

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

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Outline

1. Objective and Approach

2. Polishing Apparatus and Experimental Conditions

3. Polishing Results

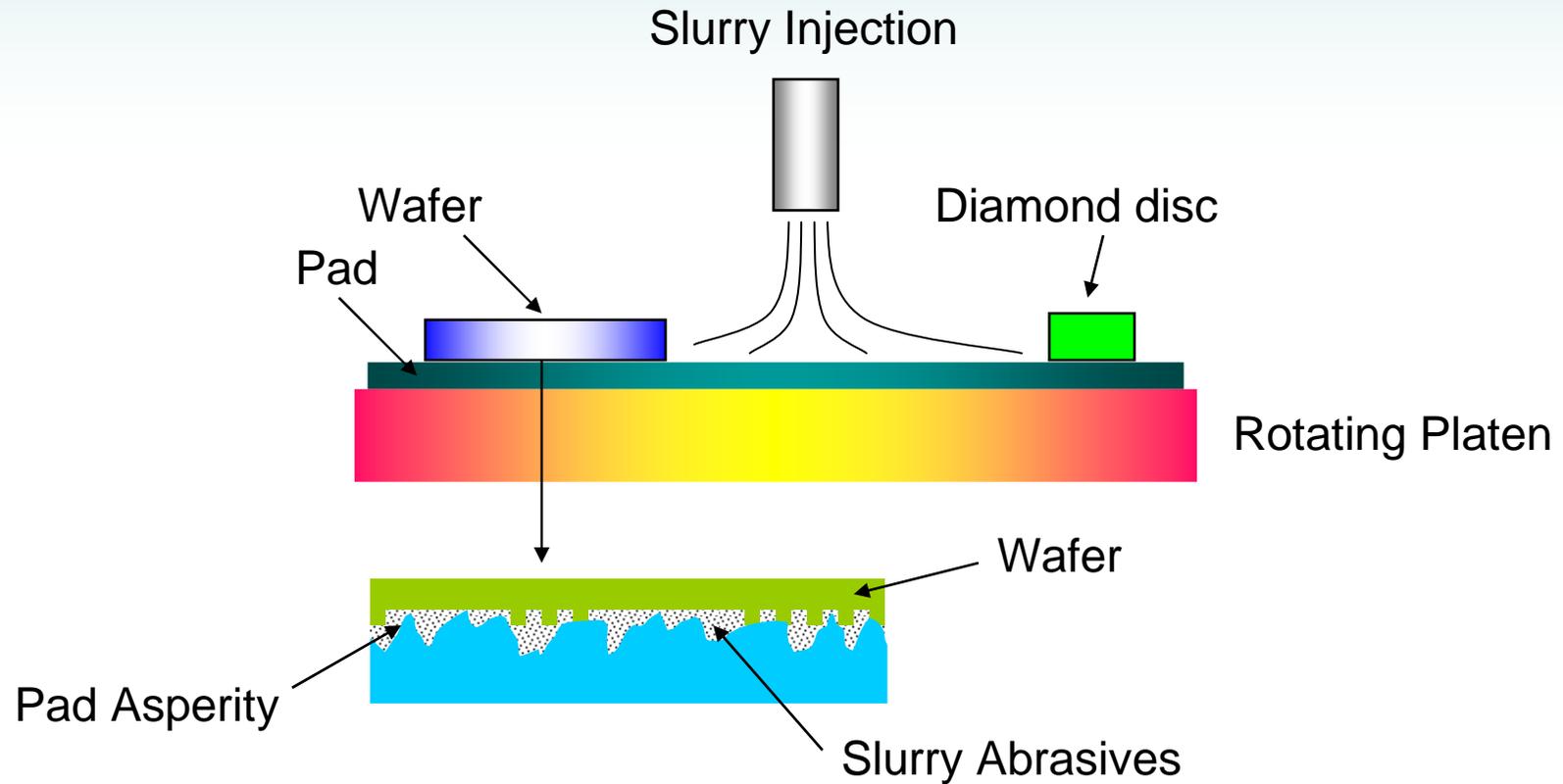
- Blanket wafer polishing
- Patterned wafer polishing

4. Pad Micro-Texture Analyses

- Contact area analysis
- Pad surface topography analysis

5. Summary

Generalized Schematic of CMP



Pad micro-texture has significant impacts on polishing performance.

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

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

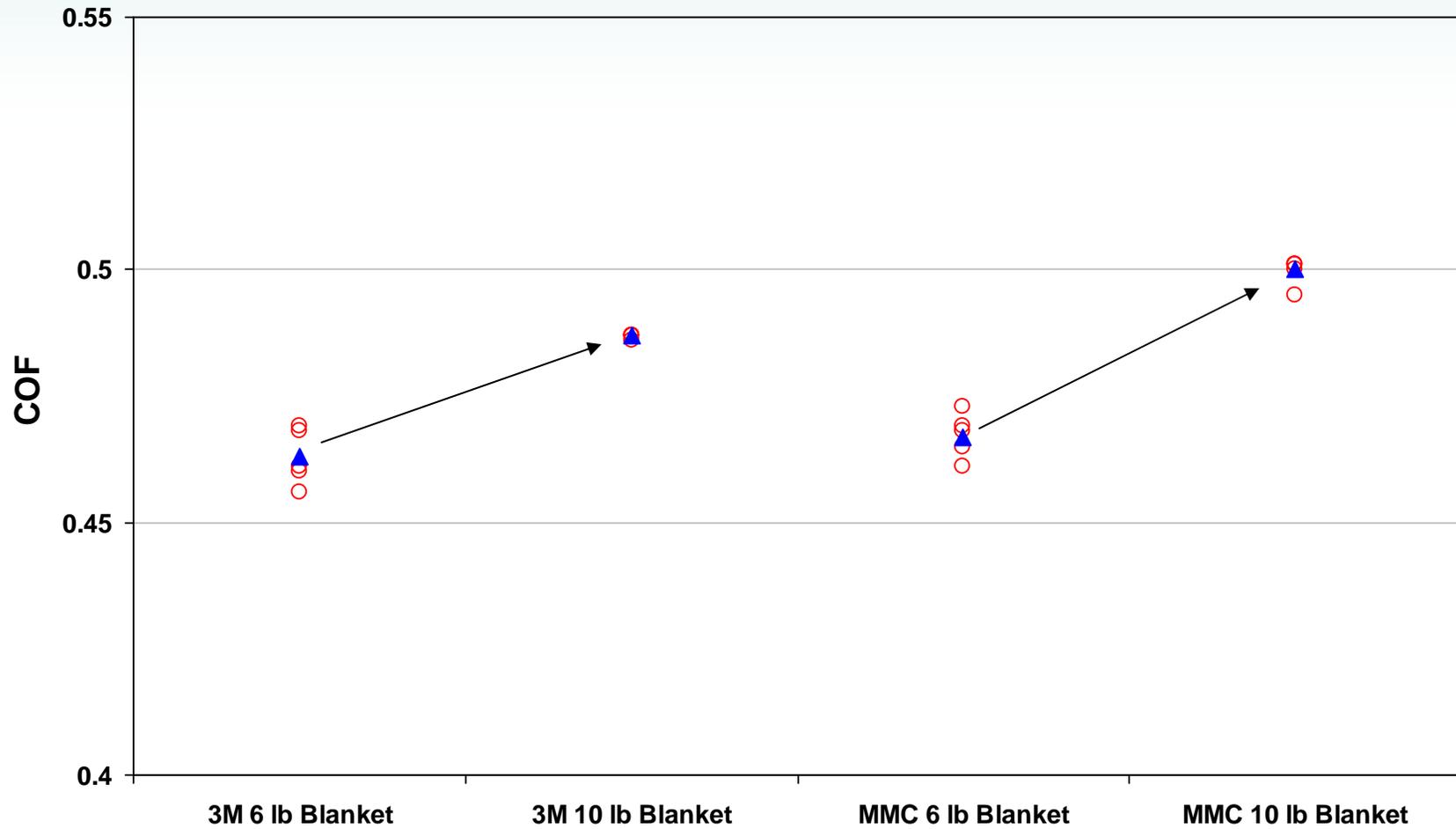
- Mitsubishi Materials Corporation 100-grit TRD disc and 3M A2810 disc rotating at 95 RPM and sweeping at 10 times/min
- In-situ pad conditioning at 6 and 10 lb_f

– 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

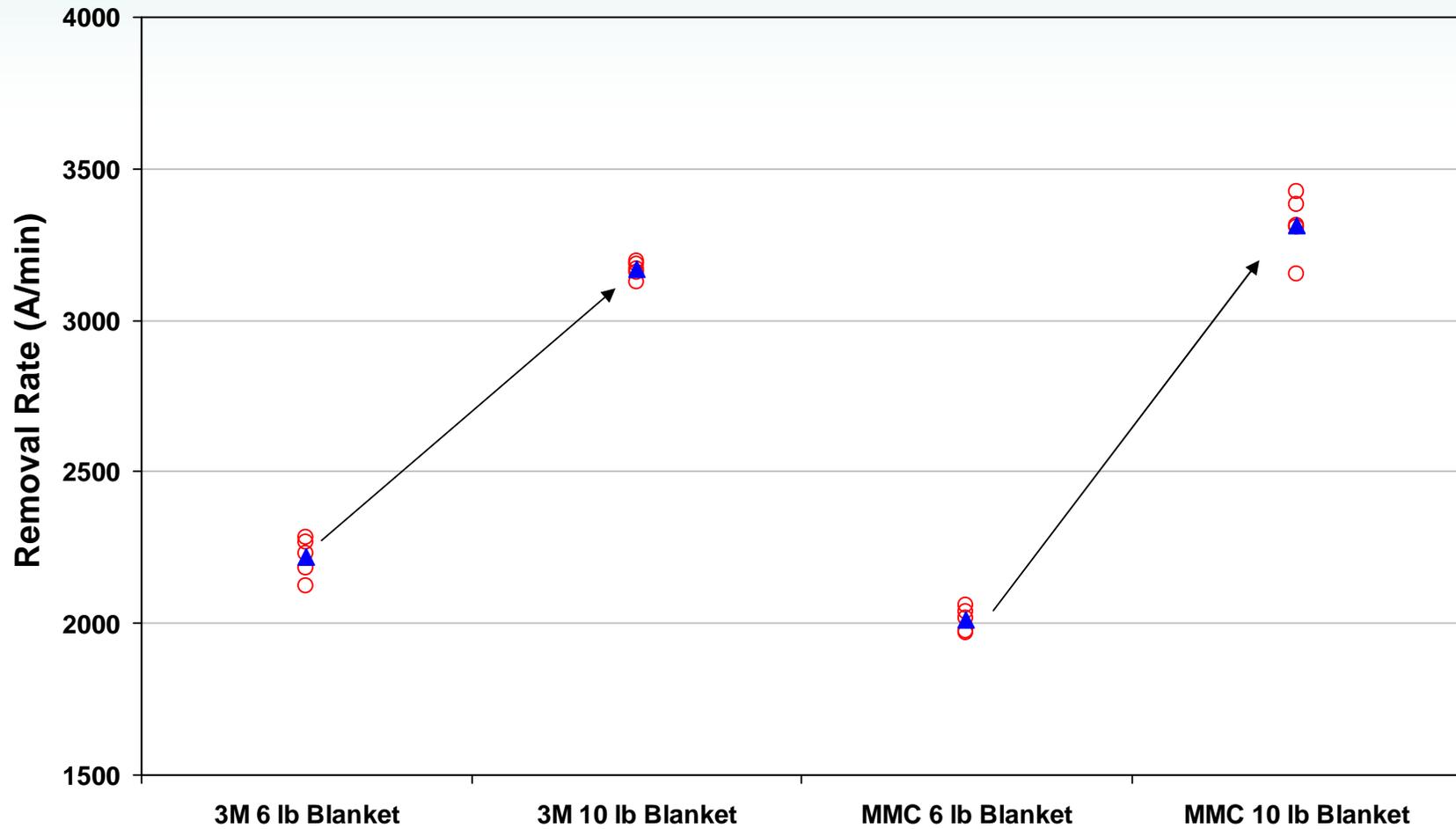
Blanket TEOS Wafer Polishing



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

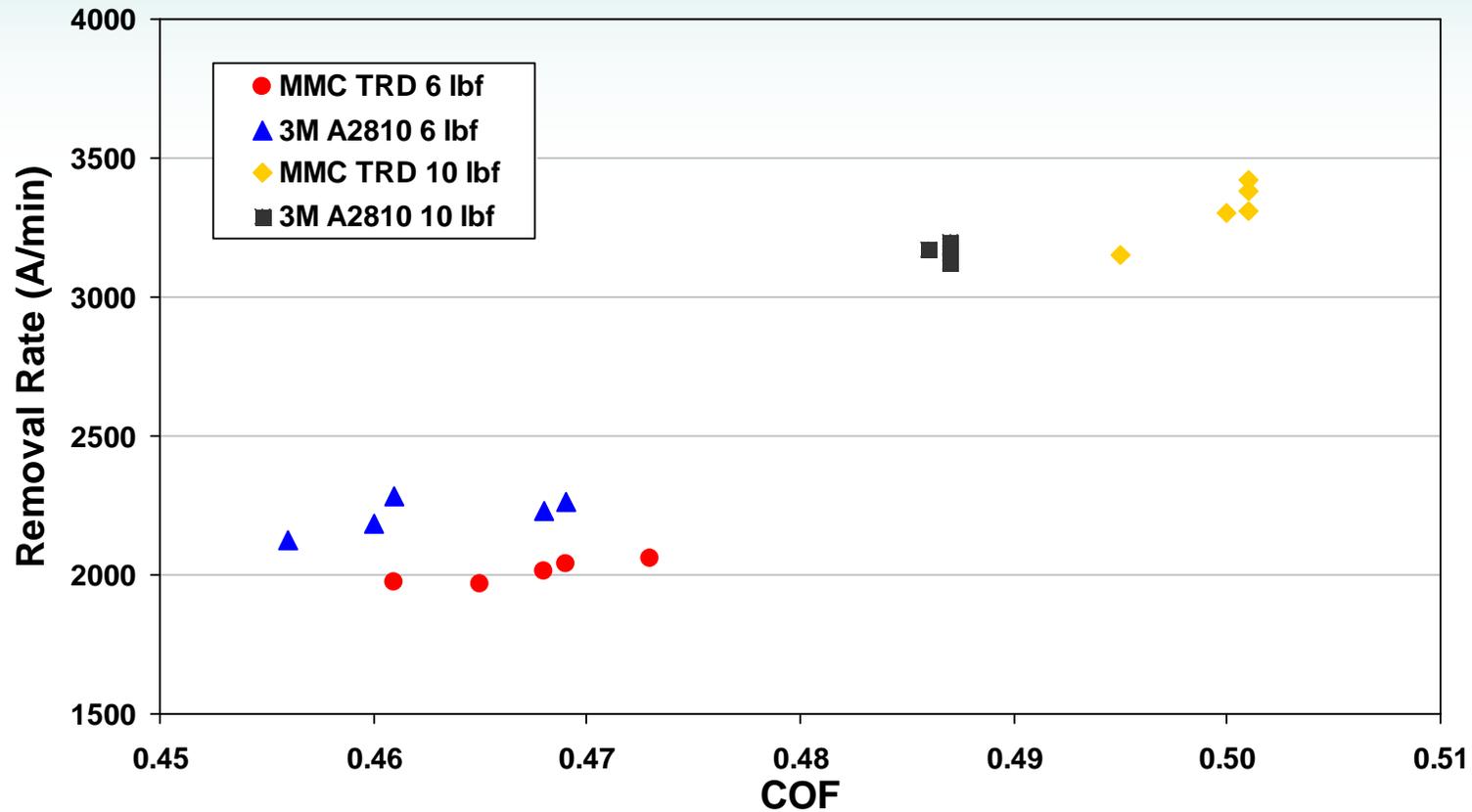
Removal Rate

Blanket TEOS Wafer Polishing



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

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, $\text{Dishing/Erosion}_{3M \text{ A2810 disc}} < \text{Dishing/Erosion}_{MMC \text{ TRD disc}}$

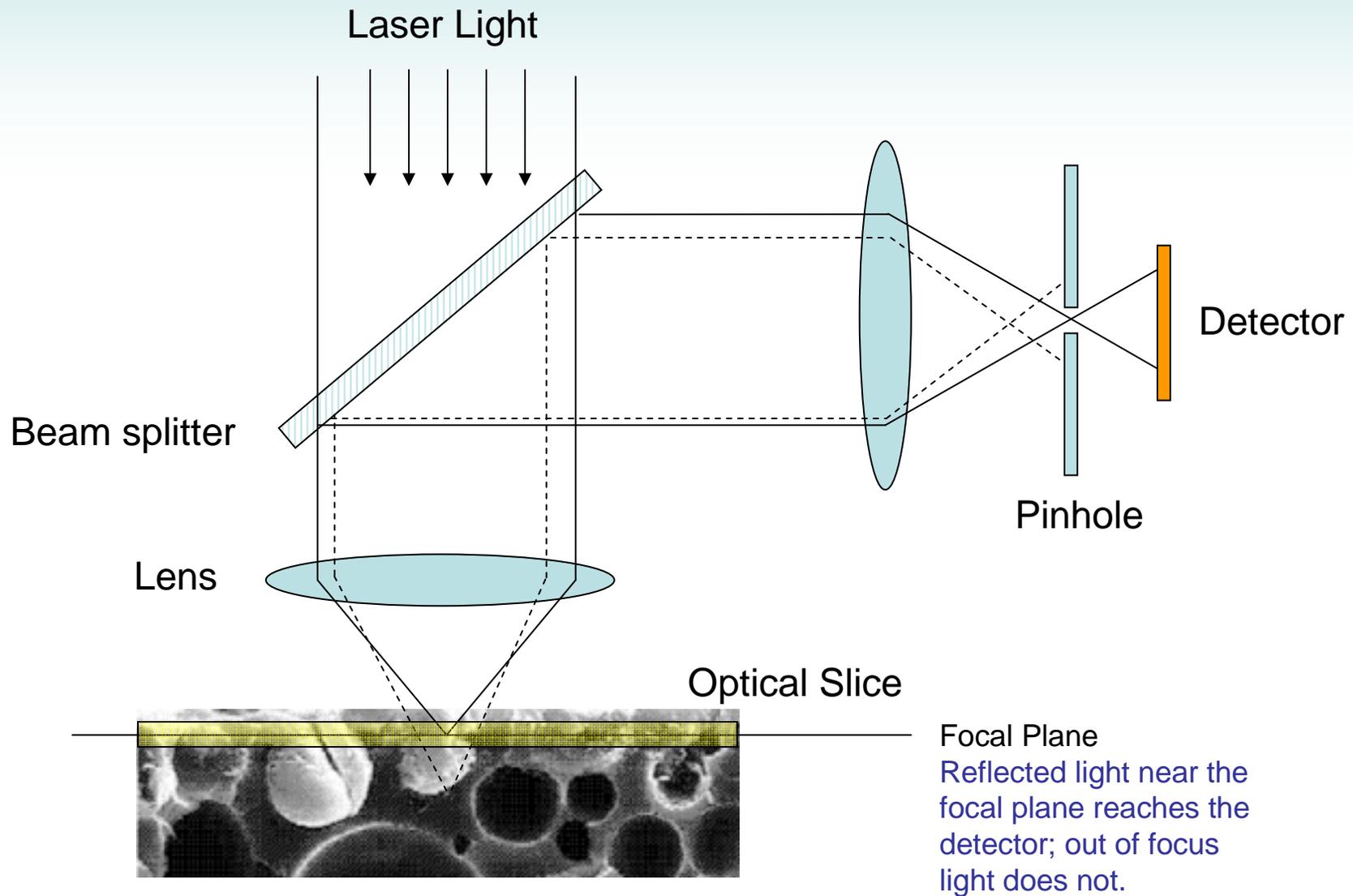
Laser Confocal Microscopy



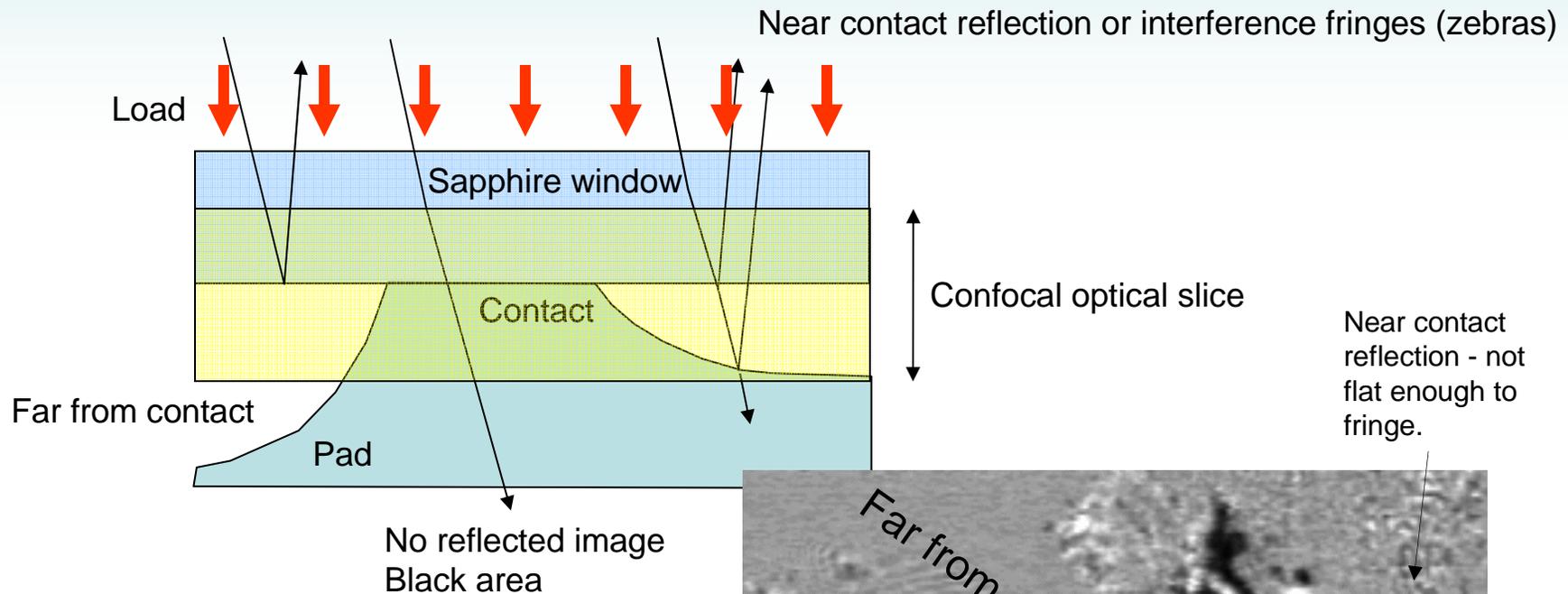
Zeiss LSM 510 Meta NLO

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

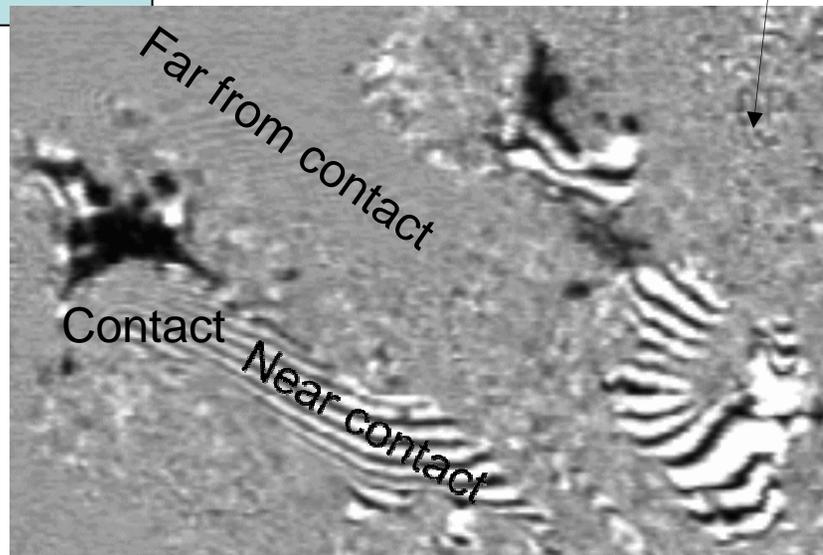
How a Laser Confocal Microscope Works



Confocal Contact Area Measurements

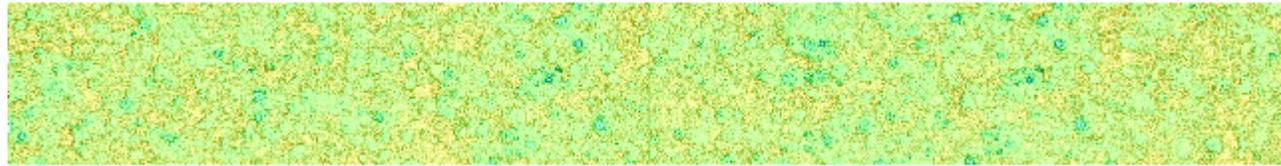


Near contact reflection - not flat enough to fringe.

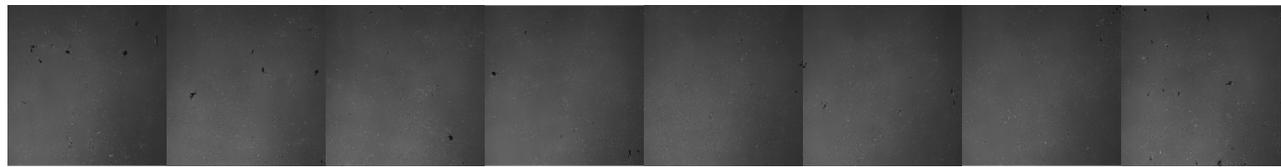


Topography and Contact Images

Topography



Contact, 4 PSI



1

2

3

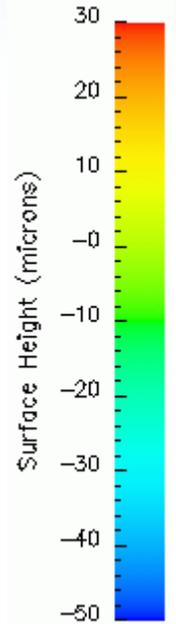
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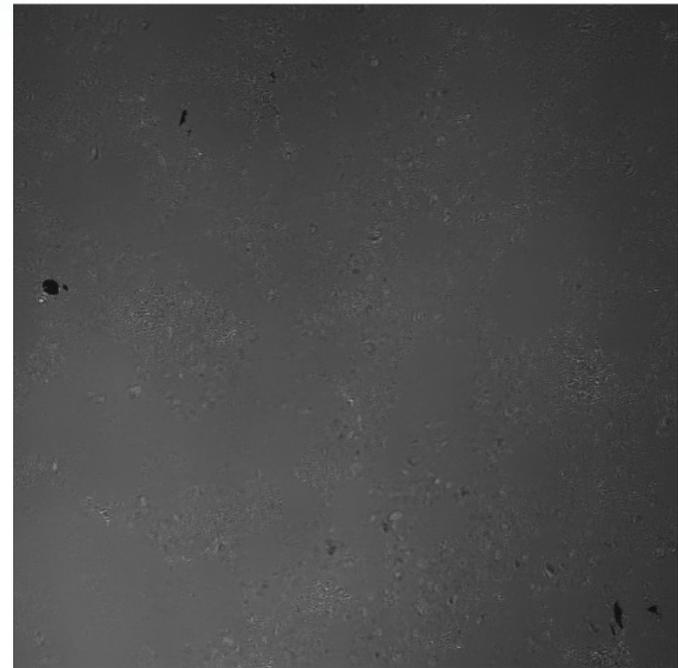
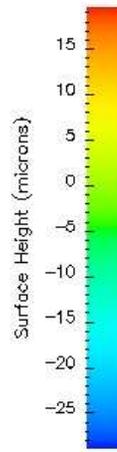
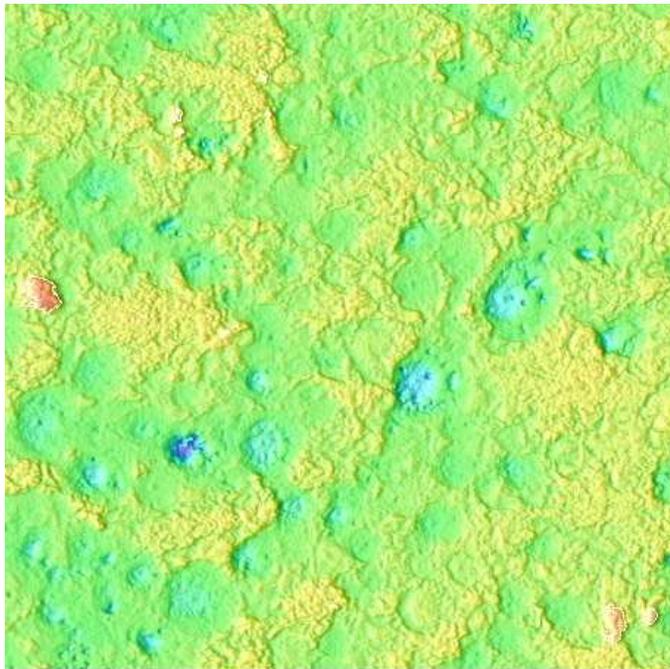
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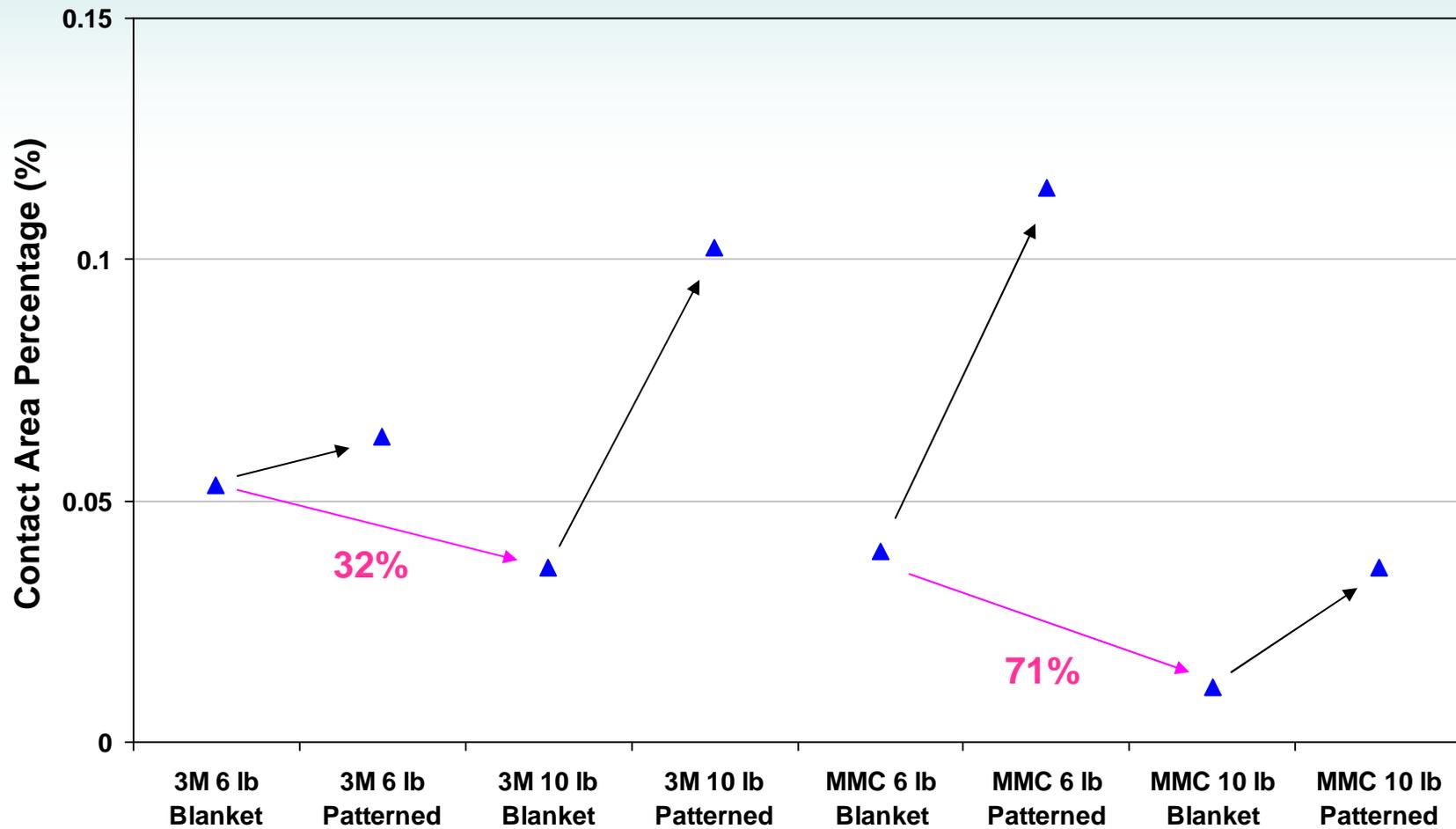
For each sample, eight topography and contact images (3.6 x 0.45 mm) were taken.

Topography and Contact Images



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

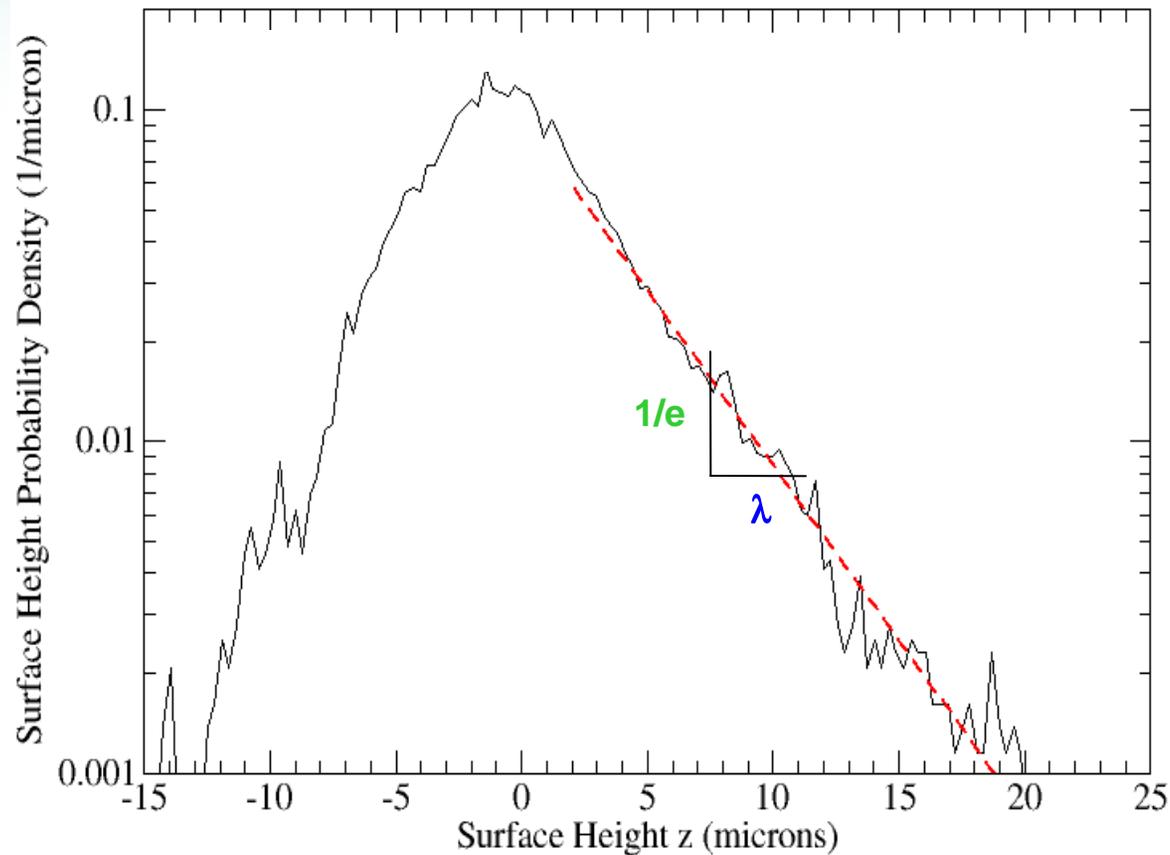
Contact Area Percentage



Contact Area Percentage_{6 lb} > Contact Area Percentage_{10 lb} for both discs during blanket wafer polishing.

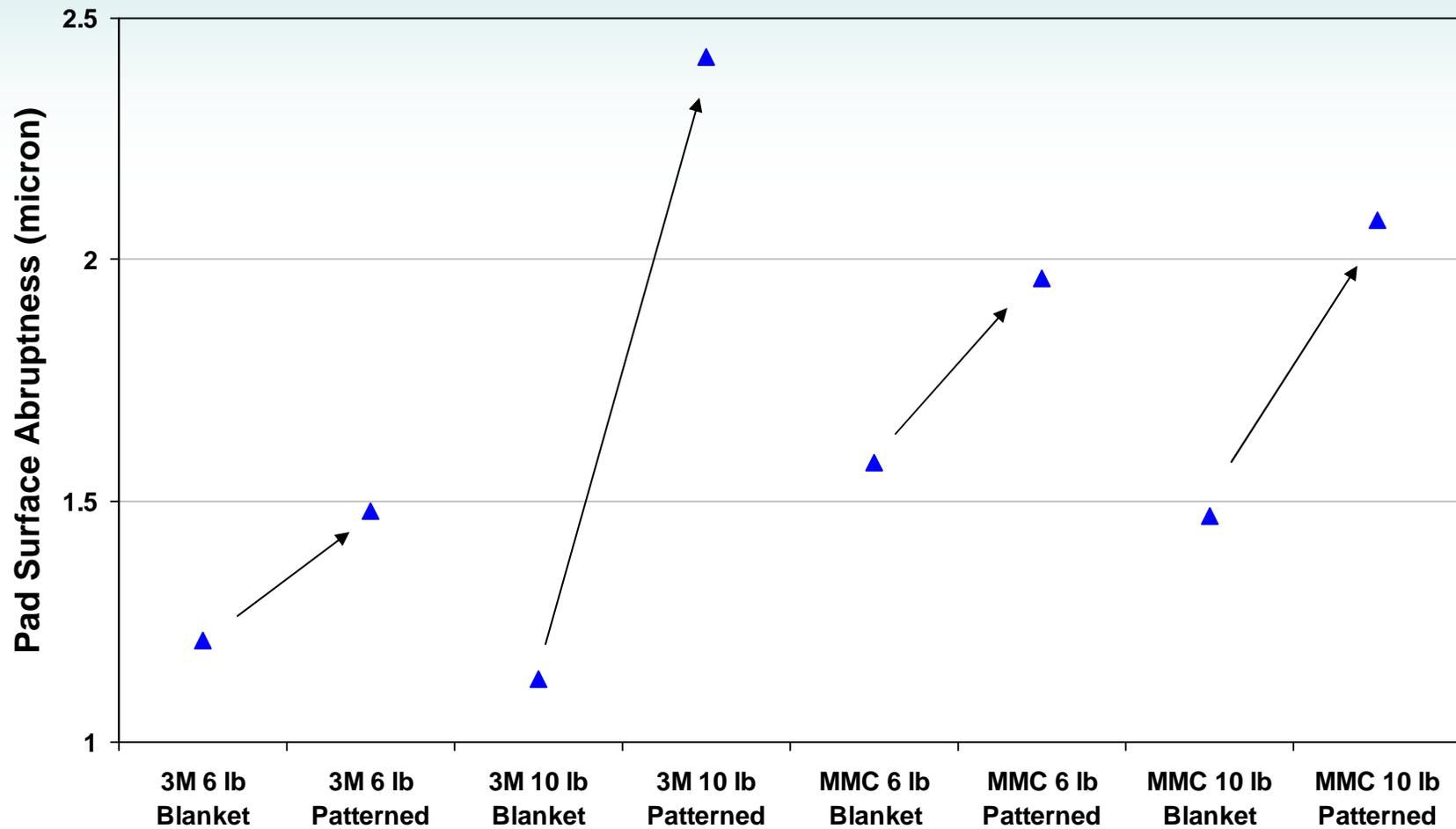
Contact Area Percentage_{Blanket} < Contact Area Percentage_{Patterned} at 6 and 10 lb for both discs.

Pad Surface Abruptness Extraction



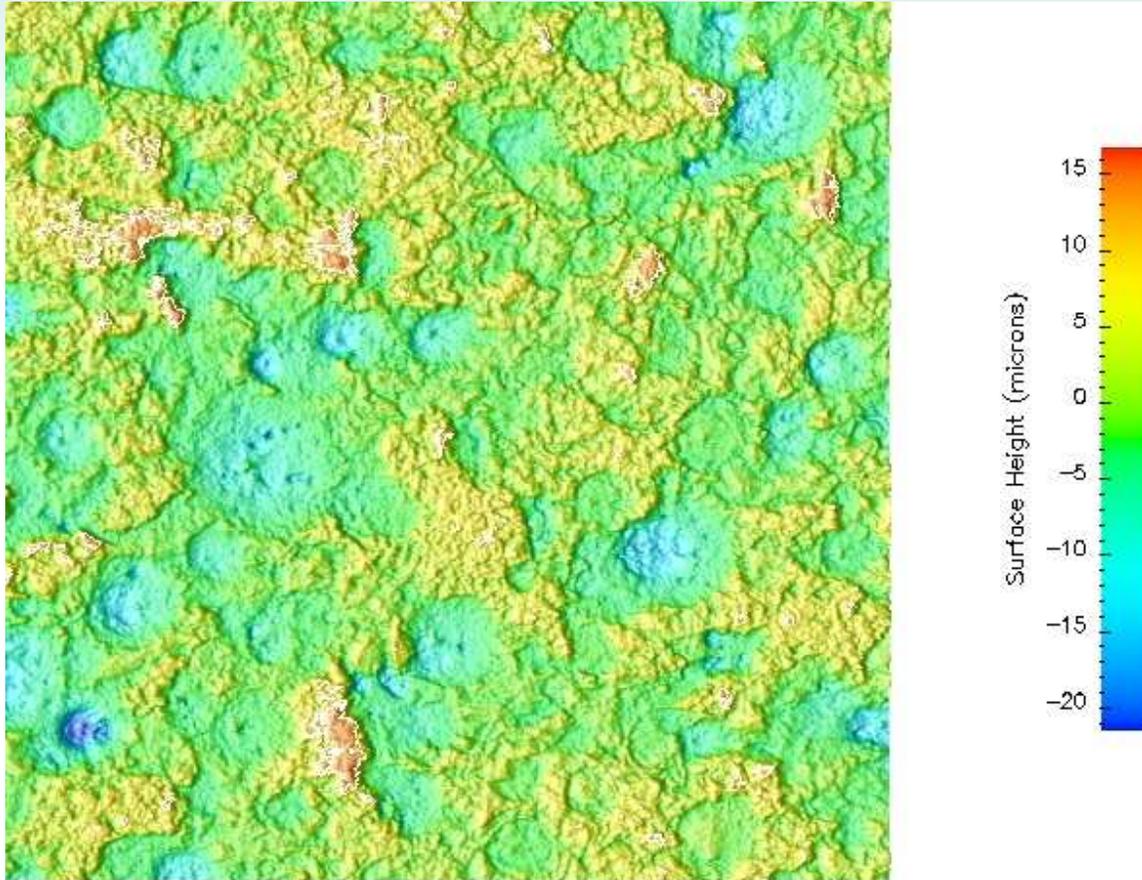
Pad surface height probability density function was established from pad surface topography analysis and pad surface abruptness (λ) was extracted.

Pad Surface Abruptness



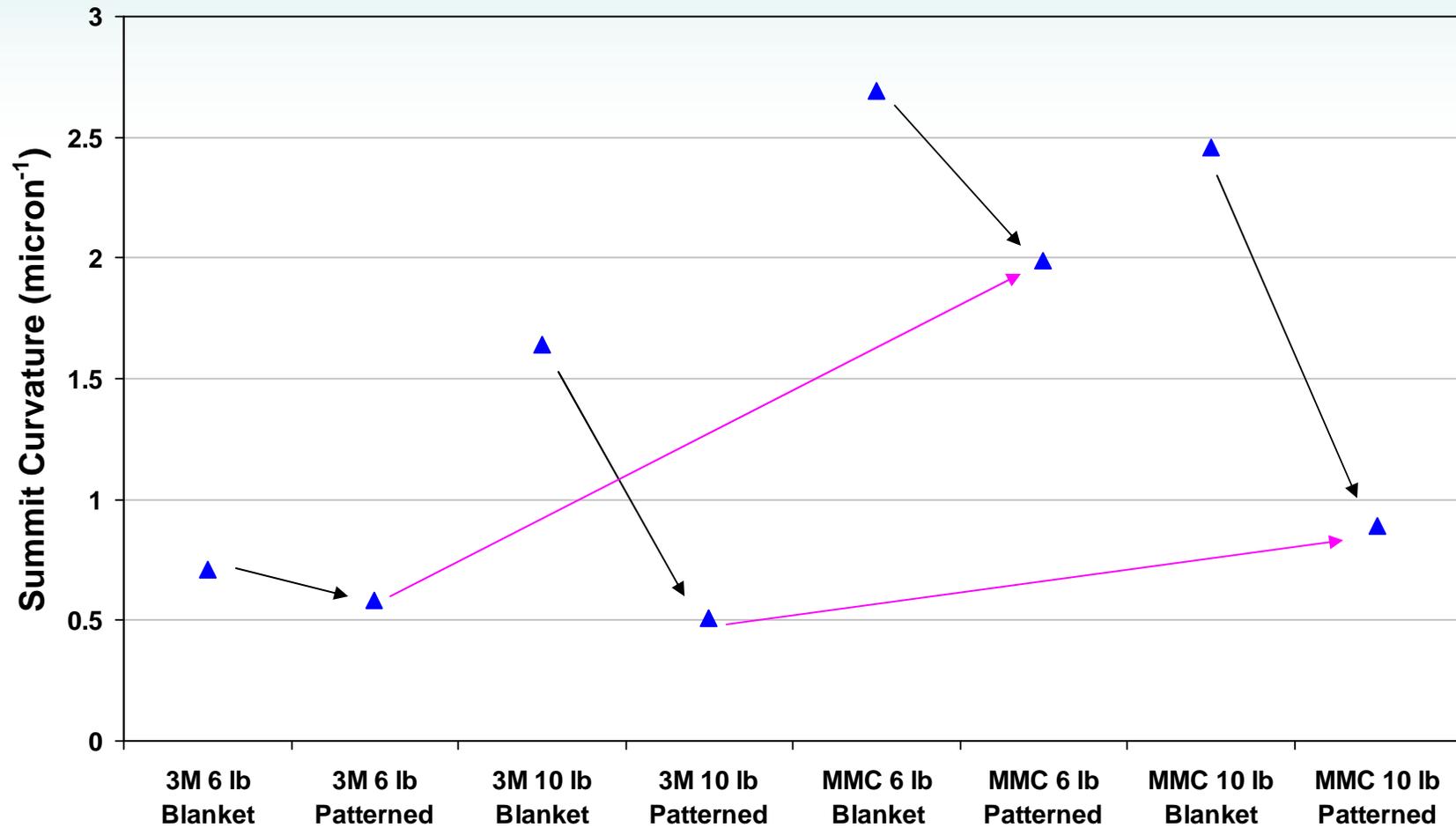
Pad Surface Abruptness_{Blanket} < Pad Surface Abruptness_{Patterned} at 6 and 10 lb for both discs.

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 significantly when the conditioning force increased from 6 to 10 lb for both the 3M and MMC diamond discs during blanket wafer polishing. This resulted in **significantly smaller contact area, larger mean contact pressure, and higher removal rate under the conditioning force of 10 lb** for both the 3M and MMC diamond discs.

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.