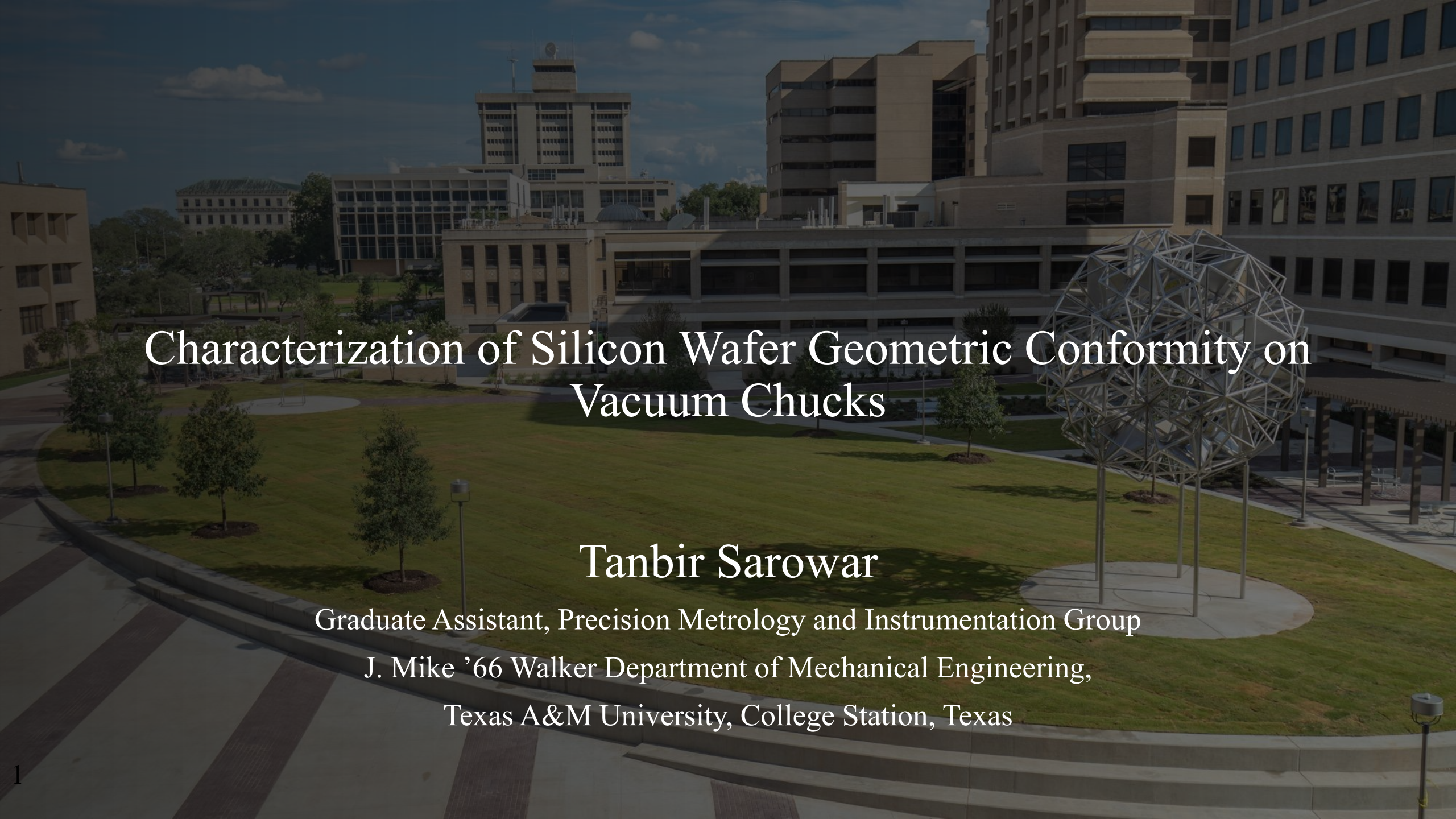




Characterization of Silicon Wafer Geometric Conformity on Vacuum Chucks

Tanbir Sarowar

Graduate Assistant, Precision Metrology and Instrumentation Group

J. Mike '66 Walker Department of Mechanical Engineering,

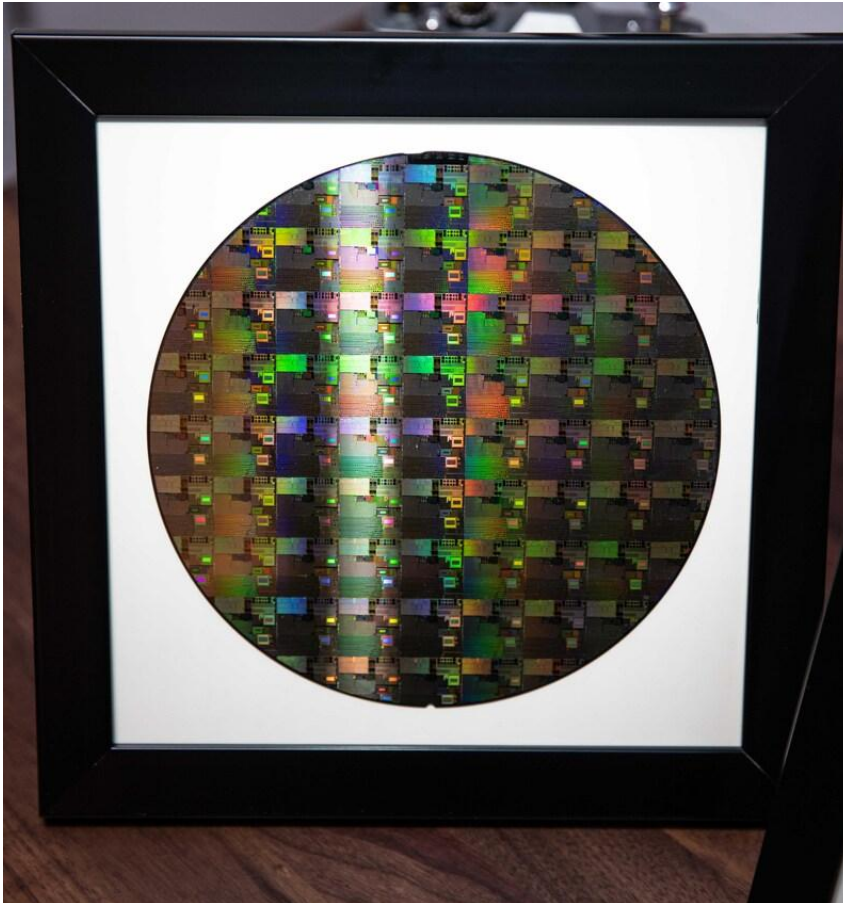
Texas A&M University, College Station, Texas

Wafer Warpage on Chucks

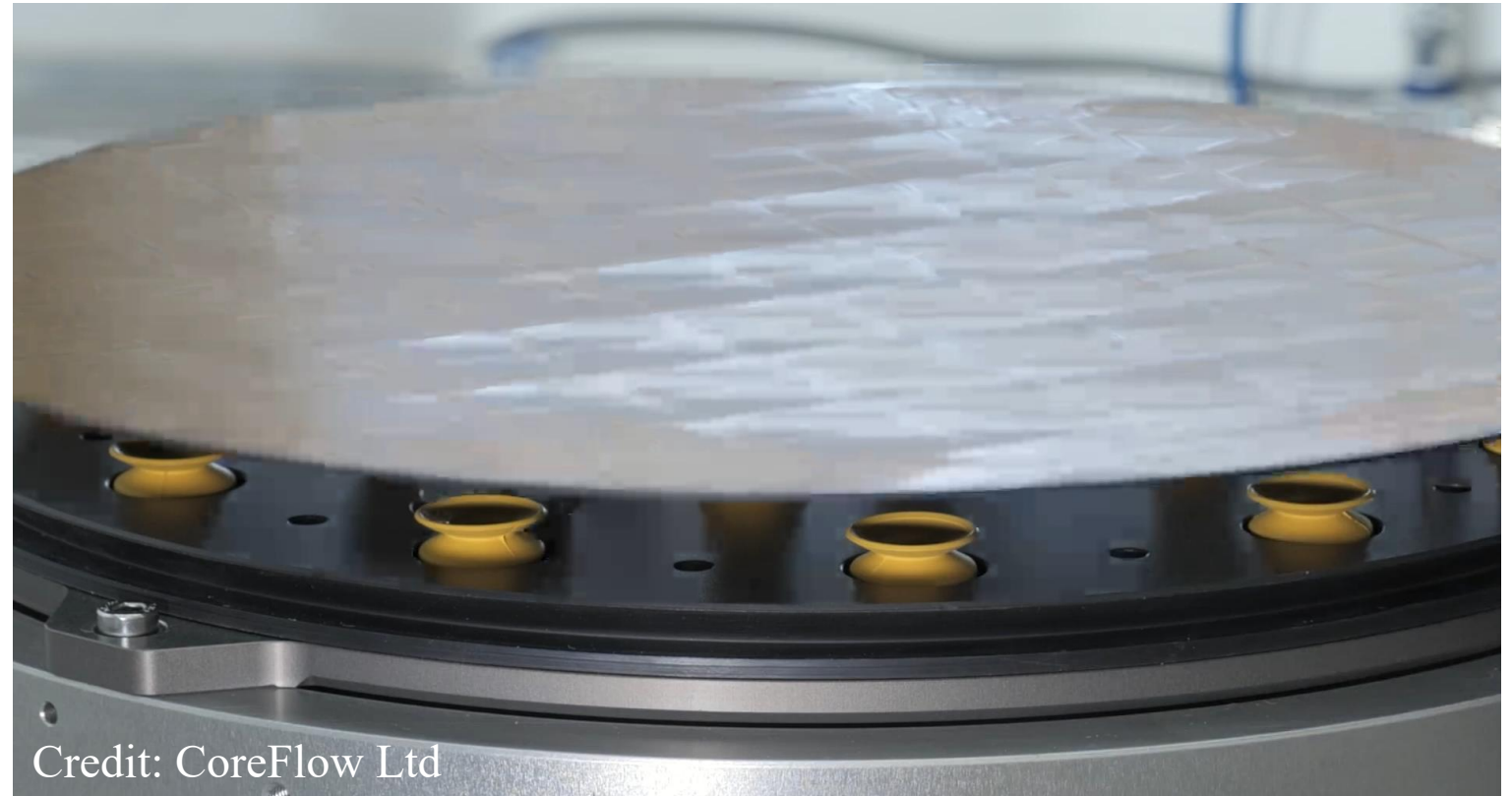


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ø300 mm wafer with transistors

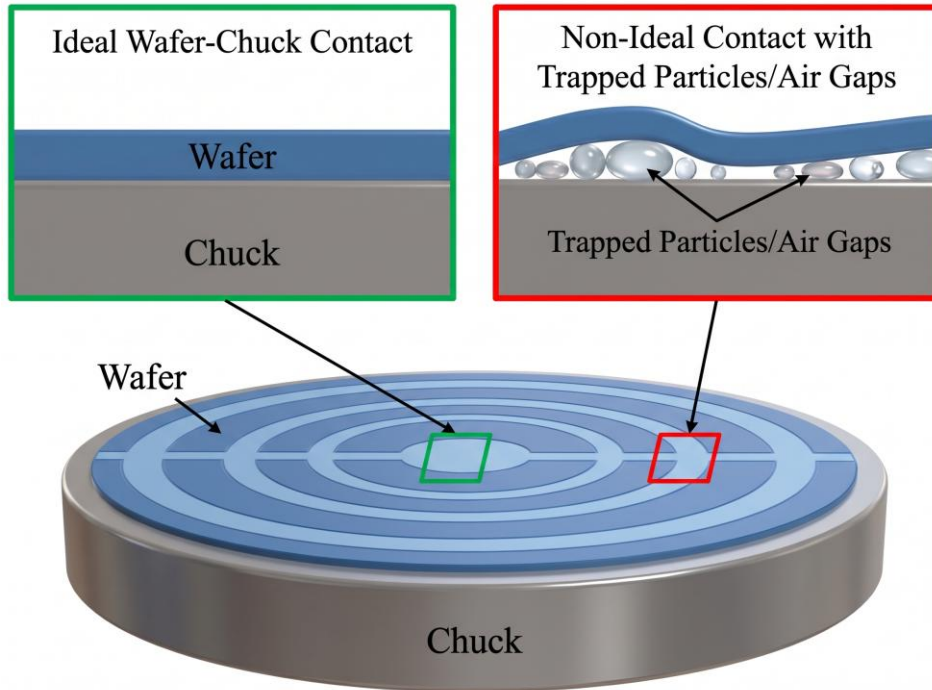


Motivation

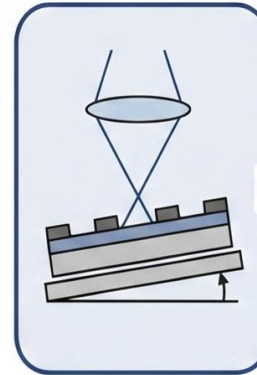


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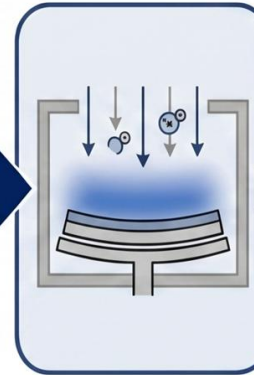


EUV Lithography



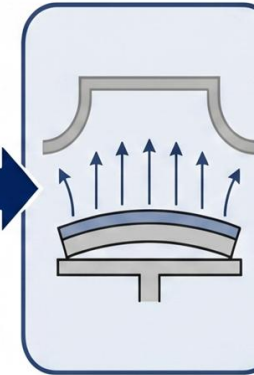
Chuck tilt shifts focal
plane → **overlay
error > 0.5 nm**

Plasma Etching



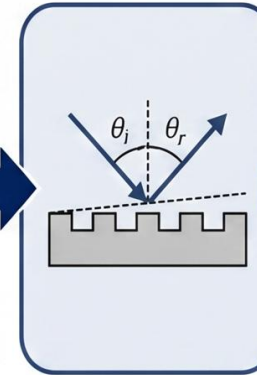
Wafer bow changes
sheath gap → **etch
rate non-uniformity**

CVD / ALD



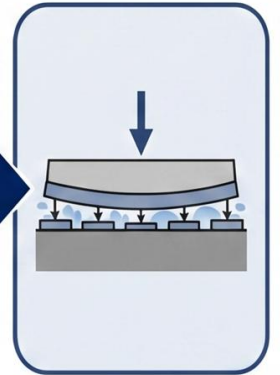
Deformation alters
precursor standoff →
film thickness variation

OCD Metrology



Surface tilt rotates
diffraction angles →
**model mismatch in
CD extraction**

CMP

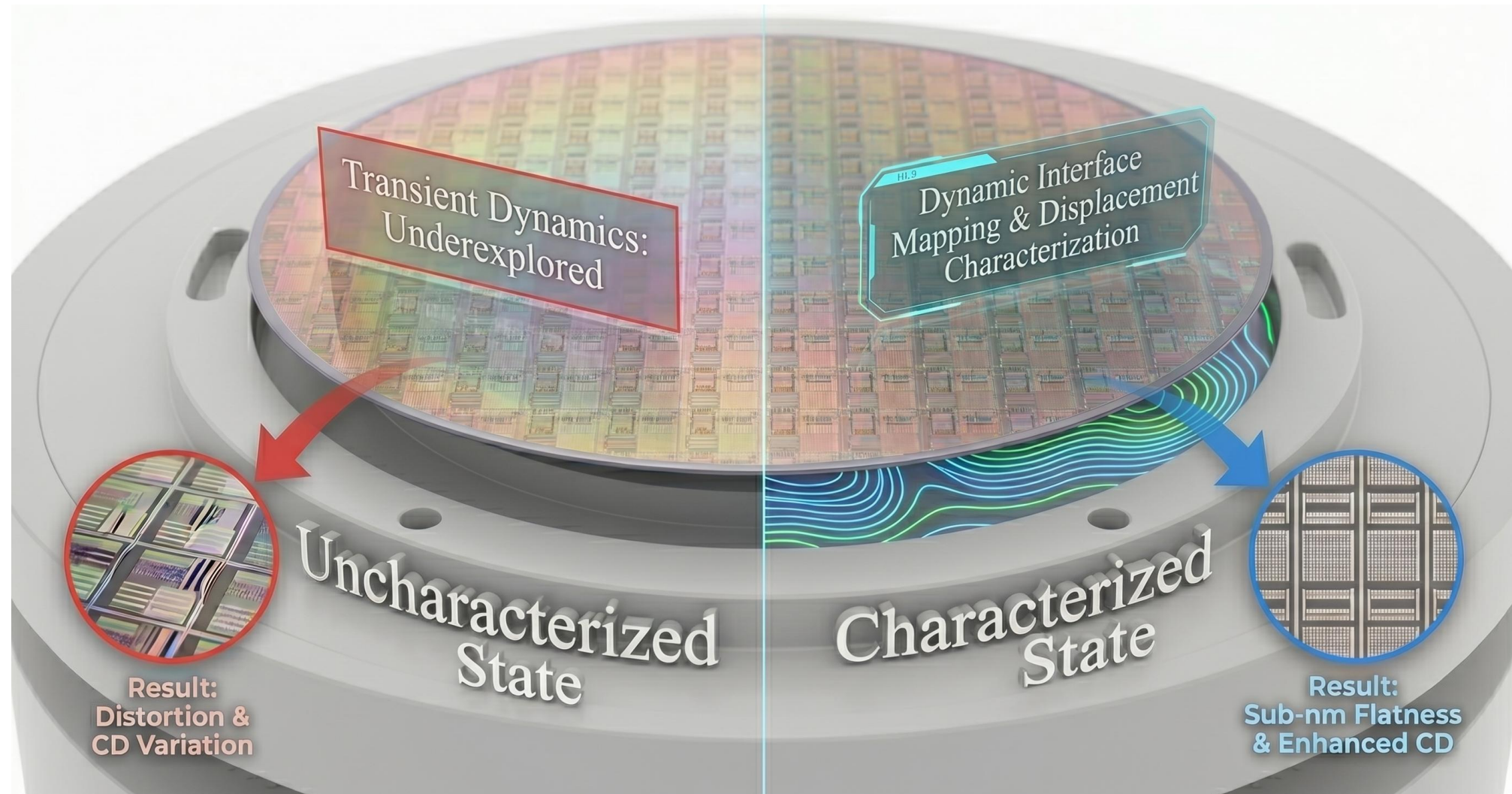


Chuck-induced stress
changes local contact
pressure → **dishing
and erosion**

Pattern Critical Dimension



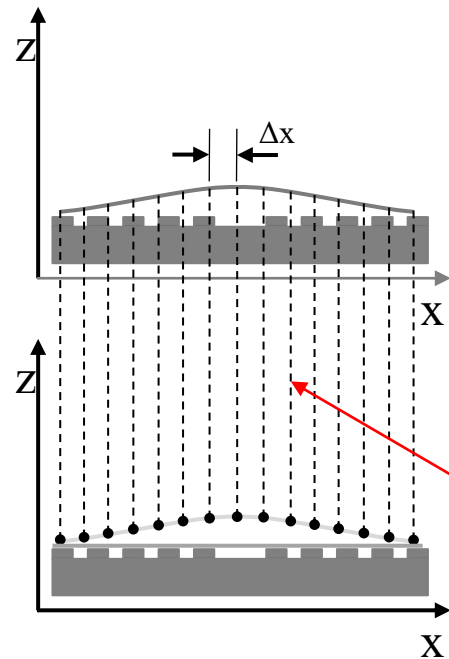
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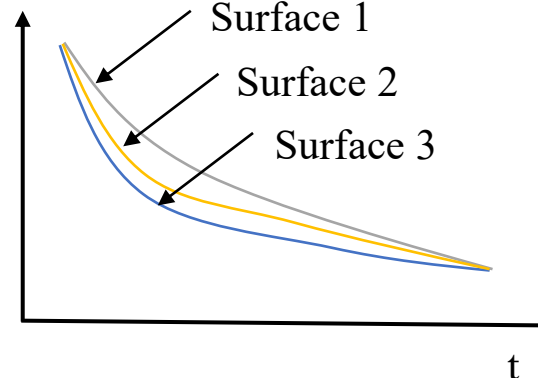
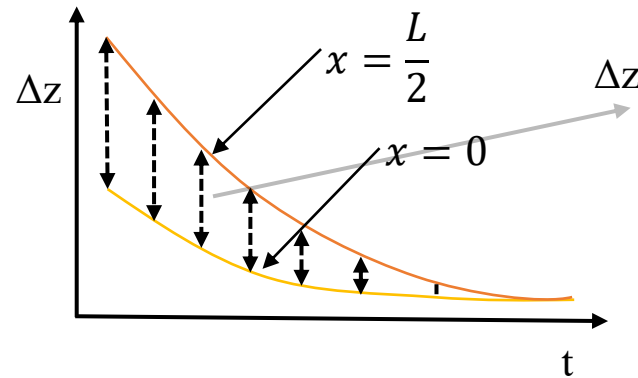
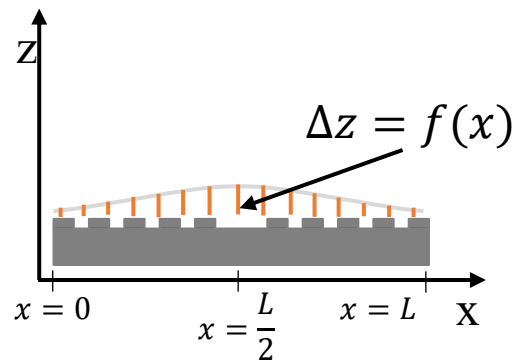
Design of Experiment



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Need to track multiple locations at the same time!



Parameter of Interests

1. Number of points along one axis
2. Time step
3. Warpage plane

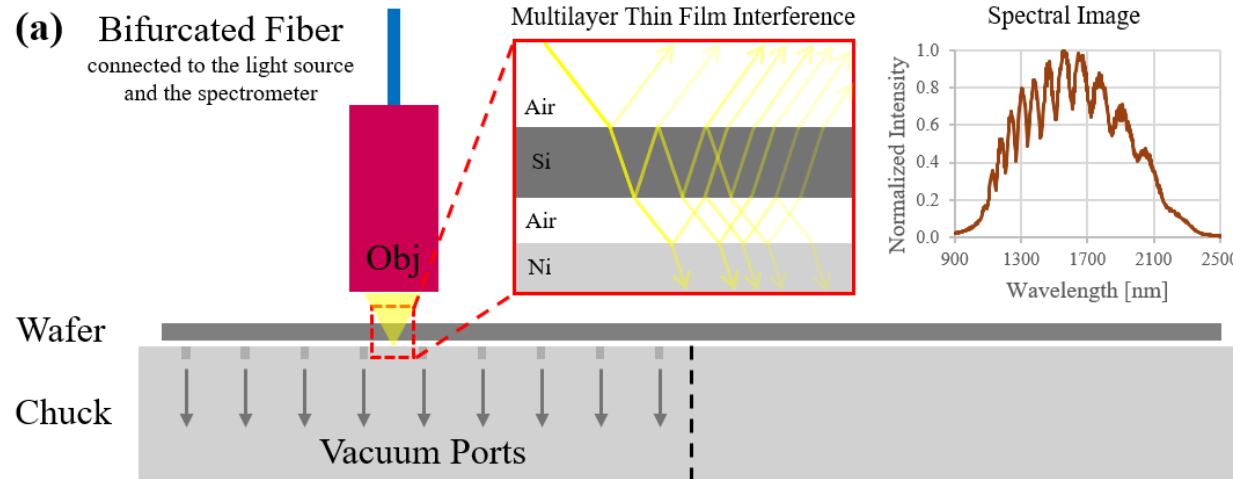
Near Infrared Reflection Spectroscopy



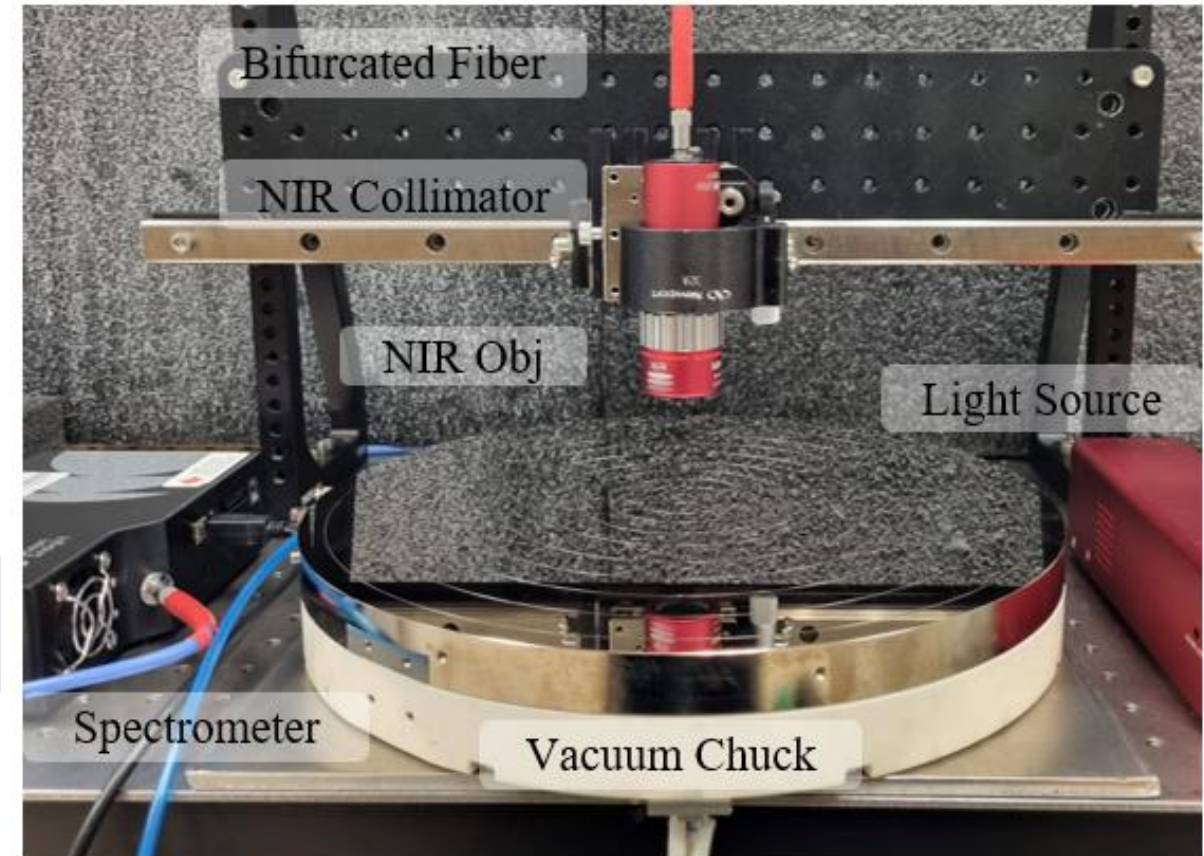
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Mechanical Engineering

$$2nd\cos\theta=m\lambda$$

Where n and d represent the refractive index and thickness of the thin-film respectively!



Principle
of
Fabry-Perot interferometer

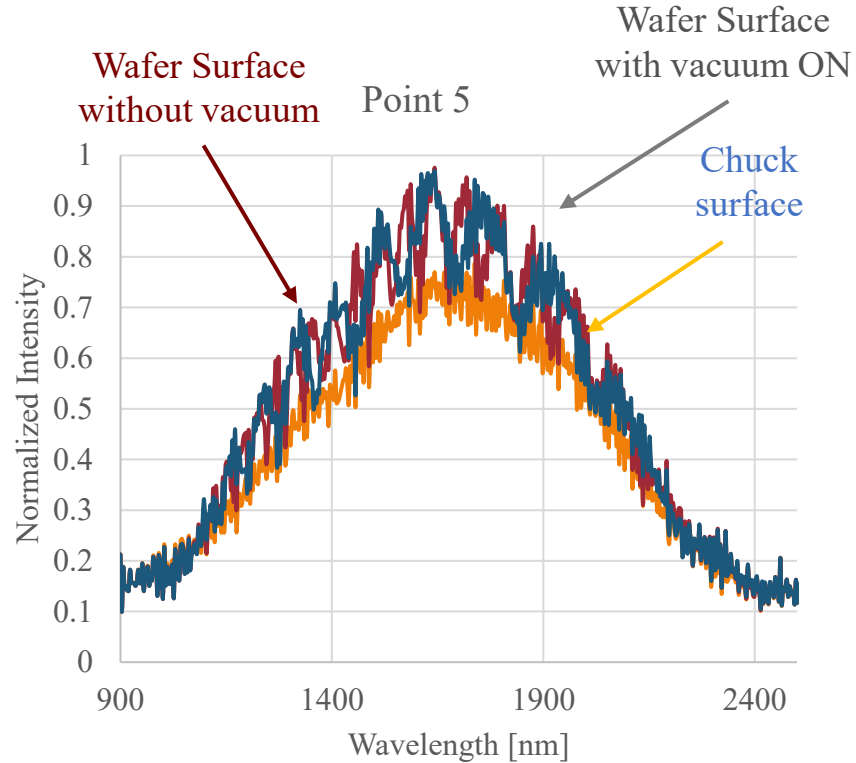


Lim, Yaeun, Tanbir Sarowar, Kuan Lu, and ChaBum Lee. "IN SITU METROLOGY OF WAFER-VACUUM CHUCK INTERFACES USING REFLECTION SPECTROSCOPY TO MEASURE AIR GAP." *Texas Journal of Microscopy* 57, no. 1 (2026): 44.

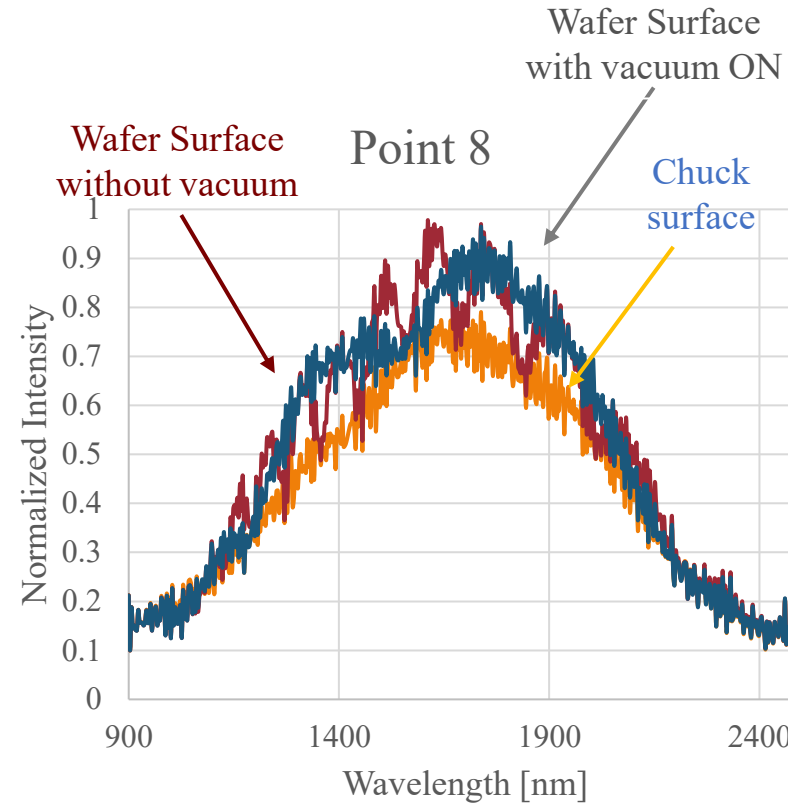
NIR Spectroscopy Methodology



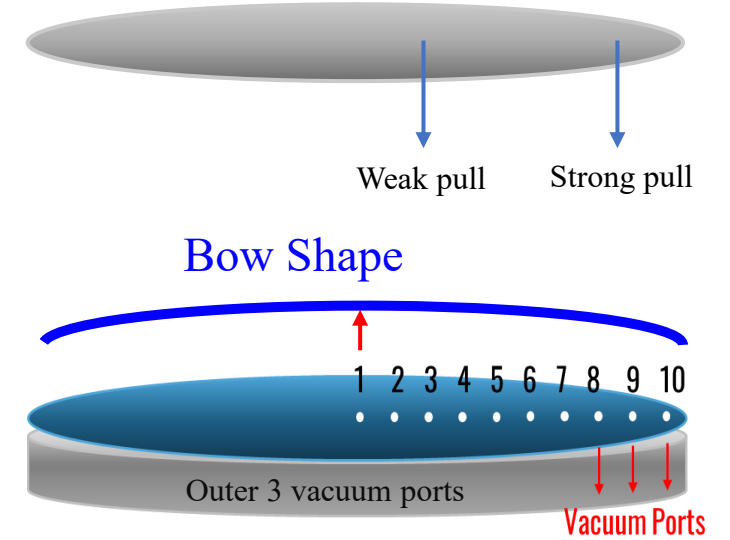
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No change in air gap while vacuum operation!



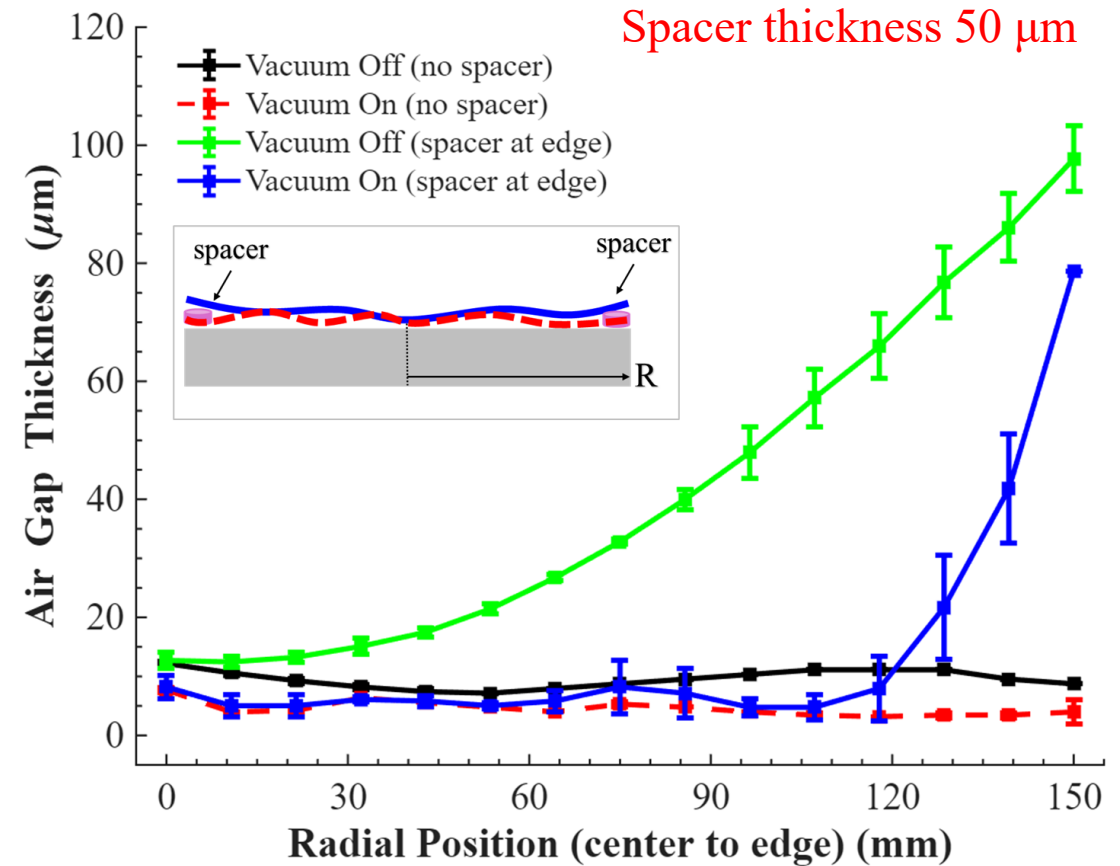
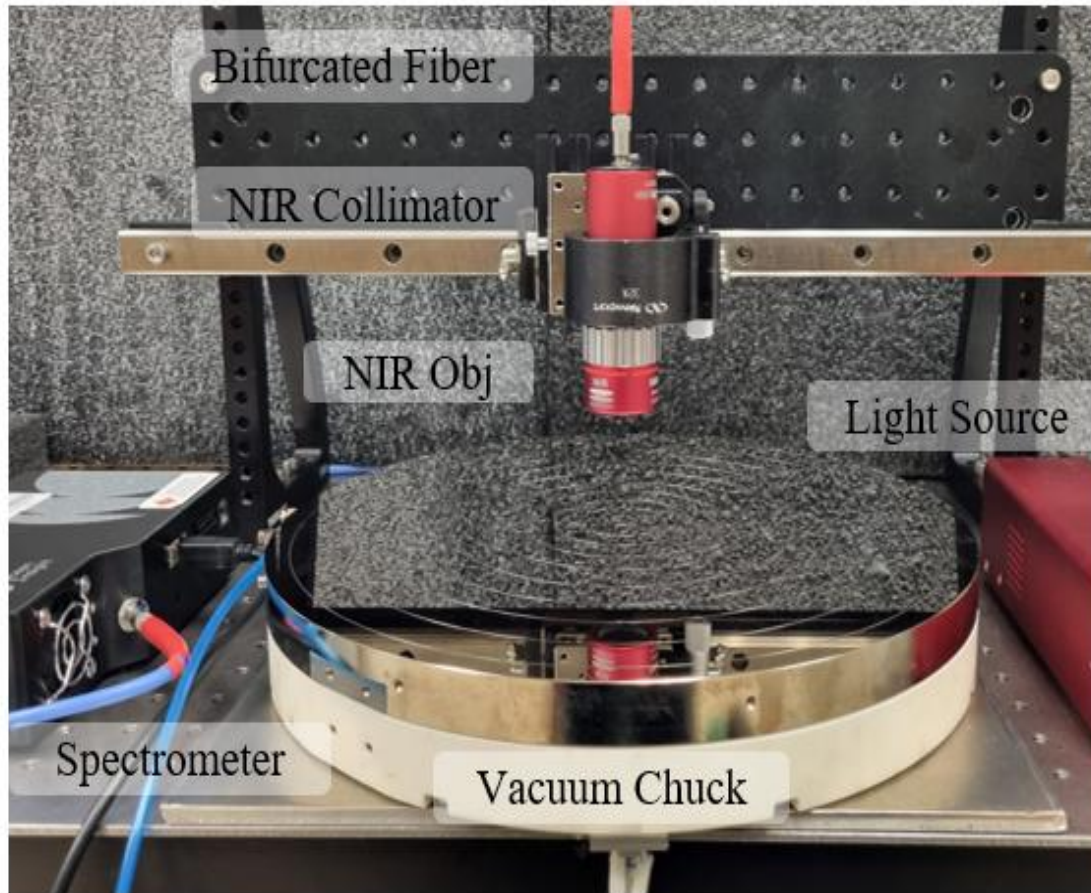
Reduced air gap while vacuum operation!



NIR Spectroscopy Data



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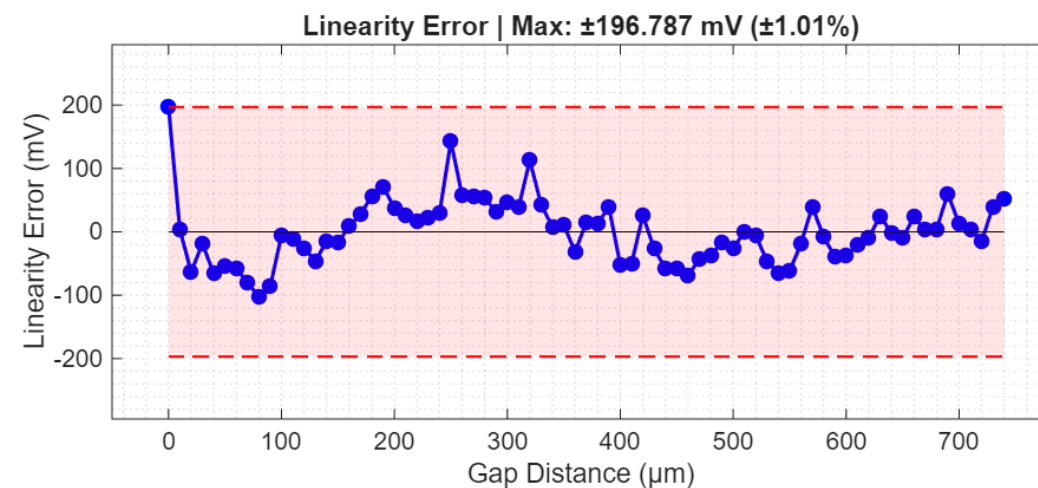
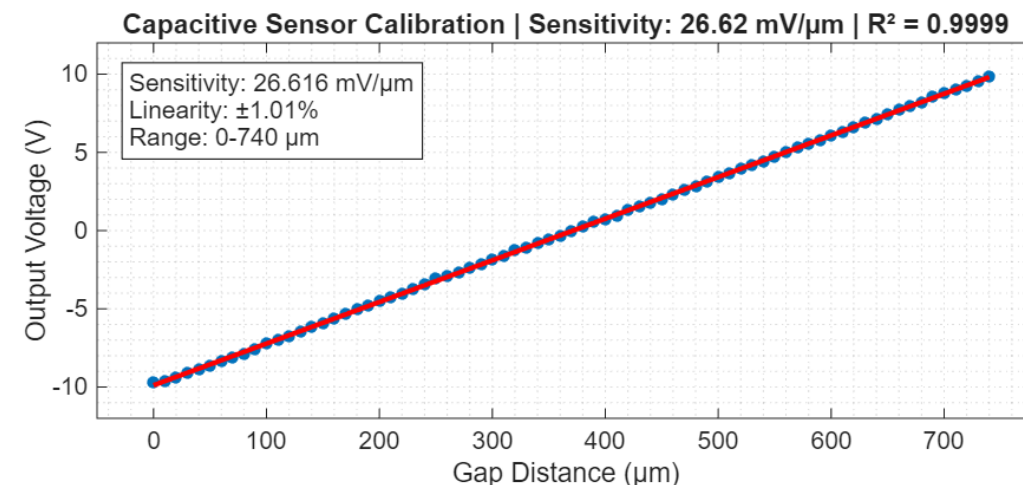
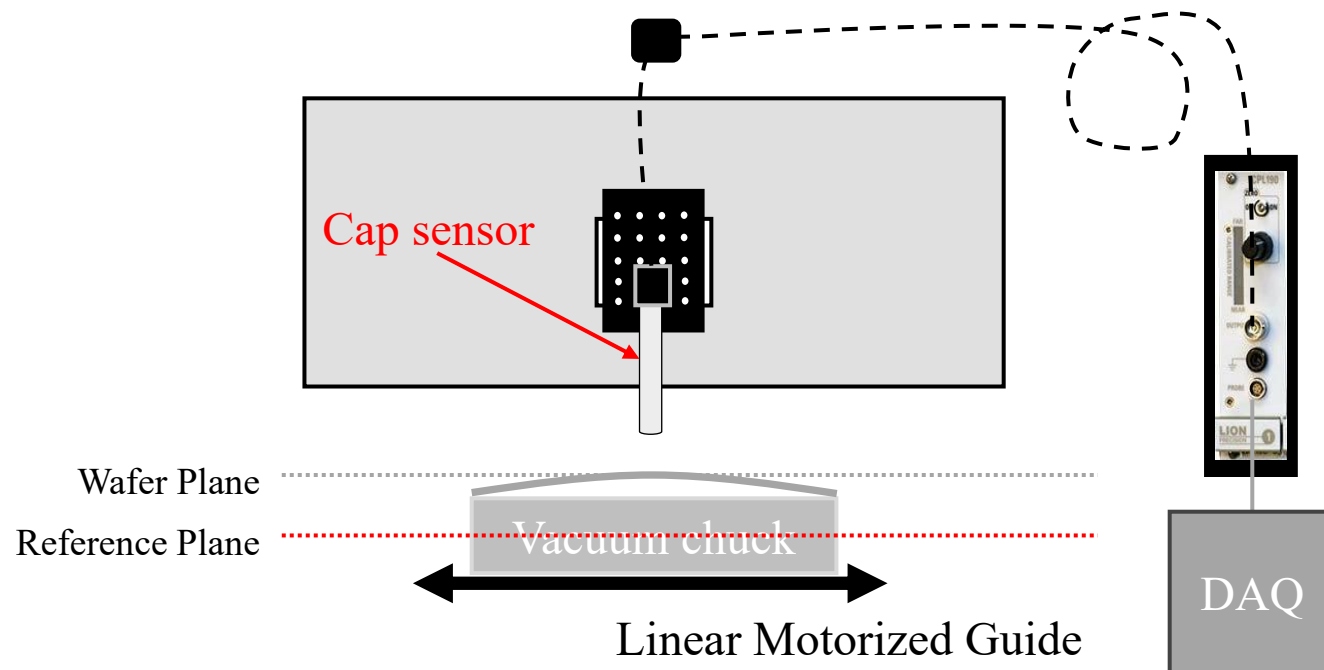


Sarowar, T., Lim, Y., Islam, M. A., Chun, H., Lu, K., & Lee, C. (2026). Wafer-vacuum chuck interface characterization by electrochemical impedance spectroscopy. *Vacuum*, 249, 115277.

Cap Sensor Validation



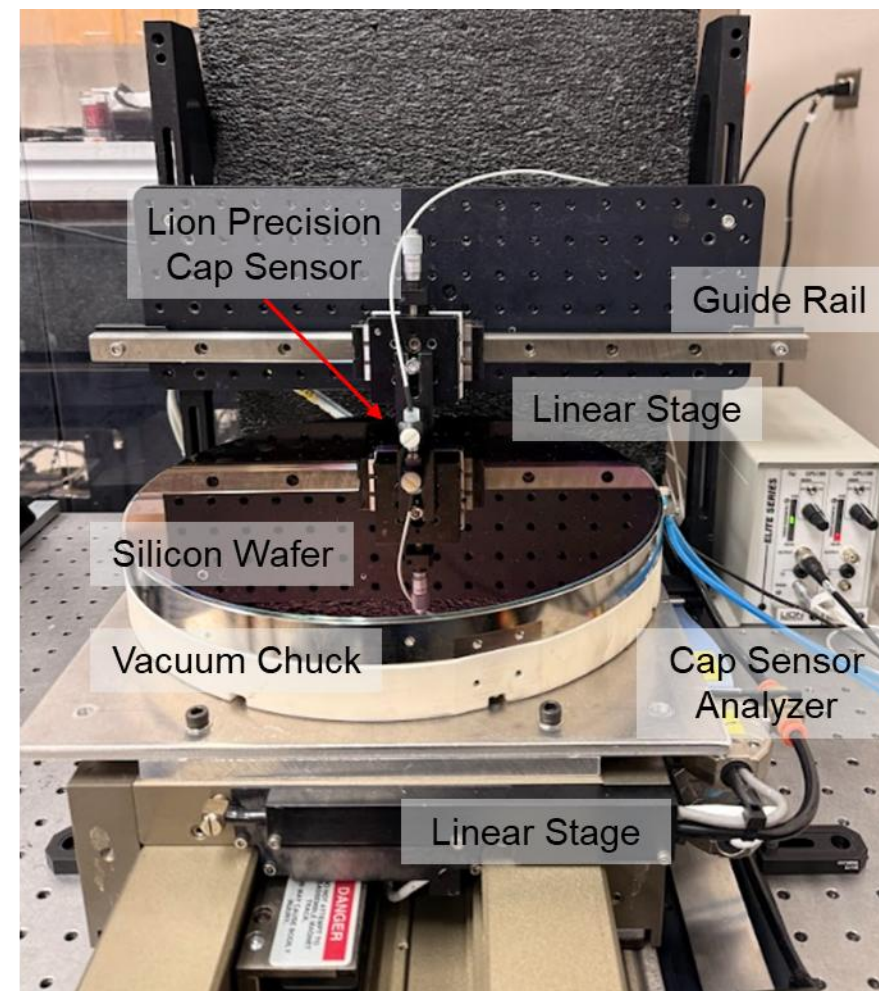
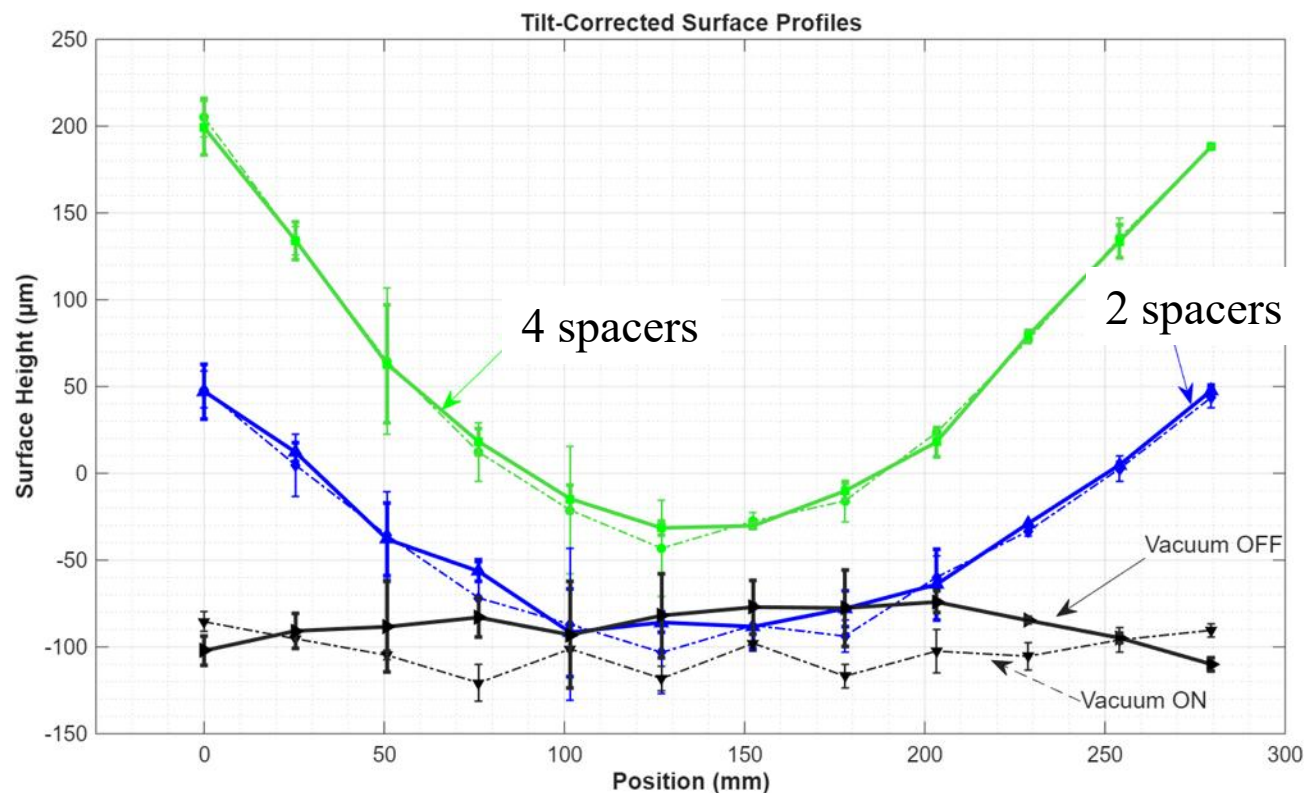
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Cap Sensor Data



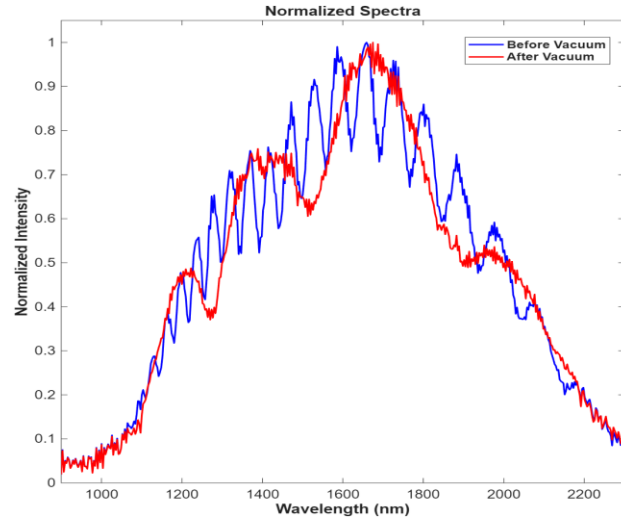
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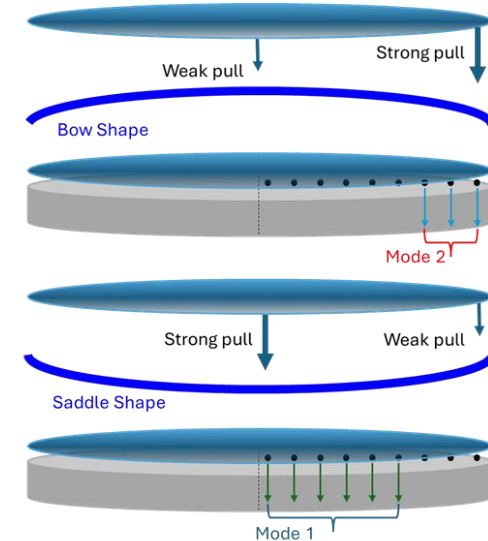
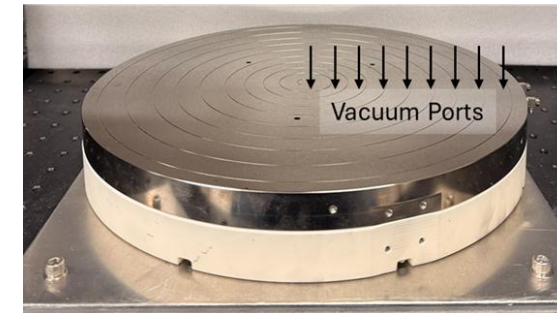
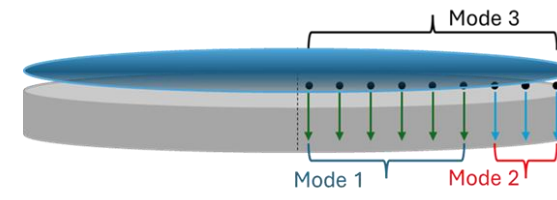
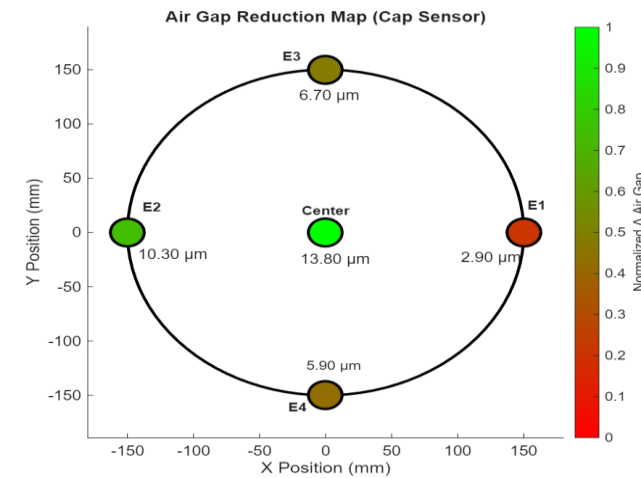
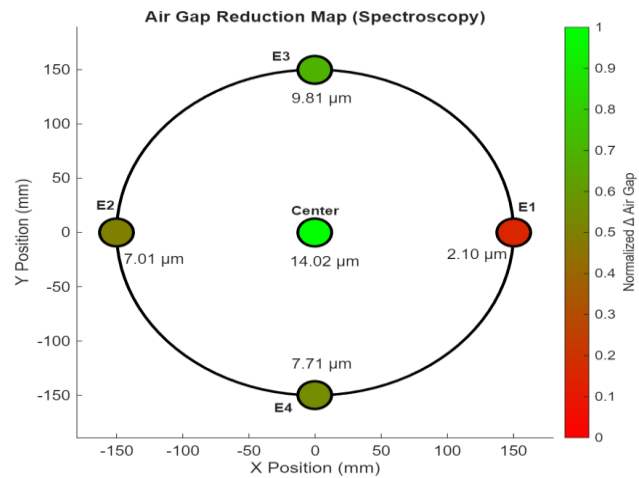
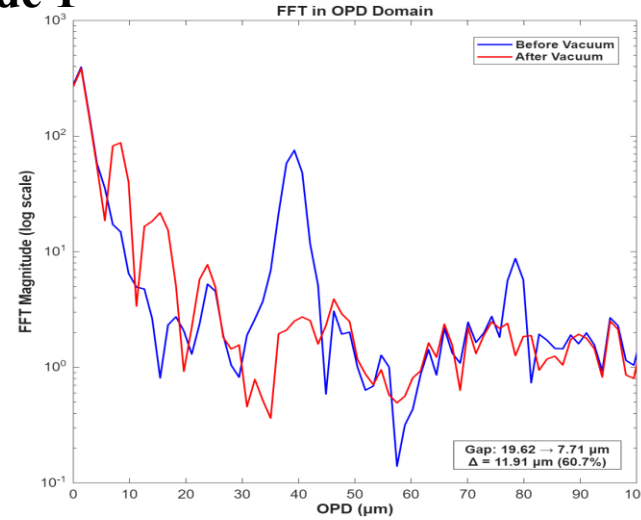
Results Comparison



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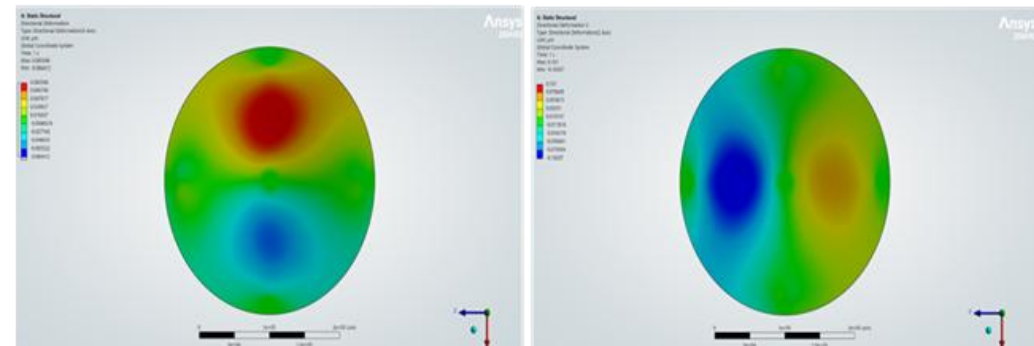
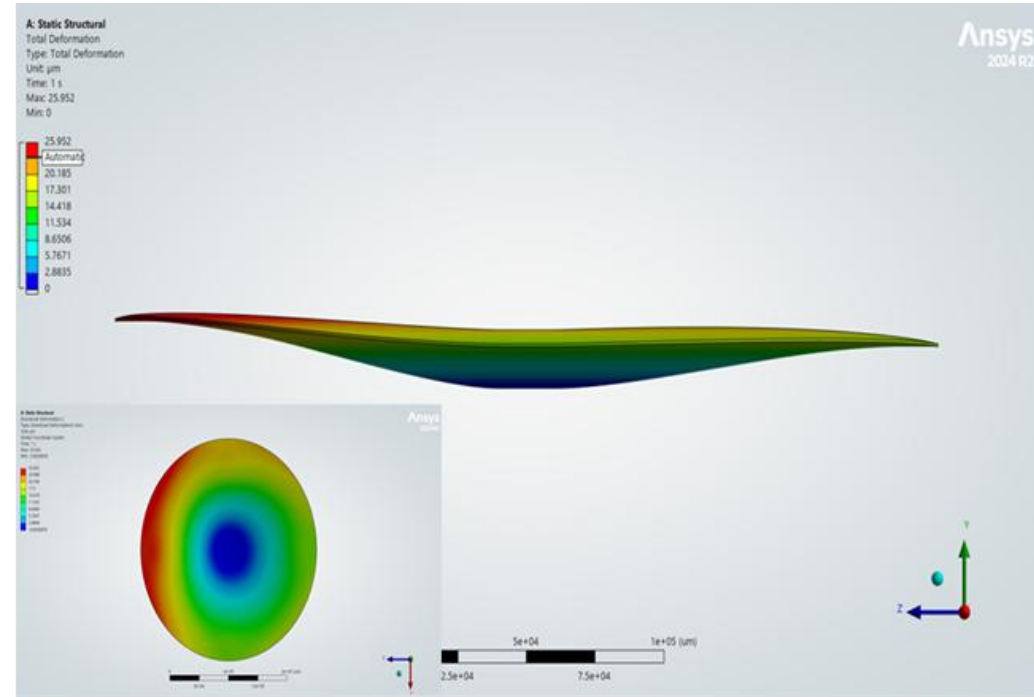
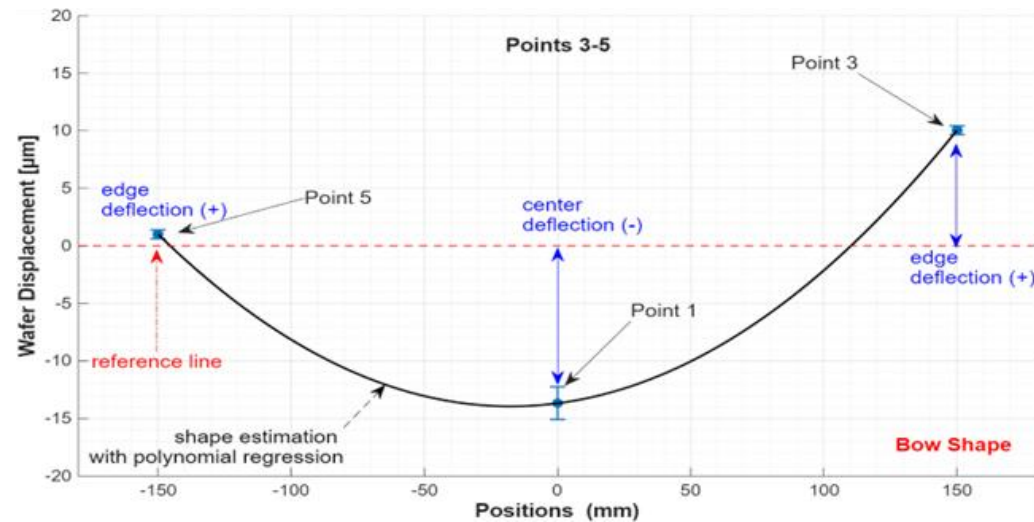
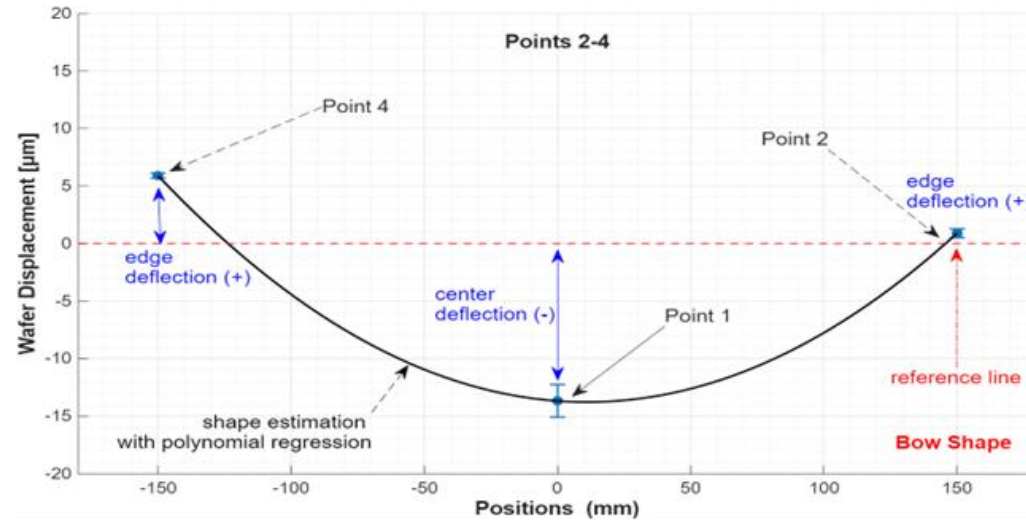
Mode 1



FEM Comparison



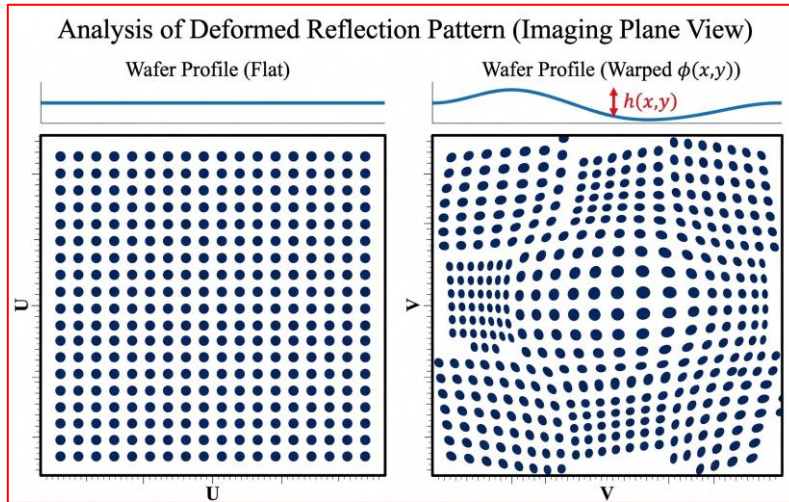
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Future Work



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Principle: Wafer warpage deforms the specular reflection of the dot pattern on the imaging sensor.

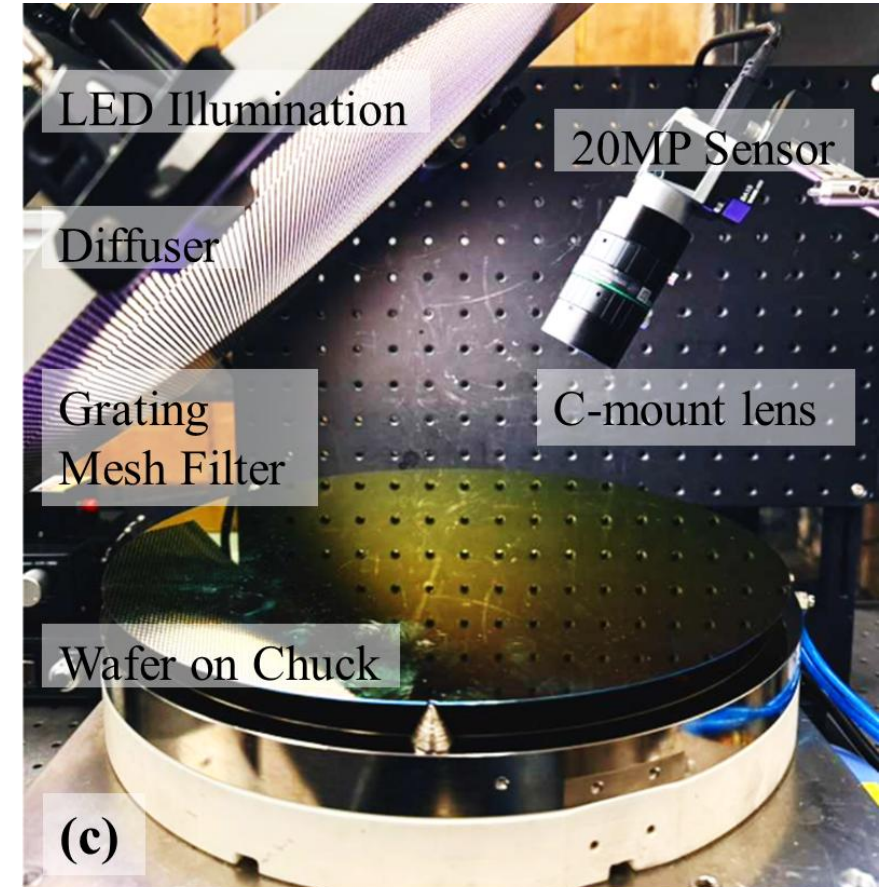
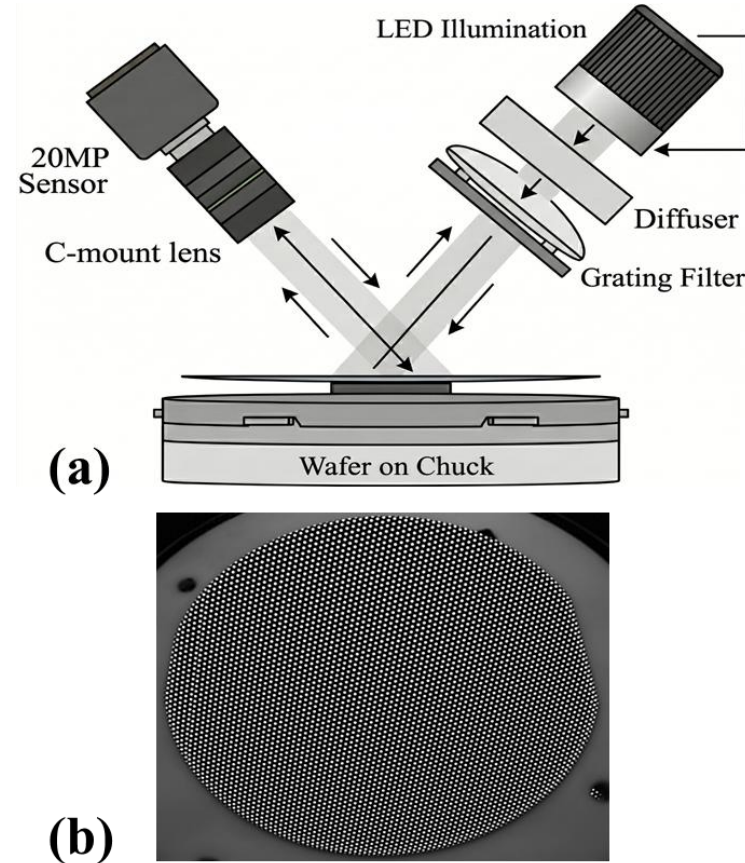


Figure 2. (a) Schematic Diagram, (b) Raw Image, (c) Experimental Setup

Dot Pattern Deflectometry



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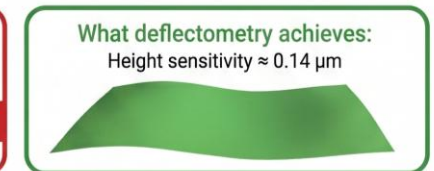
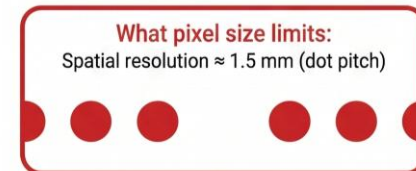
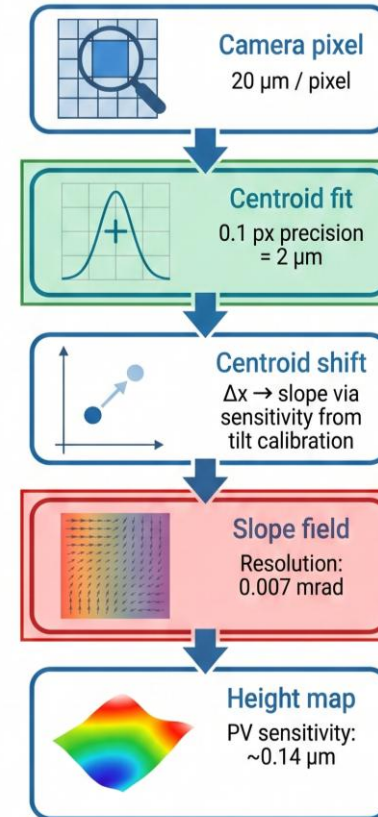
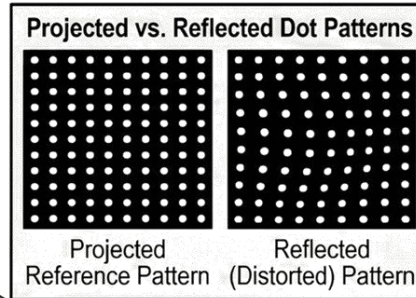
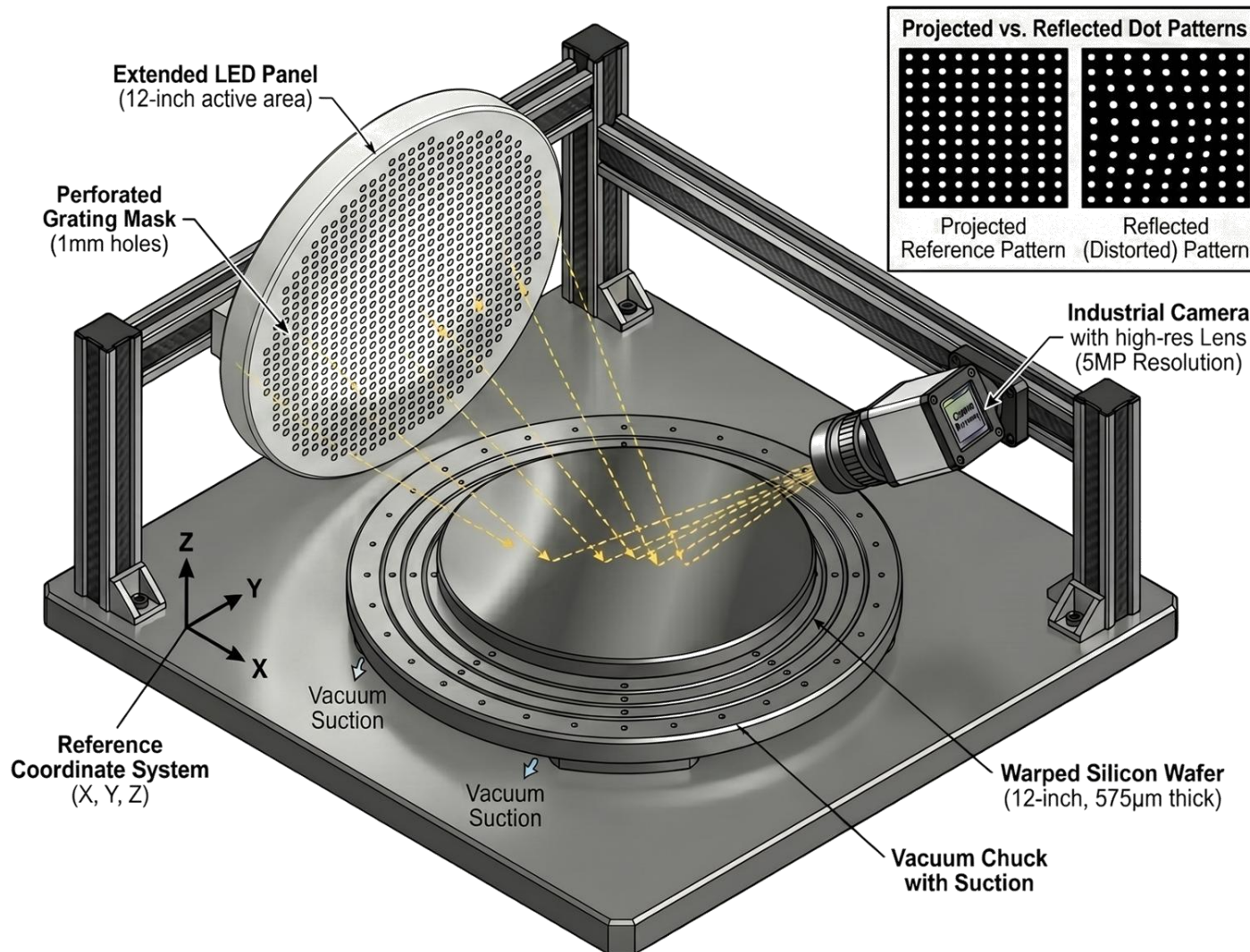
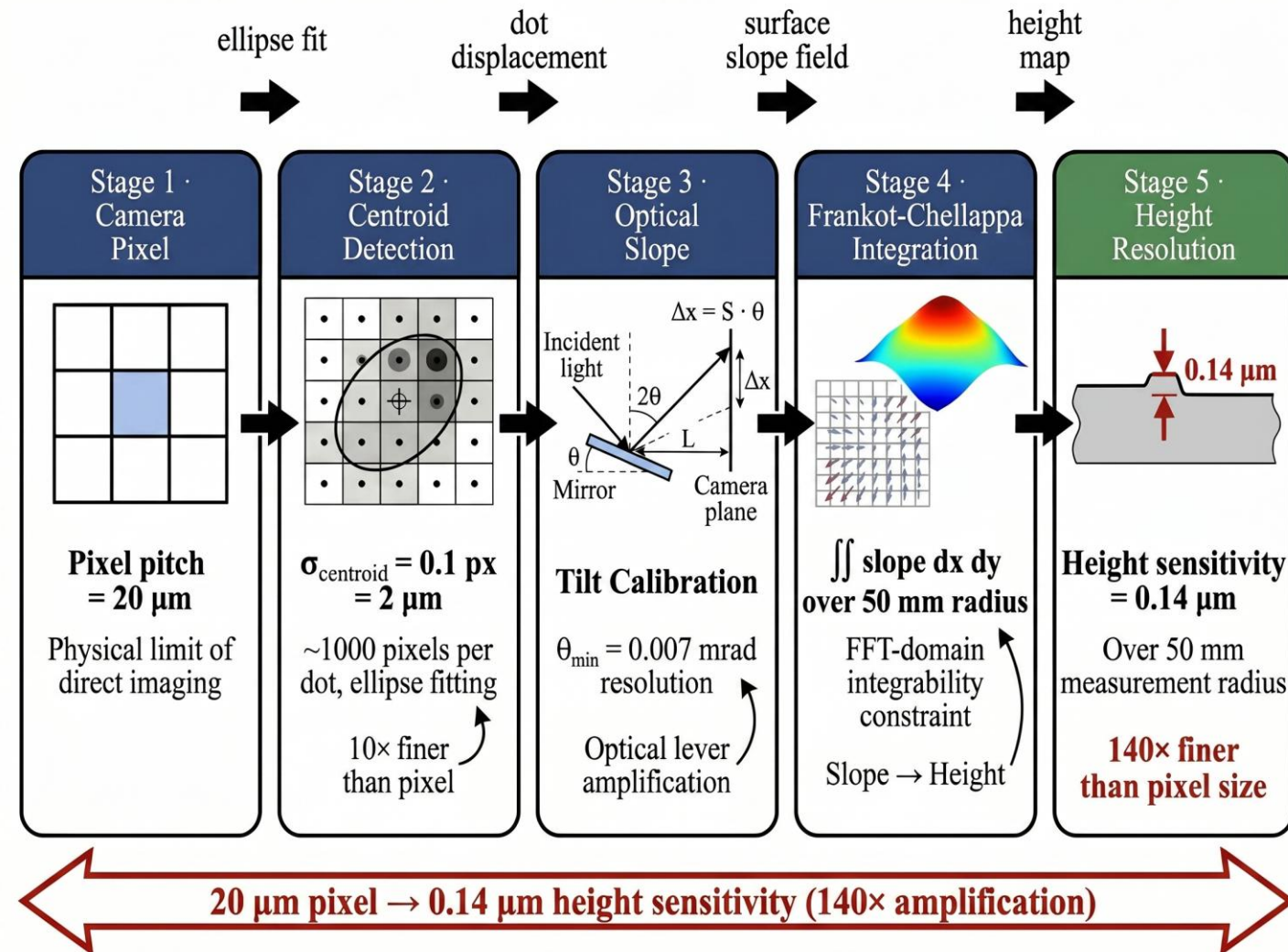


Image Processing Algorithm



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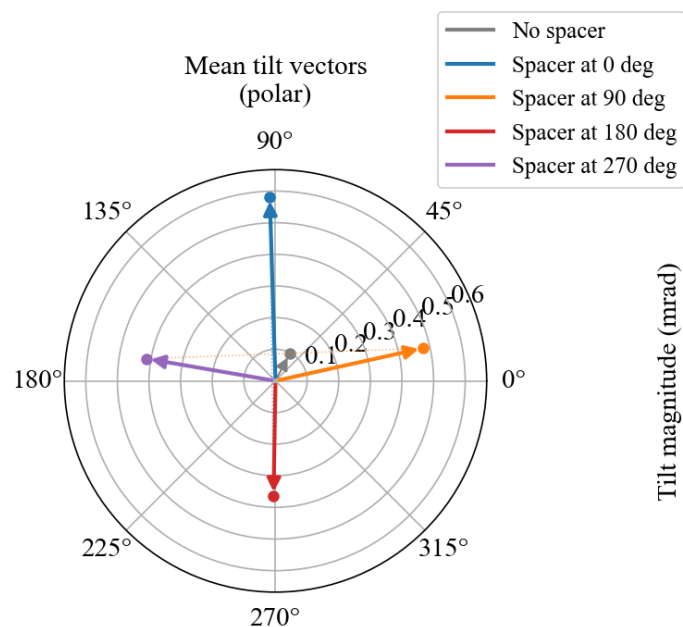
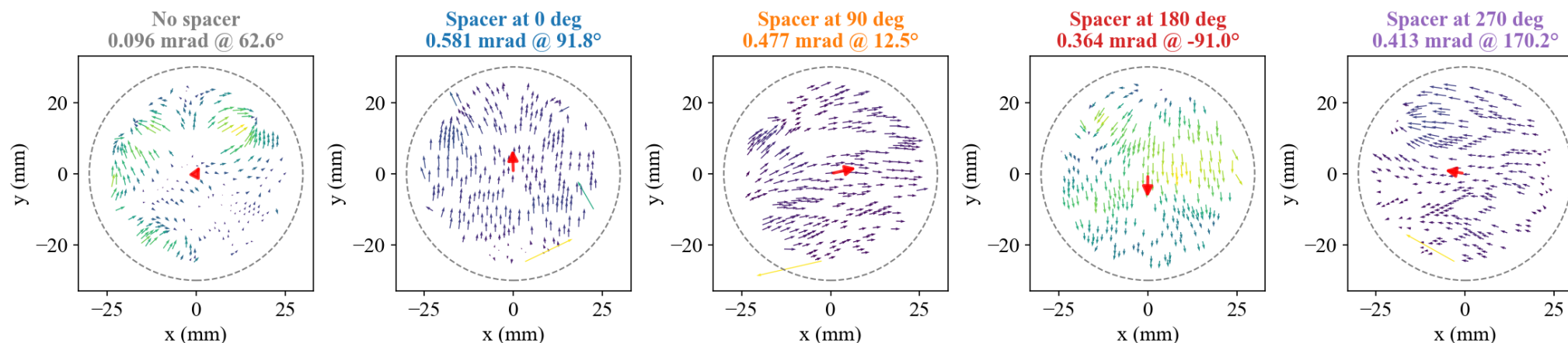
- Pixel Pitch Identification
- Dot Detection with algorithm
- Centroid fit through grid mapping
- Tilt calibration with physical known parameters
- Integration of local tilts over the entire wafer area by grid points
- Local tilts result in height irregularities



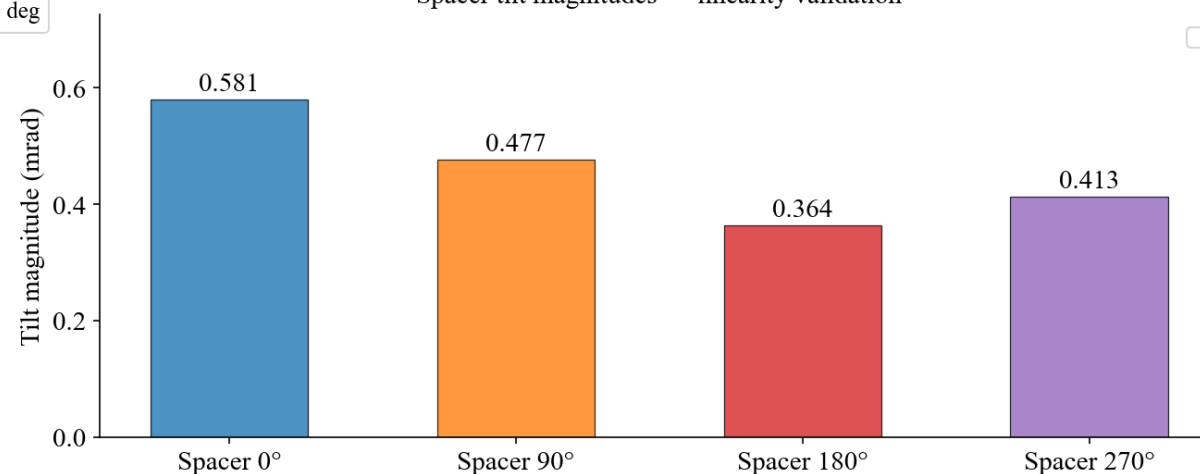
Vacuum Shift Test



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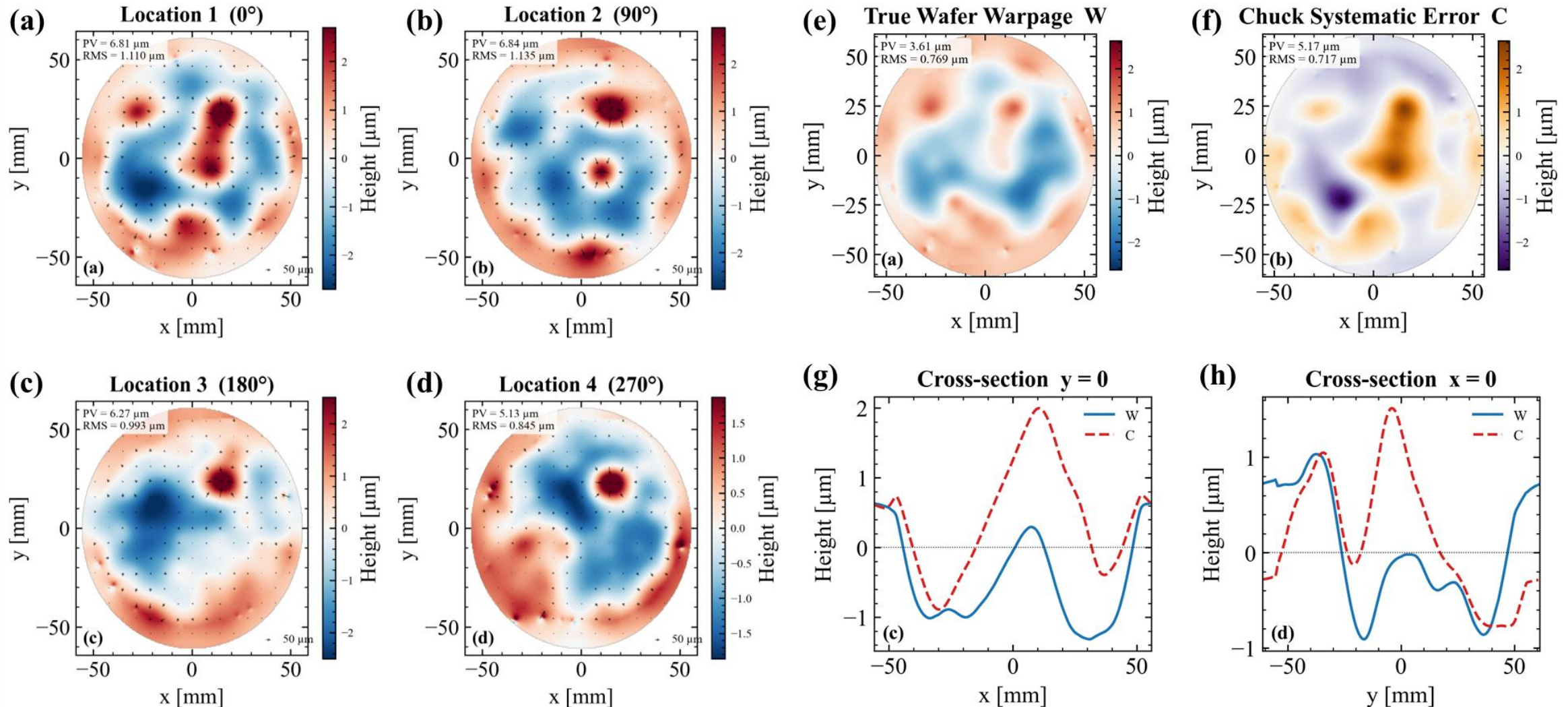
Spacer tilt magnitudes — linearity validation



Rotation Reversal Method



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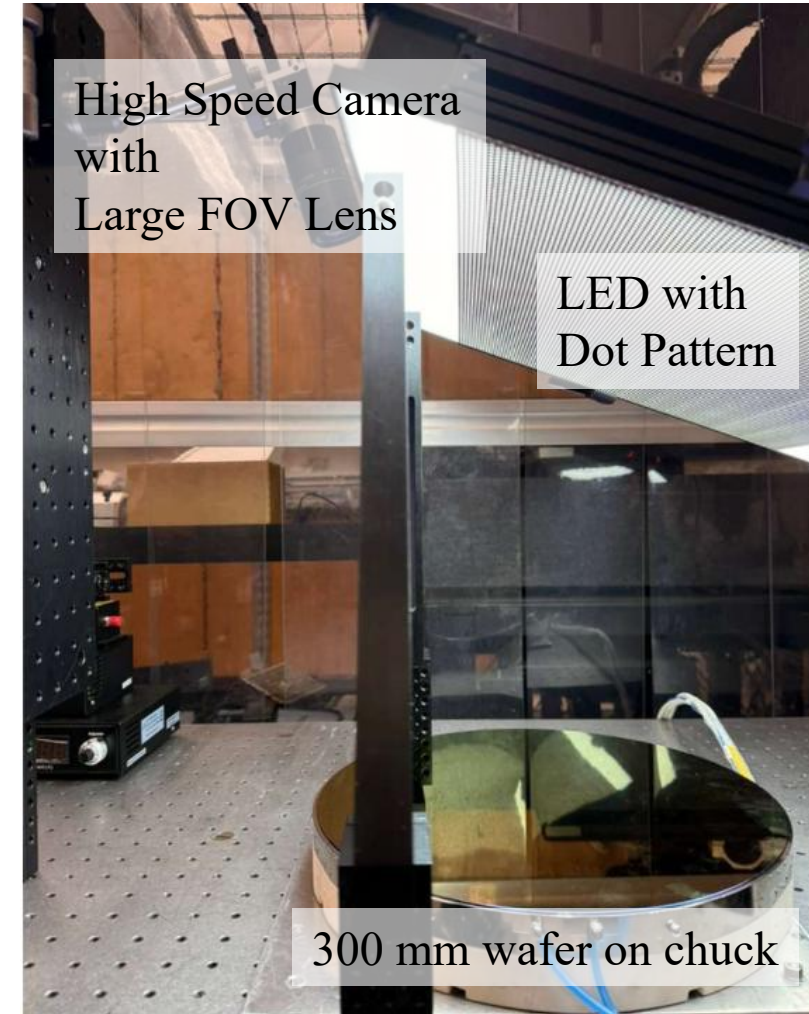
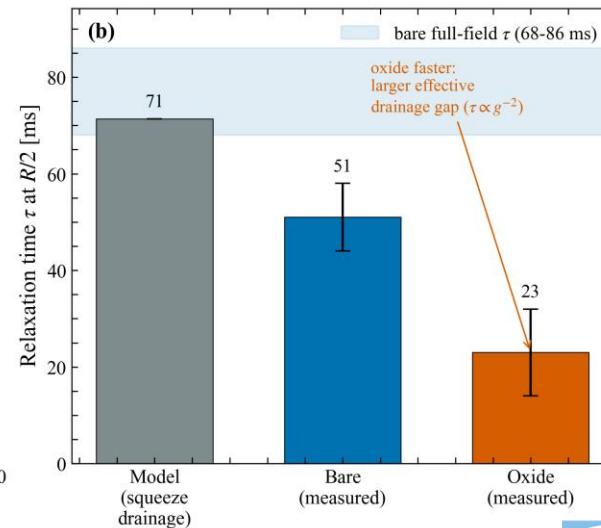
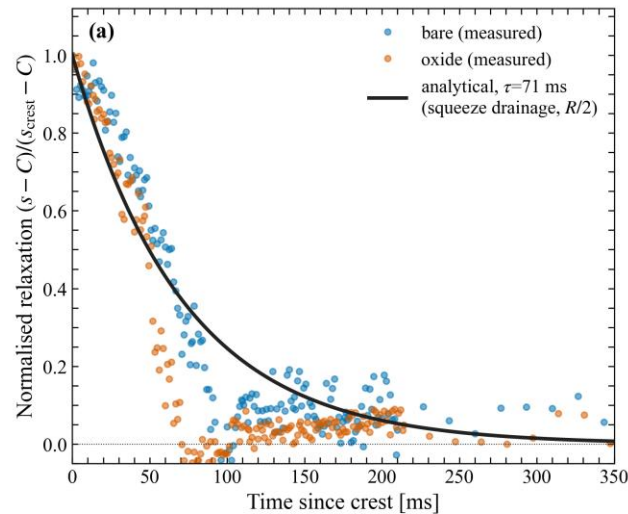
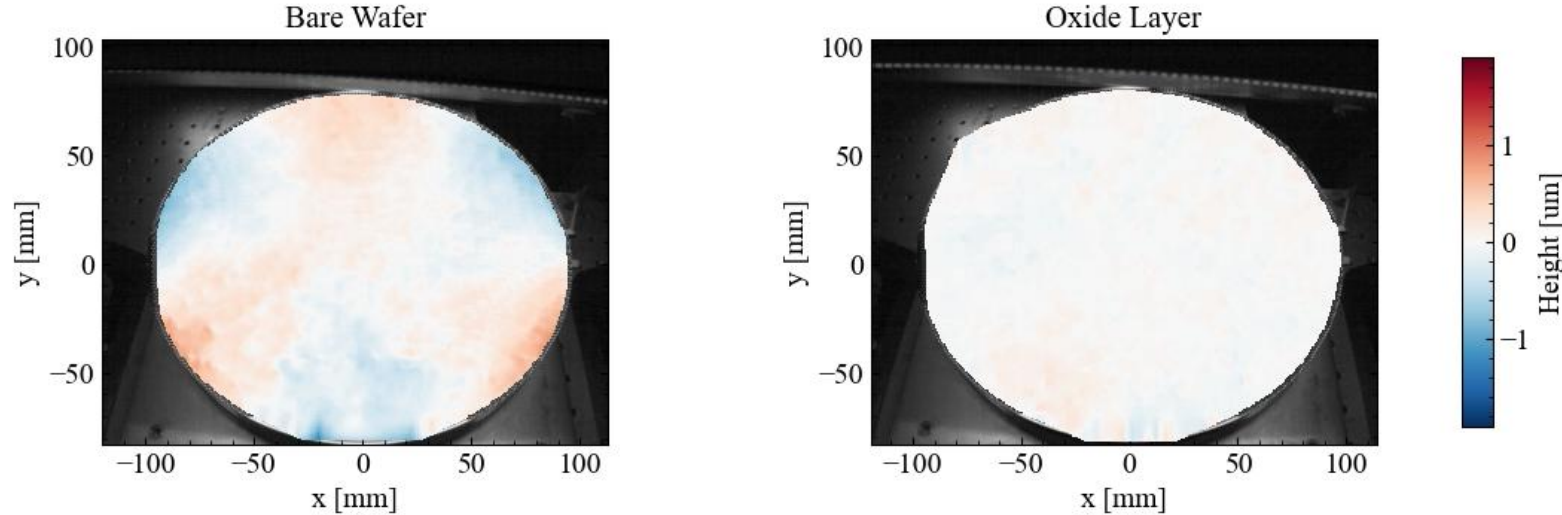


Transient Deflectometry



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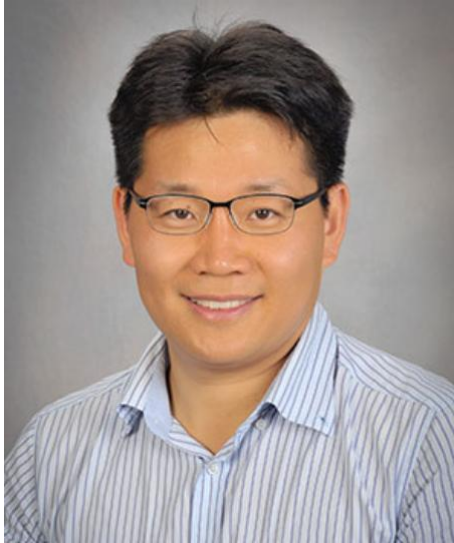
-80 ms vs seating-spike peak



Acknowledgement

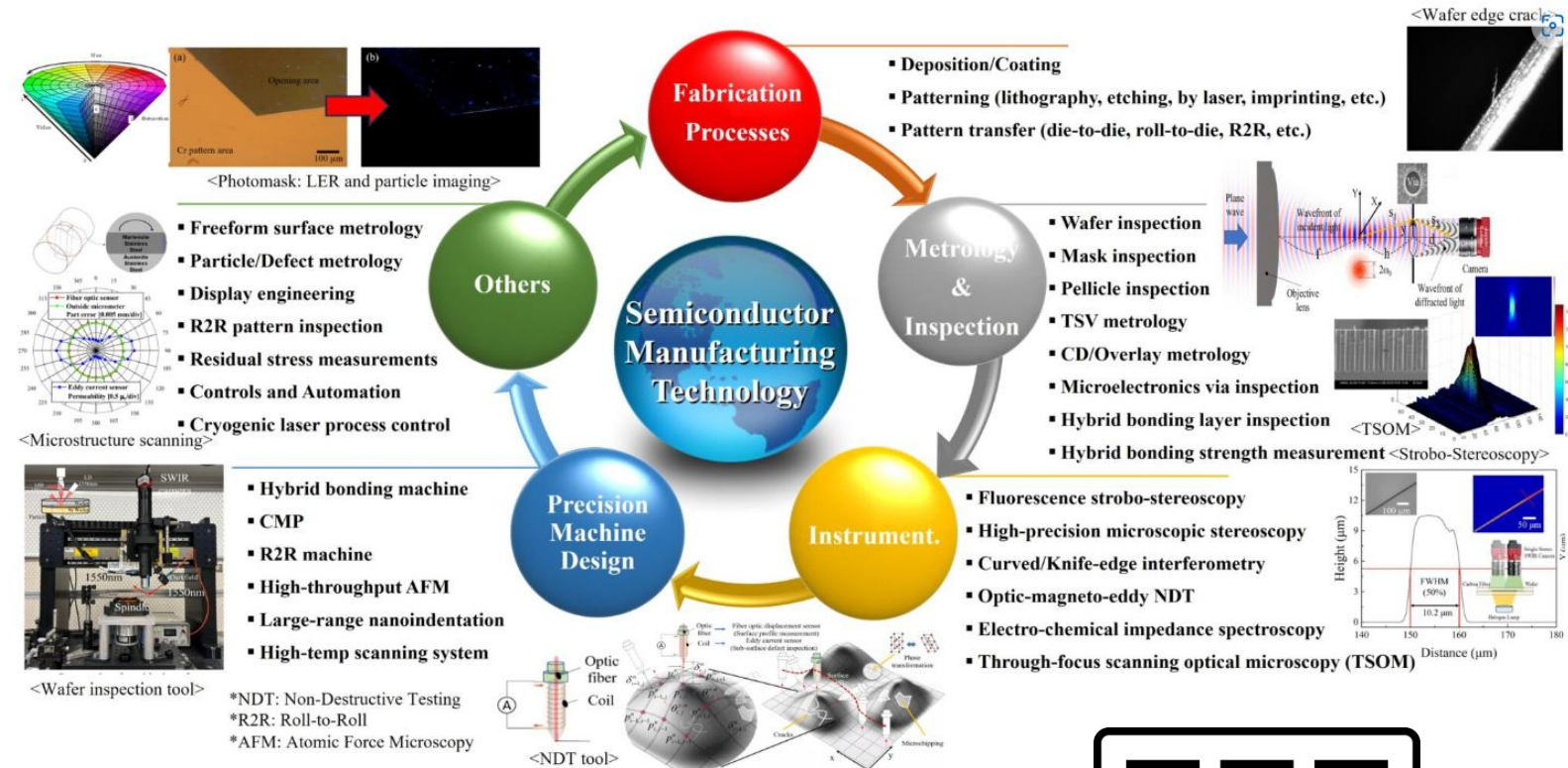


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Advisor: Dr. ChaBum Lee
Associate Professor
Morris E. Foster Faculty Fellow II
J. Mike Walker '66 Department of Mechanical Engineering
Texas A&M University

Research Website: [Precision Metrology and Instrumentation Group \(PMIG\)](https://www.precisionmetrology.tamu.edu/)



SCAN ME



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Thank You