Effect of Pad Micro-Texture on Frictional Force and Removal Rate during Copper CMP

Outline

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2. Polishing Apparatus and Experimental Conditions

3. Polishing Results

- Frictional force
- Mean pad temperature
- Removal rate

4. Pad Micro-Texture Analyses

- Contact area analysis
- Pad surface topography analysis
- SEM analysis

5. Summary

Objective and Approach

- **Objective: Investigate the effect of pad micro-texture on frictional force and removal rate during copper CMP process**

- **Approach: Polish 200-mm blanket copper wafers with 3M A2810 disc or Mitsubishi Materials Corporation 100-grit TRD discs, and analyze pad micro-texture through laser confocal microscopy and SEM**

  - **Blanket wafer polishing: frictional force and removal rate**

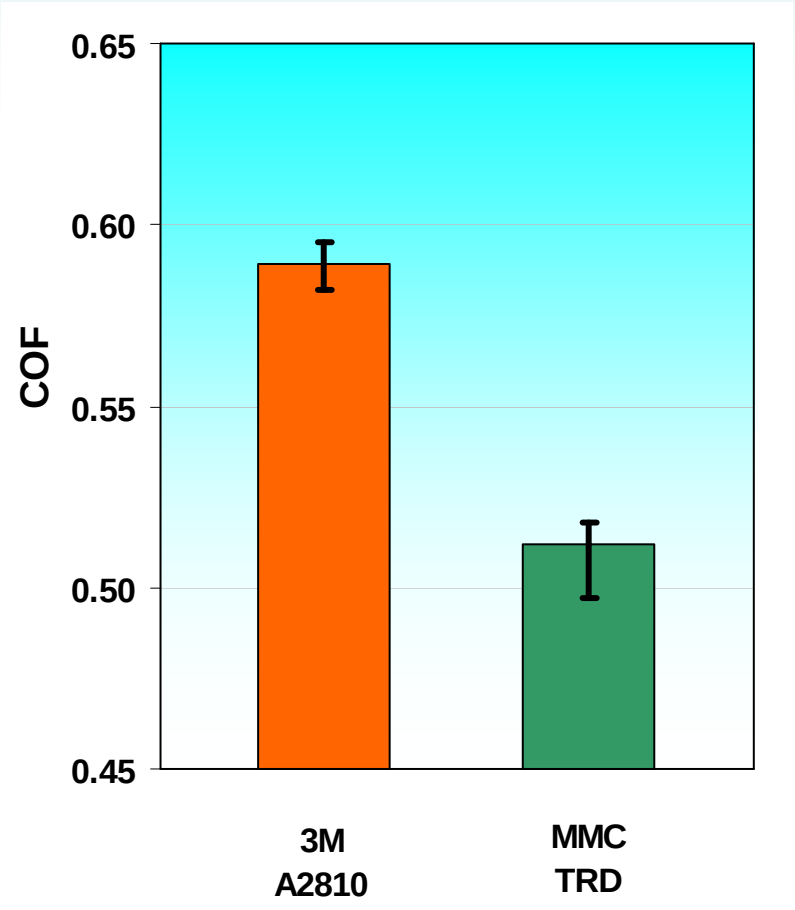
  - **Pad micro-texture analyses: contact area and near surface contact area**

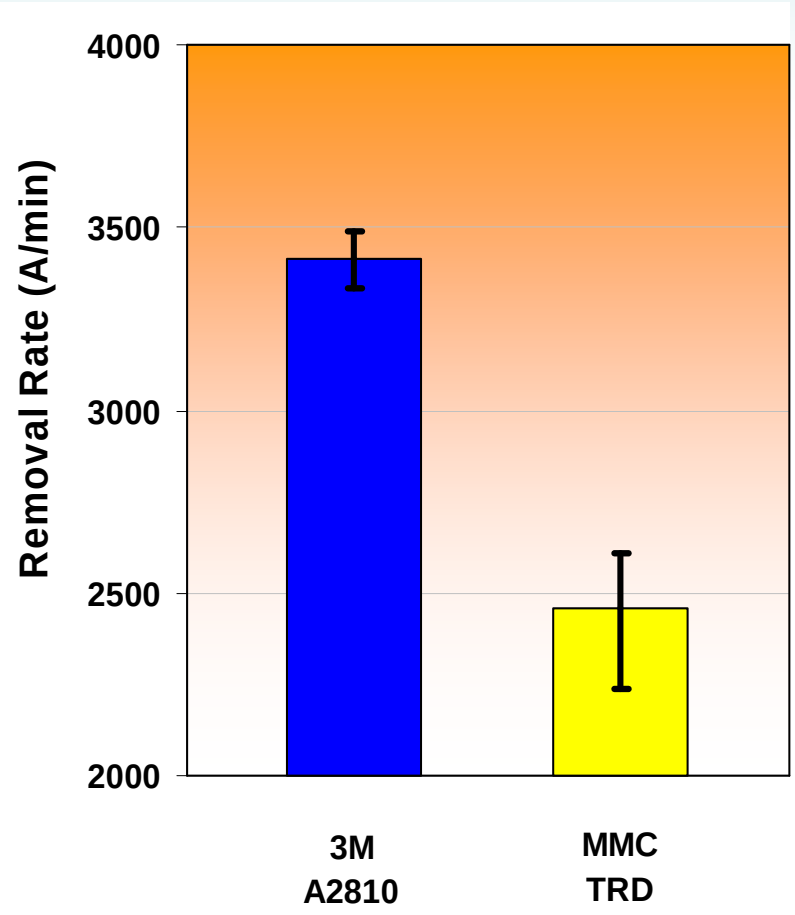
APD – 500 Polisher & Tribometer

Experimental Conditions

- **Pad**
  - IC1010 M-groove pad with Suba IV sub-pad
- **Slurry**
  - 5 volume parts of Hitachi Chemical HS 2H635-12 slurry + 5 volume parts of DI water + 10 volume parts of ultra pure 30% hydrogen peroxide
  - Flow rate: 150 ml/min
- **Wafer**
  - 200-mm blanket copper wafers
- **Pad Conditioning**
  - Mitsubishi Materials Corporation (MMC) 100-grit TRD disc and 3M A2810 disc rotating at 95 RPM and sweeping at 10 times/min
  - In-situ pad conditioning at 6 lb_f
- **Wafer Polishing**
  - Polishing pressure: 1.5 PSI
  - Sliding velocity: 1.2 m/s
  - Polishing time: 1 minute

Coefficient of Friction and Removal Rate



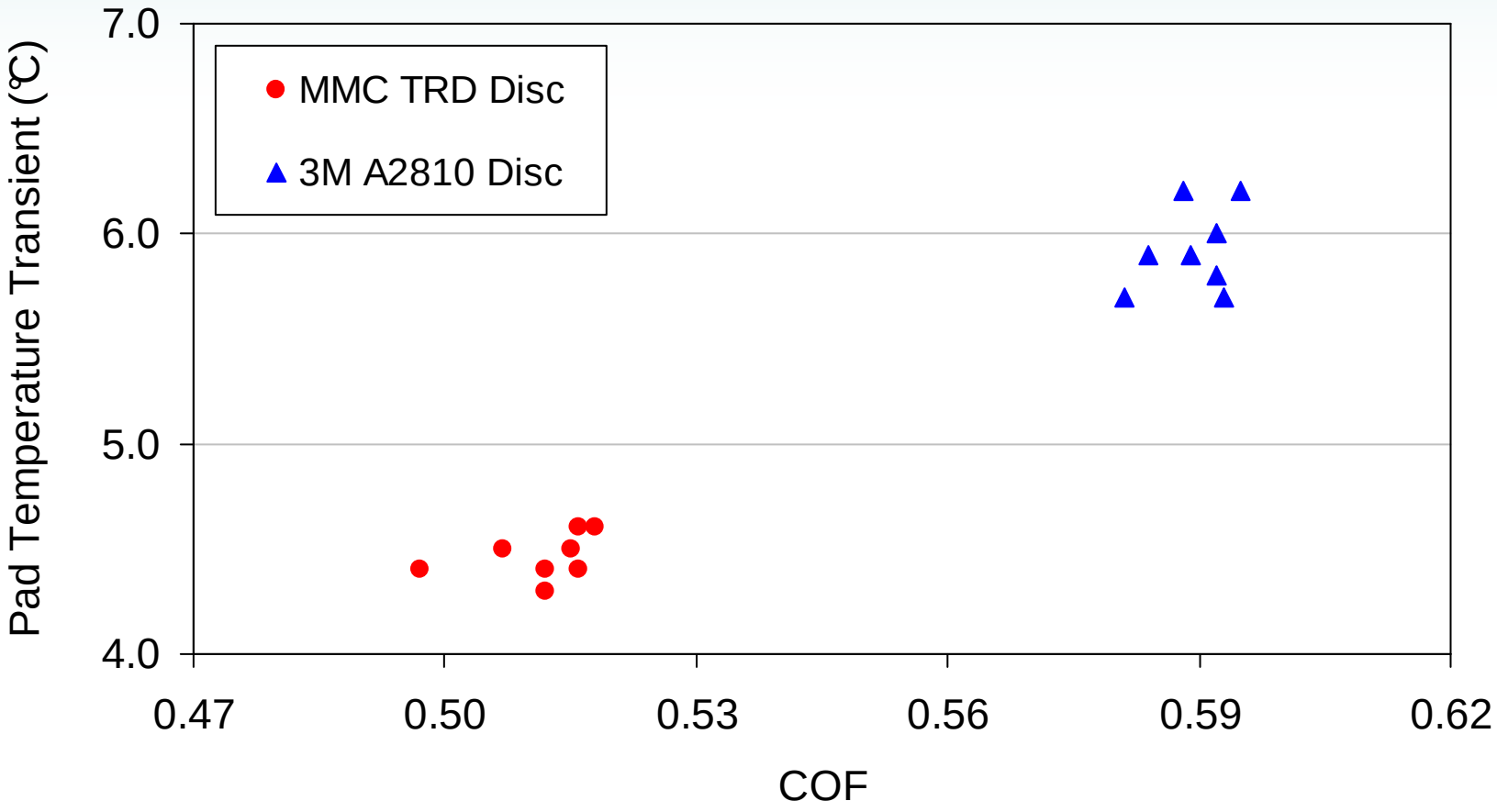


$COF_{3M\ A2810} > COF_{MMC\ TRD}$

$RR_{3M\ A2810} > RR_{MMC\ TRD}$

Pad Temperature Transient vs. COF

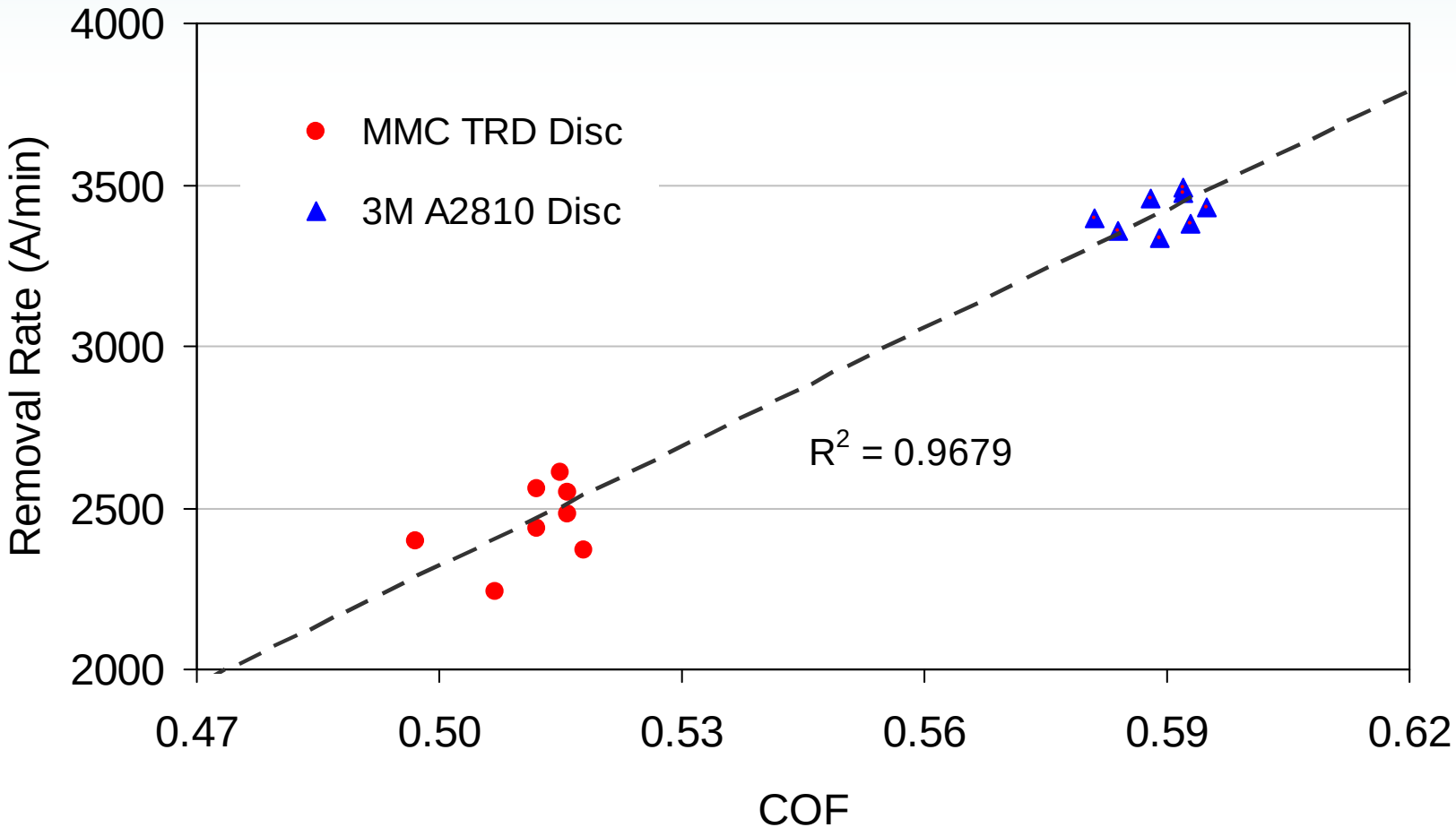
Blanket Copper Wafer Polishing



Pad temperature transient (difference between the mean pad temperature and initial pad temperature) increased with COF as expected.

Removal Rate vs. COF

Blanket Copper Wafer Polishing



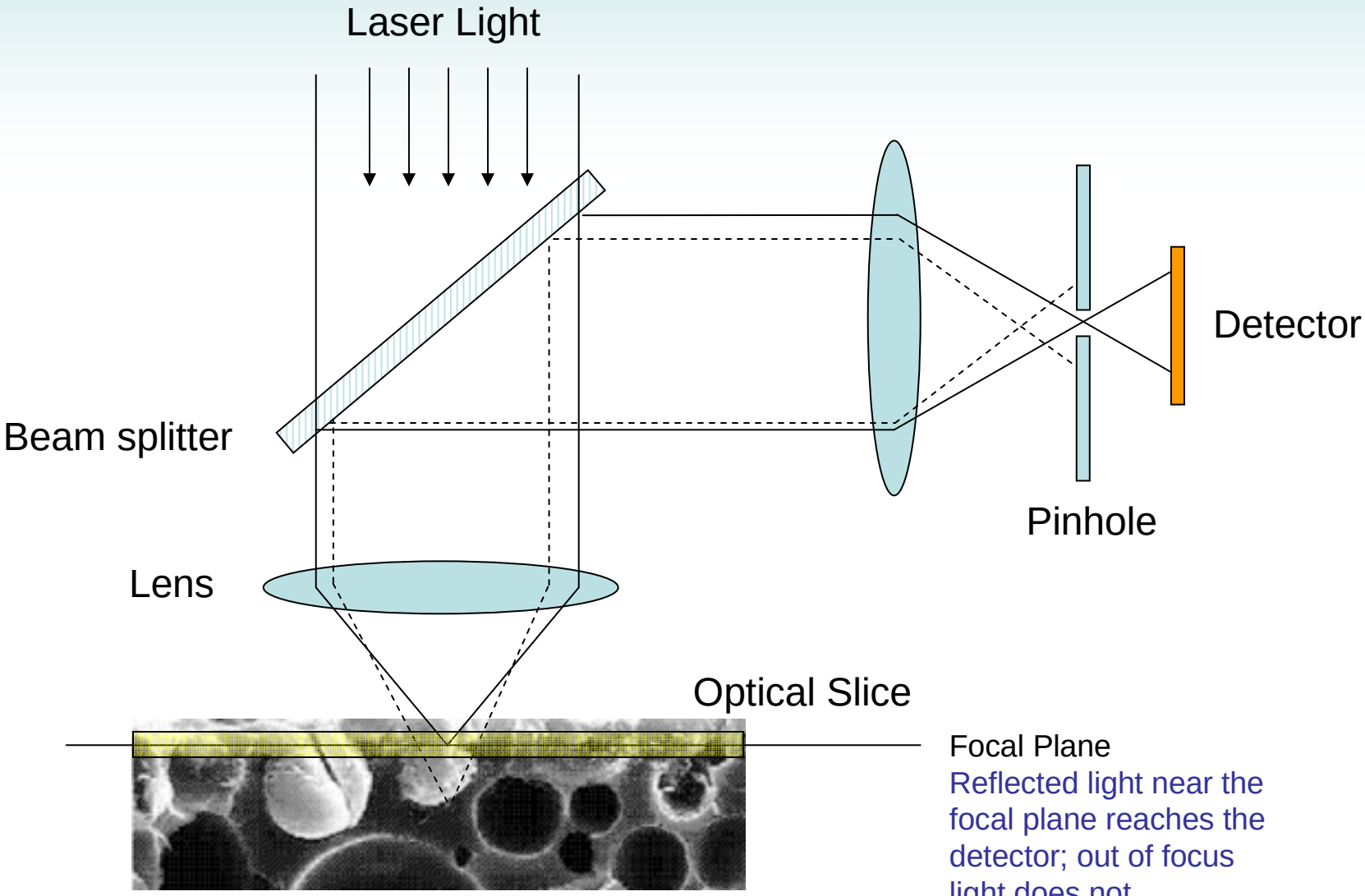
As expected, RR increased with COF

Laser Confocal Microscopy

Zeiss LSM 510 Meta NLO

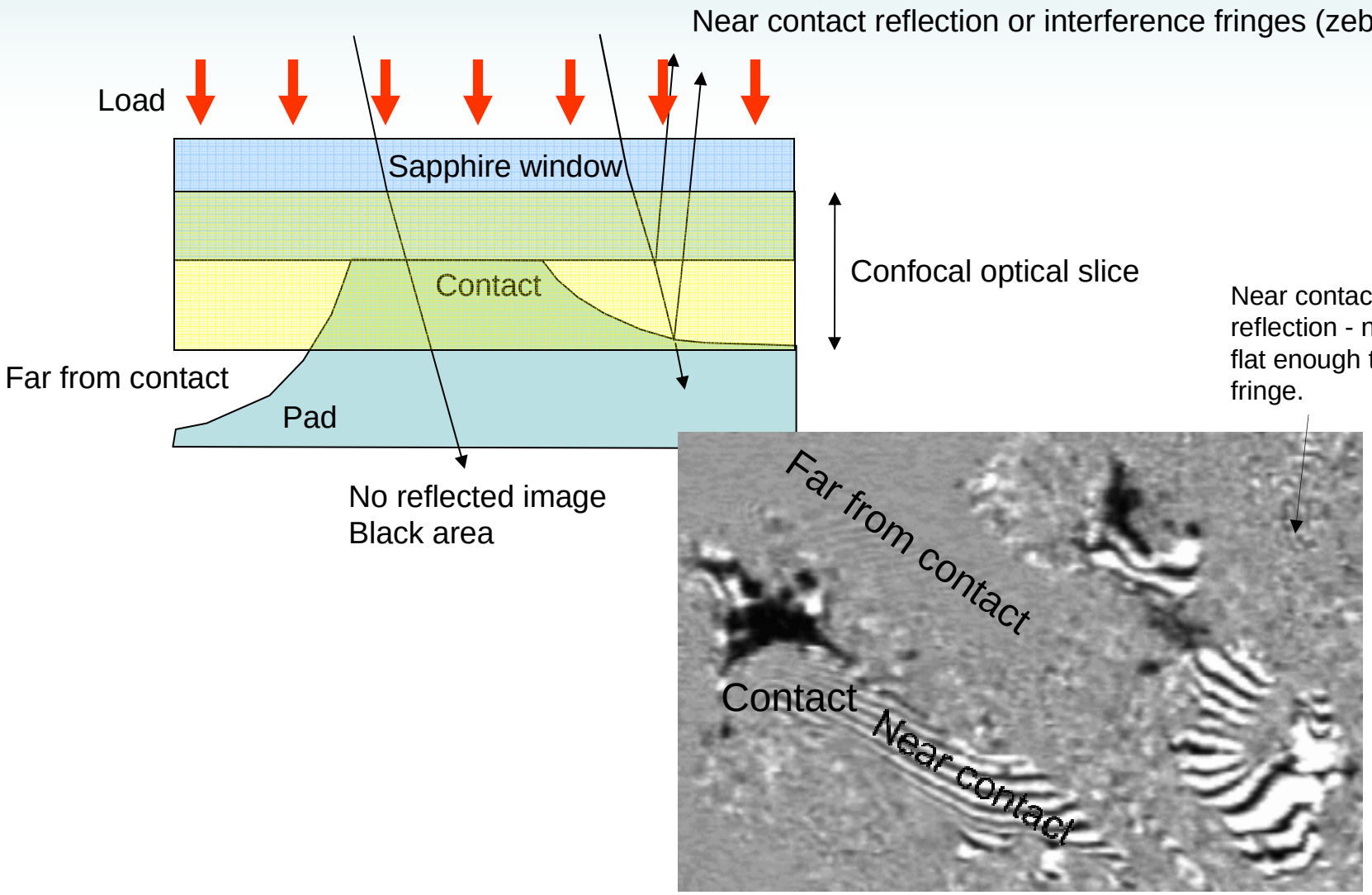
Pad surface contact area analysis were performed through laser confocal microscopy.

How a Laser Confocal Microscope Works



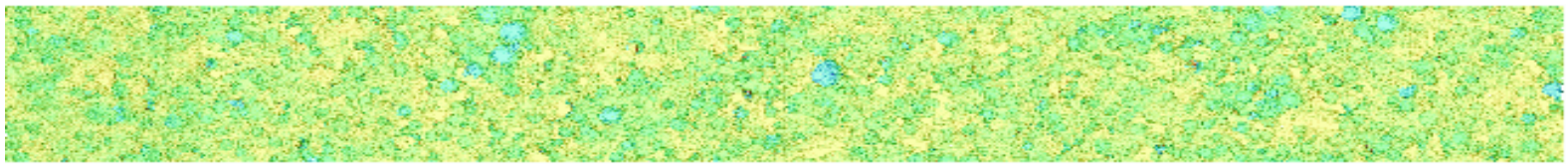
Reflected light near the focal plane reaches the detector; out of focus light does not.

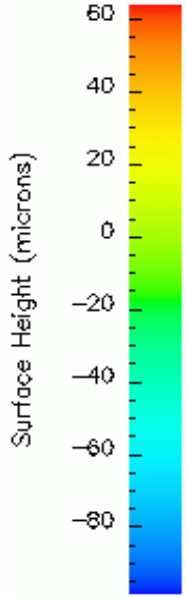
Confocal Contact Area Measurements



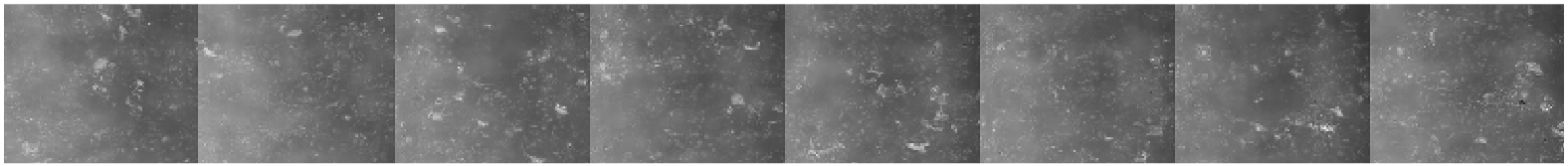
Topography and Contact Area Images
Blanket Wafer Polishing, MMC TRD Disc

Topography





Contact, 1.5 PSI

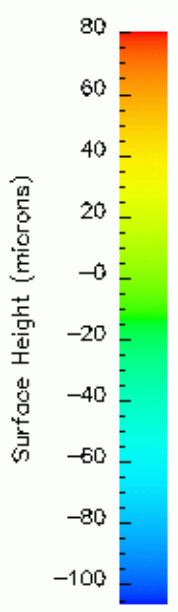


1 2 3 4 5 6 7 8 9 10

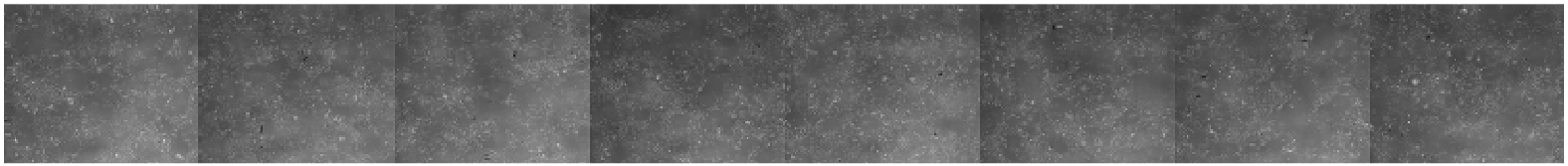
Sliding Direction

Topography and Contact Area Images
Blanket Wafer Polishing, 3M A2810 Disc

Topography



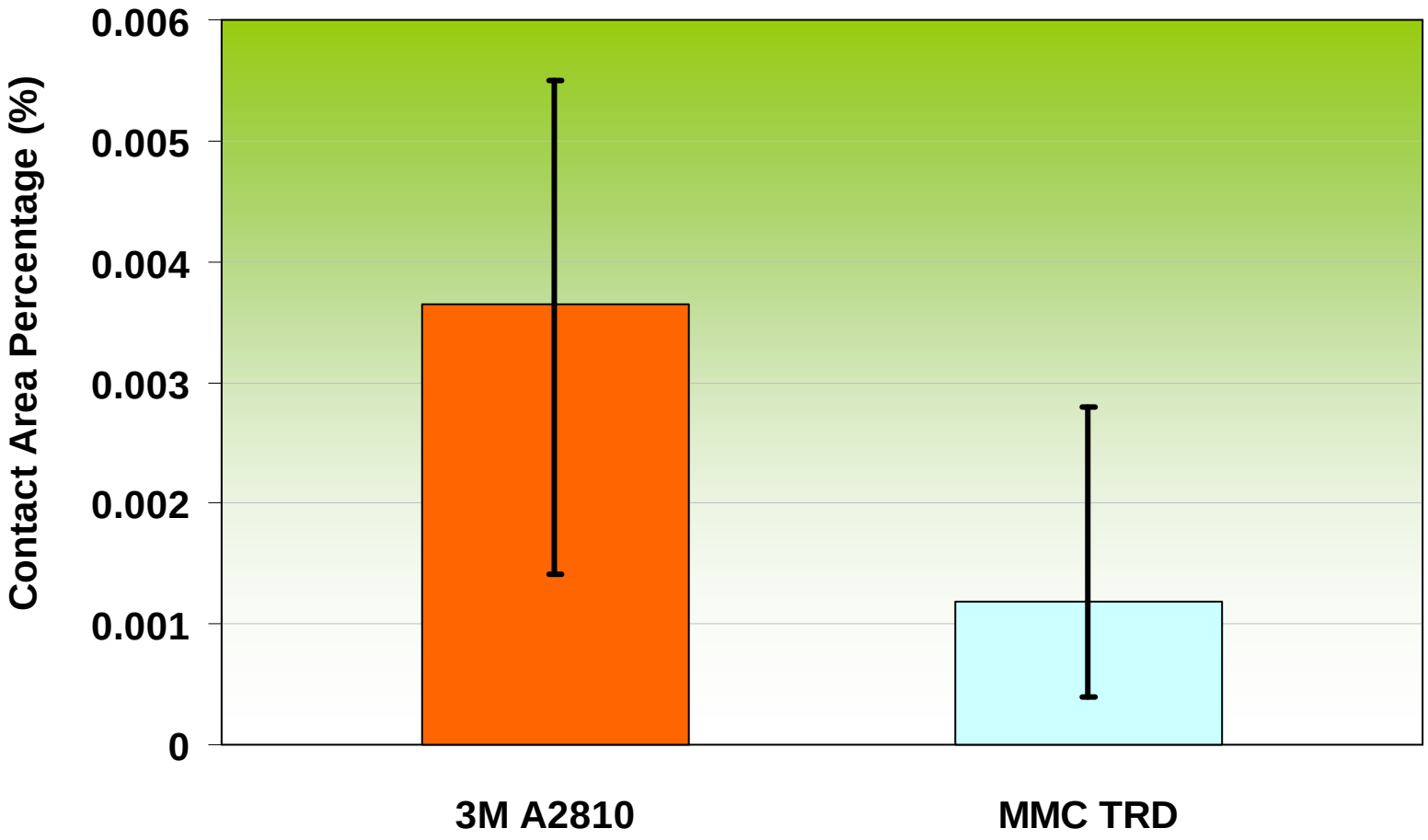
Contact, 1.5 PSI



1 2 3 4 5 6 7 8 9 10

Sliding Direction

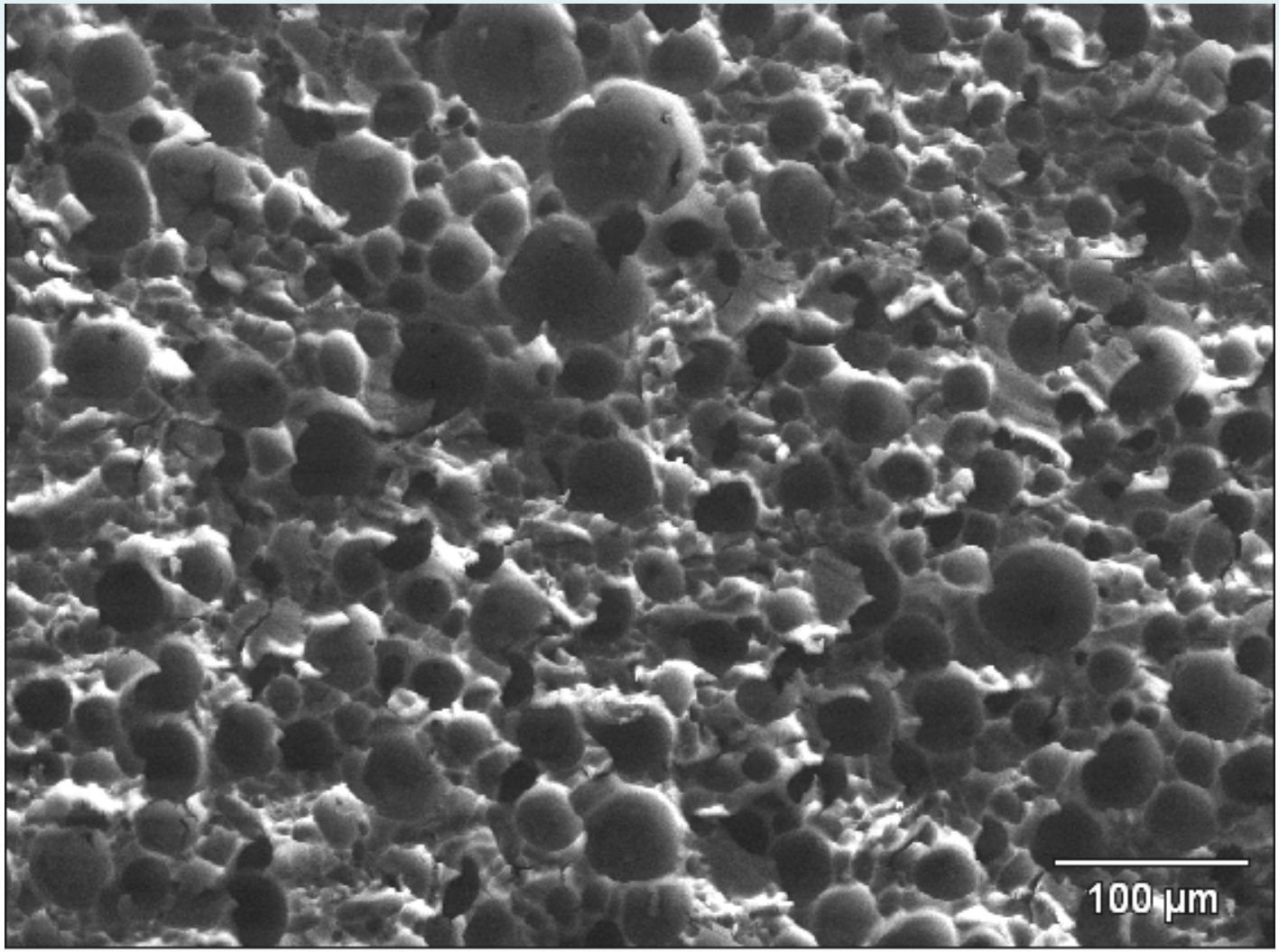
Contact Area Percentage



Contact Area Percentage $_{\text{3M A2810}}$ > Contact Area Percentage $_{\text{MMC TRD}}$

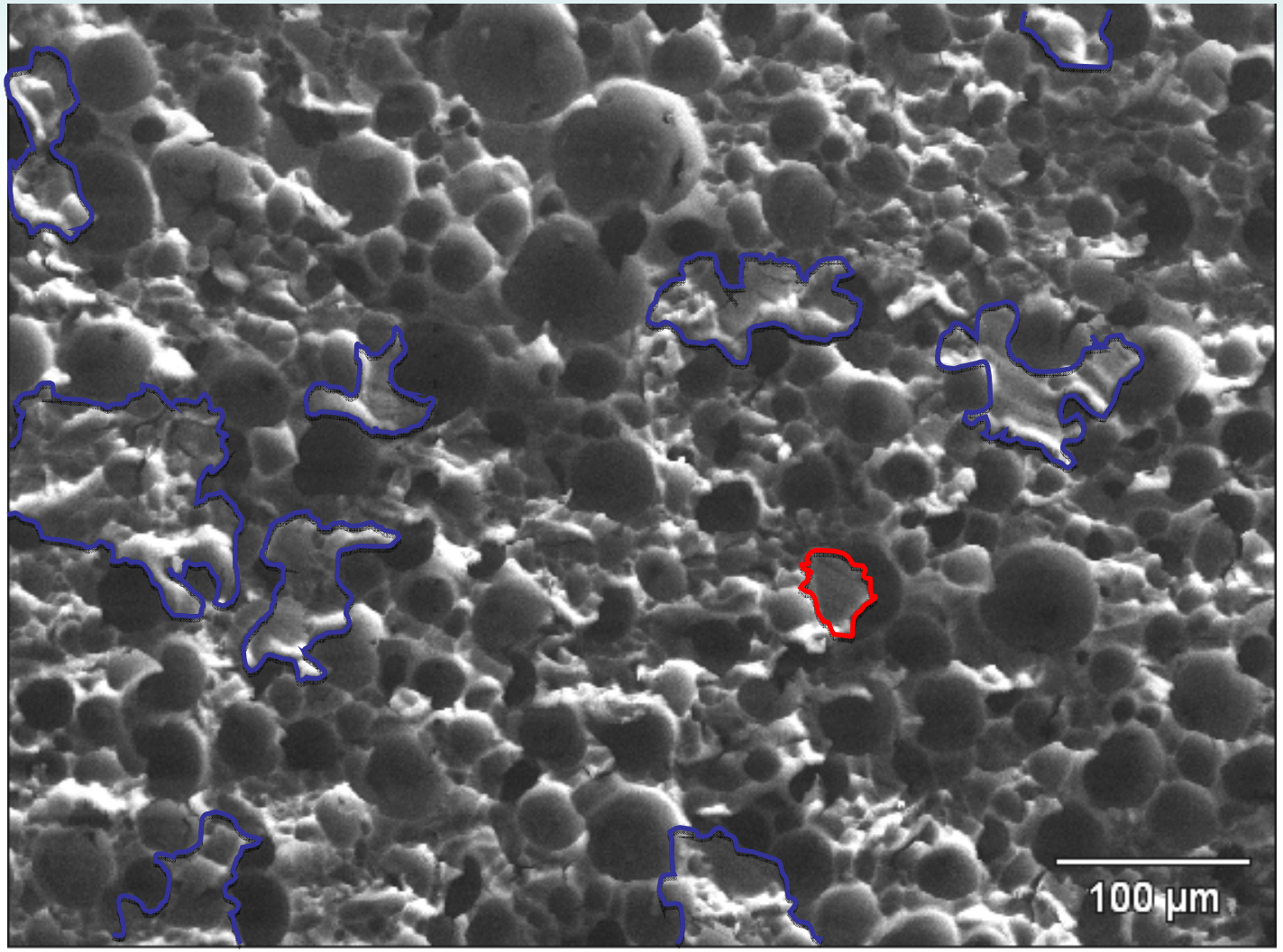
Pad Surface SEM Image

MMC TRD Disc



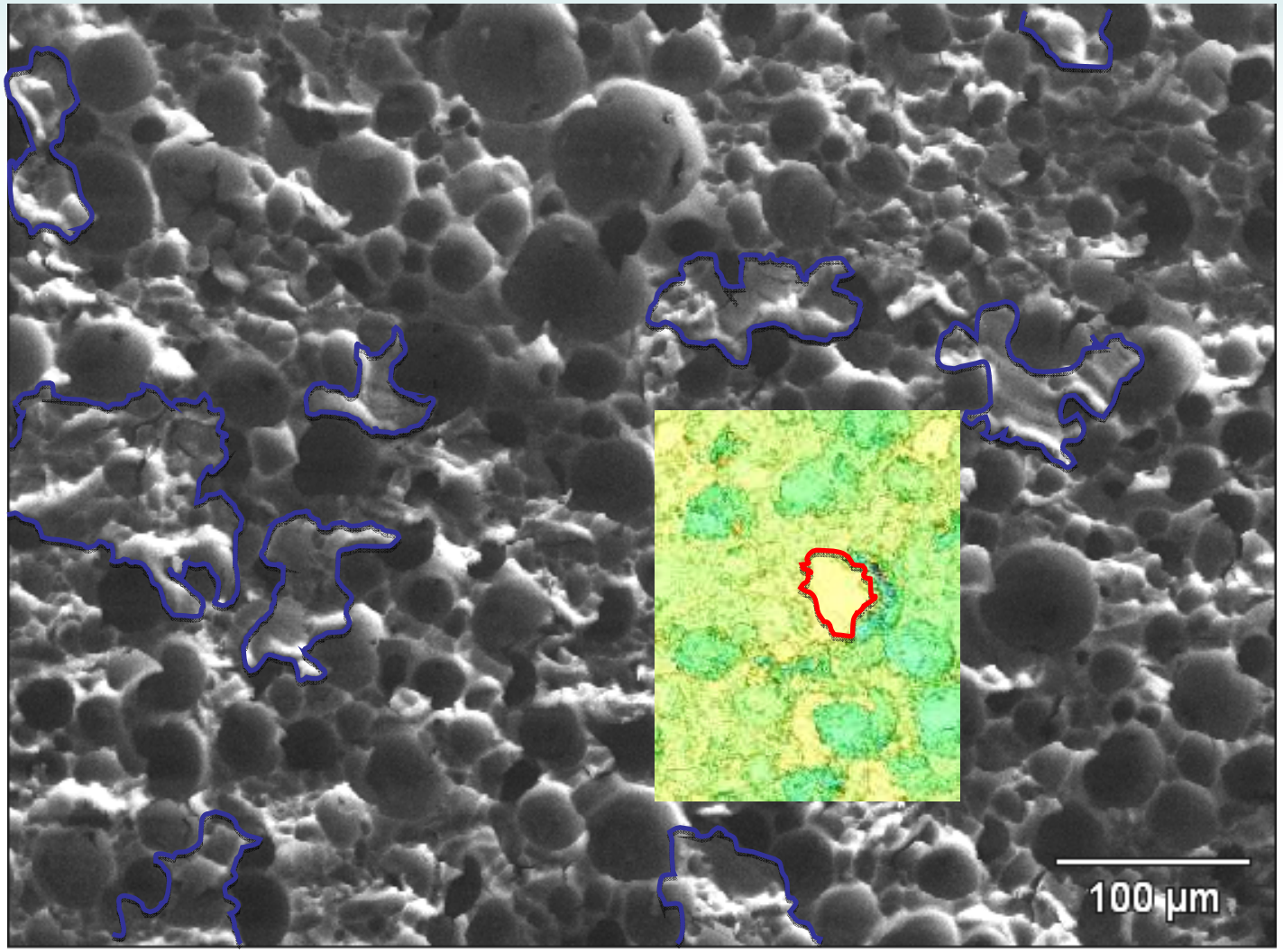
Pad Surface SEM Image

MMC TRD Disc



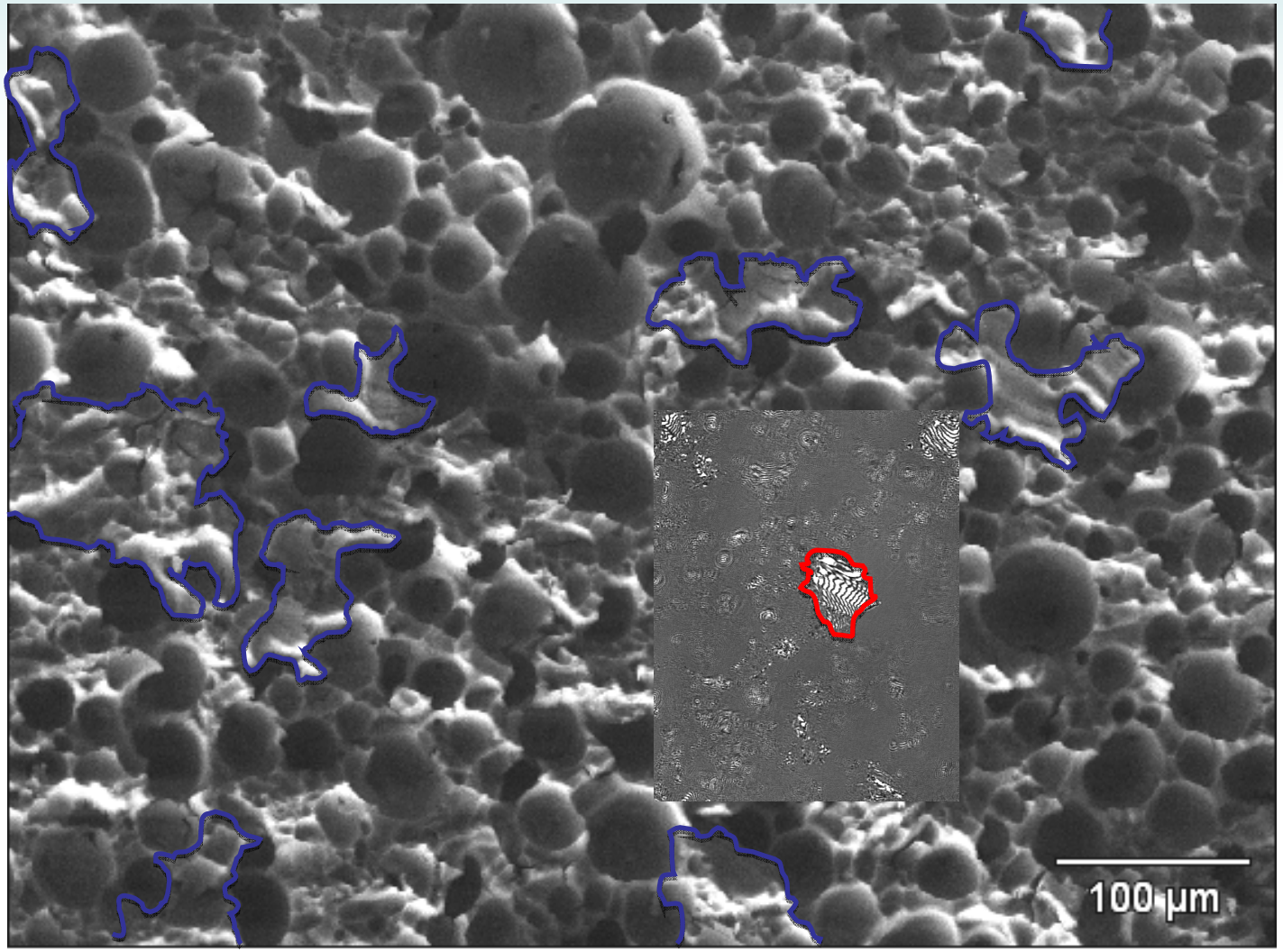
Pad Surface SEM and Topography Images

MMC TRD Disc



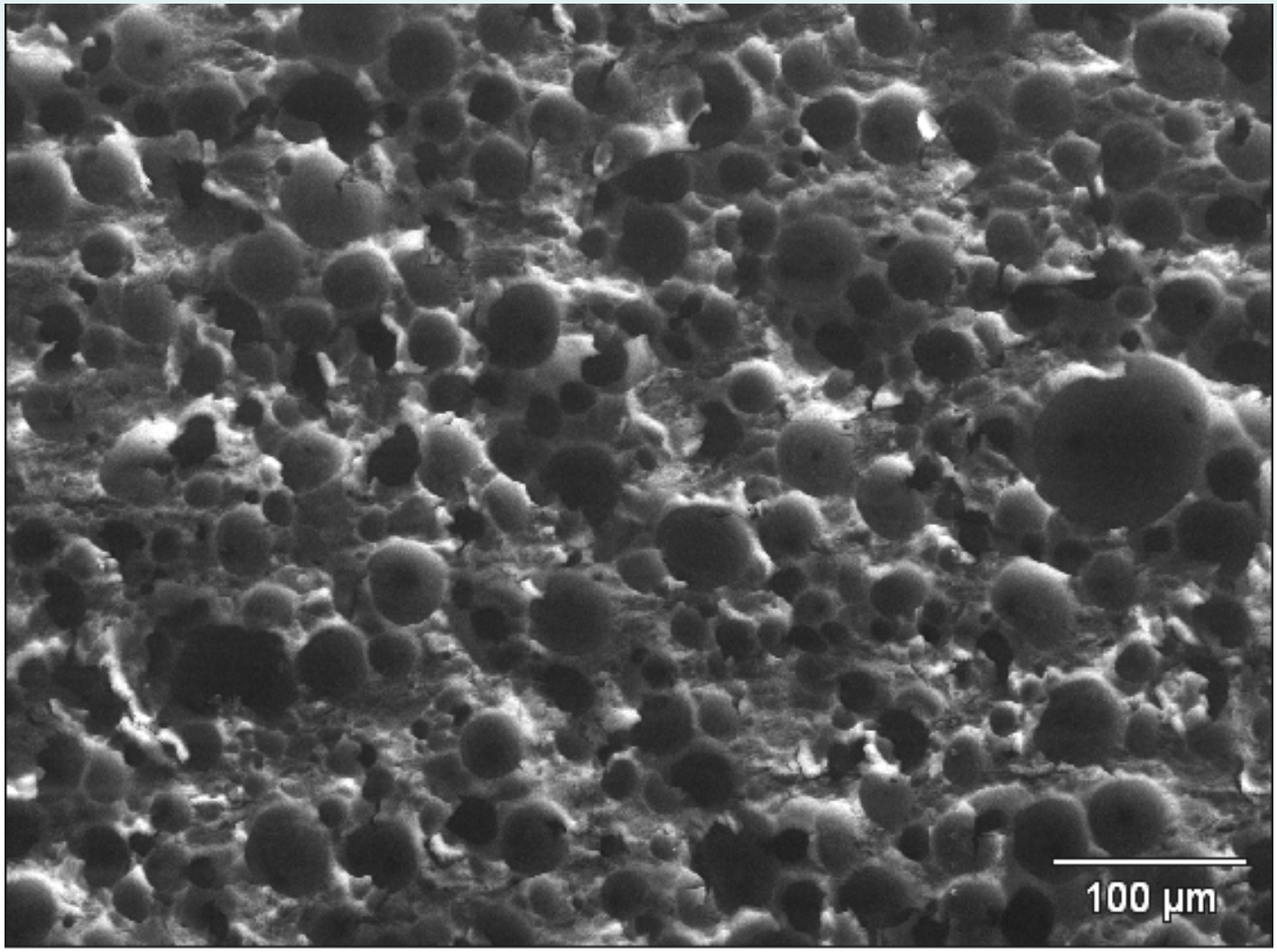
Pad Surface SEM and Contact Area Images

MMC TRD Disc



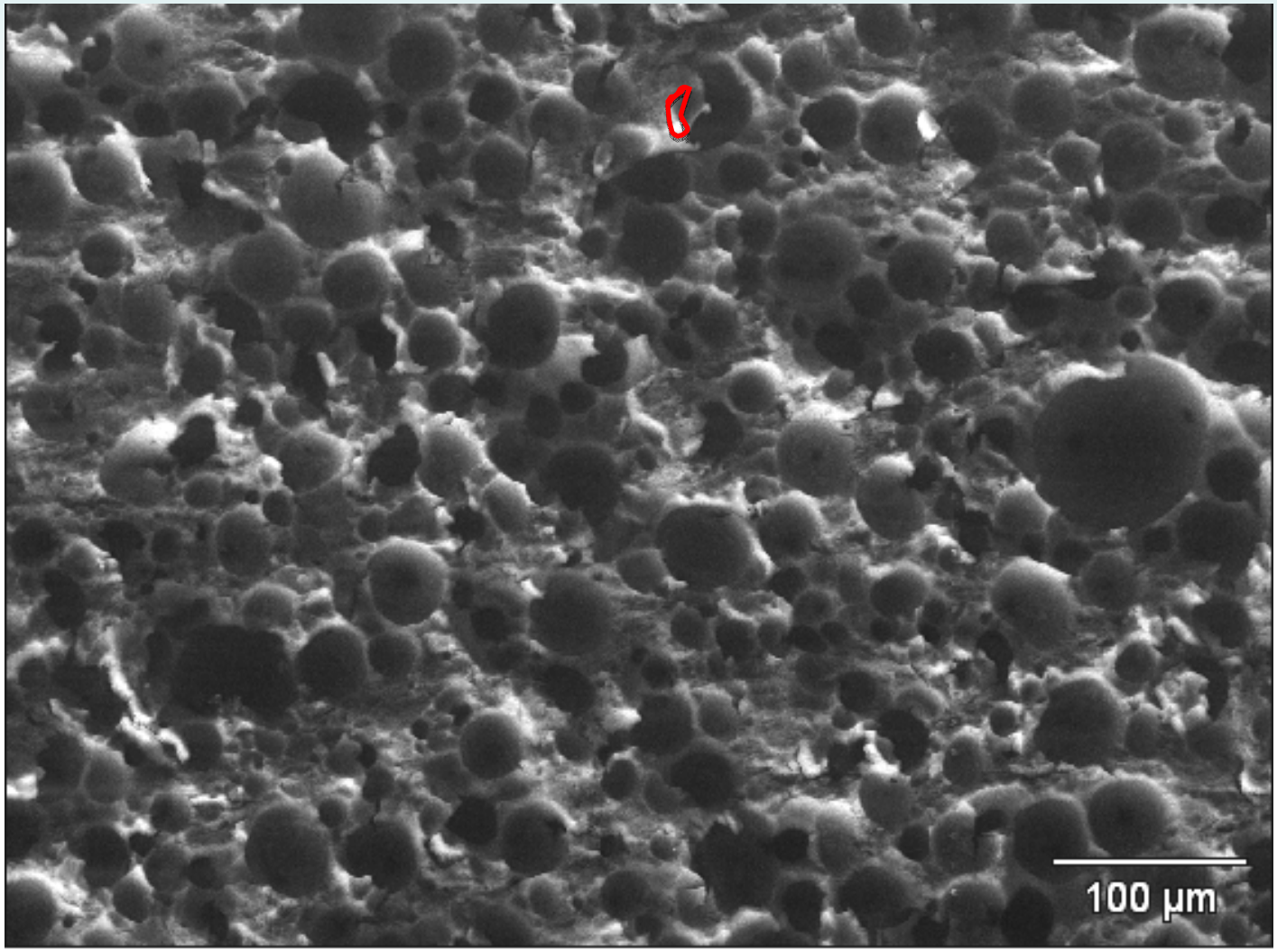
Pad Surface SEM Image

3M A2810 Disc



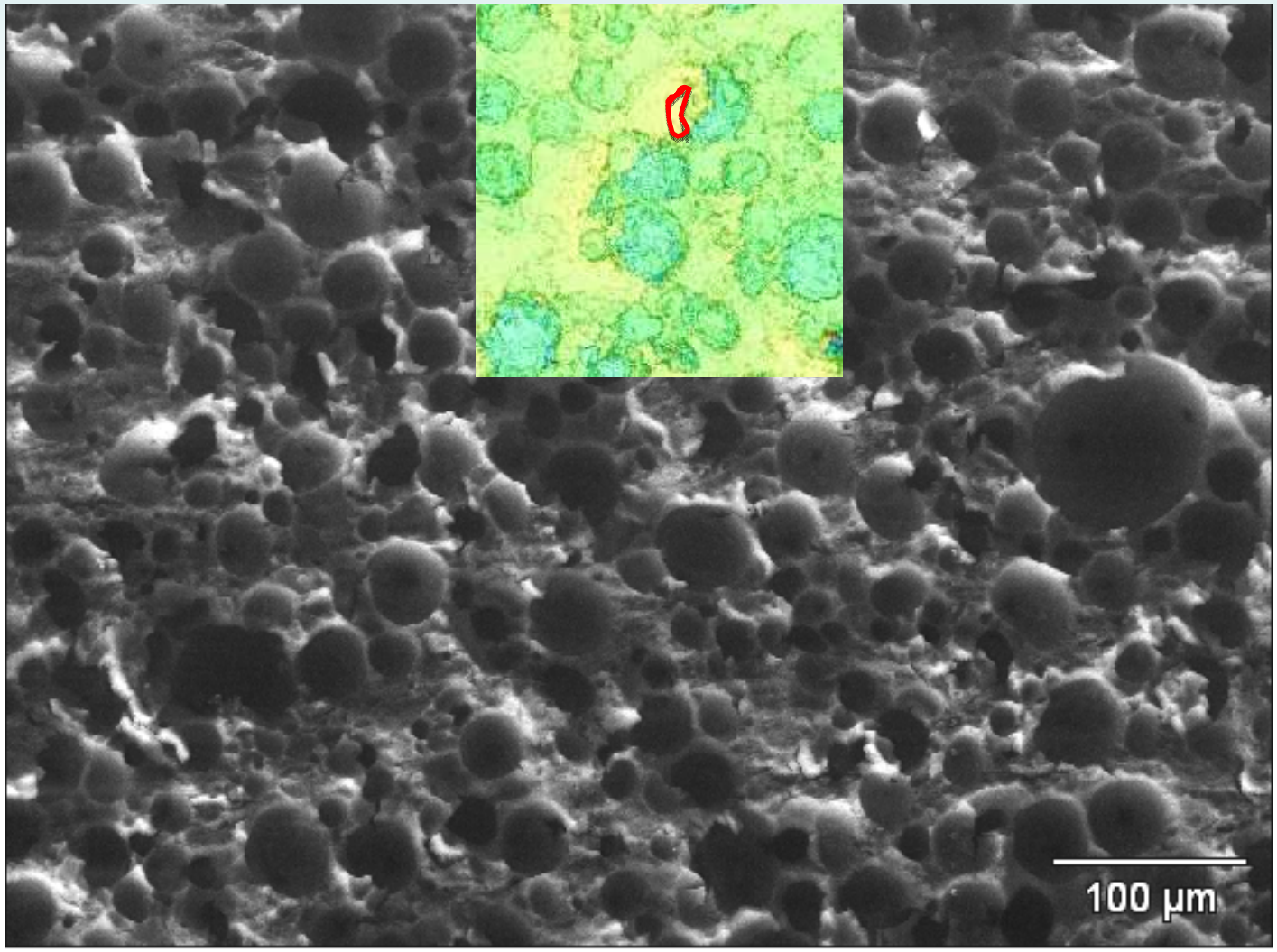
Pad Surface SEM Image

3M A2810 Disc



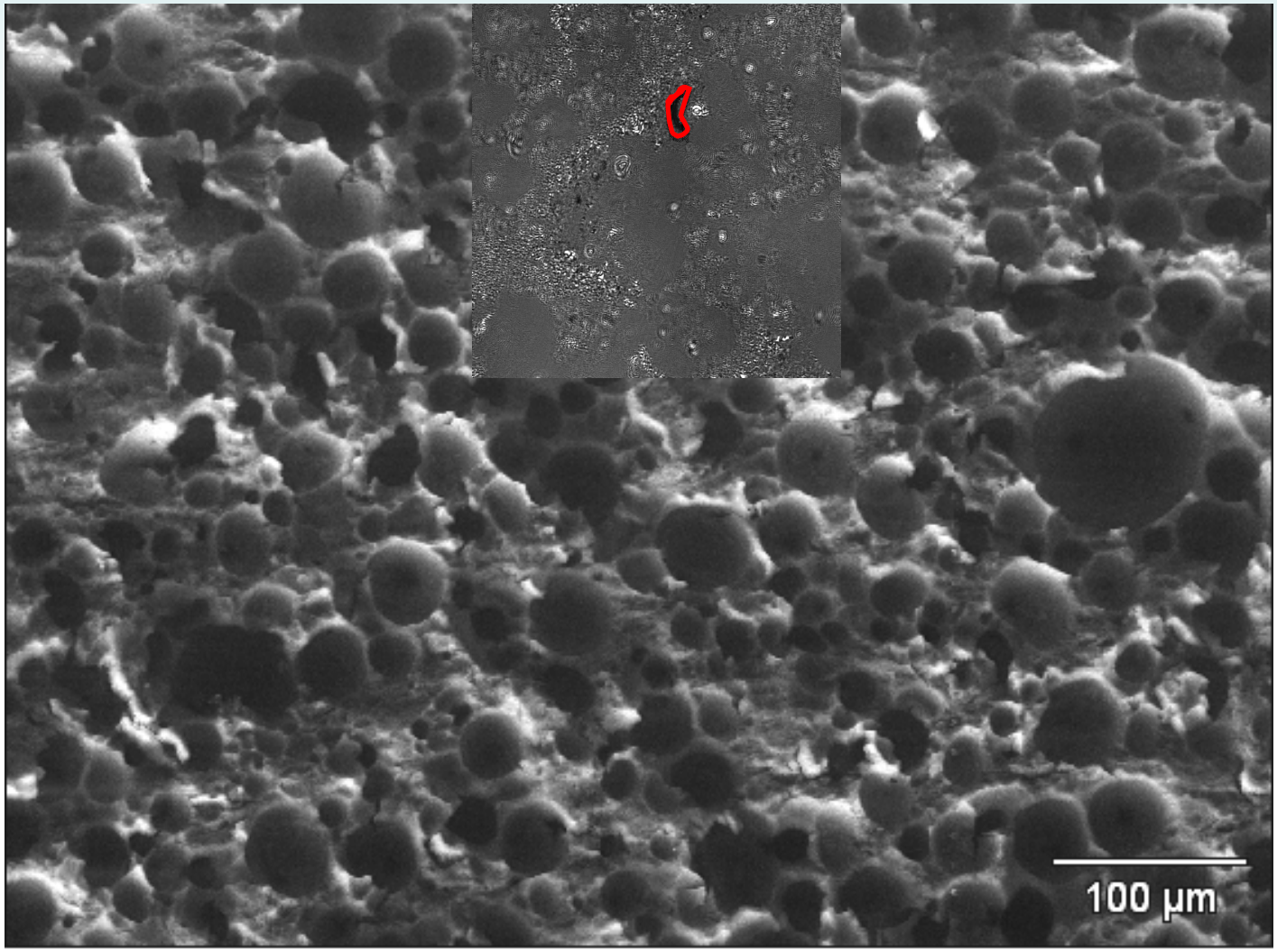
Pad Surface SEM and Topography Images

3M A2810 Disc



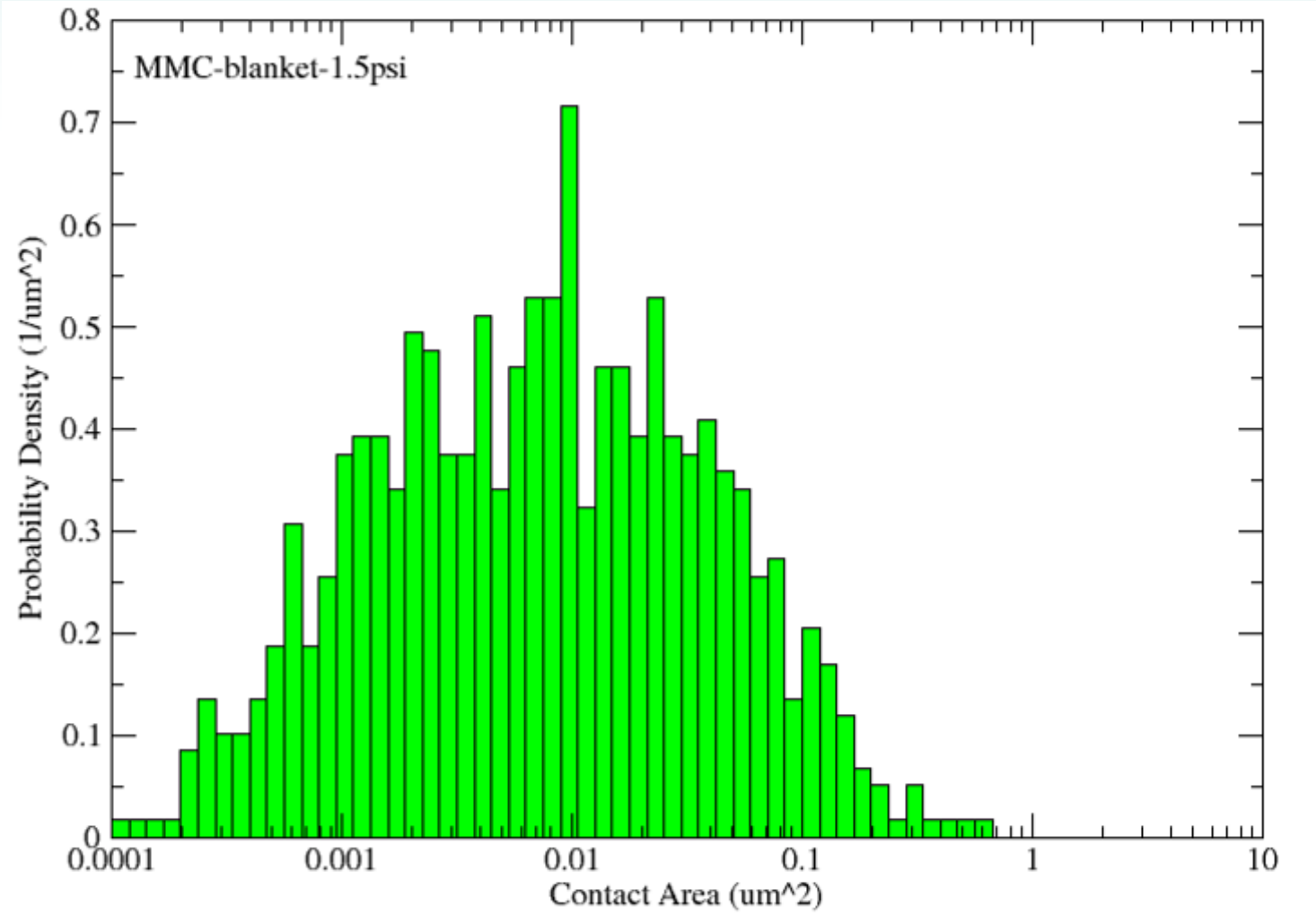
Pad Surface SEM and Contact Area Images

3M A2810 Disc



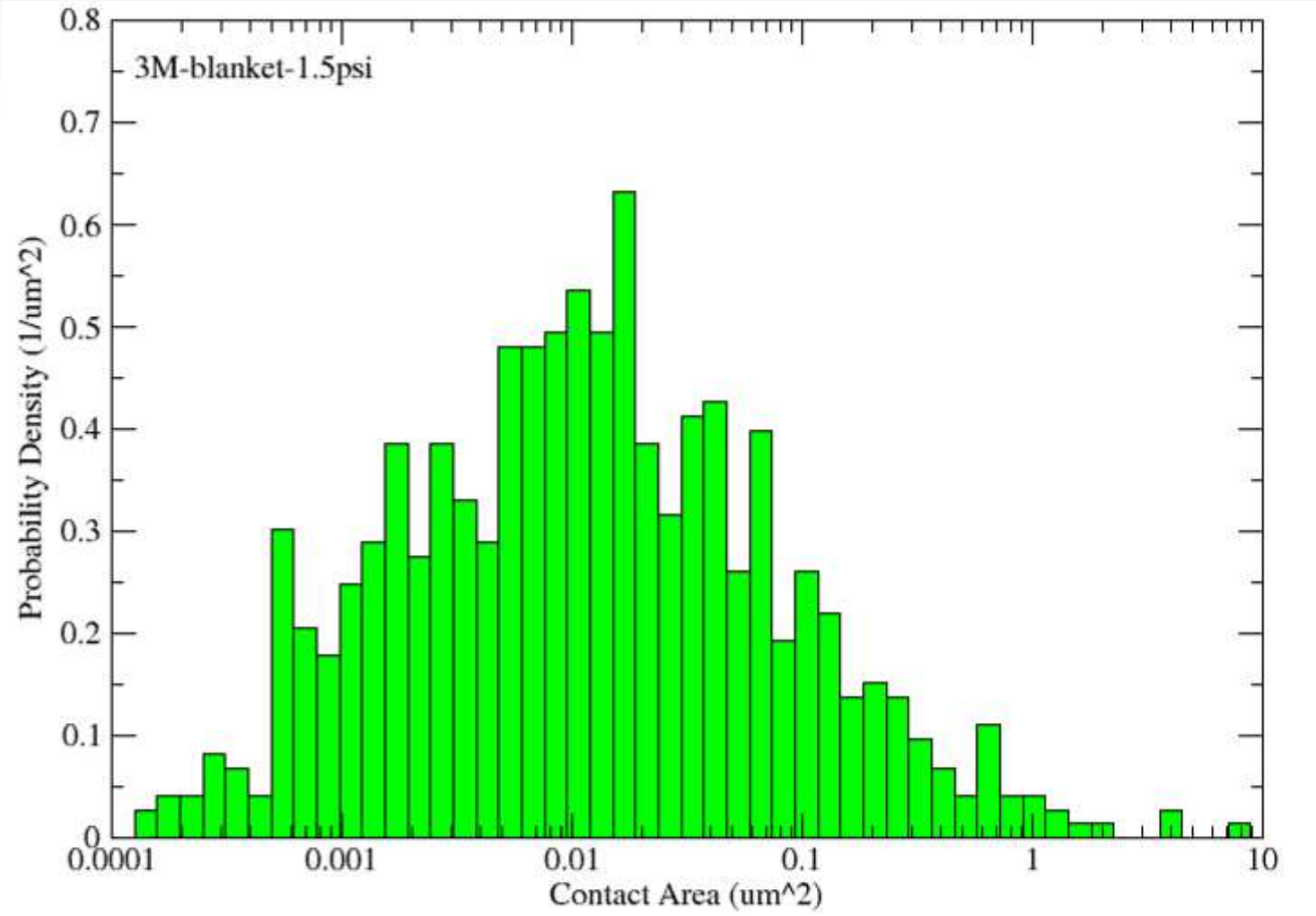
Contact Area Distribution

MMC TRD Disc



Contact Area Distribution

3M A2810 Disc



Summary

During blanket copper wafer polishing, MMC TRD disc generated fewer pad surface contact areas than 3M A2810 disc.

In addition, MMC TRD disc generated much larger flat near contact areas corresponding to pore walls that had been fractured and collapsed.

The fractured/collapsed pore walls partly covered the adjacent pores, making the pad surface more lubricated and rendering a lower COF and removal rate compared with the 3M A2810 disc.