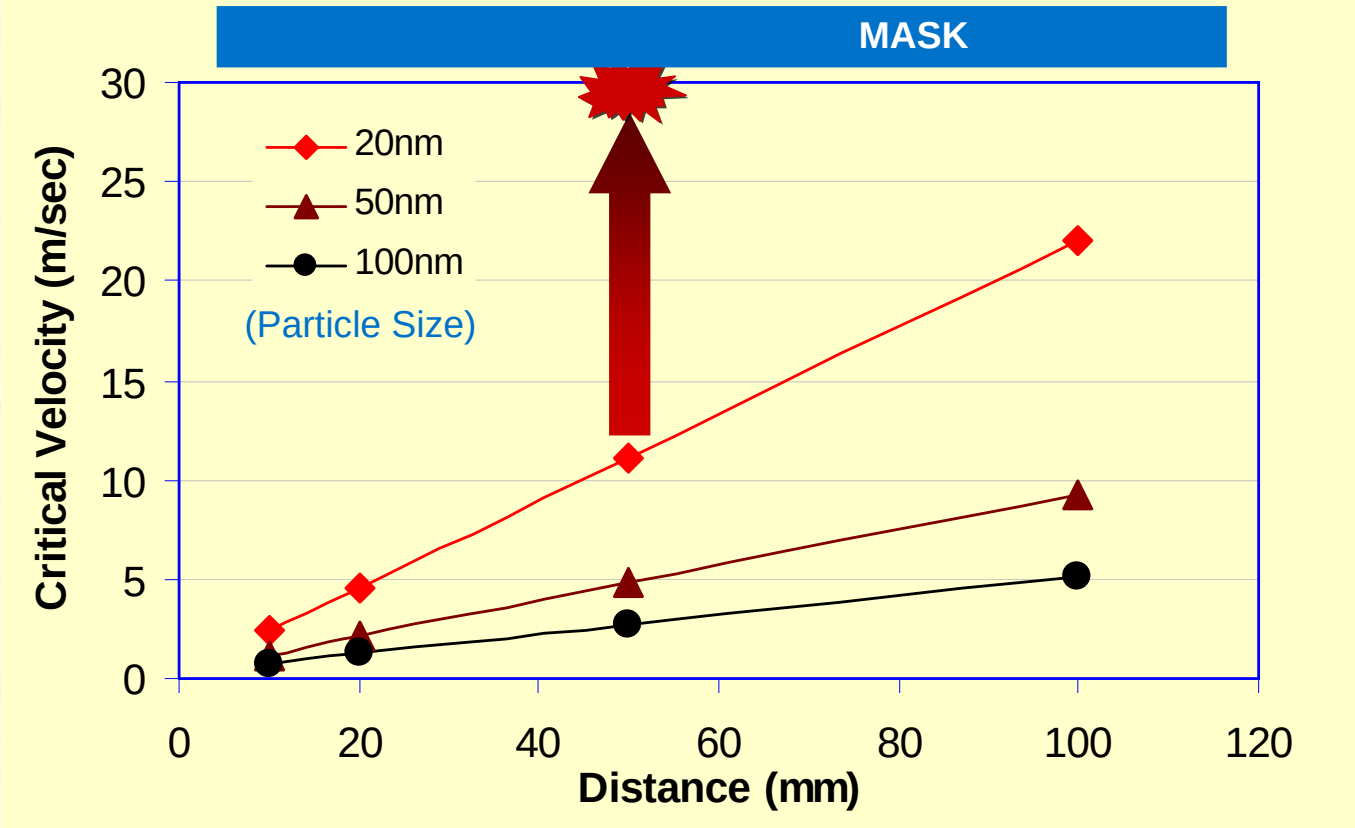
Still Need Thermophoretic Protection During Exposure?



At and above the critical velocity, a particle could reach the mask surface at and within the given distances, at 20, 50, and 100 nm sizes, respectively. (Courtesy of Dr Pui, University of Minnesota)

- **Reticle must be fully exposed during enclosure.**
- **Some protective measures have been built into exposure tools, short of a removable pellicle.**
  - But are they sufficient?

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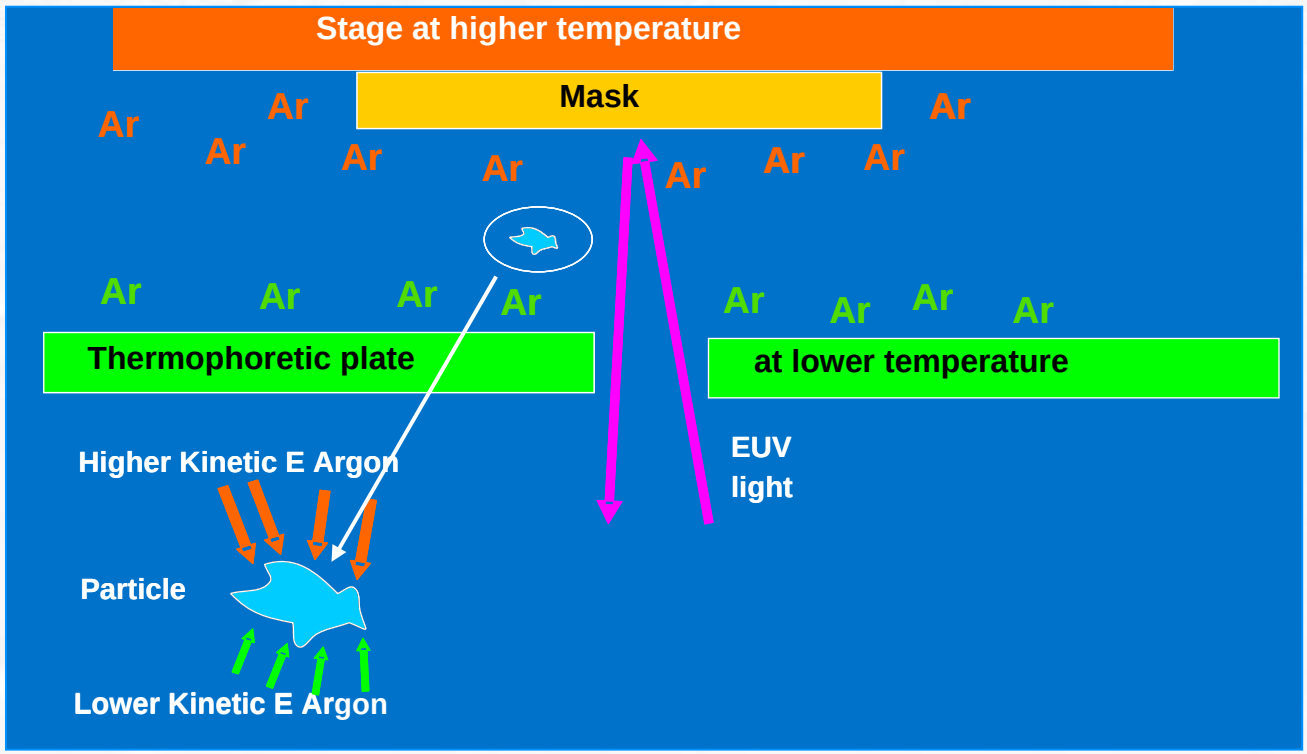
Still Need Thermophoretic Protection During Exposure?

- **Thermophoretics can provide an additional force to push particles away from diffusing toward the reticle.**
  - But, is it effective enough to make a difference?
  - SEMATECH will investigate with ~30nm inspection capability and answer this question in 2007



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Future Work

- **Continue to work with leading suppliers and consortia**
  - **Test/evaluate leading reticle carriers**
  - **Address robotic handling issues**
  - **Pilot leading carrier in small scale development line**
  - **Study reticle handling solution of Alpha exposure tool**
  - **Availability of pre-production carriers**
  - **Numerical study of leading carrier designs**
- **Vacuum protection**
  - **Study nano-particle contamination and protection below 50nm.**

    (controlled injection v. thermophoretic protection)
  - **Study e-chucking-related particle contamination**
- **Continue to provide data and direction for reticle handling standardization**
  - **Through SEMI task forces**
- **Feasibility studies of 22 nm HP requirements**

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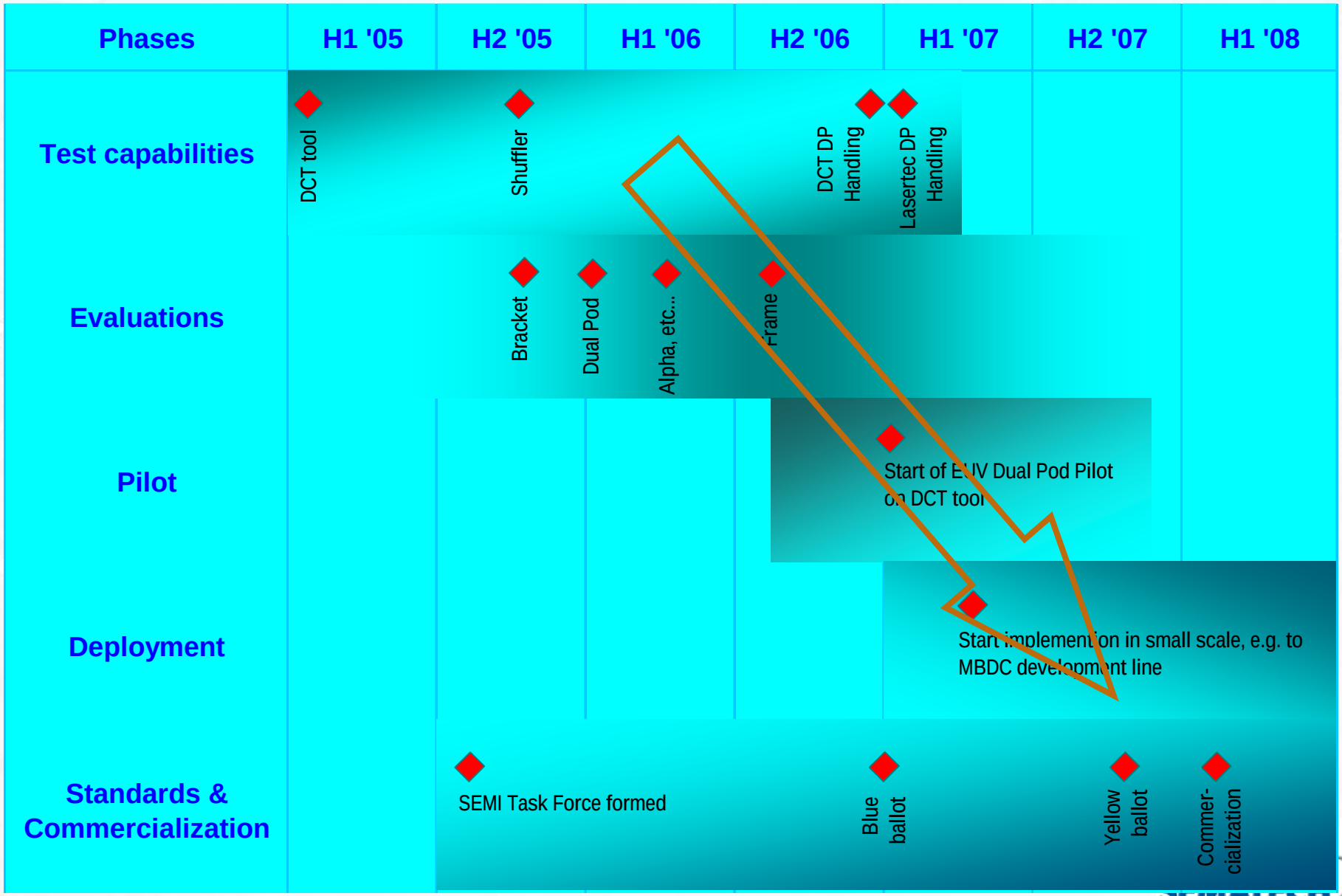
SEMATECH Reticle Handling Roadmap



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Summary

- **Leading carrier options have been emerging during 2006. Some results are promising, to meet 32 nm HP pilot/production requirements with improvements.**
  - But need continuous development/improvement.
  - Need to be validated with 35 nm inspection capability
  - Need to demonstrate particle-free robotic handling
- **SEMATECH and its partners will be generating key data in 2007, to drive reticle handling solutions towards 32 nm HP EUV production requirements.**
  - Performance of the reticle handling solution of the full field Alpha demo tool
  - Performance of leading carriers, inside and outside vacuum
  - If thermophoretics needed for vacuum protection
- **Industry EUV reticle handling standardization activities are coming along.**

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