

Advances in CMP Conditioner and Pad Metrology For the Data Storage Industry

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Robert Kertayasa, Vamsi Velidandla, Jim Xu



ZETA

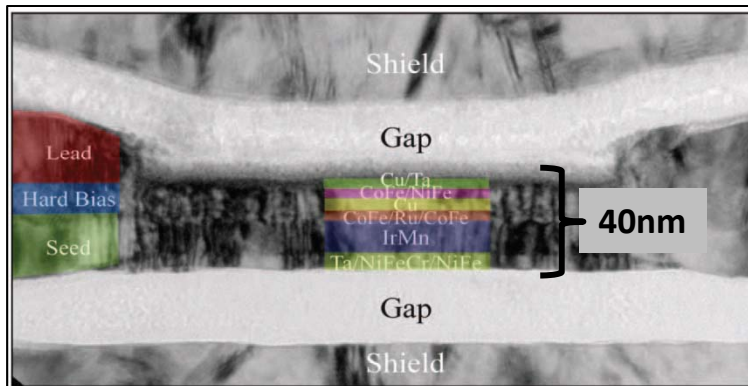
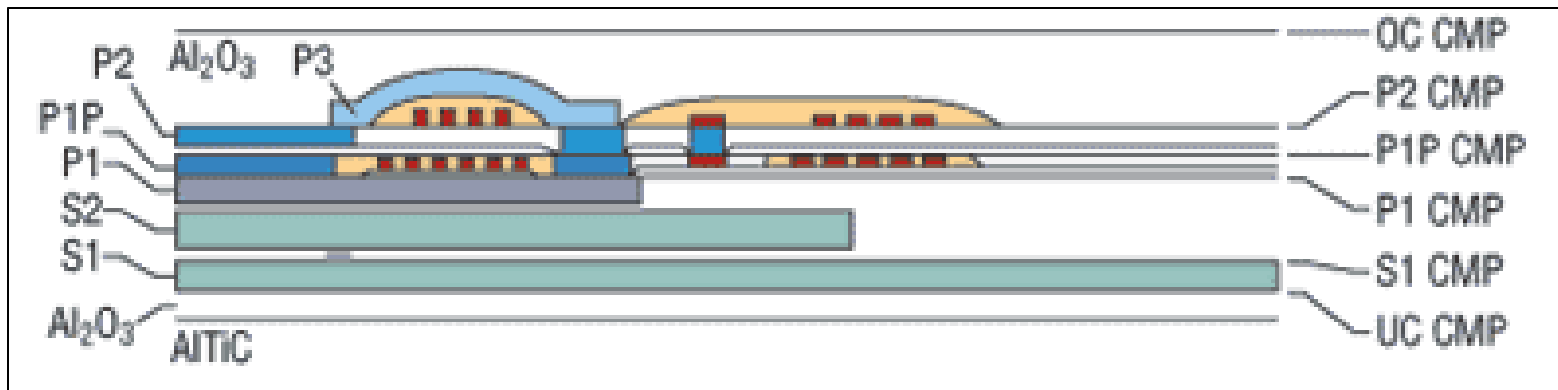
www.zeta-inst.com

1909 Concourse Drive
San Jose • CA • 95131
PHONE (408) 577-1888
FAX (408) 577-0588

Agenda

- CMP Metrology Requirements
 - Introduction to Zeta Technology
 - CMP Conditioner Metrology
 - CMP Pad Metrology
 - Other Data Storage Applications
 - Summary
-

CMP in read-write head manufacturing

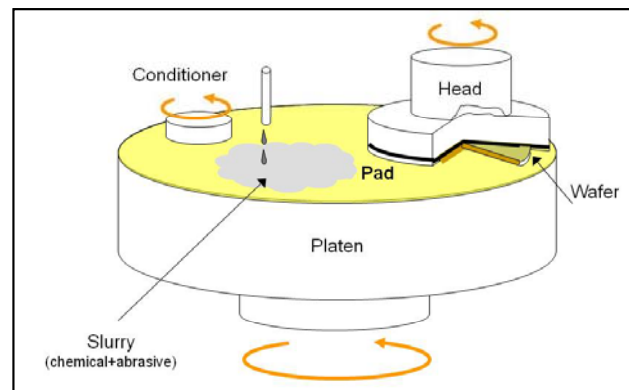


- A typical GMR head manufacturing operation has multiple CMP steps, critical for the read/write performance of a disk drive.
- Critical dimensions in the read/write heads have approached or actually become smaller than those in the semiconductor industry.

Reference : Article by M. Jiang, HGST San Jose :
<http://www.electroiq.com/index/display/semiconductors-article-display/211235/articles/solid-state-technology/volume-47/issue-9/data-storage-supplement/features/processing-considerations-for-cmp-on-thin-film-head-wafers.html>

CMP Considerations

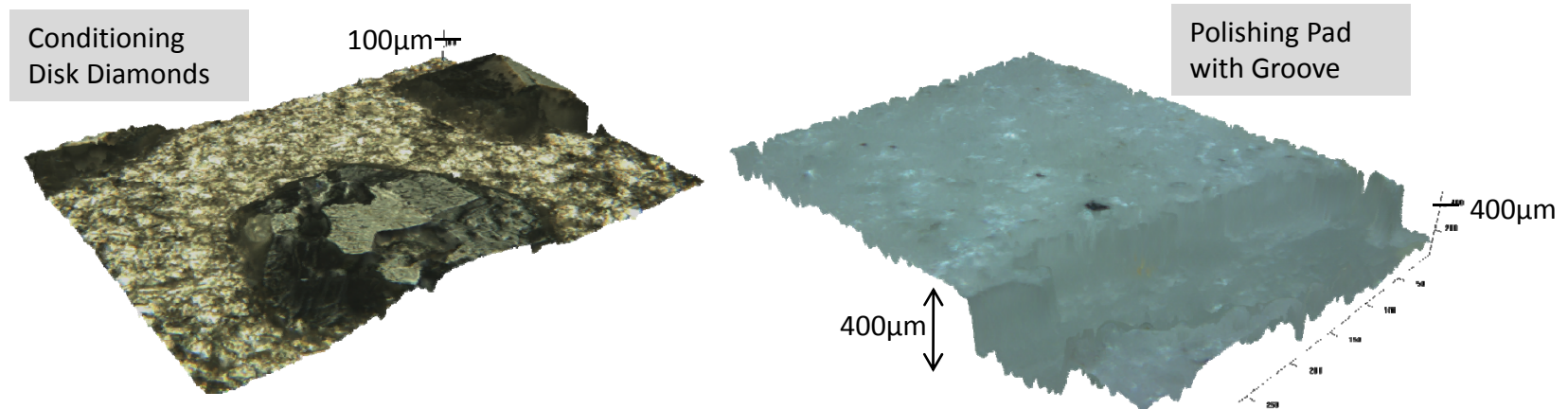
- Input variables
 - Slurry, Pad, Pad Conditioning, Polishing force etc.
- CMP on a given layer affects the subsequent layer uniformity as well as the CD control during lithography
- Current CMP monitoring metrology is aimed at monitoring the end results
 - Film thickness, surface roughness, dishing/erosion
 - Typical tools : Ellipsometer, Stylus profilers / AFM
- Input parameters such as the Pad and Pad Conditioner have not been characterized due to lack of appropriate metrology tools



Reference : Joshua Chien, UC Berkeley
<http://me.berkeley.edu/ME107B/cmp/CMPsp08v2.ppt>

CMP Pads and Conditioners

- Large Dimensions
 - Conditioning Diamonds are of the order of 50 – 100 μm tall / wide
 - Polishing Pad grooves are deeper / wider than 100 μm
 - Very high roughness – of the order of 10s of μm
- Large range of reflectivity
 - Diamonds on conditioning pads have facets at multiple orientation causing a wide range of reflectivity
 - Polishing pads are soft, flexible and may be diffusive or non-reflective



Metrology tool requirements for CMP

Attribute		AFM	STYLUS PROFILER	ZETA	INTERFEROMETER	CONFOCAL MICROSCOPE
Large vertical range	> 1mm	No	Yes	Yes	Yes	Yes
High Z resolution over the large range	~ sub- μm	No	Yes	Yes	Yes	Yes
Very low reflectivity surface	< 1% reflectivity	Yes	Yes	Yes	Yes	Yes
Very high reflectivity surface	> 90% reflectivity	Yes	Yes	Yes	Yes	Yes
Very high roughness surface	> 100 μm Rpv	No	Yes, BUT!	Yes	No	No
Large area imaging - single image	> 200 μm X 200 μm	No	Yes, BUT!	Yes	Yes	Yes
Large area imaging - stitching	mm X mm	No	Yes, BUT!	Yes	Yes	Yes
Speed of data acquisition	< 1 min per scan	No	No	Yes	Yes	Yes
True color imaging	distinguish contaminants	No	No	Yes	No	No
Cost of ownership	LOW!	No	No	Yes	No	No

Zeta Instruments has recently introduced a new **3D imaging and metrology microscope** based on its patented **ZDot™ technology**

Note : SEM has not been included in this analysis

Zeta Technology

1 CCD Color Camera

- Digital camera to capture sample images and focus map data

2 Zeta Optics Module

- ZDot signal generator
- High intensity white light LED to preserve sample color
- High efficiency optics design to optimize illumination

3 Z-drive

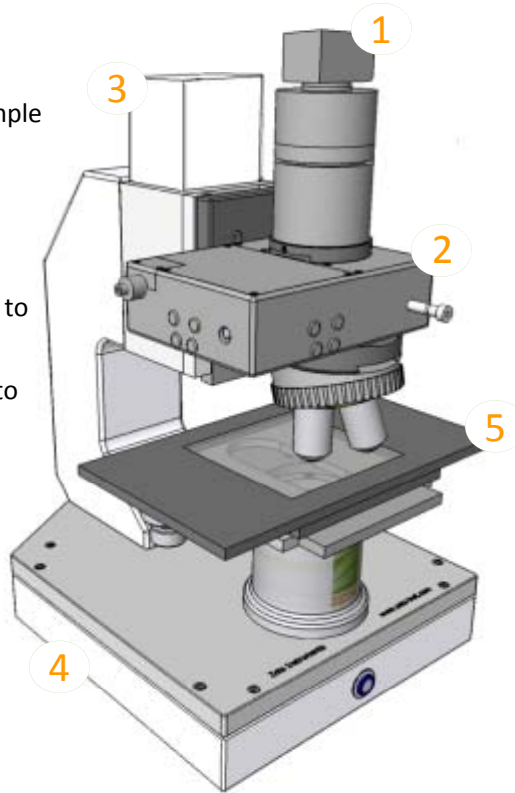
- Precision mechanism for sub-micron vertical resolution

4 Zeta Control Box

- FMM and Z-drive electronics controller

5 XY Stage

- Convenient sample positioning

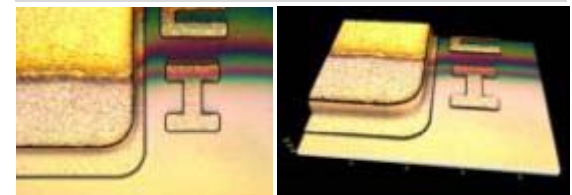


Conventional microscopes have a very limited depth of focus. Test surfaces and features are clearly visible *ONLY* when they are within the focal depth. *The Zeta system scans a sample over a user specified vertical (or Z) range. At each Z position, it records the XY location and the precise Z height of the pixels using the Zeta Optics Module.* This information is used to create a **true color 3D** image and a 2D composite image. The resulting image has an extended depth of focus so the entire surface is seen clearly. The Zeta 3D software can be used to ascertain dimensional and roughness information

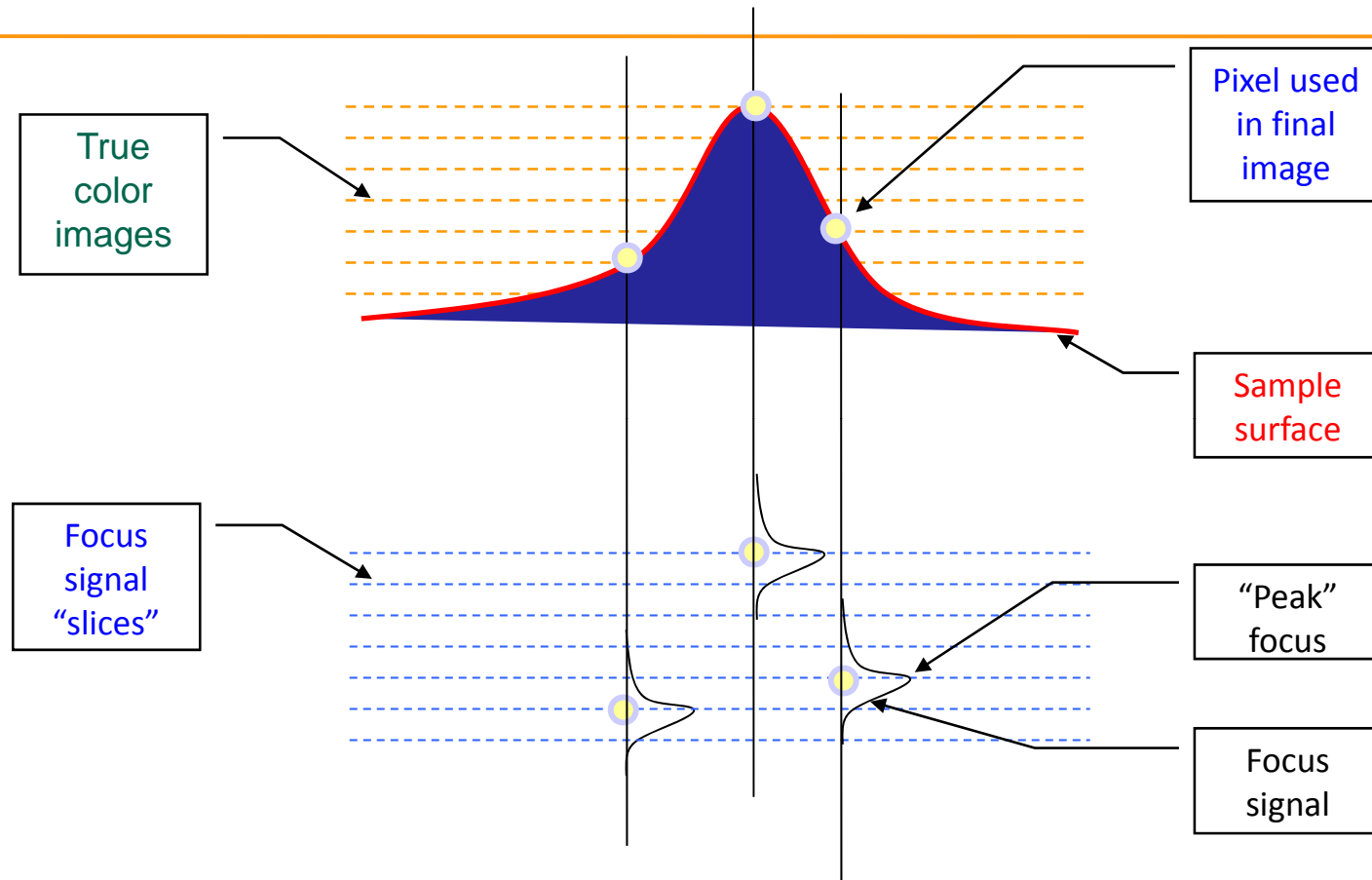
Conventional Microscope (2D Only)



Zeta Images (2D & 3D)

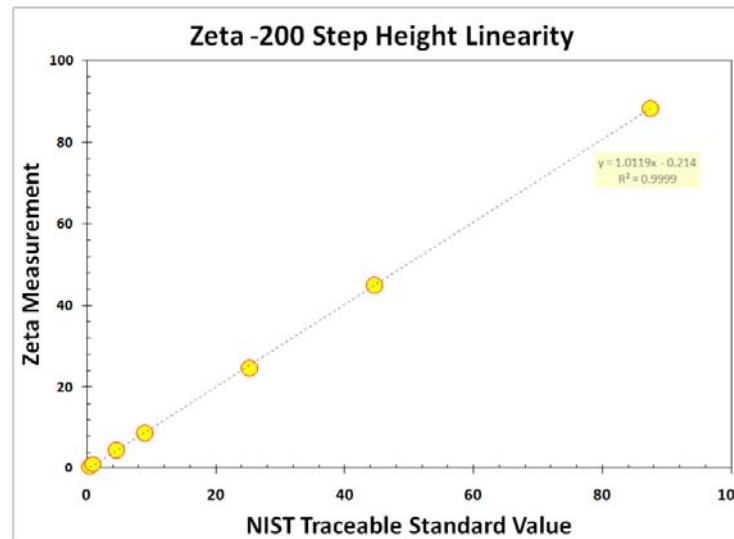
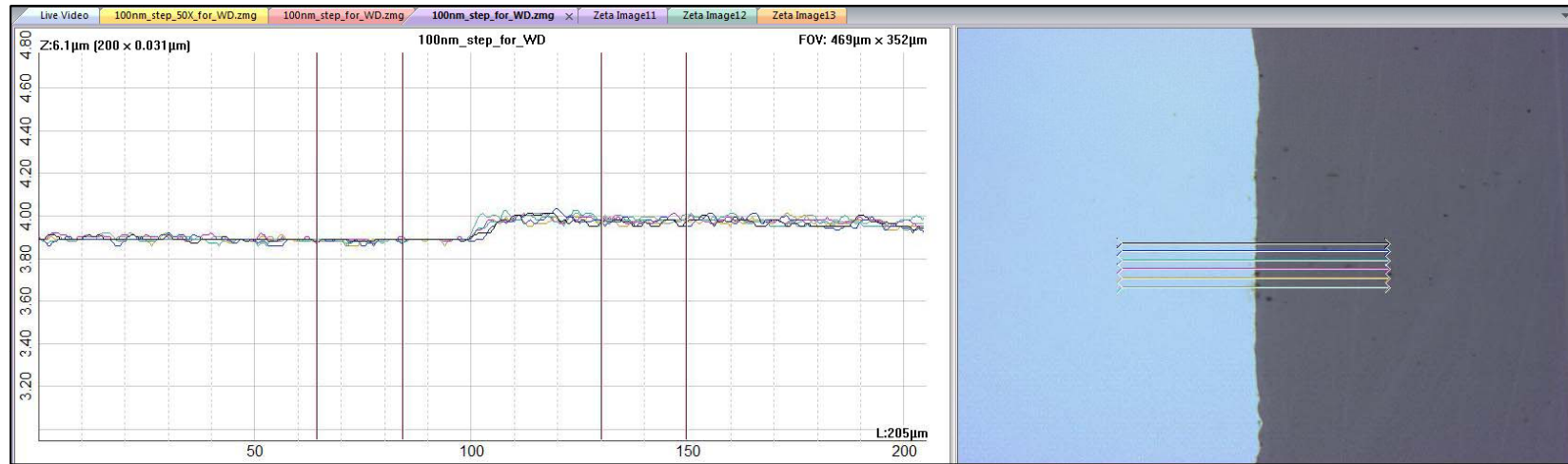


Zeta Technology



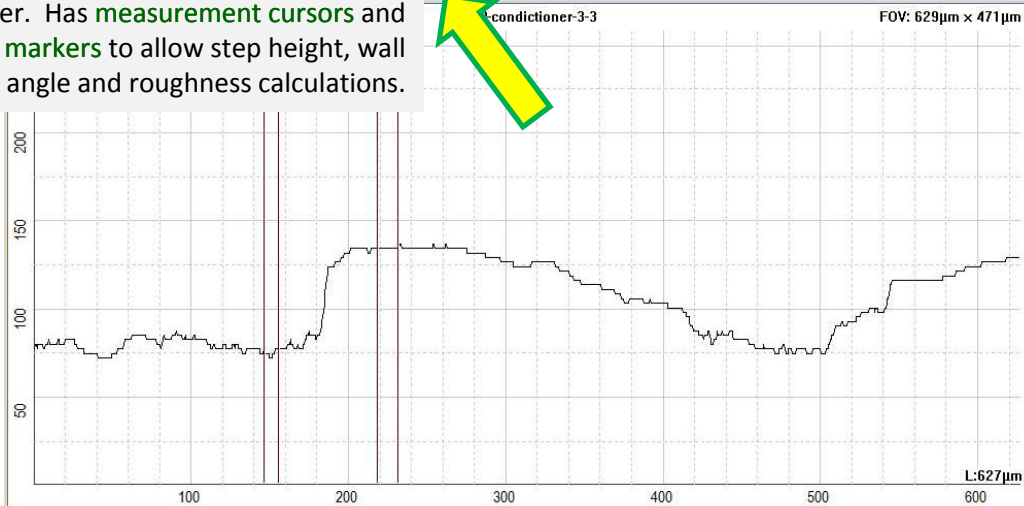
*In optical terms, the point spread function of the ZDot based technology is narrower than that of a regular 3D optical microscope. The enhanced focus detection enables a sub depth of focus **vertical resolution down to 70nm**.*

Step Height : From sub- μm to mm

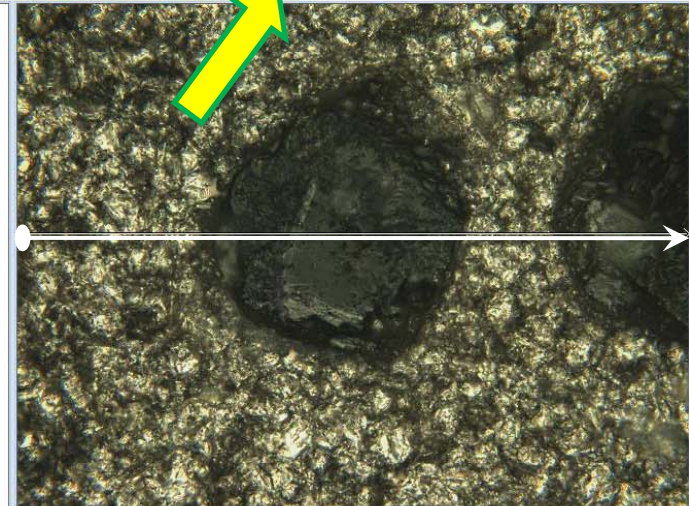


Data Analysis Tools

Cross section window. Can contain multiple traces depending on the number of cross sections drawn by the user. Has **measurement cursors** and **markers** to allow step height, wall angle and roughness calculations.



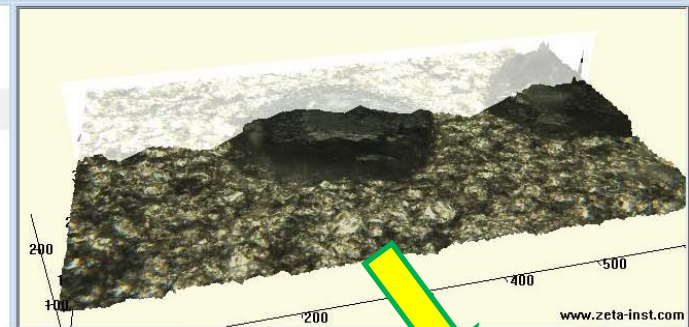
2D (top) view of the substrate. Can be used to **draw cross sections** and measure feature dimensions



Zeta Analysis Report
 Image Name: CMP-conditioner-3-3 File Name: C:\V11\Zeta Customer Sample Data\2010-09-13_CMP_Data\CMP-conditioner-3-3.zmg
 Date Acquired: Fri Sep 10 15:31:03 2010 Today: Tue Sep 14 23:23:19 2010
 Z Range: 258µm No. of Steps: 100 Step Size: 2.607µm Field of View: 629µm x 471µm

Cursor Left		Cursor Right		Cursor L-R	
Avg Ht	Width	Avg Ht	Width	Step	Angle
75.04	9.158	134.30	13.08	59.27	73.92
					38.72

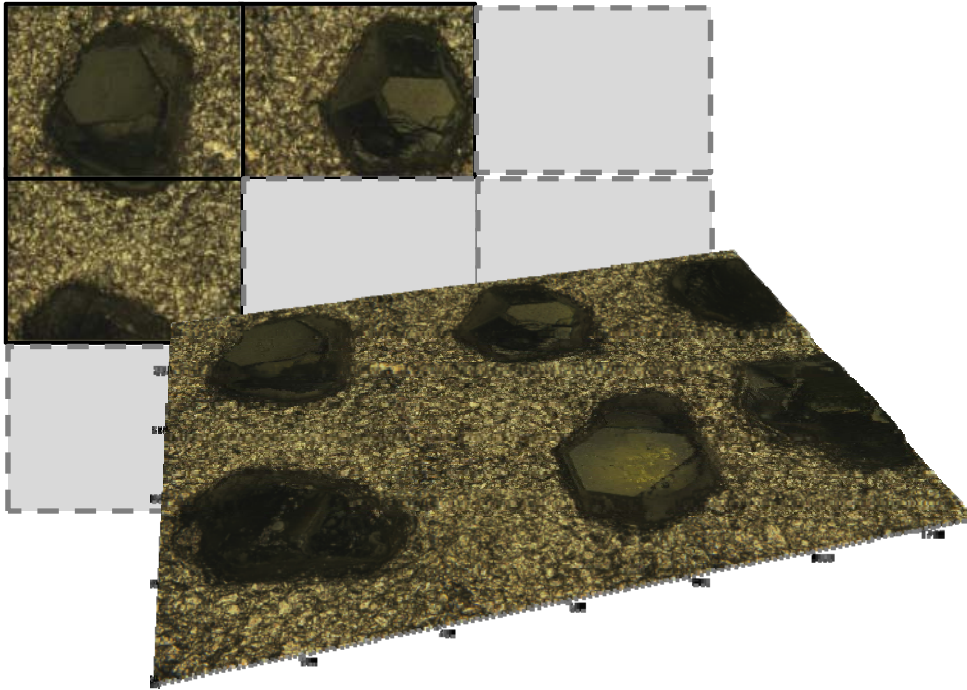
Step height value reported in the log



Data log. Contains **step height**, **wall angle** and **roughness** information calculated from the cross sectional traces. Can be exported as '*.csv' file.

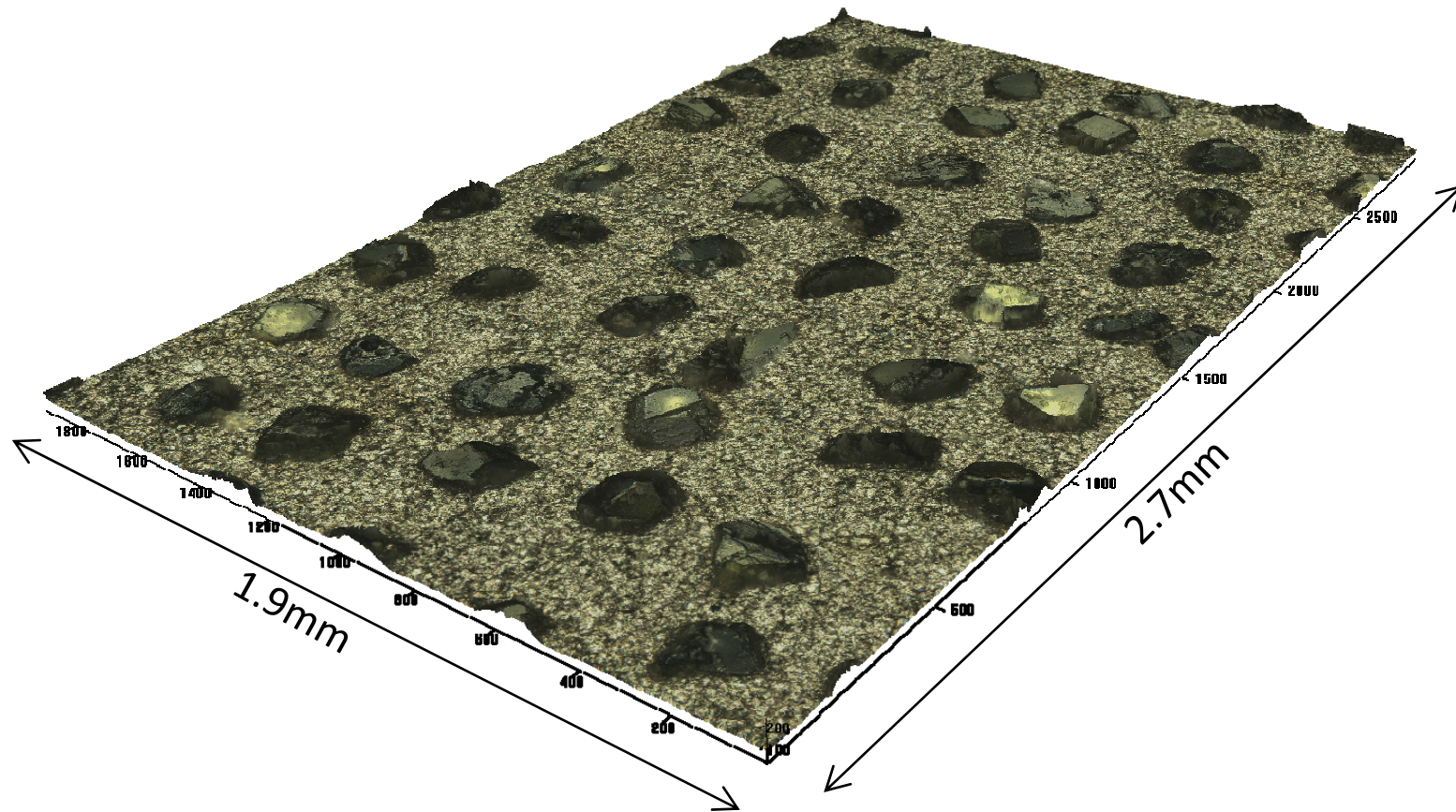
3D view of the substrate

Large Area High Resolution Imaging



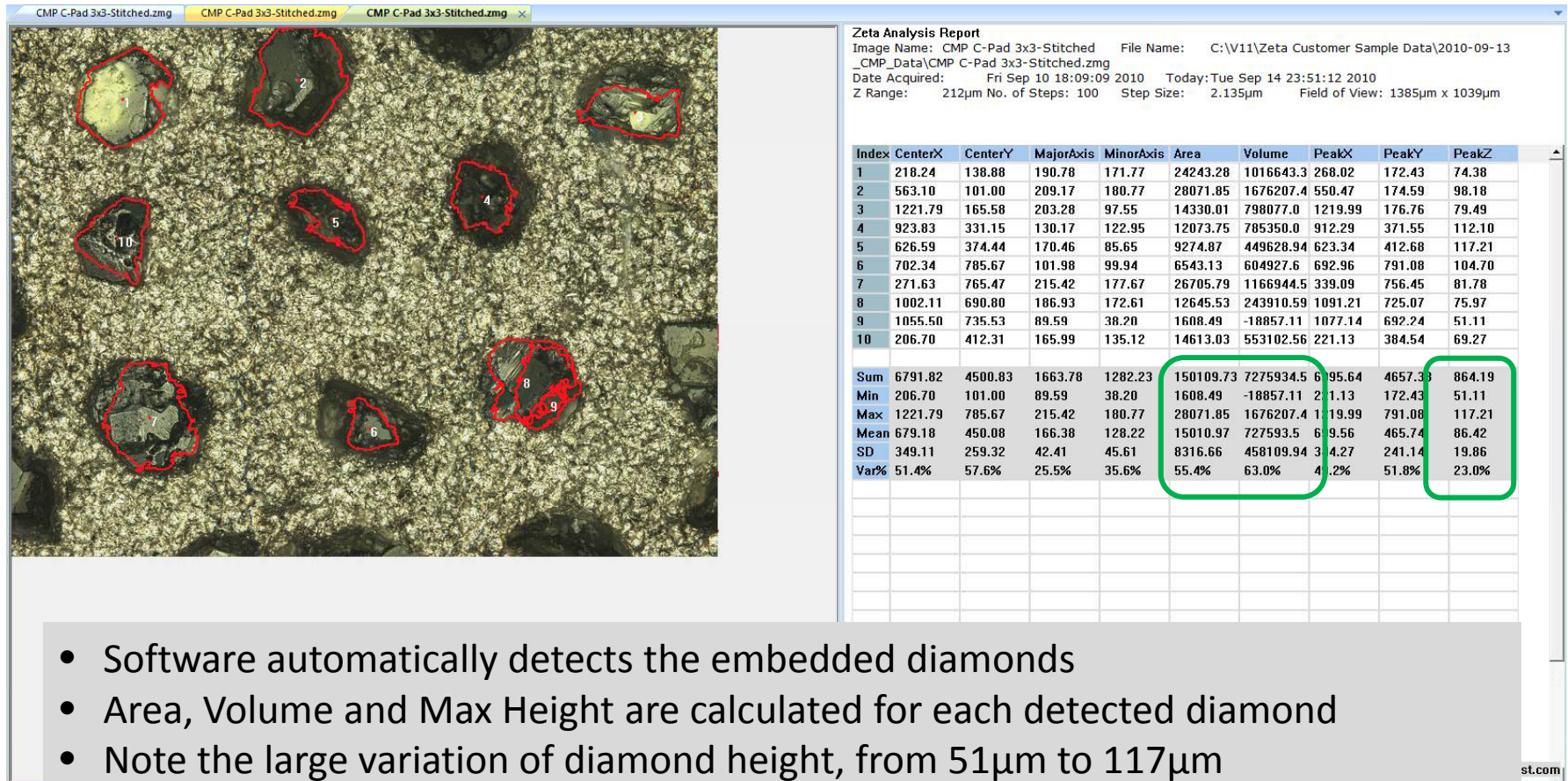
- The Zeta tool can automatically scan adjacent sites and stitch up to 48 sub-images
 - Each sub-image can be as large as 360 μ m X 280 μ m
- This large area imaging option provides a significant statistical sampling of the diamond dimensions

CMP Conditioning Disk



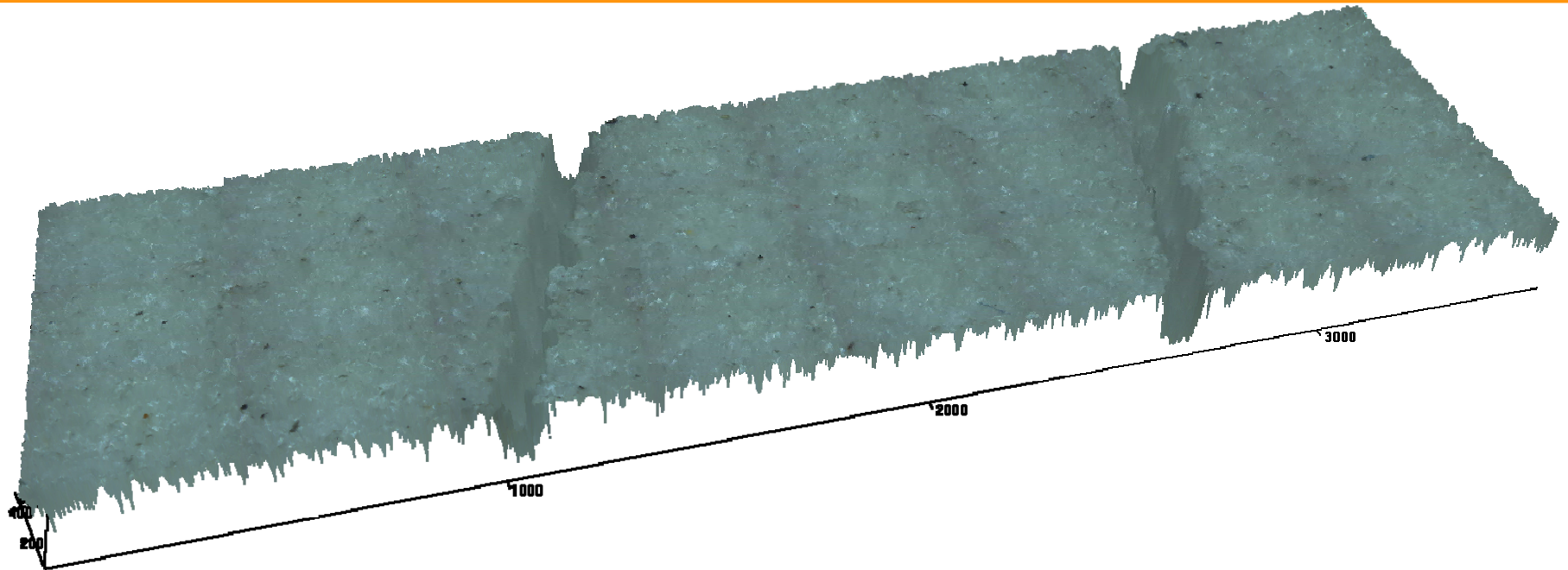
42 images adjacent images were acquired with a 50X objective and were stitched to create a large area view of the conditioning disk surface

Automatic dimensional analysis of diamonds



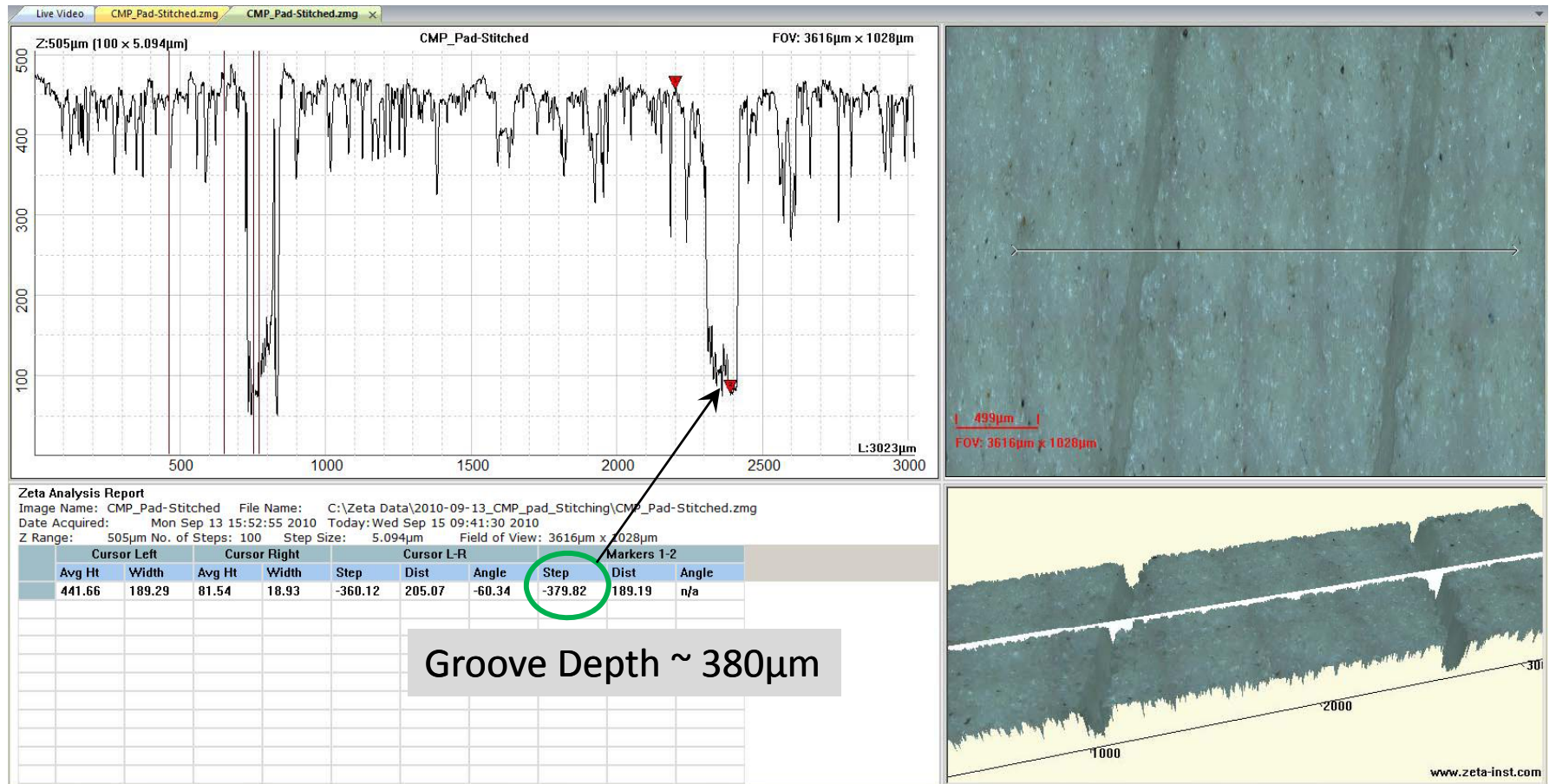
- Software automatically detects the embedded diamonds
- Area, Volume and Max Height are calculated for each detected diamond
- Note the large variation of diamond height, from 51μm to 117μm
- Only a few of the diamonds are actually doing the work, the lower diamonds are 'decorating' conditioning disk
 - Resulting non-uniform CMP Pad roughness may affect end CMP result

Polyurethane Pad: 3D Image

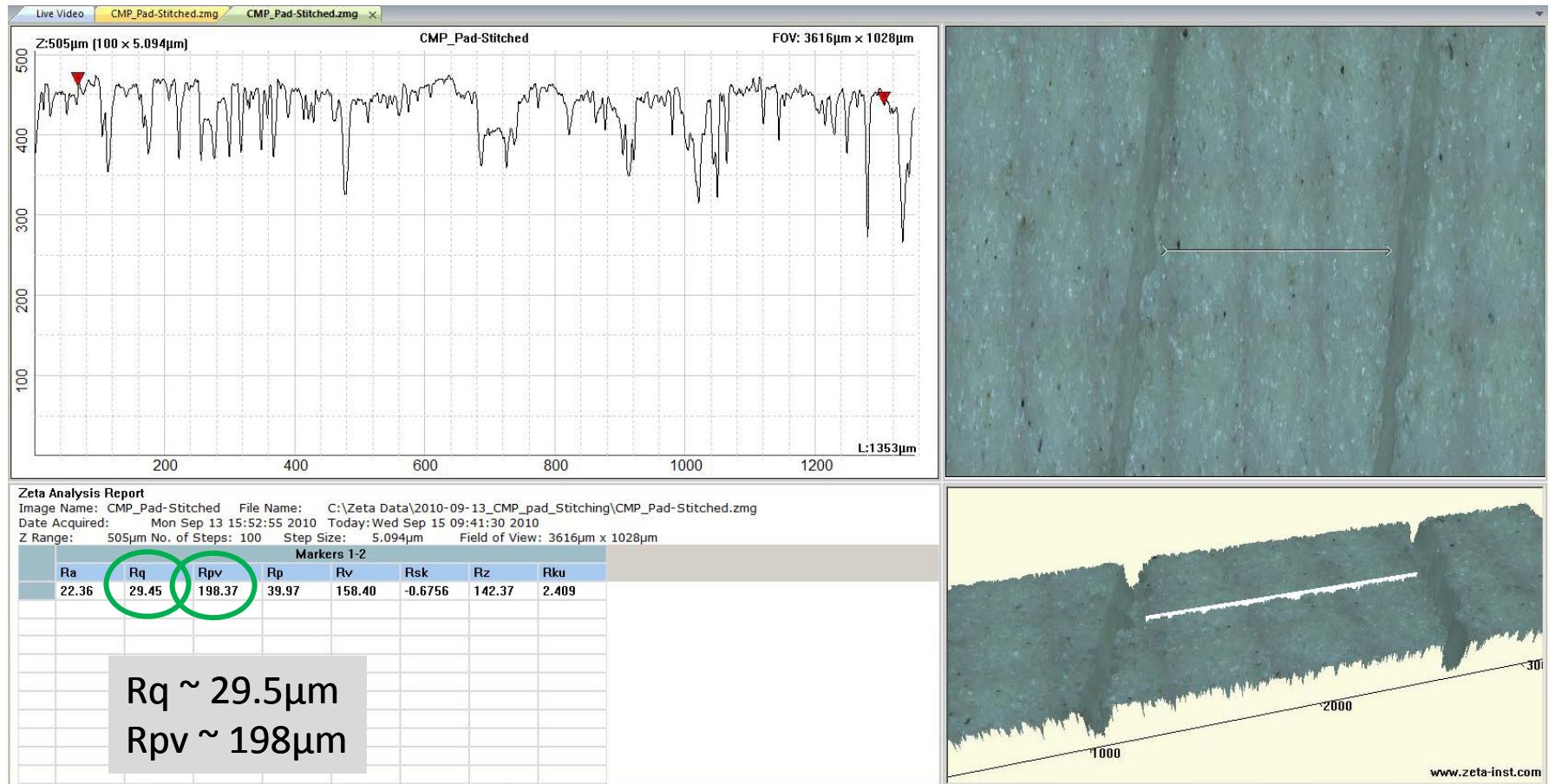


- Polyurethane Pad
 - 24 images were stitched to create this image
 - Scan time ~ 15 minutes
 - Scan area ~ 1mm X 3.7mm
 - Features are too large for a stylus profiler or AFM
- **This highly diffusive, rough material with large step heights can not be measured with an interferometer or stylus based profilers**

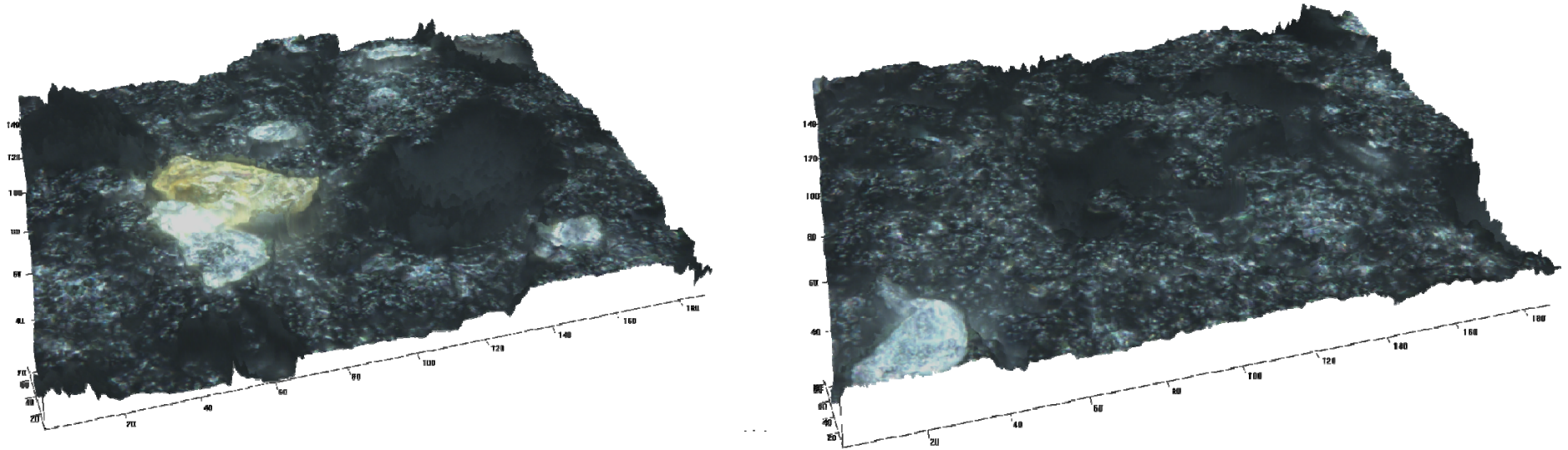
Polyurethane Pad : Groove Depth Analysis



Polyurethane Pad: Roughness Analysis

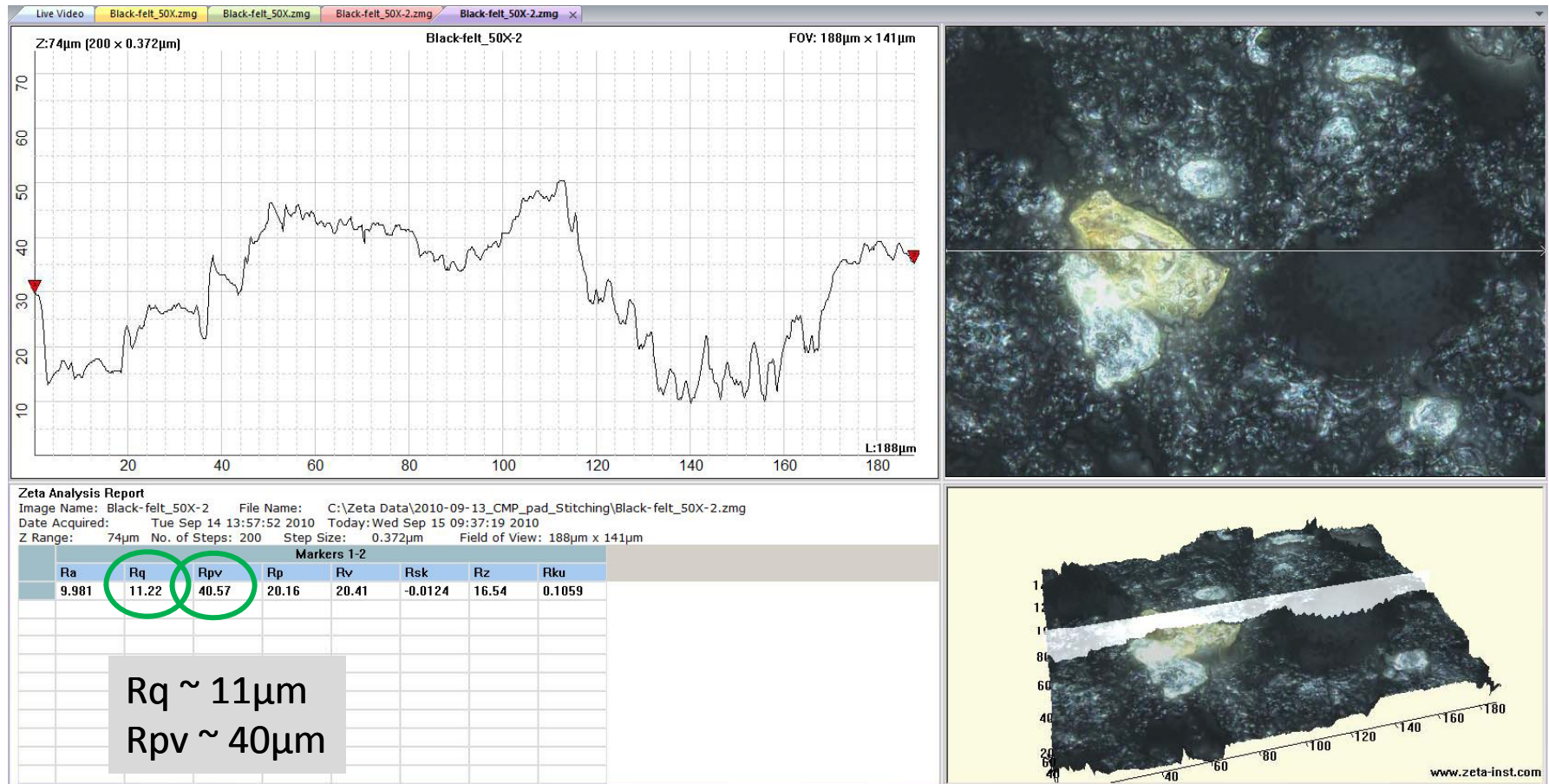


Black Felt Pad: 3D images

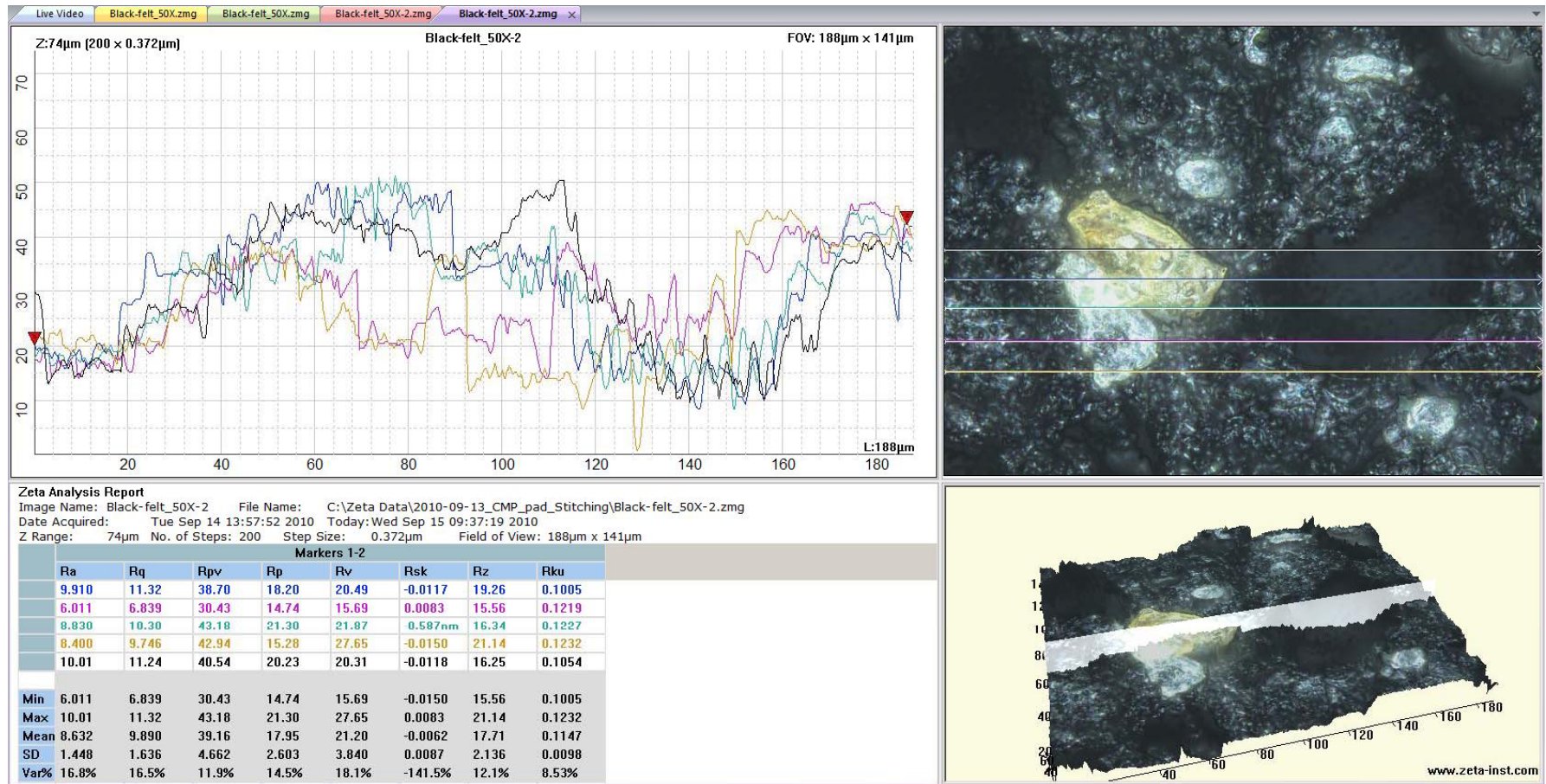


- Black Felt Pad
 - Scan time ~ 40 seconds
 - Scan area ~ 185 μ m X 150 μ m
- **This soft, very low reflectivity and very high roughness substrate is impossible to measure with any existing metrology**

Black Felt Pad: Roughness Analysis

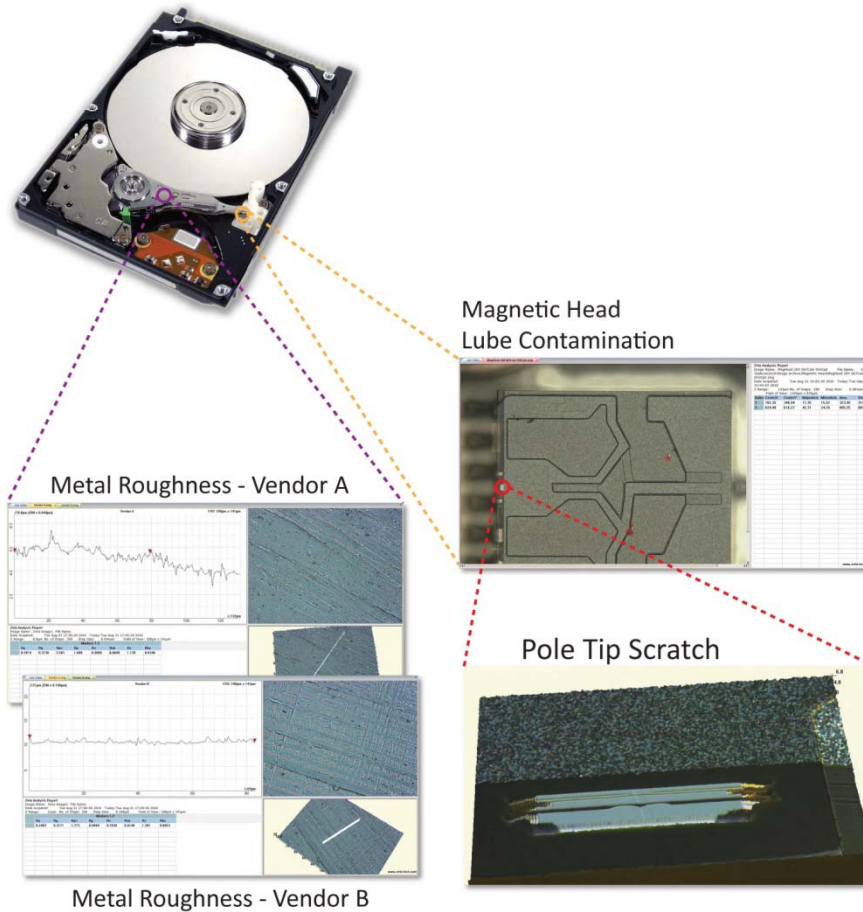


Black Felt Pad: Roughness Analysis



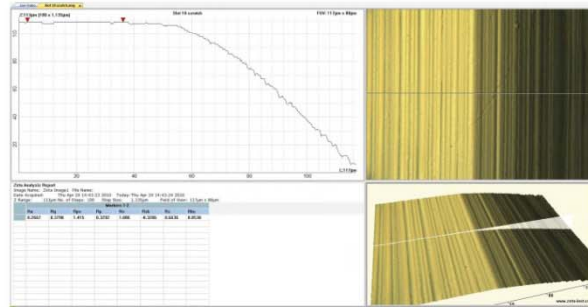
- Multiple Cross-sections can be analyzed to generate better statistics for the surface

Other Data Storage Applications

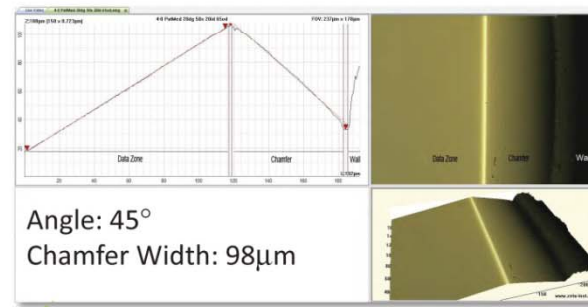


Other Data Storage Applications

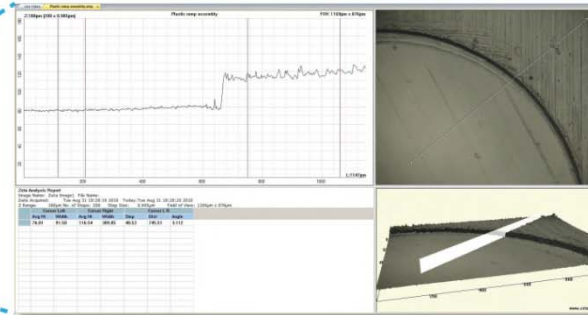
Chamfer: Roughness, Defects



Chamfer: Width, Angle



Armature Ramp Step Height



Summary

- CMP Polishing Pad and Conditioner Disk metrology has a unique set of requirements, unmet by current metrology tools
- **Zeta Instruments** has designed a **fast, non-contact optical solution** for CMP metrology
 - The Zeta 3D imaging and metrology microscope can handle **very large dimensions, high roughness, large variation in reflectivity**
- This cost effective solution can also be automated for conditioning disk metrology
 - Diamond distribution, area, volume, height analysis
- Polishing pads with very high roughness and very large groove depths can also be measured with the Zeta microscope

BACKUP

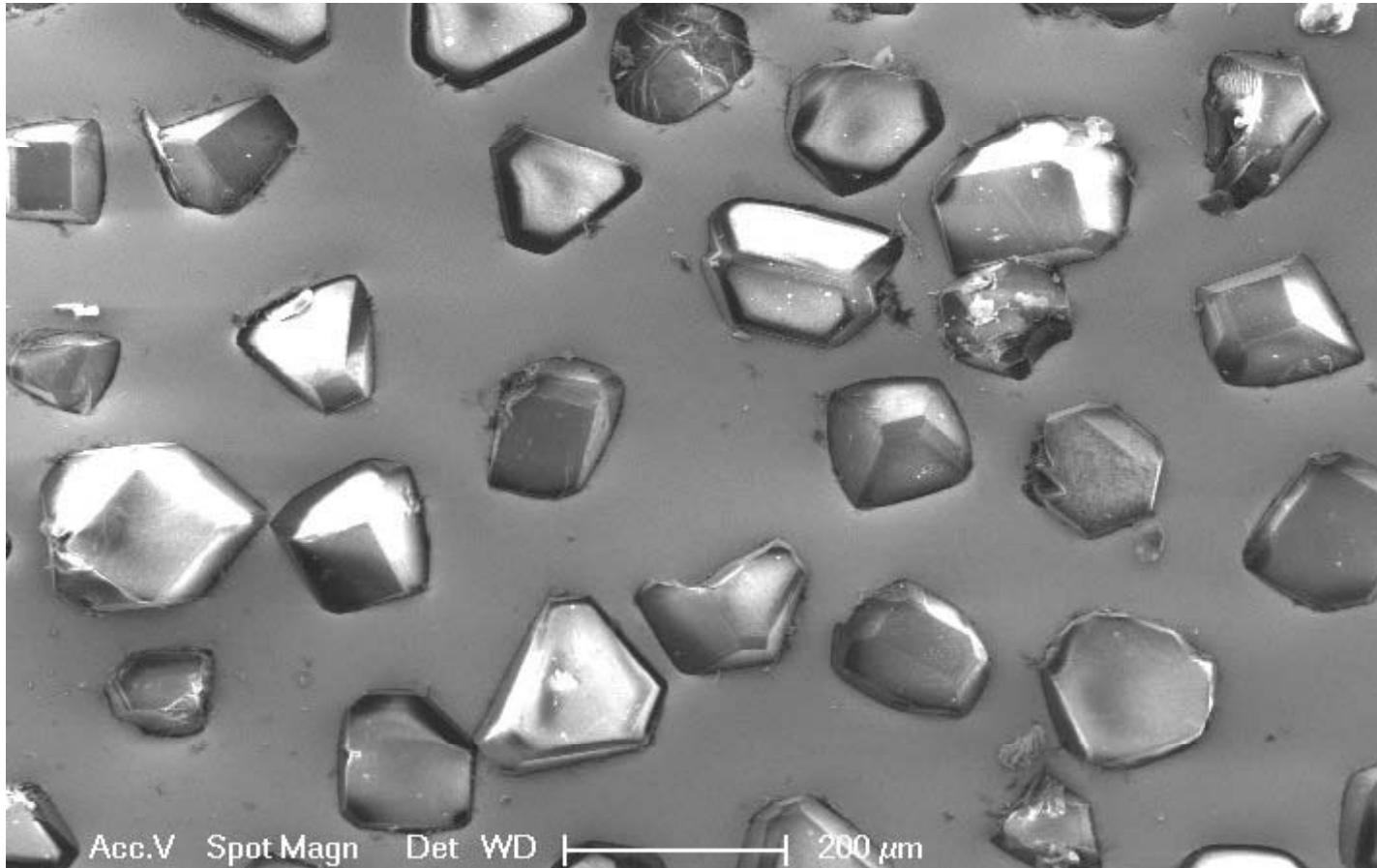


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SEM image of a conditioner



- SEM can create good 2D views of the surface, but it cannot report the dimensions
 - SEM is limited in its production worthiness
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