# NEOX Ex-Situ "Wet" CMP Pad

*Sensofar & Headway Technologies*
*Niels Schwarz and Terry Moore*

# NEOX Executive Summary

*Within CMP Manufacturing Engineering, there is a need for a tool to quickly and accurately characterize and/or monitor the wet CMP polishing pad while it is still on the polishing tool, to help determine the root cause of process excursion situations. Without the ability to accurately diagnose production problems, pads have often been unnecessarily replaced—incurring high cost and leaving the problem unresolved.*

- Helped solved two common HDD Head CMP process issues
  - **Non-Uniform Dielectric polishing rate**
  - **Increased metal dishing rate**

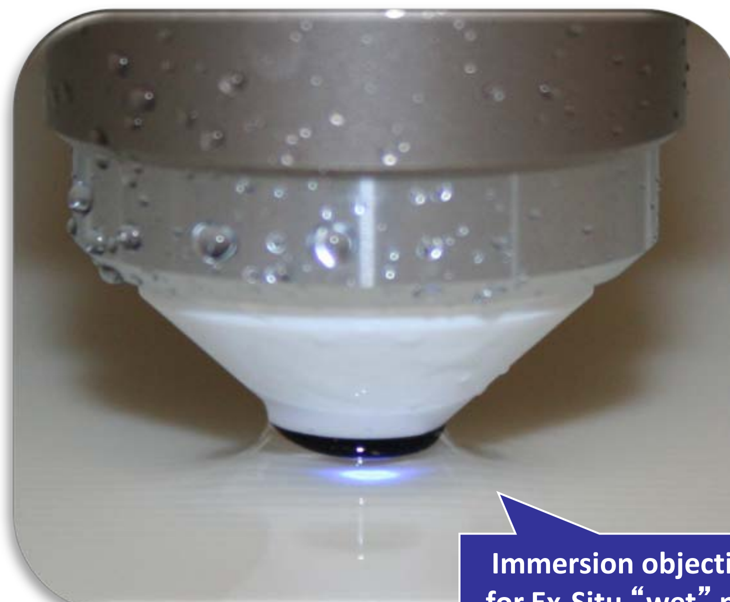
- Significant Cost Savings
  - Helped extend CMP consumables (pads/disks) by 30% reducing the cost of ownership.
  - Reduced downtime when debugging process excursions.

- Competitive Advantage
  - Non-destructive advanced technology developed specifically for the wet environment of CMP manufacturing. Yielding timely more accurate information compared to previous “contact” measurement techniques.

- Easy introduction into current processes and technology
  - The portable NEOX Plu confocal imaging microscope is an easy to use compact solution providing the CMP Manufacturing Engineer with “real-time”, not previously available information about the current wet pad state.

# NEOX ”Demo” Tool 2011

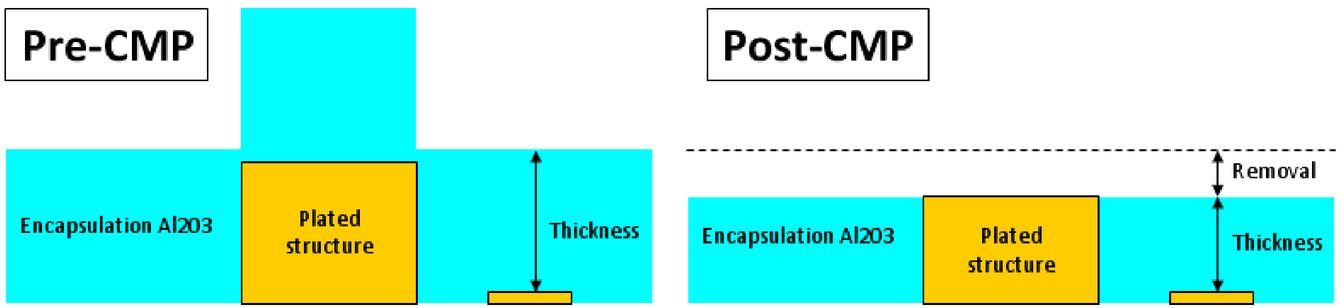




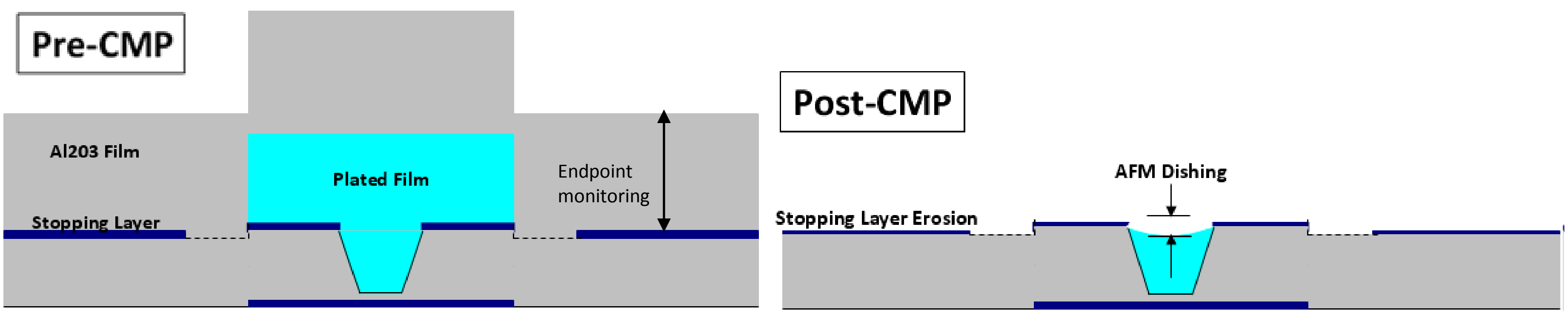
Immersion objective for Ex-Situ “wet” pad measurements

# NEOX Ex-Situ "Wet" CMP Pad Measurements

- Can the NEOX tool help identify process issues common to CMP namely;
  - Case Study 1 Process: Removal NONU Metal/Dielectric Encapsulation.
    - Metal Pattern encapsulated in a dielectric film.




  - Case Study 2 Process: Damascene CMP Accelerated Metal rate (High AFM Dishing)
    - Damanscene process.



# Case Study 1 Process: Metal/Dielectric Encapsulation

## Problem Statement:

- IC1000 Pad usage limit is 12hrs
- Exceeding limit results in a removal profile trending rapidly from **slightly edge fast** (+BENU1) to **extremely center fast** (-BENU1)

## Action:

- Using the NEOX Plu confocal imaging microscope (20x Objective), take **Ex-Situ wet pad** measurements every two hours of usage to characterize IC1000 Groove

## Results:

- NEOX data shows that **pad groove width at wafer track center is reducing as slurry is re-deposited** on the side walls of the grooves
- Groove depth data *(pad erosion)* exhibits minimal change.
- This situation results in a "fixed abrasive" condition at the wafer track center, that caused an acceleration of wafer center removal when compared to the wafer edge removal

## Solution:

- Use HPR to **cleanout grooves, and characterize w/NEOX**
- Continue on same pad and disk to **see if removal non-uniformity can be restored**

## Conclusion/Proof of Concept:

- Before and after groove cleaning the NEOX measurements showed the **pad grooves sidewalls at wafer track MD were clear of slurry**, this allowed the manufacturing team to continue processing avoiding a pad change and incurred downtime and costs
- Pad Cleaning development resulted in a **30% increase in pad life & cost saving.**

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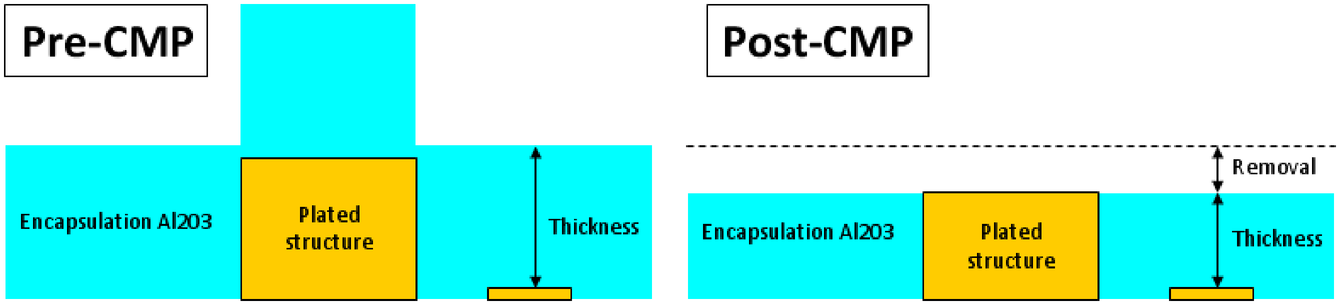
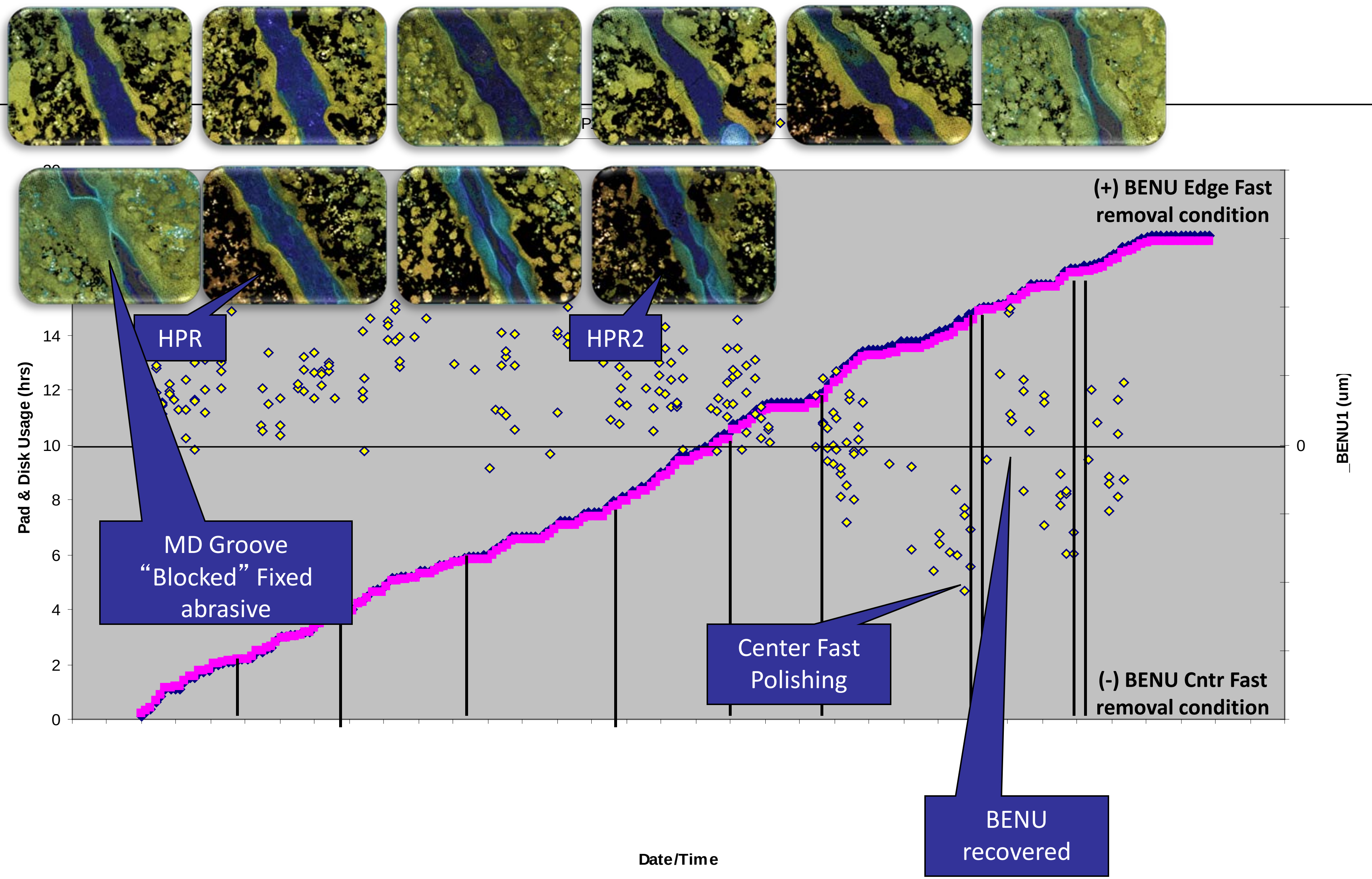
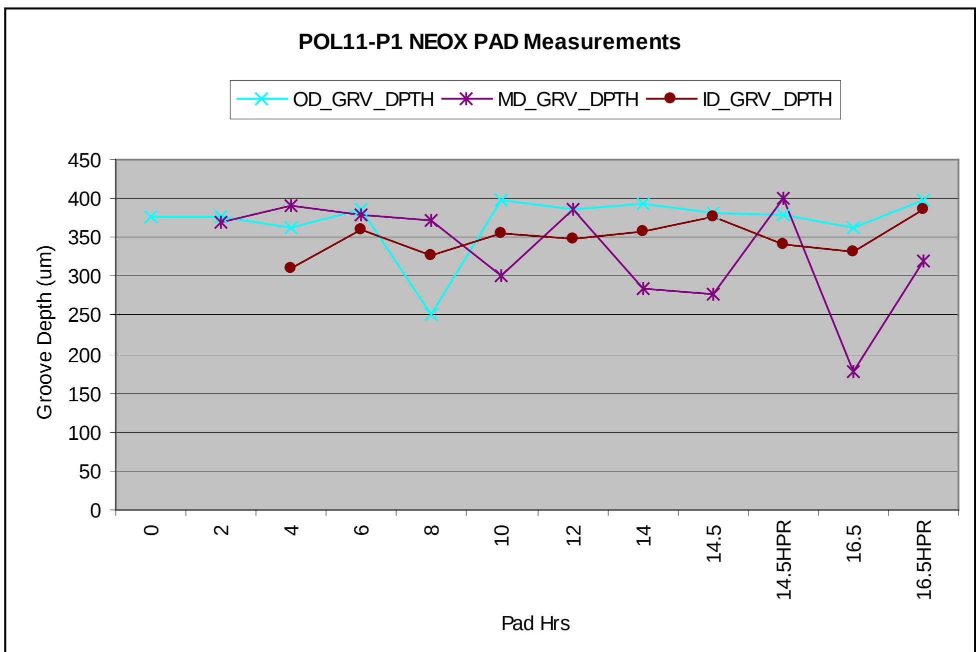


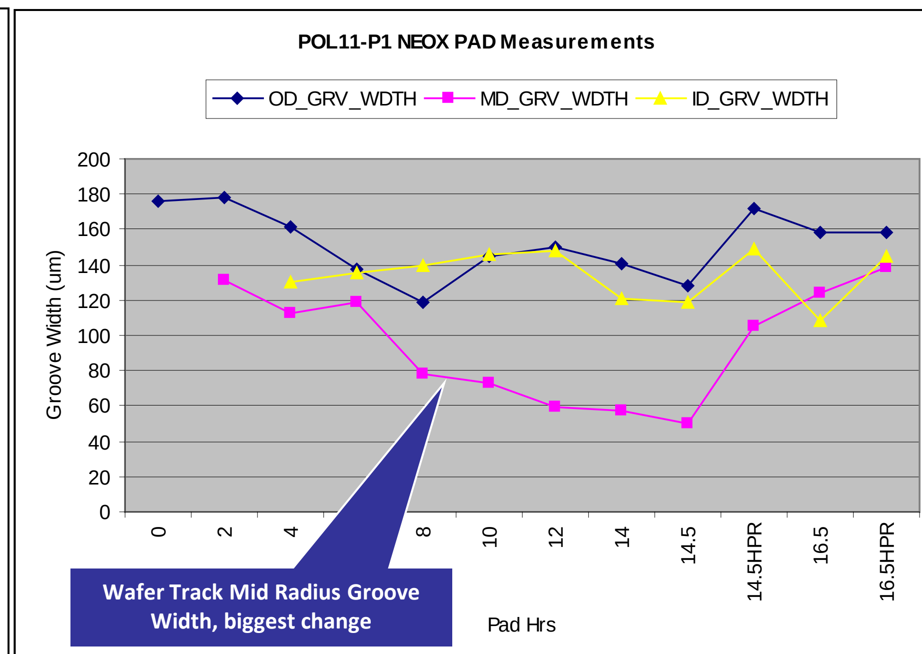
# Case Study 1: Results



# Case Study 1: Results

| | Groove Width (um) | | | Groove Depth | | |
|---|---|---|---|---|---|---|
| Pad (hrs) | OD_GRV_WDTH | MD_GRV_WDTH | ID_GRV_WDTH | OD_GRV_DPTH | MD_GRV_DPTH | ID_GRV_DPTH |
| 0 | 176 | | | 376 | | |
| 2 | 178.3 | 131 | | 377.5 | 369 | |
| 4 | 161.9 | 112 | 130.3 | 362.5 | 390 | 310 |
| 6 | 138 | 119 | 135 | 386 | 380 | 360 |
| 8 | 119 | 78 | 140 | 250 | 373 | 328 |
| 10 | 145 | 73 | 146 | 398 | 301 | 355 |
| 12 | 150 | 59 | 148 | 387 | 385 | 347 |
| 14 | 141 | 57 | 121 | 393 | 284 | 358 |
| 14.5 | 128 | 50 | 119 | 382 | 276 | 376 |
| 14.5HPR | 172 | 105 | 149 | 380 | 400 | 341 |
| 16.5 | 158 | 124 | 108 | 363 | 177 | 332 |
| 16.5HPR | 158 | 139 | 145 | 398 | 320 | 387 |



# Case Study 2 Process: *Damascene CMP*

## Problem Statement:

- On occasion polish times reduce precipitously to maintain the desired AFM dishing target. Low polish time results in residual dielectric in the field. At this point wafers need to be reworked increasing cost and the risk of over dishing. Pad & disk is changed resulting in high process consumable cost

## Action:

- Comparing a typical normal performing conditioning disk (DISK-A) and a "poor performing" conditioning disk (DISK-B). Use NEOX Plu confocal imaging (20x Objective) to take Ex-Situ wet pad measurements to characterize the IC1000 Pad state at the end of useful life

## Results:

- NEOX wet pad Ex-Situ measurements show that DISK-B had a significant buildup in pad asperity height indicating pad glazing. ***Pad glazing can drive up the contact area, or limit the amount of slurry effectively flowing through the asperities, and this can drive up polish temperatures. When polish temperatures go up, polish rates, especially with metals can go up. Further analysis of Disk-B showed an issue with the diamonds***

## Conclusion/Proof of Concept:

- NEOX Ex-Situ "wet" pad measurements were capable of resolving an IC1000 pad state change (glazing) that was associated with a process change (polish time reduction)

## Suggestions for further work:

- Develop a procedure to "rejunivate" IC1000 pad, by re-normalizing the pad asperity height distribution. Monitor asperity data to catch the on-set of pad glazing before impacting wafer quality

# NEOX Ex-Situ "Wet" CMP Pad Measurements

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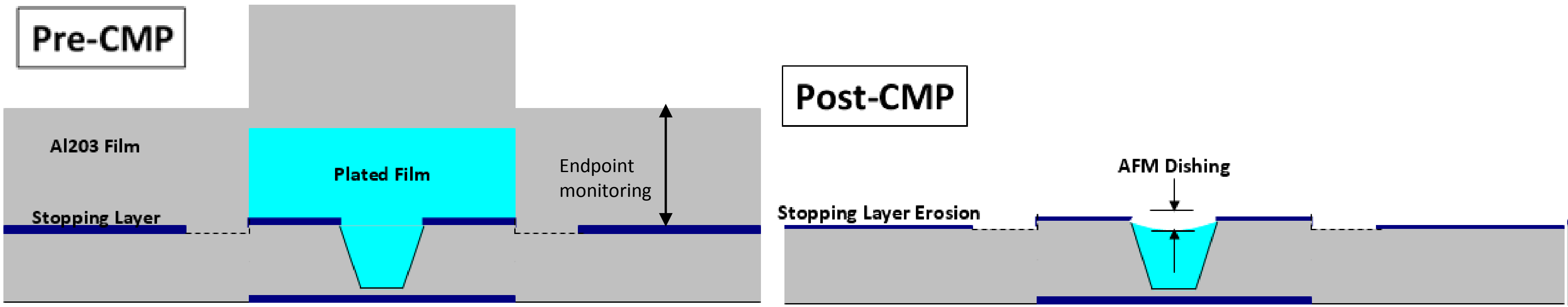
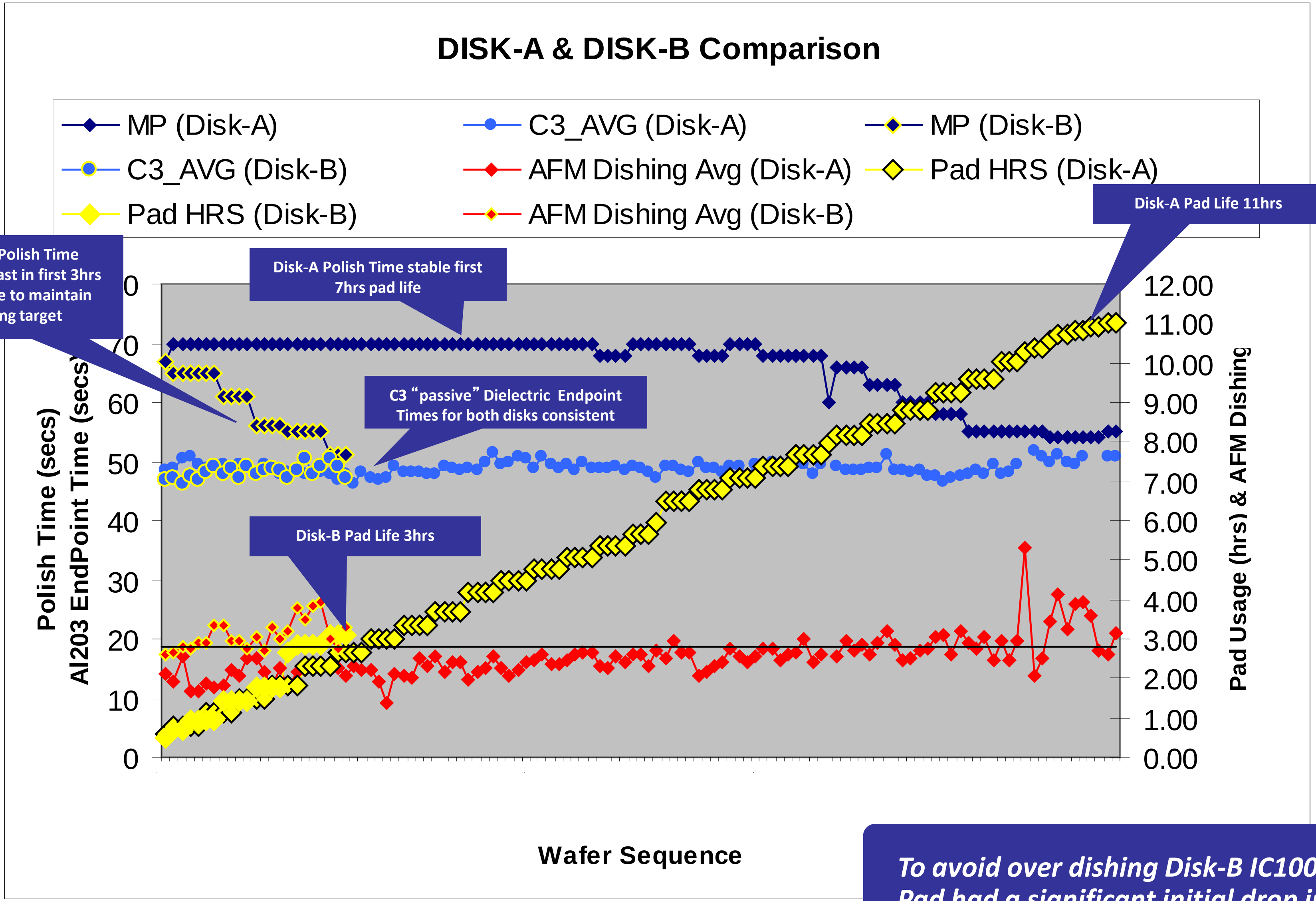


# Case Study 2 Process: *Damascene CMP Accelerated Metal rate*




***To avoid over dishing Disk-B IC1000 Pad had a significant initial drop in polish time compared to Disk-A***

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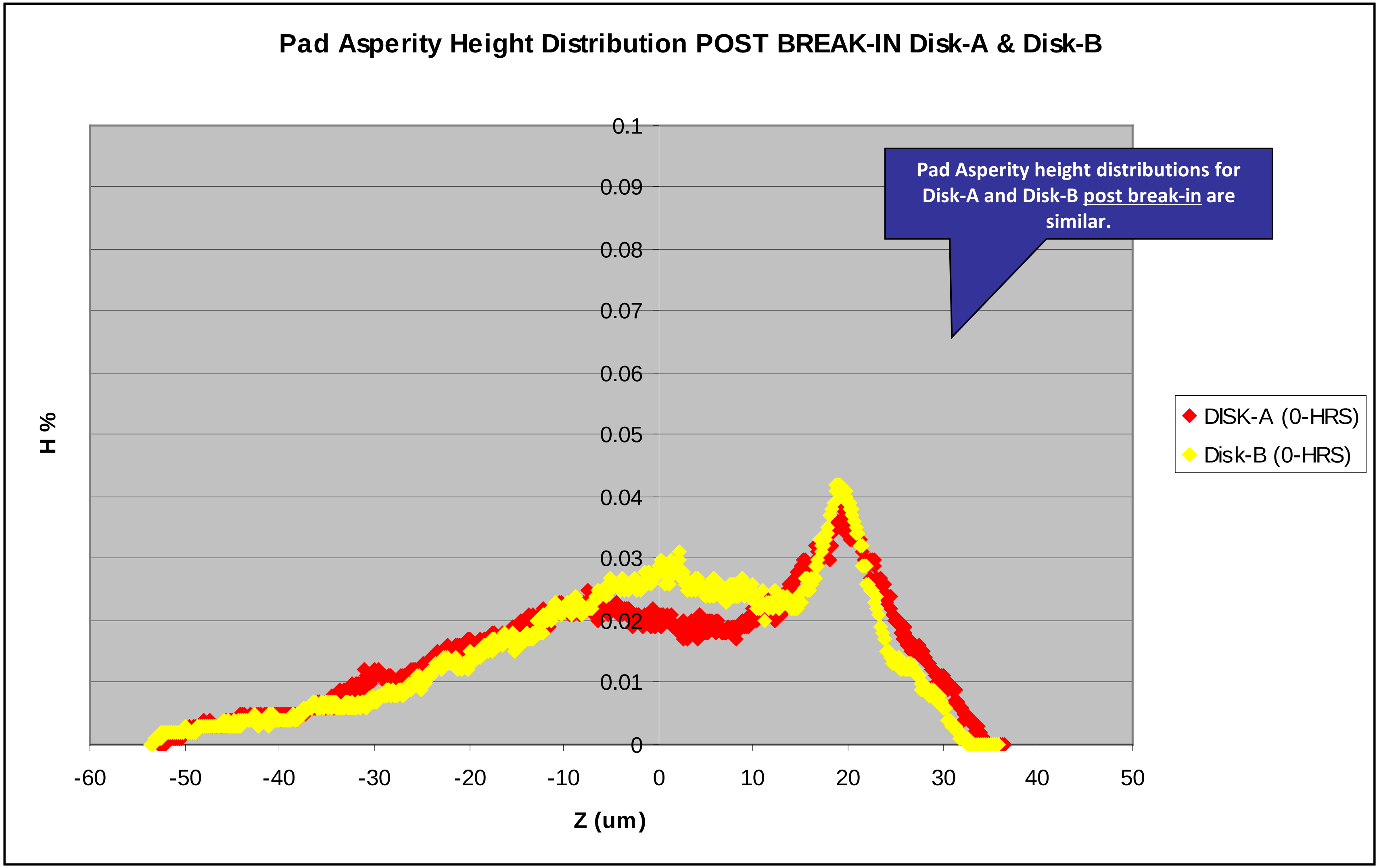


**Same IC1000 Pad Lots**

**Measurements taken at wafer track MD in both cases (POST PAD BREAK-IN)**

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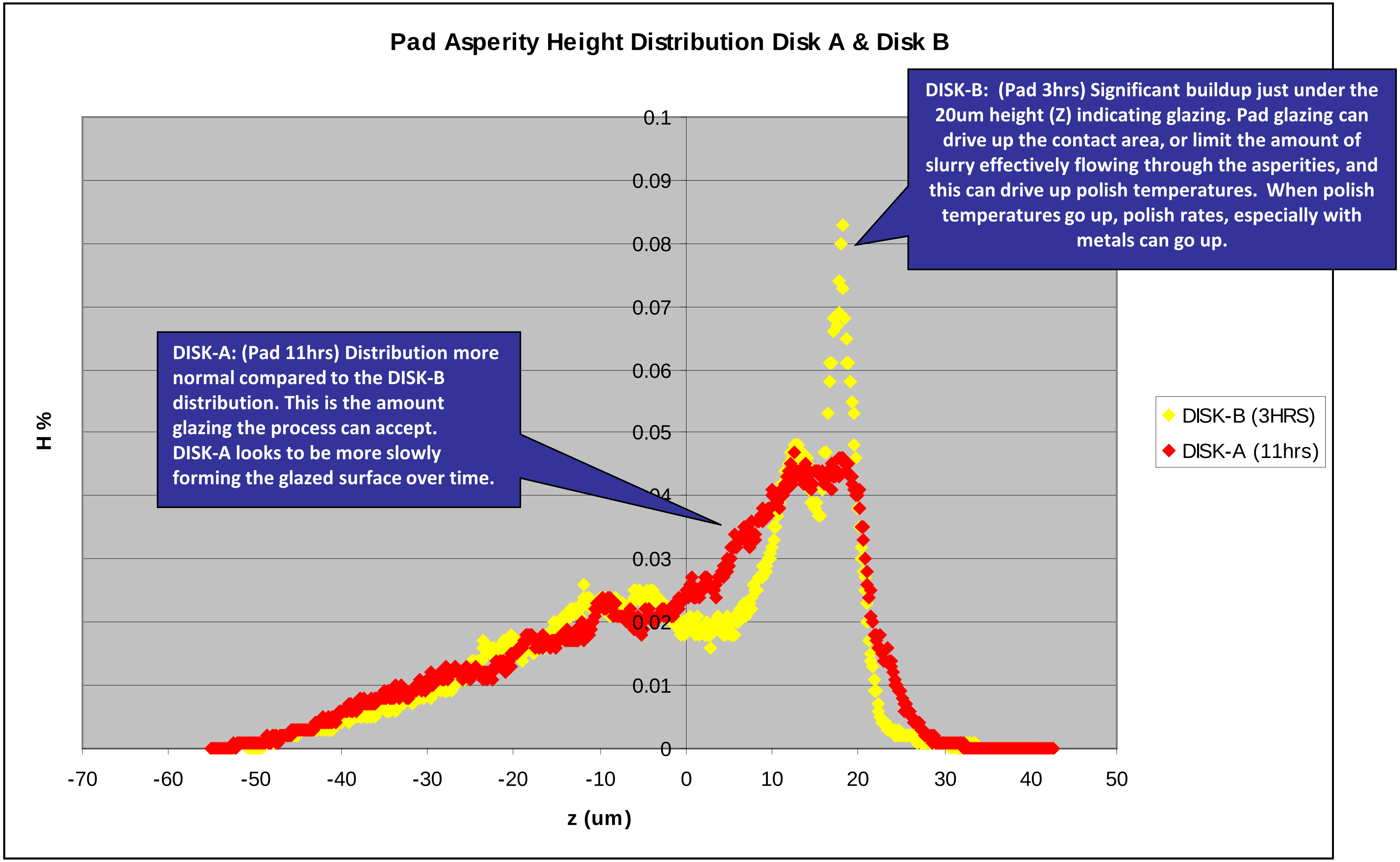


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**Measurements taken at wafer track MD in both cases (END OF USEFUL LIFE)**

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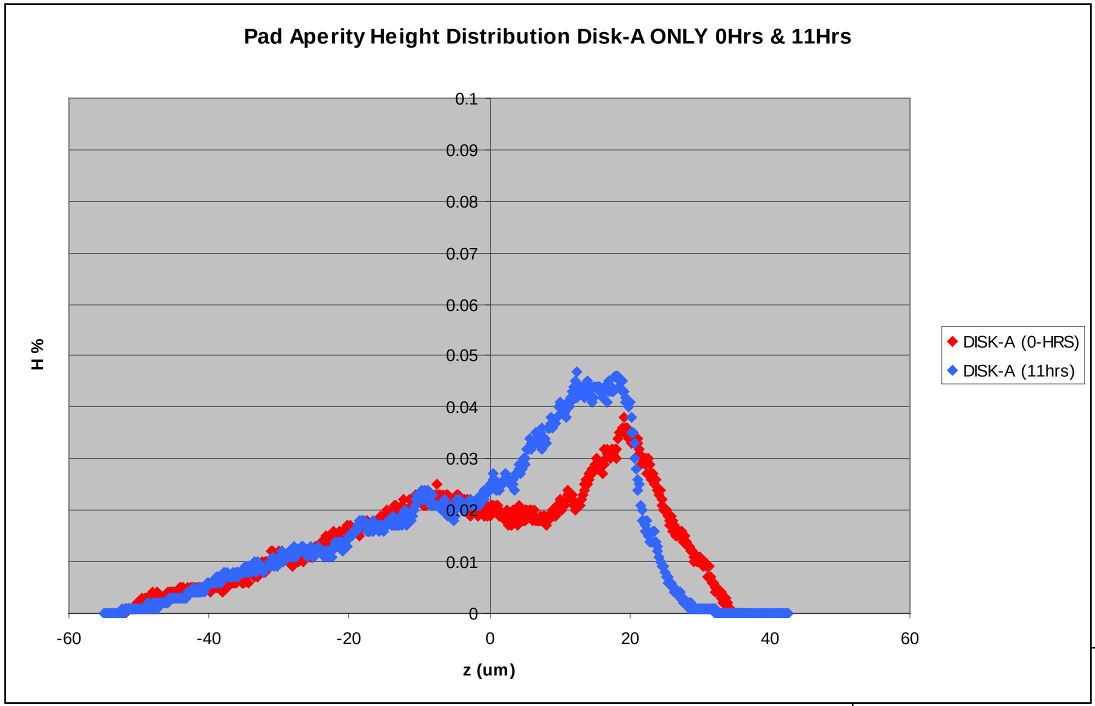
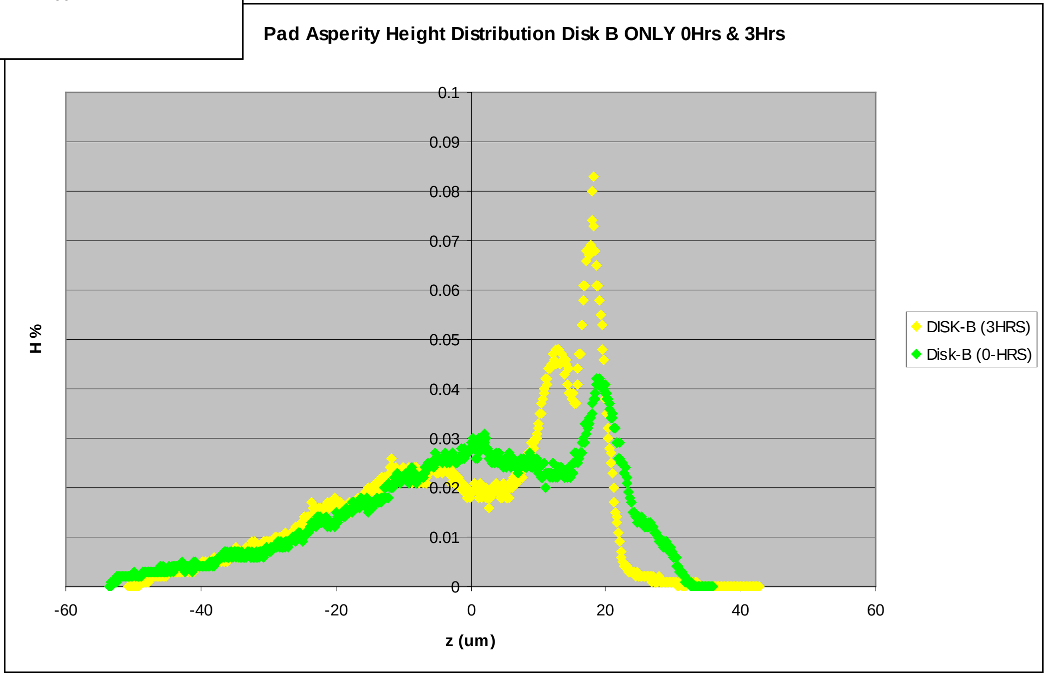


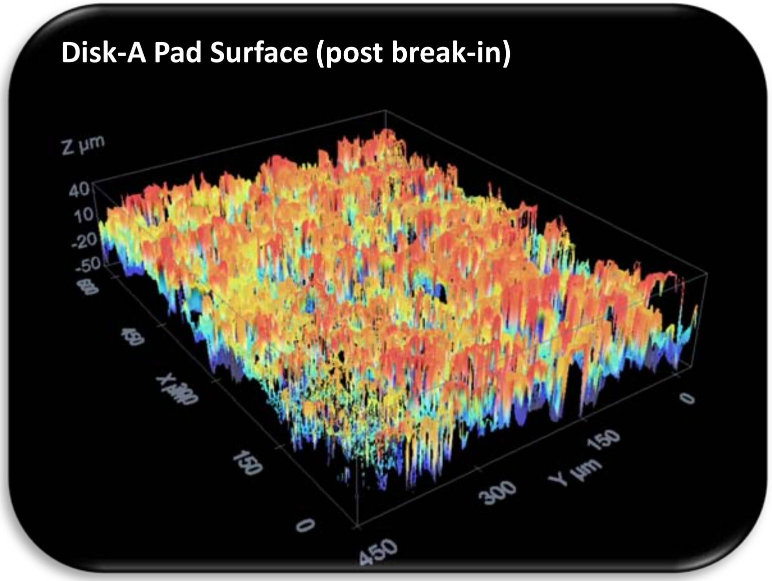




**Same IC1000 Pad Lots**

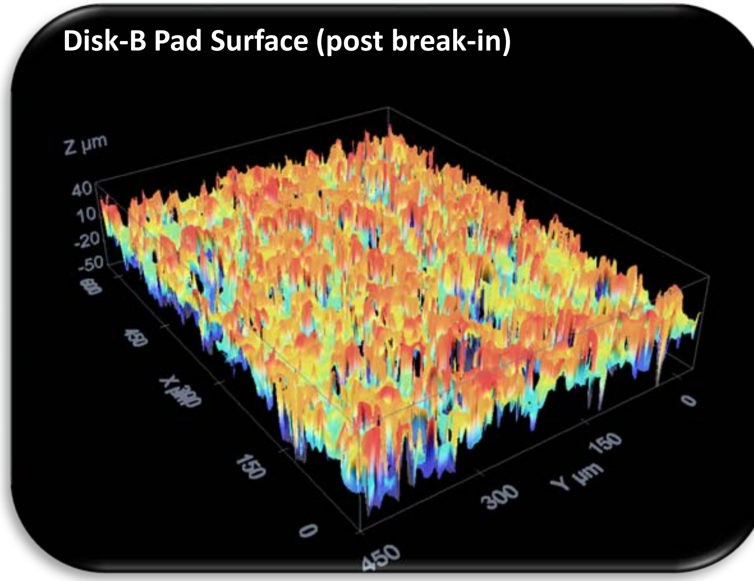
**Measurements taken at wafer track MD**

# Case Study 2 Process: *Damascene CMP Accelerated Metal rate*

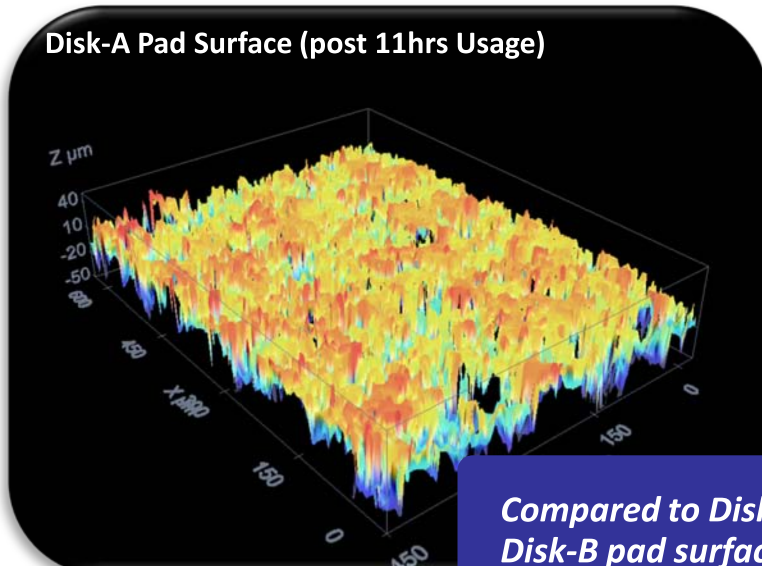
Disk-A Pad Surface (post break-in)



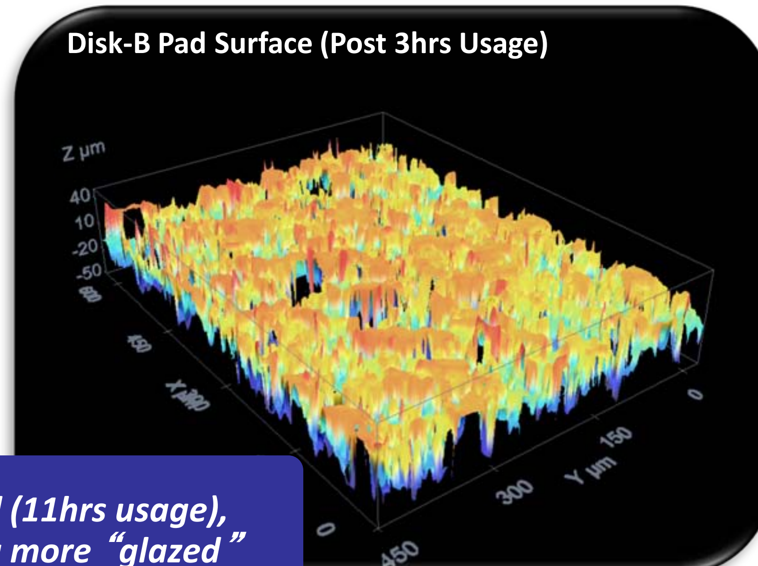

Disk-B Pad Surface (post break-in)




Disk-A Pad Surface (post 11hrs Usage)




Disk-B Pad Surface (Post 3hrs Usage)

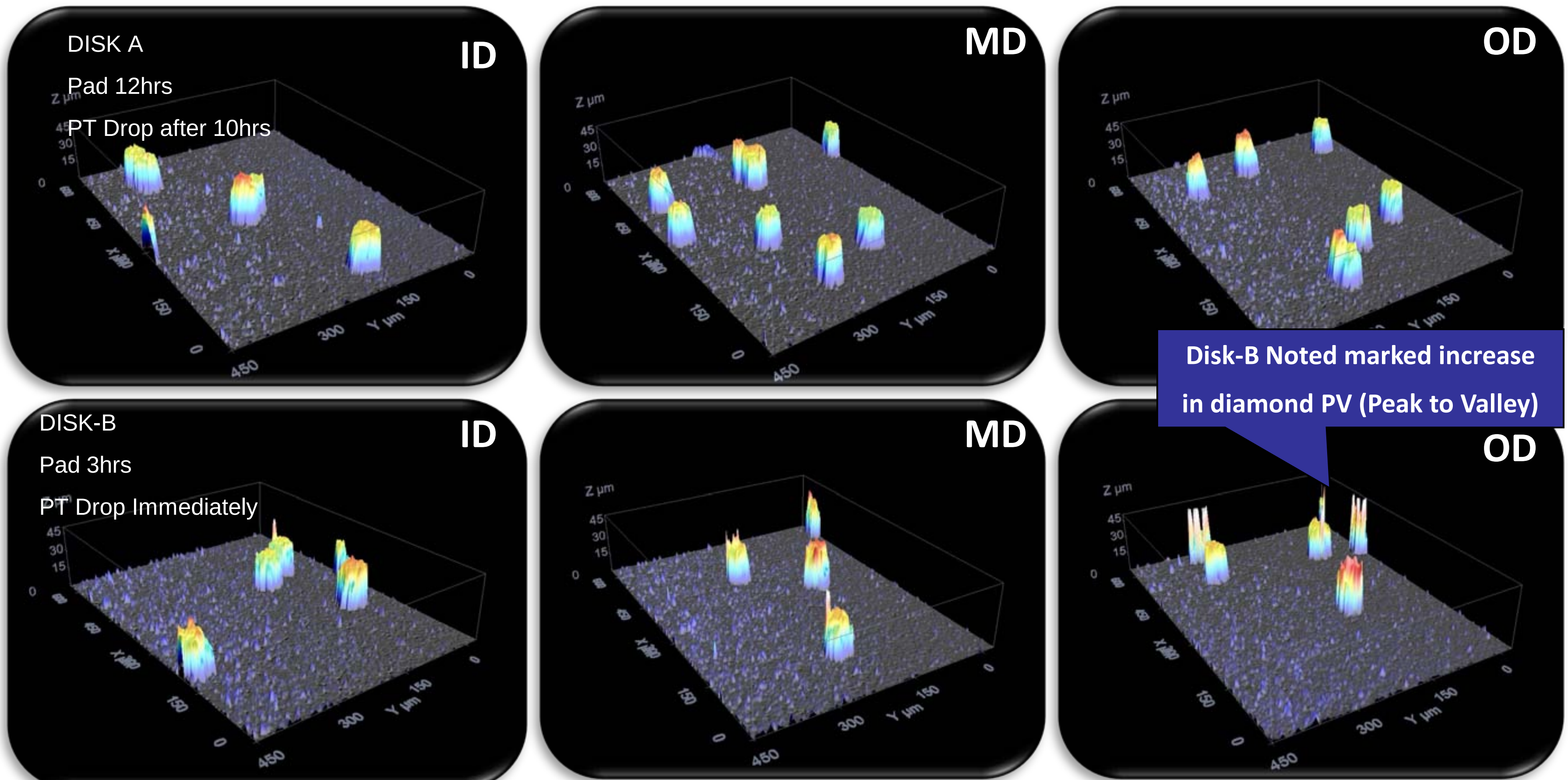



*Compared to Disk-A pad (11hrs usage), Disk-B pad surface has a more "glazed" appearance after only 3hrs of usage*

**Same IC1000 Pad Lot**

# Case Study 2 Process: *Damascene CMP Accelerated Metal rate*

*NOTEWORTHY: Using NEOX (Non-Immersion lens) Disk-B Diamonds exhibited a noted non-uniformity not seen on DISK-A, probably causing a non-uniform Pad/Disk contact and compromised pad conditioning, possibly resulting in early onset of the pad glazing*



# NEOX CMP Tool 2013

1.Microdisplay-confocal scanning

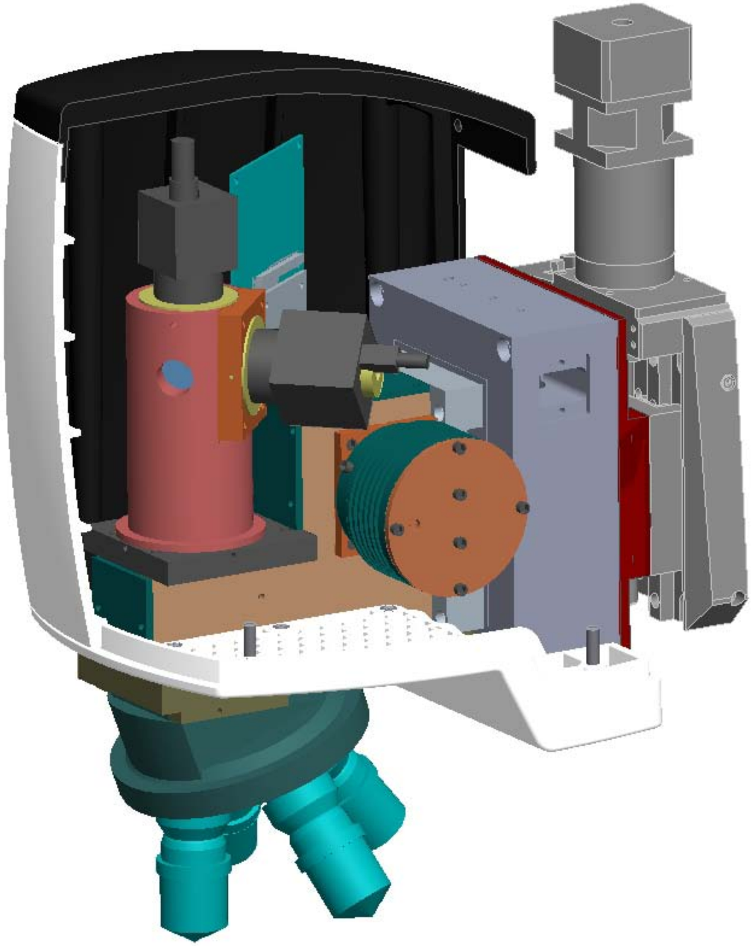
2.Color CCD camera

3.Dual vertical scanner

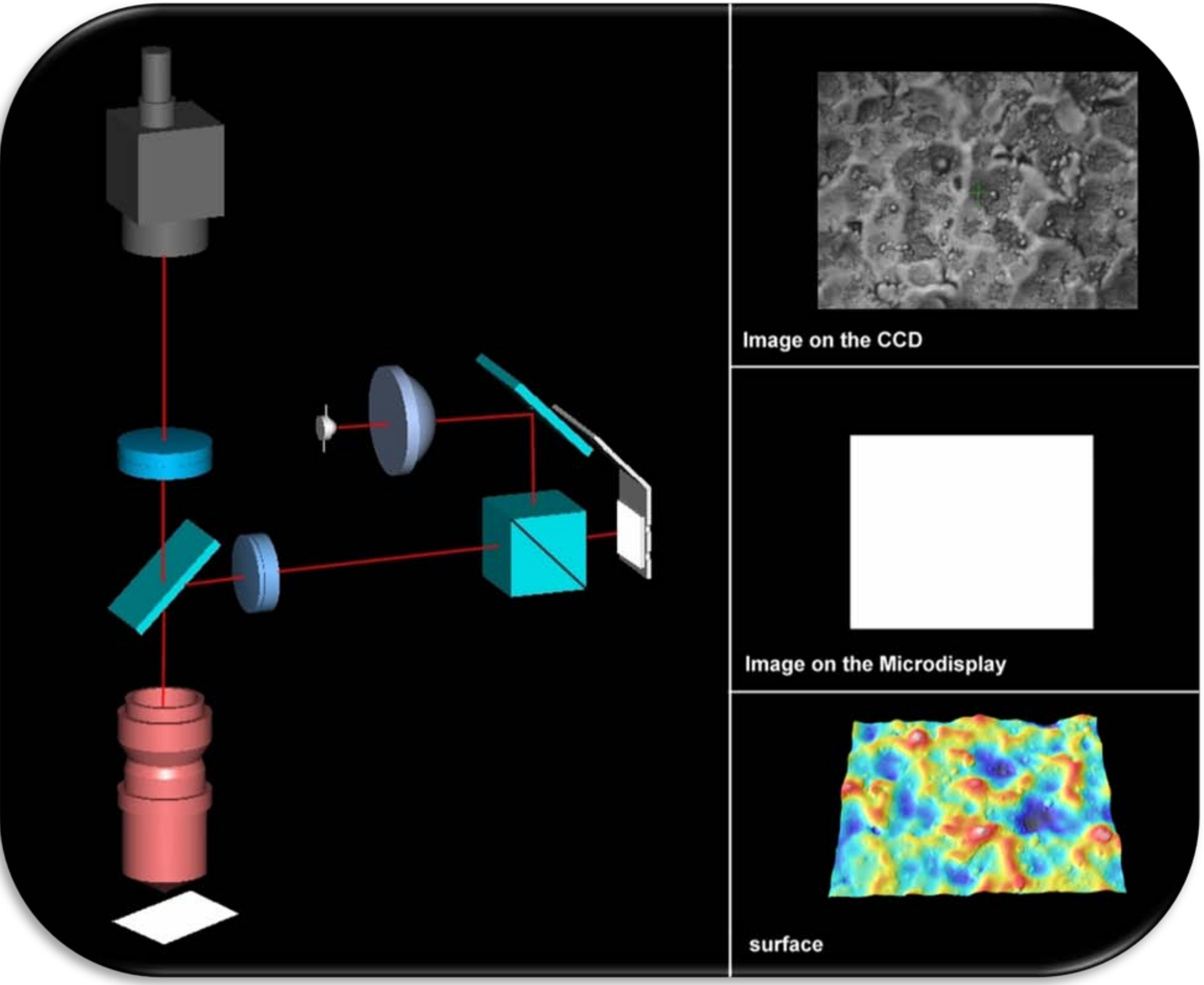
1.Dual LED

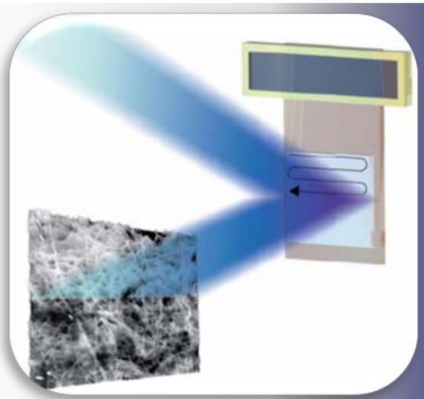
1.High speed (12.5 confocal fps)

2.Non contact immersion objetive

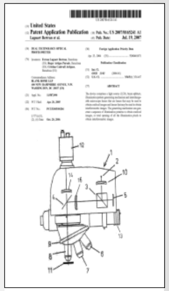


# Plu NEOX: How does it work?



## Sensofar's Patented Technology



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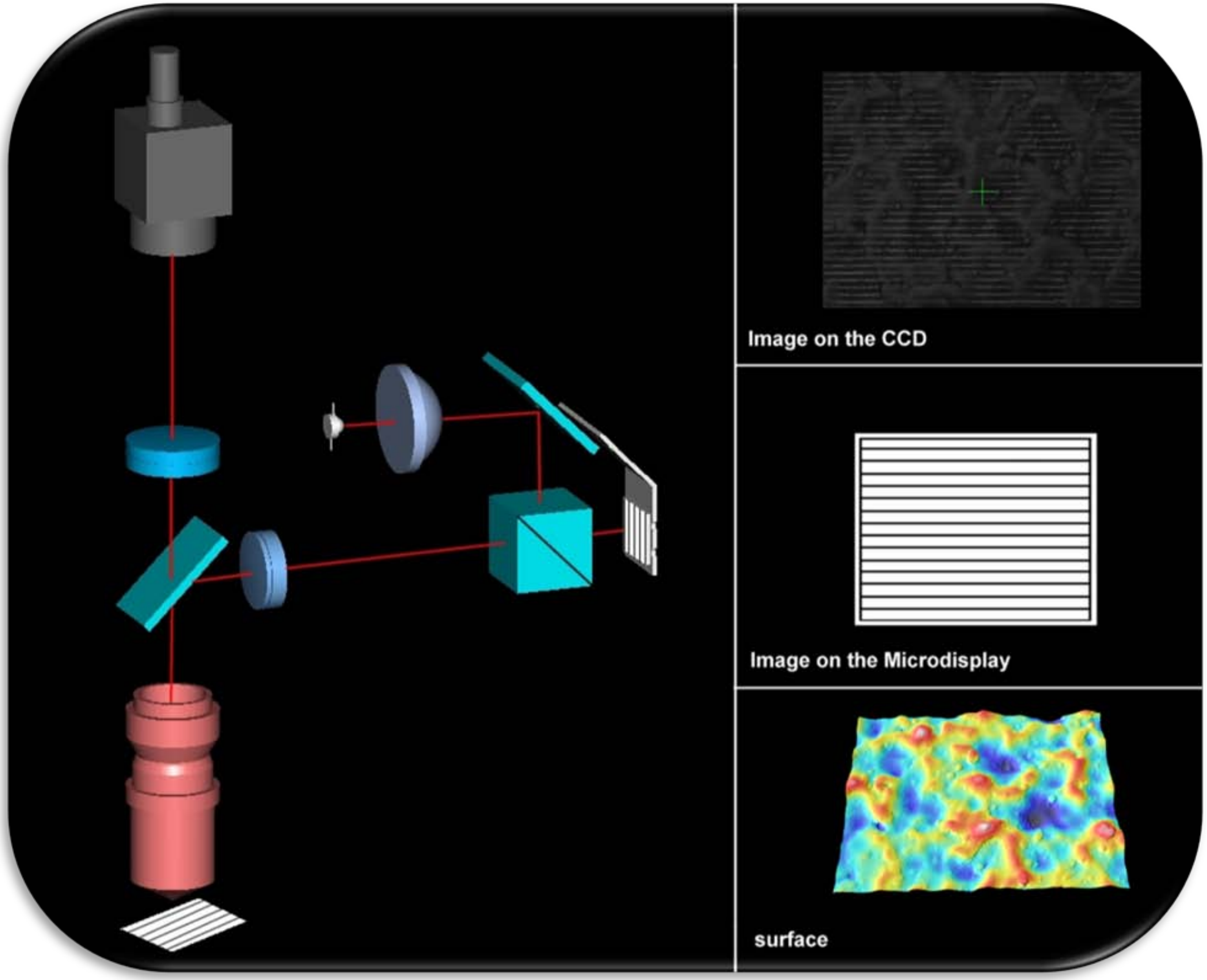


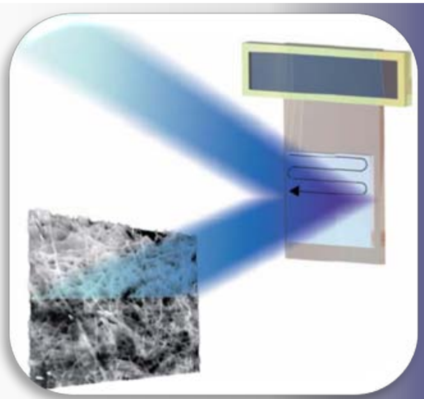

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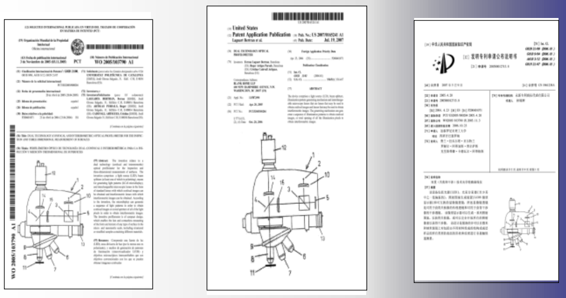

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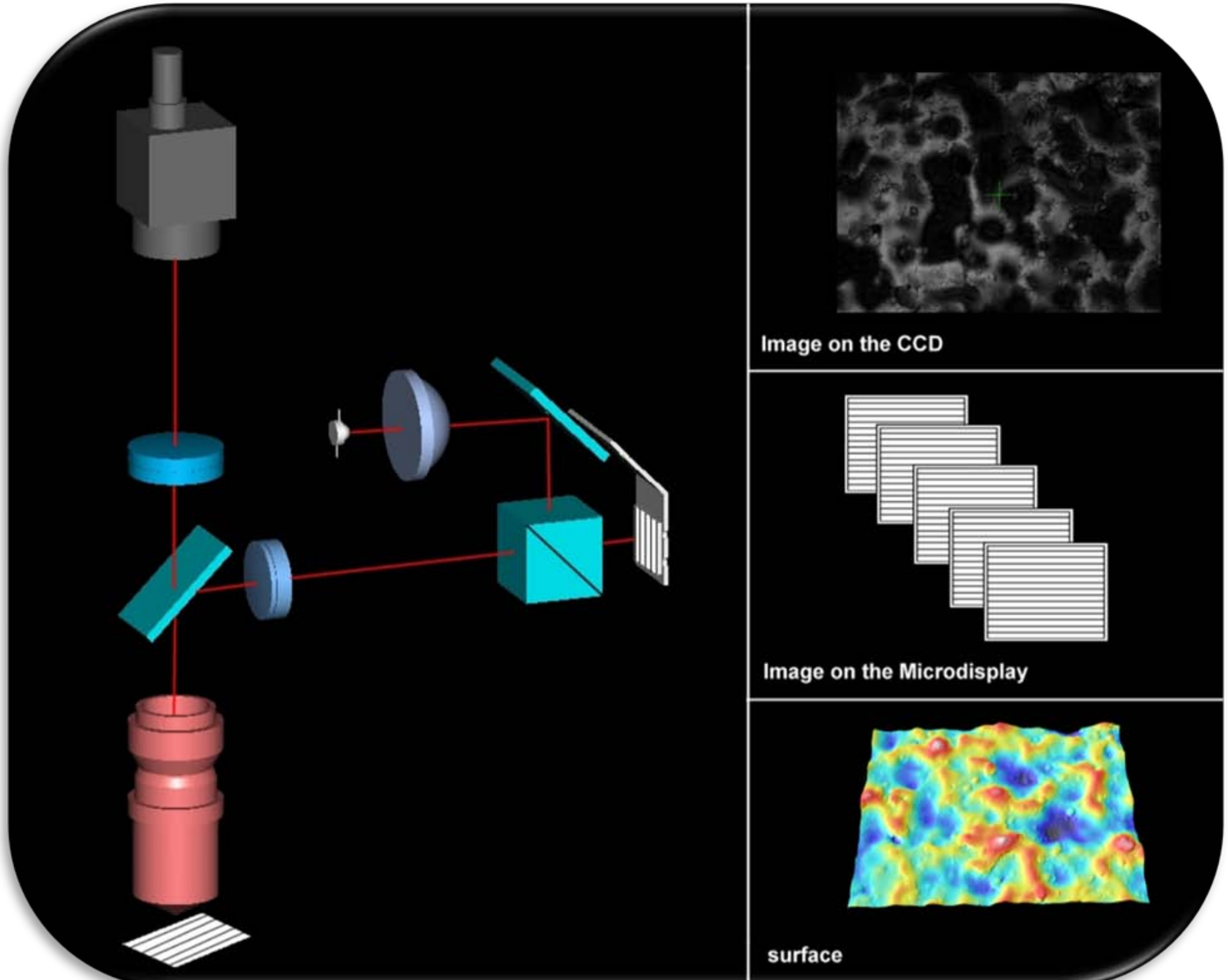


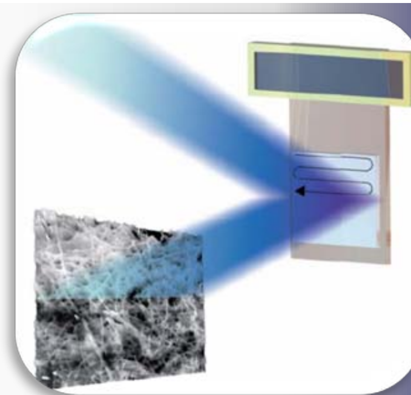

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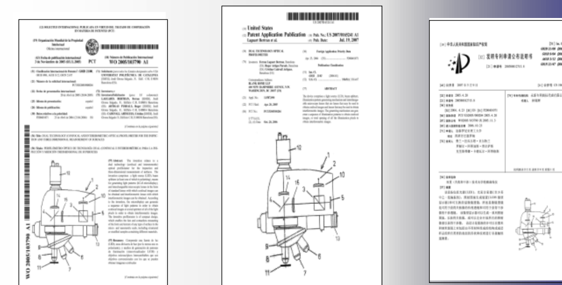

# NEOX CMP Tool 2013


Upgraded the CPU for faster processing speed

Flat Teflon feet to avoid pad damage

Carrying handles for ease of placement

# NEOX CMP Tool 2013

# Thank you