Measuring Across-Wafer Pressure Distribution During CMP

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Driving Force

Pressure mapping during CMP will allow spatial application of Preston's Equation thus leading to a quantitative model describing removal rate non-uniformities across the wafer

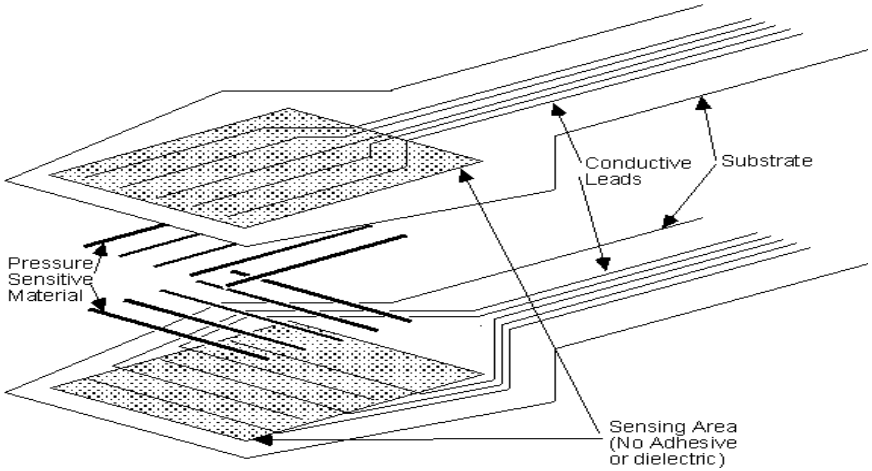
Pressure mapping will also enable the identification of anomalous stress points along the surface of the wafer during CMP

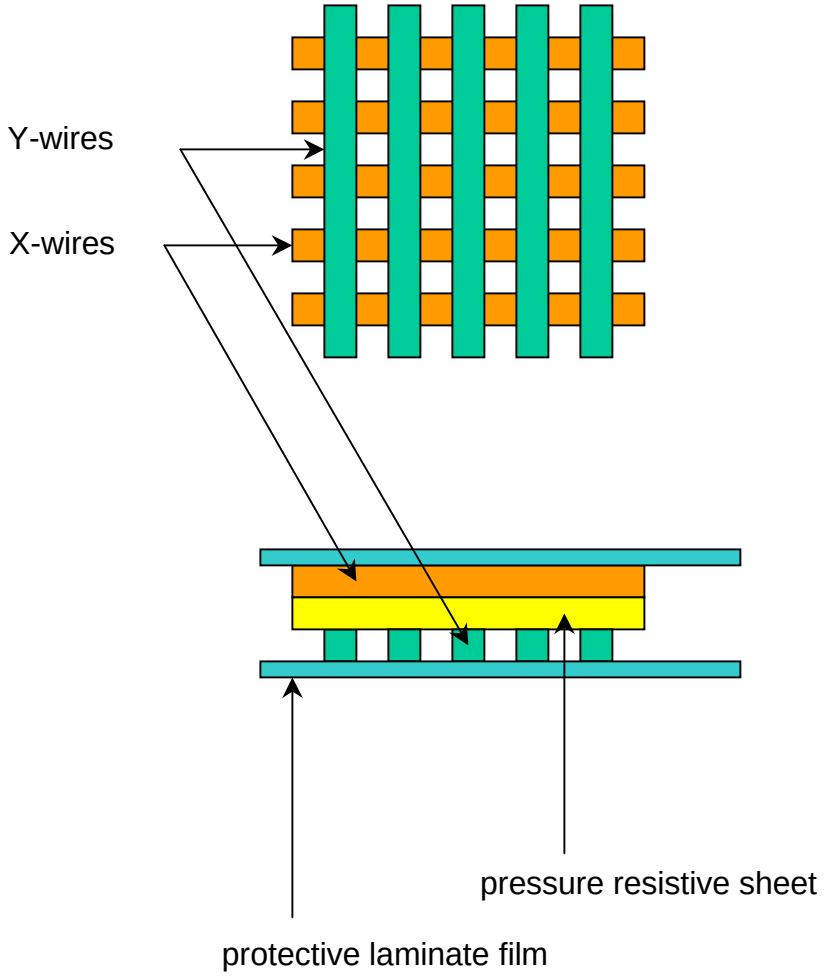
This will in turn allow the study of the effect of various wafer geometric parameters (i.e. bow, total thickness variation, nano-topography) and retaining ring designs on removal rate non-uniformities and defect densities

Outline

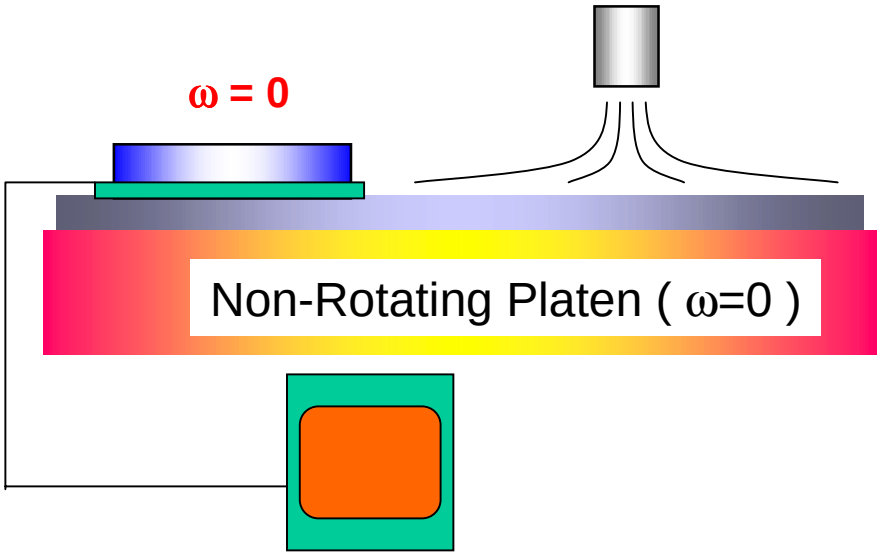
- Review of pressure sensing equipment and theory of operation
- Calibration method
- Experimental procedures
  - No. 1
  - No. 2
- Results & Discussion
  - No. 1
    - 100 mm silicon wafer (with retaining ring and carrier film)
    - 75 mm glass plate
  - No. 2
    - 100 mm silicon wafer (with retaining ring and carrier film)
      - Colloidal silica slurry (diluted and undiluted)
      - Fumed silica slurry (diluted and undiluted)
- Future plans

Tekscan Wafer Pressure Mapping Sensor

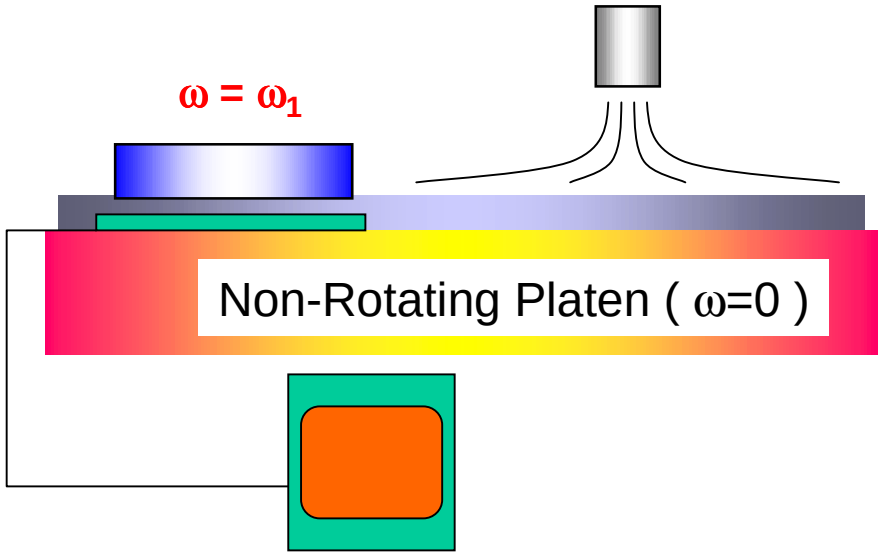




Pressure Mapping Procedures



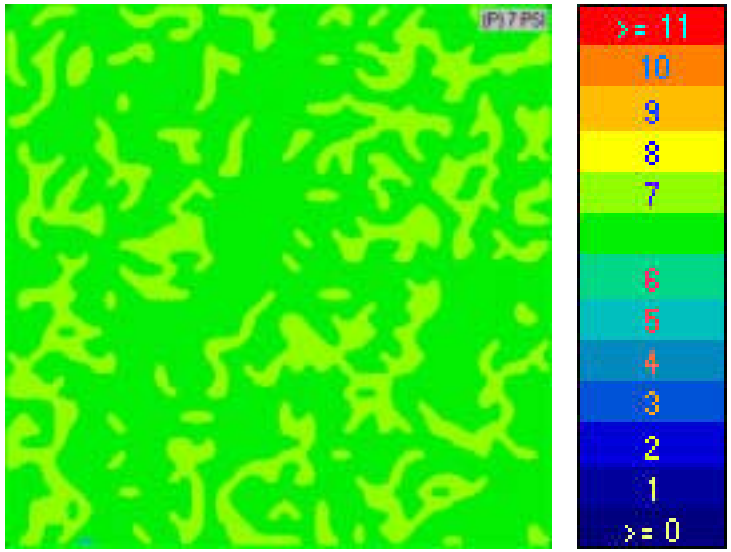
No. 1 (static)



No. 2 (pseudo-dynamic)

Calibration Method

- Converting resistance to force:
  - Sensor is installed & calibrated using the Tekscan Pressure Bladder System
  - The sensor initially observes a uniform force over the entire cell system
    - Equilibration occurs to normalize any cells that may be out of range
    - Calibration is initiated by relating a known pressure over the entire sensor to the detected resistance
      - Calibration is accurate for pressure ranges within 7 psi of the calibrated pressure

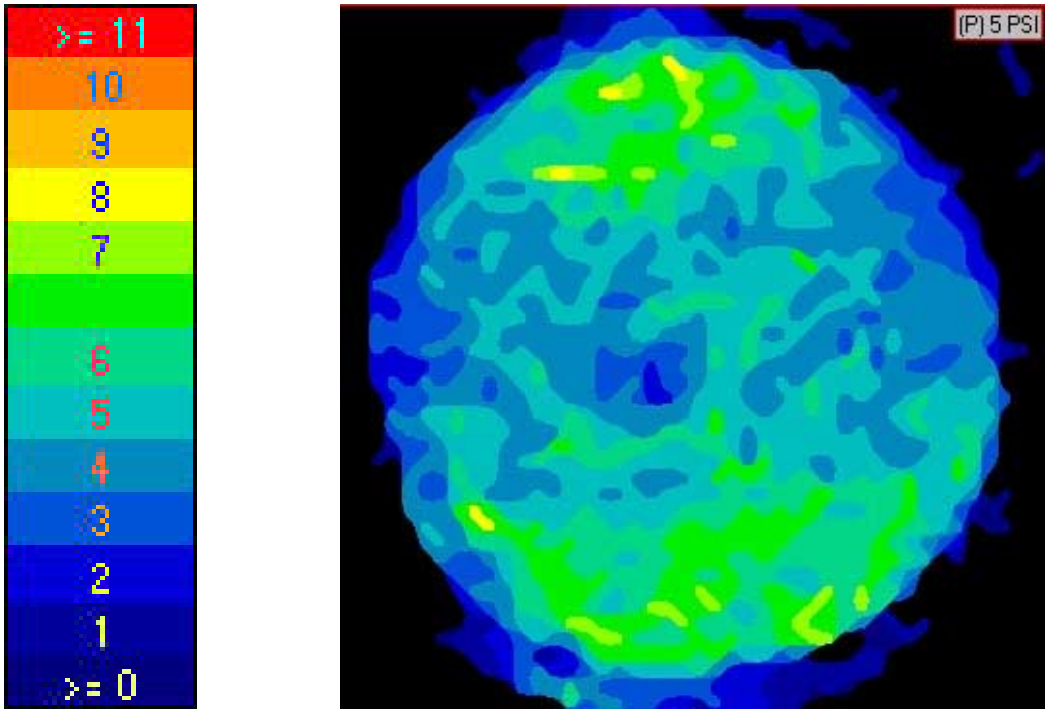


Experimental Procedure No. 1

- Prior to analysis:
  - Sensor is installed & calibrated using the Tekscan Pressure Bladder System
  - While turning at 40 rpm, the pad is soaked with Fujimi PL-4217 slurry for 5 minutes
  - Platen rotation is turned off
  - Sensor is placed directly between wafer and pad
  - Contact is made between wafer and pad
  - Wafer and platen remain stationary during analysis (static condition)
- During analysis:
  - 30-second force & pressure data acquisition at pre-set applied wafer pressures
- Following analysis:
  - Wafer is disengaged from the pad
  - Sensor is removed

Results

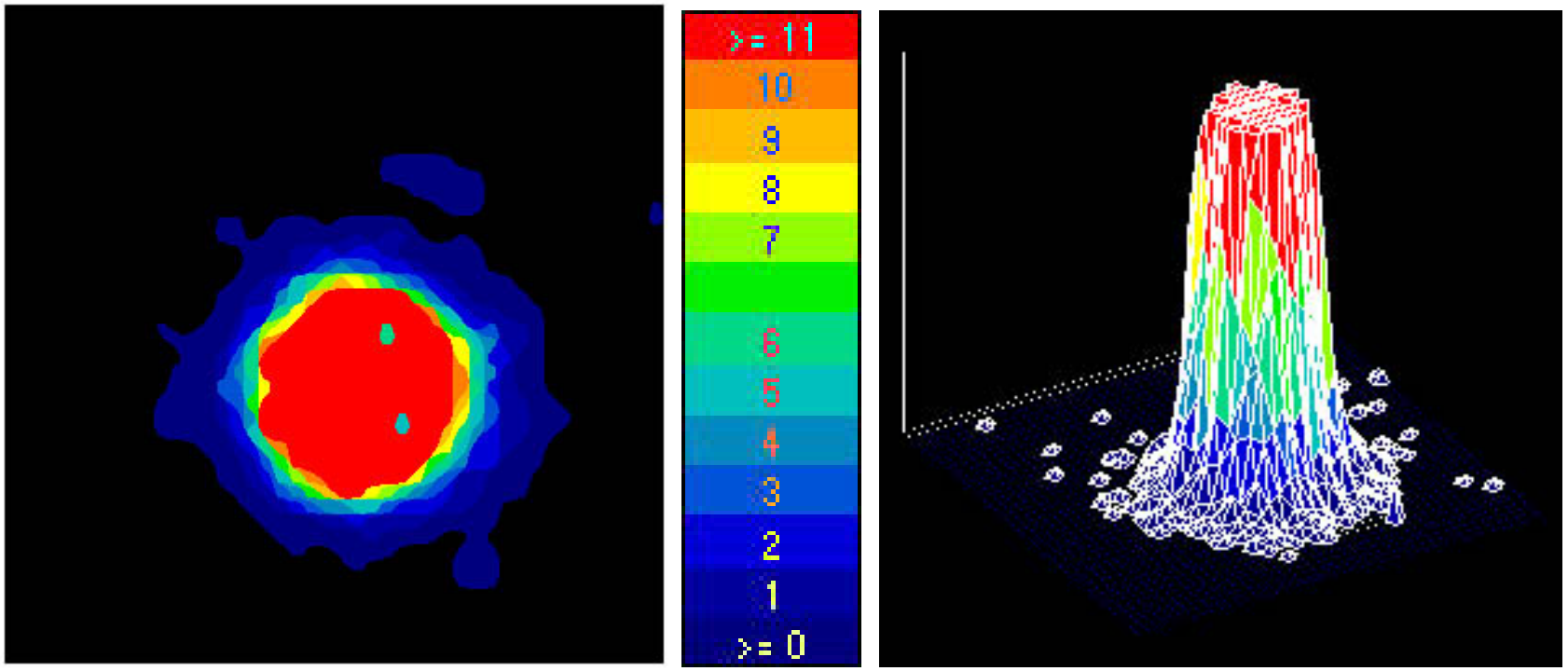
100 mm Silicon Wafers



Contour snapshot of pressure under wafer at 5 psi
(2.5% solids Fujimi PL-4217)

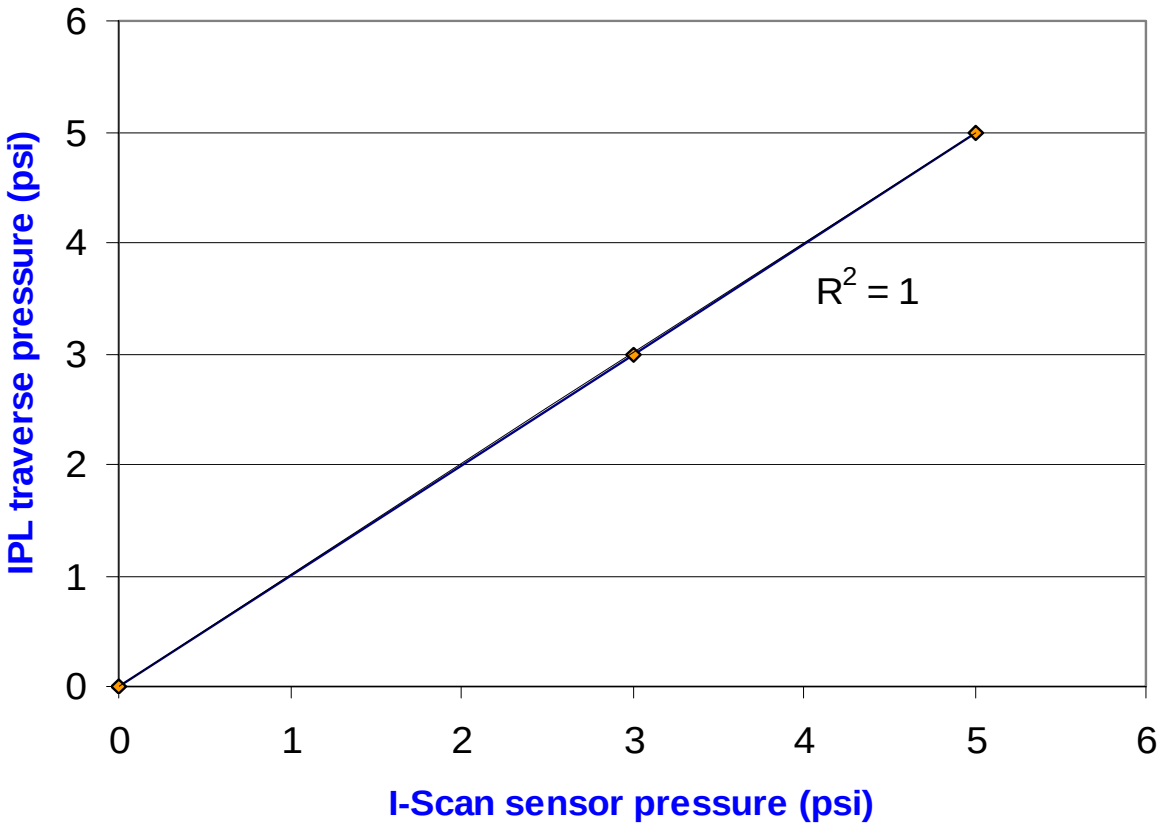
Results

75 mm Convex Glass Wafer Obtained from Tufts University



Contour snapshot of pressure under glass wafer at 5 psi (water)

Comparison of Pressure Obtained from Tekscan vs. Pressure Applied by Traverse Assembly

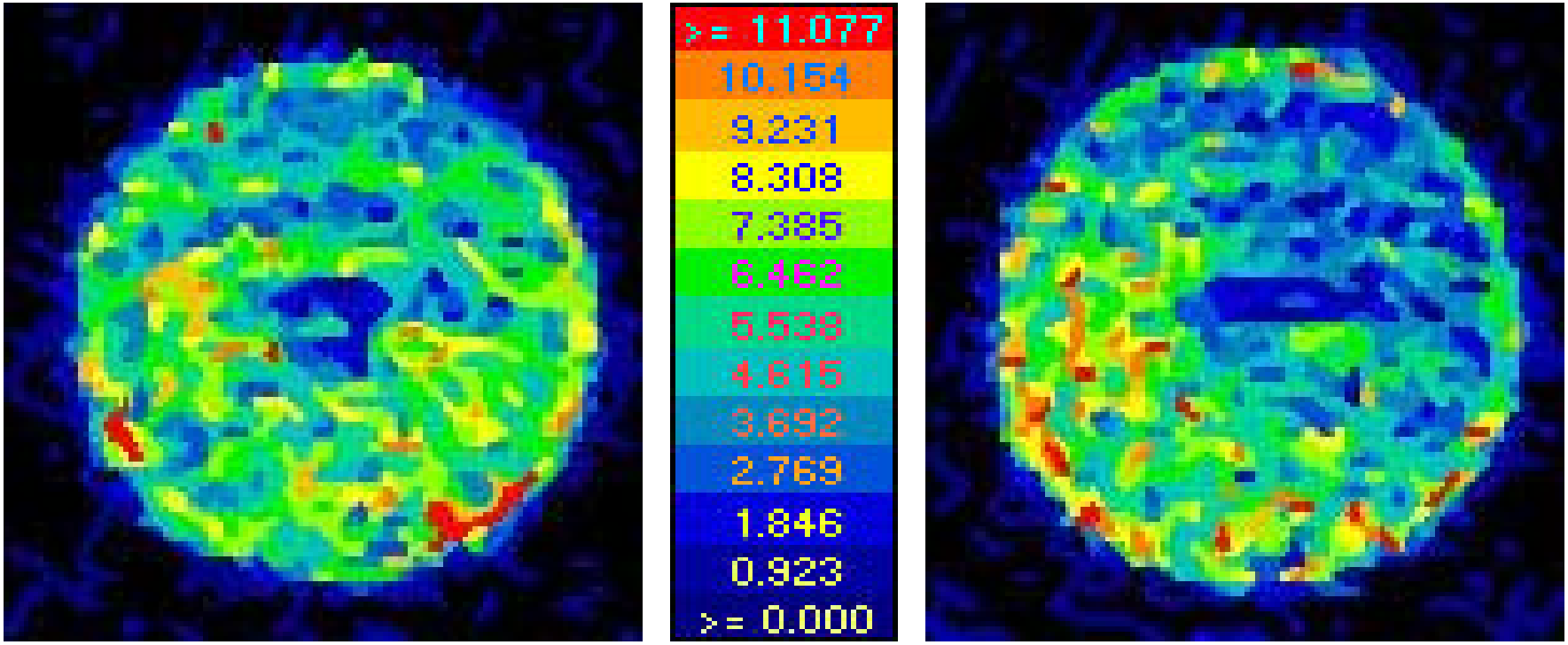


Experimental Procedure No. 2

- Prior to analysis:
  - Sensor is installed & calibrated using the Tekscan Pressure Bladder System
  - Sensor is aligned & attached between platen and pad, directly under the wafer
  - While turning at 40 rpm, the pad is soaked with slurry for 5 minutes
  - Platen rotation is turned off
  - Contact is made between wafer and pad
  - Platen remains stationary during analysis
  - Wafer rotation is turned on at 60 rpm (pseudo-dynamic)
- During analysis:
  - 30-second force & pressure data acquisition at pre-set applied wafer pressures
- Following analysis:
  - Wafer is disengaged from the pad

Results

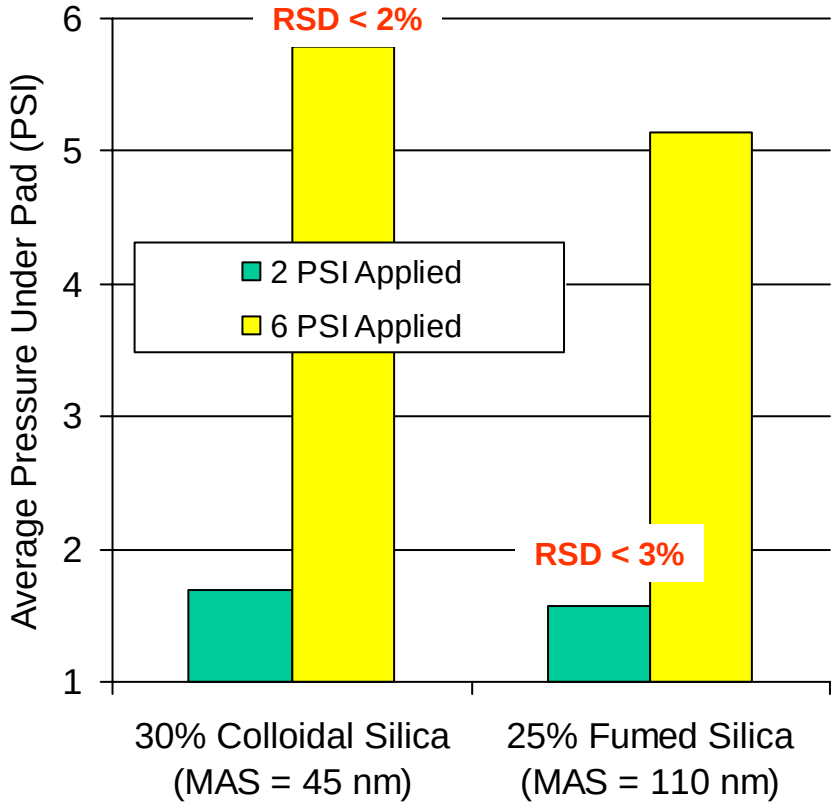
100 mm Silicon Wafers



Contour snapshot of pressure under wafer at 6 psi (Undiluted Syton)

Contour snapshot of pressure under wafer at 6 psi (Undiluted Fujimi PL4217)

Effect of Slurry Type on Average Pressure Under the Pad

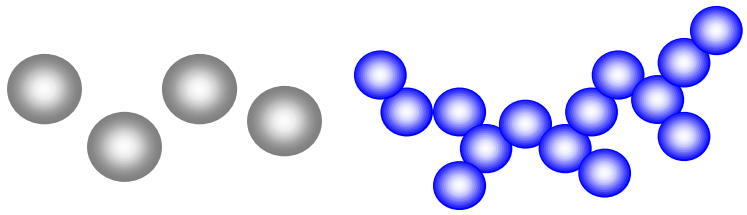


$$\pi = \frac{P_{measured}}{P_{applied}} = \frac{5.784}{6.000}\Big|_{colloidal} = 0.964$$

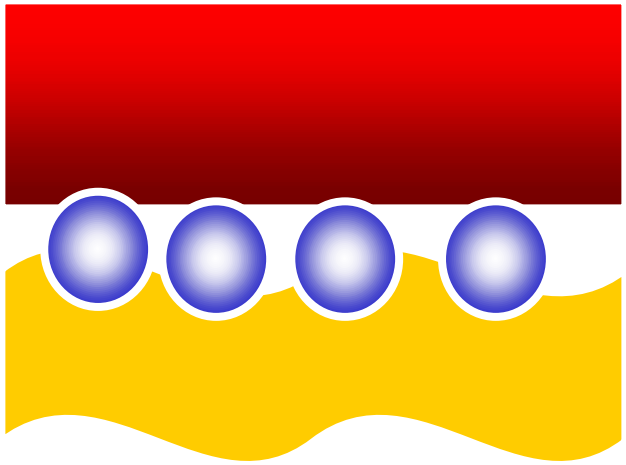
$$\pi = \frac{P_{measured}}{P_{applied}} = \frac{1.688}{2.000}\Big|_{colloidal} = 0.844$$

$$\pi = \frac{P_{measured}}{P_{applied}} = \frac{5.142}{6.000}\Big|_{fumed} = 0.857$$

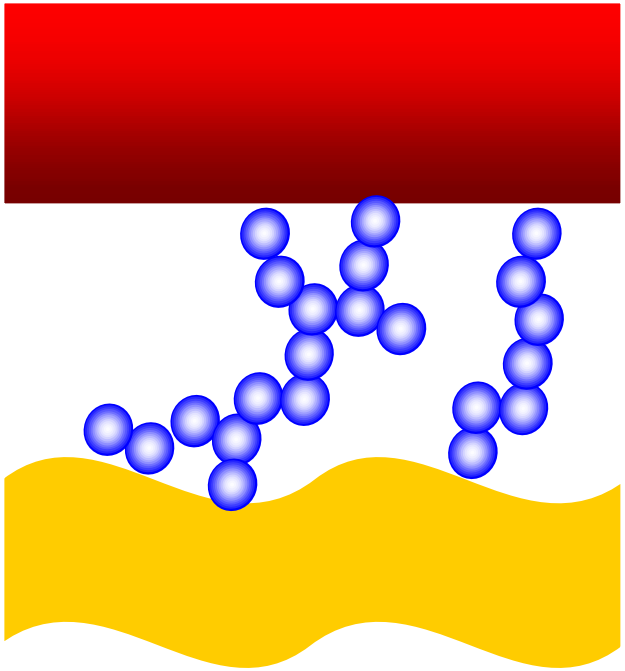
$$\pi = \frac{P_{measured}}{P_{applied}} = \frac{1.574}{2.000}\Big|_{fumed} = 0.787$$



Effect of Slurry Type on Average Pressure Under the Pad



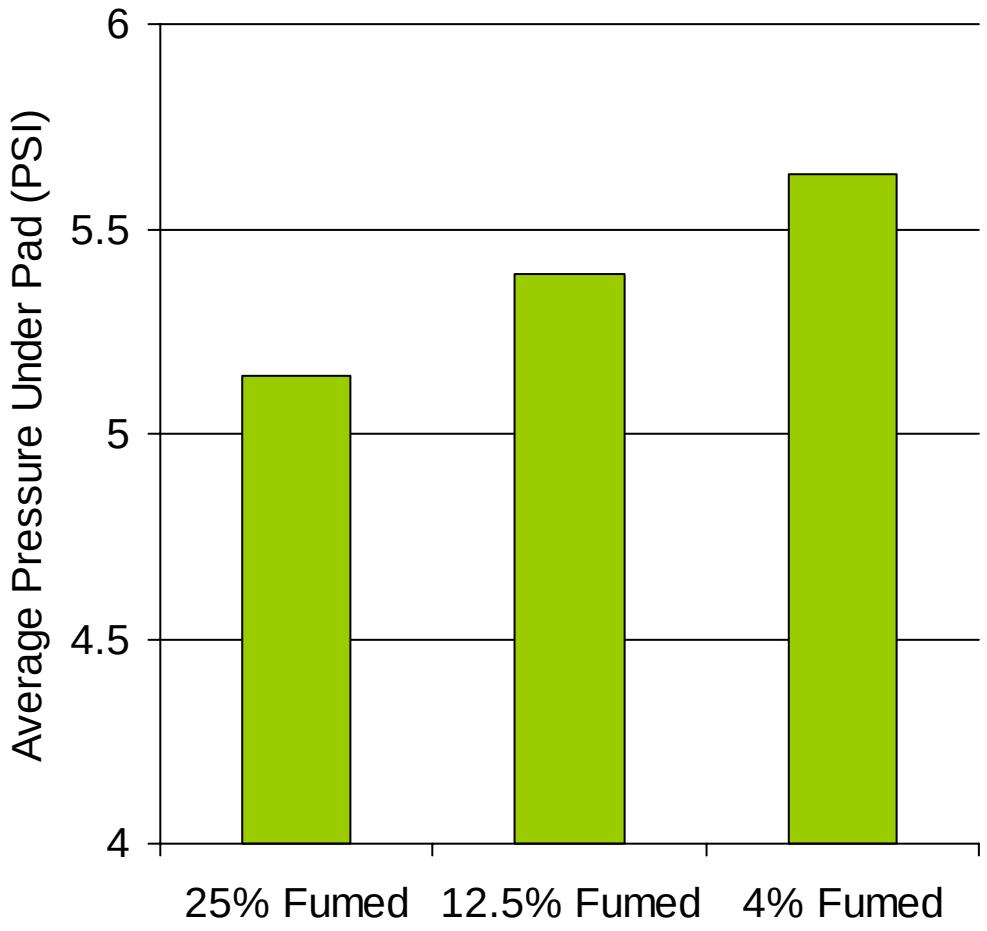
Colloidal Slurry



Fumed Slurry

Effect of Slurry Dilution on Average Pressure Under the Pad

(Fumed Silica Slurry at 6 PSI)



Future Plans

- Develop pressure sensing method for dynamic mode
- Determine how the following parameters affect pressure distribution under wafer during CMP:
  - Wafer shapes (i.e. bow, TTV and nano-topography)
  - Slurry type and dilution
  - Pads
  - Pad groove shapes
  - Diamond grit sizes
  - Conditioning recipes
  - Slurry flow rates
  - Wafer pressures
  - Wafer and platen rotational speeds
- Develop comprehensive within-wafer uniformity removal rate model consistent with above observations