Optical Inspection of Transparent Materials

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Lumina Instruments

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Lumina Instruments, headquartered in San Jose, California, USA, develops and manufactures optical scanning systems to do full surface imaging of sub-nanometer film defects on transparent, translucent, and opaque substrates.

The Lumina AT1's laser scanning technology system enables the scanning of non-circular, fragile or irregular shaped samples.

The AT1 accommodates transparent, silicon, compound semiconductor, or metal substrates, with sizes up to 300-mm x 300-mm.

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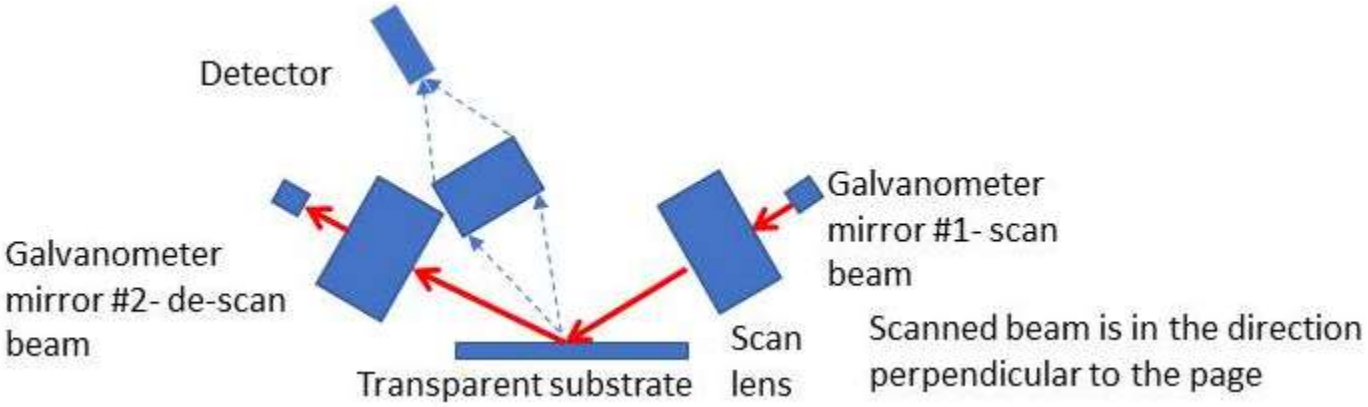
Agenda

- Description of Lumina's technology
- How the technology works
- What does it measure
- Examples of imaging on glass and sapphire surfaces
  - A sapphire surface
  - Monolayer stains on a thin glass wafer
  - Statics and dynamics of an adhesive on glass
  - Sectioning an interior layer within a glass component
  - Using the slope channel to image glass topography
  - Imaging residual stress within glass
- Summary

Lumina AT1 - Description

The Lumina Instruments AT1 introduces an innovative technology in laser scanning which enables:

- Full surface scan and imaging of sub-nanometer film coatings and defects
- High immunity to vibration (unlike interferometers)
- Capable on transparent, semiconductor, or metal substrates
- Shape independent (non-spinning system)
- Scan time for a full surface scan of a 150 mm wafer is 3 minutes



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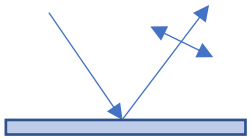
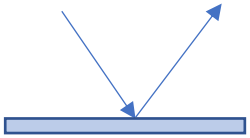
Lumina's capabilities on transparent substrates

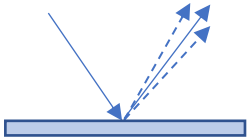
- Lumina's AT1 allows you to see what's on the upper most surface of a transparent surface in four different ways: Polarization change, Reflectivity, Slope and Dark field.



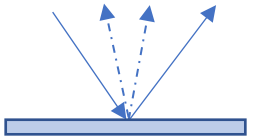
Polarization



Reflectivity

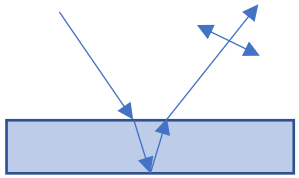


Surface Slope

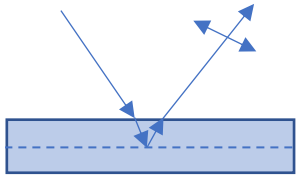


Dark Field

- Detection of internal defects (such as residual stress) and separate these from top surface defects:



- Section the internal structure of a glass component:



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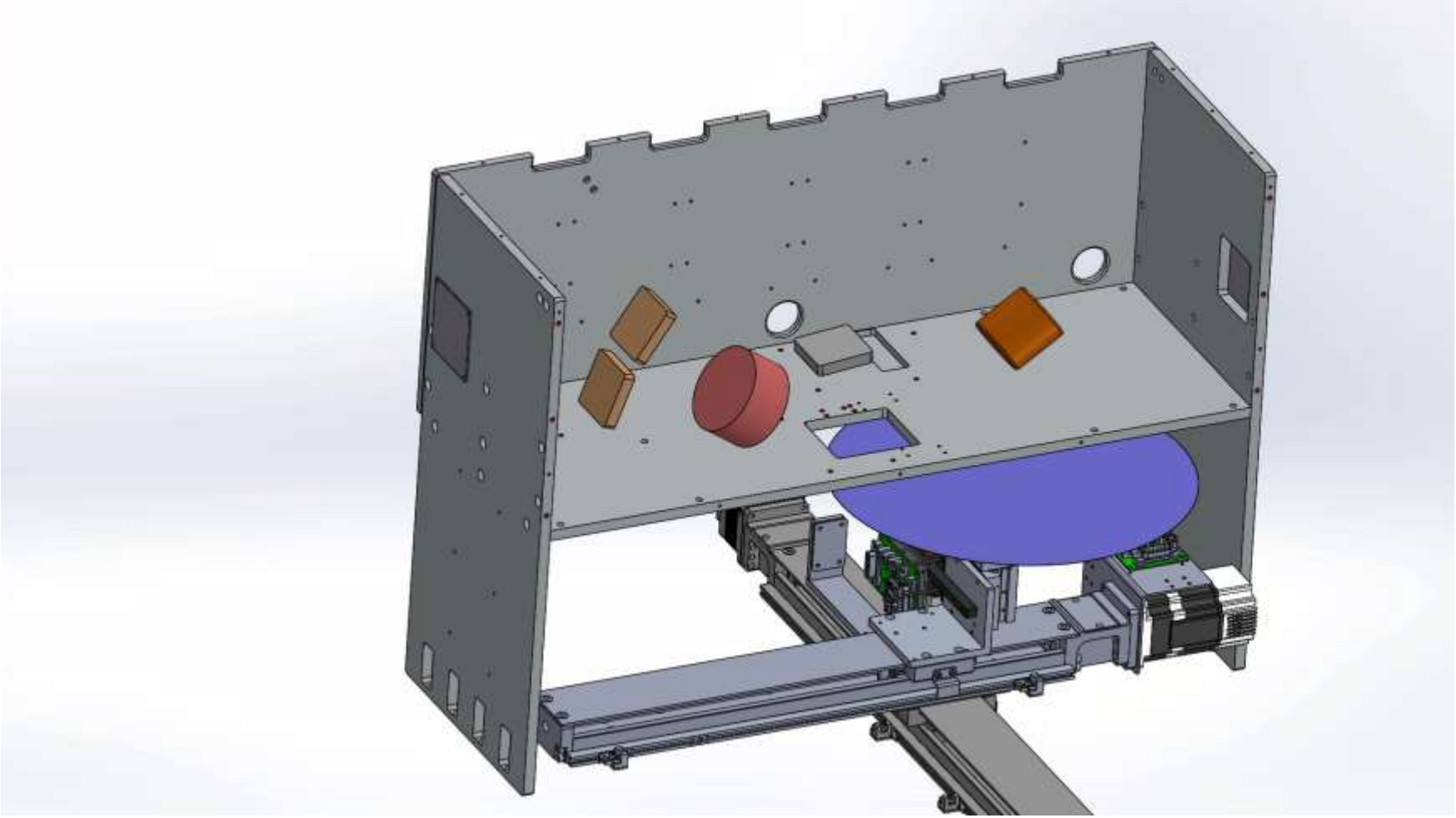
Optical Scanner for Thin Film Defects - AT1



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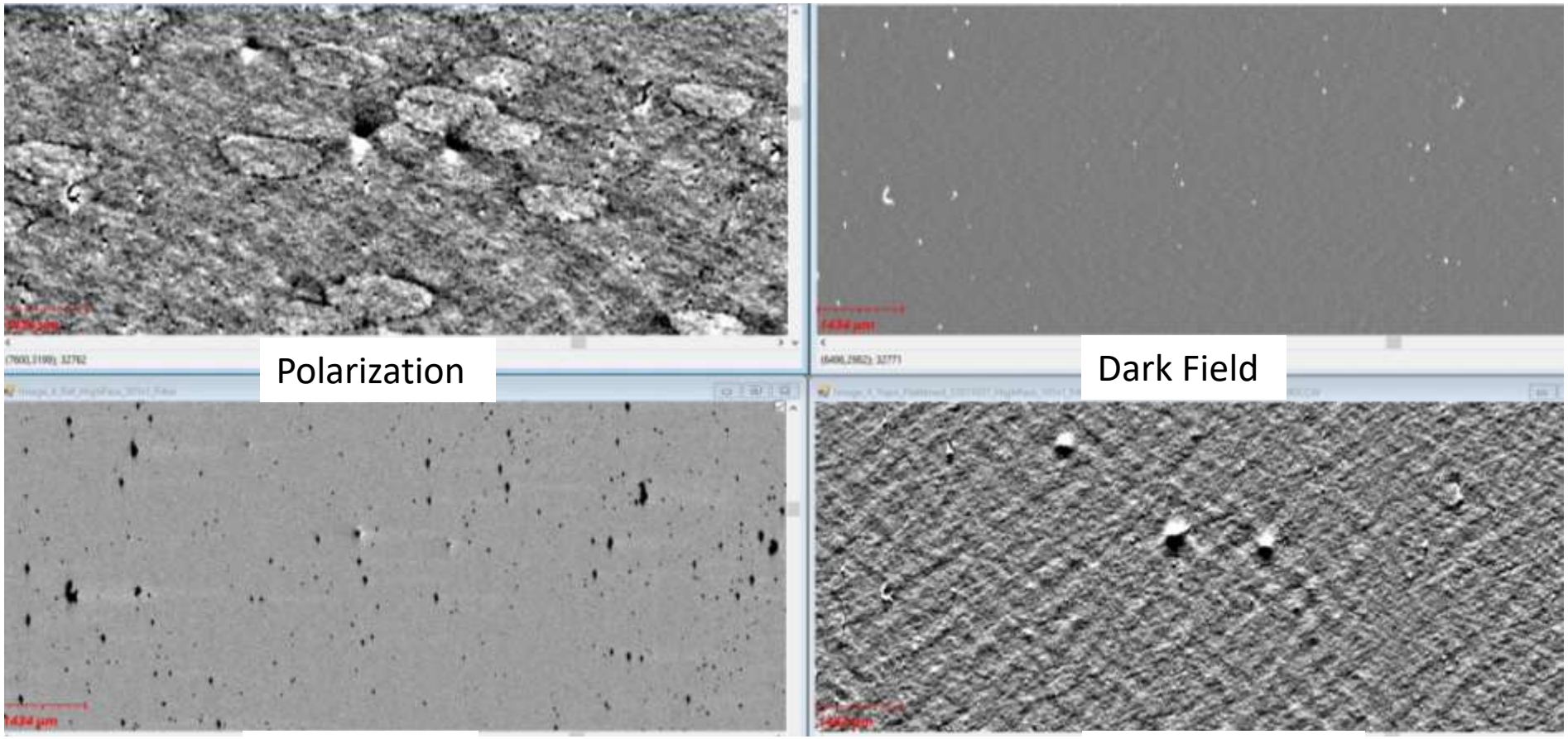
Four simultaneous channels of data on the top surface of a Sapphire substrate



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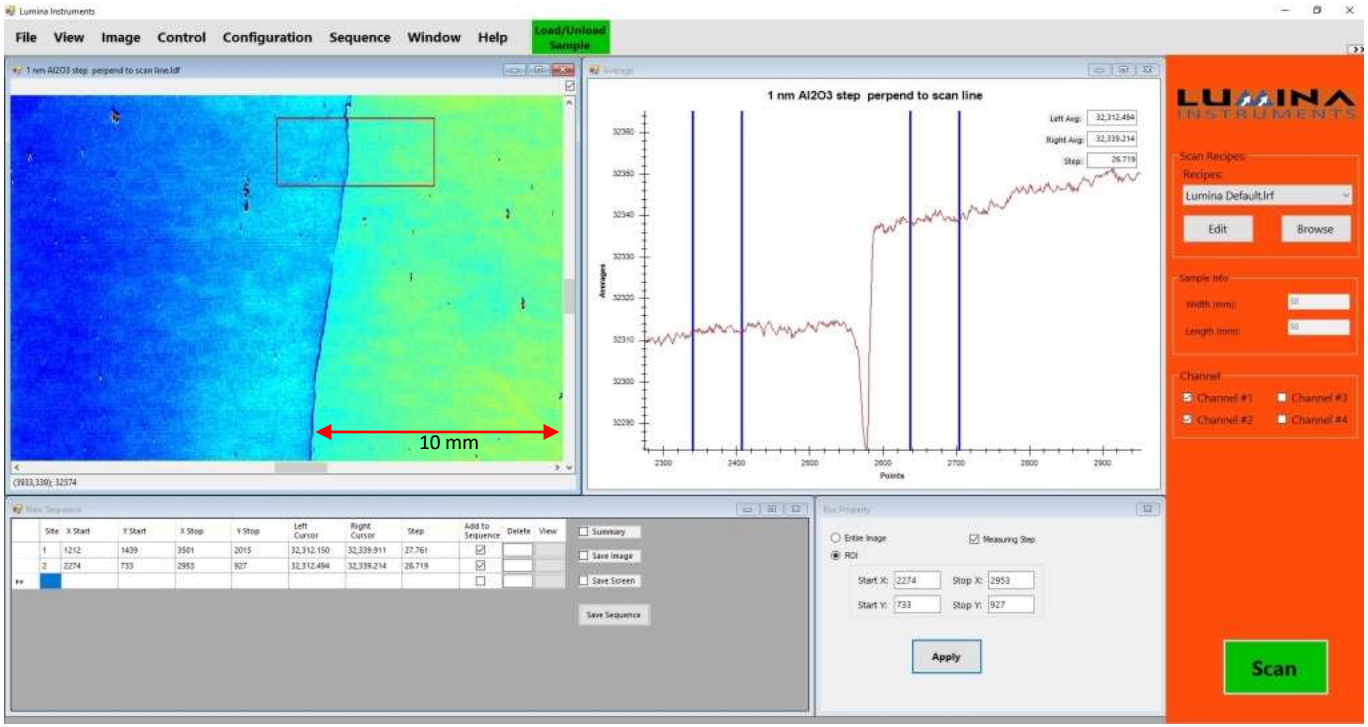
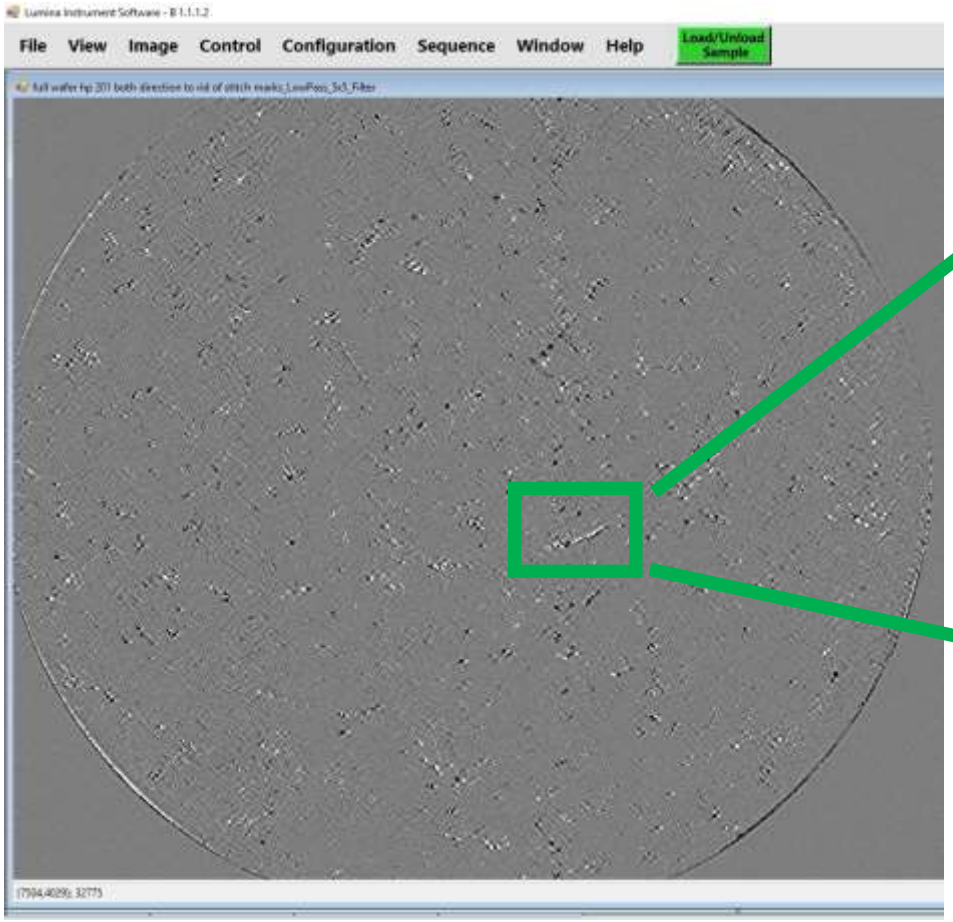
Example of system sensitivity to detection of transparent film on transparent material

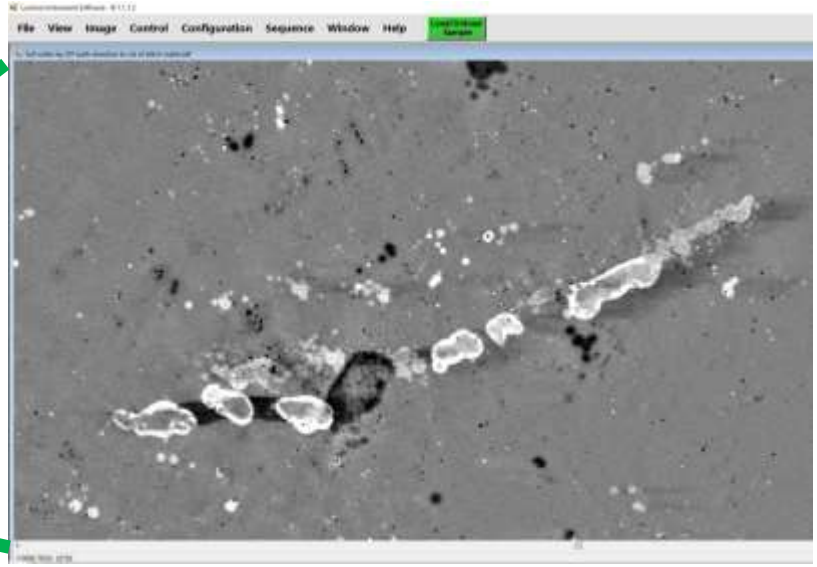
25x25 mm bare glass was half coated with 10Å Al_2O_3 film. Sample is scanned by Lumina AT1 in under 20 seconds. The 10Å step height of a transparent film on a transparent substrate is easily detected. ***Only possible with AT1 technology.***

10Å AlOx thin film on BK-7 Bare Glass



Full scan of 150-mm diameter Interposer Glass





Zoom view showing stains on both top and bottom surfaces

Glass thickness is 100 microns

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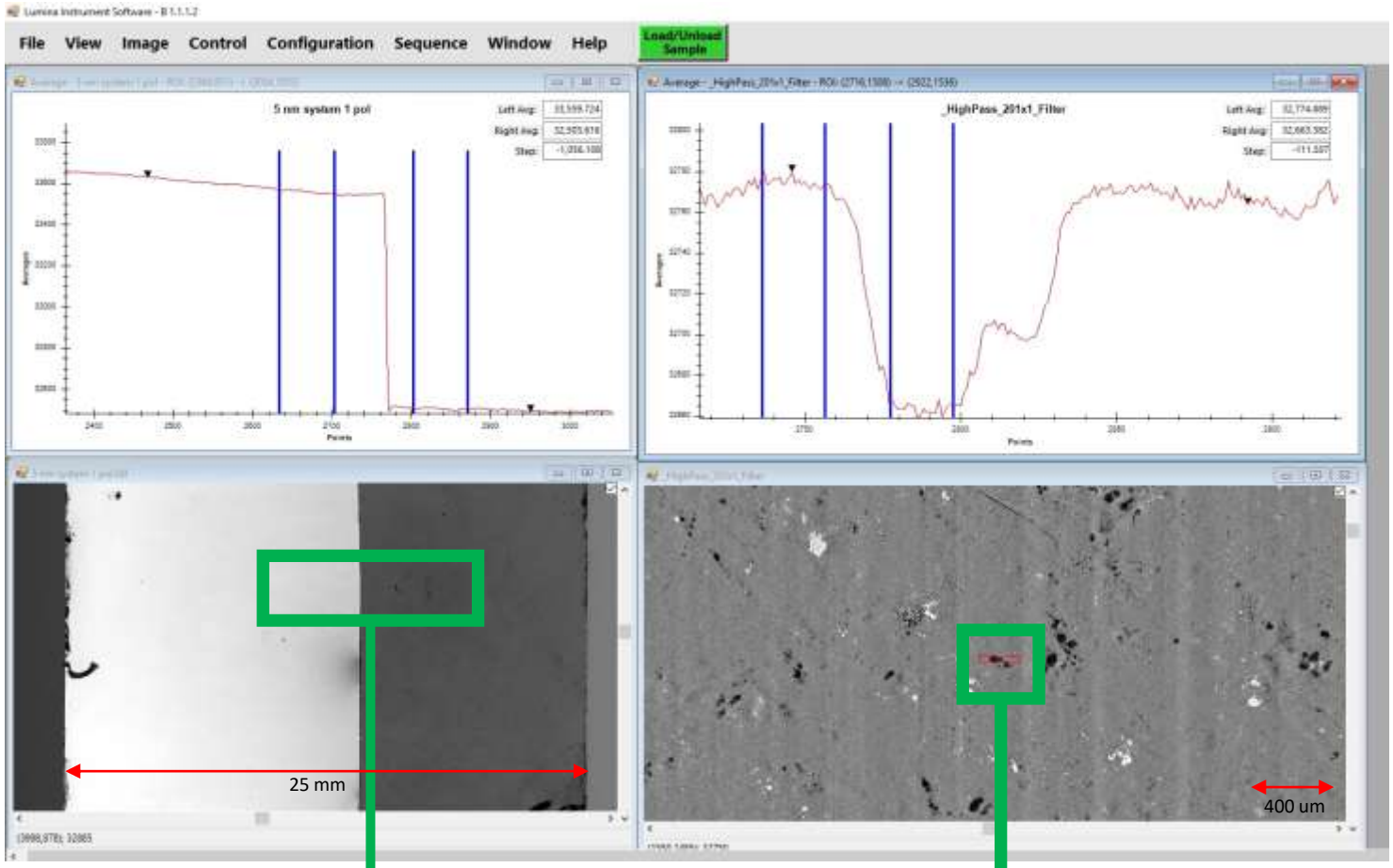
Comparison between 50Å step height and 5Å stain on Interposer Glass



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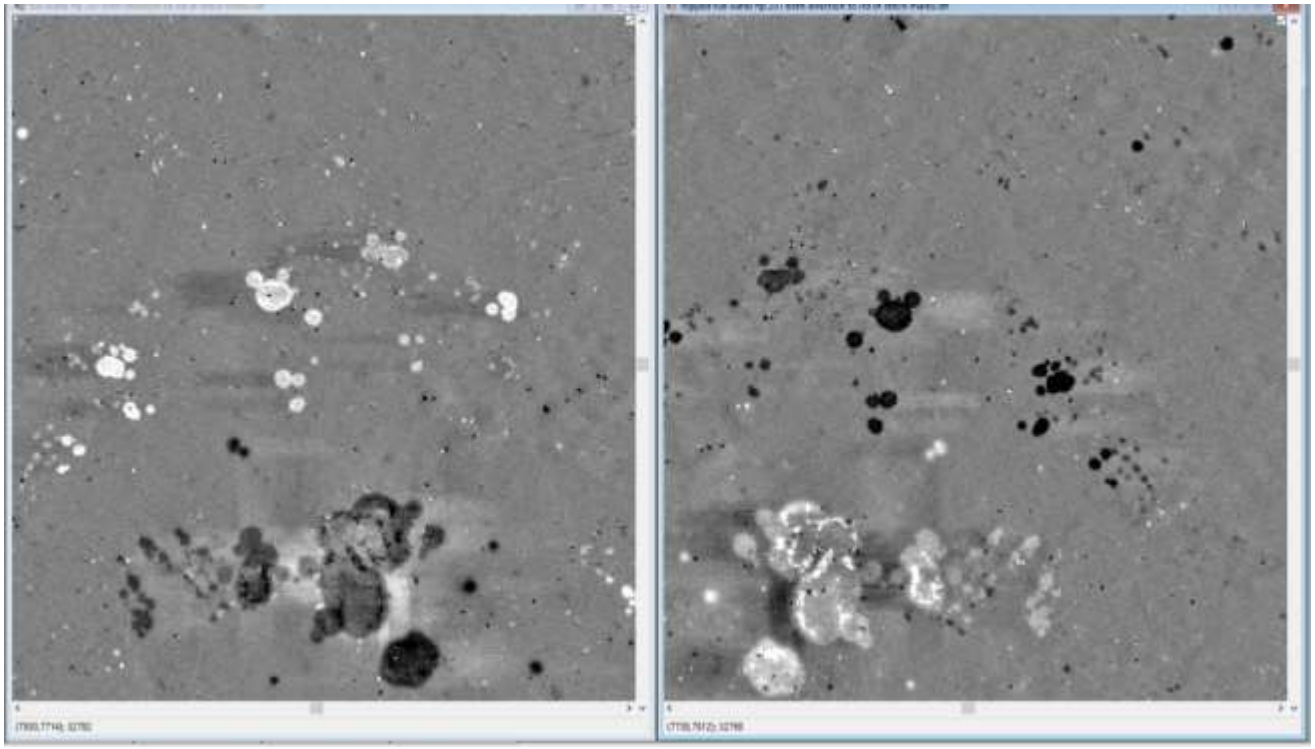
Distinguish stains on top and bottom surfaces of 100 µm thick glass



Scan on Top surface

Wafer flipped to scan on bottom surface

Dark defects are on the top surface. White defects are on the bottom surface.

Monolayer stains on a glass substrate

Surface stains and scratches from wash process

Top Surface polarization channel

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Top surface polarization image

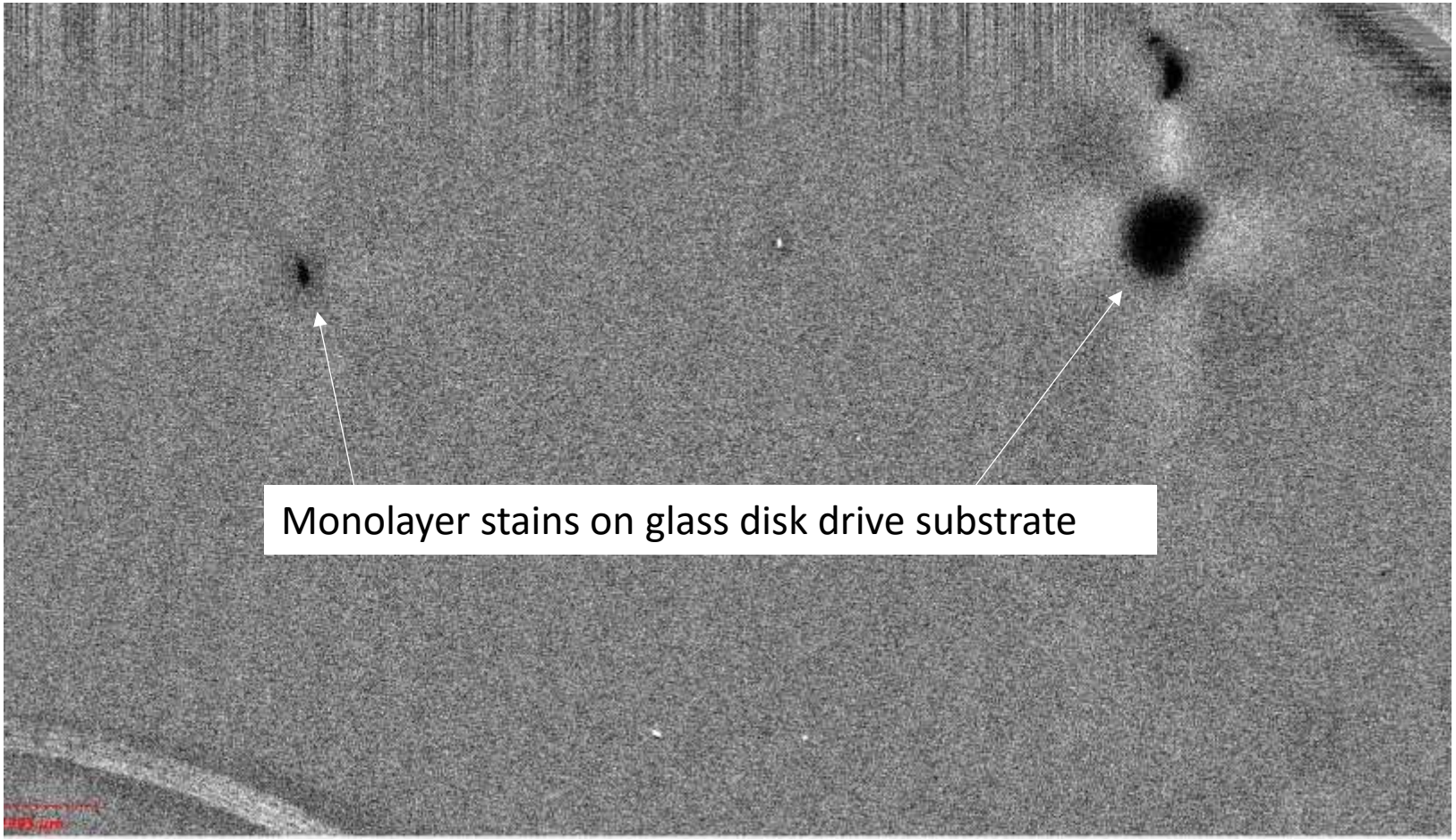

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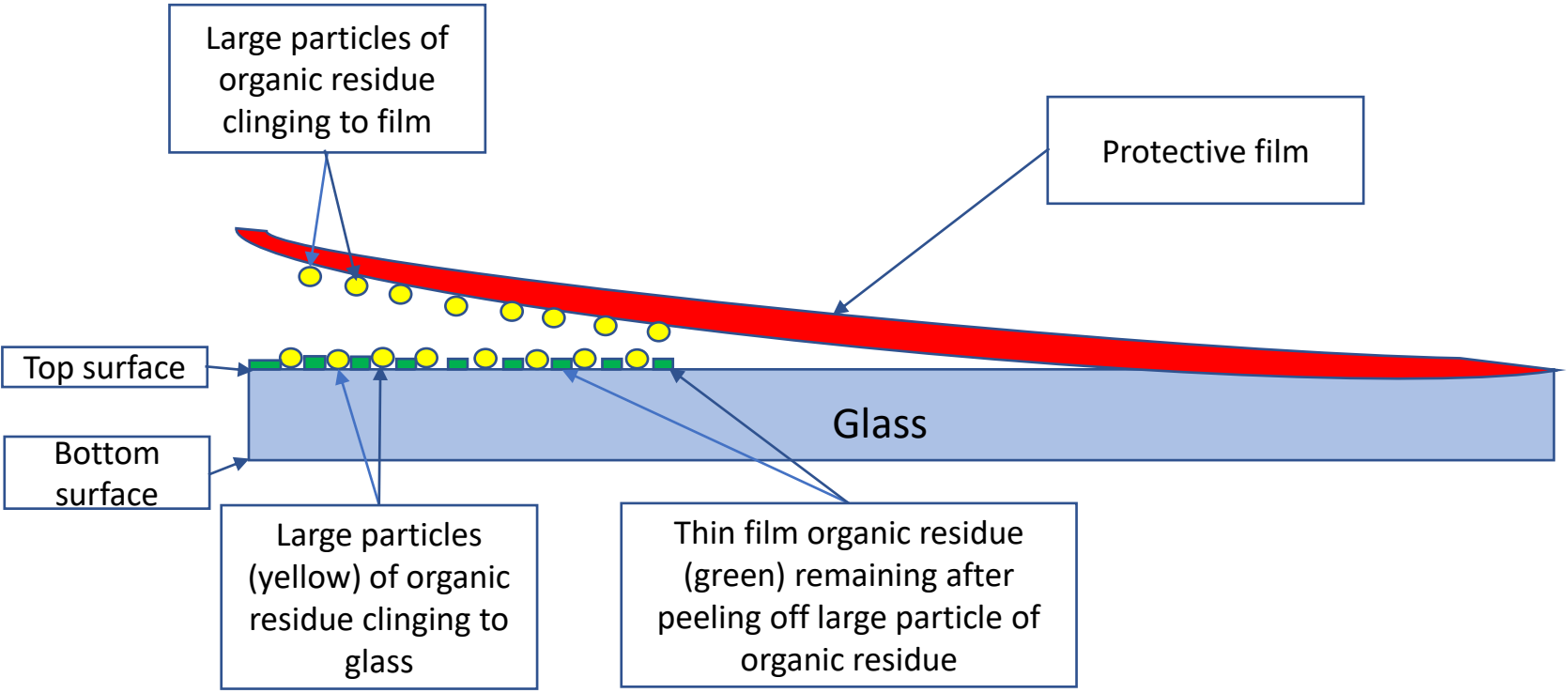
Illustration of process of peeling off protective film from a glass surface

The data indicates that when the protective film is removed what remains consists of large particles of organic residue interspersed with a thin film of organic residue. The thin film of organic residue is what remains when a corresponding large particle of residue is removed from the glass by the action of removing the film.



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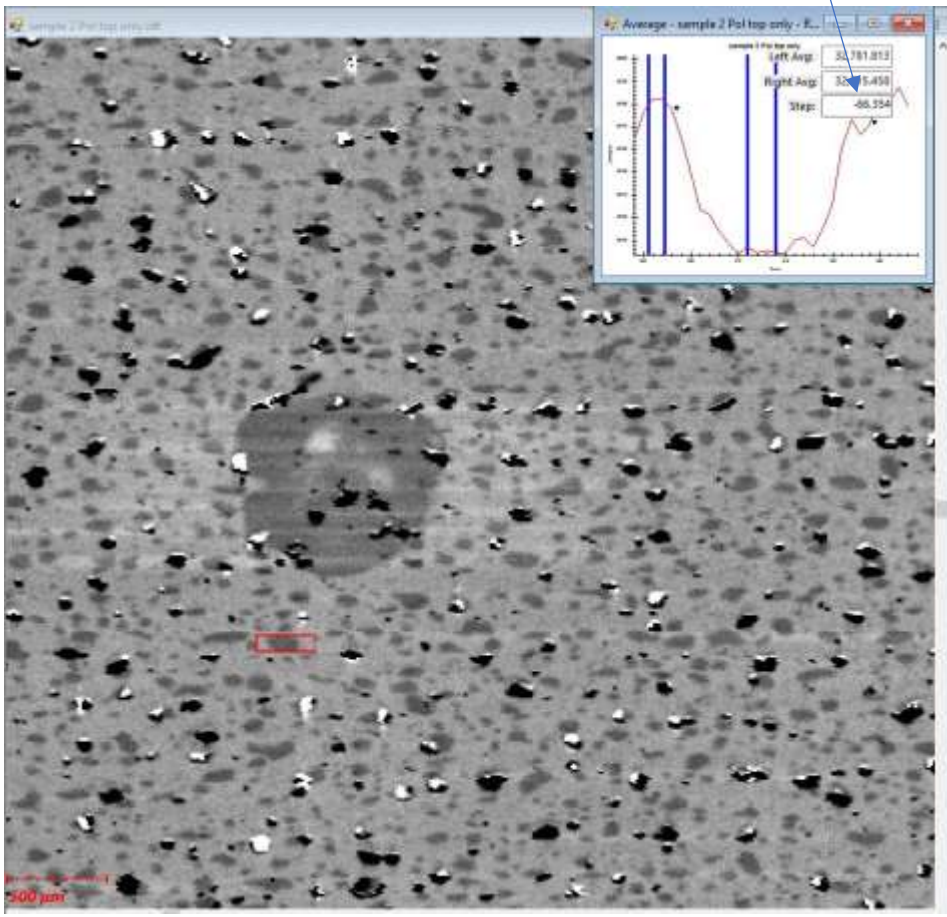
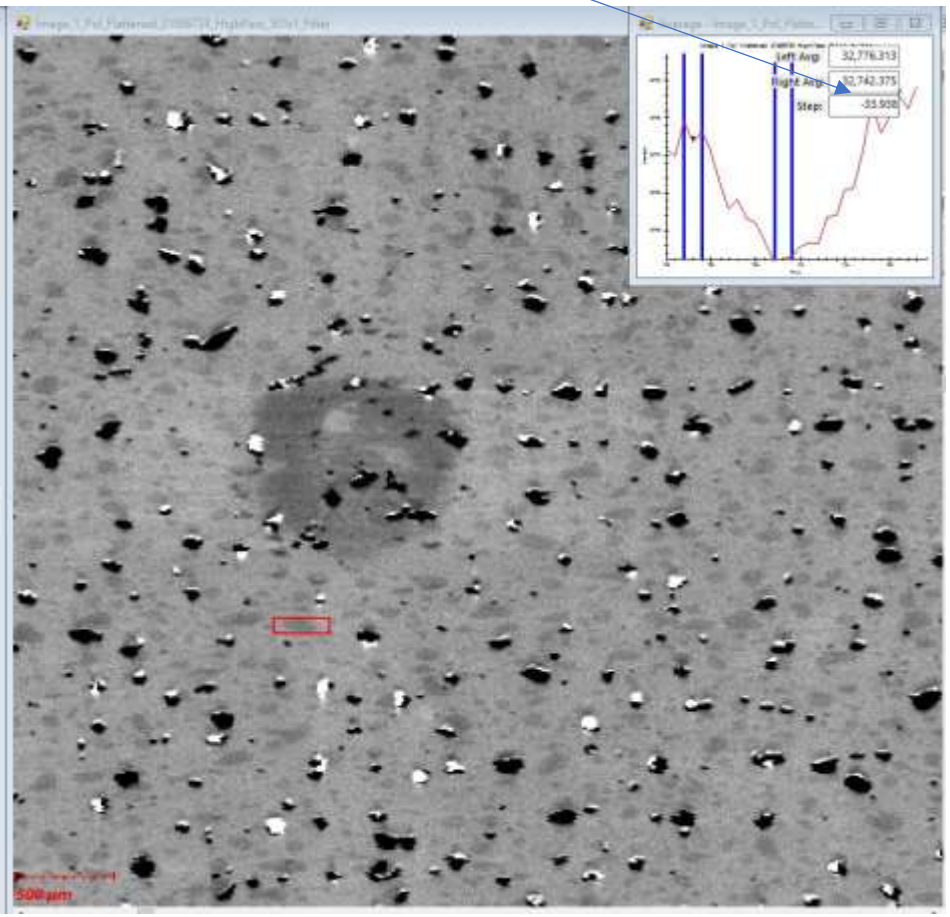
Stain evaporation over 18 hr time period

Over a period of 18 hrs. the amplitude of the thin film organic layer decreases by a factor of 2. The change is from 66 adc counts to 33 adc counts. This evaporation implies that the thin film organic stain is composed of low molecular weight components



Stain pattern immediately after removing plastic protective sheet



Stain pattern 18 hrs. after removing plastic protective sheet

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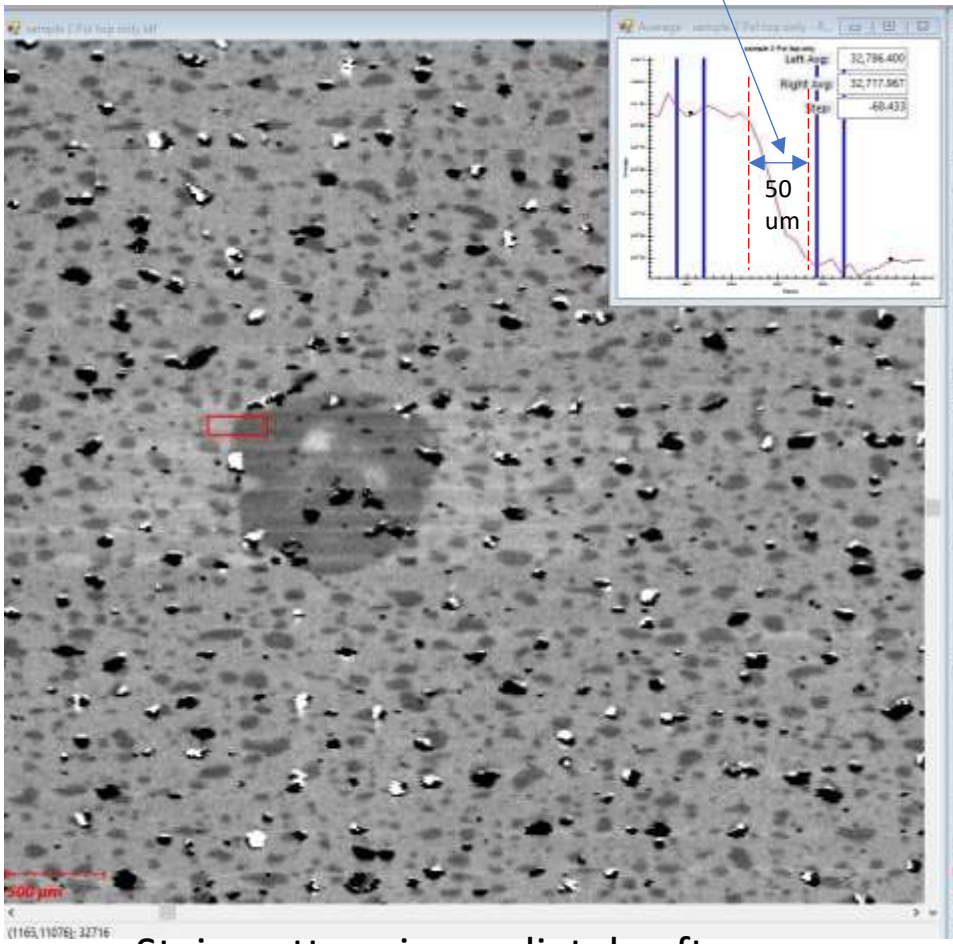
Migration of stain boundary over 18 hrs.

Over a period of 18 hrs. the stain boundary migrates. Over 18 hrs. the stain boundary migrates from a 50 µm width to a 120 µm width



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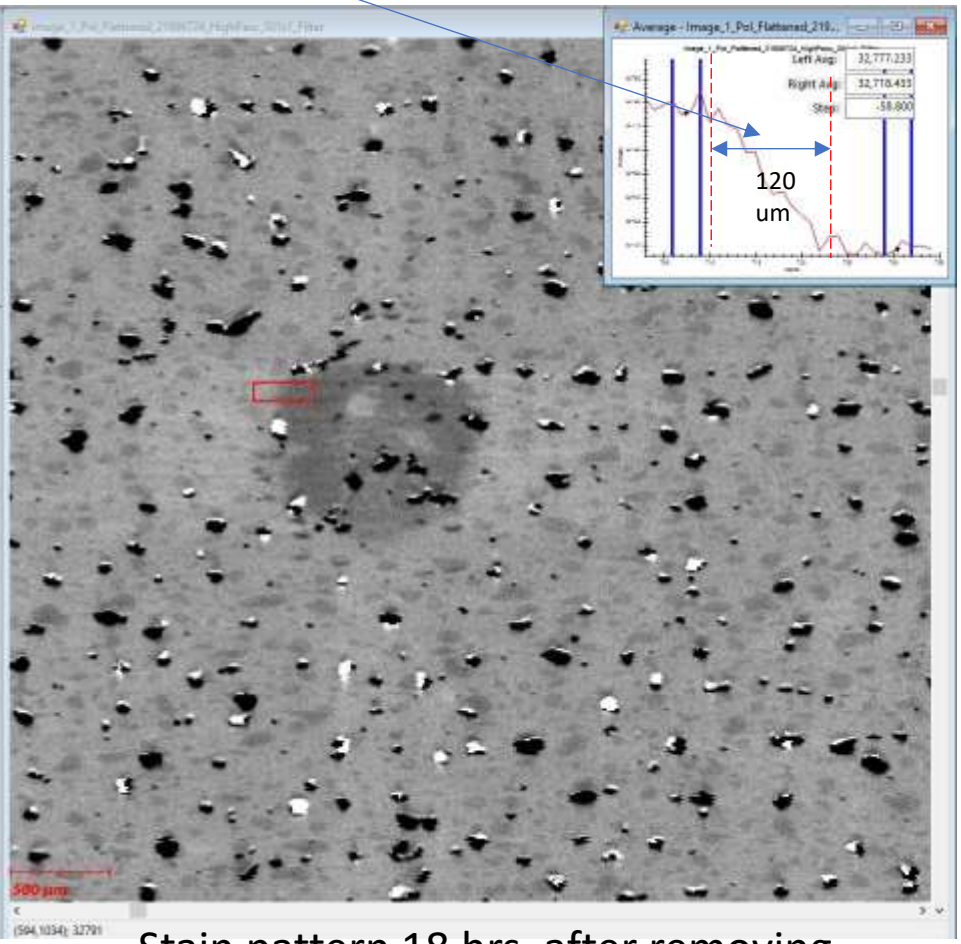

Stain pattern 18 hrs. after removing plastic protective sheet

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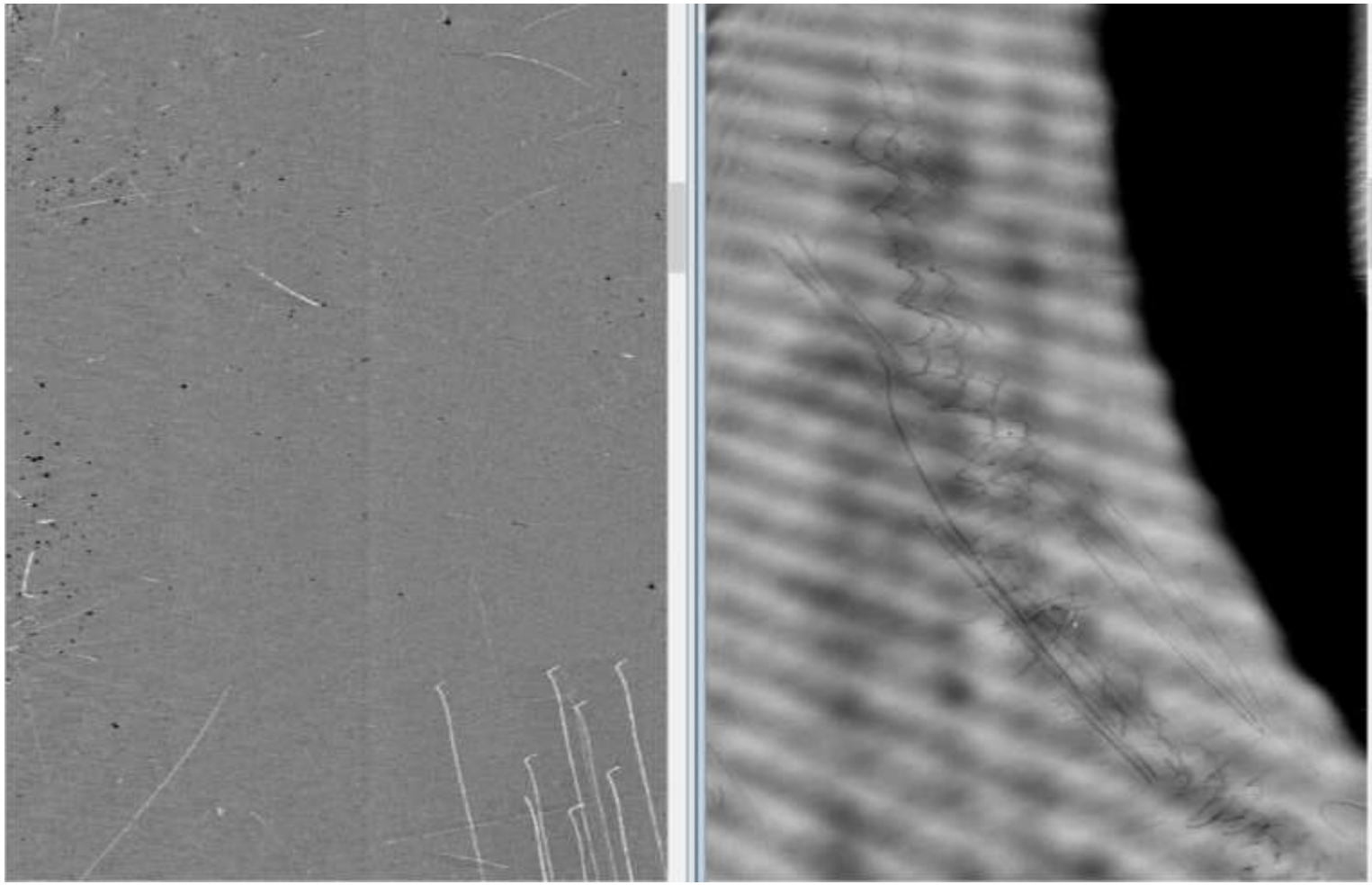
Zoom of previous slide – notice that there is no cross talk between the top surface and the center section

Top surface scratches



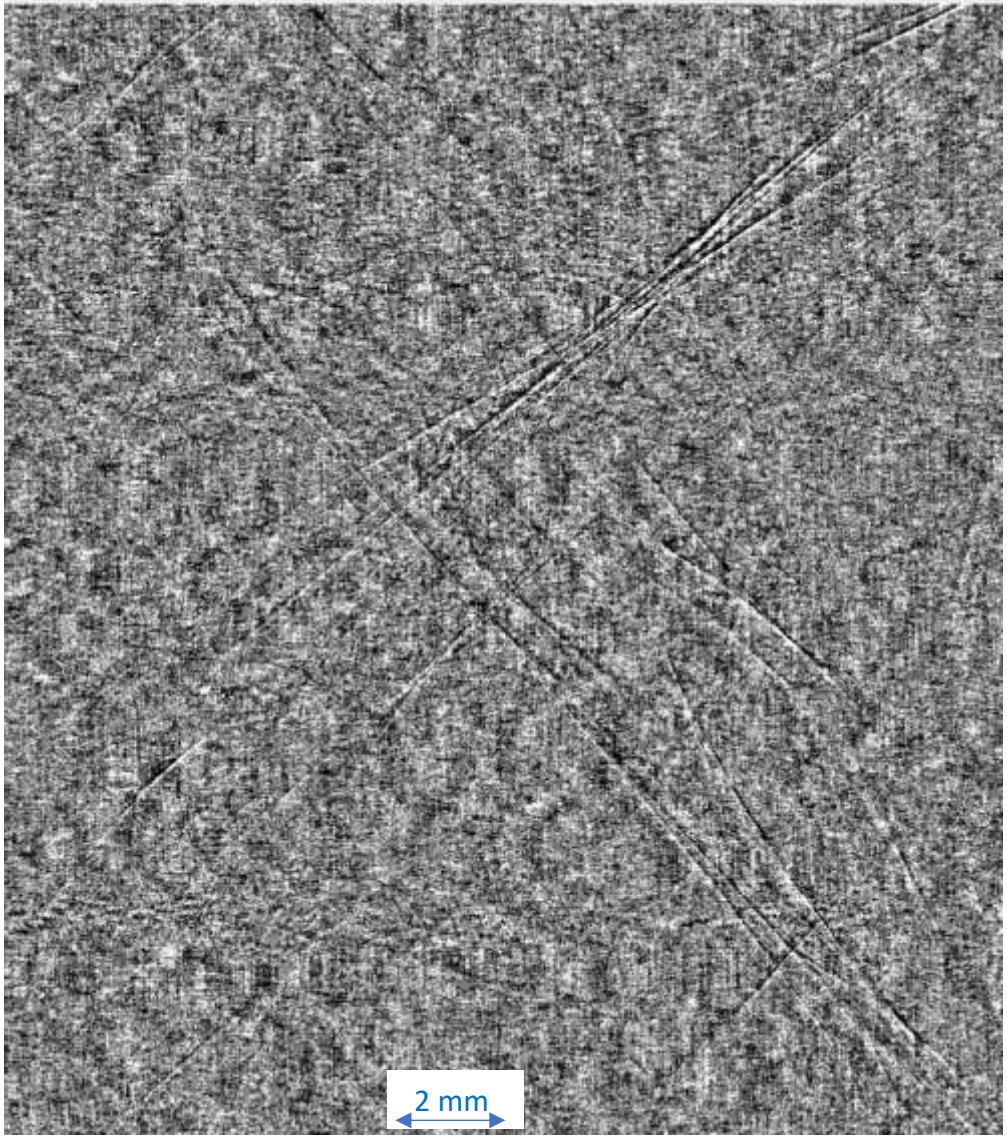
Center section scratches

Surface scratches and particles

Internal (0.5 mm below surface) defects

Slope image on a transparent glass data storage substrate

Very shallow (~10 Å deep by 50-100 µm wide) polishing features on a glass substrate



Top Surface slope channel

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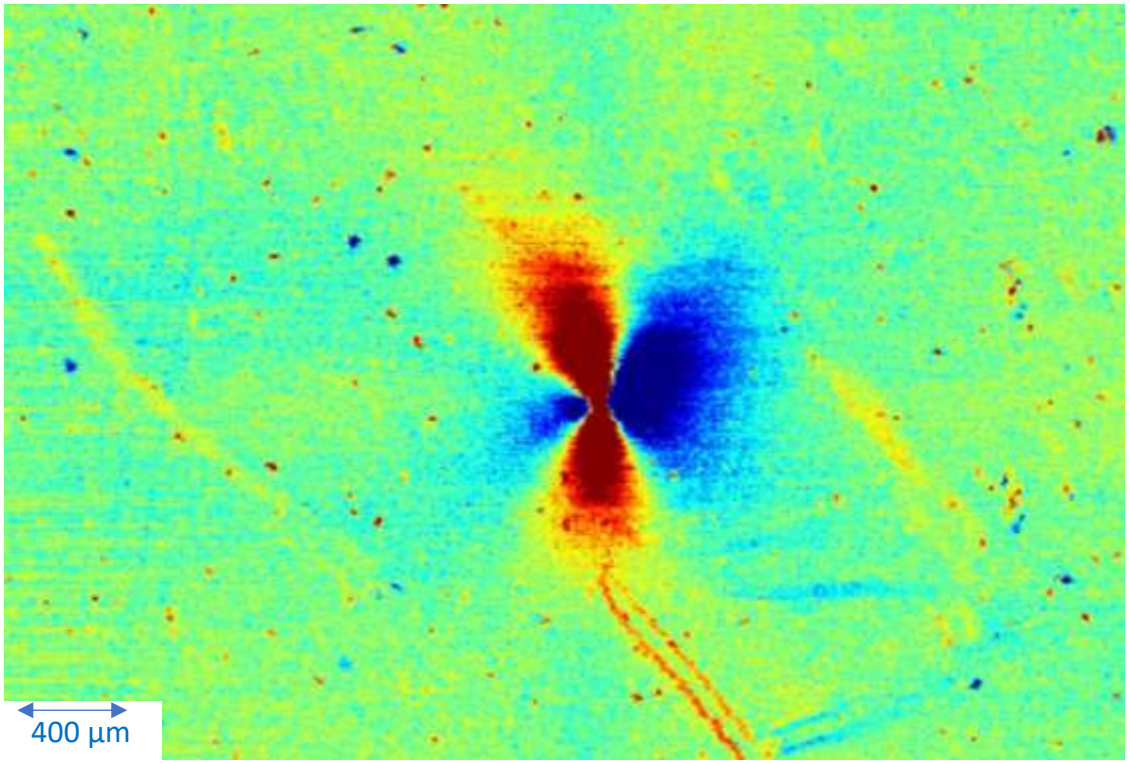
Internal residual stress within a glass substrate



Internal defect (polarization channel)

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Summary

- The Lumina Instruments AT1 is a process control tool for inspecting glass or other transparent materials. Samples must be flat but otherwise they may be any shape and they may be fragile.
- This tool can image a transparent surface with four independent methods: polarization, reflectivity, slope and dark field.
- It is also possible to image internal defects such as residual stress or inclusions.
- An additional capability is the ability to image a narrow section within the bulk of a glass device and nicely separate this section from the top and bottom surfaces.
- The AT1 requires 3 minutes to scan a 150 mm wafer