

Applications of MRF

Case Study – Improve Surface Roughness –
Ultra Low Surface Roughness Polishing

Presented By:

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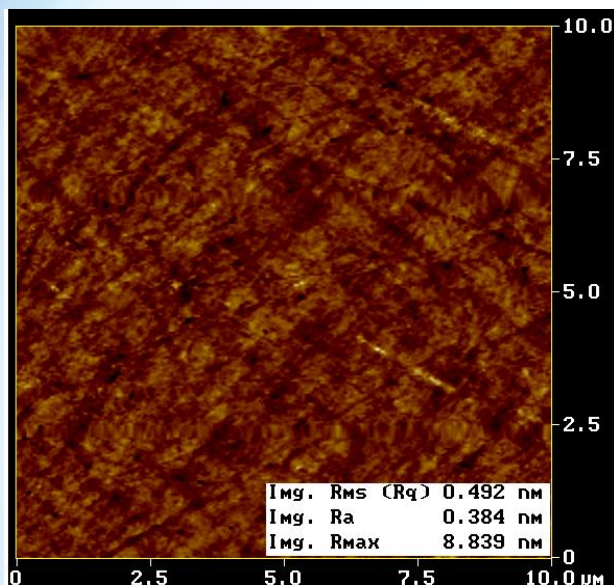
Ultra-low Surface Roughness Polishing

Motivation

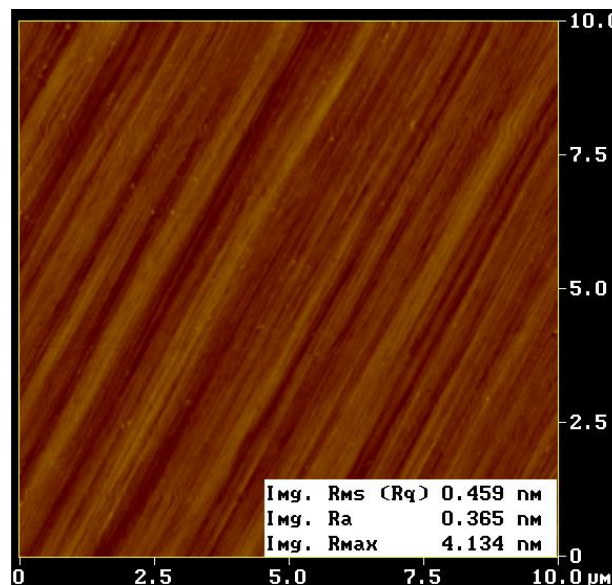
- ❖ MRF generally maintains or improves surface roughness
 - Minimum roughness obtained with MRF typically 3-5 Å
 - Results depend on substrate material and MR fluid used
- ❖ Several key applications require significantly smoother surfaces, even below 1 Å:
 - EUV lithography, high-power laser optics, X-ray mirrors
- ❖ Conventional polishing methods (pitch or synthetic pads) can sometimes achieve lower surface roughness ($< 2 \text{ \AA}$)
 - Generally requires highly skilled optician
 - Low yields due to unpredictability of process, resulting in high costs
- ❖ Our goal was to significantly improve MRF, to deliver a predictable, ultra-low surface roughness polishing process

Typical Results with Fused Silica

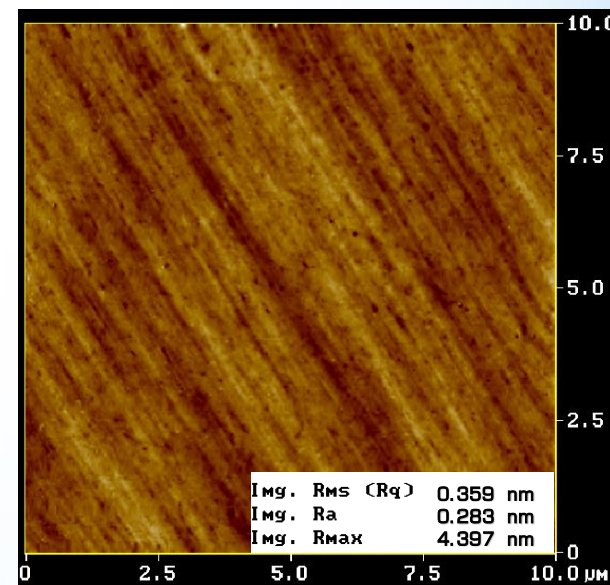
- 50mm diameter fused silica plano part, measured with Atomic Force Microscope (AFM)



Conventional Pitch
Polishing
rms = 4.9 Å



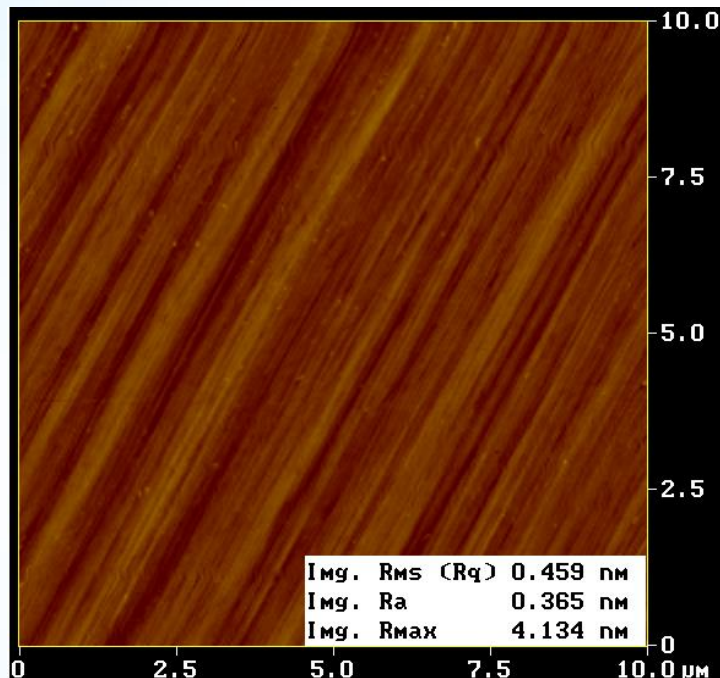
MRF Polished with
D11 fluid
rms = 4.6 Å



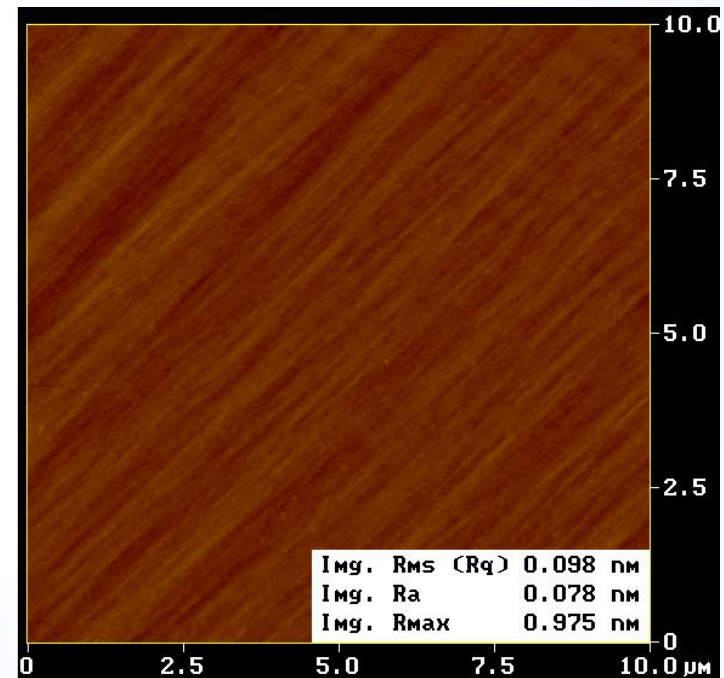
MRF Polished with
C10 fluid
rms = 3.6 Å

Improved Results with Fused Silica

◆ Results obtained with new C30 fluid



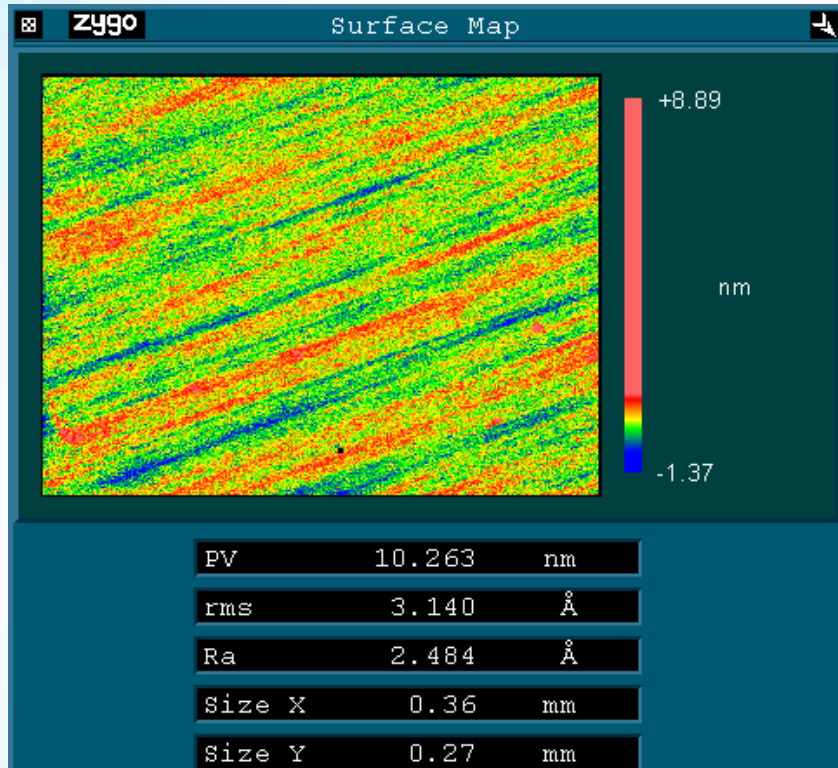
MRF Polished with
D11 fluid
rms = 4.6 Å
0.25 μm removed



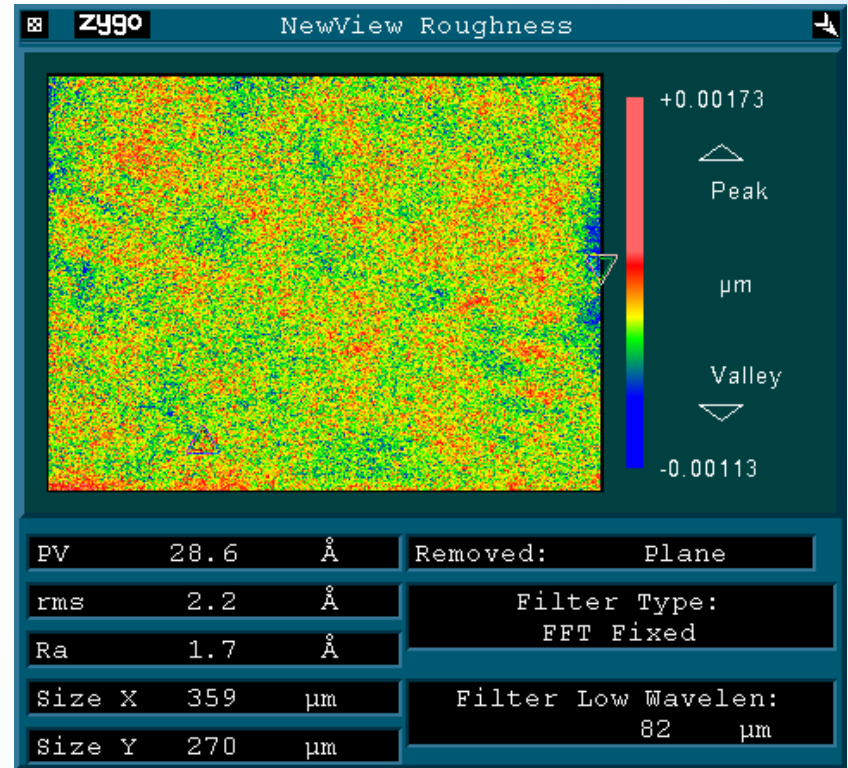
MRF Polished with
C30 fluid
rms = 1.0 Å!
10 nm removed!

Improved Results with Fused Silica

- ◆ Typical MRF flow pattern drastically reduced with C30
 - Measured with white light interference microscope



MRF Polished with D11 fluid
rms = 3.1 Å



MRF Polished with C30 fluid
rms = 2.2 Å

Measured near center at 20x magnification, 80um high pass filter applied