Fused Silica Hard Pellicles: A Viable Solution for 157nm

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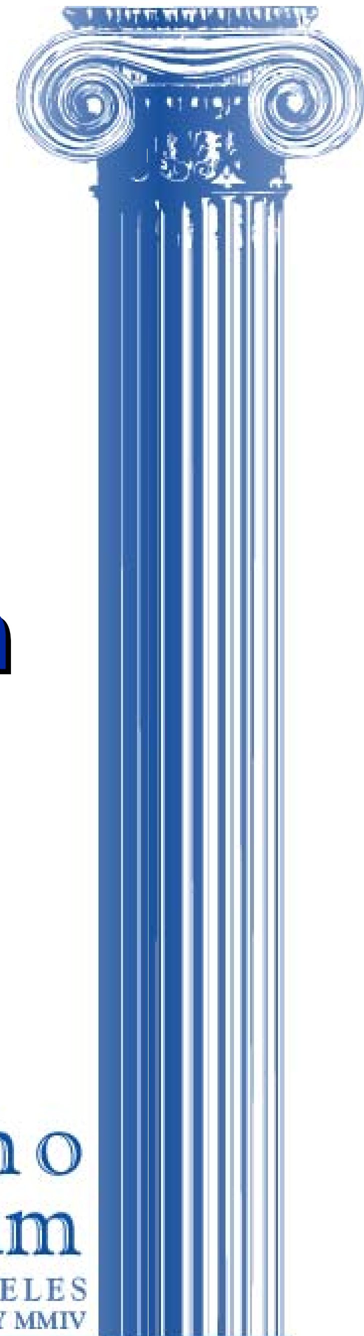

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For further details, see recent and soon to be published papers at SPIE and in JM3

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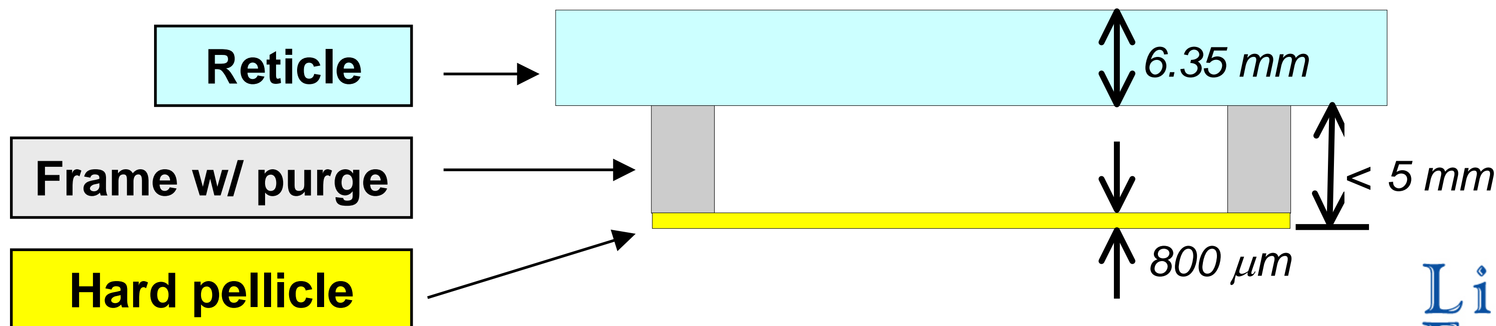
Why Fused Silica Hard Pellicles?

- **Problem: reticle protection at 157nm**
  - Polymer pellicles fall far short of laser durability requirements at necessary transmission levels
- **Hard pellicles are durable, but add new issues**
  - Pellicle optically thick
    - Must meet stringent specifications on fabrication and mounting
    - Exposure & inspection tools must compensate
  - Purge
  - Logistics

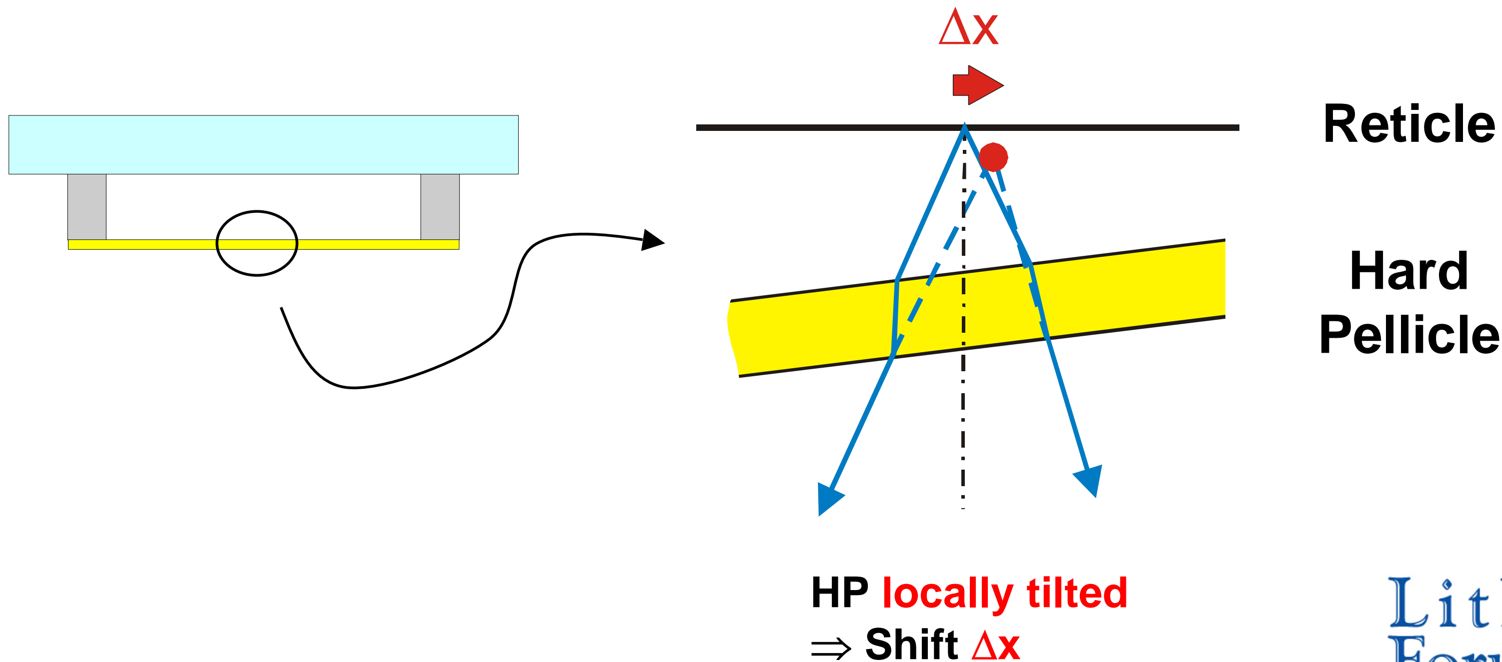


Central Challenges

- Fabrication & mounting
- Lithographic imaging
- Infrastructure

Key Requirements for Hard Pellicles

- **Specifications have been developed**
  - SEMI standard process initiated; at blue ballot
- **Toughest target: keep contribution to distortion < 2nm**
  - Refractive index homogeneity
  - Variation of local tilt



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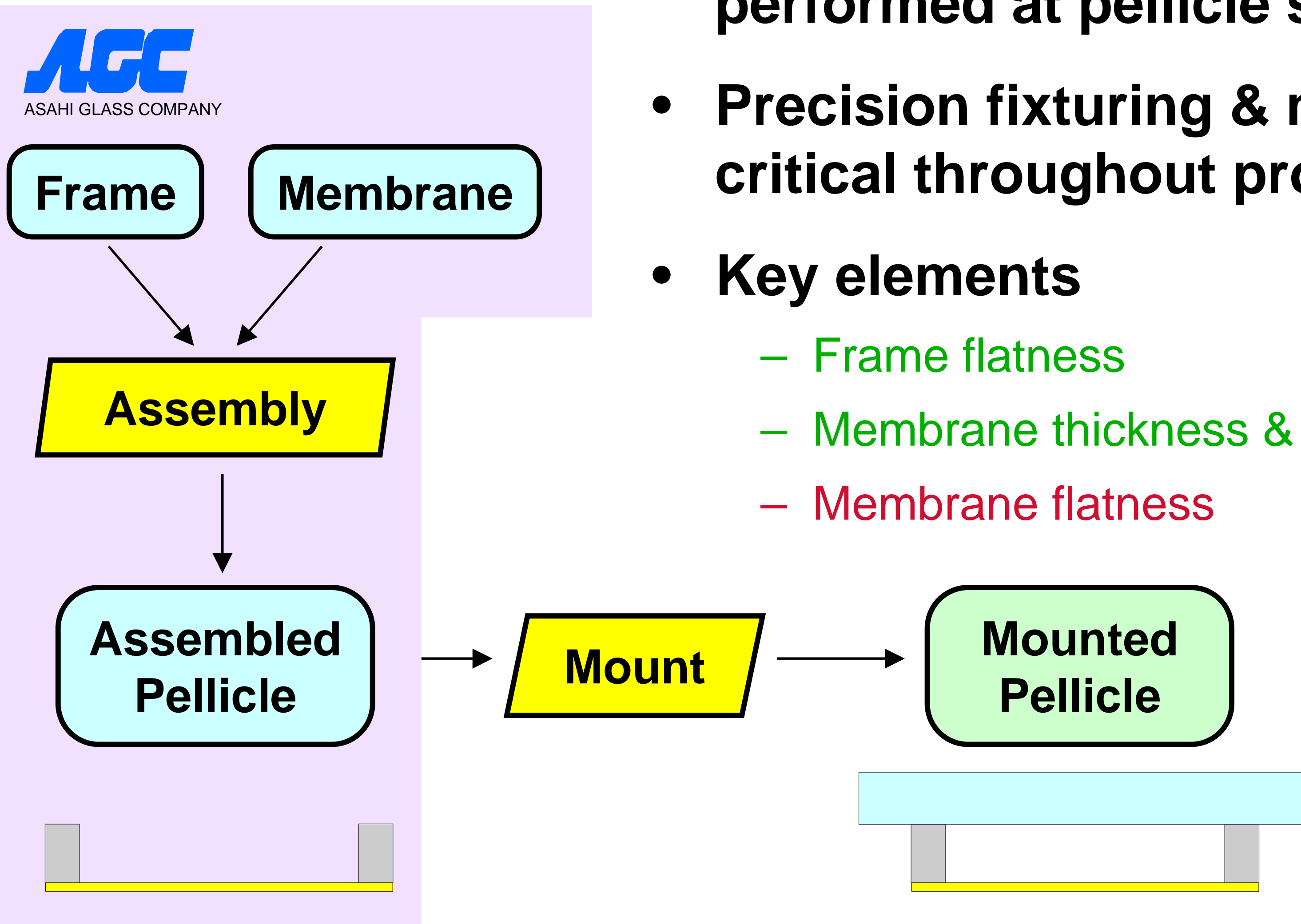
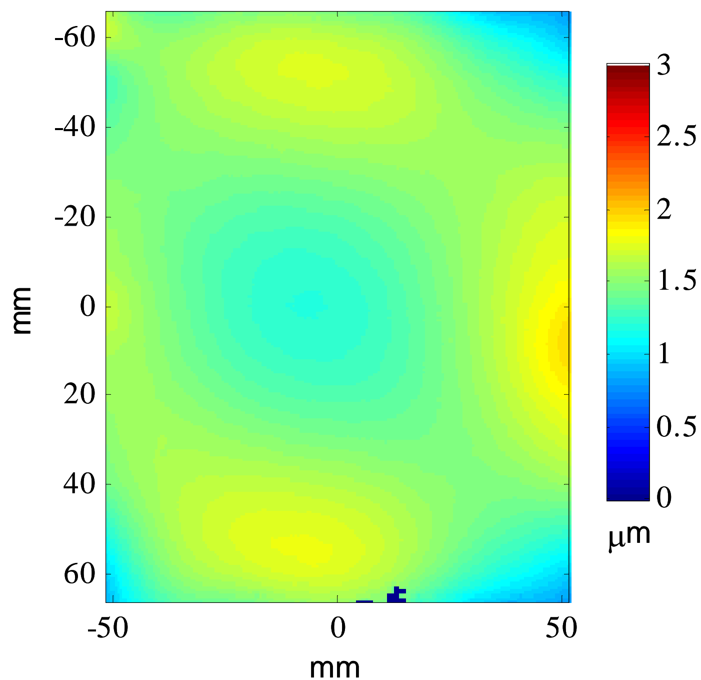
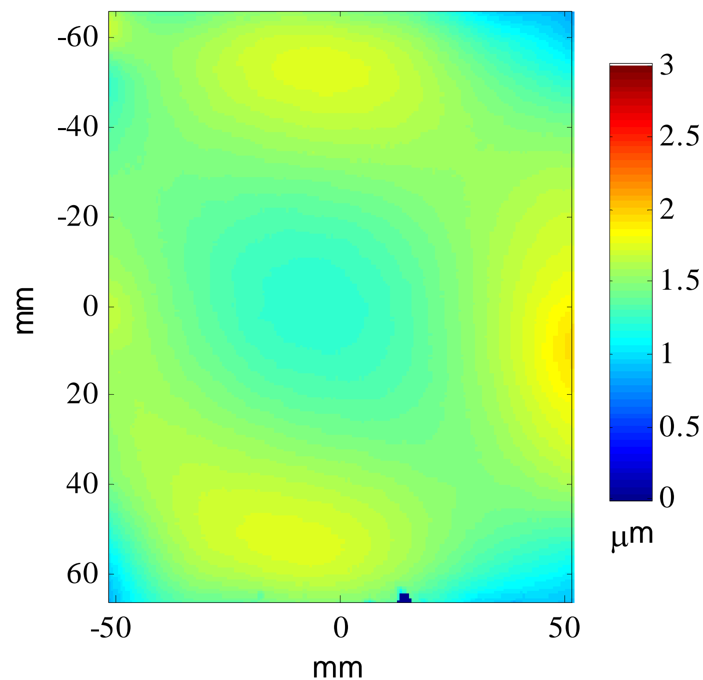
Fabrication & Mounting Process

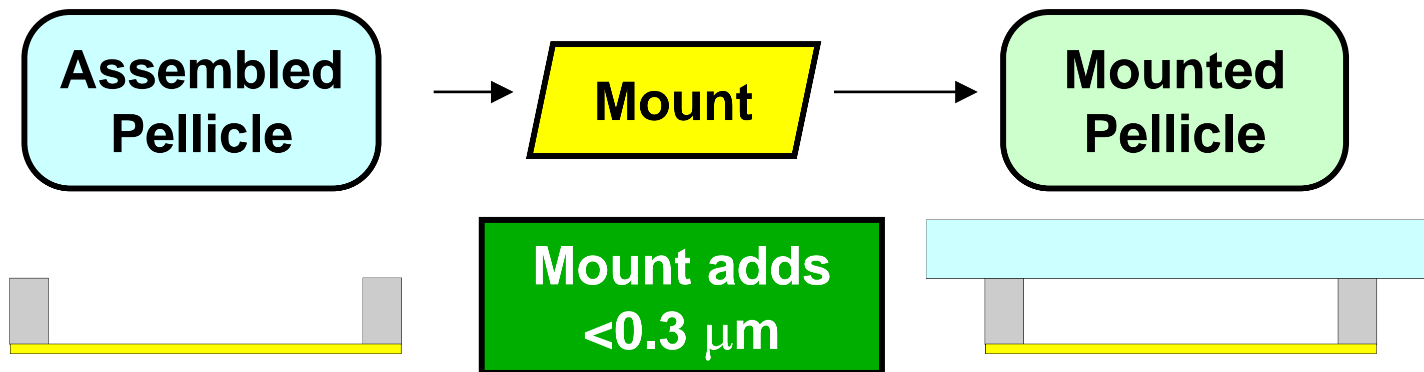
- **Steps through assembly performed at pellice supplier**
- **Precision fixturing & metrology is critical throughout process**
- **Key elements**
  - Frame flatness
  - Membrane thickness & homogeneity
  - Membrane flatness



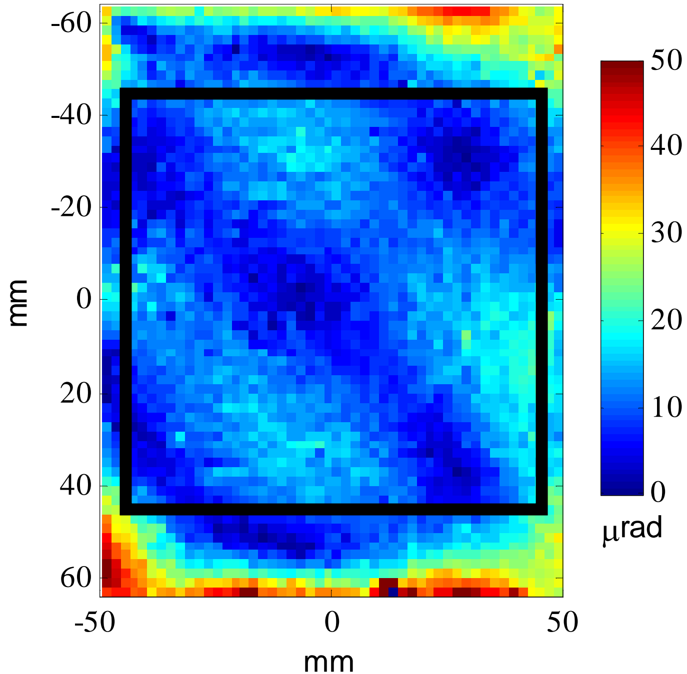
Pellicle Flatness

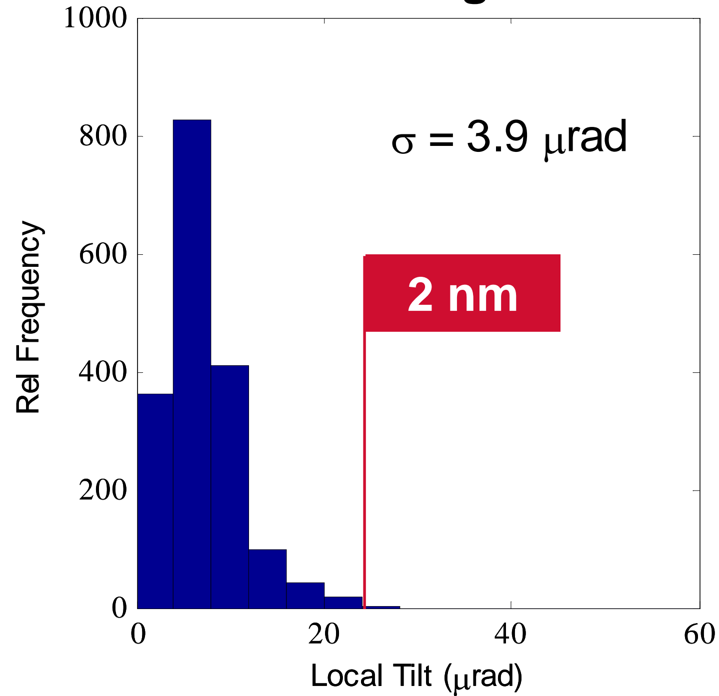


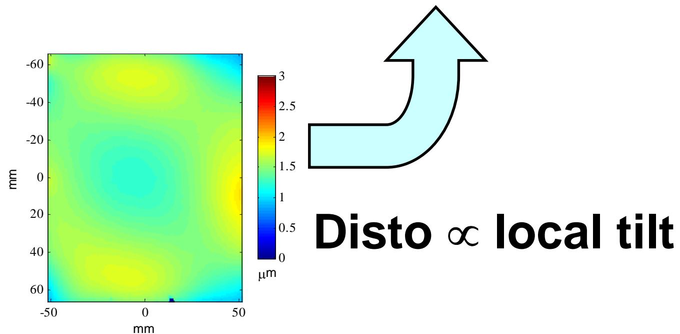




Impact on Distortion







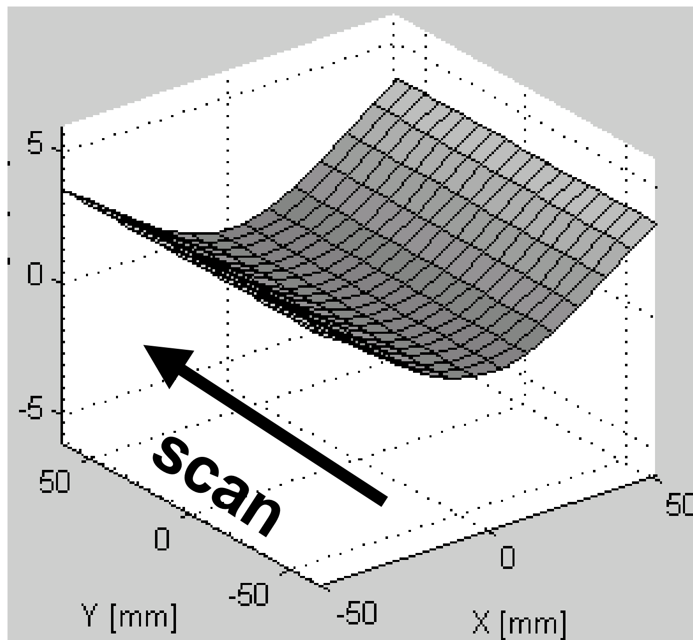
Distortion

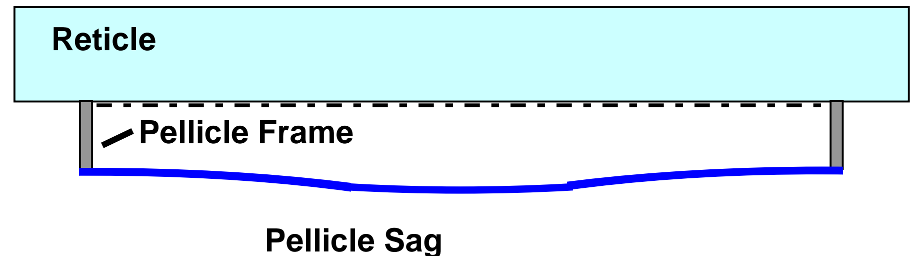
26mm x 33mm field: 90% < 2nm

22mm x 22mm field: 99.7% < 2nm

Alternate Approach: 1-D Membrane Shape

- **ASML proposal: allow pellicle to sag along scan axis**
  - Remove fabrication constraint for overall flatness
  - Perform small scanner corrections for magnification & distortion
  - Corrections can be performed automatically by scanner





ASML

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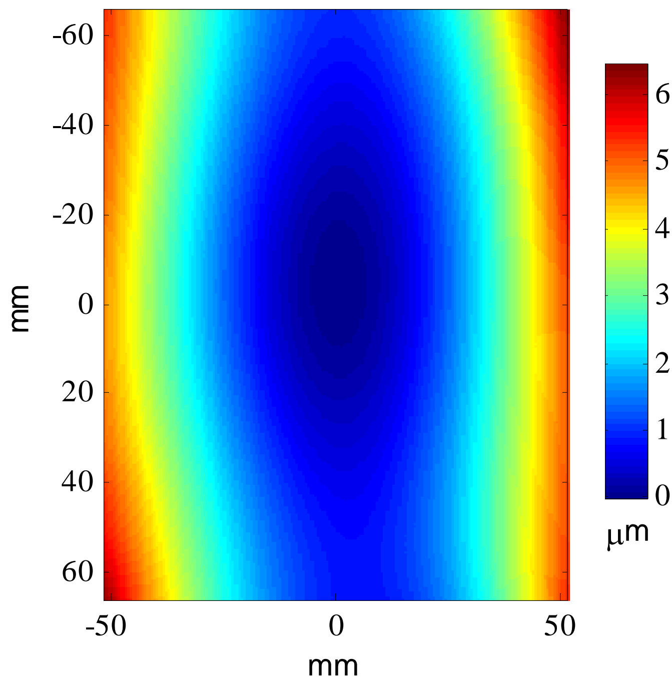
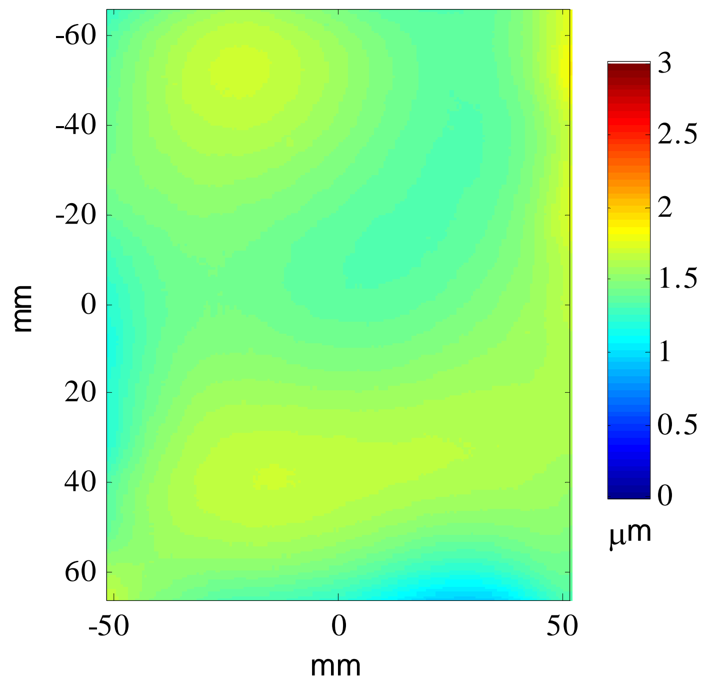
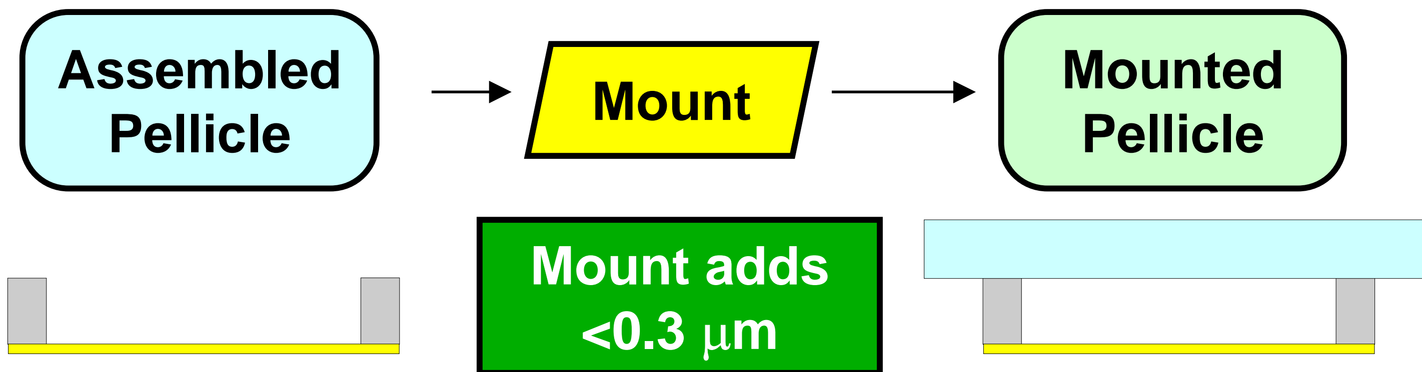
Pellicle Flatness (1-D Shape)







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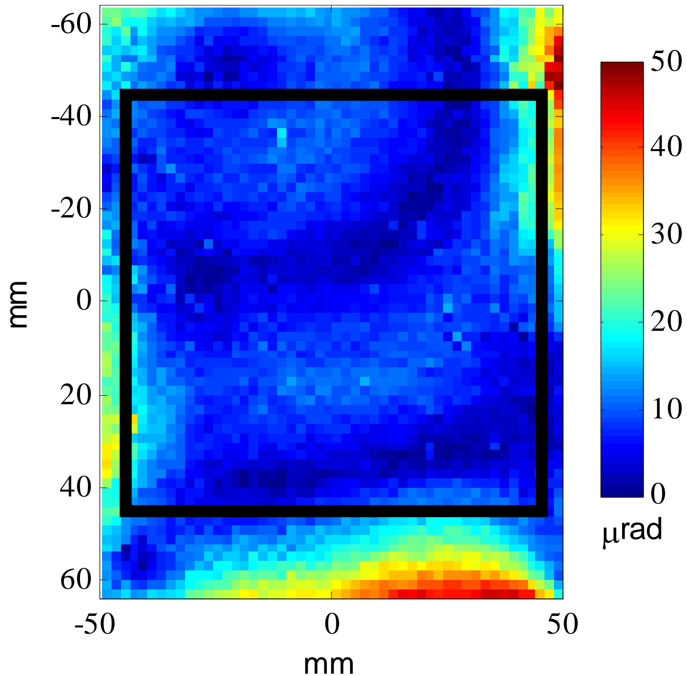
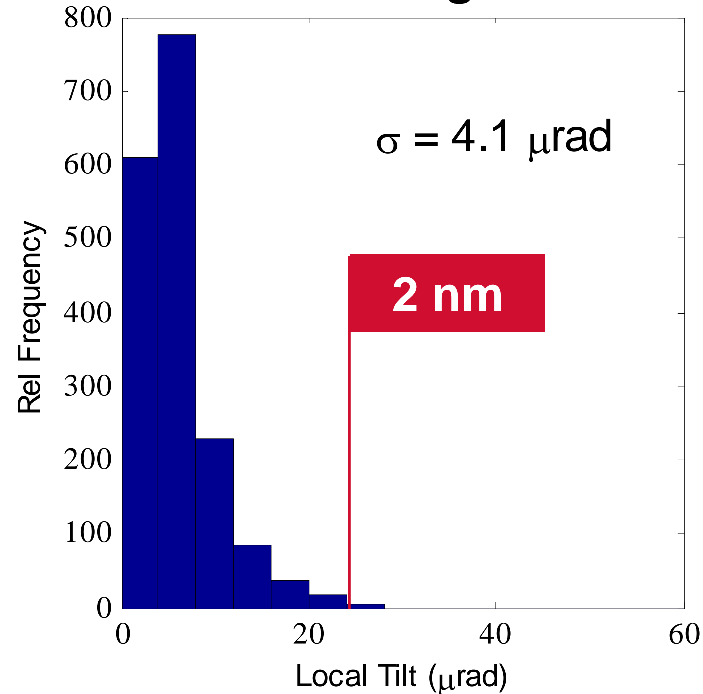
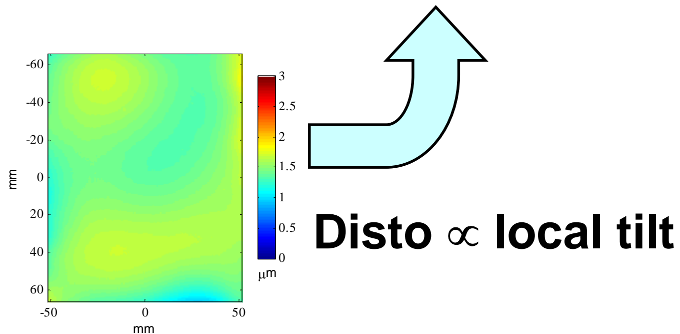
Impact on Distortion (1-D Shape)







Distortion

26mm x 33mm field: 92% < 2nm

22mm x 22mm field: 99.7% < 2nm

Initial result for 1-D shape: expect additional improvements

What Changed in Past 6 Months?

- **Improved pellicle fabrication (AGC)**
  - Both standard and 1-D shapes
- **Deterministic mounting process developed (ISMT)**
- **Inclusion of additional scanner corrections (ASML)**

Pellicles can be fabricated and mounted very close to requirements

Central Challenges

- Fabrication & mounting
- Lithographic imaging
- Infrastructure

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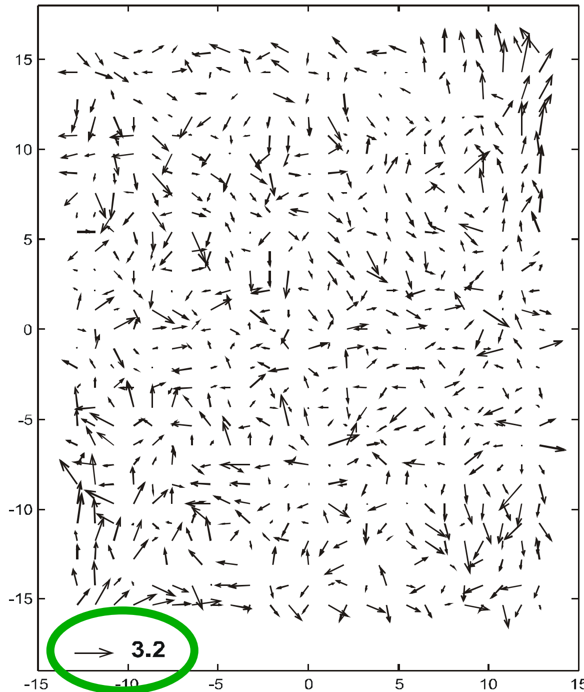
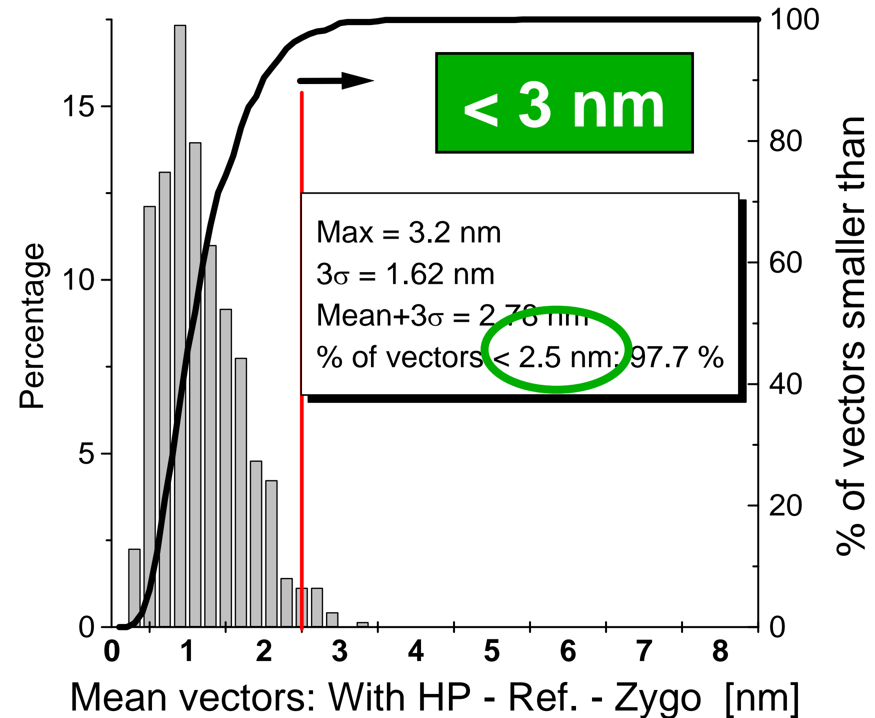
Distortion Correlates with Flatness Metrology



Experiments at 193nm

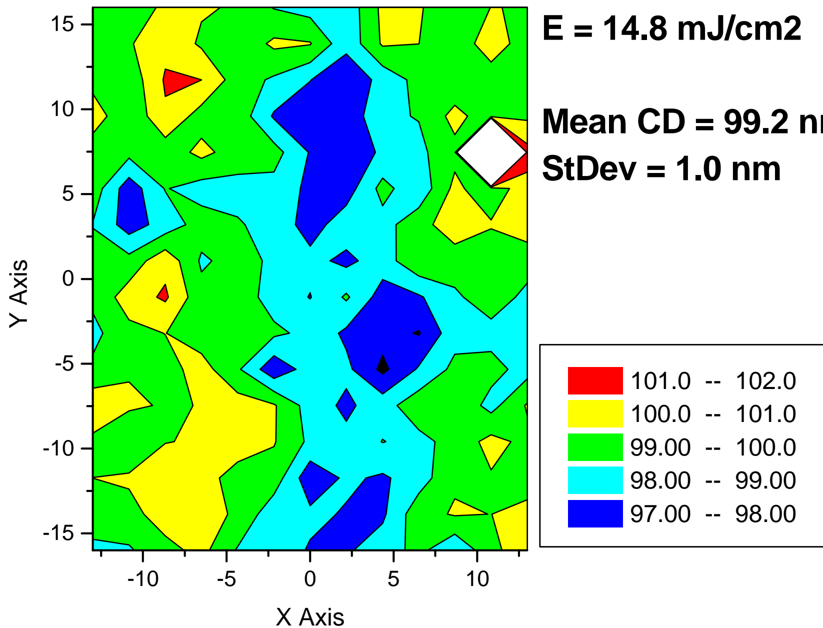


- **Correlation obtained within noise of scanner**
  - No systematic component in difference
  - Maximum residual ~3 nm
  - Solid understanding of related imaging effects

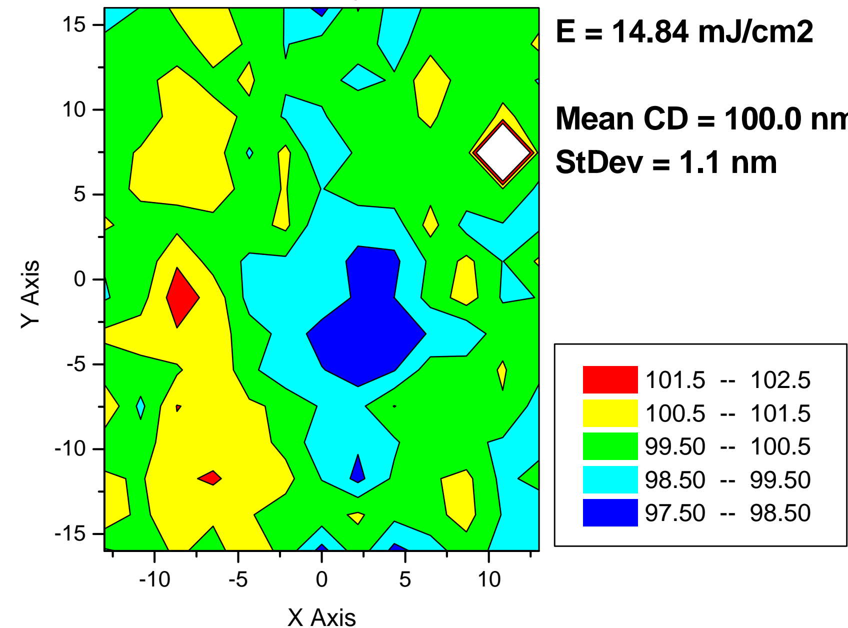
Hard Pellicle has no Impact on CDU

Experiments at 193nm

Without HP



With HP



Dose-to-Size: no difference
Intra-field StdDev: no difference

Lithographic Imaging

- **Distortion**
- **Process window**
- **Aberrations**
  - Verified to be negligible through aberration monitors
- **Purging**
  - Experiments on 157nm scanner & teststands
- **High speed scanning effects**
  - Modeling and offline experiments
  - Primary issue is MSD-type contribution (<<1nm)

Do not expect big surprises, however, imaging verification at 157nm yet to be performed

Central Challenges

- Fabrication & mounting
- Lithographic imaging
- **Infrastructure**

Marginal Cost of Hard Pellicles

- **Unit cost**
  - AGC estimates $1500 in HVM
  - Possibility for recycling may offset increased unit cost
- **New tools in mask shops**
  - Mounting
  - Flatness metrology
  - Inspection
    - Inspection tool must include lens/stage adjustments: designs exist showing this is technically possible with no loss of performance
  - AIMS
    - No change: perform before pellicle mounting
- **Marginal cost per reticle will be higher**
  - Appears manageable

Schedule Assessment

- **Pellicles available now for process development**
- **Gating factors**
  - Mounting tool
    - Current approach must be automated: estimate mid-2005 for beta
  - Contamination inspection tool
    - Contingent upon critical mass of orders
    - Earliest is mid-2006
- **Possible workarounds for early 157-nm scanners?**
  - Perform inspection through checkerboard wafer inspection

Conclusions

- **Pellicle fabrication & mounting very near requirements**
  - Substantial progress in past 6 months
- **Lithographic imaging w/ hard pellicles well understood**
  - Any residual surprises will be very small
- **Implementation path defined**
  - Tool purchases for mask shops expected to be gating factor

- **Remaining challenges are in implementation and commercialization**

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