Chucking of EUV Masks

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Outline

- Critical issues of mask chucking
- Alternative chucking concepts
- Open questions
- Possible project

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Critical Issues in EUV Mask Chucking

- Tight placement budget allows only ≈ 2 nm placement error due to clamping in e-beam writer and litho tool.
- Non-telecentricity → out-of-plane distortions (OPDs) affect in-plane-distortion (IPD) on wafer
- 50 nm mask surface roughness = 0.7 nm IPD on wafer
- For most critical spatial frequencies: IPD = 1/2 * OPD
- OPD due to multilayer stress (400 MPa): 900-1000 nm
- → use of different chucks will lead to IPDs of up to 40 nm. Pattern correction or stress compensation layers required.
- Backside particles
- Long-term stability of chucking forces
- Long-term stability of layer stress

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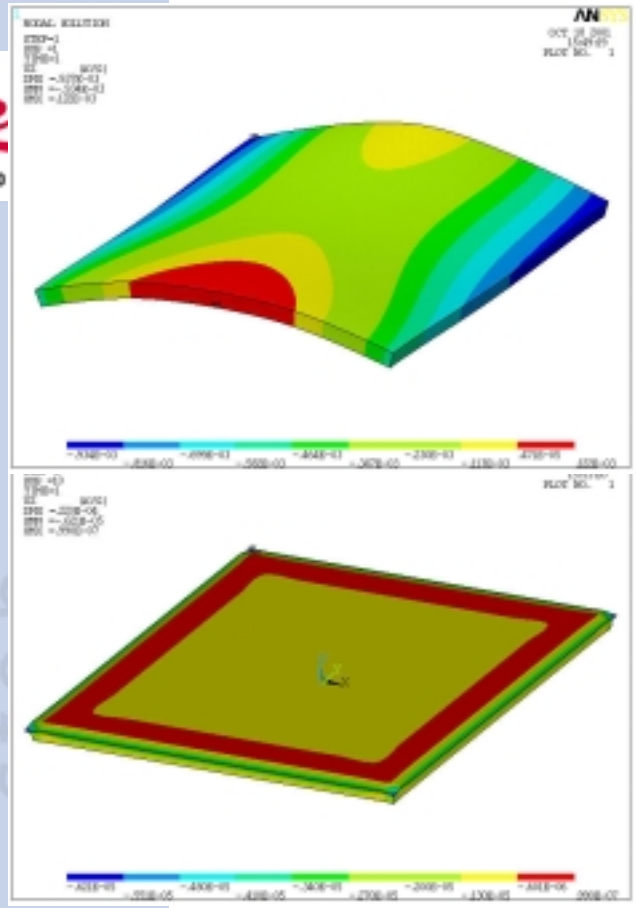
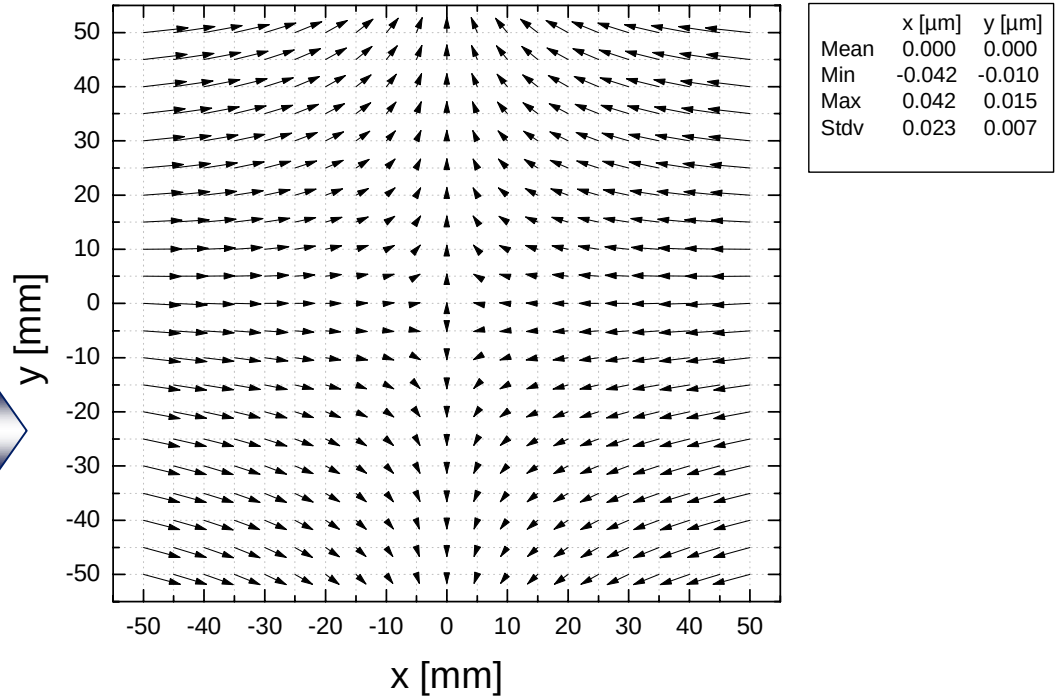
Consequences of Critical Issues

- Flat e-chuck :
  - Backside coating necessary
  - Backside particle inspection necessary
  - Stability of chucking forces has to be measured/controlled
  - Electrical and surface properties of backside have to be controlled
  - Electrical shielding necessary in e-beam writer
  - Particle attraction during use in air (temperature control for metrology!)
- 3-point chuck :
  - Mask bow will require pattern correction on 3-pt. chuck or use of compensation layers
  - Placement results will have to be transformed into flat state
  - Particle generation by chuck pins has to be controlled
  - Stress stability, absolute stress and stress homogeneity have to be controlled precisely

Influence on Image Placement





	x [µm]	y [µm]
Mean	0.000	0.000
Min	-0.042	-0.010
Max	0.042	0.015
Stdv	0.023	0.007

- OPD on 3-pt. chuck (above): 1056 nm
- Mask chucked flat on electrostatic chuck (below)
- Max. IPD due to use of different chuck types : 42 nm

Current Chucking Concept

	E-beam Writer	LMS IPRO	EUV Tool
Flat chuck			☒
3-point chuck	☒	☒	

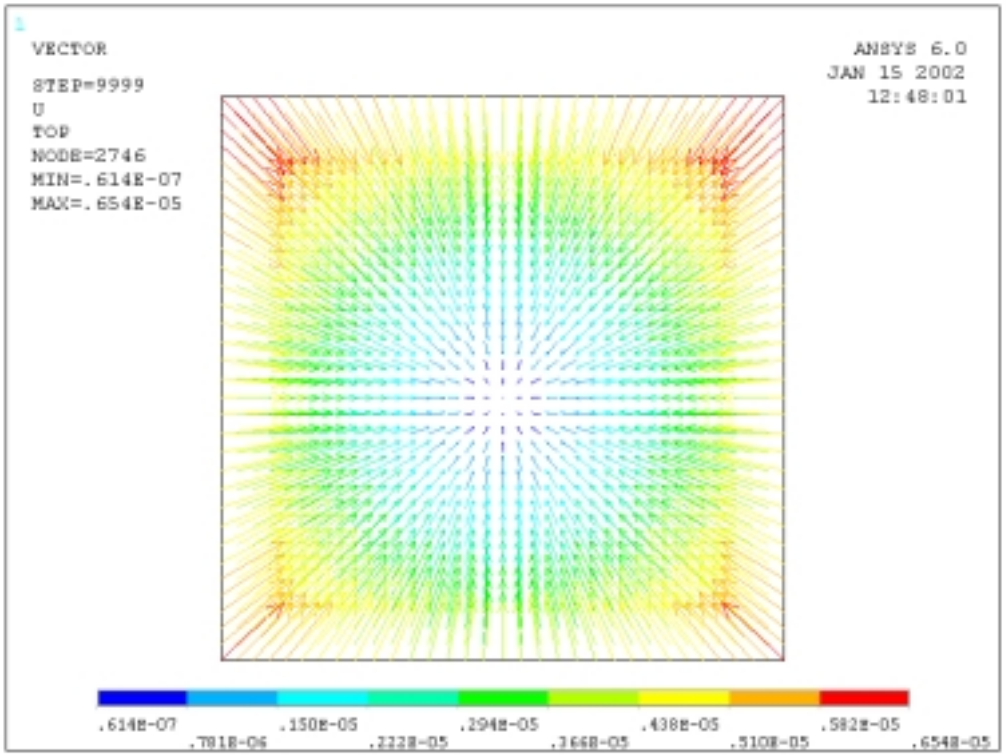
- Benefits :
  - Same chuck for e-beam writer and metrology tool
  - High repeatability of chucking forces
- Problems for EUV :
  - Effects of non-telecentricity not measured by metrology tool
  - Transformation of measurement result into flat state necessary
  - Potential error sources

Chuck Alternative # 1: Mixed Chucks

	E-beam Writer	LMS IPRO	EUV Tool
Flat chuck		☒	☒
3-point chuck	☒		

- Required actions /Challenges:
  - Specify layer stress and stress stability of every layer
  - Apply pattern correction in e-beam writer or by FE model
  - or adjust and control backside stress for bow compensation
- Benefits :
  - high repeatability of chucking forces in e-beam writer
  - no need to transform IPRO results into flat state
  - no potential error source due to e-beam deflection by chuck fields
  - no re-design for e-beam writer chuck

Requirements on Layer Stress Homogeneity



40 MPa ML stress change on full area : 4.8 nm max IPD on 3-point chuck.

- Absolute global stress value needs to be specified with ≈ 8 MPa precision for 1 nm IPD control
- Local variation of 40 MPa on 40x40 mm^2 area causes 0.8 nm IPD

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Chuck Alternative #2 : Standardized Flat Chucks

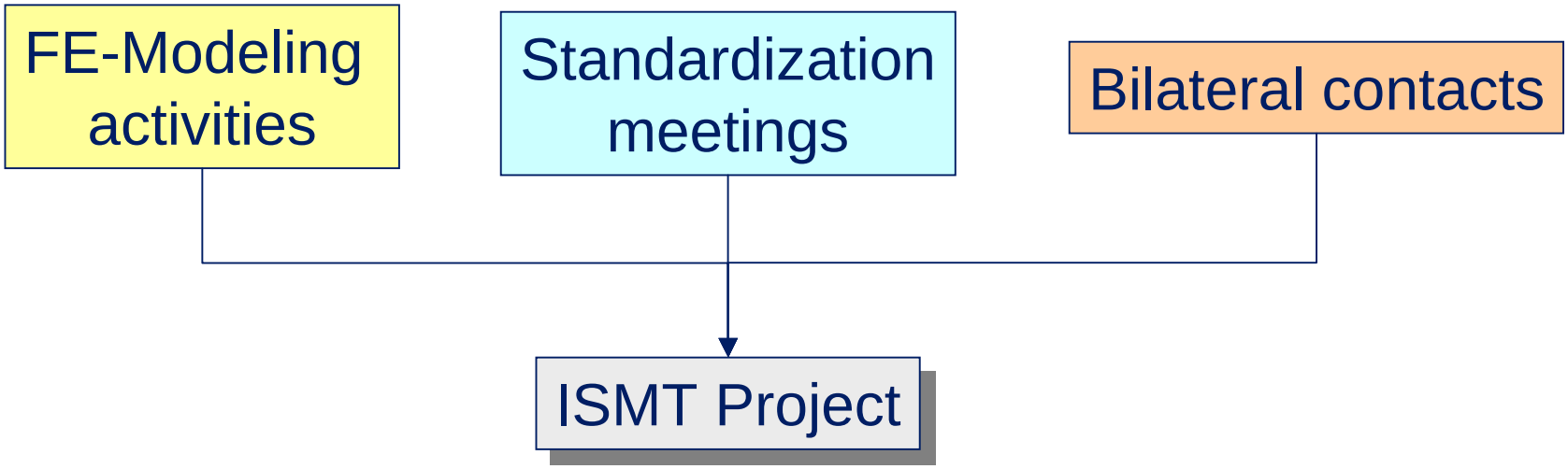
	E-beam Writer	LMS IPRO	EUV Tool
Flat chuck	☒	☒	☒
3-point chuck			

- Required actions/ challenges :
  - integrate e-chuck into e-beam writer
  - control stability of chucking forces (backside layer surface,...)
  - potential source for backside particles
- Benefits :
  - no need for pattern correction
  - stress compensation not necessarily needed (within certain range)

Remaining Questions/ Technical Issues

- Could flat e-chuck be replaced by equivalent vacuum chuck for use in air ?
- Particle attraction of e-chuck when used in air ?
- Temperature control of metrology tool (LMS) when vacuum necessary ?
- How to control stability of chucking forces ?
- How to control heat contact conductance ?
- Constraints on mask processing due to backside surface (adsorptive layers, conductivity change,...) ?
- Need to change process line to backside-compatible handling ? (most likely : yes, since metrology measurement in flat state)

Potential ISMT Project Outline



- Goal of Project :
  - Act as platform to combine various standardization activities
  - Get input from tool suppliers as well as mask manufacturers
  - Provide industry consensus on chucking issue
  - Accelerated development, driven by project frame (milestones...)

Scope and Structure of Project

- Scope :
  - Compare and evaluate chucking concepts
  - Design and build test chuck, verify chuck performance experimentally
  - Create standard for basic chuck properties

Project Member	Function	Affiliation
Tool manufacturers	Give input on constraints due to tool design	„Steering council“
Mask manufacturers	Give input on constraints due to handling, processing, costs	„Steering council“
Chuck R&D	Evaluate concepts, design chuck	Project member
Chuck manufacturer	Build test chuck	Project member
Mask R&D, mask manufacturers	Verify experimental results	Project member

Boundary Conditions from a Maskmaker's View

- **Compatibility**
  - Blank structure (layers, backside...) should be as compatible with current tools as possible
  - Processing of blanks should be as compatible with current processes as possible
  - Different concepts (mixed, flat...) for different tool suppliers not acceptable
  - Blank-dependent data correction not acceptable
- **Handling**
  - Chucking concept and blank structure have to be adjusted to handling concept
- **Costs**
  - Chucking concept should not reduce blank yield (additional layers, additional constraints...)