# Effect of Pad Micro-Texture on Frictional Force, Removal Rate, and Wafer Topography during ILD/STI CMP Processes


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# Outline

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## 2. Polishing Apparatus and Experimental Conditions

## 3. Polishing Results

- **Blanket wafer polishing**
- **Patterned wafer polishing**

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- **Contact area analysis**
- **Pad surface topography analysis**

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# Objective and Approach

- **Objective:** **investigate the effect of pad micro-texture on frictional force, removal rate, and wafer topography during ILD/STI CMP processes**

- **Approach:** **polish 200-mm blanket TEOS and SKW3-2 STI wafers under 6 and 10 lb conditioning forces with a 3M A2810 disc and a Mitsubishi Materials Corporation 100-grit TRD disc, and analyze pad micro-texture through laser confocal microscopy**

  - **Blanket wafer polishing: frictional force and removal rate**
  - **Patterned wafer polishing: dishing and erosion**
  - **Pad micro-texture analyses: contact area, surface abruptness, and summit curvature**

# Araca APD – 500 Polisher & Tribometer

# Experimental Conditions

– **Pad**
  - **IC1000 A2 K-groove pad with Suba IV sub-pad**

– **Slurry**
  - **Hitachi Chemical STI slurry**
  - **Flow rate: 150 ml/min**

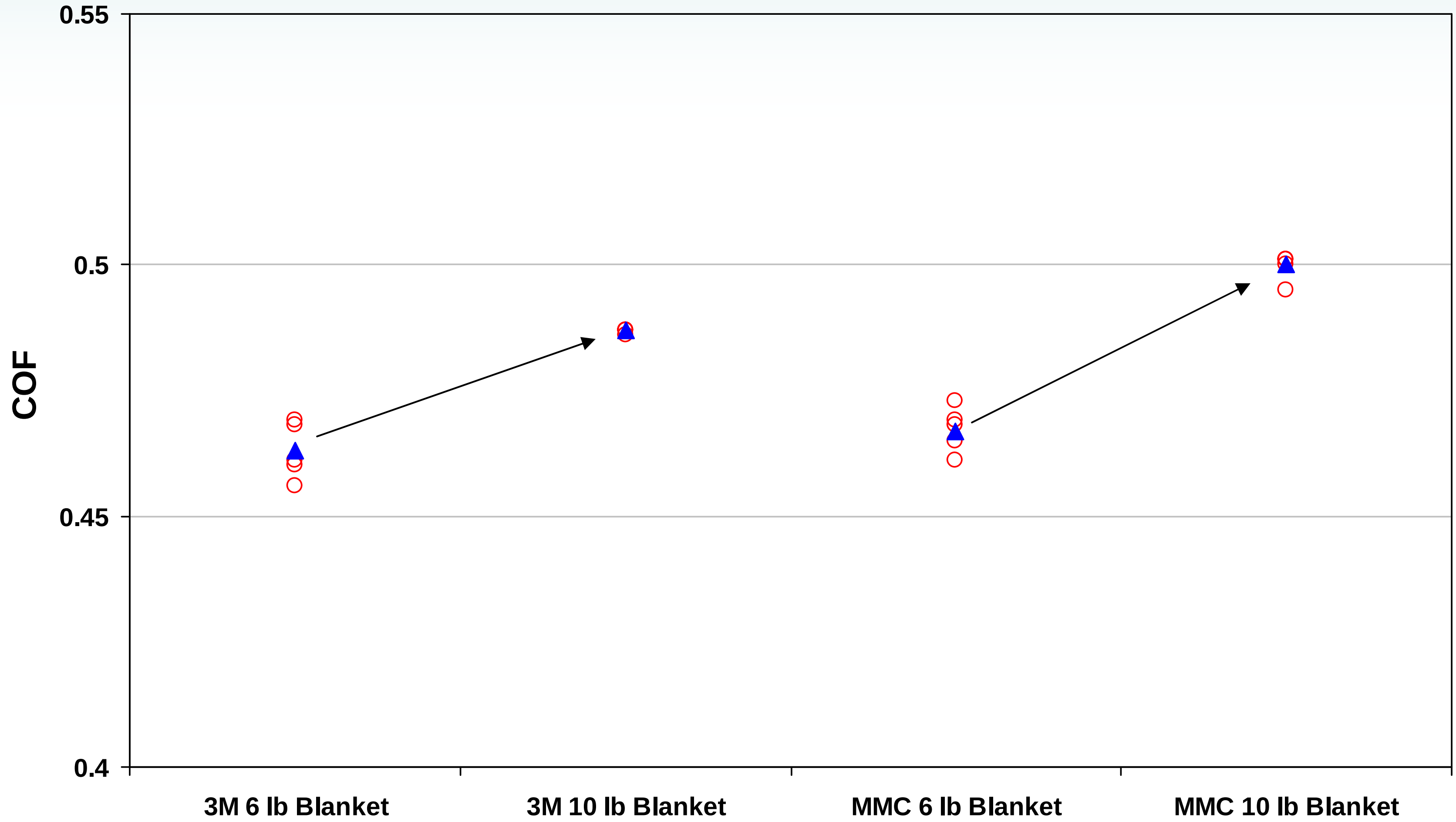
– **Wafer**
  - **200-mm blanket TEOS wafers**
  - **200-mm patterned SKW3-2 STI wafers**

– **Pad Conditioning**
  - **Mitsubishi Materials Corporation 100-grit TRD disc and 3M A2810 disc rotating at 95 RPM and sweeping at 10 times/min**
  - **In-situ pad conditioning at 6 and 10 $lb_f$**

– **Polishing**
  - **Polishing pressure: 4 PSI**
  - **Sliding velocity: 1.2 m/s**
  - **Blanket TEOS wafer polishing time: 1 minute**
  - **SKW3-2 STI wafer polishing time: 5 minutes at conditioning force of 6 lb and 3 minutes at conditioning force of 10 lb**

# Coefficient of Friction

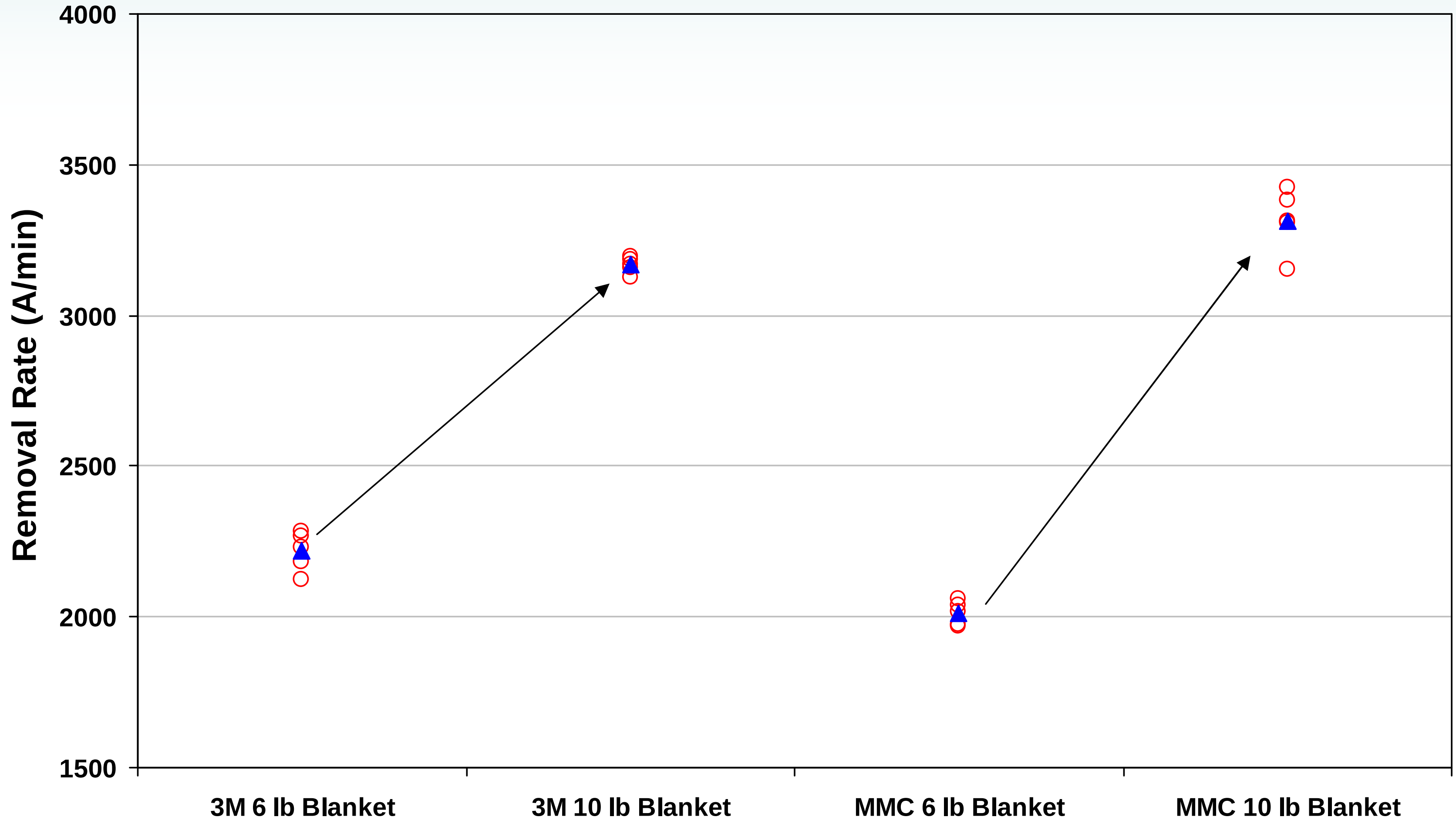
## Blanket TEOS Wafer Polishing




**For both the 3M A2810 disc and MMC TRD disc, $COF_{6\ lb} < COF_{10\ lb}$.**

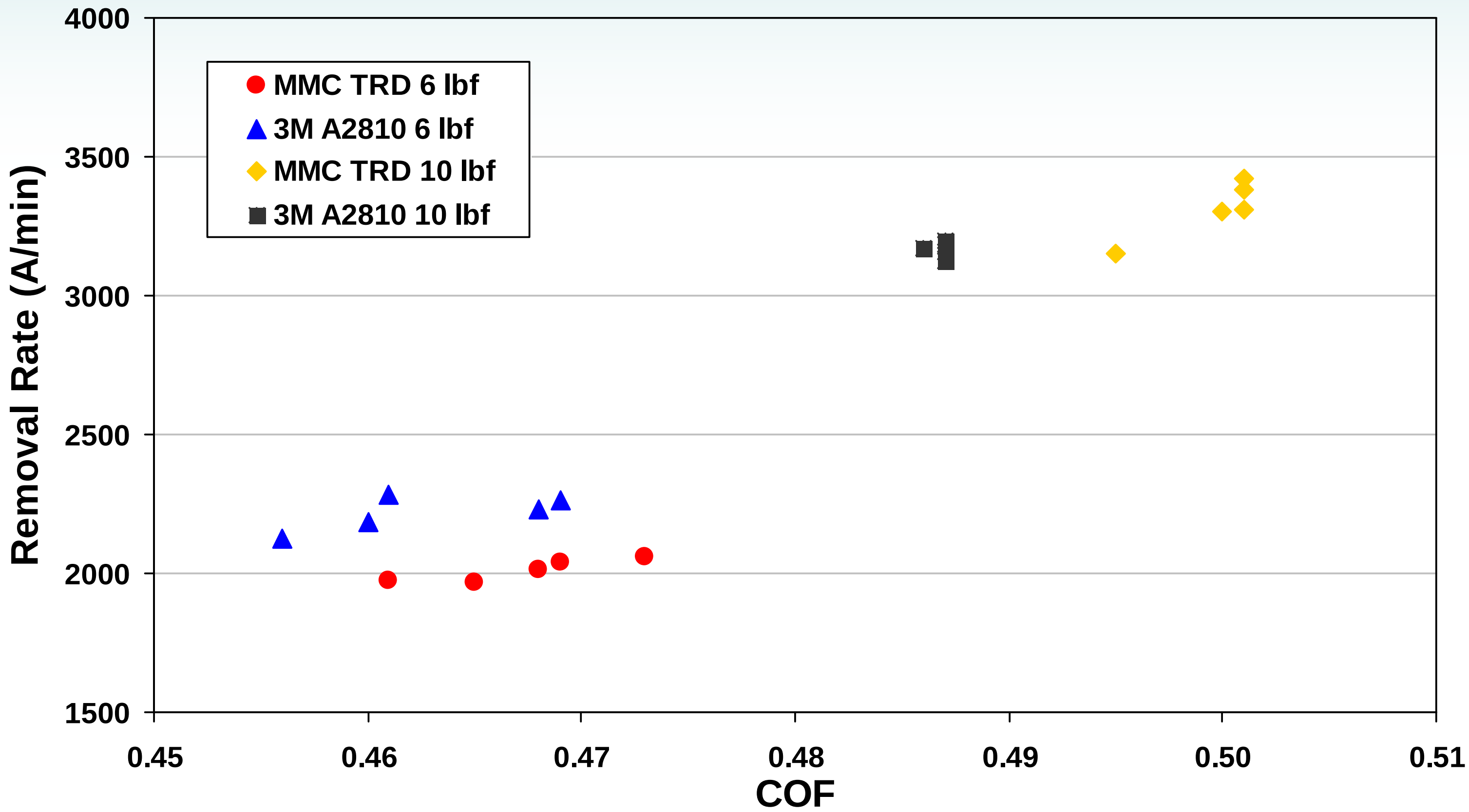
# Removal Rate

## Blanket TEOS Wafer Polishing




**For both the 3M A2810 disc and MMC TRD disc, Removal Rate$_{6\ lb}$ < Removal Rate$_{10\ lb}$.**

# Removal Rate vs. COF




**The removal rate increased much more significantly with the conditioning force (65% for the MMC TRD disc and 43% for the 3M A2810 disc) than the COF (7% for the MMC TRD disc and 5% for the 3M A2810 disc).**

# Dishing and Erosion Analysis

## Center Die, 100 Micron Pitch

| Conditioning Force (lb) | Diamond Disc | Dishing (A) | | | | | Erosion (A) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Pattern Density | | | | | Pattern Density | | | | |
| | | 10% | 30% | 50% | 70% | 90% | 10% | 30% | 50% | 70% | 90% |
| 6 | 3M A2810 | 125 | 1200 | 300 | 300 | 275 | 110 | 134 | 125 | 113 | 117 |
| | MMC TRD | 325 | 2800 | 500 | 500 | 325 | 330 | 215 | 406 | 129 | 172 |
| 10 | 3M A2810 | 275 | 600 | 200 | 125 | 175 | 34 | 22 | 49 | 11 | 4 |
| | MMC TRD | 750 | 1400 | 300 | 225 | 275 | 103 | 23 | 86 | 24 | 18 |

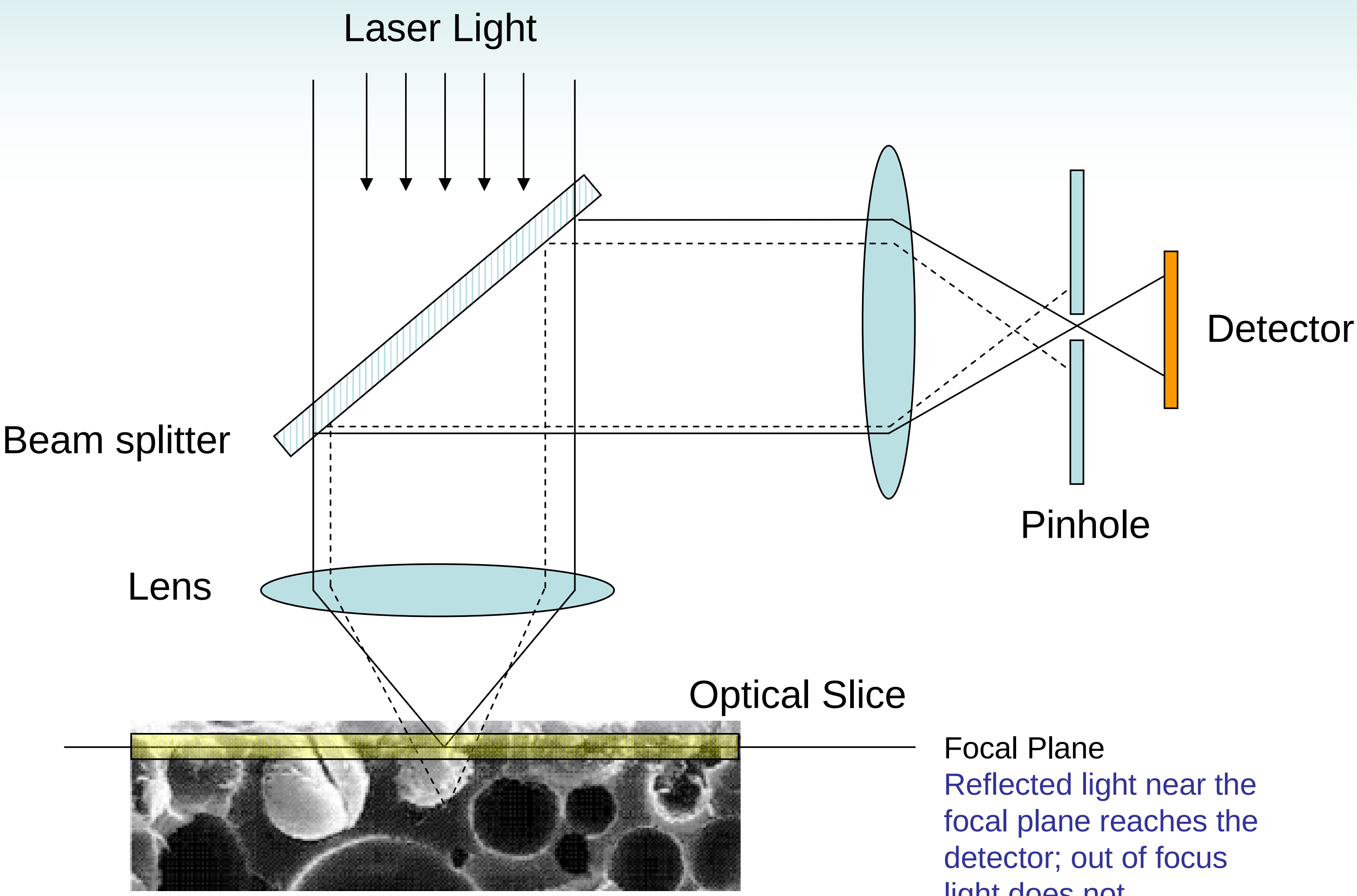
**At both conditioning forces, Dishing/Erosion$_{\text{3M A2810 disc}}$ < Dishing/Erosion$_{\text{MMC TRD disc}}$.**

# Laser Confocal Microscopy

Zeiss LSM 510 Meta NLO

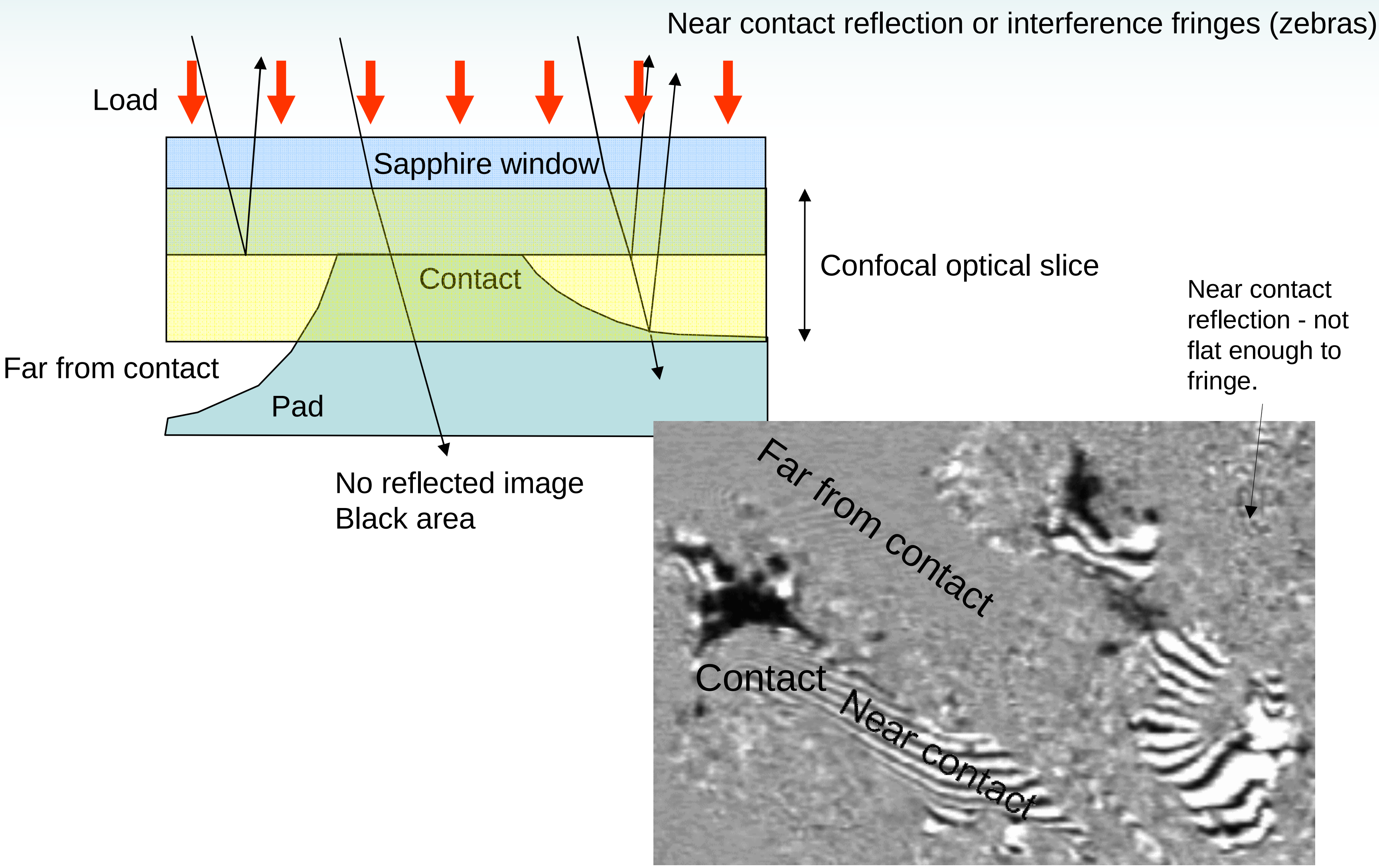
**Pad surface contact area and topography analyses were performed through laser confocal microscopy.**

# How a Laser Confocal Microscope Works




Reflected light near the focal plane reaches the detector; out of focus light does not.

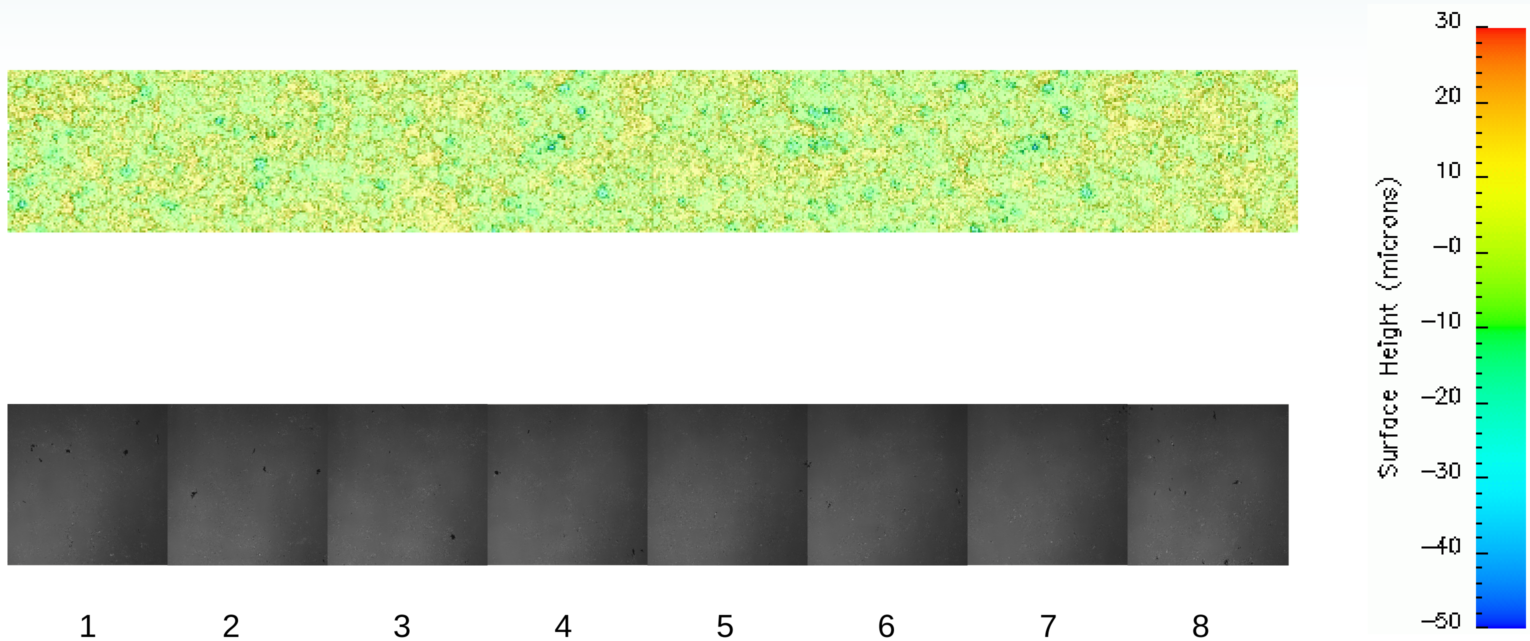
# Confocal Contact Area Measurements



# Topography and Contact Images

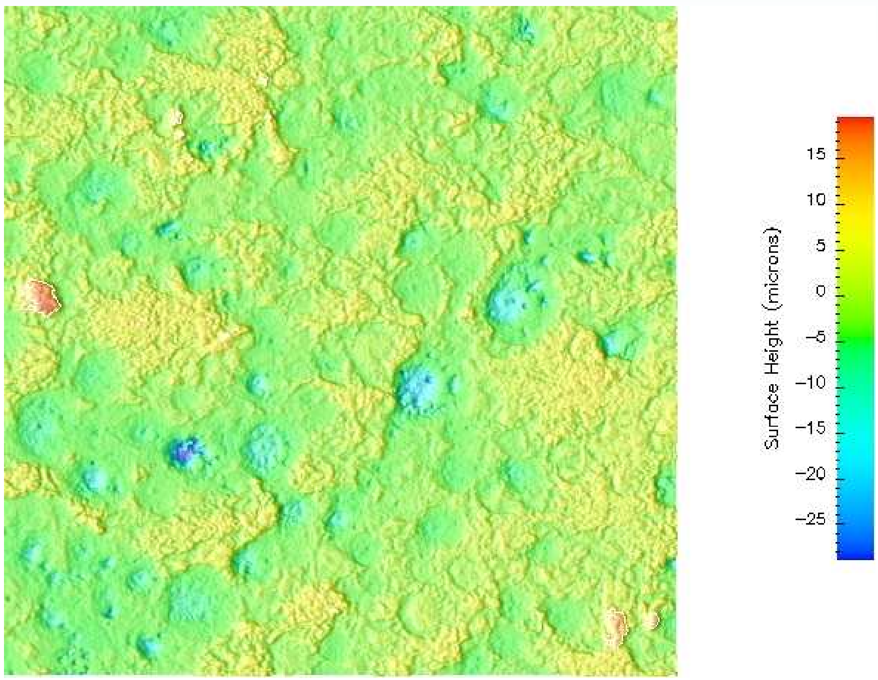
**Topography**

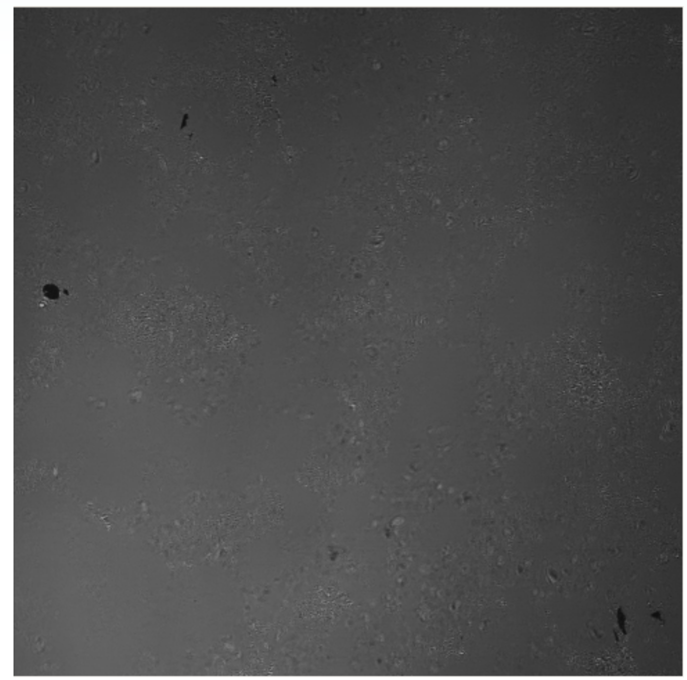
**Contact, 4 PSI**




**For each sample, eight topography and contact images (3.6 x 0.45 mm) were taken.**

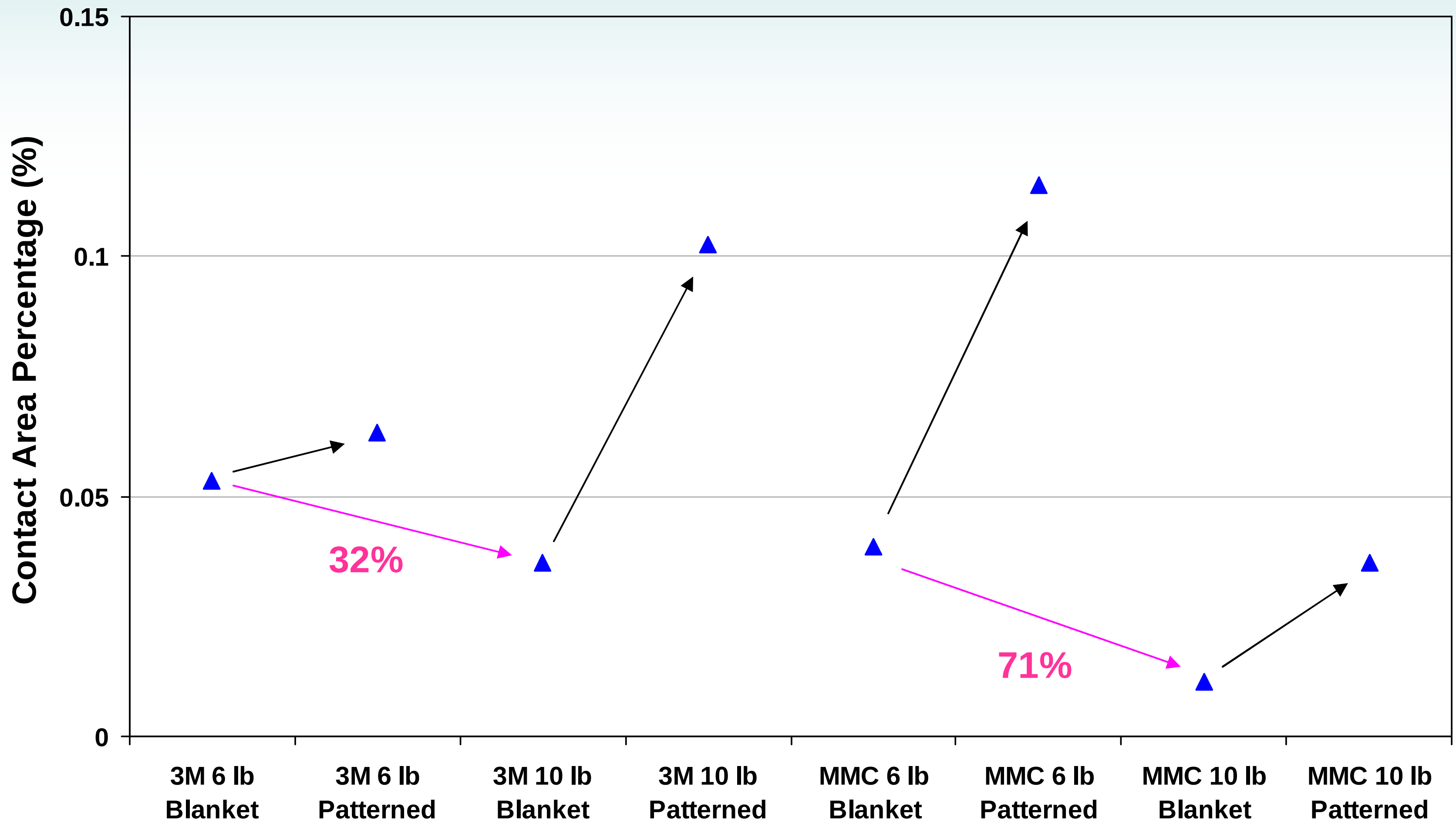
# Topography and Contact Images



**The topography image was matched to the contact area image to locate contact areas.**

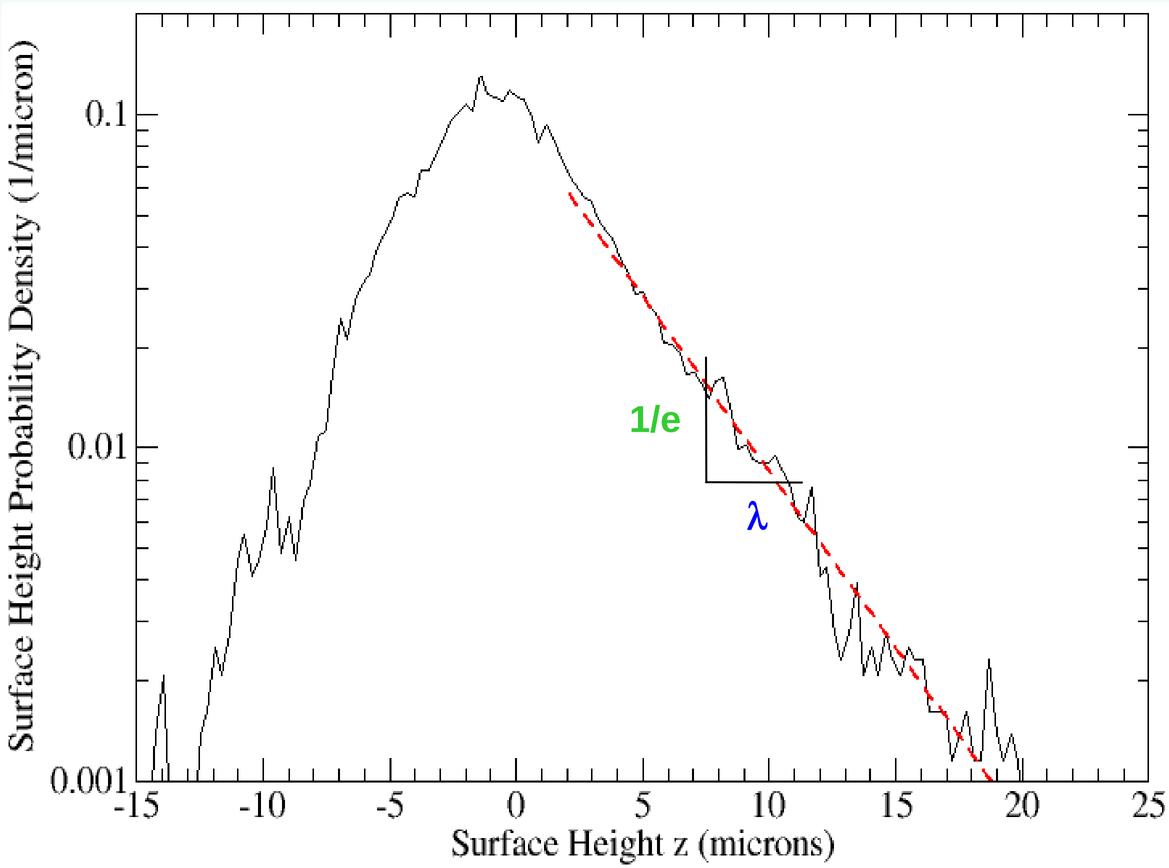
# Contact Area Percentage




**Contact Area Percentage$_{6\ lb}$ > Contact Area Percentage$_{10\ lb}$ for both discs during blanket wafer polishing.**

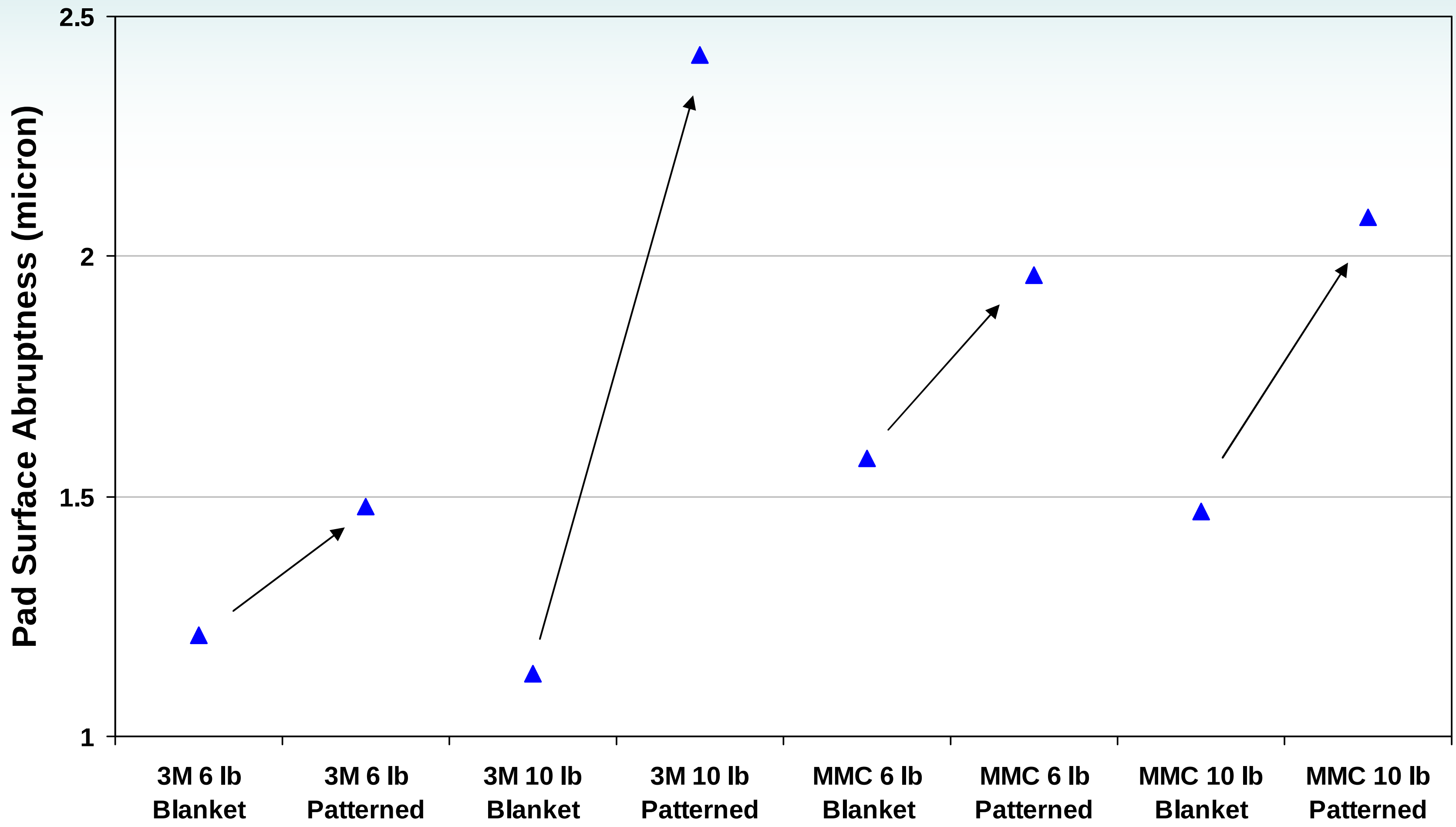
**Contact Area Percentage$_{Blanket}$ < Contact Area Percentage$_{Patterned}$ at 6 and 10 lb for both discs.**

# Pad Surface Abruptness Extraction



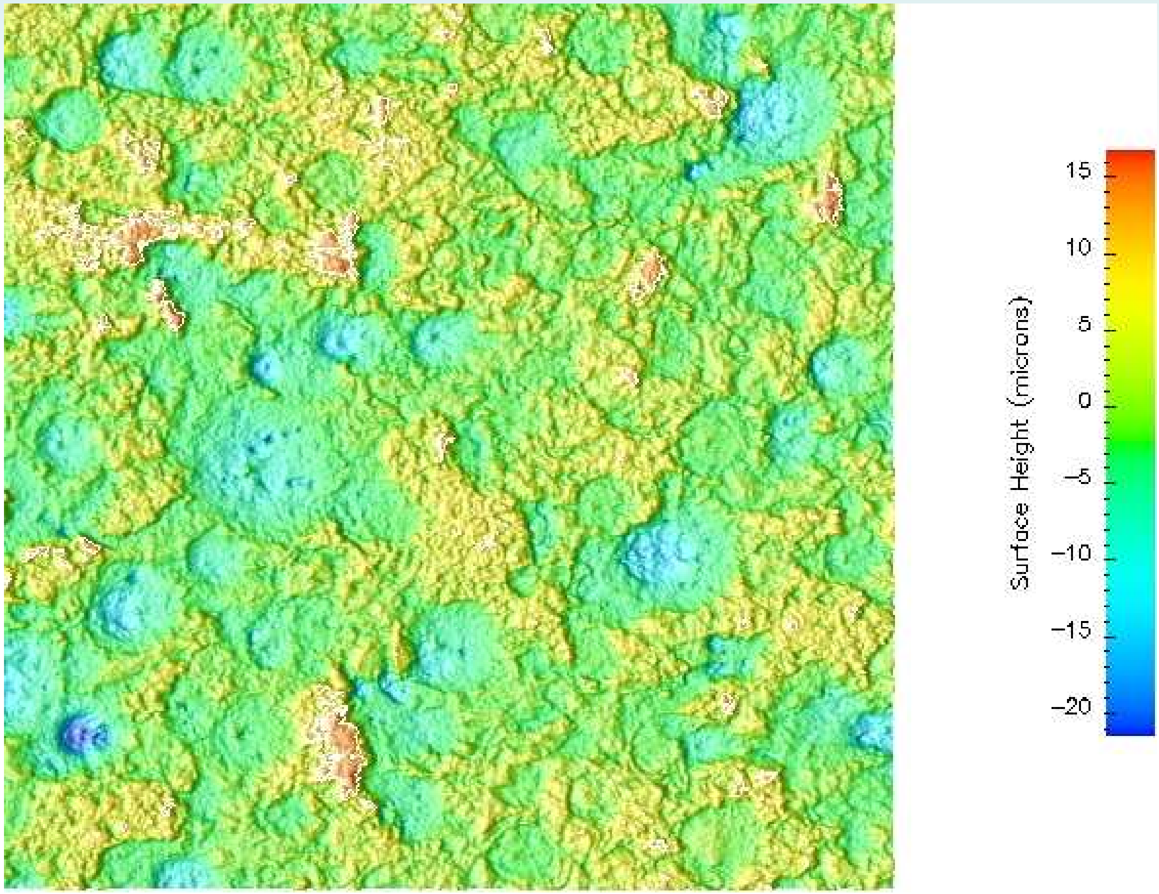

**Pad surface height probability density function was established from pad surface topography analysis and pad surface abruptness (λ) was extracted.**

# Pad Surface Abruptness



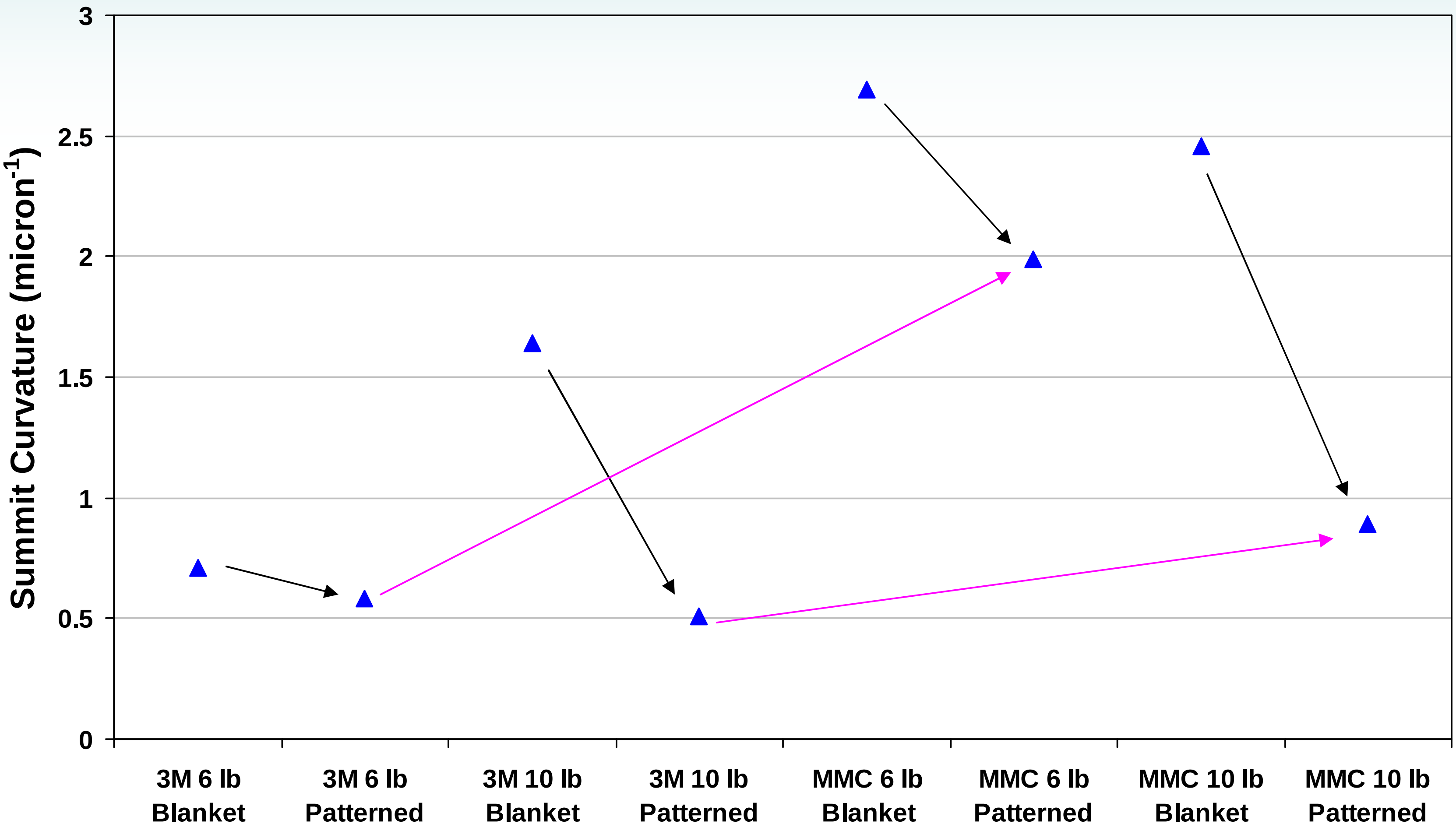

**Pad Surface Abruptness$_{Blanket}$ < Pad Surface Abruptness$_{Patterned}$ at 6 and 10 lb for both discs.**

# Summit Analysis




**Large asperities, or summits, on the surface of each pad sample were identified. The curvature of each summit at the highest point was analyzed.**

# Mean Summit Curvature




**Summit Curvature$_{Blanket}$ > Summit Curvature$_{Patterned}$ at 6 and 10 lb for both discs.**

**Summit Curvature$_{3M}$ < Summit Curvature$_{MMC}$ at 6 and 10 lb during patterned wafer polishing.**

# Summary

Contact area percentage decreased with an increase in the conditioning force for both the 3M and MMC diamond discs during blanket wafer polishing. This resulted in smaller contact area and larger mean contact pressure under the conditioning force of 10 lb, rendering a higher COF and removal rate for both the 3M and MMC diamond discs during blanket wafer polishing.

Contact area during blanket wafer polishing was smaller than that during patterned wafer polishing for both the 3M and MMC diamond discs. This was attributed to the topography on the patterned wafer surface that created extra collisions with pad summits. In addition, the topography analysis showed that the extra collisions with pad summits during patterned wafer polishing resulted in less abrupt pad surface with flatter pad summits.

Summit curvature analysis indicated that the mean summit curvature of the MMC disc was larger than that of the 3M disc at both 6 and 10 lb conditioning forces during patterned wafer polishing. Sharper pad summits contributed to higher dishing and erosion for the MMC disc.