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Innovative "Featured-Surface" Cleaning Materials Engineered for Advanced Vertical Probe Technologies

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Introduction

- Wafer testing of advanced devices requires probe card technologies with high density probe arrays and lower contact forces, greatly affecting the overall mechanical performance of probing.
- Flat, un-featured, compliant, and elastomeric cleaning materials have proven successful in controlling process contamination and removing adherent materials to improve contact reliability.
- International Test Solutions has developed cleaning materials with microscopic, engineered surface features to further control cleaning efficiency, with tightly controlled, uniform surface geometries.

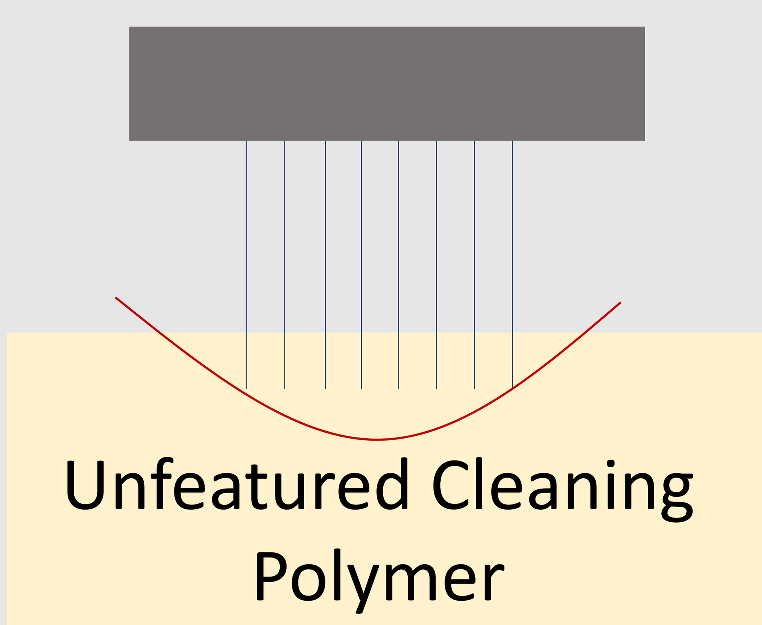
Objectives

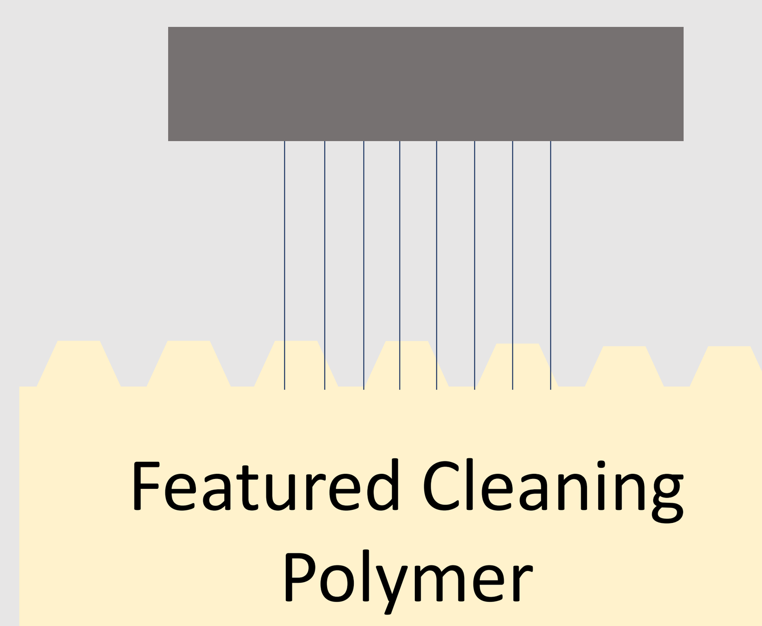
- Evaluate the differences between comparable non-featured and featured materials.
- Determine feature size effects on cleaning and forming efficiencies.
- Assess long-term wear performance of micro-featured polymer cleaning materials.

Performance Model

Red line indicates expected deflection.

Non-uniform material deflection results in uneven cleaning performance for tight pitch probe arrays.

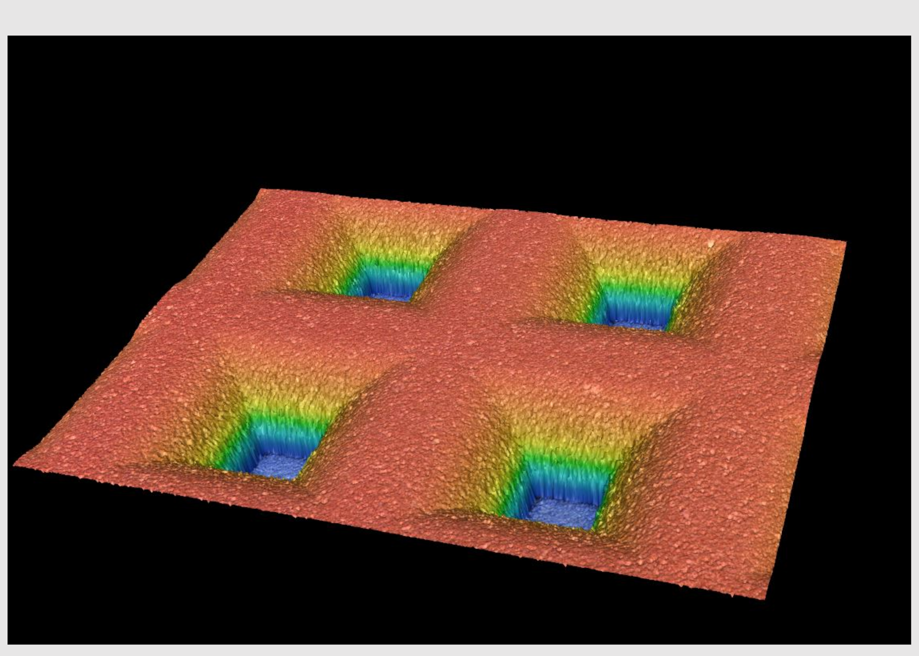




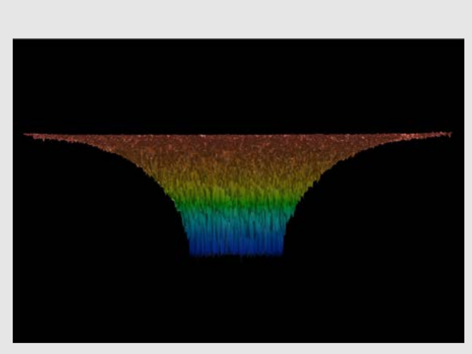
Featured materials may allow for more uniform deformation and more even probe wear in a tight pitch probe array.

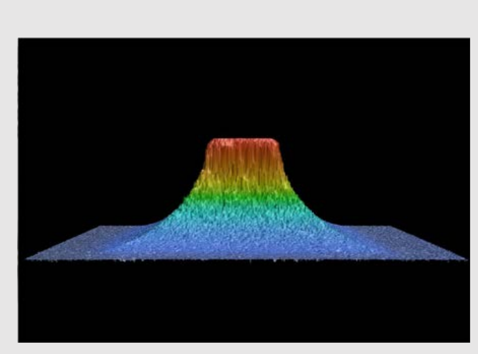
Unfeatured Cleaning Polymer	Featured Cleaning Polymer
Surface compliance affects cleaning efficiency.	Compliance may be decoupled across material.
Peripheral probes receive uneven cleaning.	Peripheral probes receive same cleaning as center.
Sides of probe only cleaned by penetration.	Probe receive frictional cleaning at regular OT.

WFL "Waffle" Shape versus PMD "Pyramid" Shape

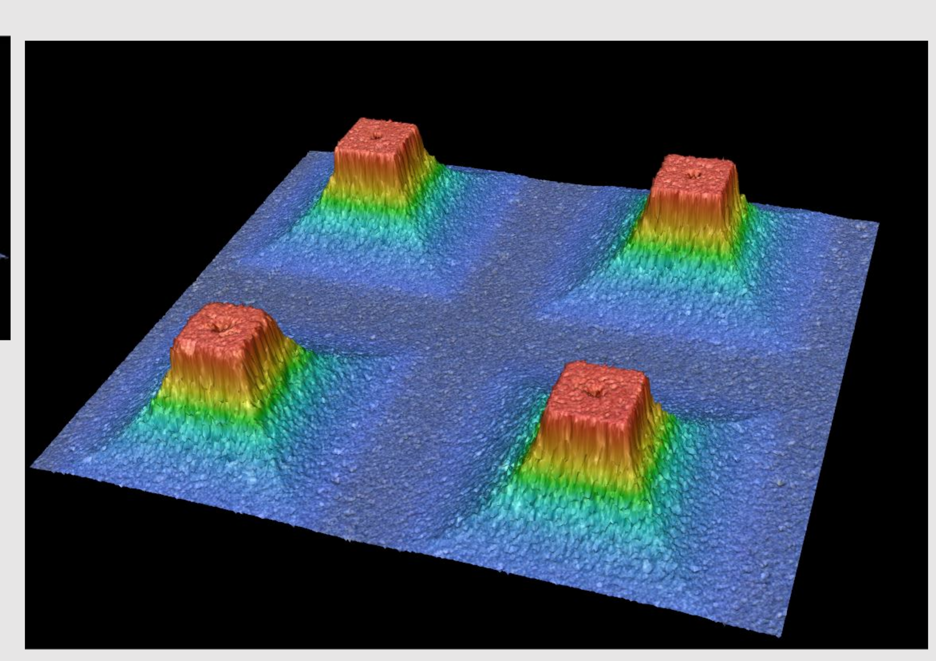


Example of WFL surface micro-features.





- In the WFL style material, all of the features are connected by streets.
- In the PMD style material, each feature acts independently.

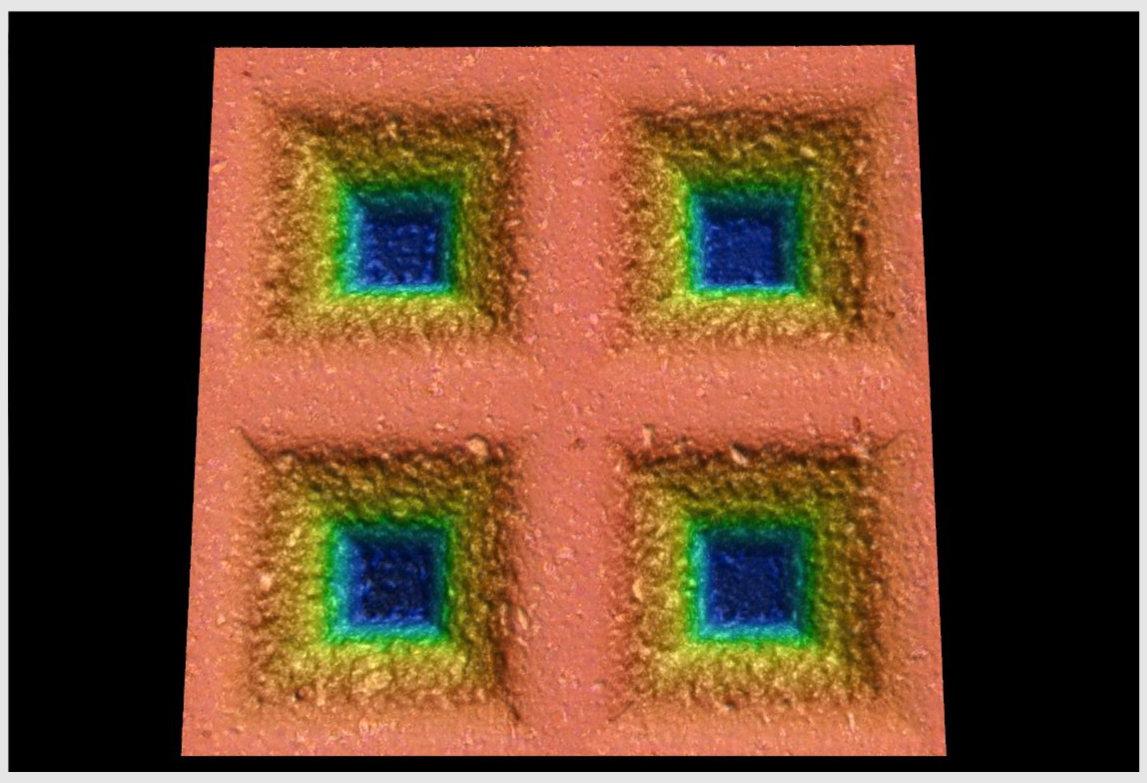


Example of PMD surface micro-features.

Test Parameters

Probe Type: Vertical, Tungsten, Flat, 50µm Tip Diameter
Probe Pitch: (5) Probes each at 200µm, 150µm, and 100µm
Programed OT: 125µm
Temperature: Room Temperature (25°C)

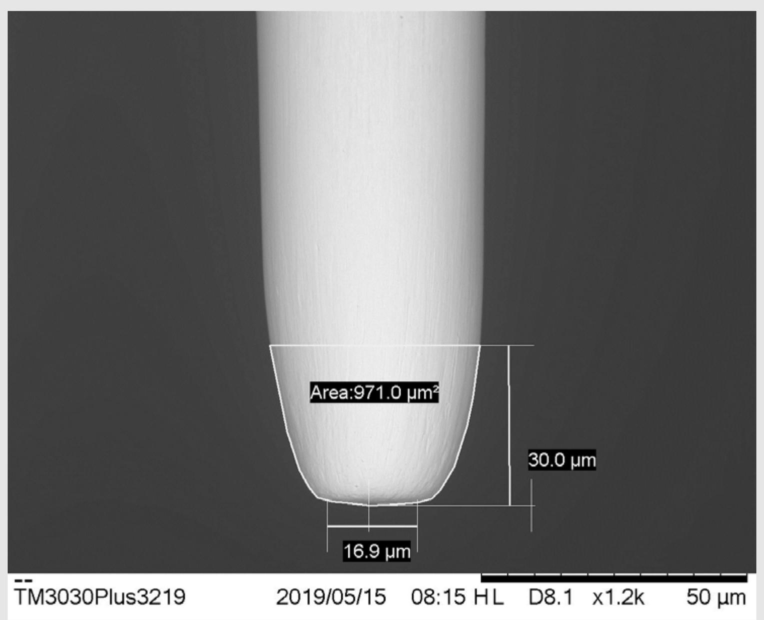
Materials	WFL2.0	PMD-35	WFL-35
Feature Type	Waffle	Pyramid	Waffle
Feature Height	85µm	35µm	35µm
Base Width	35µm	25µm	25µm
Side Angle	Curved R85	Curved R35	Curved R35
Feature Pitch	225µm	115µm	115µm



WFL2.0 Material top view.

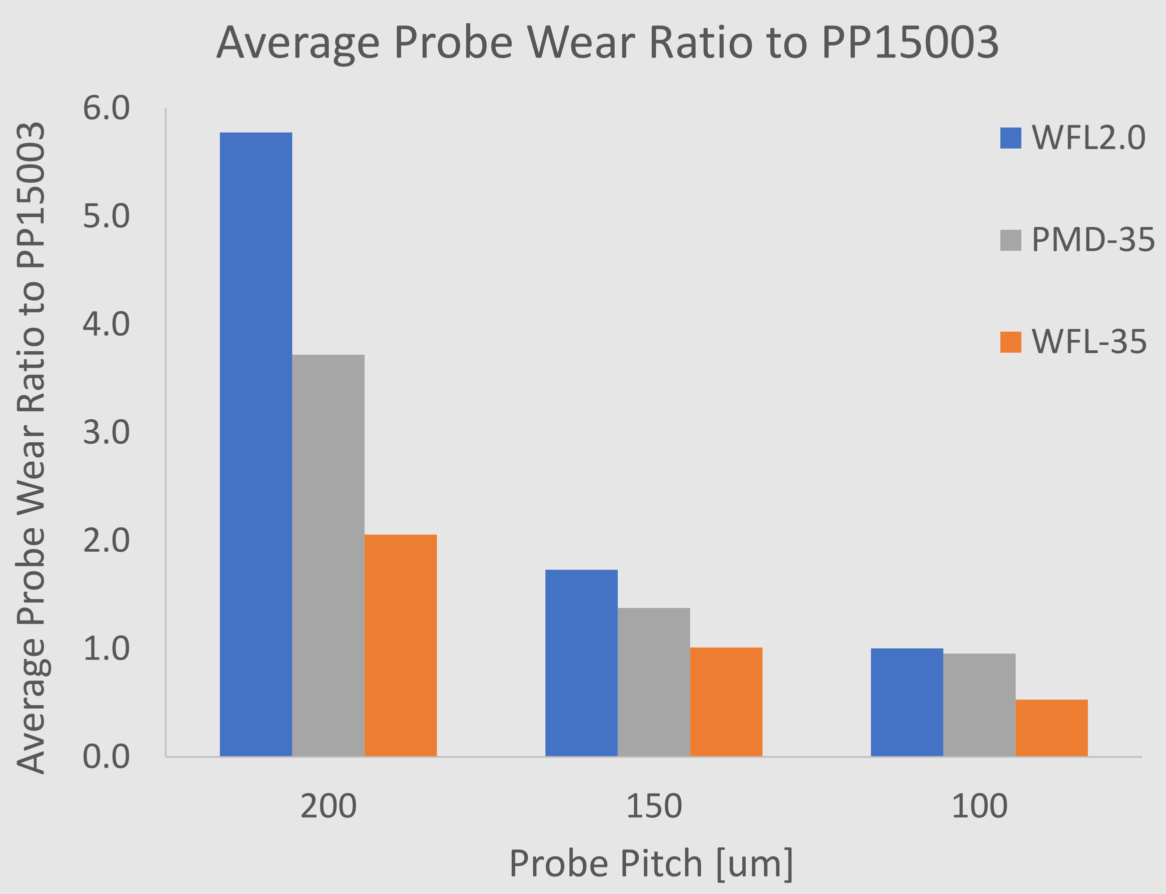
Evaluation Criteria

- Each material was probed for 50,000 touchdowns.
- Each probe fixture contained (5) probes of all three specified pitches.
- Each fixture was designed to be non-compliant and used rigid probes to eliminate the variable of probe deflection.
- SEM images were taken at T0 and T50k.
- Imaging software was used to determine probe tip area before and after test.
- Reduction in probe tip area of each featured material was calculated as a ratio to a flat, unfeatured control material Probe Polish® 150 (PP15003).



Example of an area measurement taken within 30µm of the probe tip.

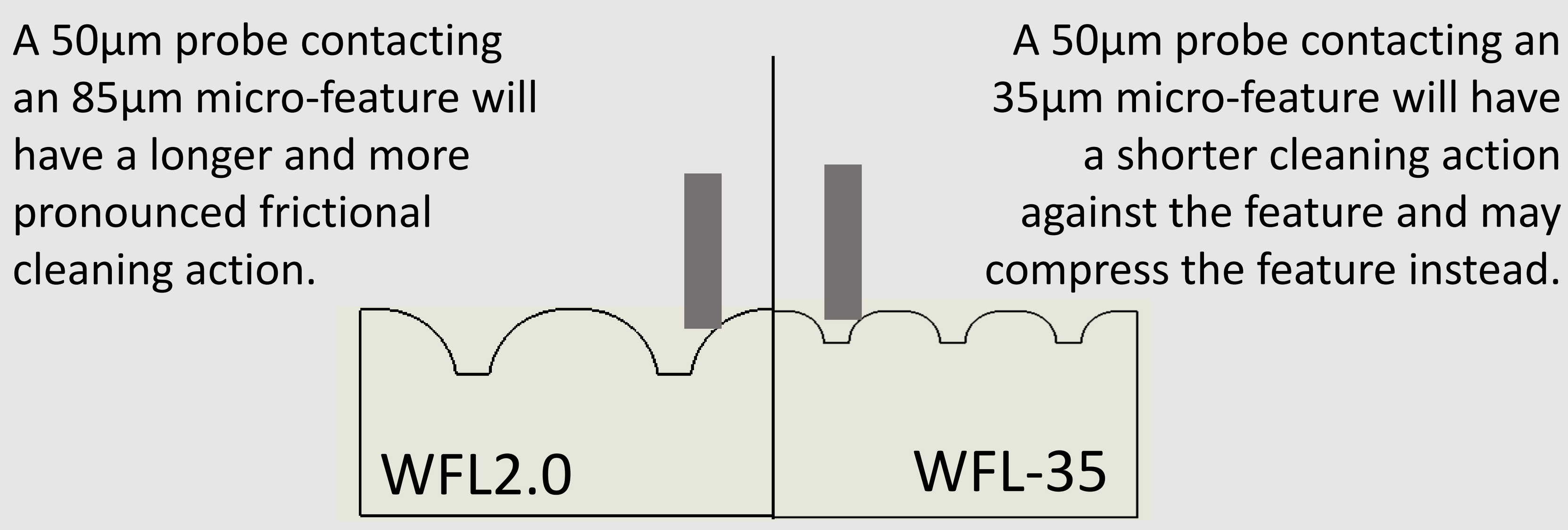
Experimental Results



The average of the wear ratio between the specified featured material and the PP15003 control material is represented above.

At 100µm pitch, each probe was given an individual ratio to PP15003. Probe 1 represents the left most probe and probe 5 designates the furthest right.

- At the widest pitch (200µm), the featured materials had significantly greater cleaning efficiency than PP15003, with WFL2.0 having the highest wear ratio of 5.8.
- As probe pitch was reduced from 200µm, the wear ratio of WFL2.0 and PMD-35 became similar to that of PP15003.
- The PMD-35 geometry had a consistently greater wear ratio than the similarly sized WFL-35 geometry.
- At the tightest probe pitch (100µm), WFL2.0 and PMD-35 had a similar cleaning efficiency to PP15003, while the WFL-35 had a lower wear ratio.



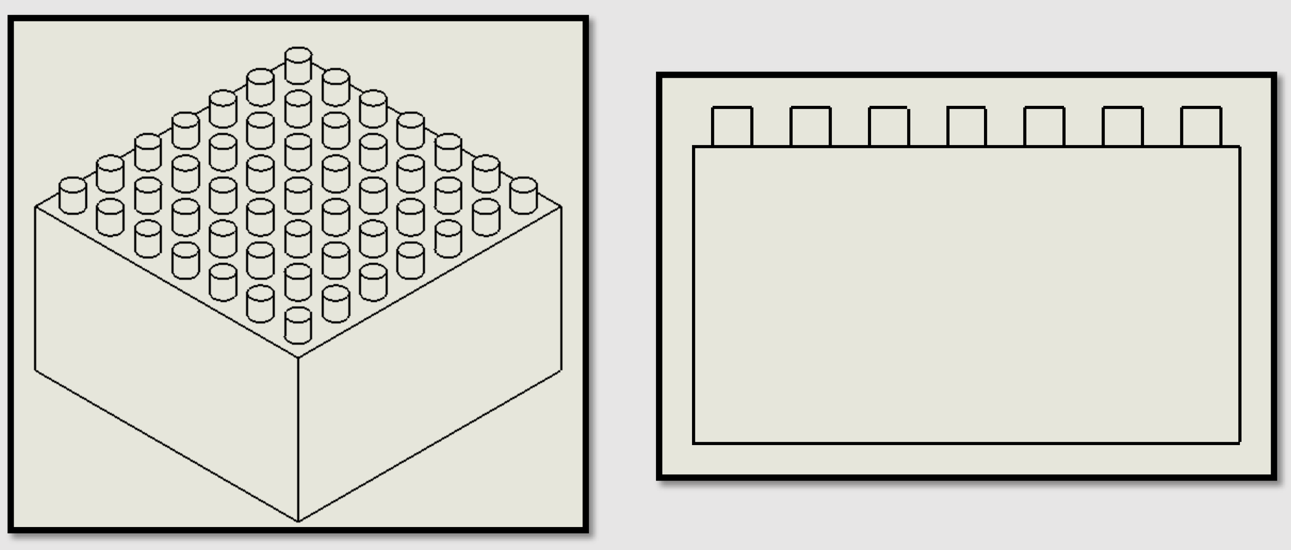
- Each micro-featured material has a local maximum at probe 3, most notably PMD-35.
  - This could suggest that there is less of an effect due to polymer deflection than with the unfeatured PP15003.

Conclusion

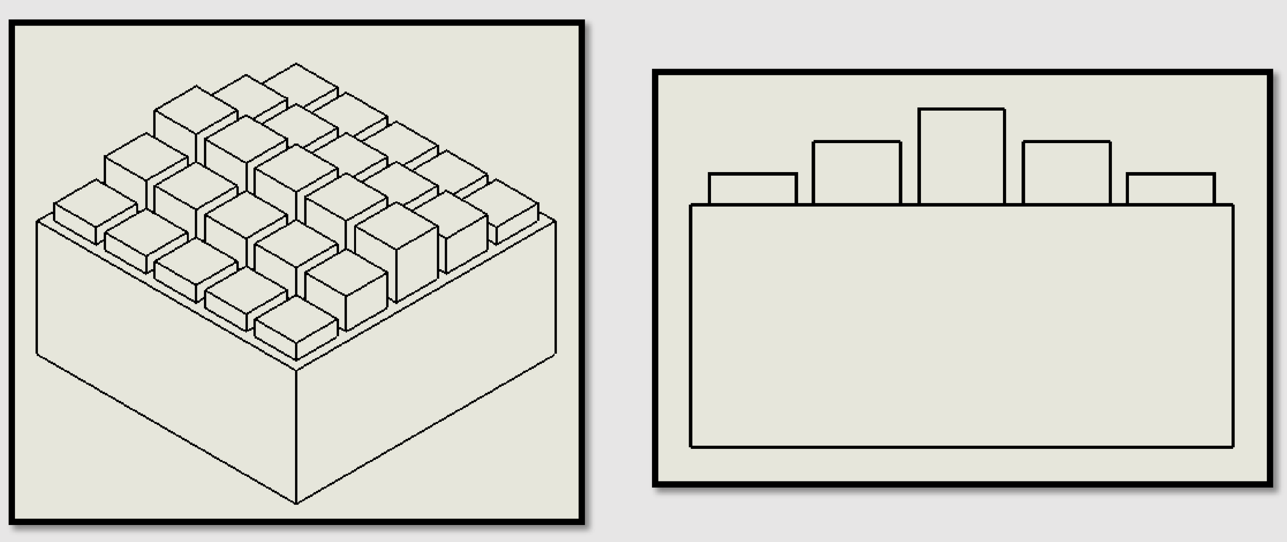
- Functional micro-featured materials had significantly greater forming efficiency compared to the “flat” material at 200µm pitch, while at 150µm and 100µm pitch the materials had comparable performance.
    - Increased wear at 200µm is likely due to the transverse cleaning action of the probes against the features, which is not possible in a flat, unfeatured material.
    - Comparable wear performance at 150µm and 100µm pitch suggests that for the material geometries, large probe diameter, and pitches used in this investigation, there is a higher incidence of probe to probe interaction.
- Larger pitch and feature size of the WFL2.0 proved to be more aggressive than the smaller pitch and feature size of WFL-35 and PMD-35.
    - WFL2.0 could have been more effective due to the 50µm probe being more optimally sized for the 85µm features compared to the much smaller 35µm features.
- The results suggest that some micro-featured geometries could exhibit performance similar to flat, unfeatured materials depending on probing conditions.

Future Work

Future Geometry Ideas:



Columnated materials with straight sides, variable street widths, and feature-to-feature pitch spacing.



Multi-leveled terraced material with a repeating waviness function across the surface.

For further investigation:

- Assessing the wear ratio performance of a PMD2.0 geometry versus the WFL2.0 as a function of pitch.
- Further investigation of wear ratio as a function of micro-feature geometry (shape and size).
- Determine relationships for wear ratio and uniformity versus micro-feature size and geometry for the following:
    - Probe properties, such as size and tip shape.
    - Array size and multi-site array
    - Probe pitch and multi-site skip.

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- Thank you to our colleagues at JEM America for building the test fixtures and Advanced Probing Systems for providing the probes.