The Effect of Conditioner Design on Pad Texture

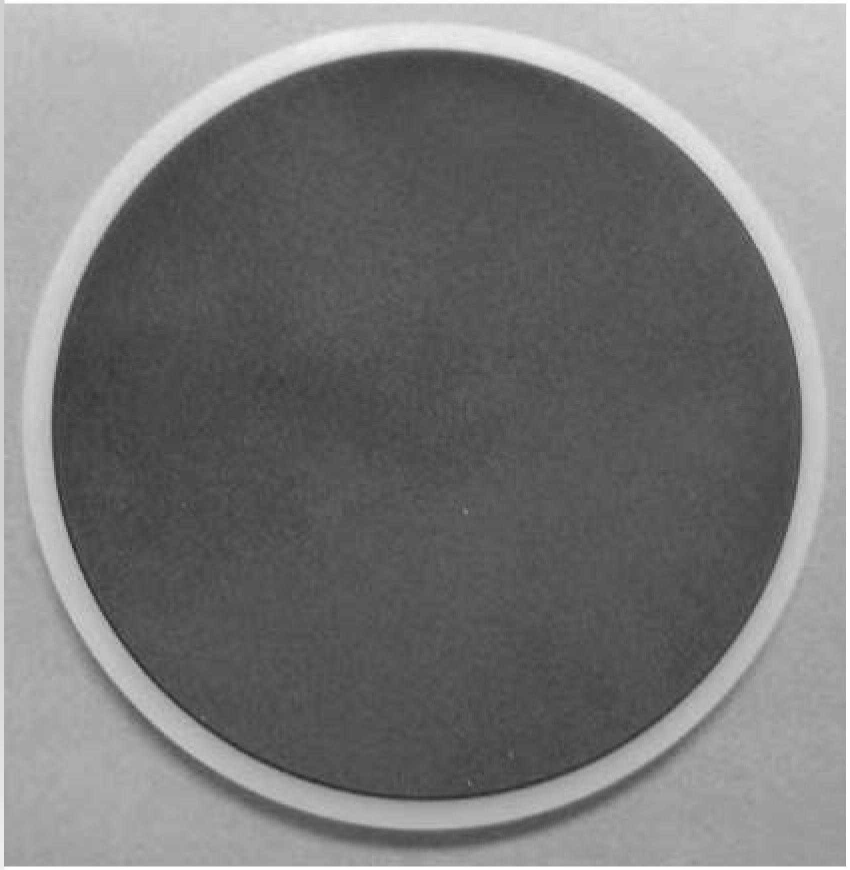
Morgan Advanced Ceramics

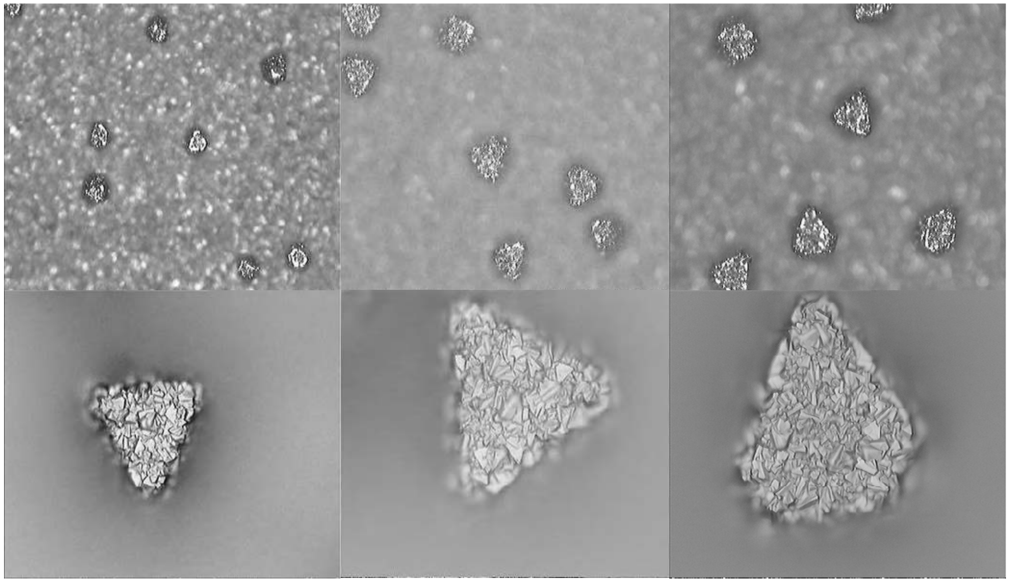
Diamonex® Products Division

David Slutz

July 17, 2008

Phoenix® CMP Pad Conditioner

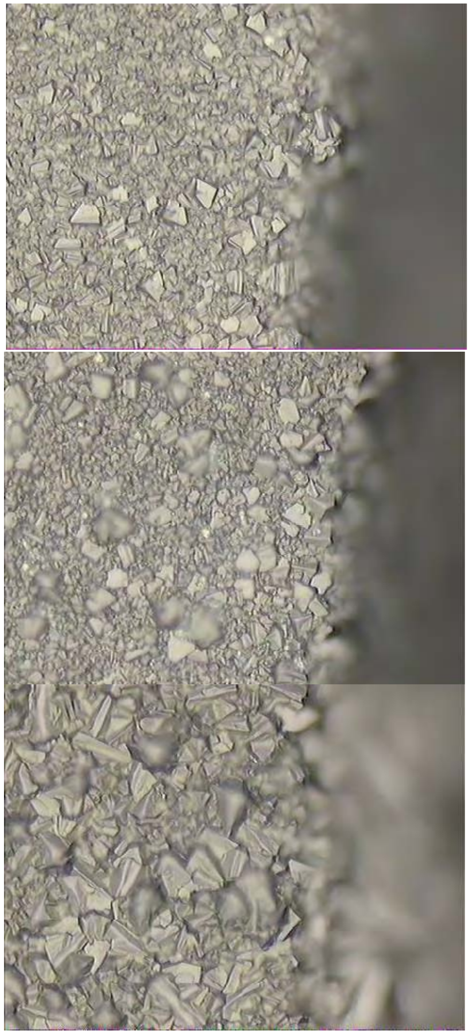




Fine Medium Coarse

CVD Diamond Coated Diamond Grit

Phoenix® edge CMP Pad Conditioner



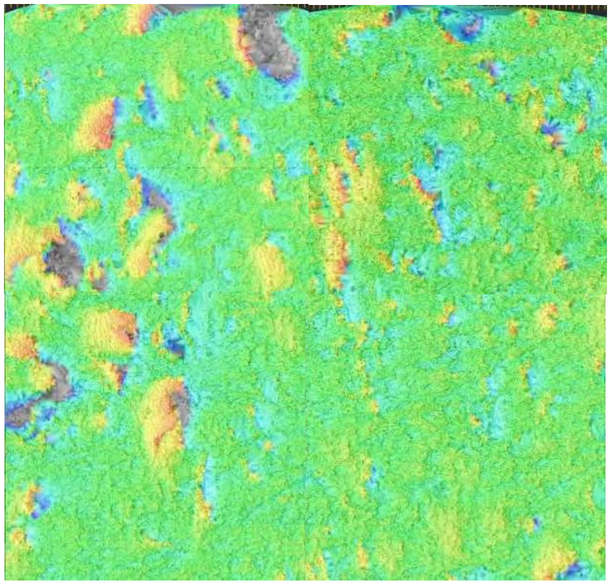
Design A

Design B

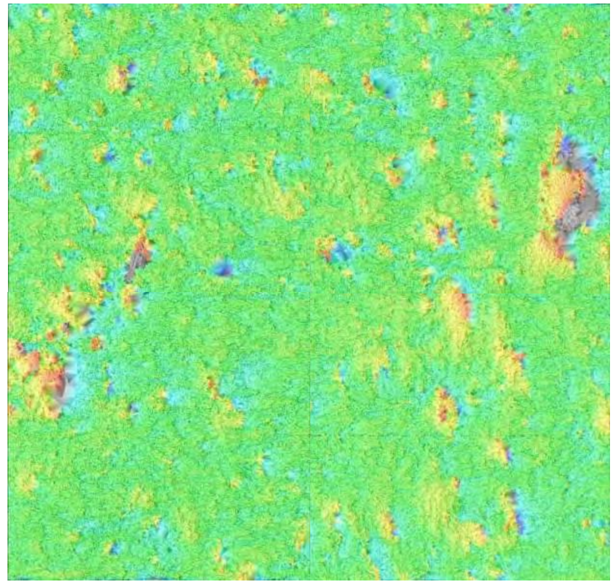
Design C

Pad Texture Results

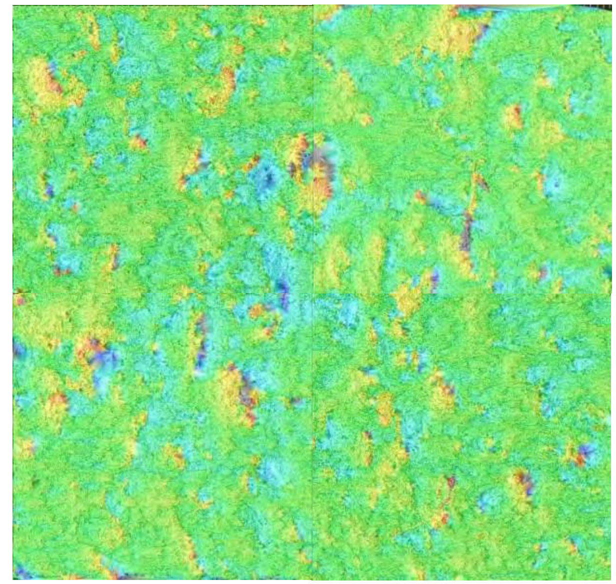
Phoenix Medium Grit Conditioner- Interferometry



Inner

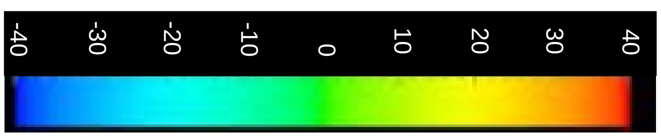


Middle



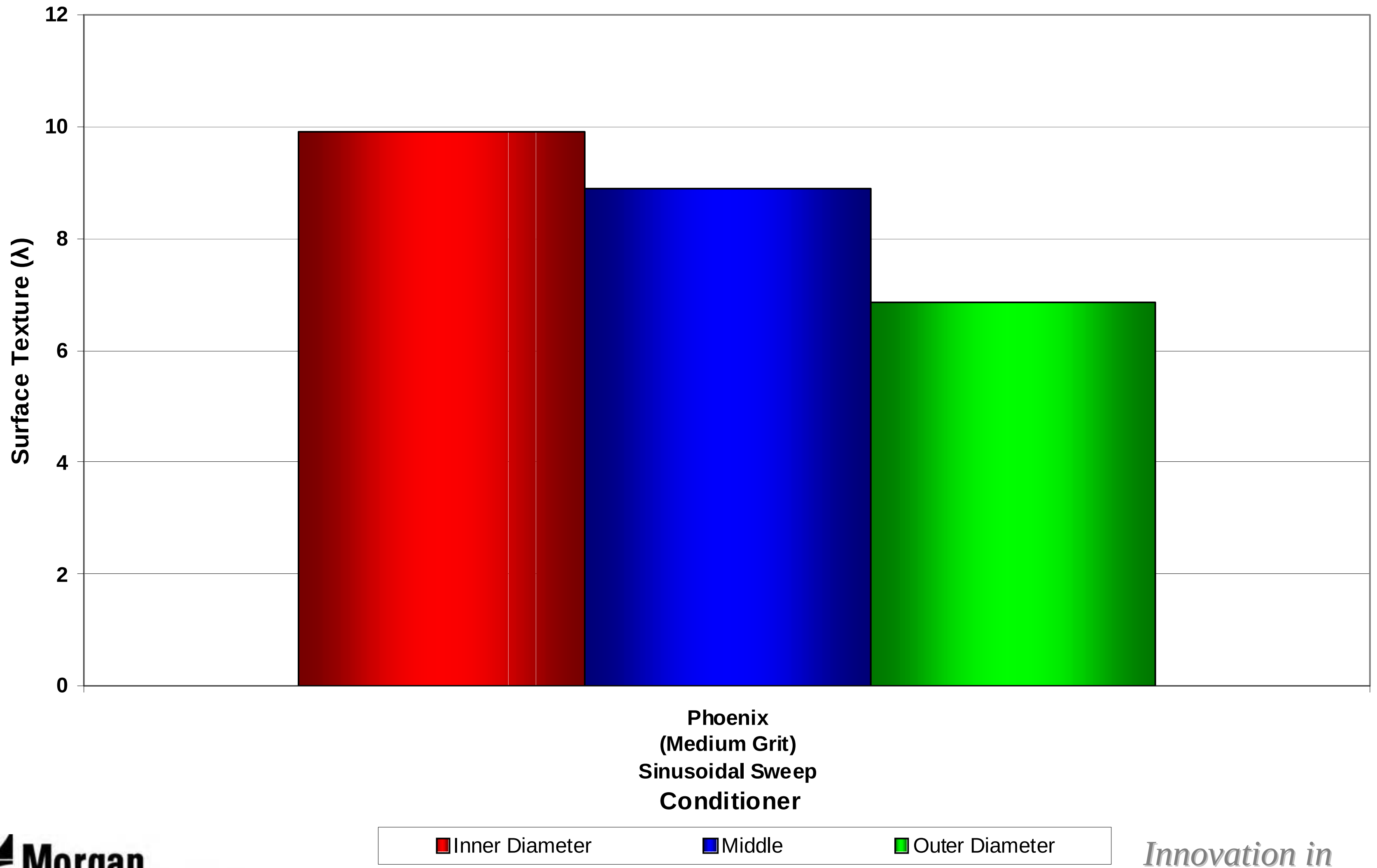
Outer

Surface Height (microns)



Numerous large asperities, source of wafer defects.

Pad Texture (Medium Grit)



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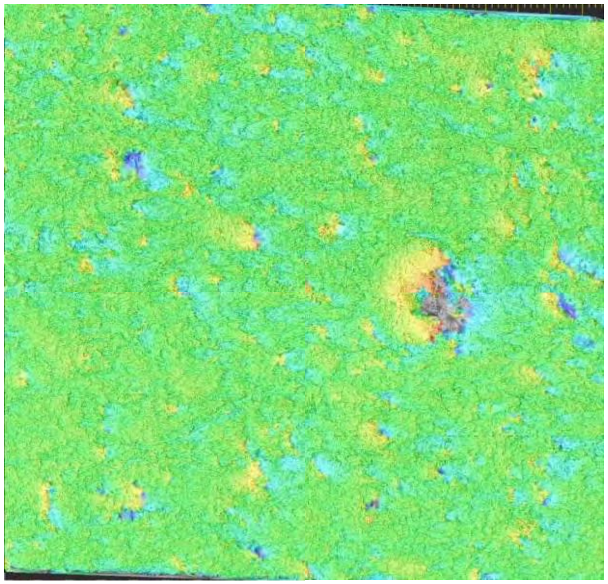
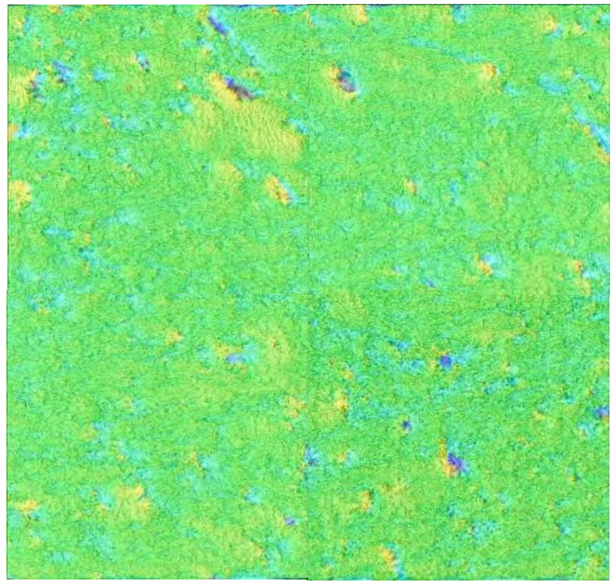
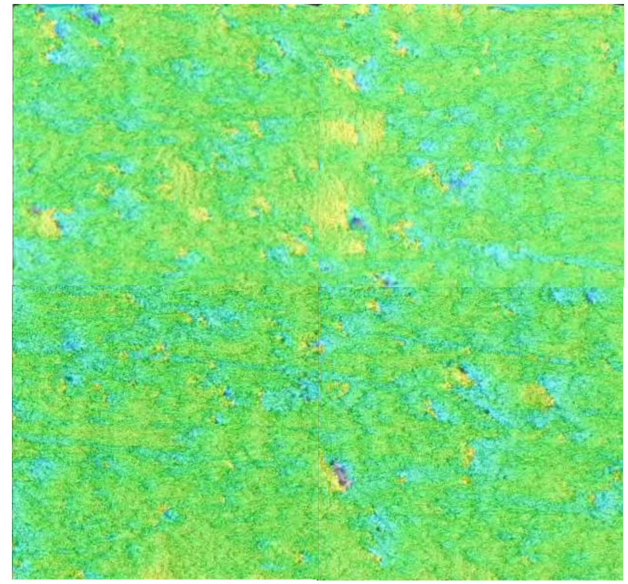
Phoenix Fine Grit - Interferometry Line 2

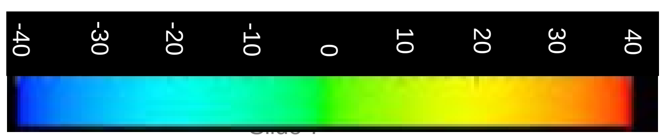




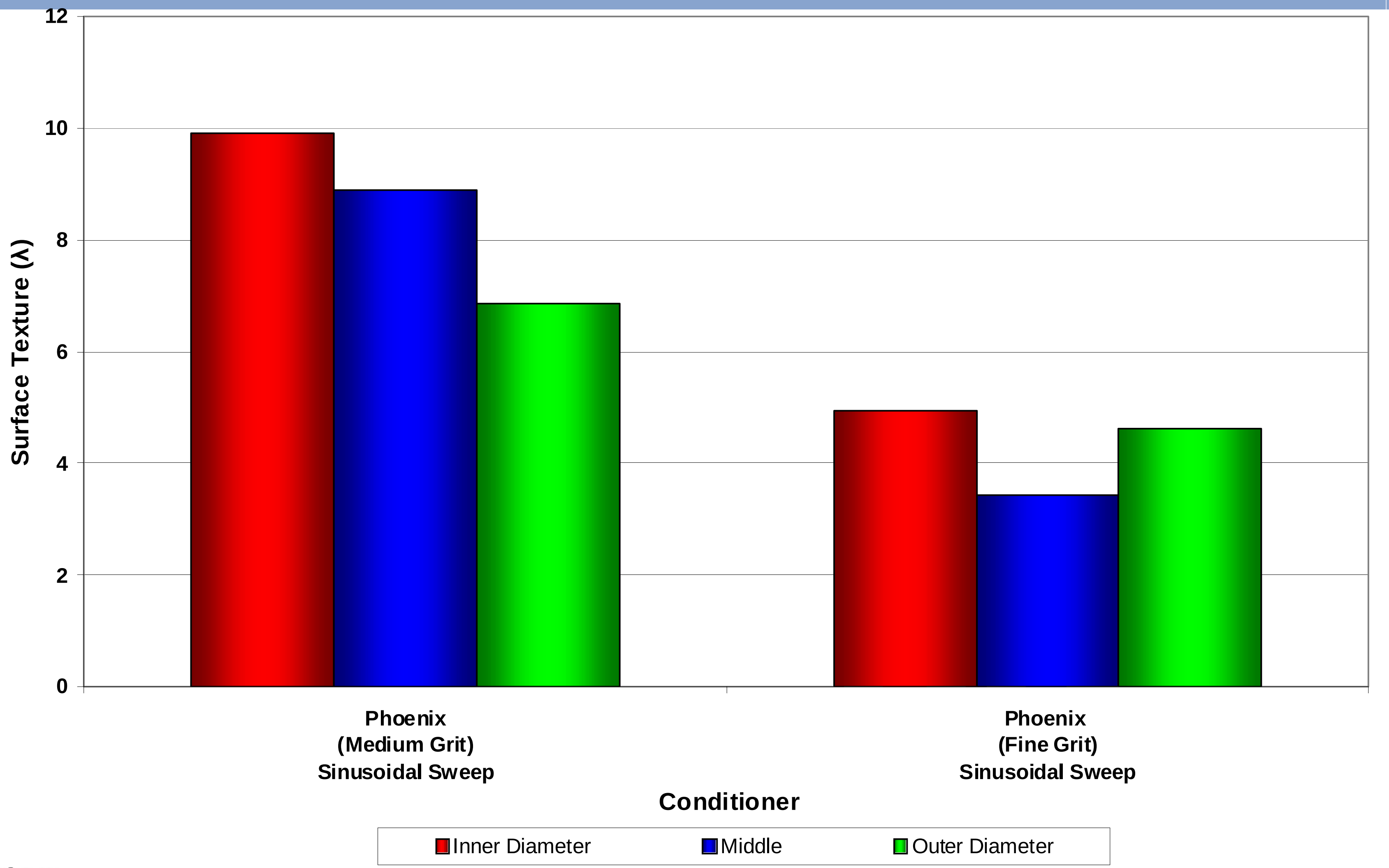


Inner **Middle** **Outer**

Surface Height (microns)



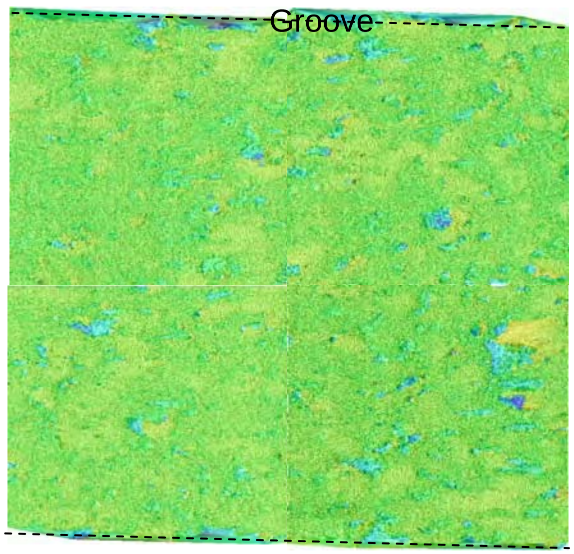
Pad Texture

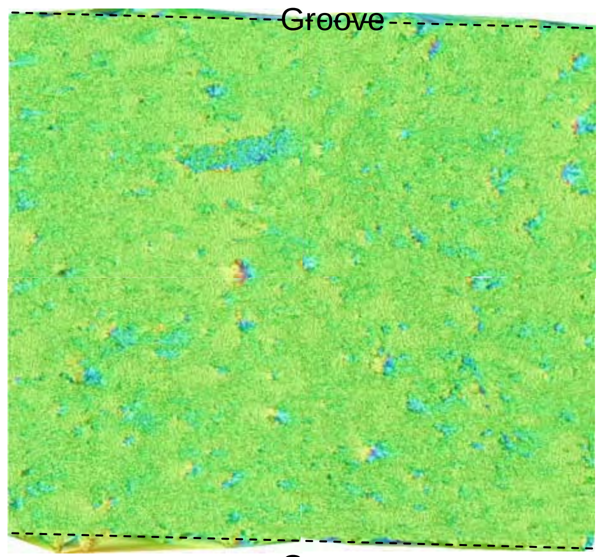


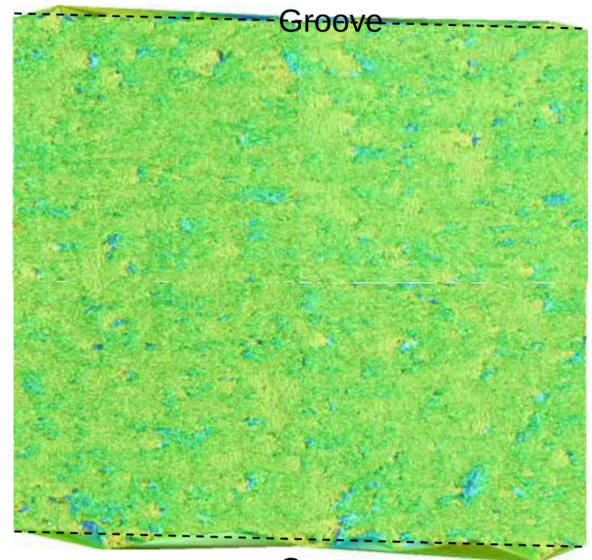
12
10
8
6
4
2
0
Surface Texture (Å)
Phoenix
(Medium Grit)
Sinusoidal Sweep
Phoenix
(Fine Grit)
Sinusoidal Sweep
Conditioner
Inner Diameter
Middle
Outer Diameter

Phoenix edge pad Conditioner - Interferometry

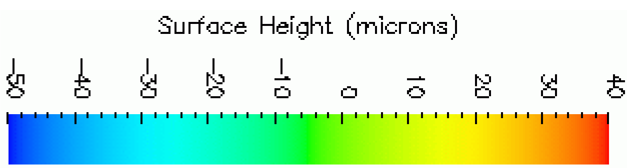
2x2 mm image





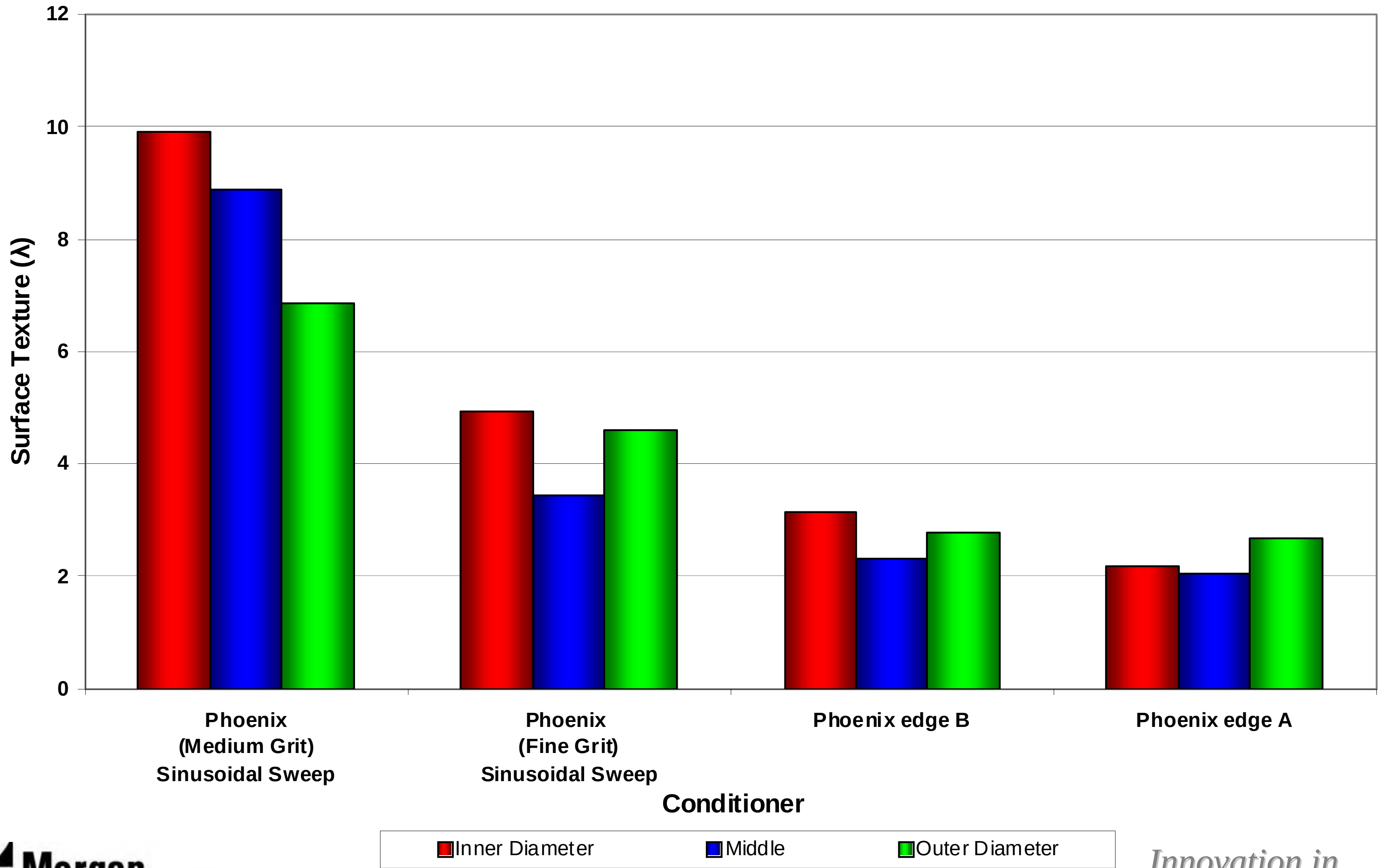


Inner(2.75") **Middle(5.125")** **Outer(7.50")**

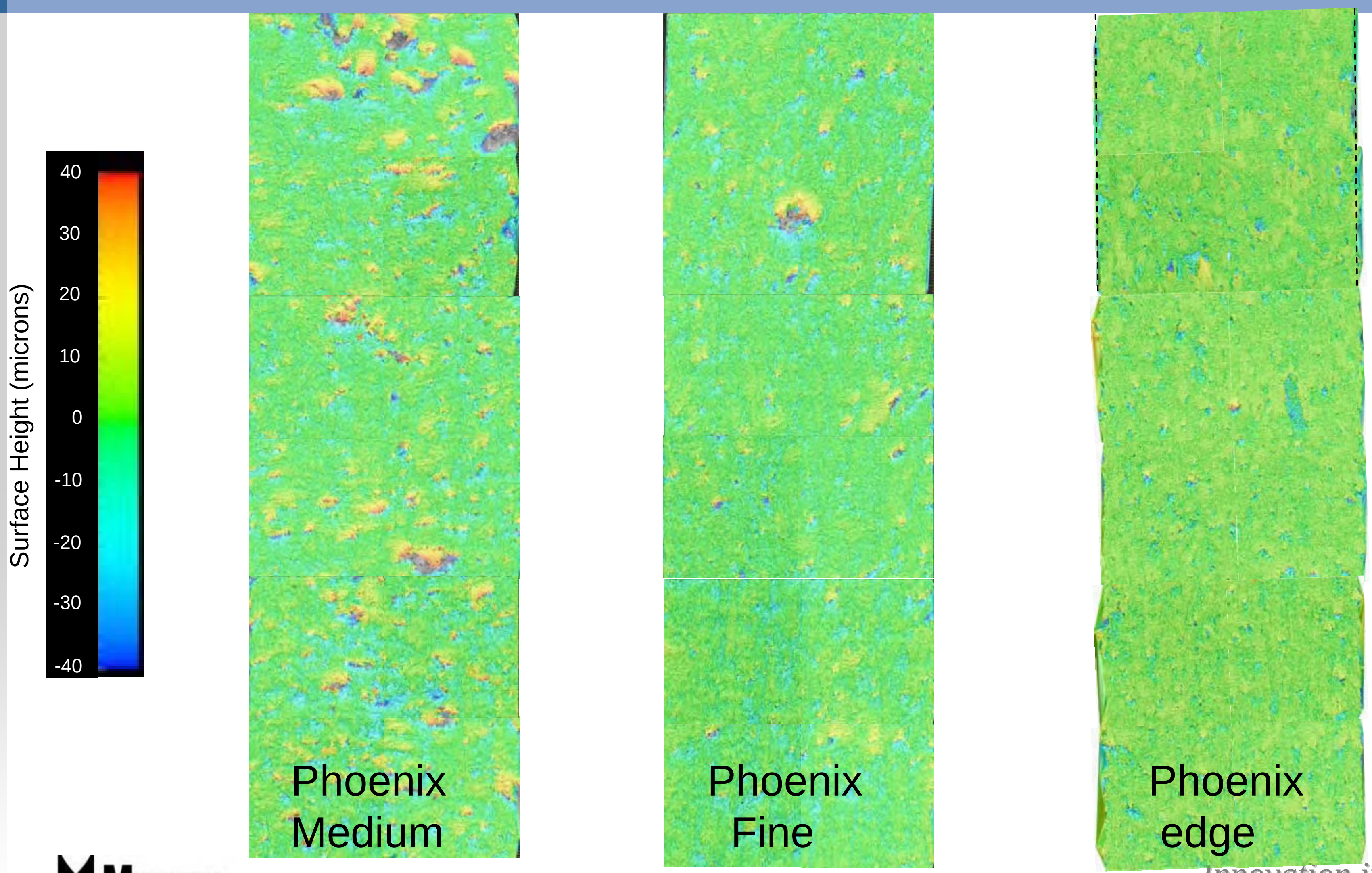


Fewer large asperities, more uniform surface.
Increased contact area, reduced defects.

Pad Surface Texture Comparison



Interferometry Data



Pad Texture Result

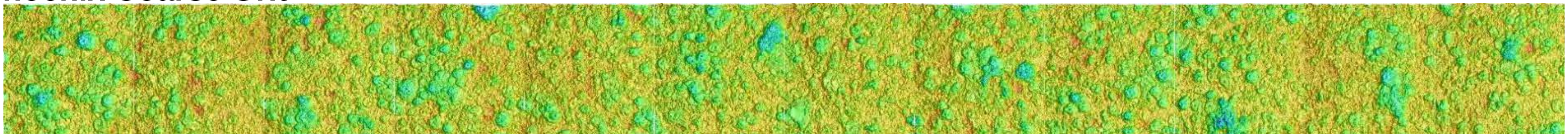
for Copper Process

Experiment Conditions

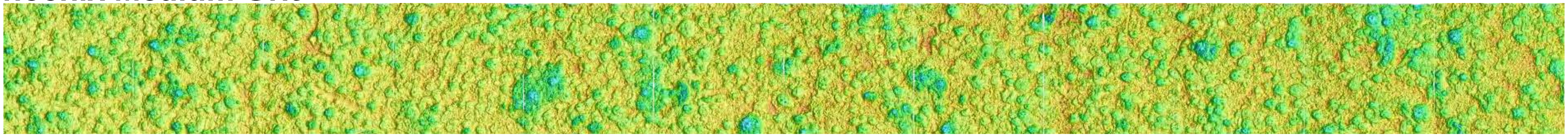
- **Wafer**
  - **200-mm blanket copper wafer**
- **Pad**
  - **IC1020 M groove**
- **Slurry**
  - **200 ml of Fujimi PL-7103 slurry + 800 ml of DI H_2O + 33 grams of 30% ultra pure H_2O_2**
- **Rinse**
  - **DI H_2O flow rate 2,000 ml/min for 30 seconds.**
- **Pad Conditioning**
  - **Morgan Diamond Discs**
    - **Phoenix Fine grit**
    - **Phoenix Medium grit**
    - **Phoenix Coarse grit**
    - **Phoenix edge Design C (2 runs)**
  - **In-situ pad conditioning = 6 lb_f**
  - **Tweaked optimized sweep**
  - **2^{nd} Phoenix edge- sinusoidal sweep**
- **Wafer Polishing**
  - **Polishing pressure = 2 PSI**
  - **Platen sliding velocity = 42 RPM**
  - **Polishing time = 60 seconds**

Composite Topography Images

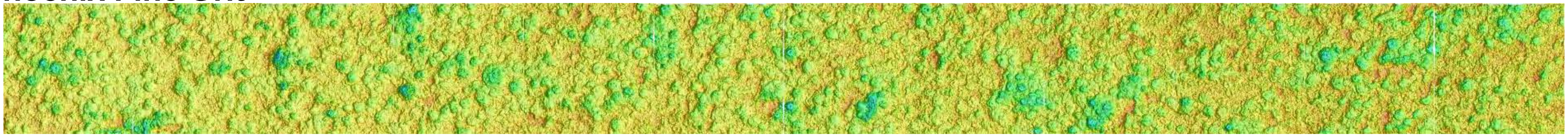
Phoenix Coarse Grit



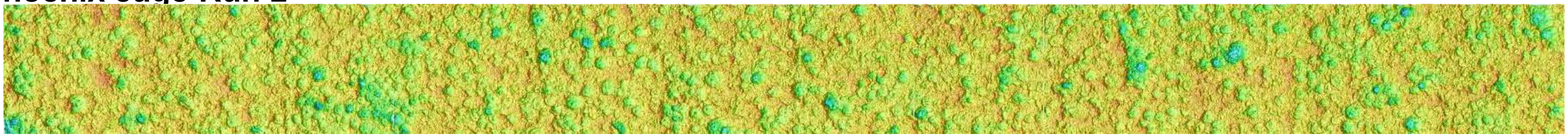
Phoenix Medium Grit



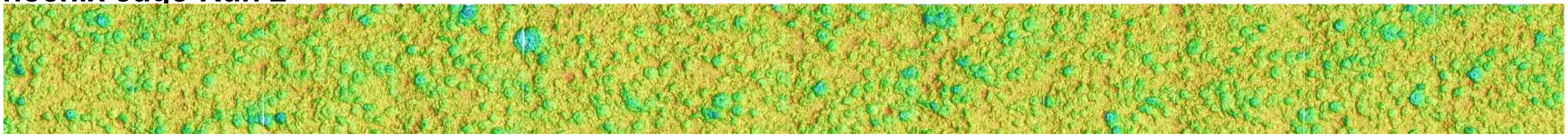
Phoenix Fine Grit

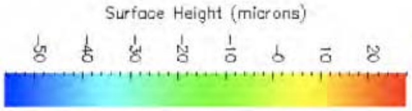


Phoenix edge-Run 1

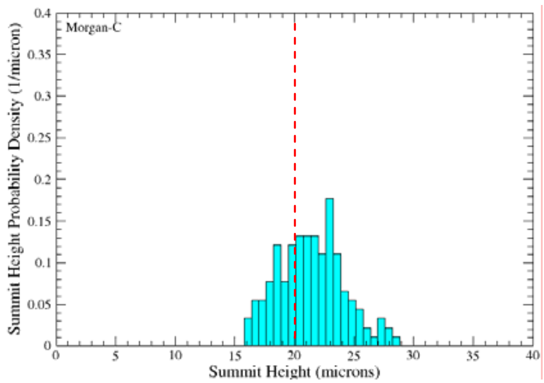


Phoenix edge-Run 2

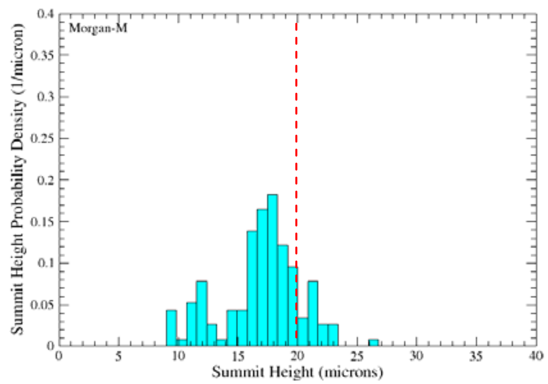




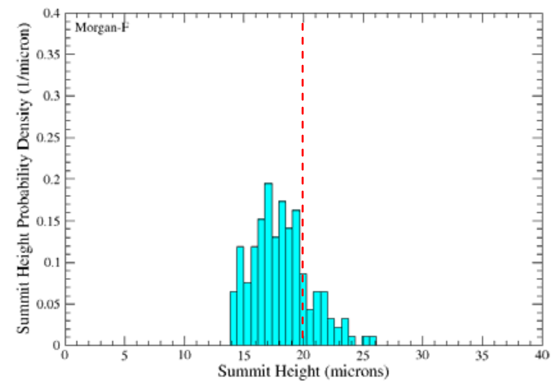
Summit Height Distributions



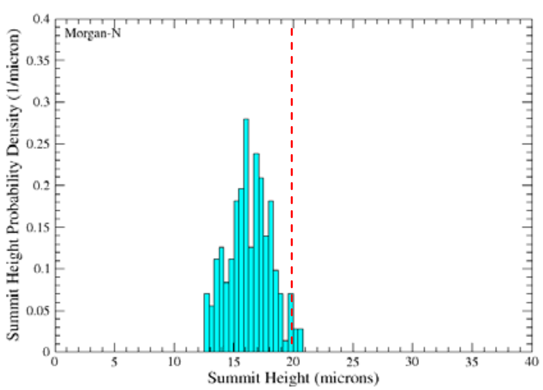
Phoenix Coarse



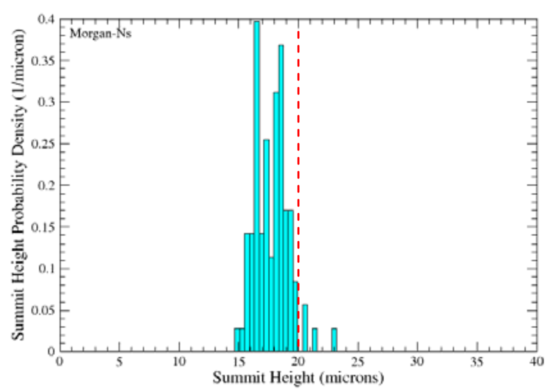
Phoenix Medium



Phoenix Fine

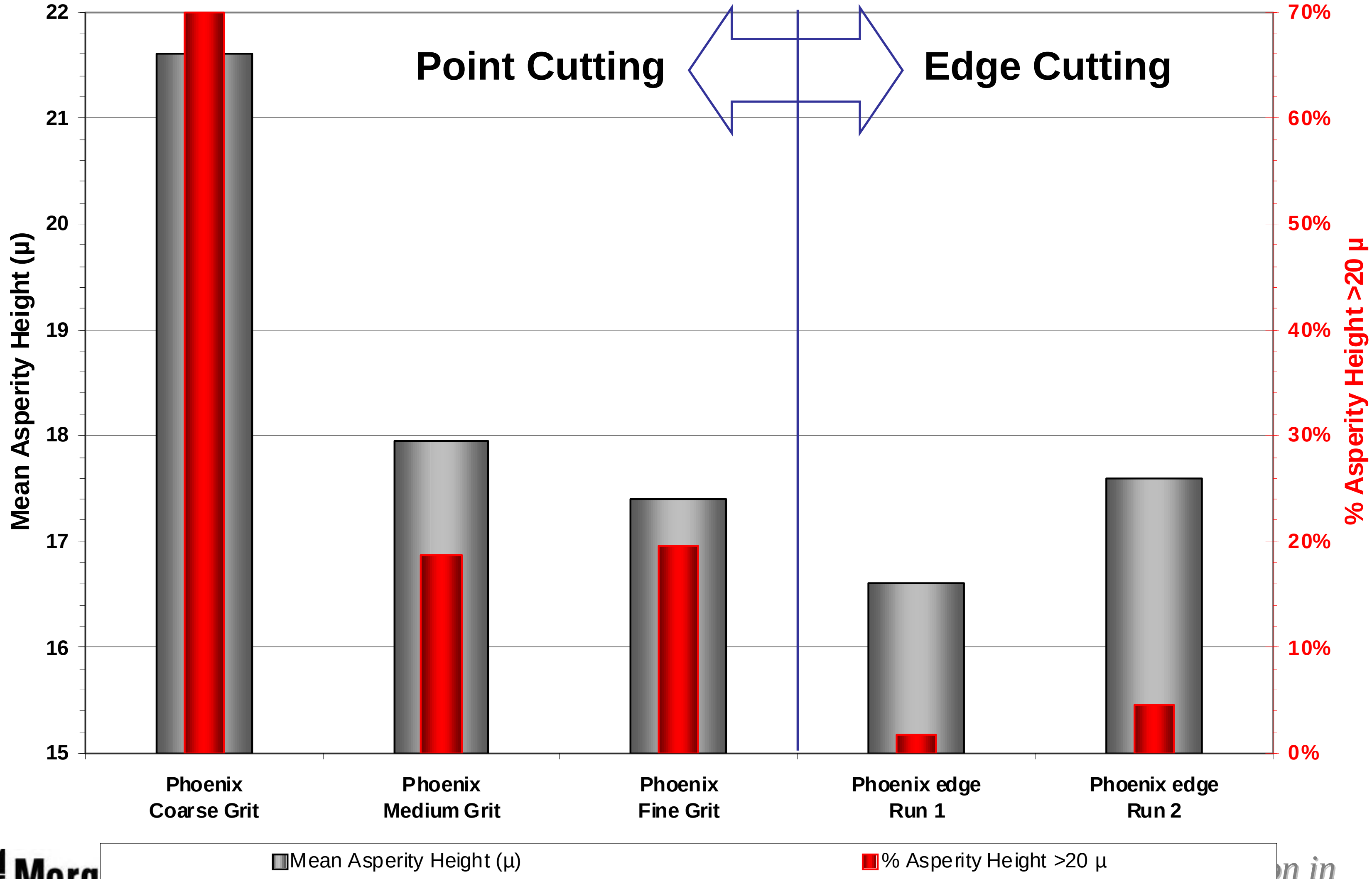


Phoenix edge-Run 1

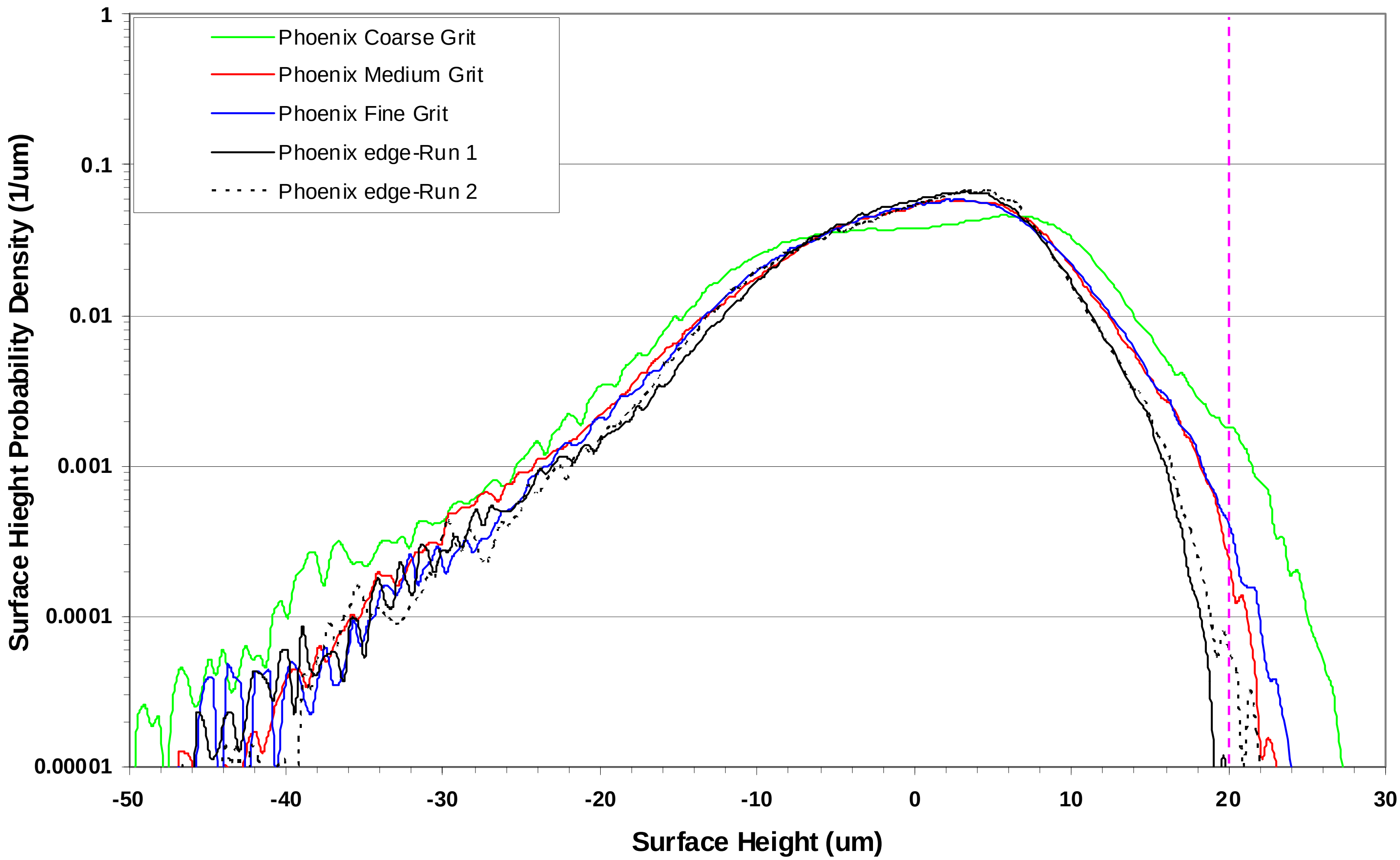


Phoenix edge- Run 2

Asperity Height (Mean & >20um)



Surface Height Probability Density Functions



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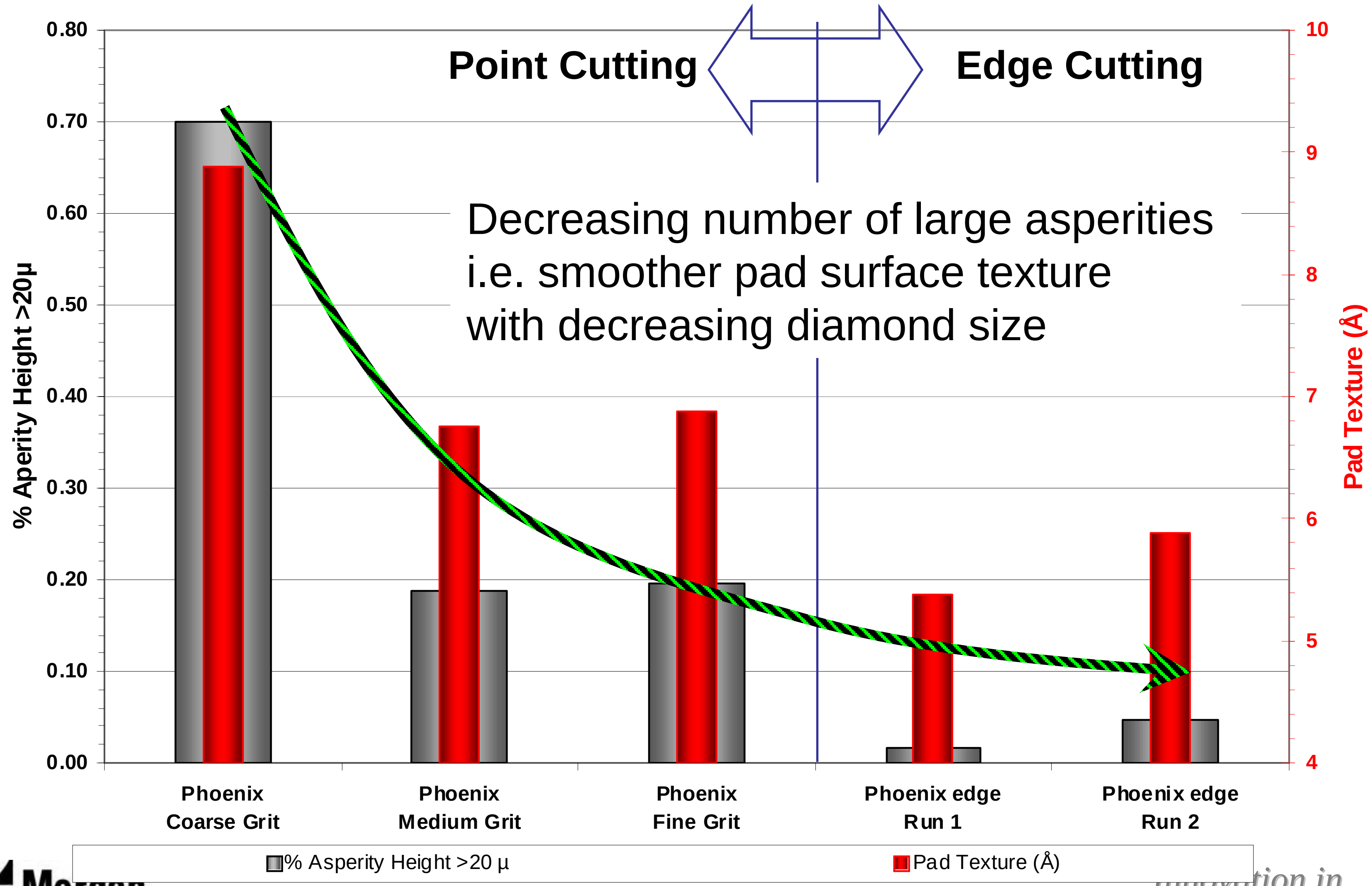
Pad Texture and % Asperity Heights >20µ



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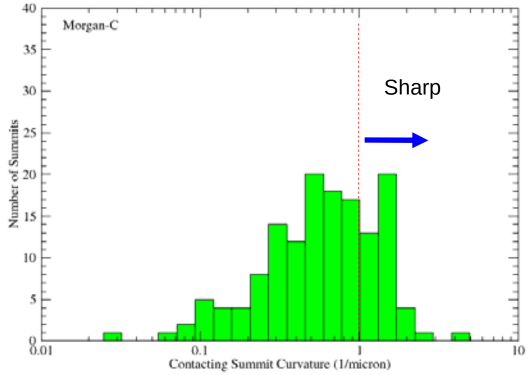
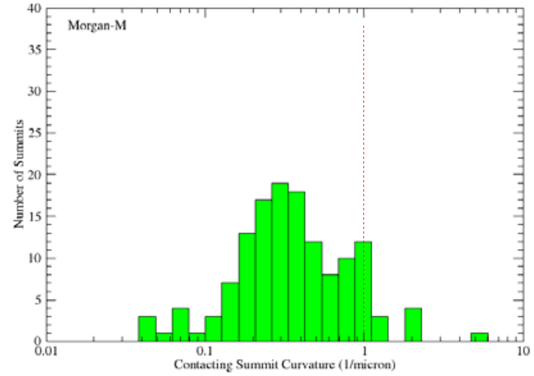
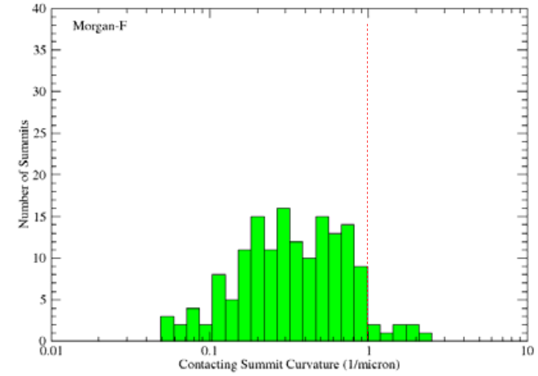
Summit Sharpness



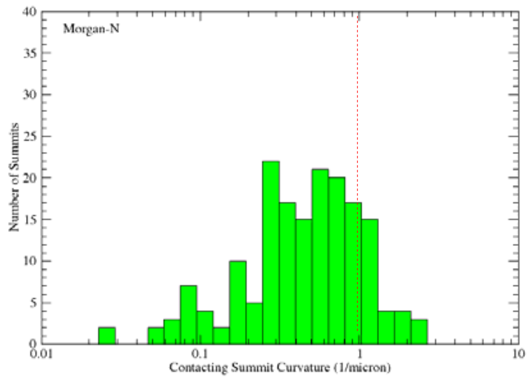
Phoenix Coarse



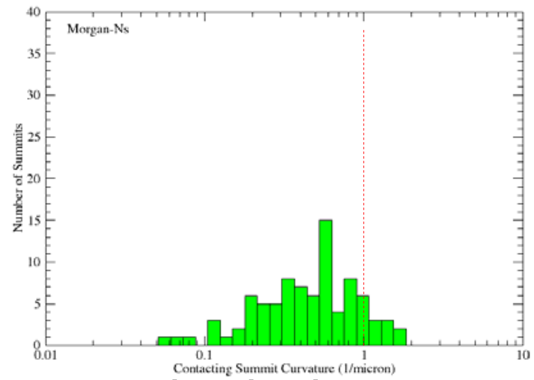
Phoenix Medium



Phoenix Fine



Phoenix edge-Run 1



Phoenix edge- Run 2

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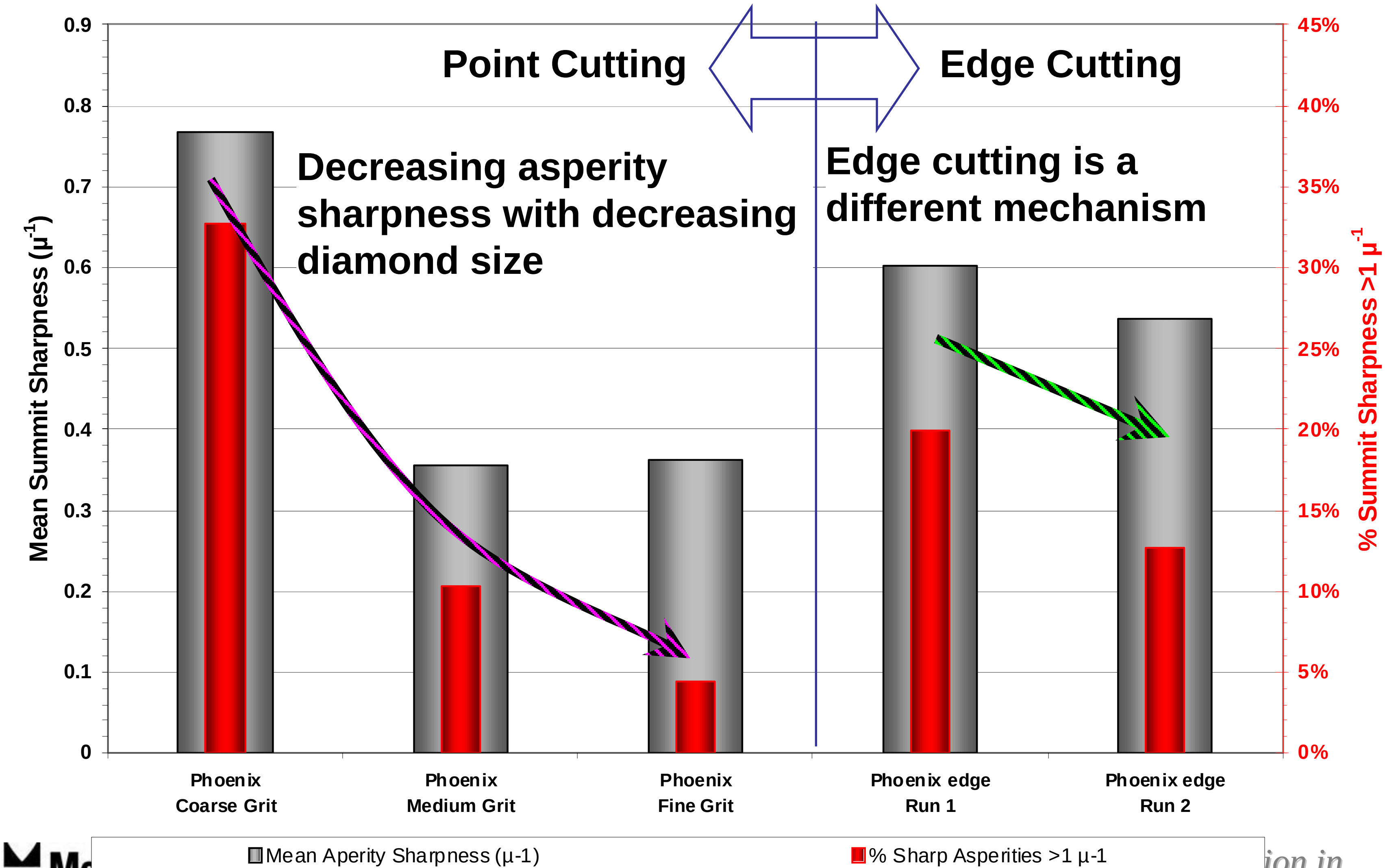
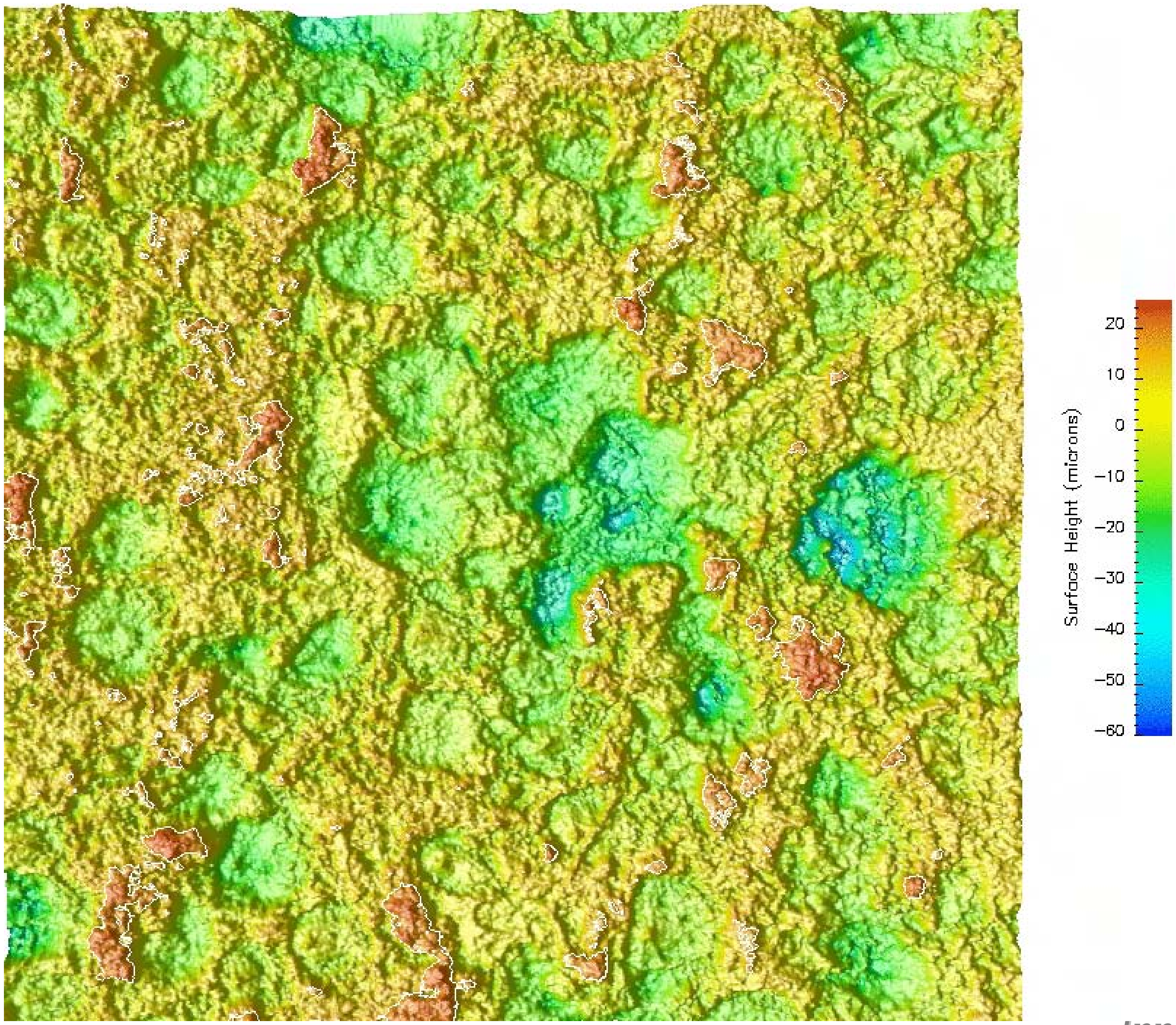
Summit Sharpness (Mean & Sharp)



Phoenix Coarse Grit- Image 8



Contour at
z=14.0 μm

50 μm

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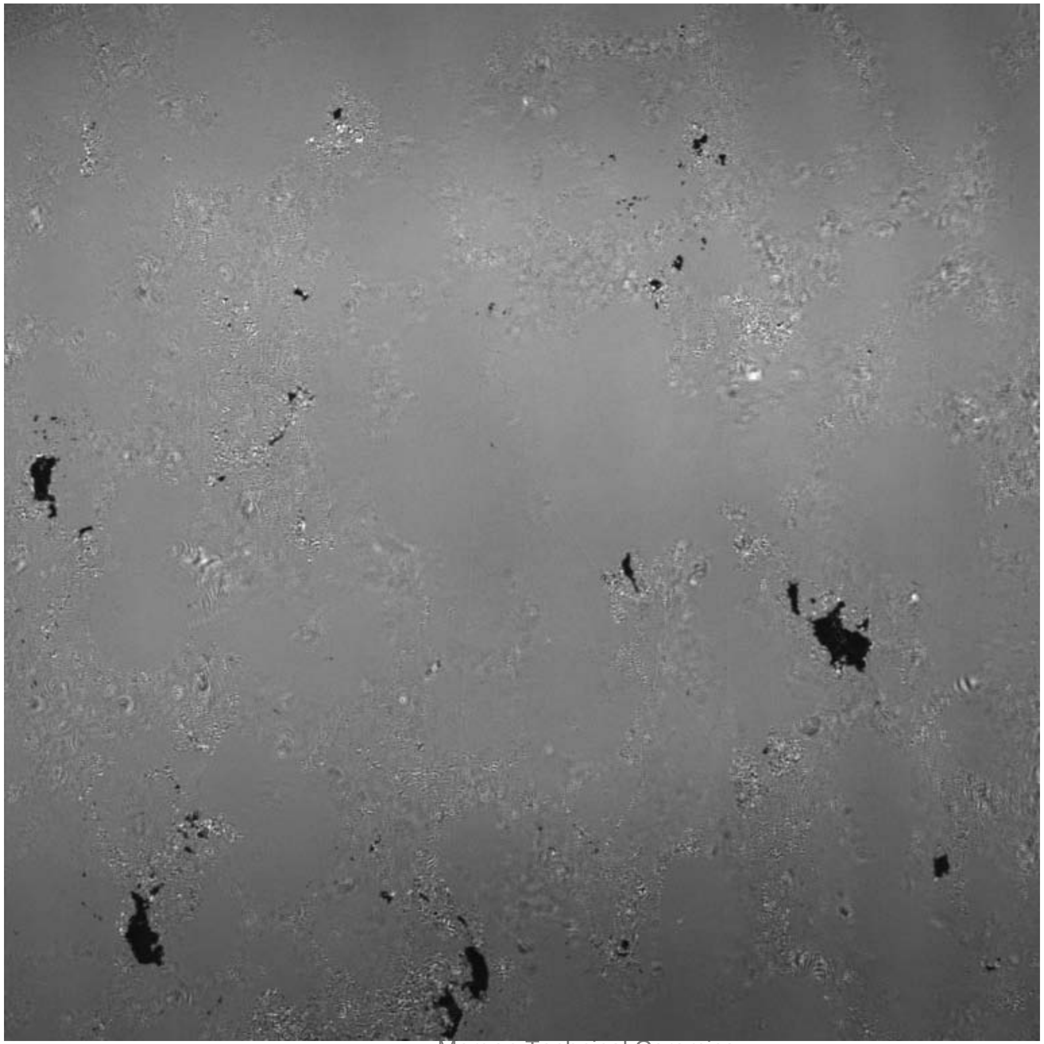
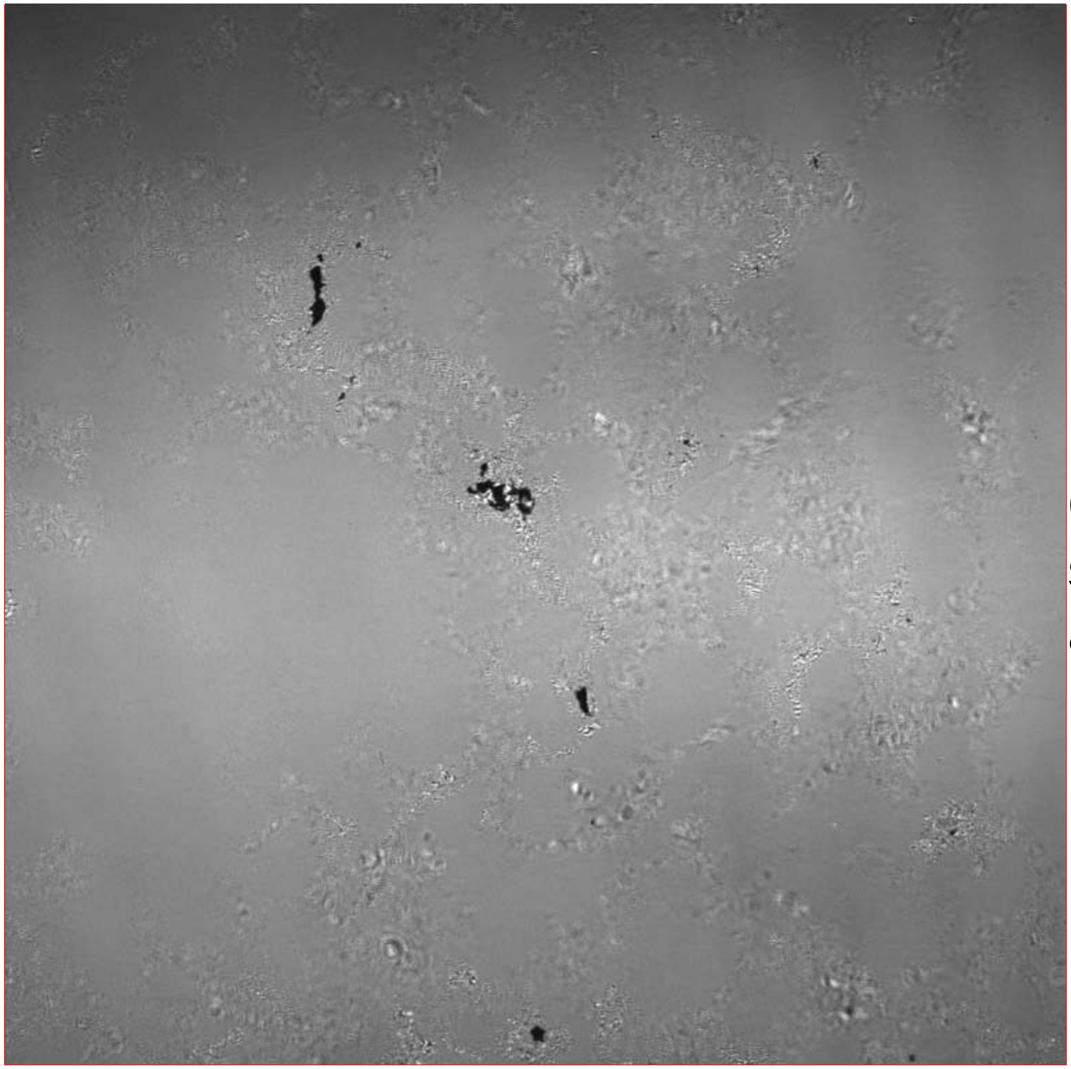
Phoenix Coarse Grit- Image 8 at 2 psi



50 μm

Contact Area Shape is mostly round

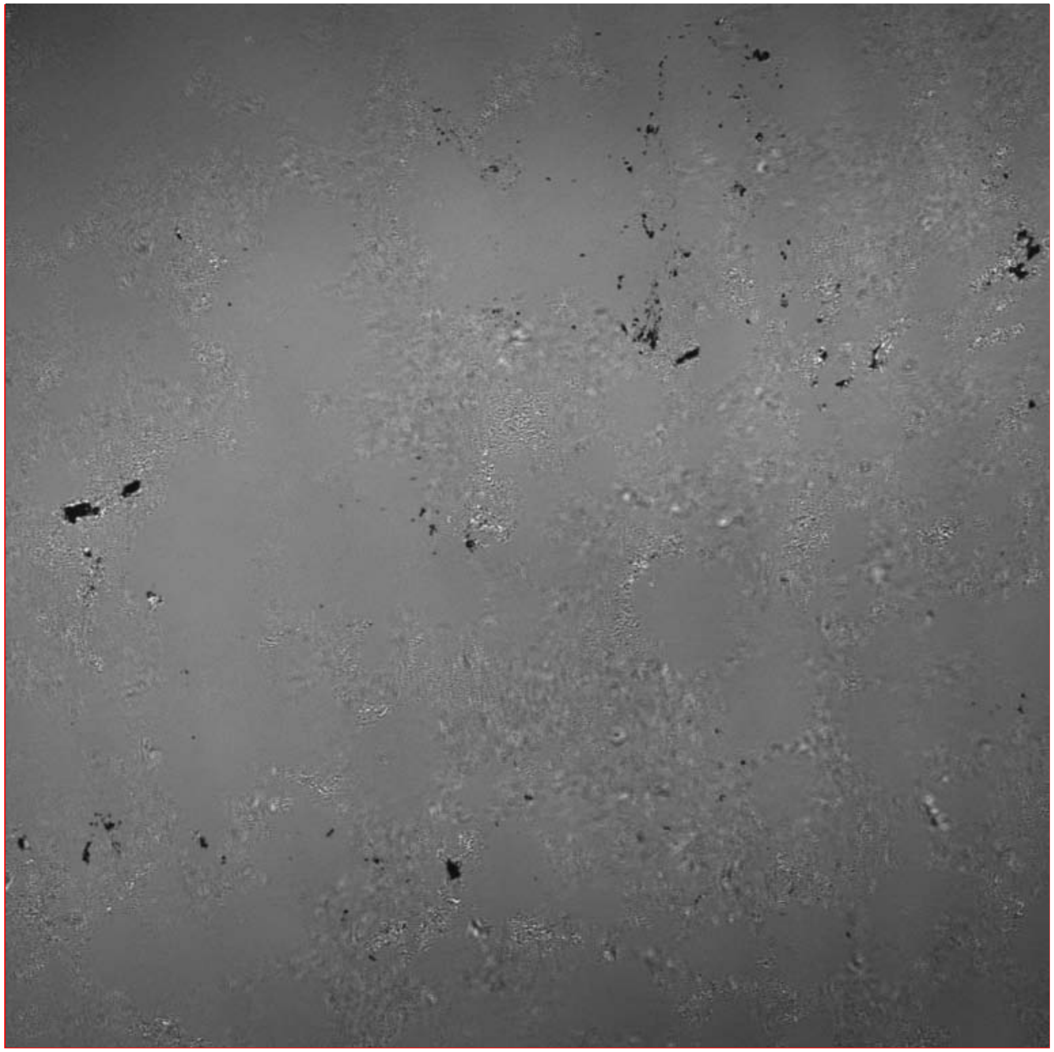
Phoenix Medium Grit- Image 5 at 2 psi



Contact Area shapes are round and elongated

50 µm

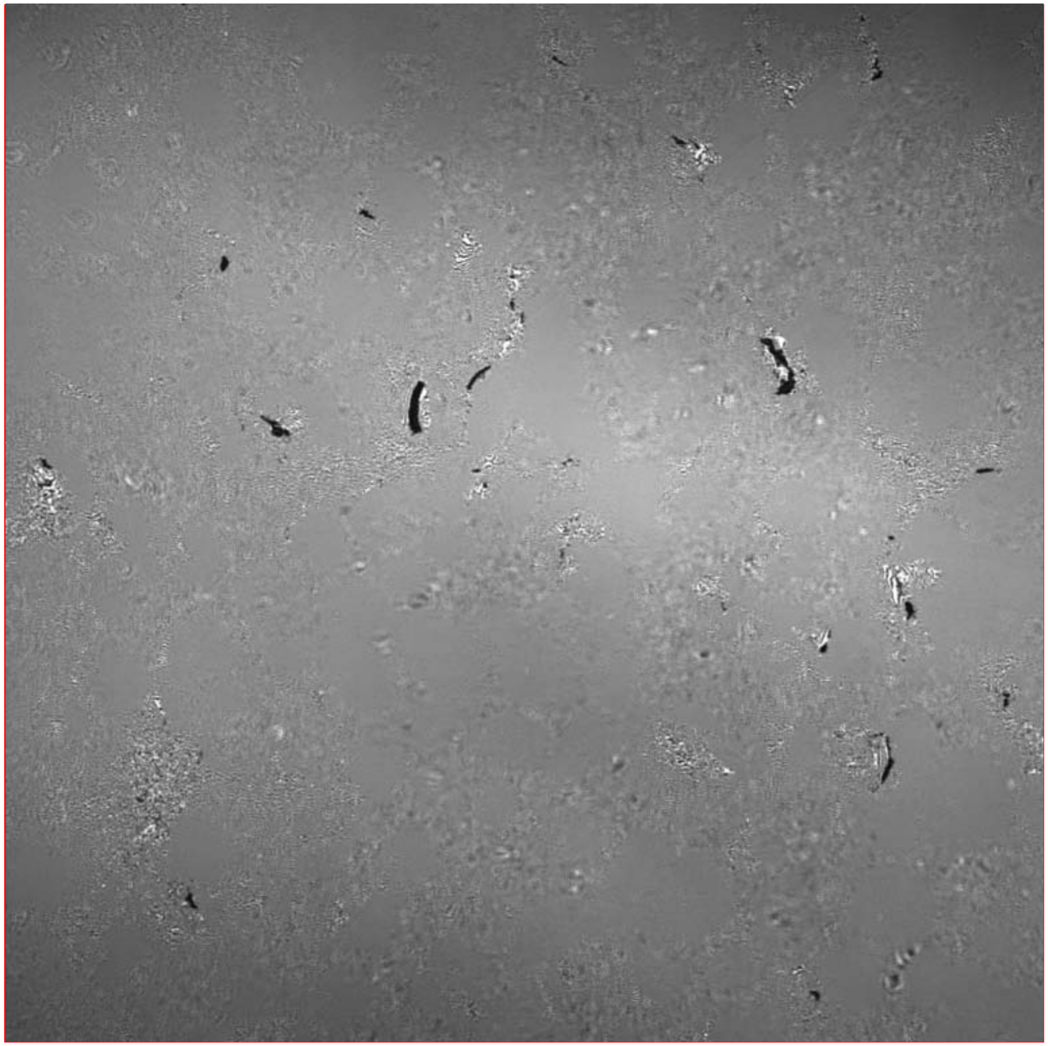
Phoenix Fine Grit- Image 3 at 2 psi



50 µm

Contact Area shapes are mostly elongated

Phoenix edge- Image 12 at 2 psi

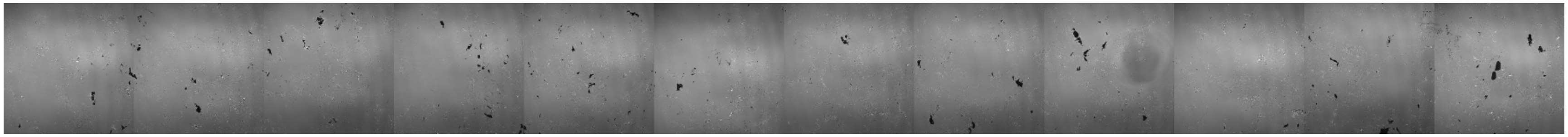


50 µm

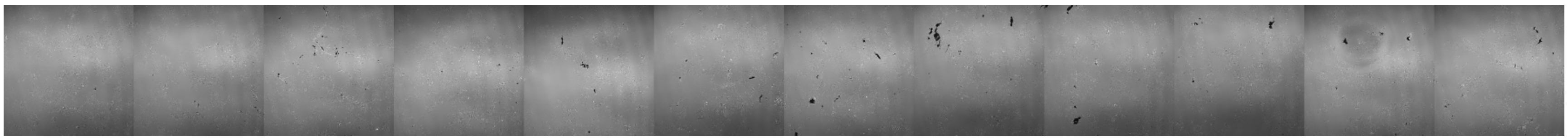
Contact area shapes are elongated and curled

Composite Contact Area Images

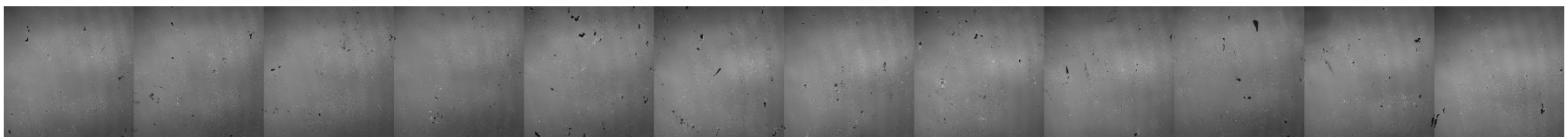
Phoenix Coarse Grit



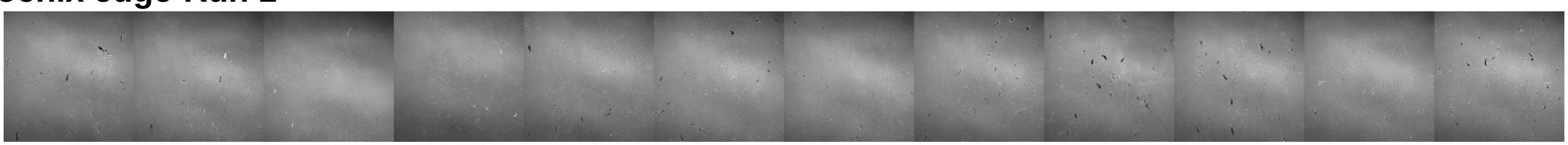
Phoenix Medium Grit



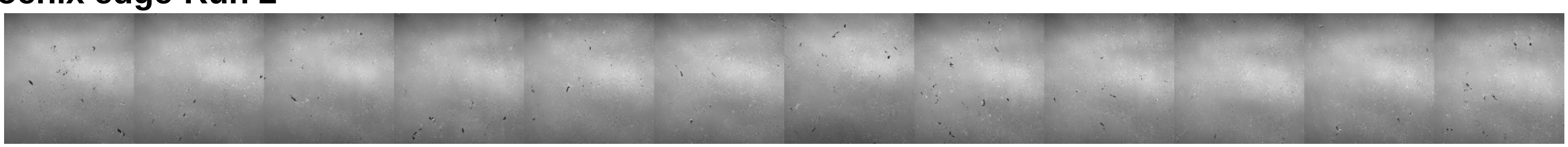
Phoenix Fine Grit



Phoenix edge-Run 1

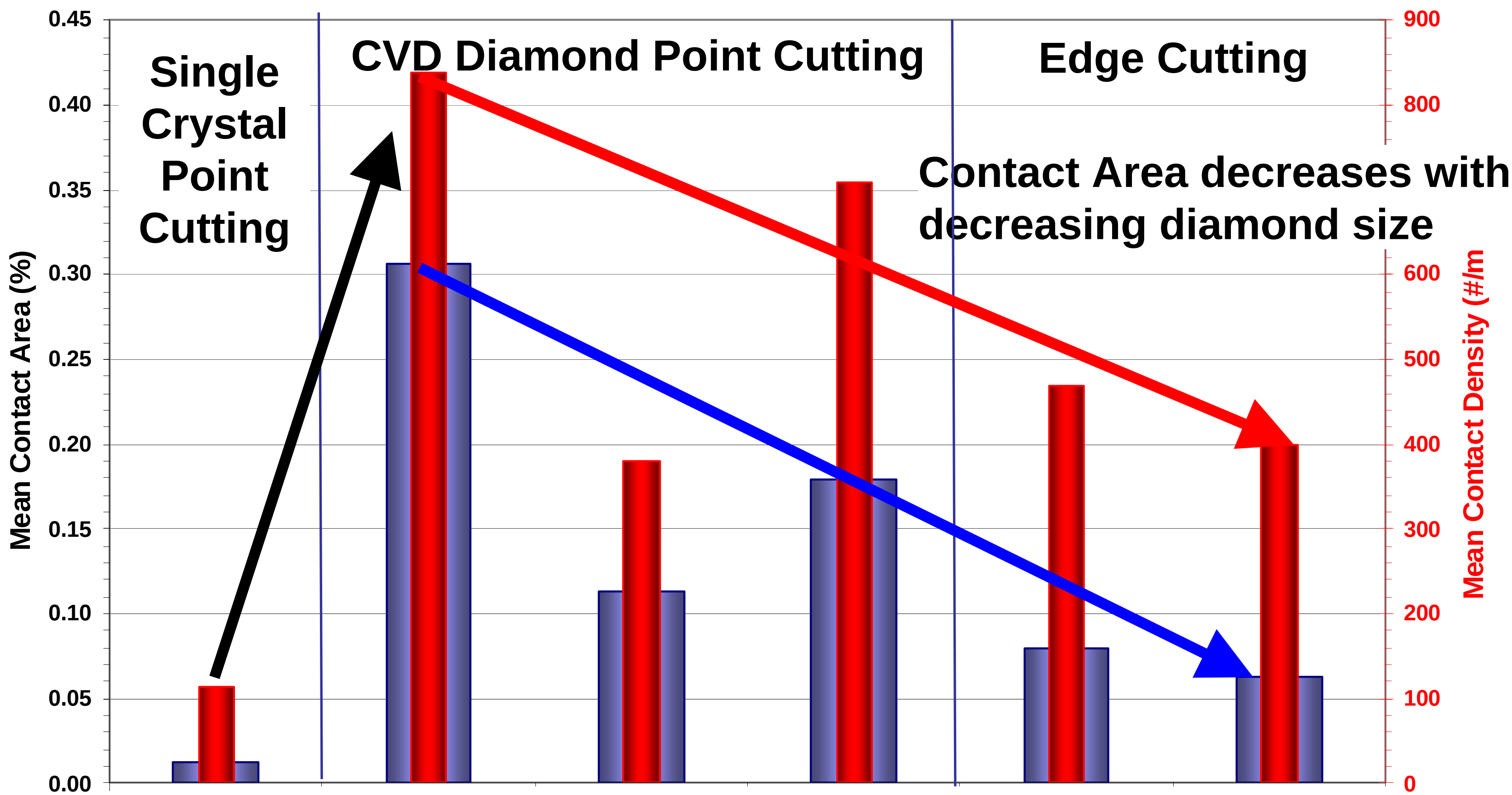


Phoenix edge-Run 2



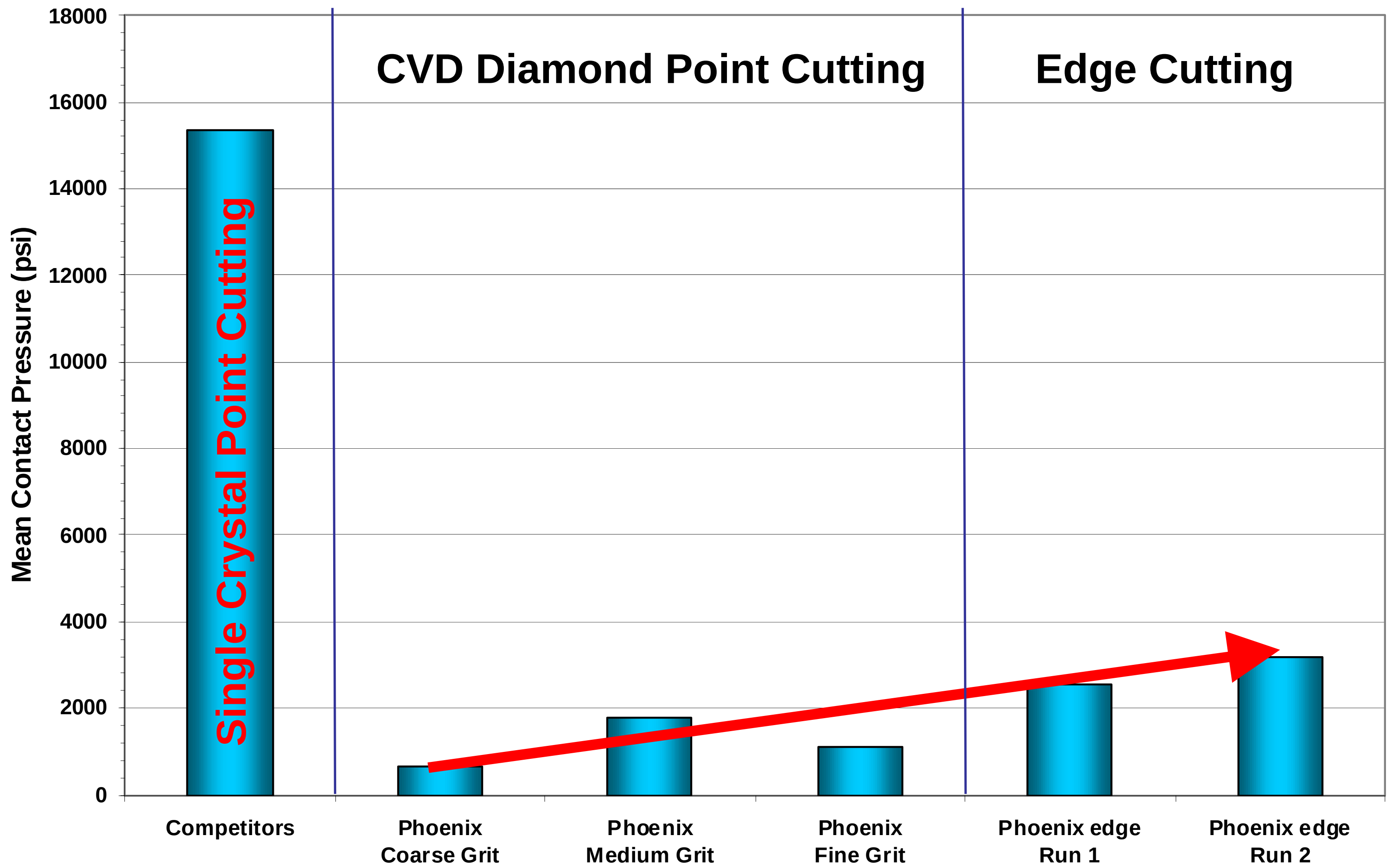
Sliding Direction

Contact Area Percentage & Point Density



The CVD Diamond on the single crystal diamond produces a pad surface with much higher contact area than bare diamond

Mean Contact Pressure



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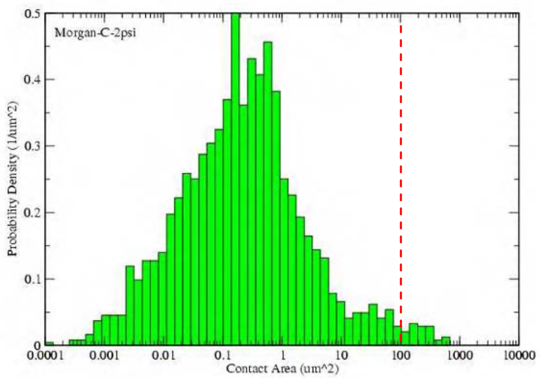
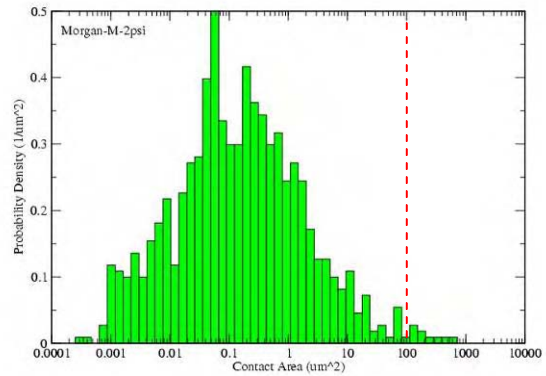
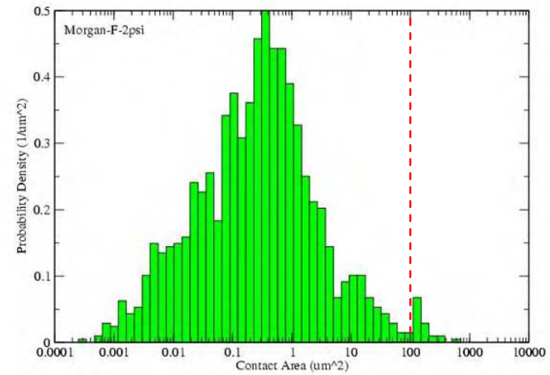
Contact Area Size Distribution



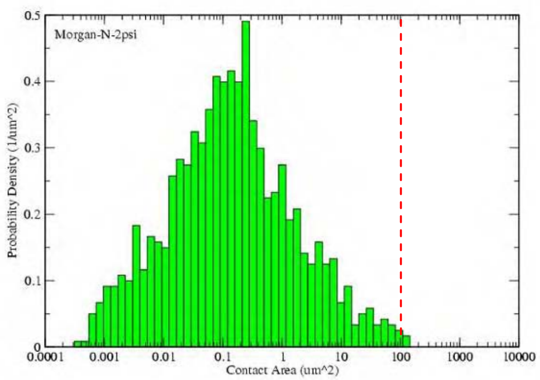
Phoenix Coarse



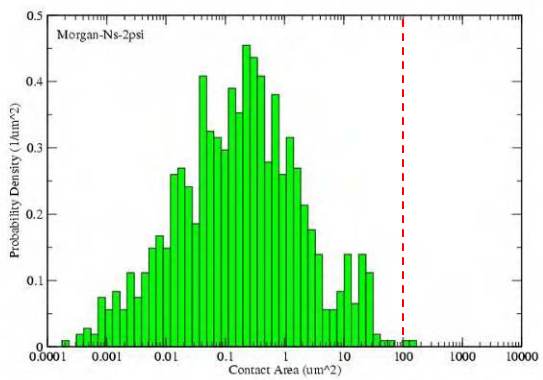
Phoenix Medium



Phoenix Fine

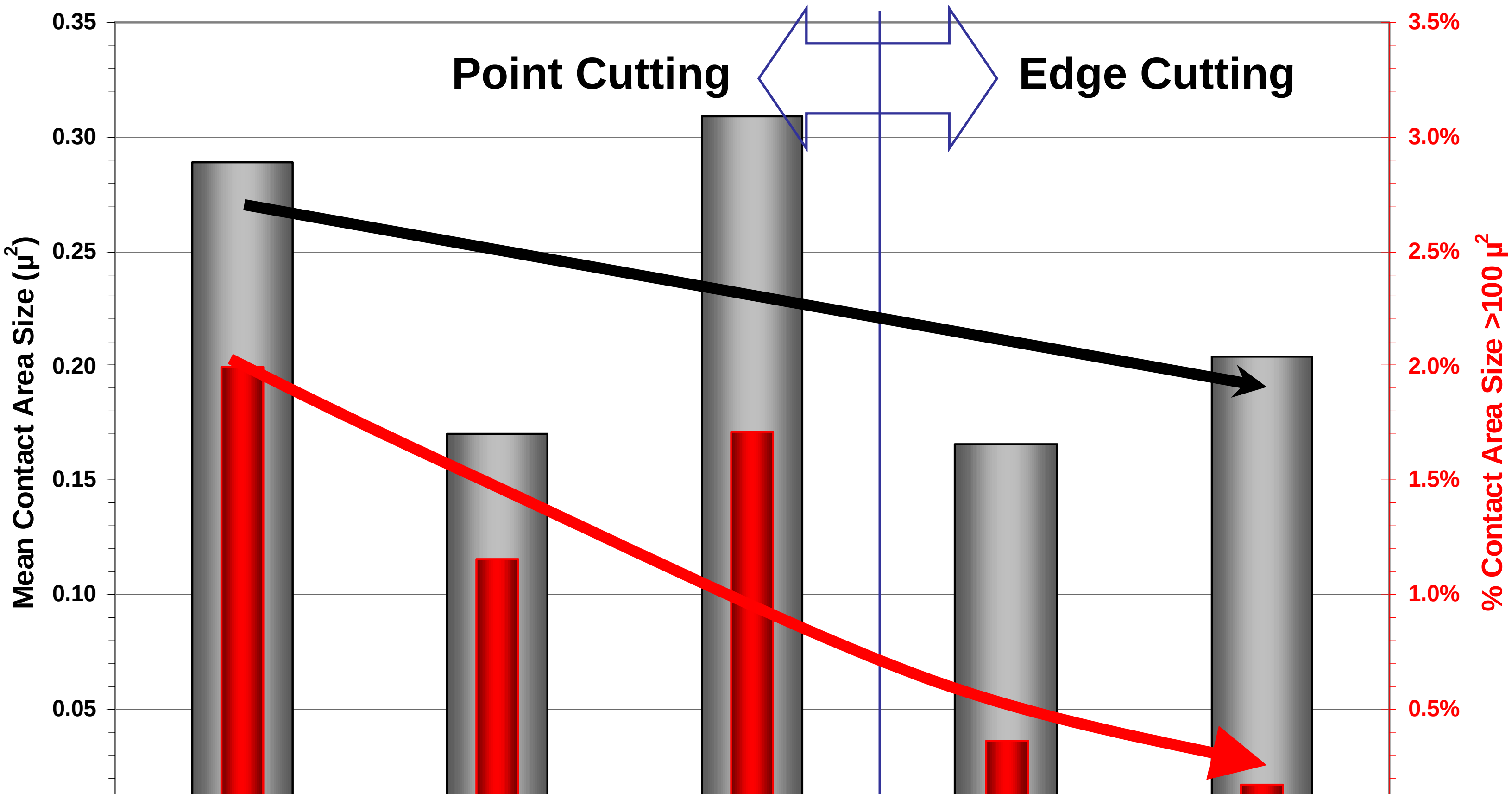


Phoenix edge- Run 1



Phoenix edge- Run 2

Contact Area Size (Mean & Large)



Size of the contact areas decreases with decreasing diamond size in particular the number of largest areas

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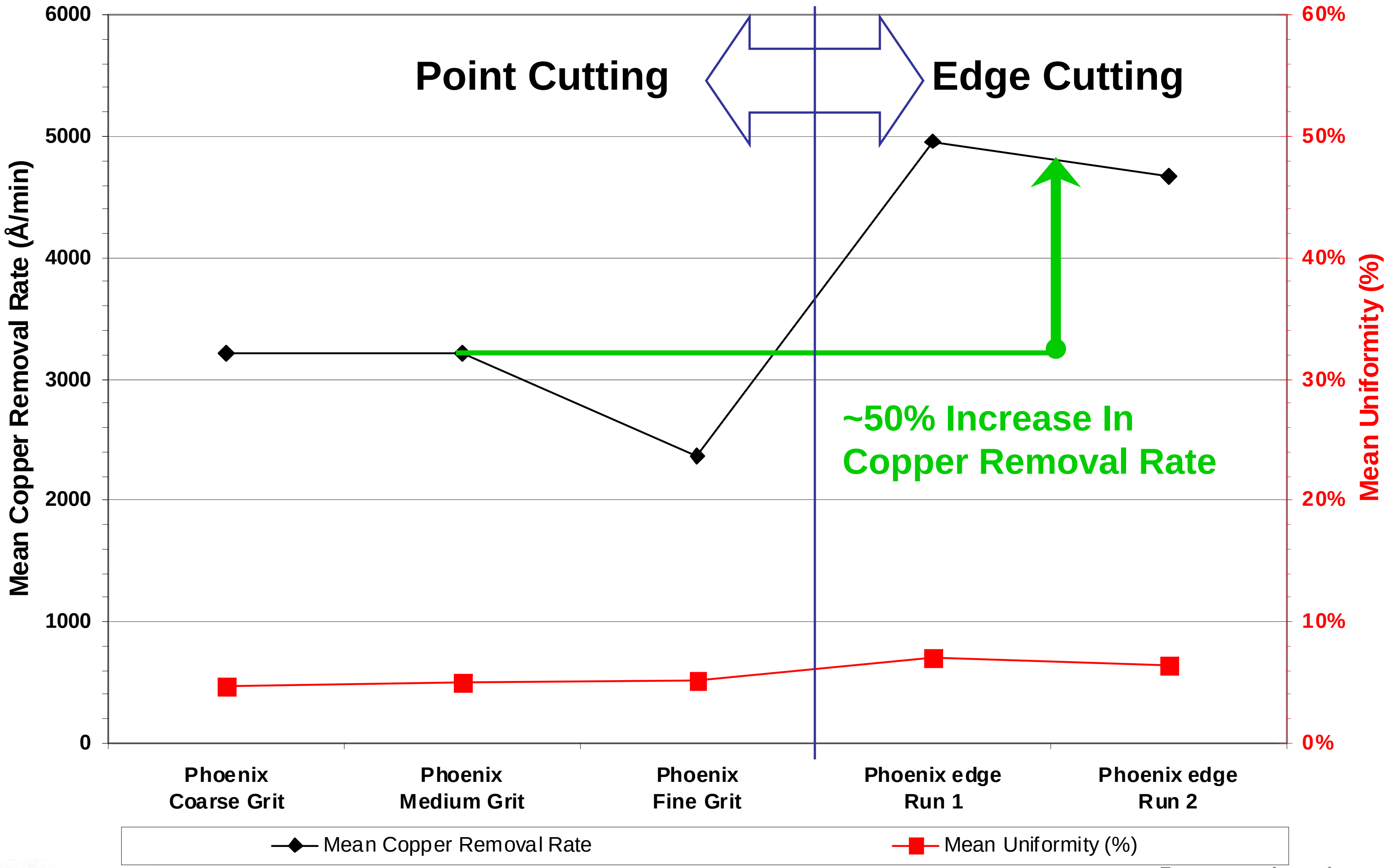
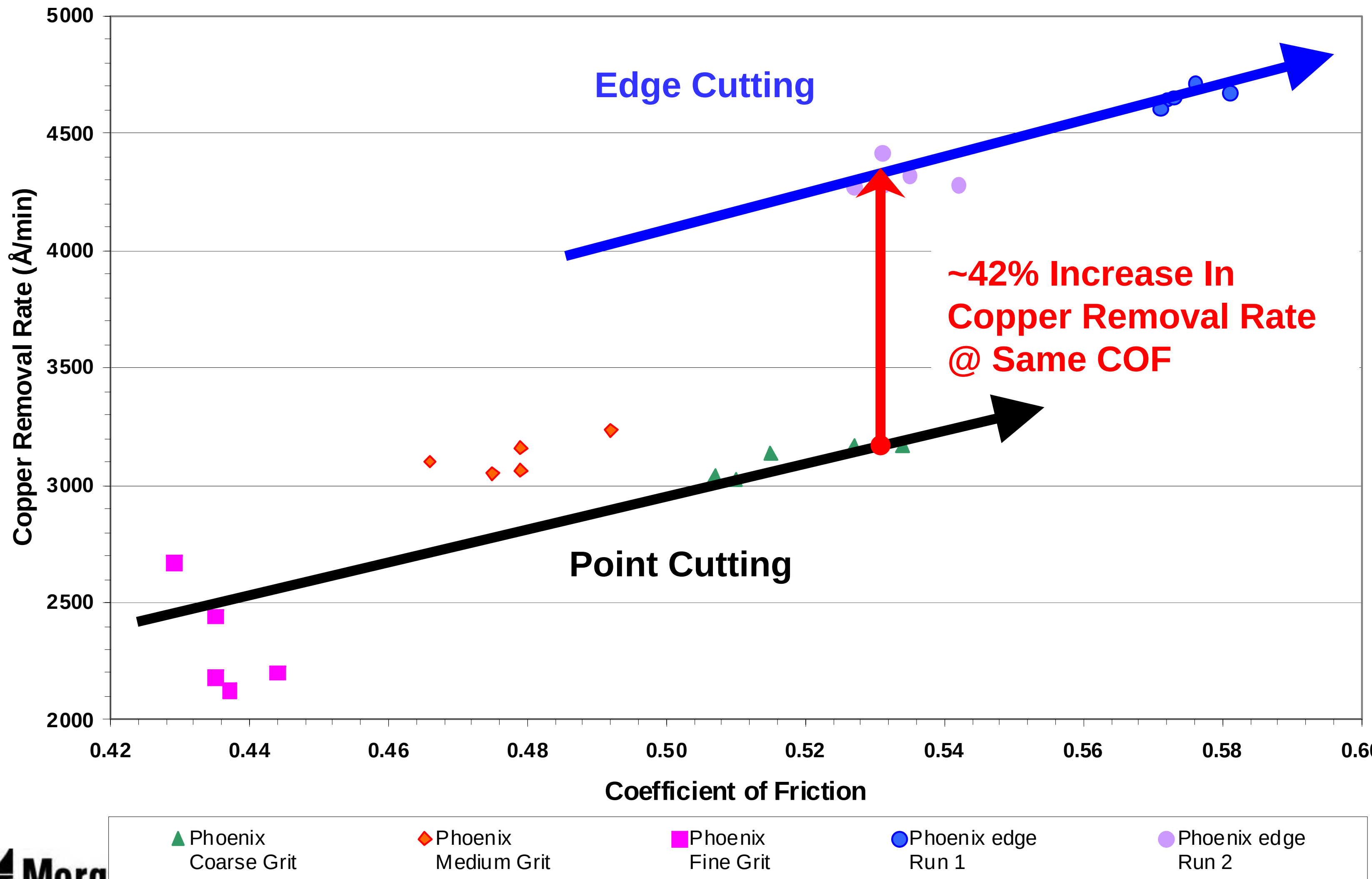
Copper Process Data Results

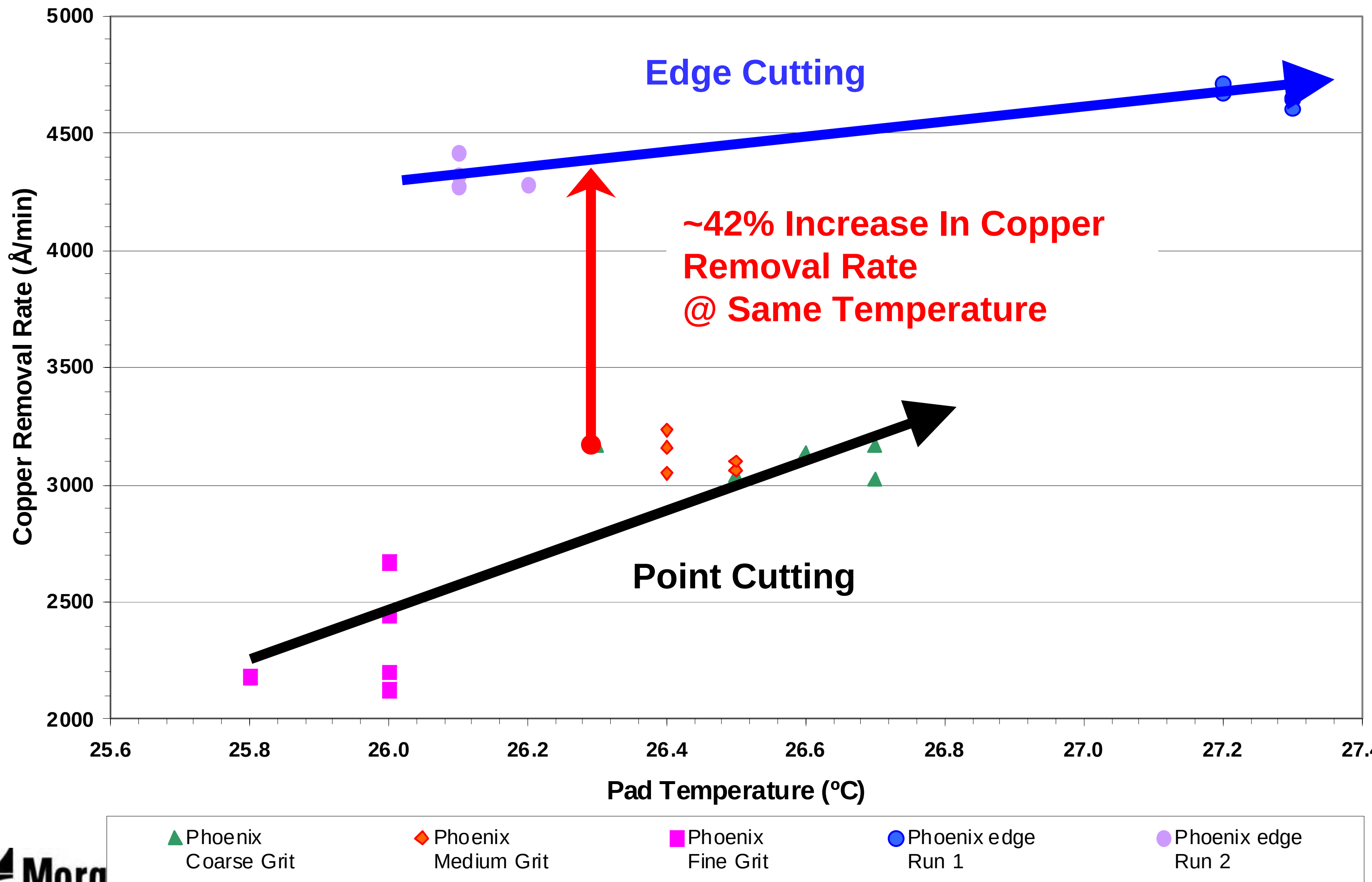
Copper Removal Rate & Non-Uniformity



Copper Removal Rate vs. COF



Copper Removal Rate vs. Pad Temperature



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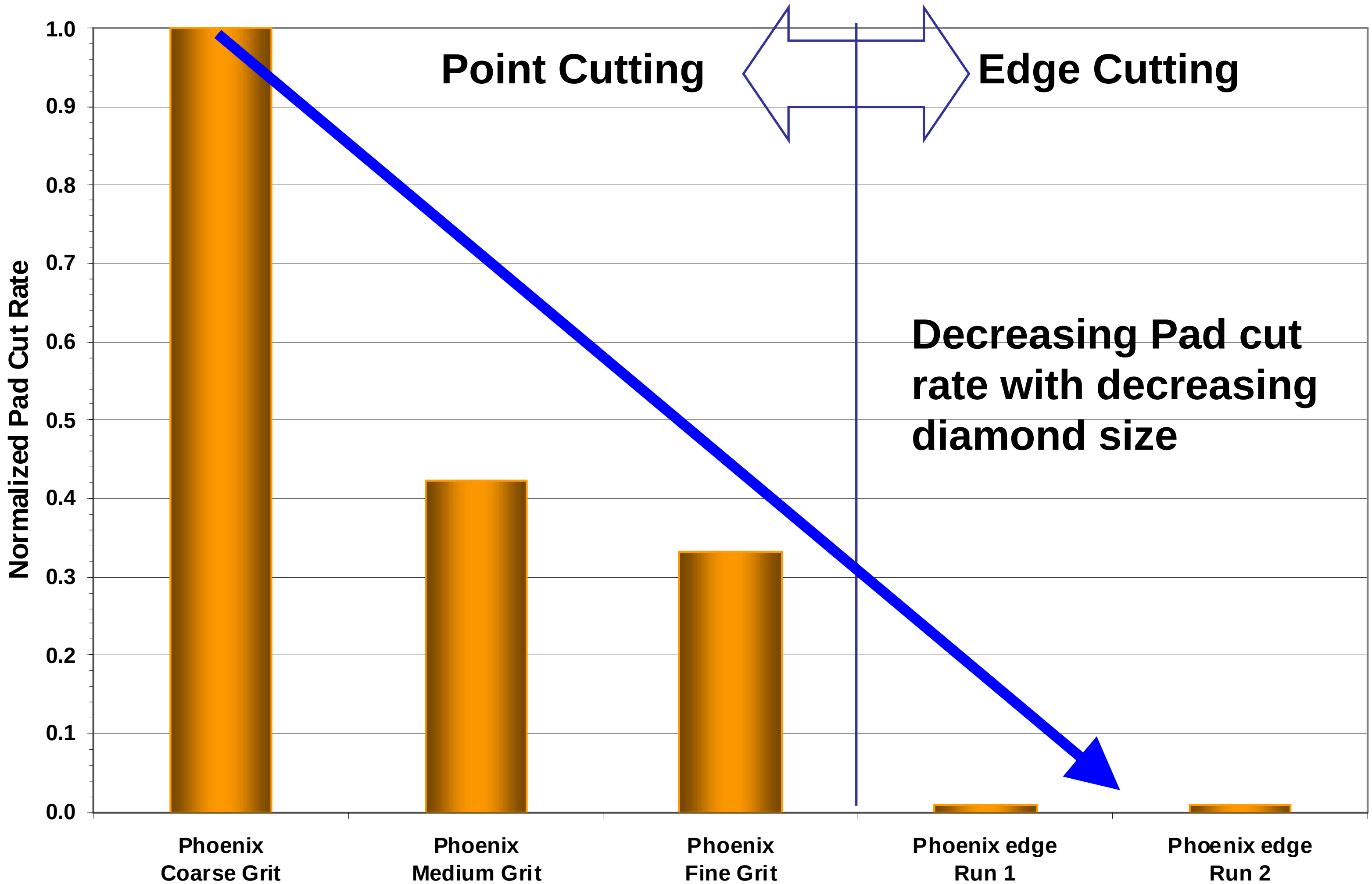
Pad Cut Rates



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Summary-Edge Cutting verses Point Cutting

- Pad Texture
  - Edge cutting produces a smoother pad texture with fewer large asperities
  - Edge cutting produces asperity shapes with a sharpness in the mid range of point cutting. However, for point cutting the number of sharp asperities decreases with diamond size.
  - Edge cutting produces smaller elongated curled contact area shapes as opposed to larger round contact regions for point cutting.
  - Edge cutting produces less contact area, fewer number of contacts, and fewer large contact regions.
- Copper Process
  - Edge cutting resulted in ~50% increase in copper removal rate over point cutting.
  - Edge cutting resulted in comparable non-uniformity
  - Edge cutting resulted in vastly reduced pad cut rate over point cutting

Final Thoughts

- What causes the increase in copper removal rate?
  - COF & pad temperature can not explain the increase in MRR for edge cutting
  - Pad surface features and interaction with wafer
    - No one pad feature shows a direct relationship to MRR.
    - Combination of pad features might explain the increase in MRR
  - Slurry flow and mixing due to the geometric design of the spiral conditioner is a strong possibility.
- Future Work:
  - Continue work to find any correlation between Pad texture and MRR
  - Investigate the effect of conditioner geometry on MRR
  - Marathon study to determine Phoenix edge conditioner life, stability of process, and defectivity

Acknowledgements

Thank You