

Novel Method to Measure the Sharpness of CMP Pad Conditioner Abrasive Tips

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Introduction

Microreplication

Advanced Metrology for Pad Conditioners

Metrology for Tip Sharpness

Case Studies

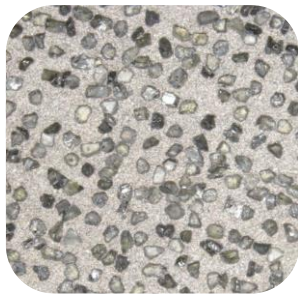
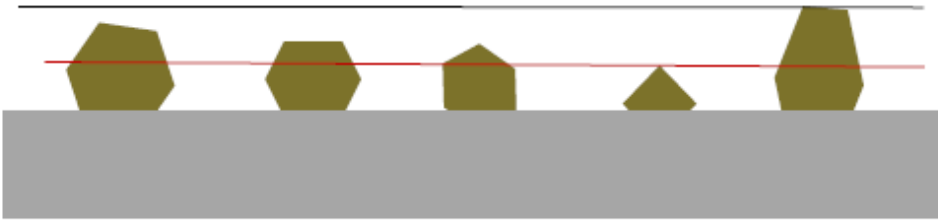
- End of life studies
- Tool troubleshooting

Summary

Why Microreplication for Pad Conditioning?

Diamond Grit Pad Conditioner

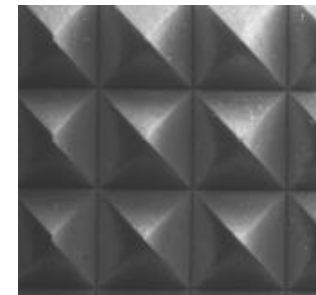
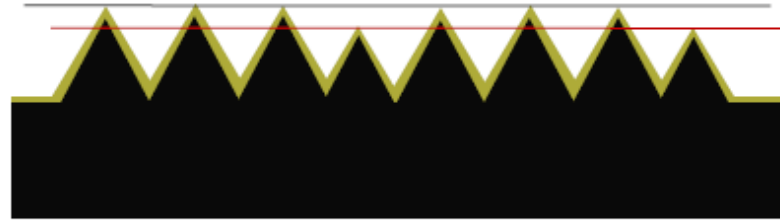
- Shape of contact feature varies randomly
- Height dispersion of contact features varies randomly
- Type of contact cutting feature varies depending on grit type



Diamond Grit
Pad Conditioner

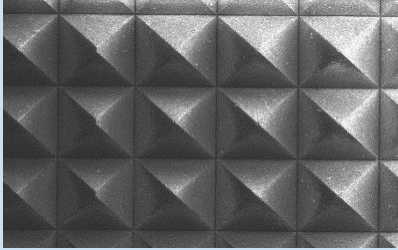
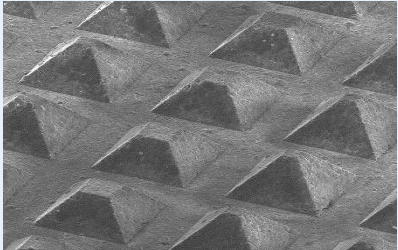
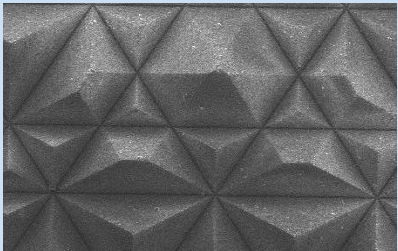
Microreplicated Pad Conditioner

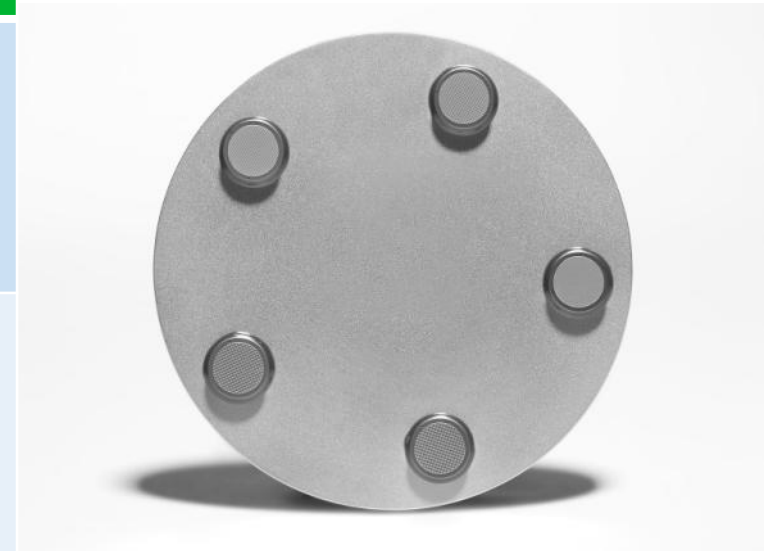
- Shape of contact feature is designed and replicated
- Height dispersion of contact features is designed-in
- Type of contact cutting feature designed-in
- Consistency disk-to-disk from replication process



Microreplicated surface

Microreplicated Pad Conditioners

Pad Wear (typical IC)	Engineered Surface Design Attributes	Example Surfaces
Medium to lower pad wear	<ul style="list-style-type: none">• Pyramid structures.• All sharp tips.• Bimodal, trimodal tip heights with varied offsets.	
Lower pad wear	<ul style="list-style-type: none">• Pyramid structures.• Sharp and truncated (blunt) tips.• Bimodal, trimodal tip heights with varied offsets.	
Higher pad wear	<ul style="list-style-type: none">• Polygon structures• Sharp tips and sharp lines.• Multiple tip heights with varied offsets.• Irregular tip orientation.	



3M™ Trizact™ Pad Conditioner
B75-2990-5S2

Advanced Metrology for Microreplicated Conditioners

Diamond Grit

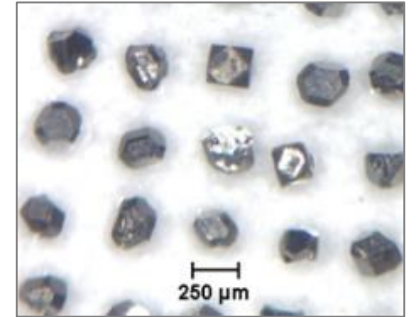
- Variance in quantity and spatial placement of “active” cutting tips
- Varied facet orientation of the cutting grits

Microreplication

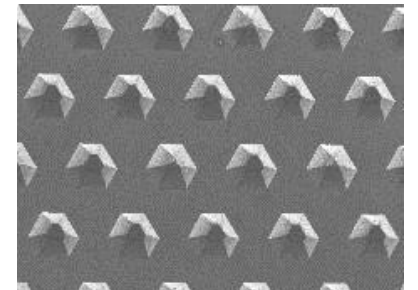
- Consistent placement and sizing of structures and cutting features
- Consistent pattern, enabling advanced metrology for tip-by-tip analysis

Metrology used for Microreplicated Conditioners

- *Coplanarity Tip Count* – measures the number active tips within a defined reference plane
- *Coplanarity Angle* – measures the angle of a mounted element to a defined reference plane
- *Element Flatness* – measures the number of active tips for each element within a defined reference plane
- *Depression Angle* – measures the sharpness of microreplicated tips

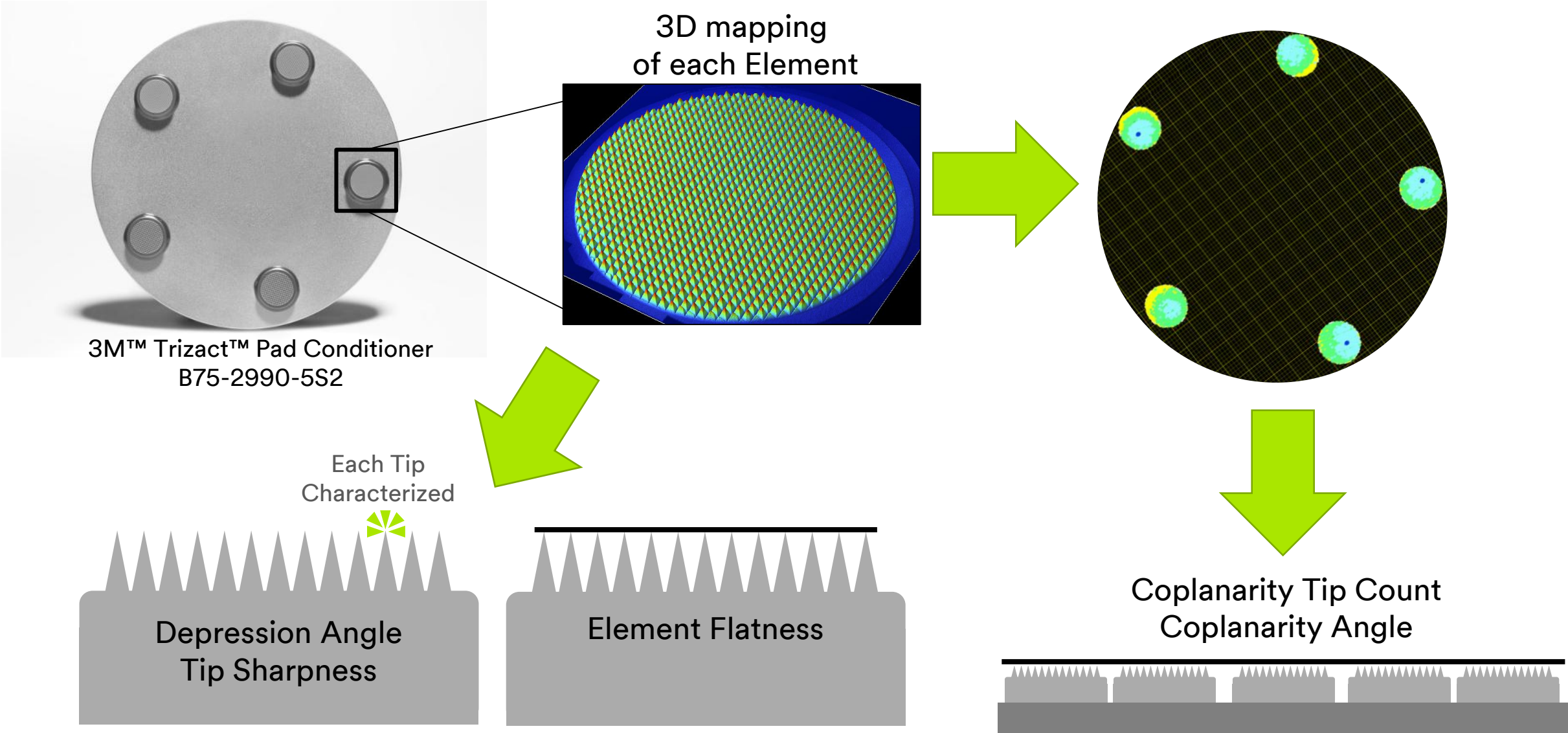


Typical diamond grit pad conditioner abrasive surface.



Microreplicated pad conditioner abrasive surface (ref B6-1900-5S2)

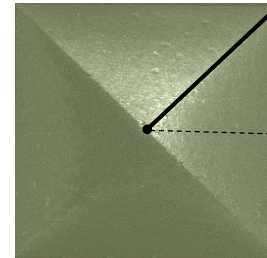
Example Metrology Flow



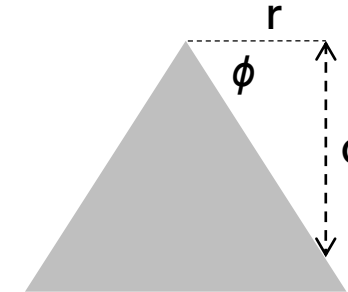
Depression Angle Measurement for Tip Sharpness

- Applied to structures with a defined tip apex and facet edges
- Tip Sharpness quantified by determining the “depression angle” ϕ , using fixed distance r from tip apex and measured distance d .
- All facet edges are averaged for a mean depression angle (MDA) per each tip reported in radians.

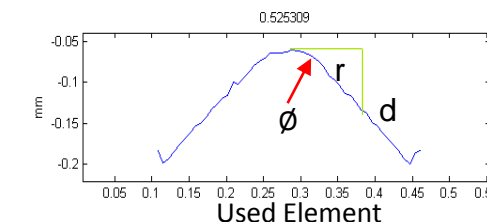
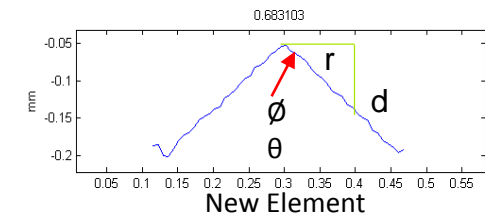
Top view –
detect tip apex and
corner orientations



Side view –
compute Depression Angle ϕ
 r is fixed, d is measured.



$$\phi = \arctan\left(\frac{d}{r}\right)$$



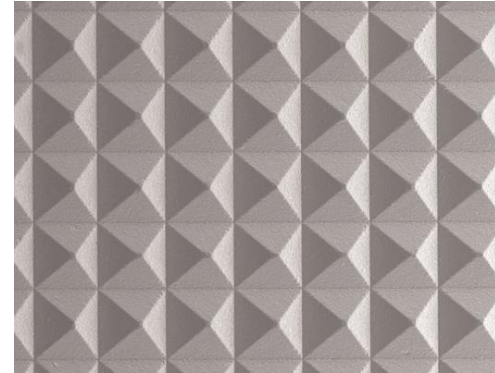
Tip Sharpness Metrology in Use Today

Tip Sharpness measurement currently used for microreplicated primary/active cutting tips for :

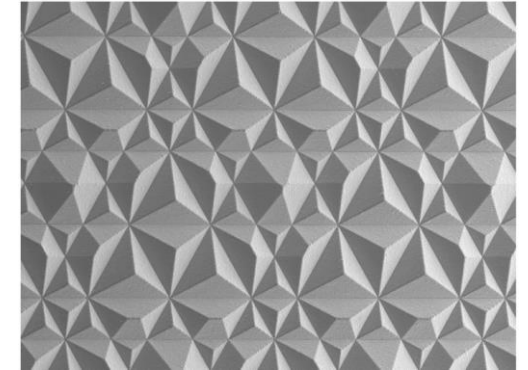
- Square pyramids
- Hexagonal pyramids
- Multi-faceted, multi-sided features

Applications for use:

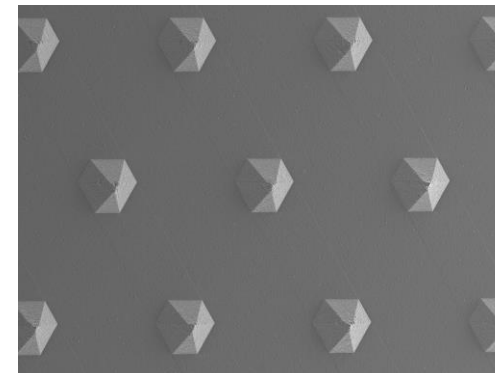
- Quality Control (QC) metrology
- Post-use investigations
- Cutting mechanism understanding
- Fine-tuning conditioner performance for unique pad materials



Four-sided pyramid structures



Mixed , multi faceted pyramid structures



Six-sided pyramid structures

The background is an abstract composition of various green triangles and polygons in different shades, creating a dynamic, low-poly geometric pattern.

CASE STUDY –

**Using Tip Sharpness for Conditioner
End-of-Life Understanding**

Using Tip Sharpness for Conditioner End-of-Life Understanding

Scope of Work, Customer A

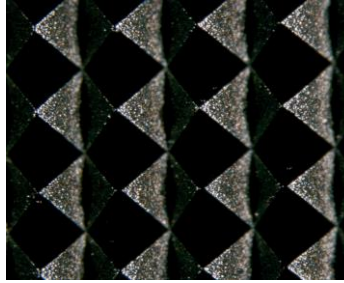
- Replacing POR conditioner with Trizact
- Trizact B75-2990 and B5-M990 removed from service at typical POR end-of-life wafer count
- Tip sharpness compared pre- and post-use

Results

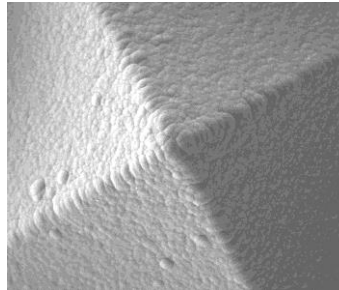
- Tip sharpness (MDA) measurements indicate minimal/modest change in sharpness
- Confirmation with optical and SEM images

Conclusions

- Conditioner sharpness indicates longer life possible
- Customer moved forward with test plan for consumable life increases beyond POR

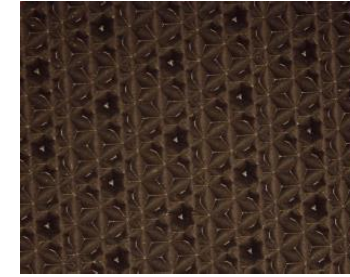


Optical image, 80X magnification

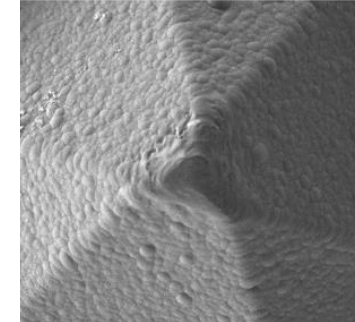


SEM confirms minimal wear on the active tips

Status	MDA
New	0.573
Used	0.569



Optical image, 30X magnification



SEM confirms modest wear on the active tips

Status	MDA
New	0.442
Used	0.371

Using Tip Sharpness for Conditioner End-of-Life Understanding

Scope of Work, Customer B

- Replacing POR conditioner with Trizact
- Trizact B5-M990 removed from service at typical POR end-of-life wafer count
- Tip sharpness compared pre- and post-use

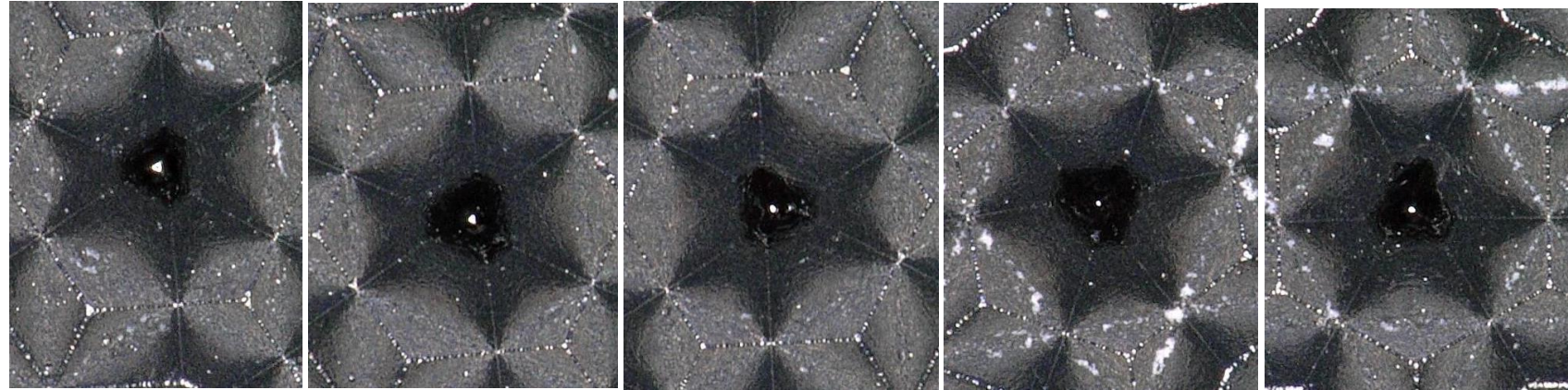
Results

- Tip sharpness (MDA) measurements indicates change in sharpness consistent with end of life
- Similar and consistent results for several disks analyzed throughout test period
- Confirmation with optical and SEM images

Conclusions

- Tip wear consistent with end of life
- Customer moved forward with test plan for POR change

Dark area near the tip is the polished zone



Element 1

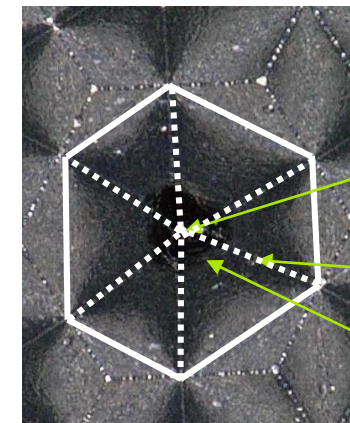
Element 2

Element 3

Element 4

Element 5

Status	MDA
New	0.453
Used	0.185



Tip apex

Facet edges

Dark region, depth of pad penetration

The background is an abstract composition of various shades of green, ranging from light lime to deep forest green. These colors are arranged in a complex, low-poly geometric pattern of overlapping triangles and polygons, creating a dynamic and modern visual effect.

CASE STUDY –

**Using Tip Sharpness to
Troubleshoot Tool Fit-up Issues**

Using Tip Sharpness to Troubleshoot Tool Fit-up Issues

Scope of Work

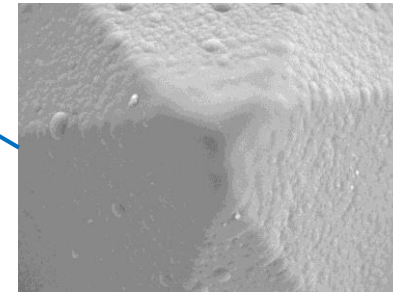
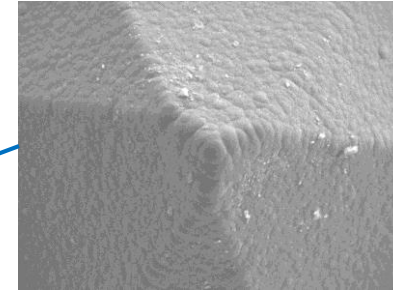
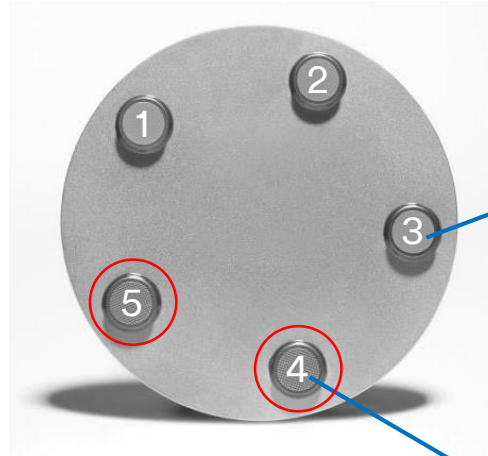
- Conditioner returned post-use with evidence of high wear on two adjacent elements, minor wear on remaining three elements
- Inspected with optical microscopy, SEM, and interferometer in order to quantify root cause of uneven tip wear

Results

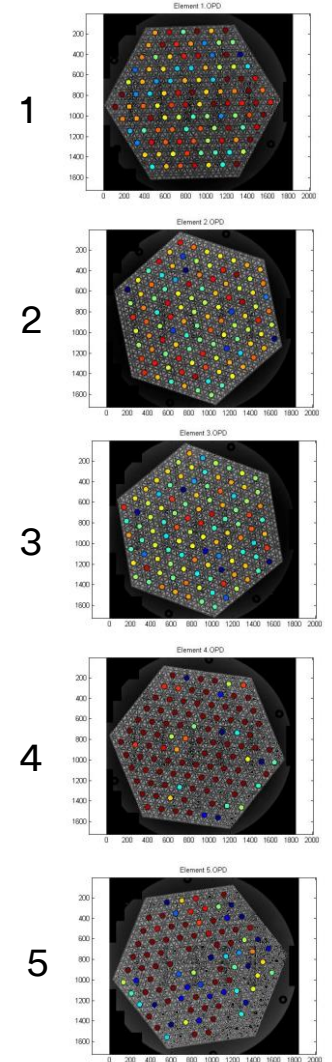
- Element-to-element and within element measurements validated disk assembly to be within specification
- Short run-out test with laboratory CMP tool confirmed proper operating function
- Tip sharpness (MDA) measurements quantified high wear of tips of two elements.

Conclusion

- Customer tool gimbal found to be defective, forcing only one side of disk into the pad.



	Initial	Final
Element	MDA	MDA
1	0.4391	0.3980
2	0.4460	0.4396
3	0.4472	0.4734
4	0.4447	0.1978
5	0.4438	0.3584



Summary

Tip Sharpness measurement uses Mean Depression Angle (MDA) to quantify the sharpness of microreplicated cutting tips.

Consistency of Microreplication technology enables the use of MDA metrology

Applications for use:

- Quality Control (QC) metrology
- Post-use investigations
- Cutting mechanism understanding
- Fine-tuning conditioner performance for unique pad materials
- Insight for future designs for new tips and new cutting features

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