

Pad Deformation

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Tufts

-Chris

-Vin

Cabot

-Sam

-Frank

-Jim

CMP
@Tufts

SRC

-UofA

Ara

-MIT

Gareth

Duane

...

Intel

-Mansour

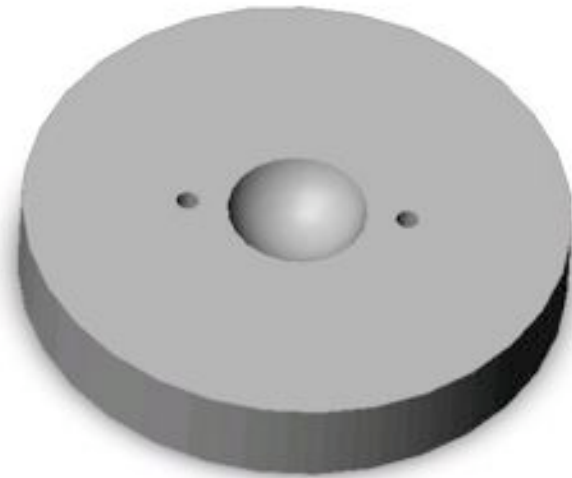
Chris B.



Goal

- Measure between pad and wafer **during polish in an instant in time**
- Look at
 - pad deformation
 - % contact
 - air bubbles etc.

1:2 Polishing Platform

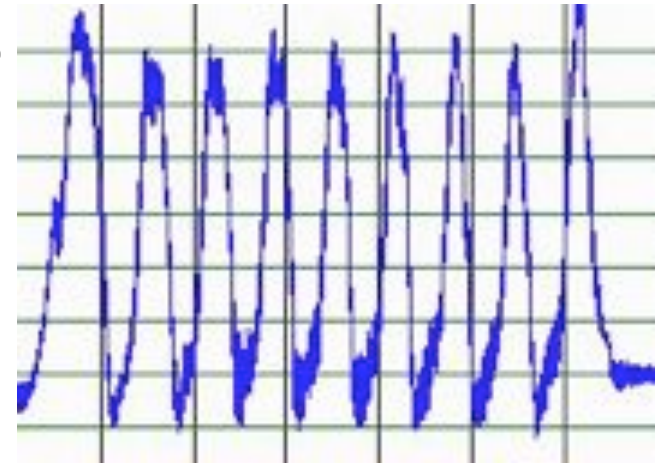


Friction System



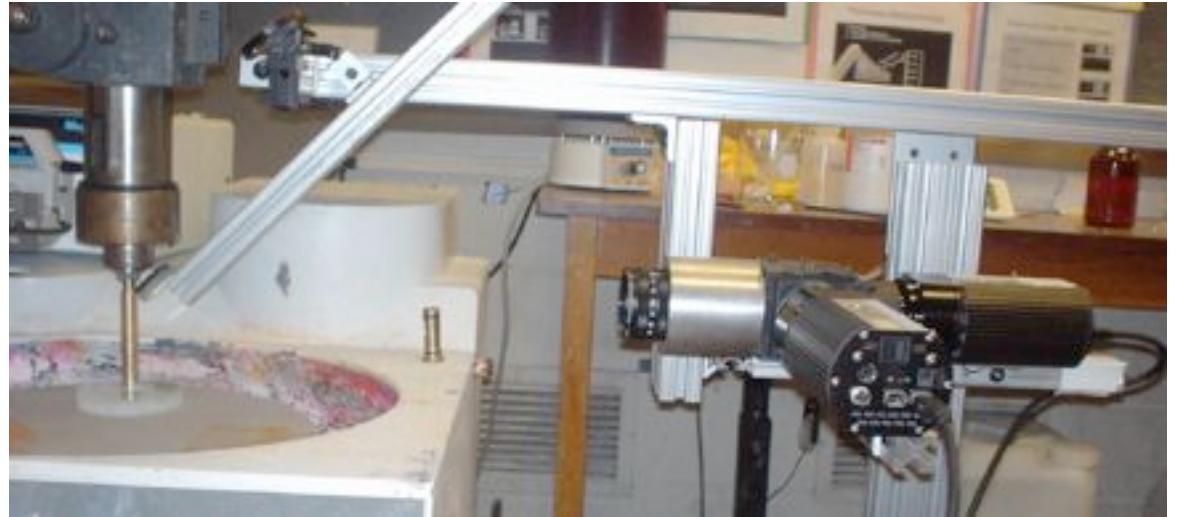
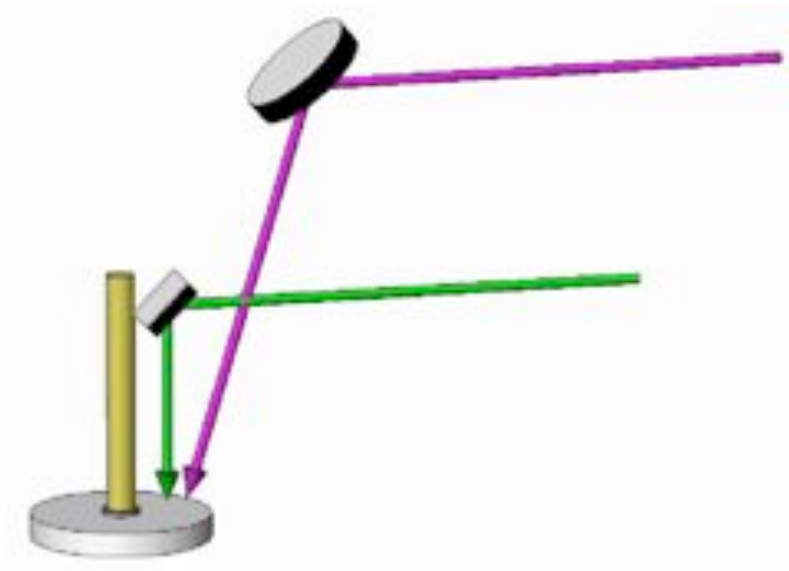
- Load Cells
- 6 DOF

Force



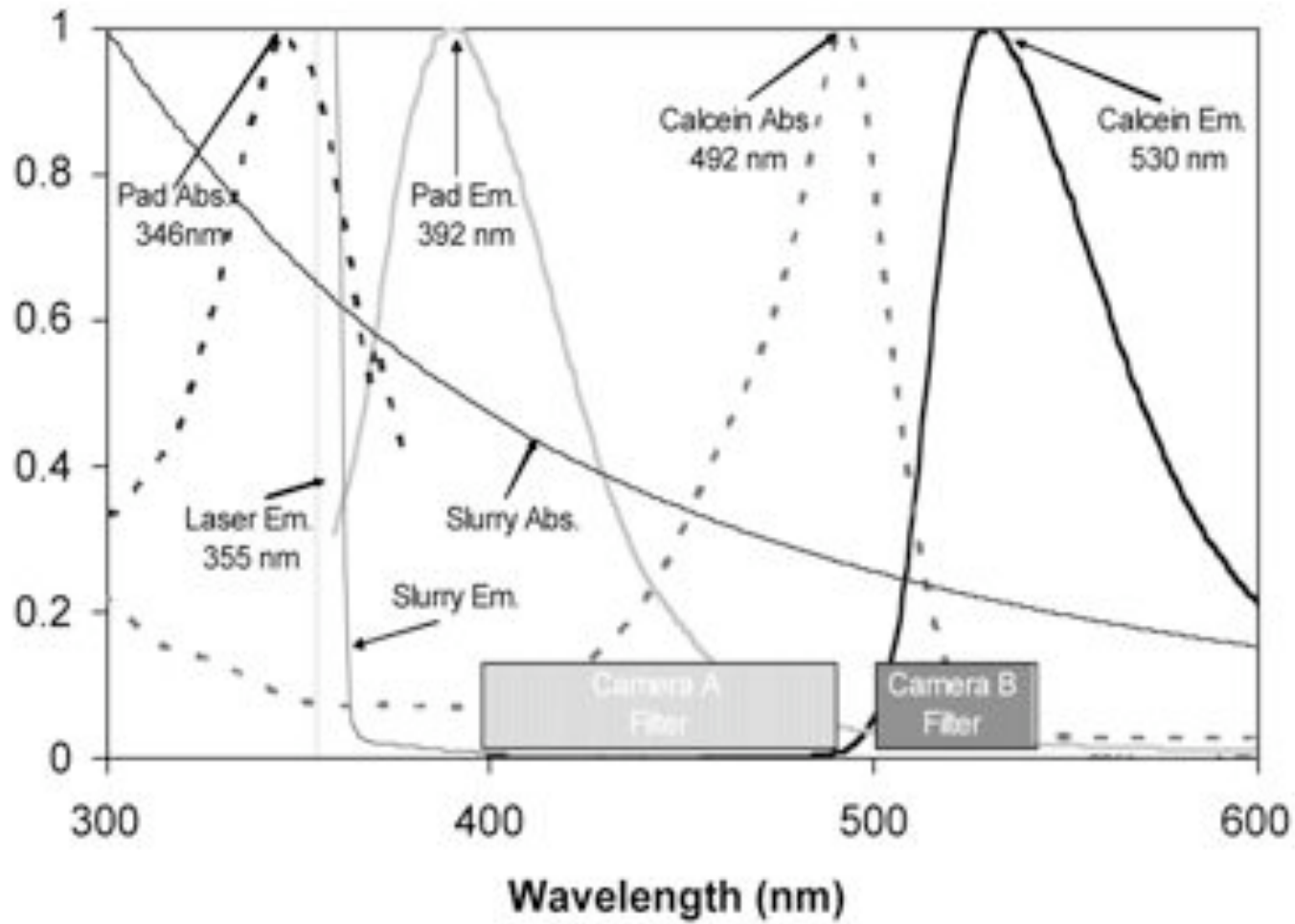
Time

Camera System

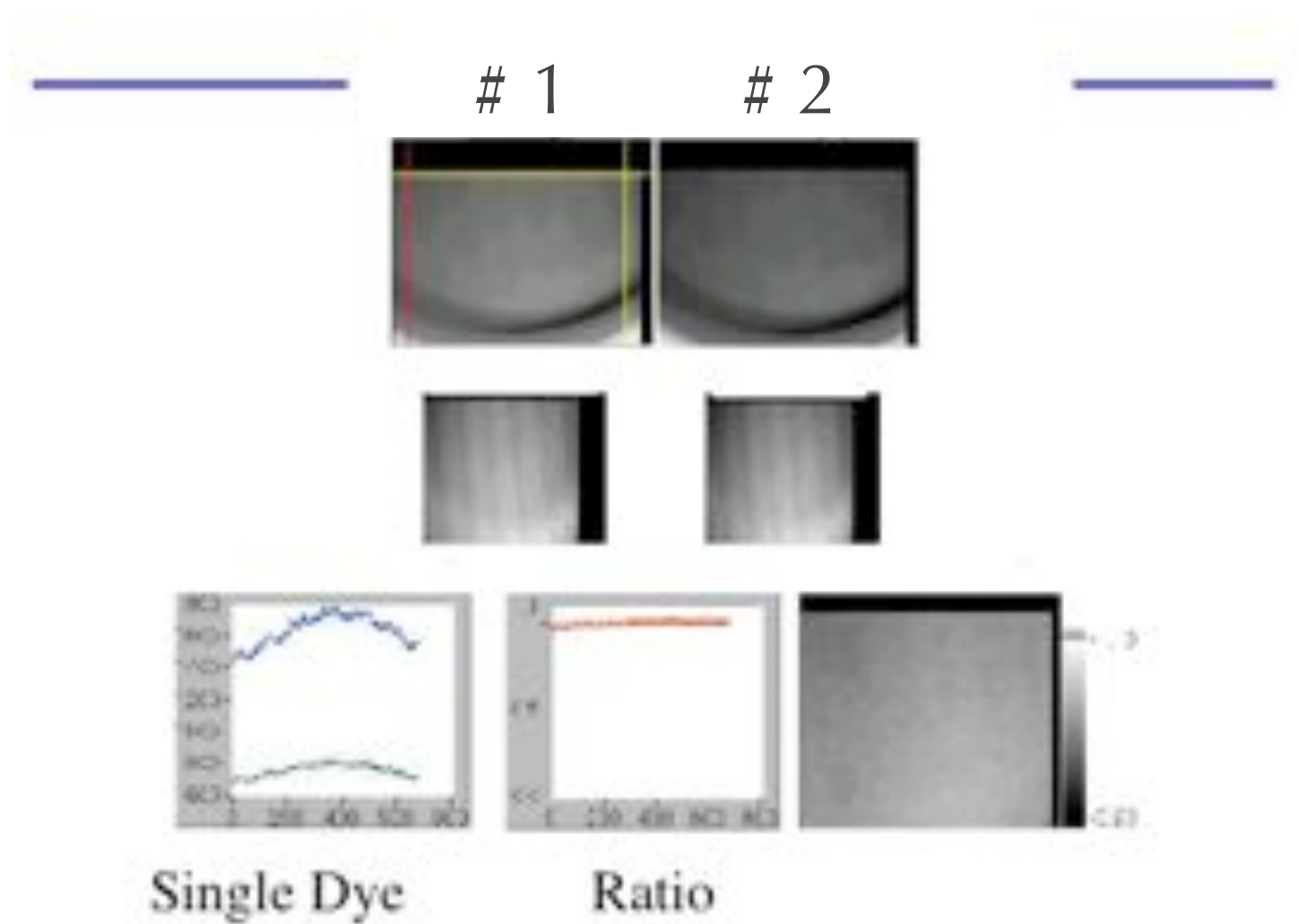


- 12-bit high resolution CCD
1024 x 768 pixel array
- Optically split & filtered
- Spatially aligned & orthogonal

Using Pad Glow



DELIF Example



Procedure

Process Parameters

60 min pad break in (w/ slurry)

35 mL/min slurry injection (pad center)

In situ pad conditioning

Intermittent polishing data (taken after 1 min)

Measured

friction

bow-wave temperature (thermocouple)

under-wafer temperature (DELIF)

slurry thickness

mean residence time

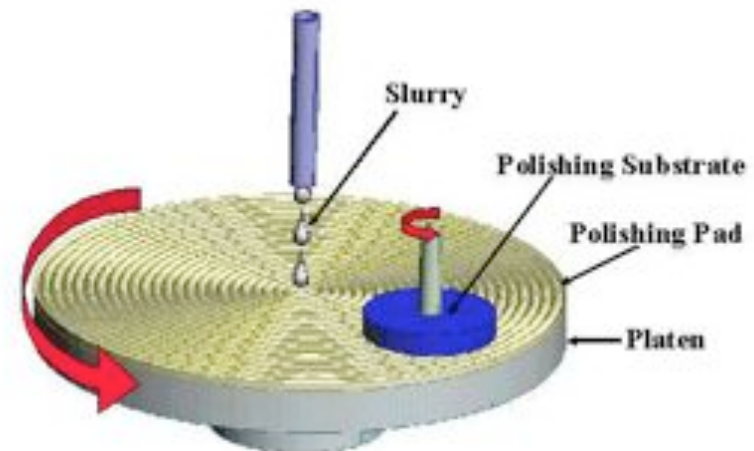
Varied

wafer curvature

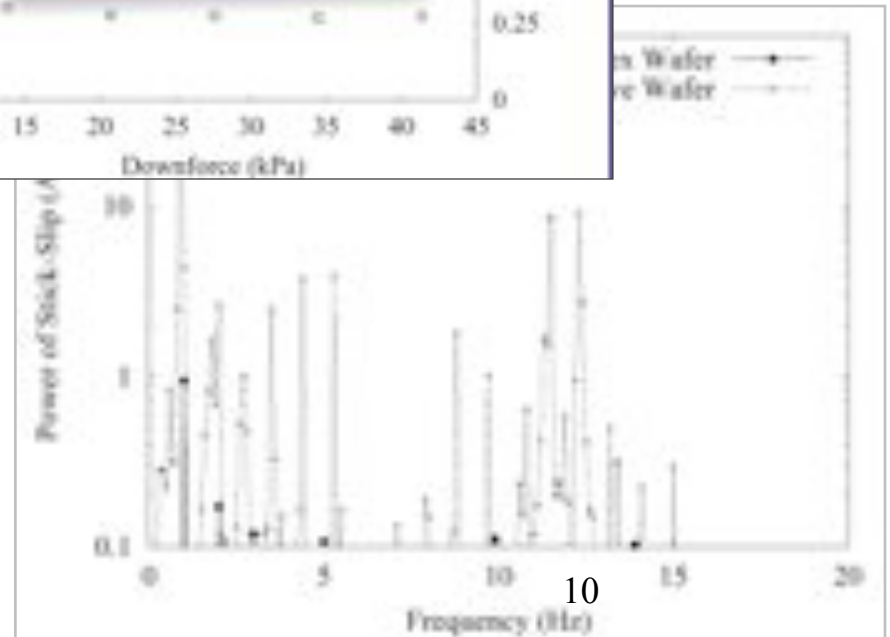
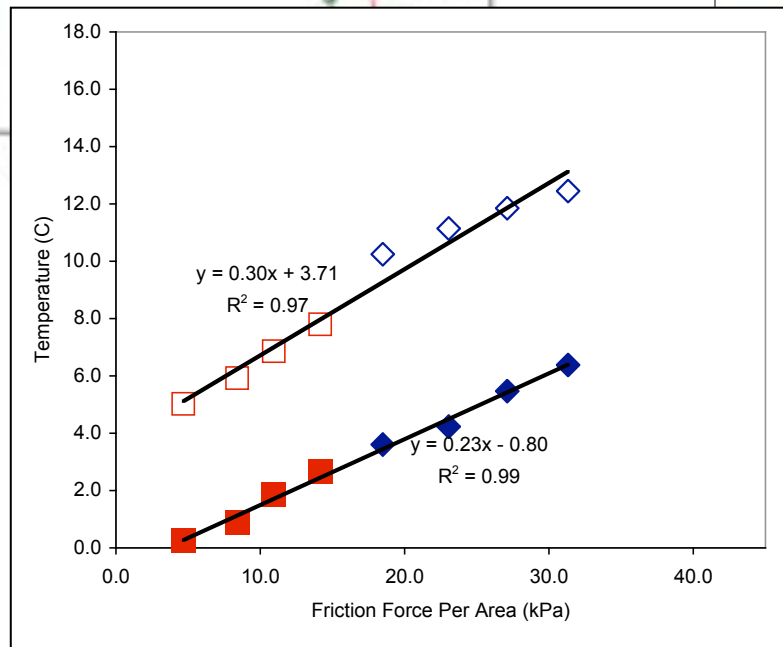
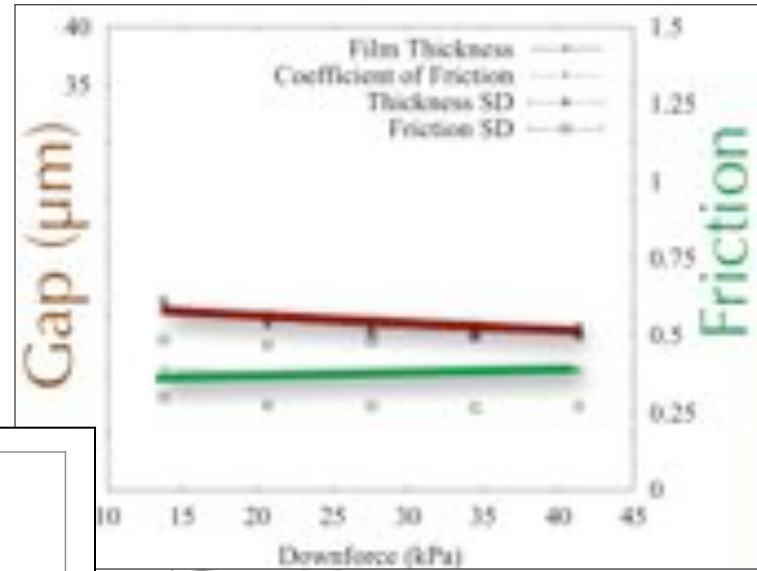
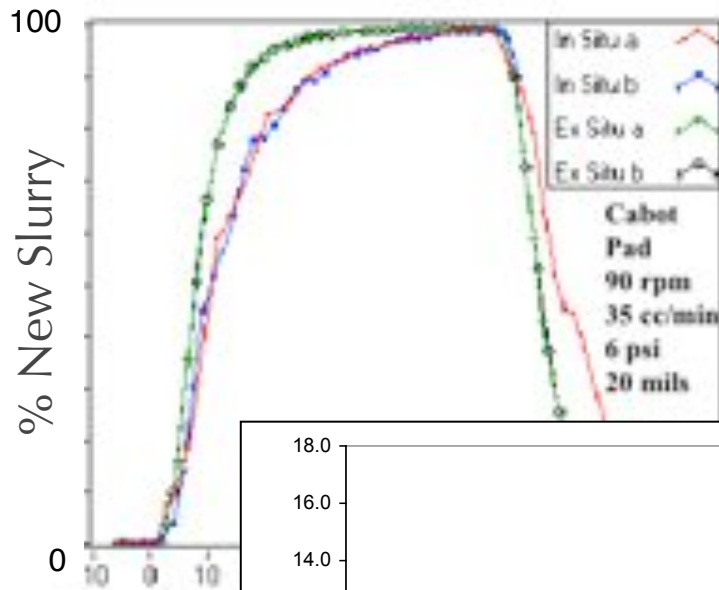
applied wafer pressure (5-40 kPa - 1 - 8 psi)

slurry particle concentration 3 and 13 wt %

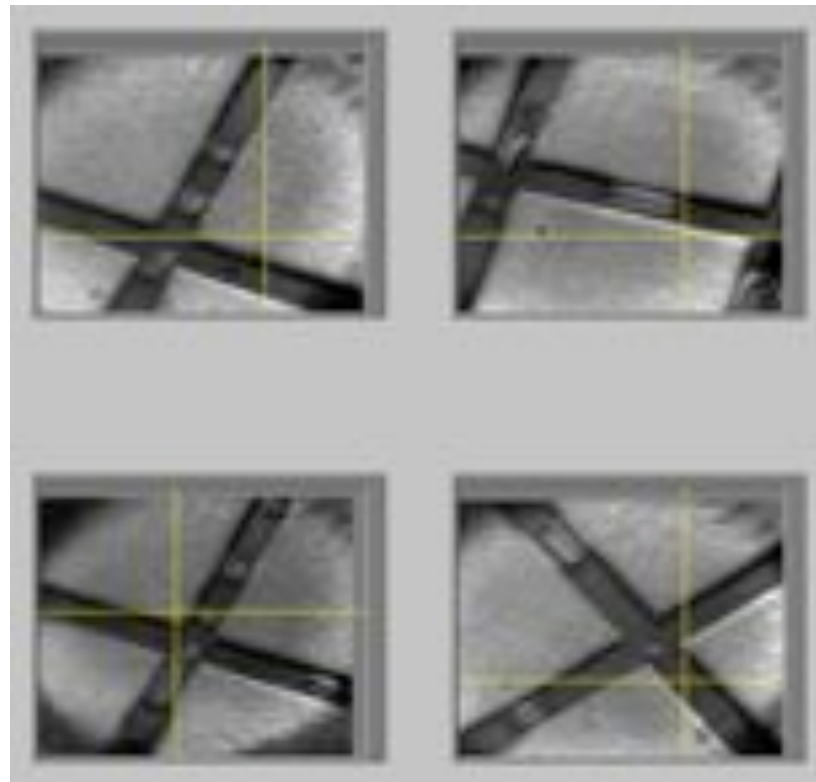
relative linear velocity: 0.3 - 1 m/sec



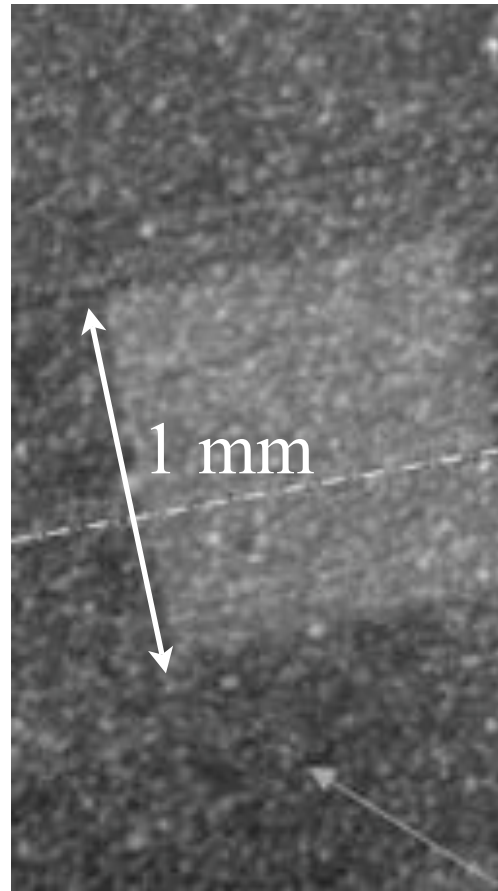
Review



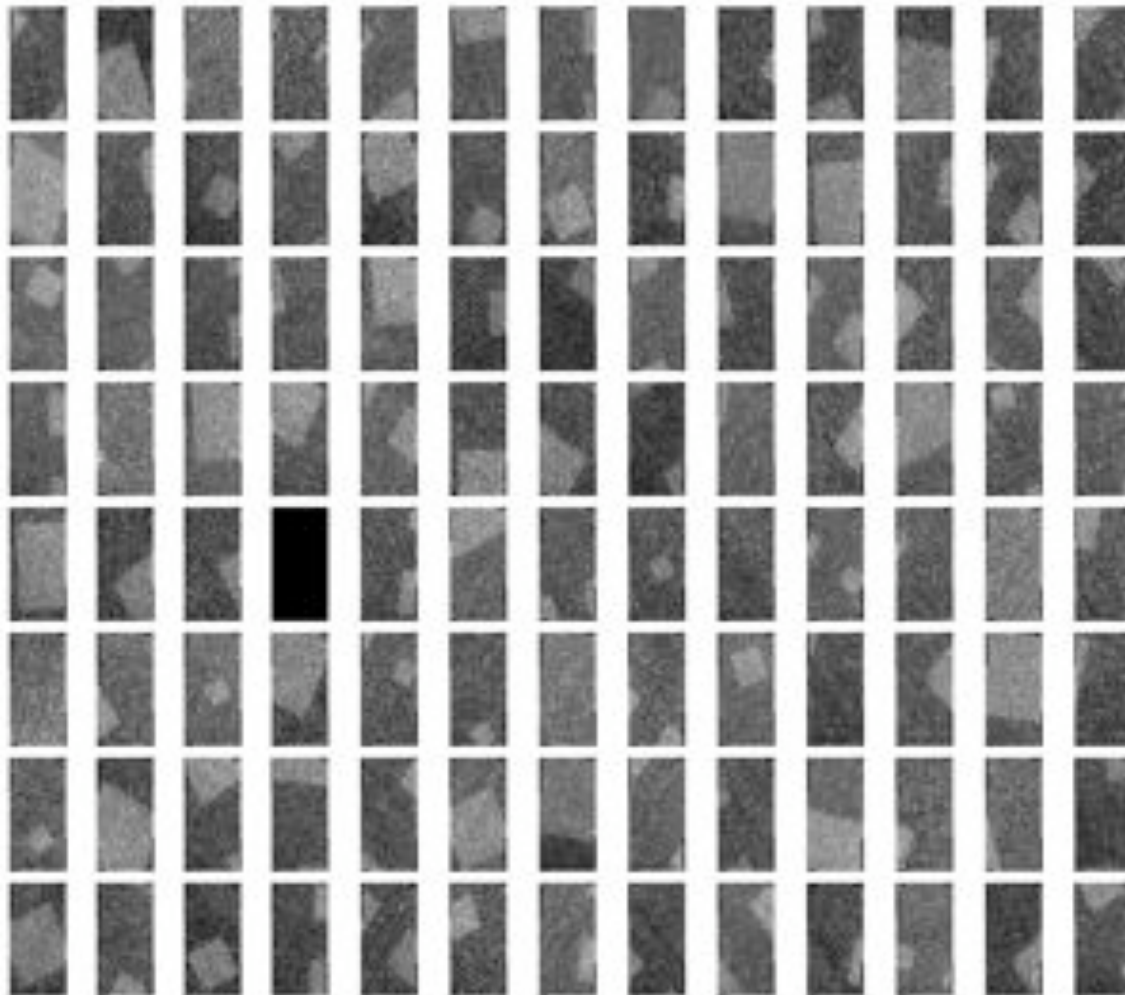
In an instant



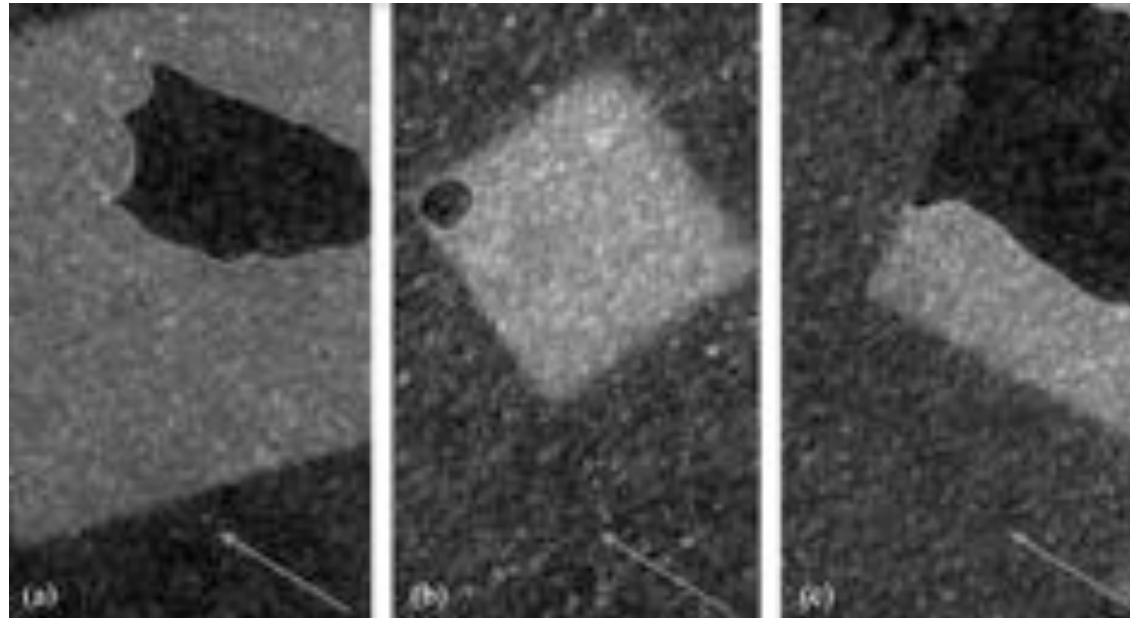
Zooming in



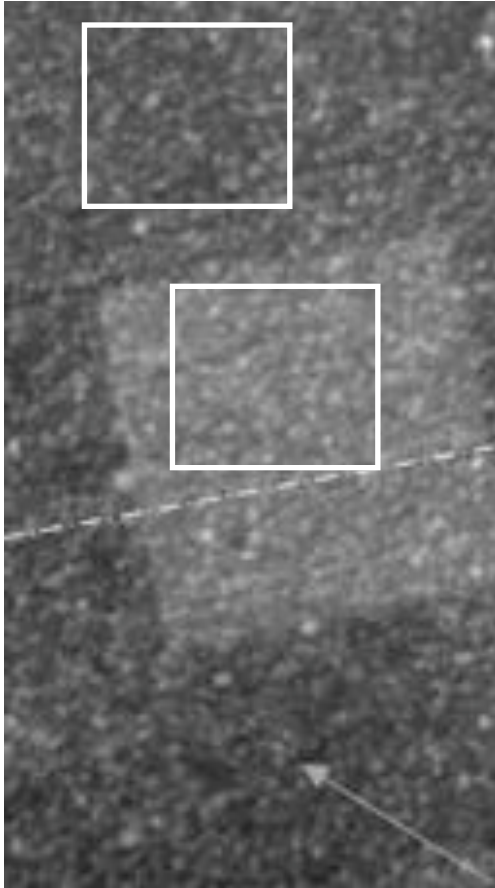
many of them



Air Bubbles



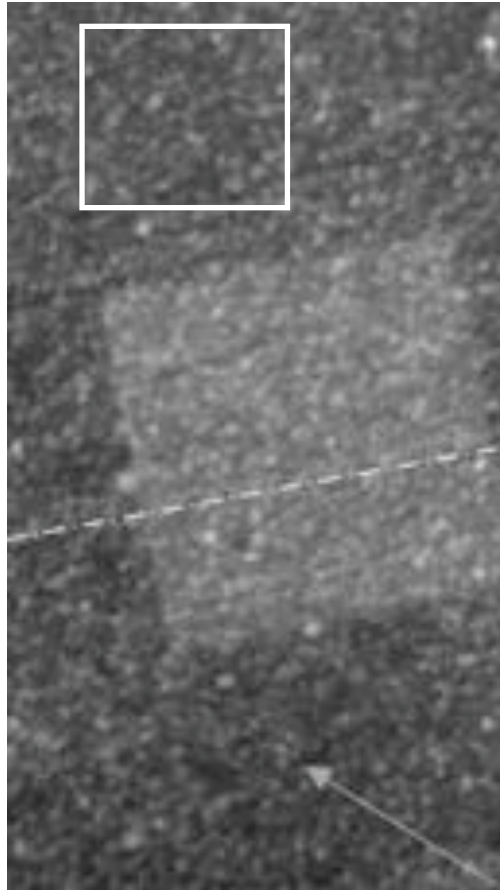
Roughness



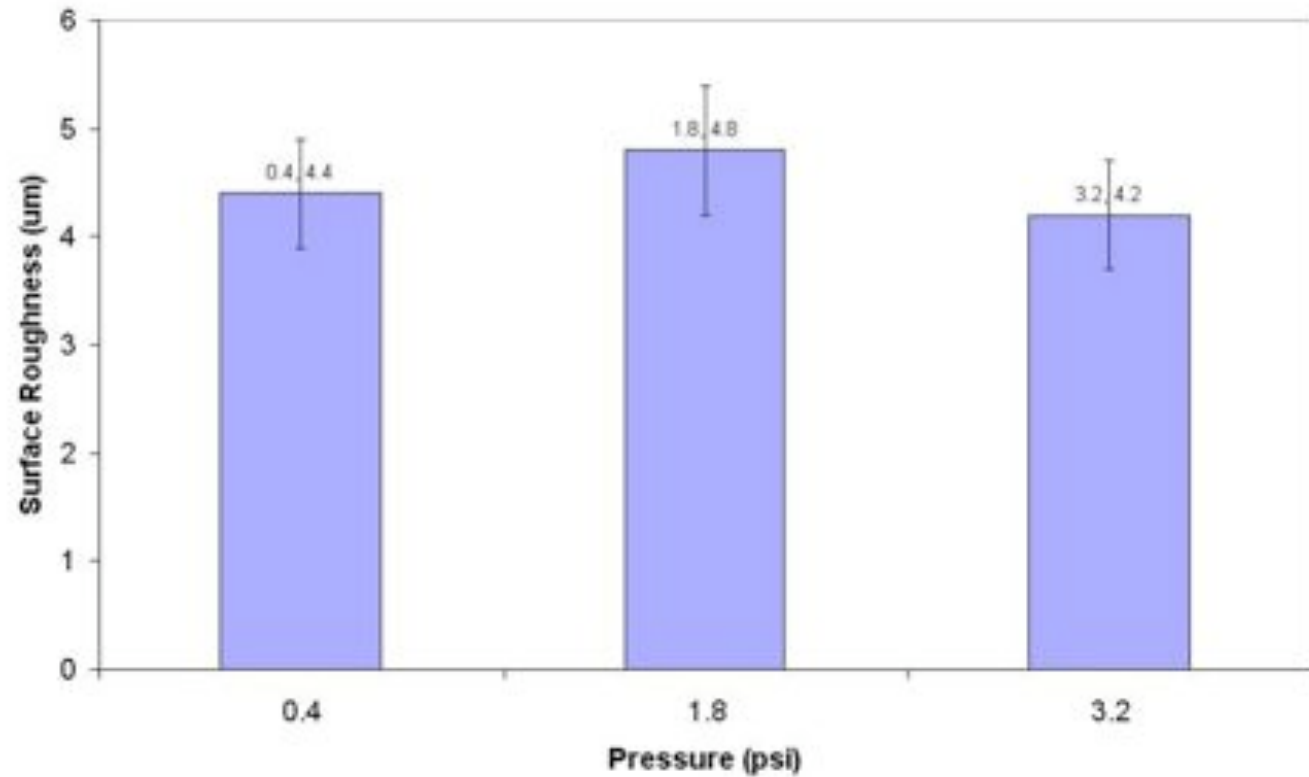
- 4.3 μm inside
 - agrees with profilometer
- 3.3 μm outside

- Measure Transition?

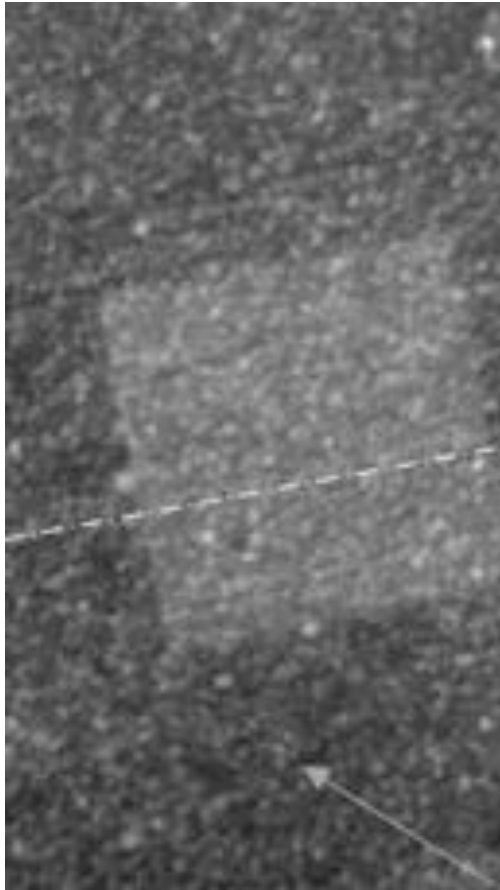
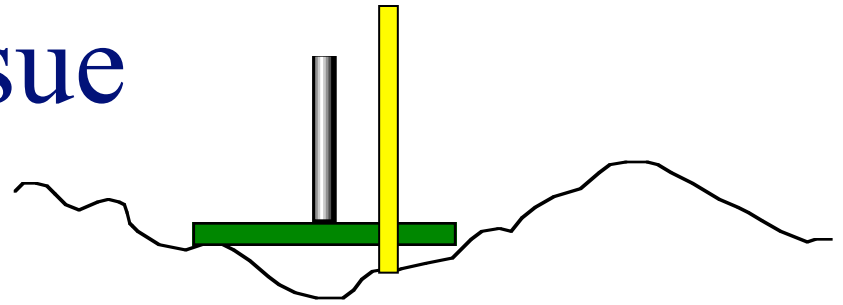
Surface Roughness - dynamic



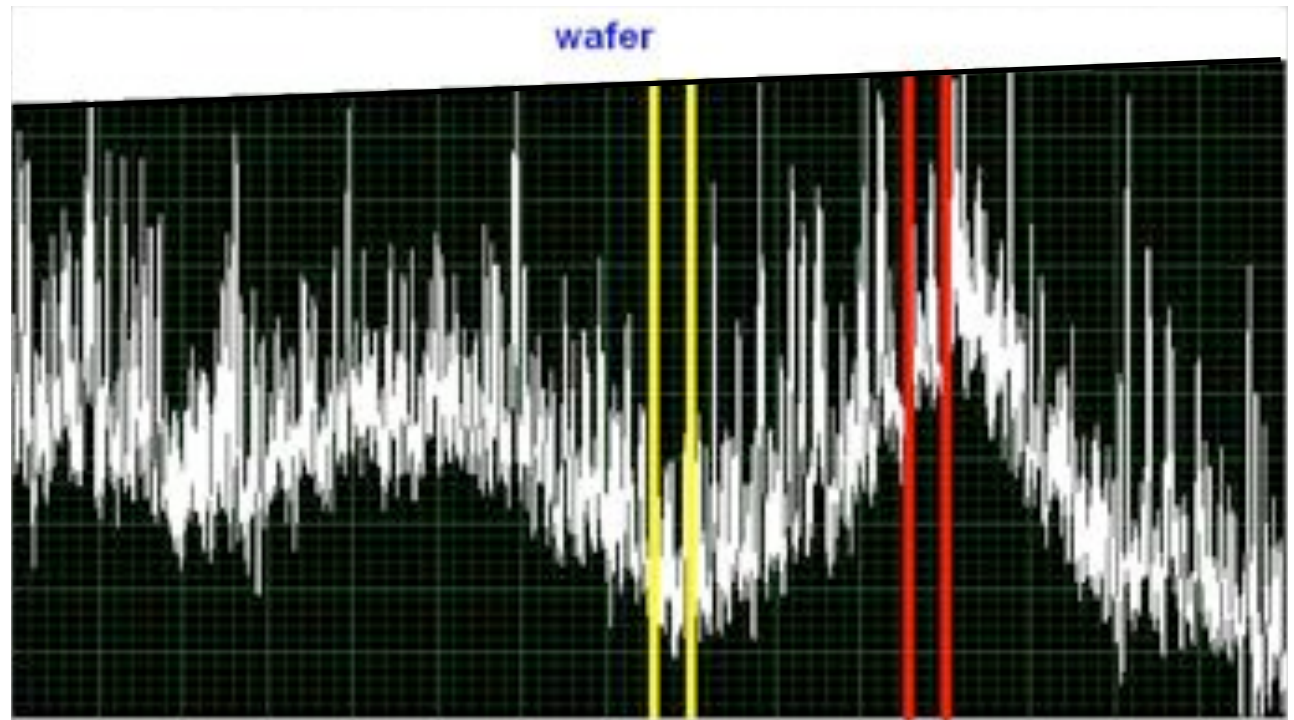
Average Surface Roughness with Variable Down-Force



Zooming issue

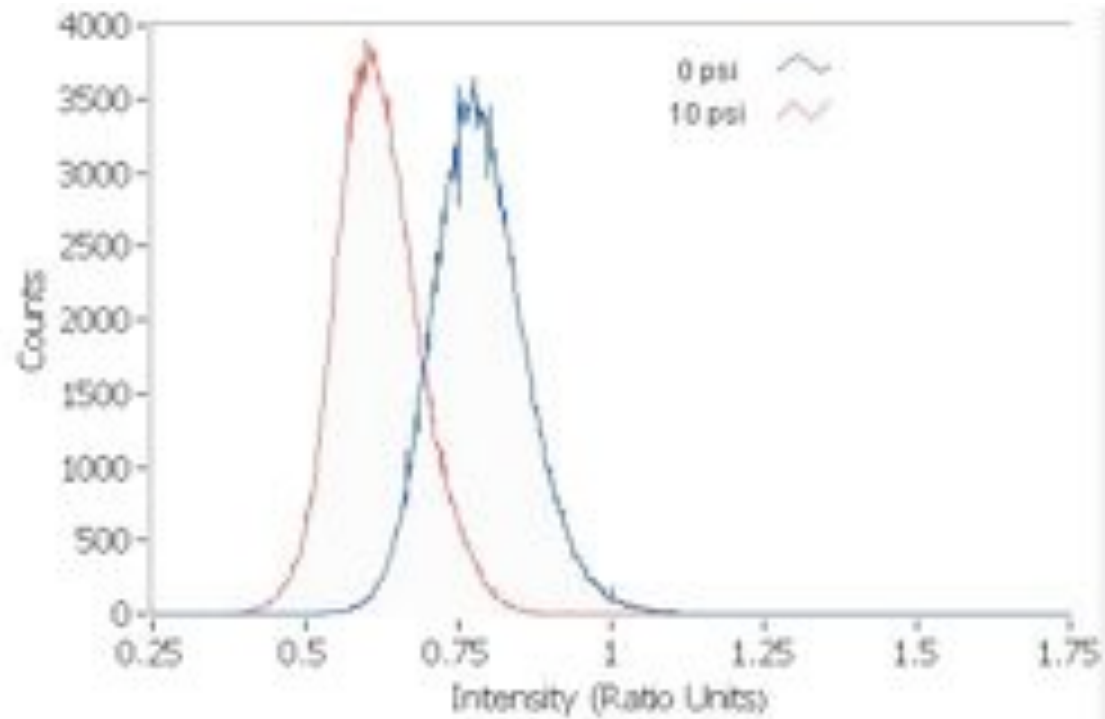


Height (μm)

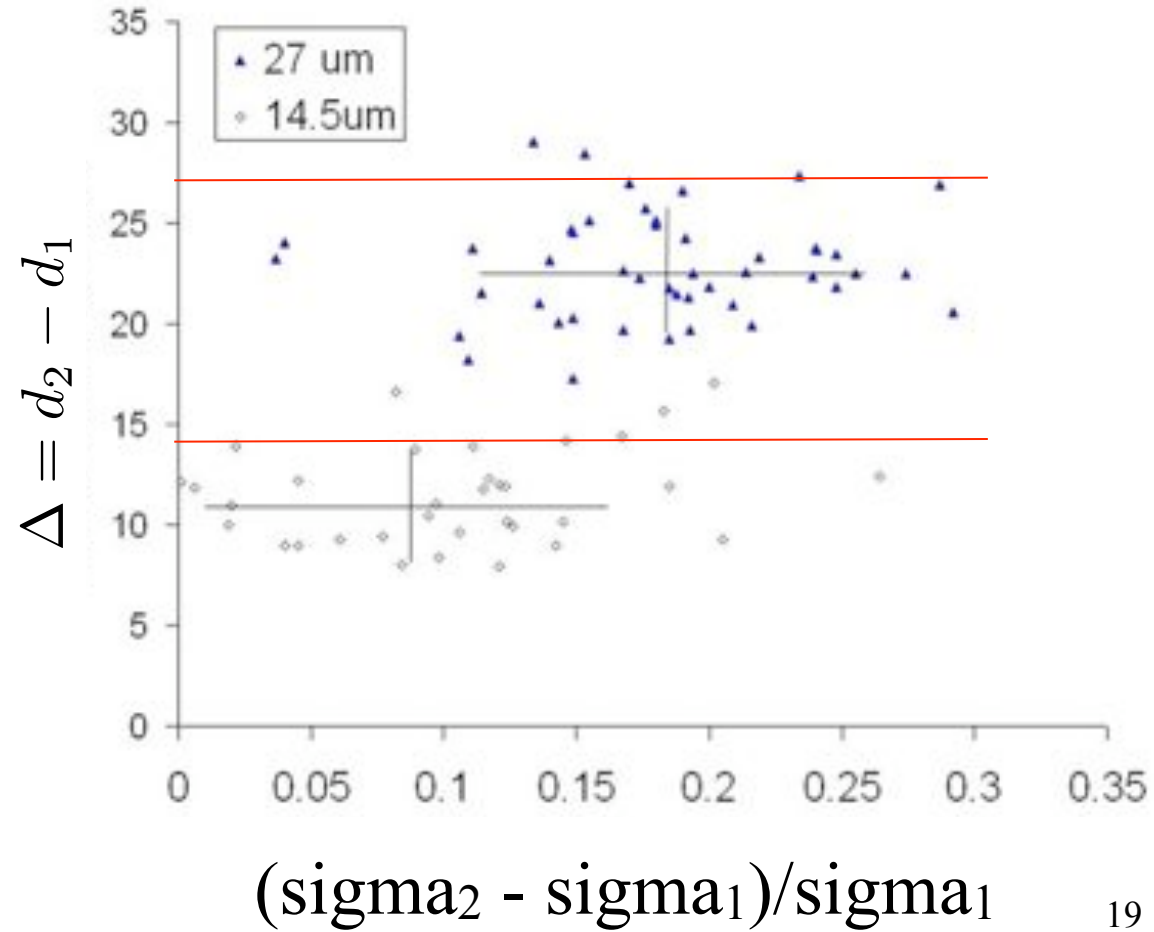
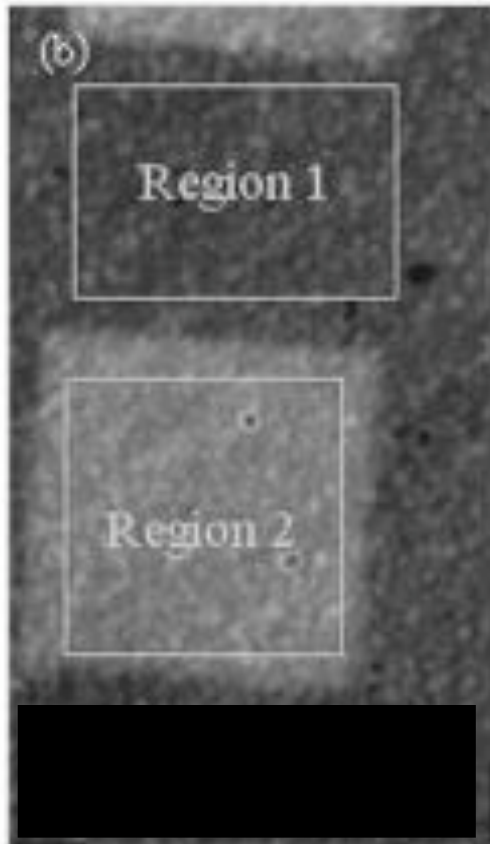


Position on Pad

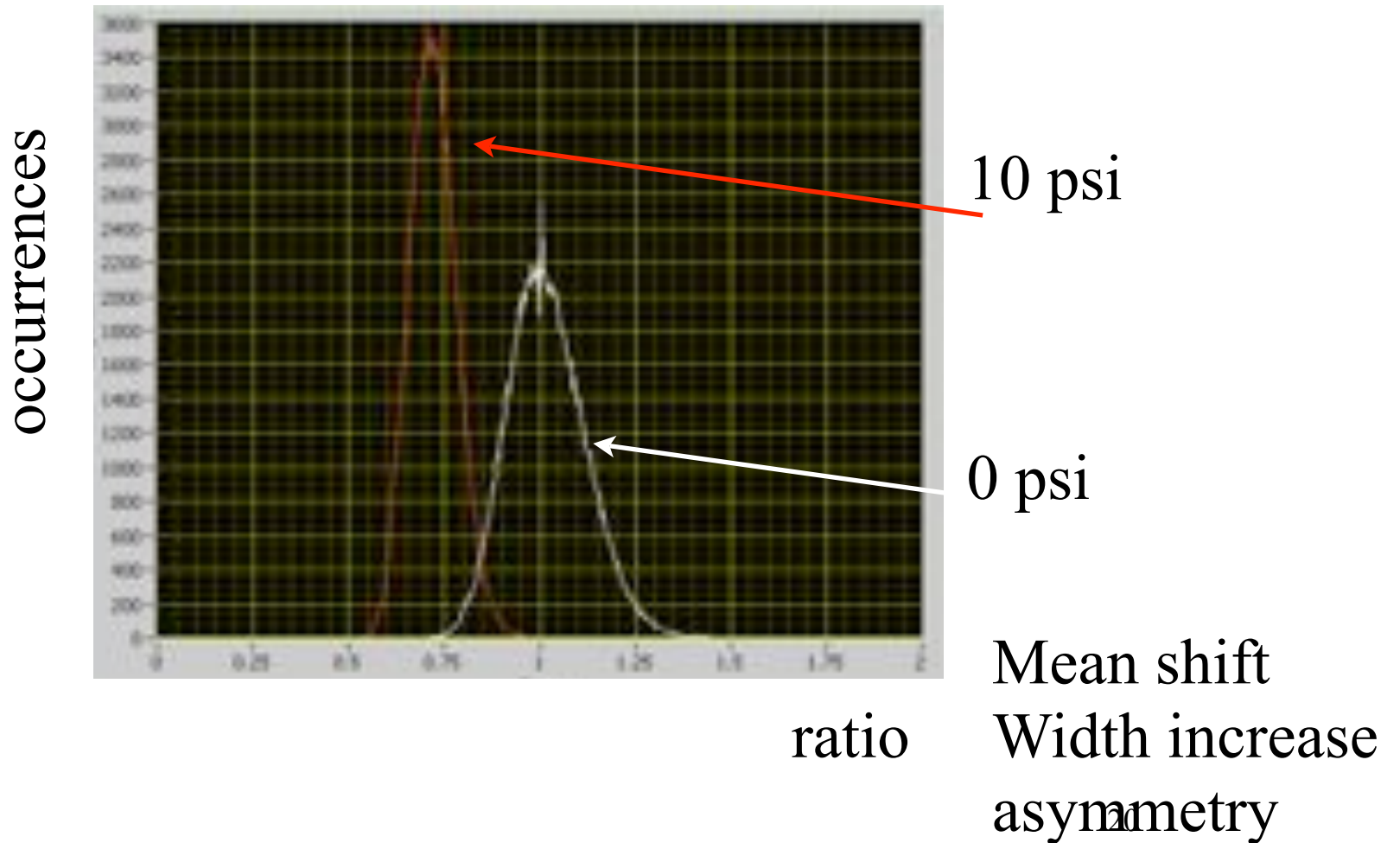
Inside the Well - static

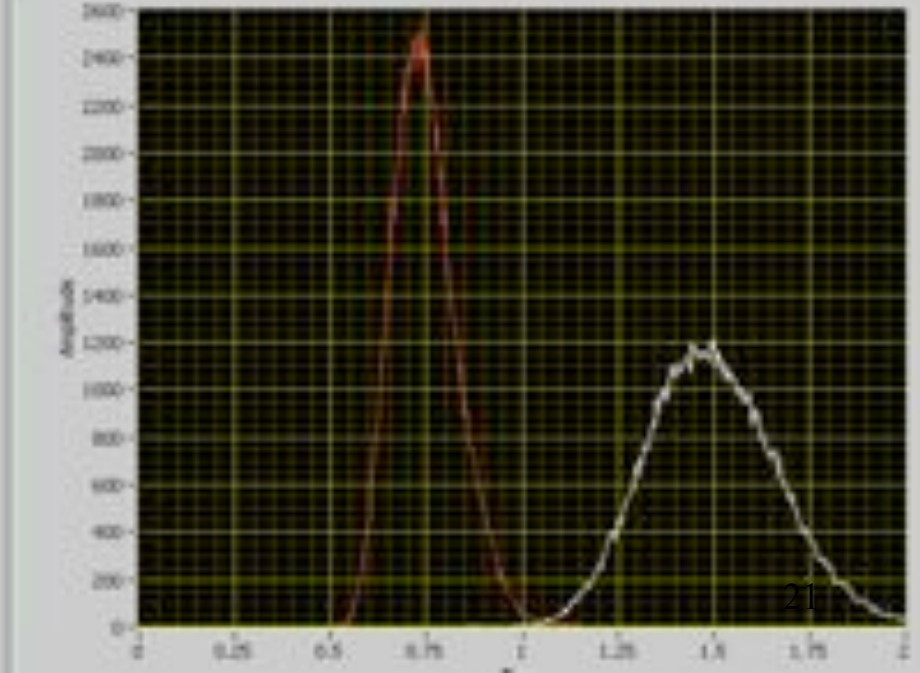
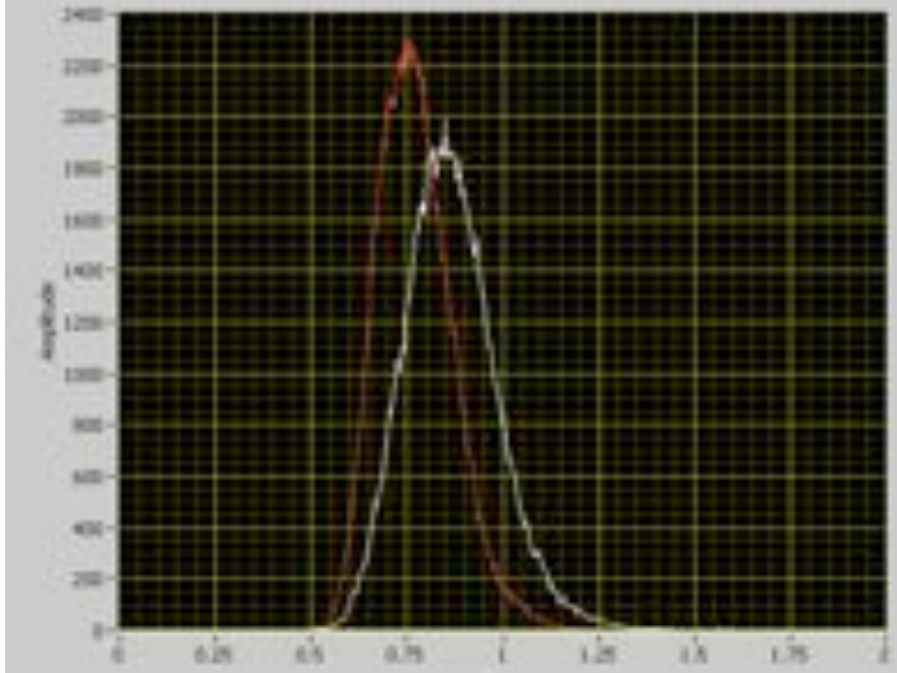
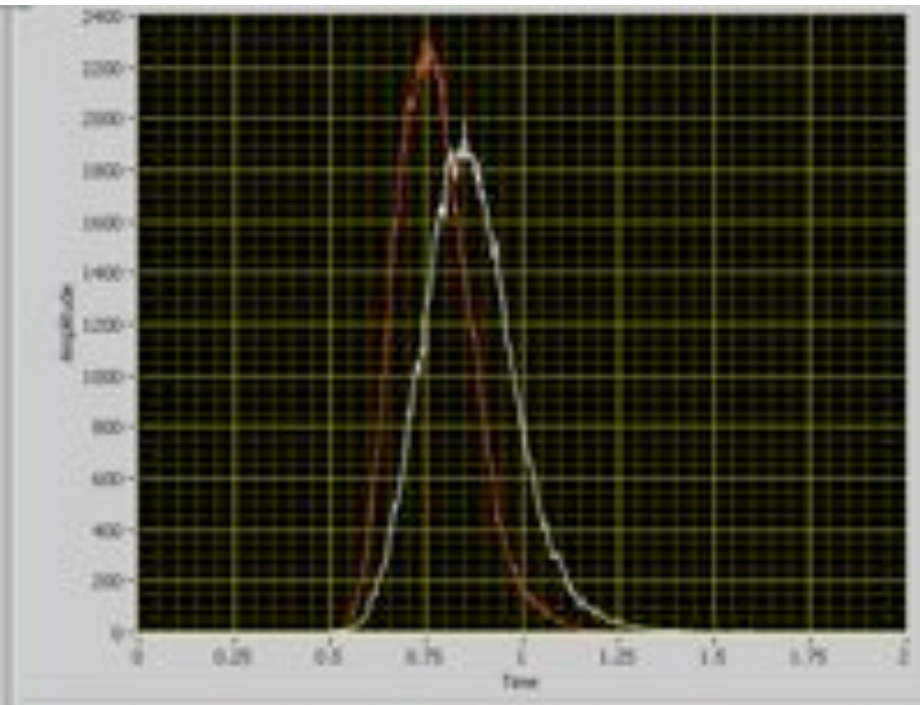
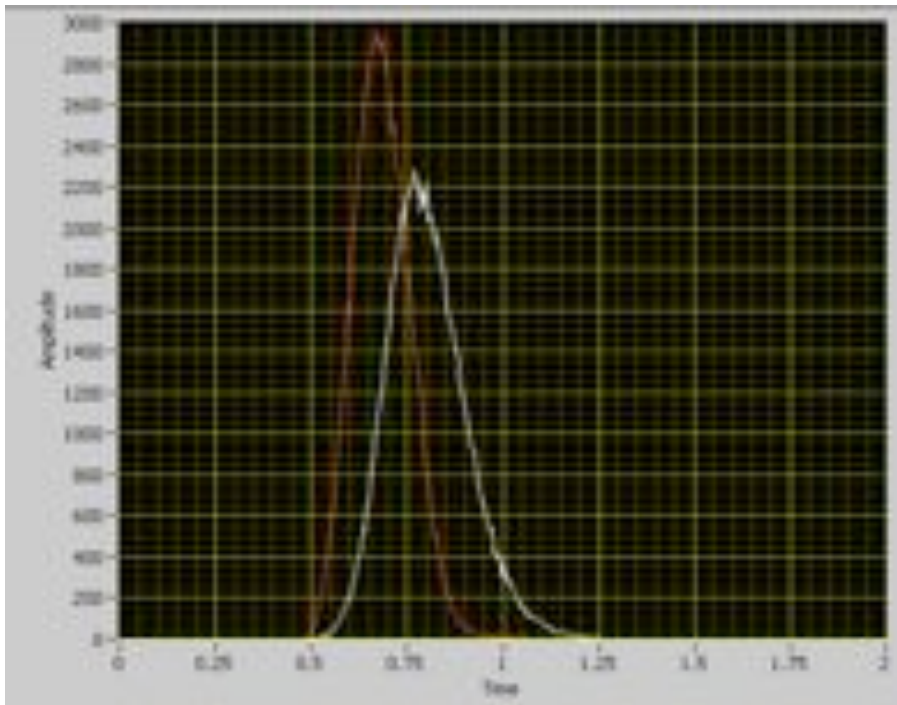


In and Out of the Well

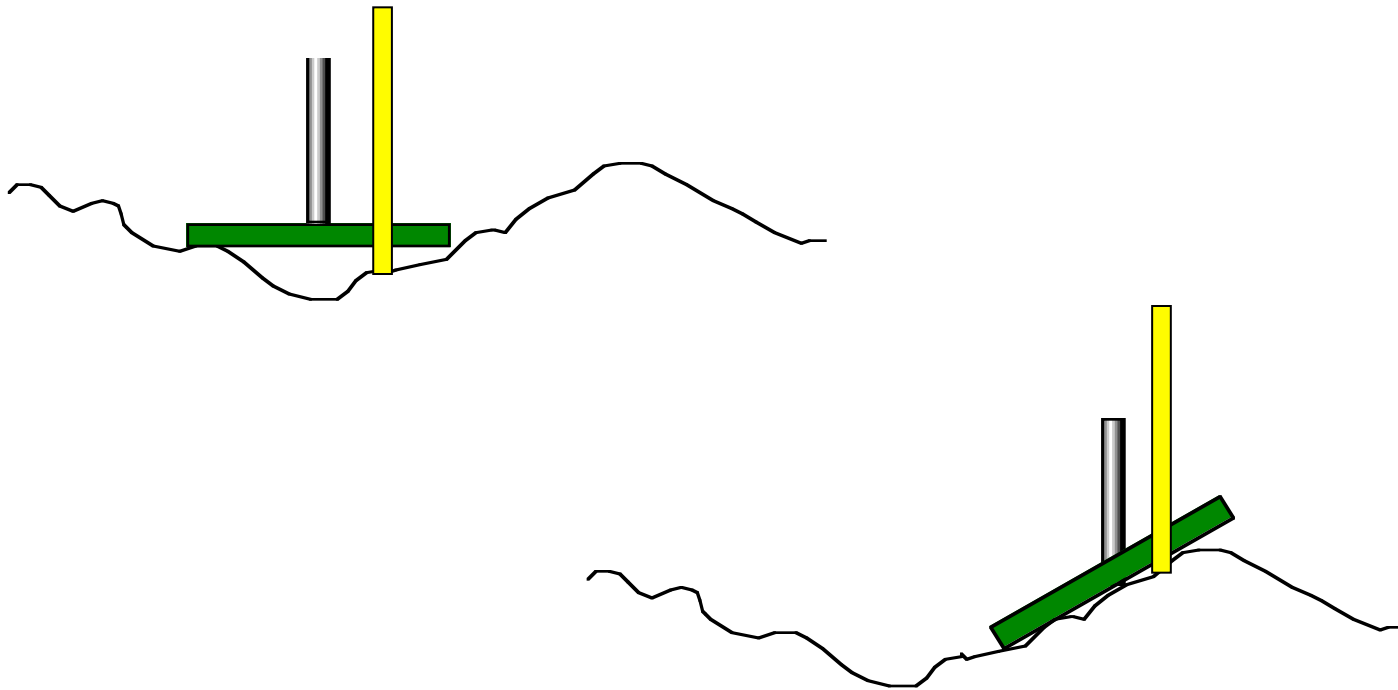


Gap Distribution





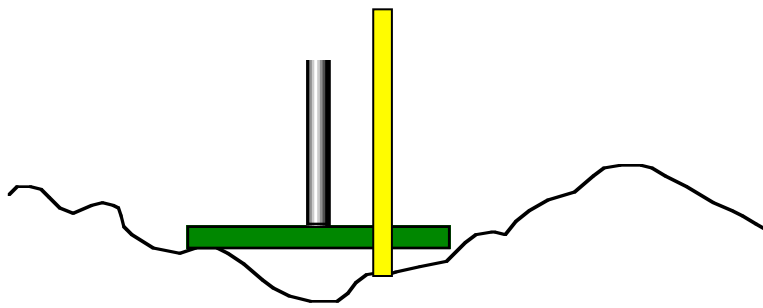
What does this mean?



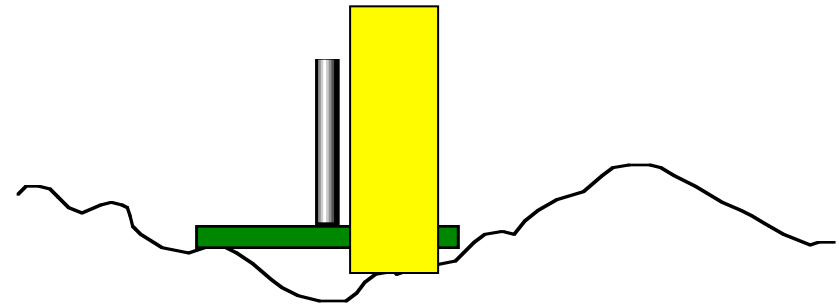
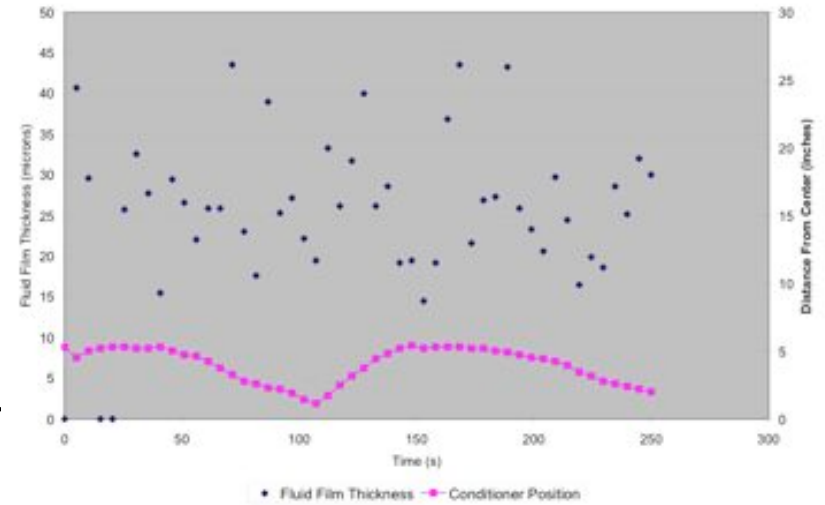
How do we correct for this?

- Larger imaging area?
- Mapping “wafer” angle in real time?
- Don’t correct for it?

Correlating to Friction?



None



Some?

What can we measure?

- 1/4 wafer (zoom out)
- multiple cameras?
- Lighting issues?

Conclusions

- Able to see between pad and wafer during polish
- In-situ measurements
 - gap
 - pad rebound
 - contact?
 - friction
 - forces (all three)
 - moments

Future

- Pad rebound
 - Downforce?
 - Well depth?
 - Subpad?
 - Grooves?
- Pad-wafer Contact