Contamination on Transparent and Opaque Materials

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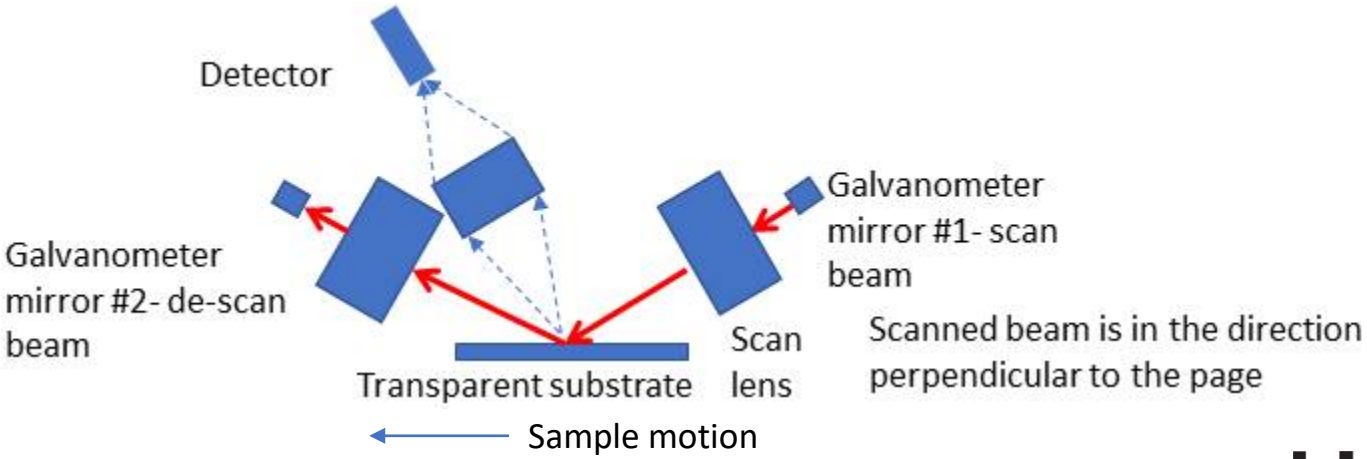
Lumina AT2 - Description

The Lumina Instruments AT2 is an innovative technology in laser scanning which is based upon:

- A 30 µm laser spot is rapidly scanned along a 100 mm line
- Sample moves in X-direction and light beam is reflected to four detectors.
- Results are images of the full surface from the four detectors.

Source: Green Laser (532 nm).
Spot Size: 30 µm circular moving spot size.
Scan time: Fast!



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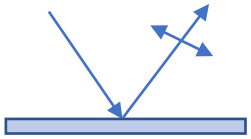
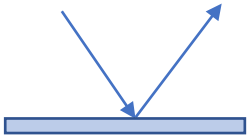
Lumina's capabilities on transparent and opaque substrates

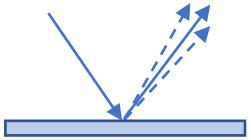
- Lumina's AT2 allows you to see what's on the upper most surface of a transparent or opaque surface in four different ways: Polarization change, Bright Field, Slope and Dark field.



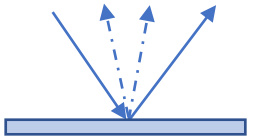
Polarization



Bright Field

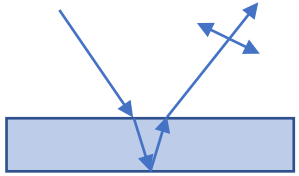


Surface Slope

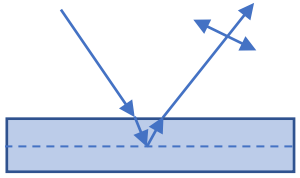


Dark Field

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



- Detect the location of internal defects (inclusions) within a glass substrate:



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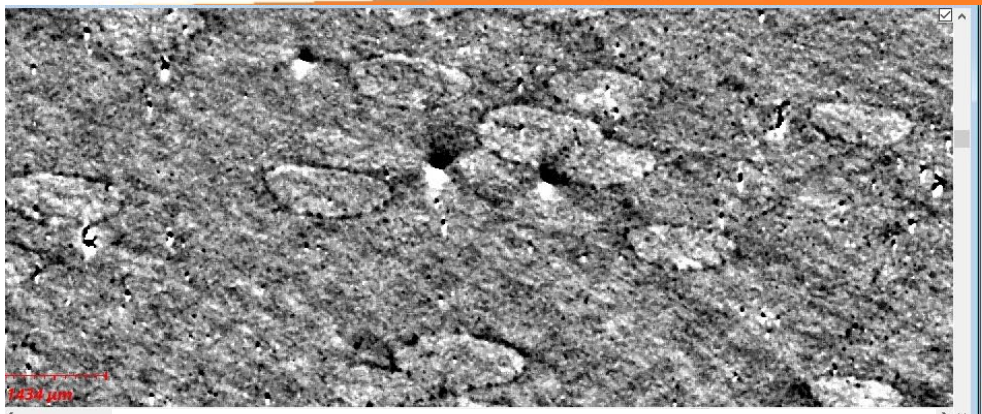
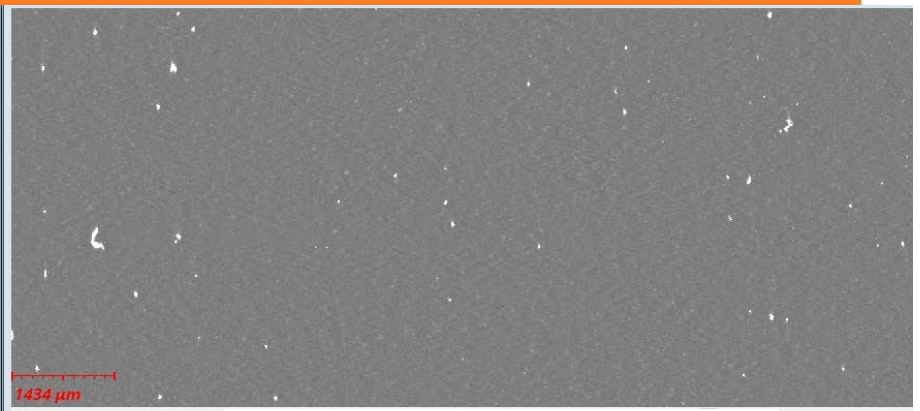
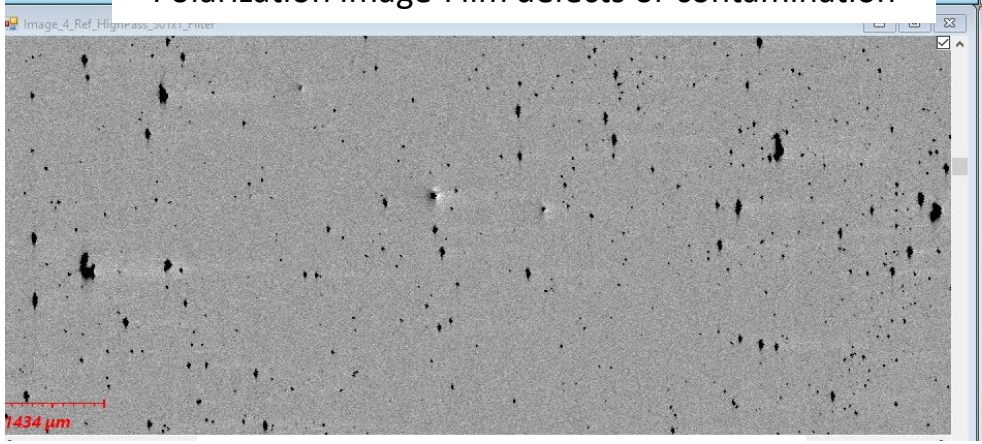
Four simultaneous channels of data on the top surface of a Sapphire substrate



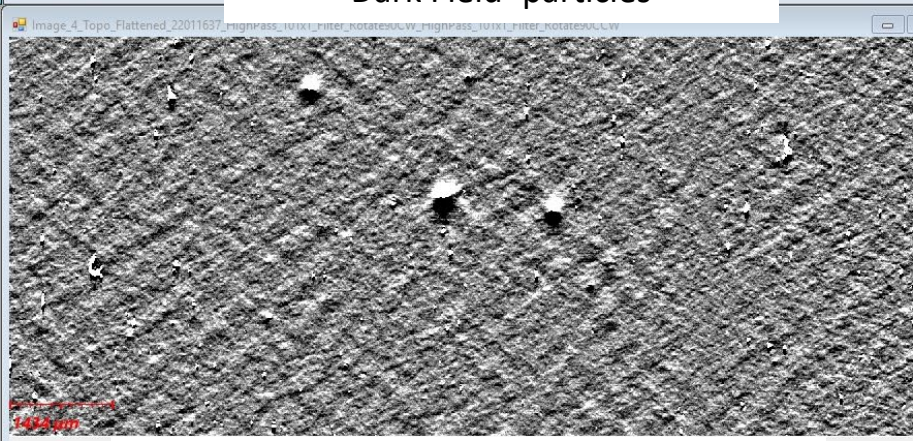
Polarization Image-Film defects or contamination



Dark Field- particles



Bright Field- scratches and particles



Surface slope- pits, bumps and scratches

Notice that only the polarization image shows the contamination and this is not visible on the bright field image. This is a important feature for separating contamination from other reflectivity changes

Agenda

Three different types of samples were scanned:

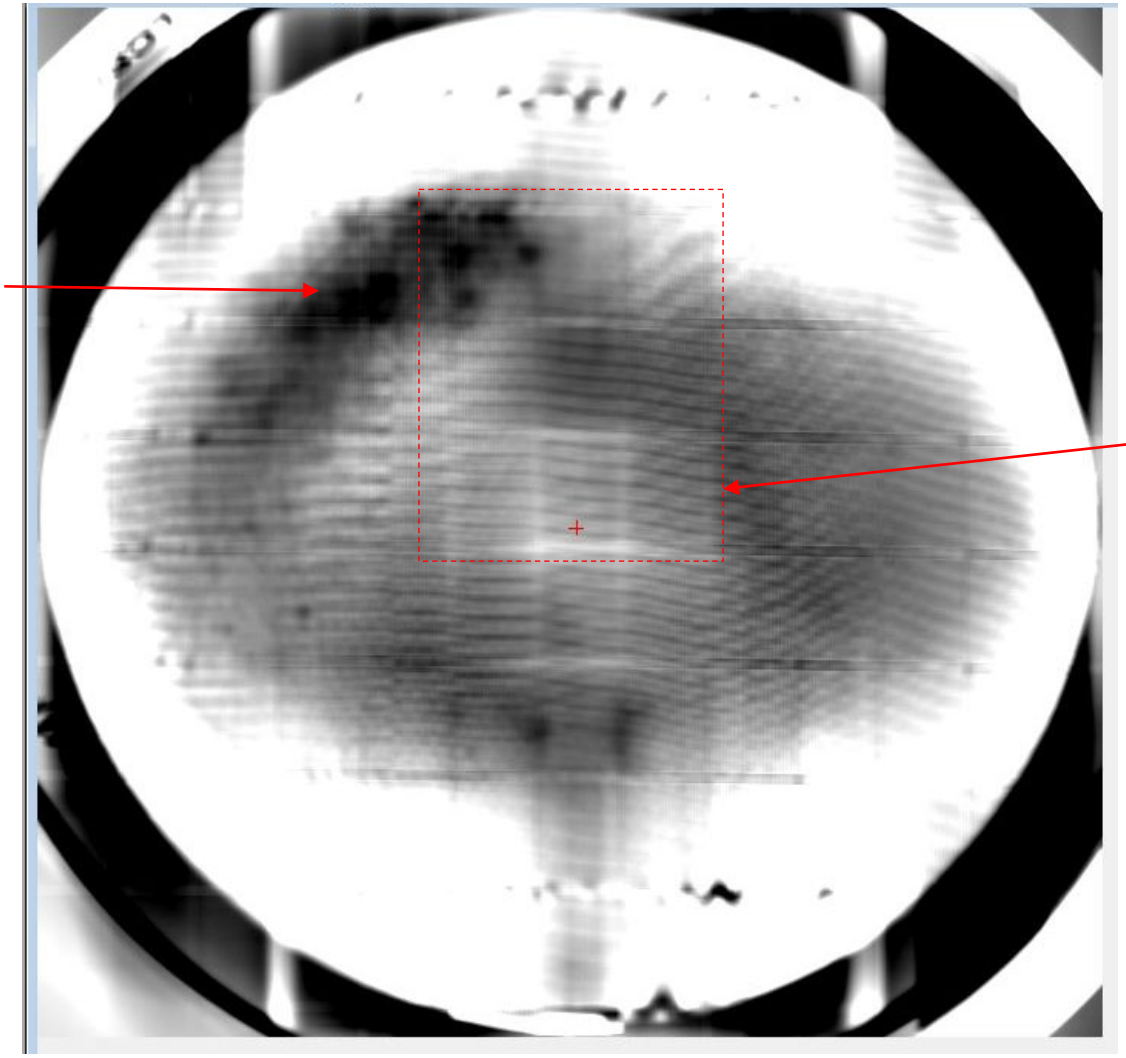
1. Patterned and thinned 300 mm Si wafer on a 450 mm tape frame
2. 300 mm glass interposer wafer: reclaimed and cleaned
3. Before and after cleaning images of 150 mm glass wafer showing the effectiveness of the cleaning process

Patterned and thinned Si wafer

- 300 mm wafer on a 450 mm tape frame
- This is a very fragile wafer and the Lumina technology lends itself to scanning this type of sample since it does not require spinning the wafer
- I will show results from two wafers. The first one with a donut shaped area of contamination and the second with a center blob of contamination

Wafer #1: Processed polarization image of thinned and patterned Si wafer

The dark areas are regions of contamination



Following slide 9 is a zoom in of the dotted region

Notch at 6 O'clock

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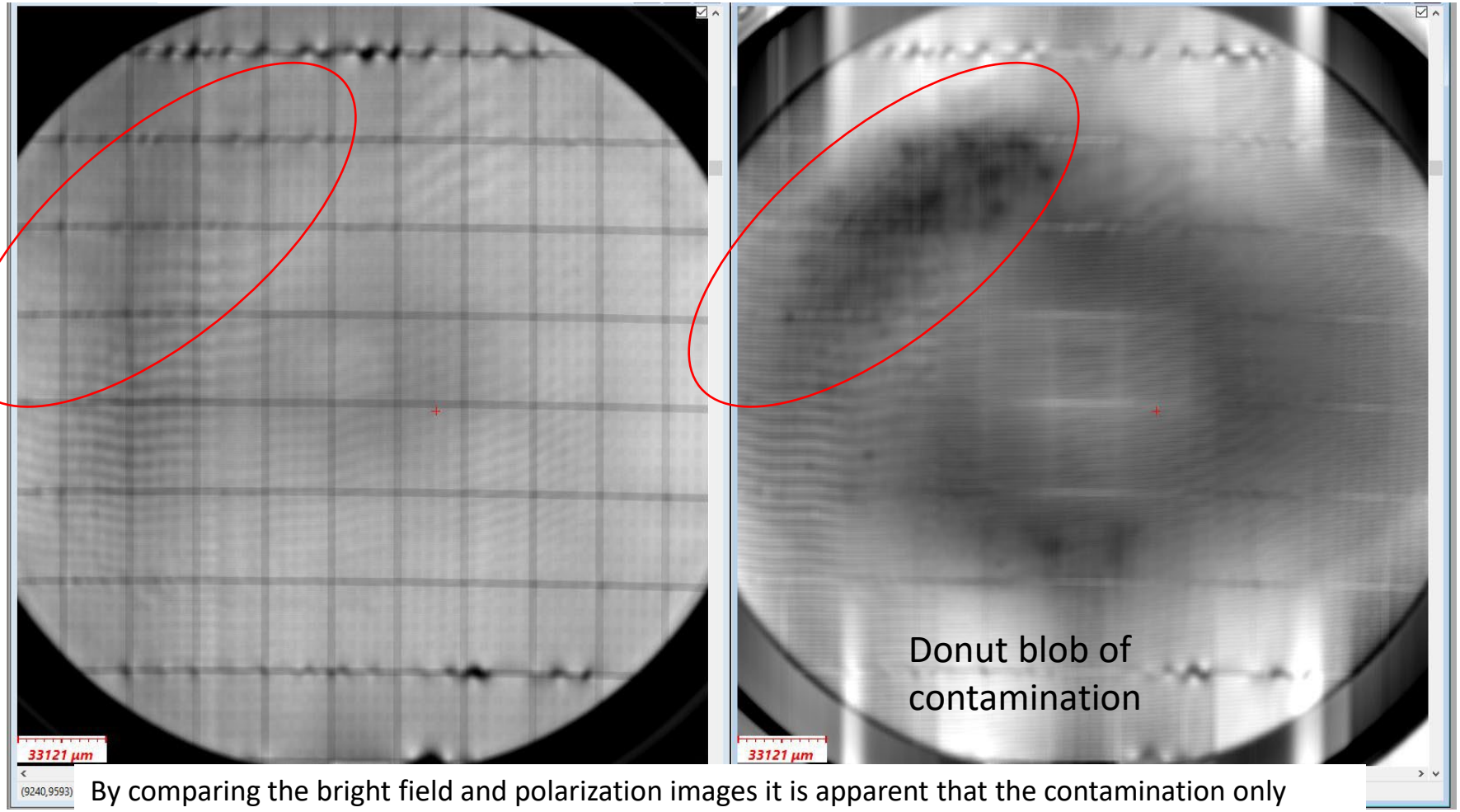
How do I know this is contamination? By comparing the bright field and polarization images!

Bright Field

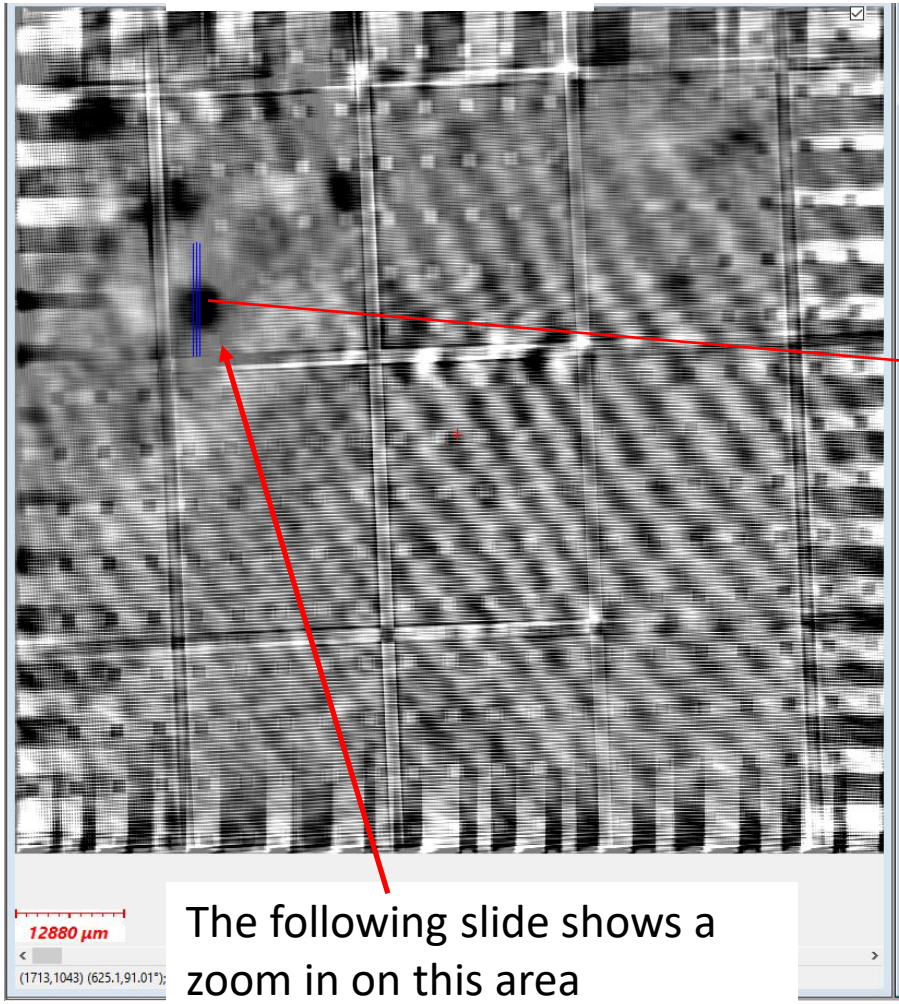
Polarization

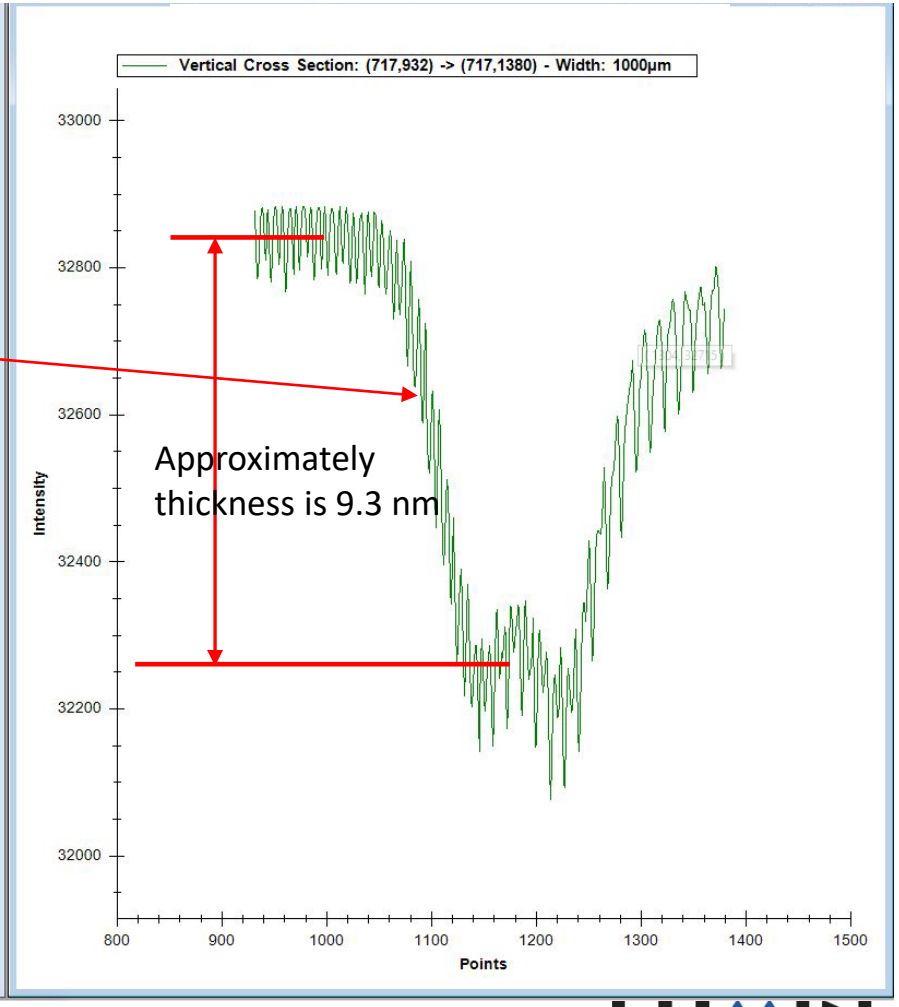


By comparing the bright field and polarization images it is apparent that the contamination only appears in the polarization image. This is the characteristic signal of contamination and has been shown to be true on many different types of substrates.

Zoom in on contaminated region with approximate calibration of thickness

Polarization





The following slide shows a zoom in on this area

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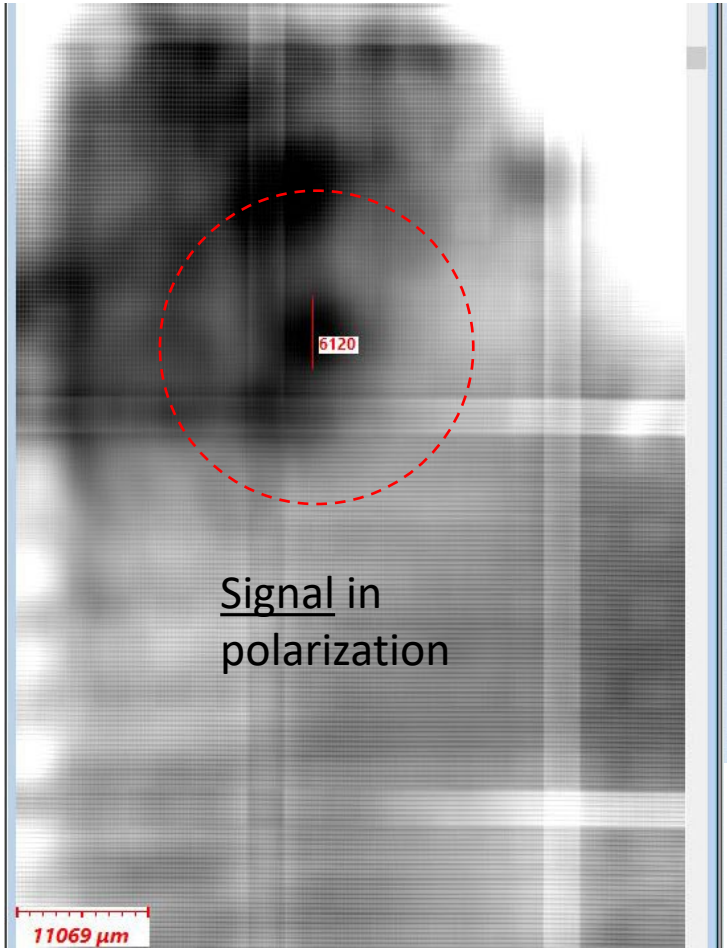
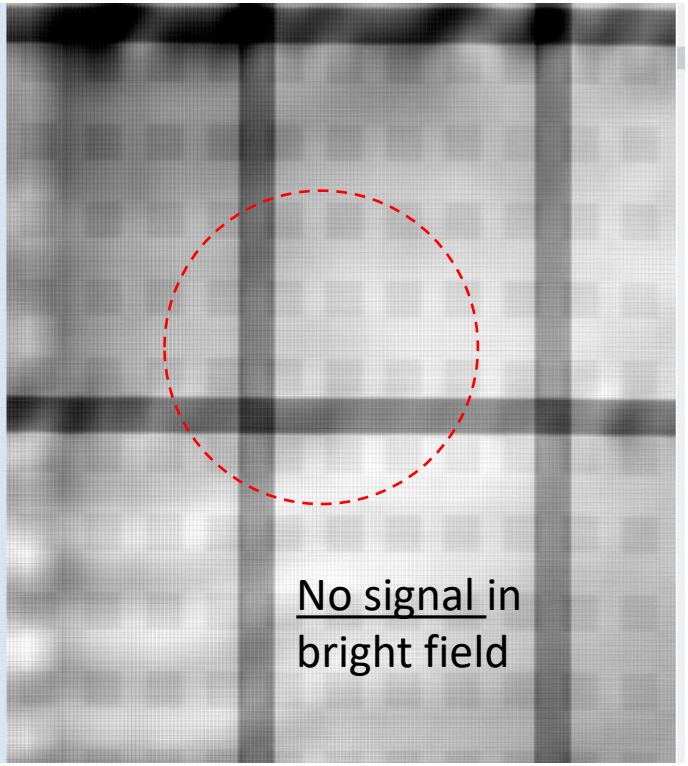
Zoom in and compare polarization image with bright field image



Processed polarization image



Processed bright field image

Signal in polarization and no signal in bright field implies a thin film contaminate is on top of the dies

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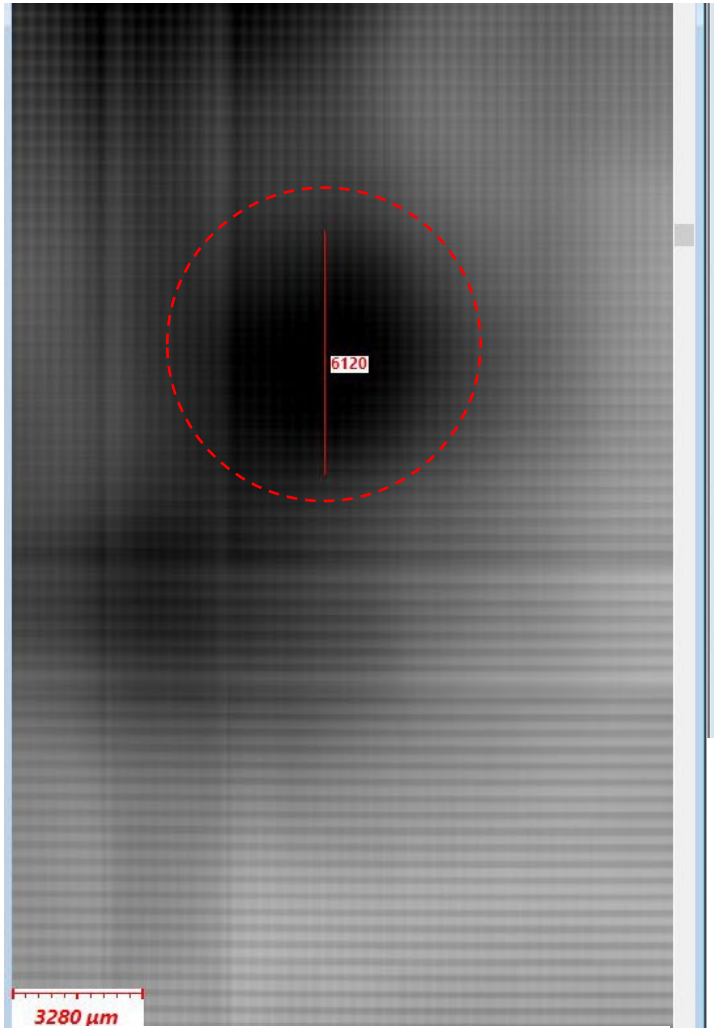
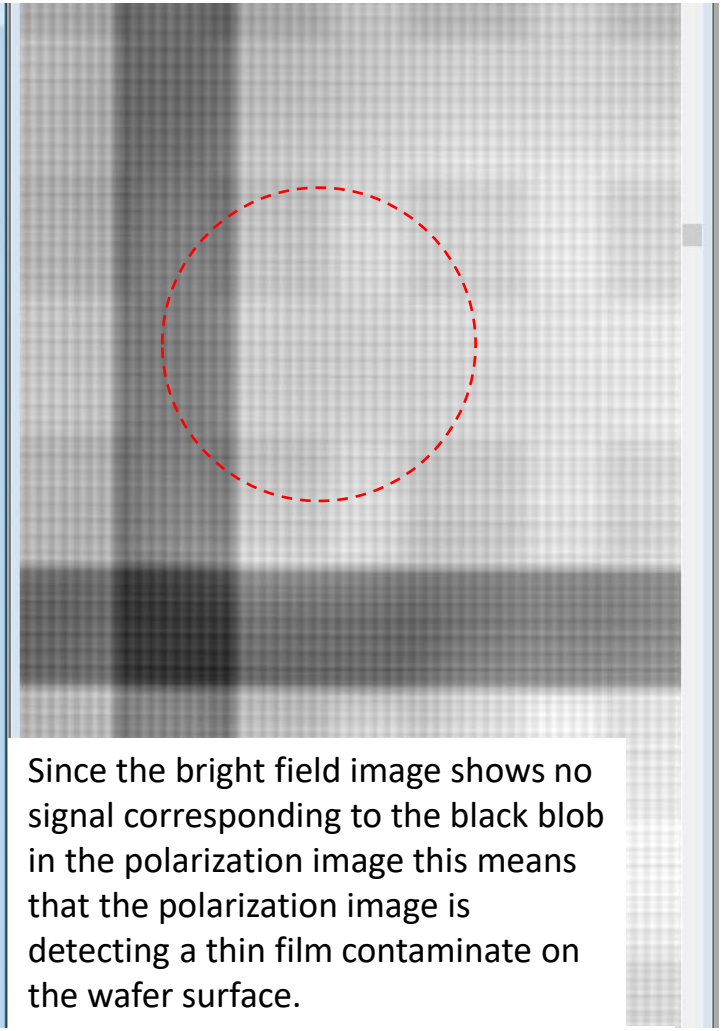
Final zoom in to compare polarization image with bright field image



Processed polarization image



Since the bright field image shows no signal corresponding to the black blob in the polarization image this means that the polarization image is detecting a thin film contaminate on the wafer surface.

Processed bright field image

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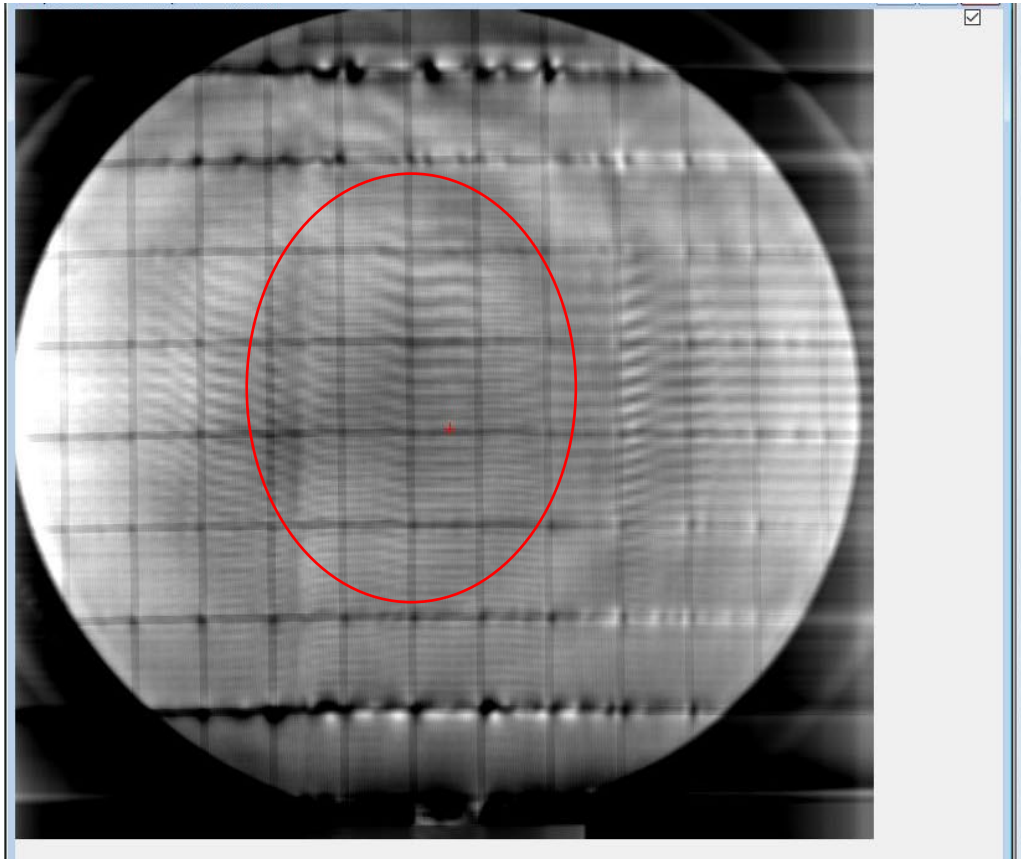
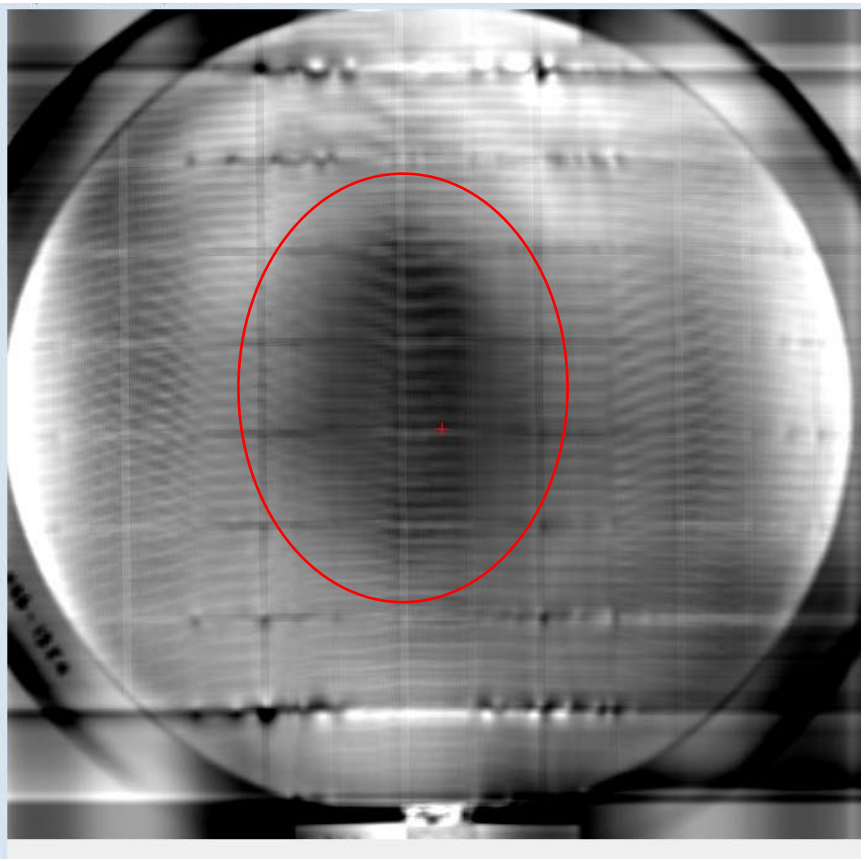
Wafer #2: Contamination blob in the center



Bright Field



Polarization

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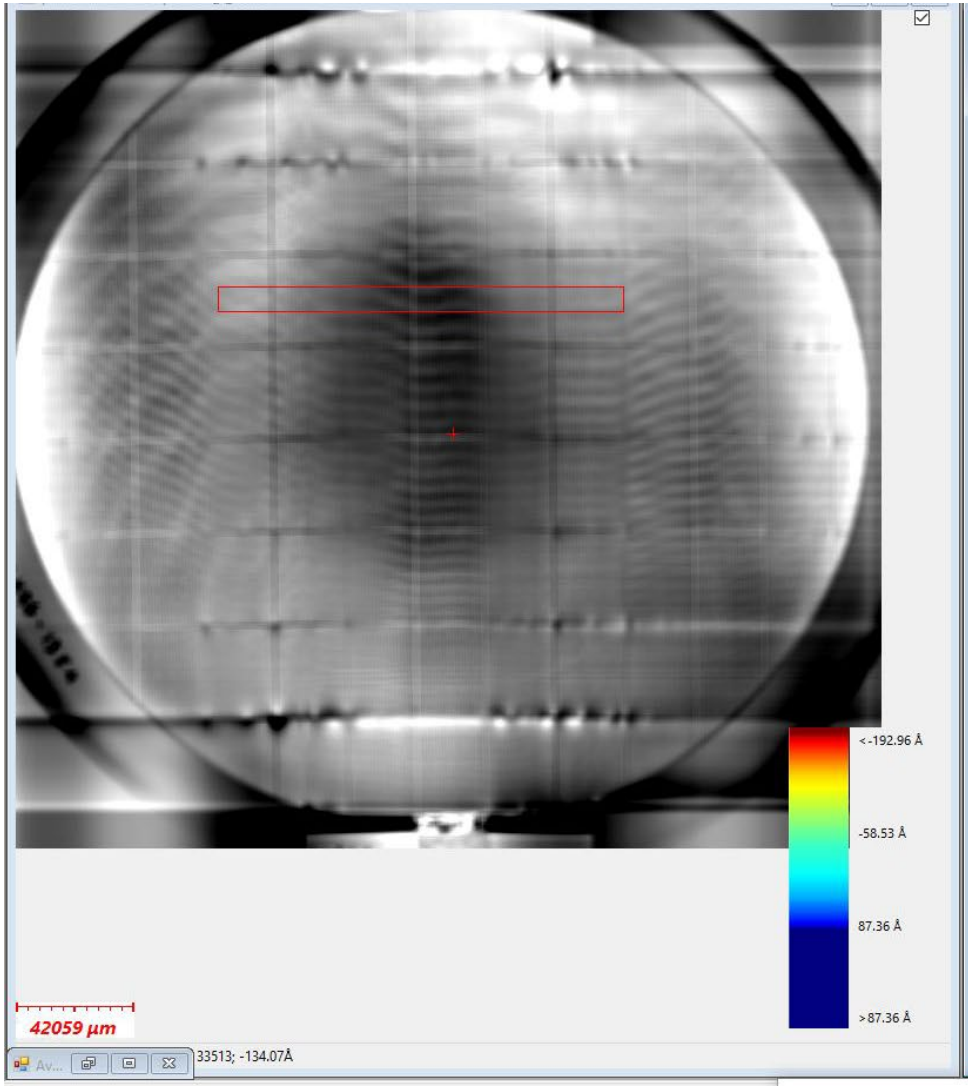
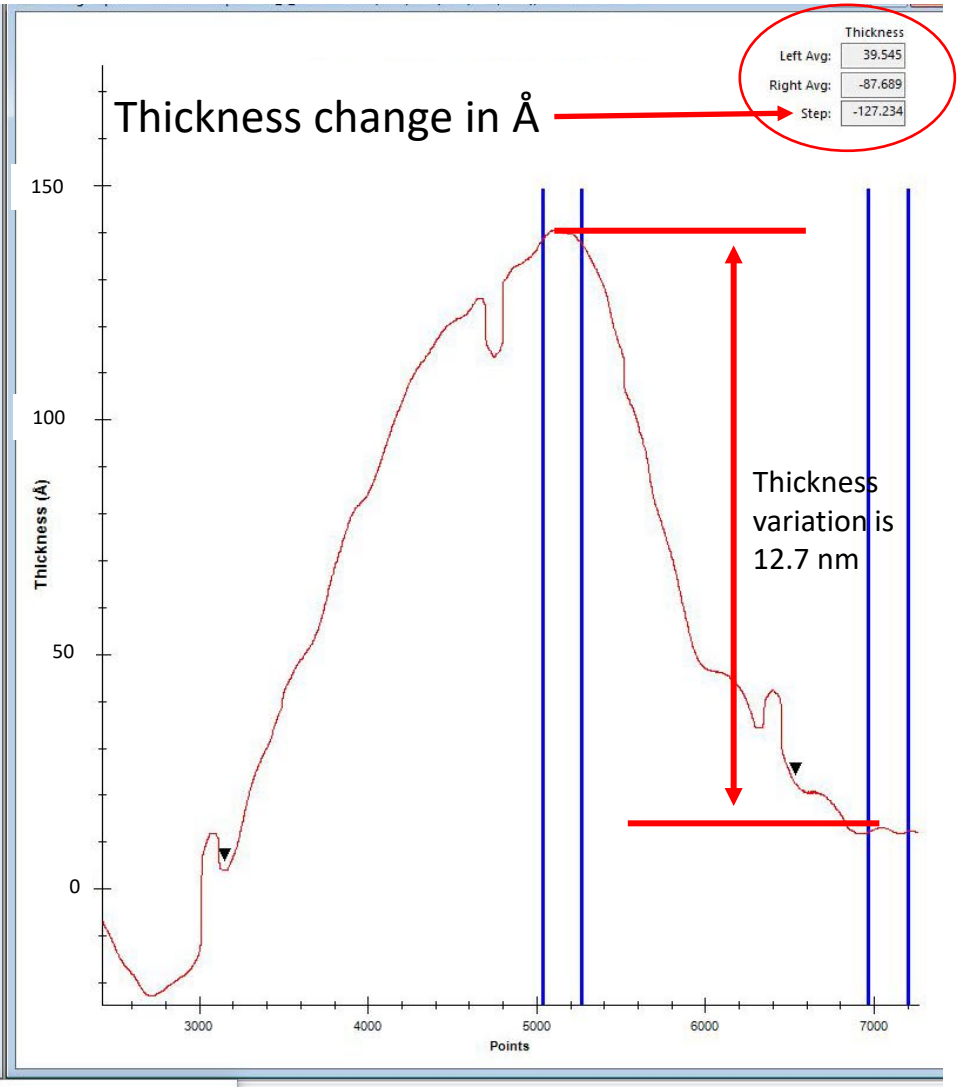
Blob in the center- thickness variation of center contaminate





Key Findings

- The diced wafers have two spatial orientations of contamination. One I will call the donut and the other the center blob.

- The approximate thickness of the contamination ranges from 9 to 13 nm. This calibration is assuming the index of refraction of the contamination is approximately 1.53.

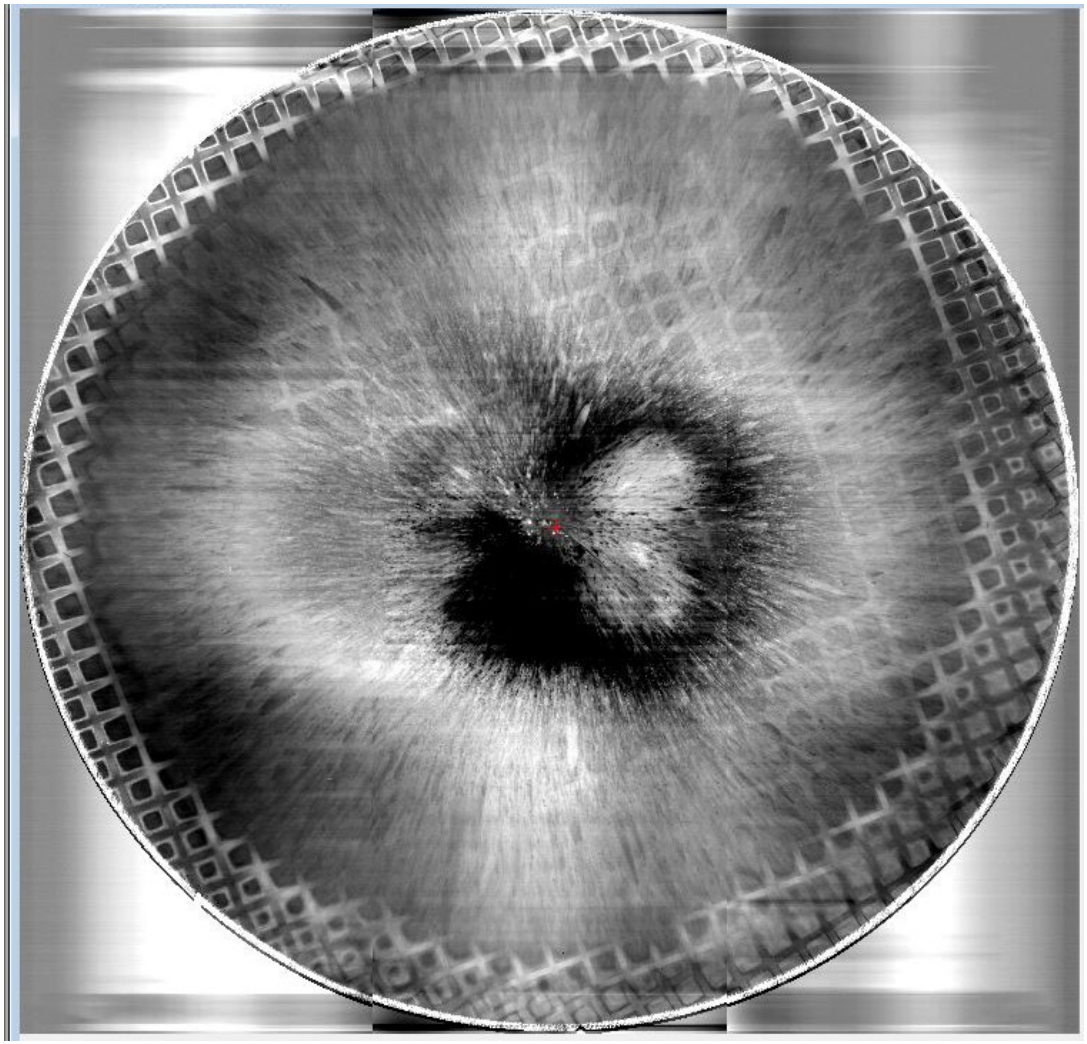
- This technique shows the presence or absence of contamination and the approximate thickness, *however it doesn't tell you what it is*. Dan Sullivan of EAG in the next talk will discuss the chemical signature of the contamination.

Reclaimed 300 mm glass interposer wafer

- 300 mm interposer wafers
- Wafer has been reclaimed and the result shown is after the wafer has been cleaned
- The wafer has considerable top and bottom surface contamination as shown in the polarization images. This wafer show a maximum contamination thickness of approximately 9 nm.
- Both sides of the wafer are scanned simultaneously
- The physics of the measurement separates out the top and bottom contamination.
- The dark areas are contamination on the top and the bright areas are on the bottom of the wafer

Polarization map of reclaimed 300 mm glass wafer

Bright areas are contamination on the bottom of the wafer and the dark areas are on the top of the wafer



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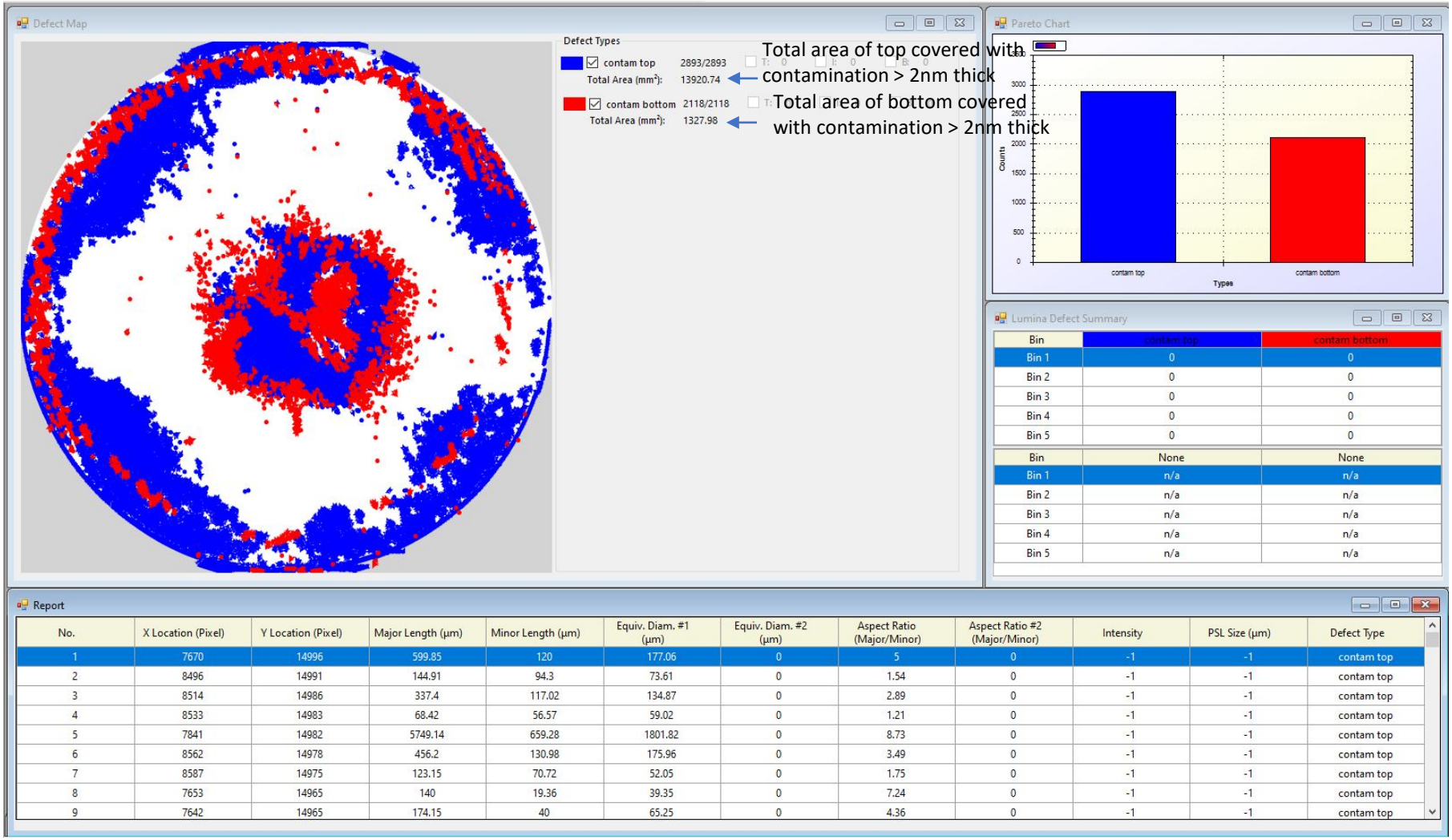
Regions on wafer where contamination is > 2 nm. Blue is top and red is bottom of wafer



No.	X Location (Pixel)	Y Location (Pixel)	Major Length (µm)	Minor Length (µm)	Equiv. Diam. #1 (µm)	Equiv. Diam. #2 (µm)	Aspect Ratio (Major/Minor)	Aspect Ratio #2 (Major/Minor)	Intensity	PSL Size (µm)	Defect Type
1	7670	14996	599.85	120	177.06	0	5	0	-1	-1	contam top
2	8496	14991	144.91	94.3	73.61	0	1.54	0	-1	-1	contam top
3	8514	14986	337.4	117.02	134.87	0	2.89	0	-1	-1	contam top
4	8533	14983	68.42	56.57	59.02	0	1.21	0	-1	-1	contam top
5	7841	14982	5749.14	659.28	1801.82	0	8.73	0	-1	-1	contam top
6	8562	14978	456.2	130.98	175.96	0	3.49	0	-1	-1	contam top
7	8587	14975	123.15	70.72	52.05	0	1.75	0	-1	-1	contam top
8	7653	14965	140	19.36	39.35	0	7.24	0	-1	-1	contam top
9	7642	14965	174.15	40	65.25	0	4.36	0	-1	-1	contam top

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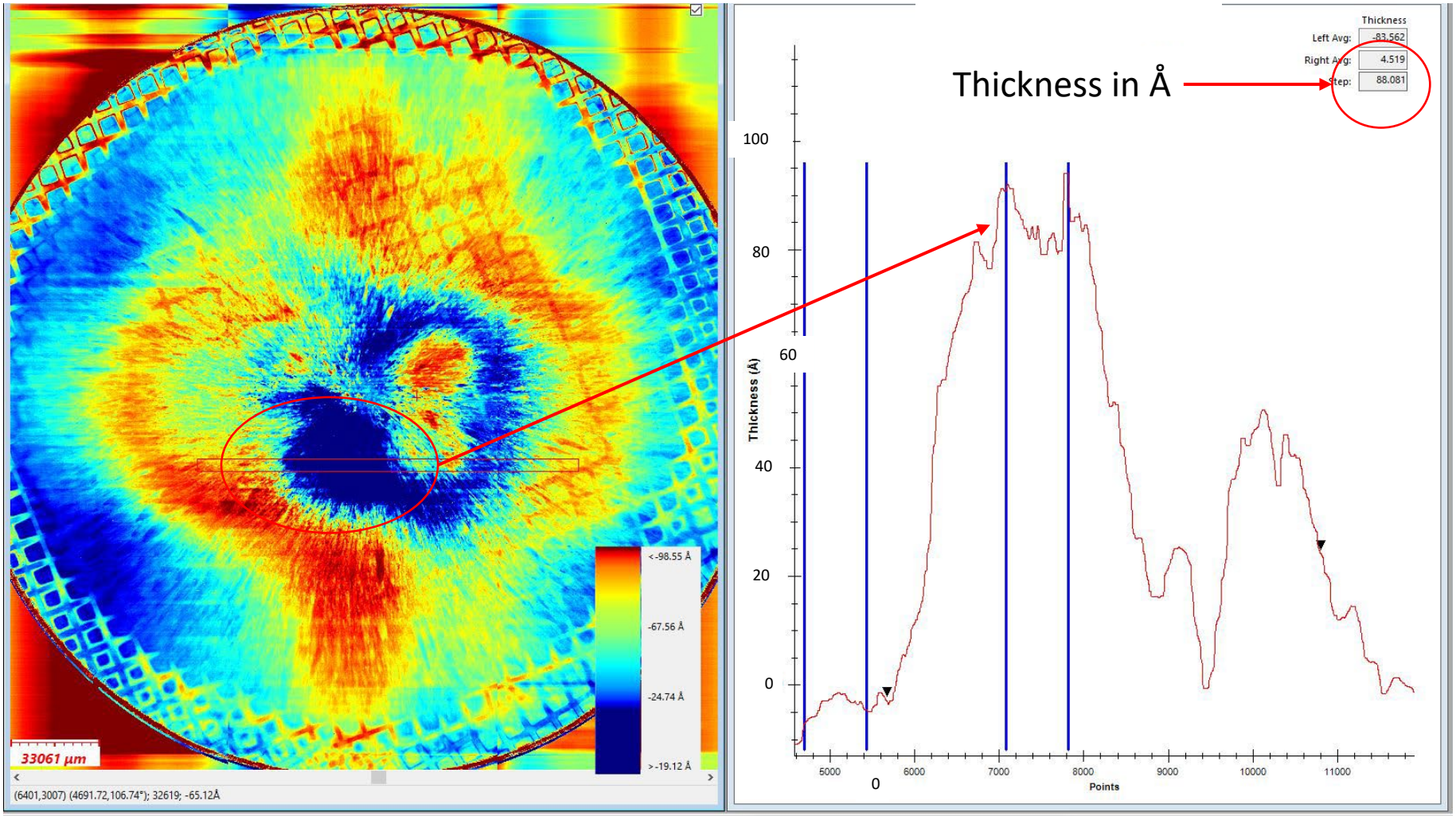
Cross section across a region near the center of the wafer where thickness change is 8.8 nm



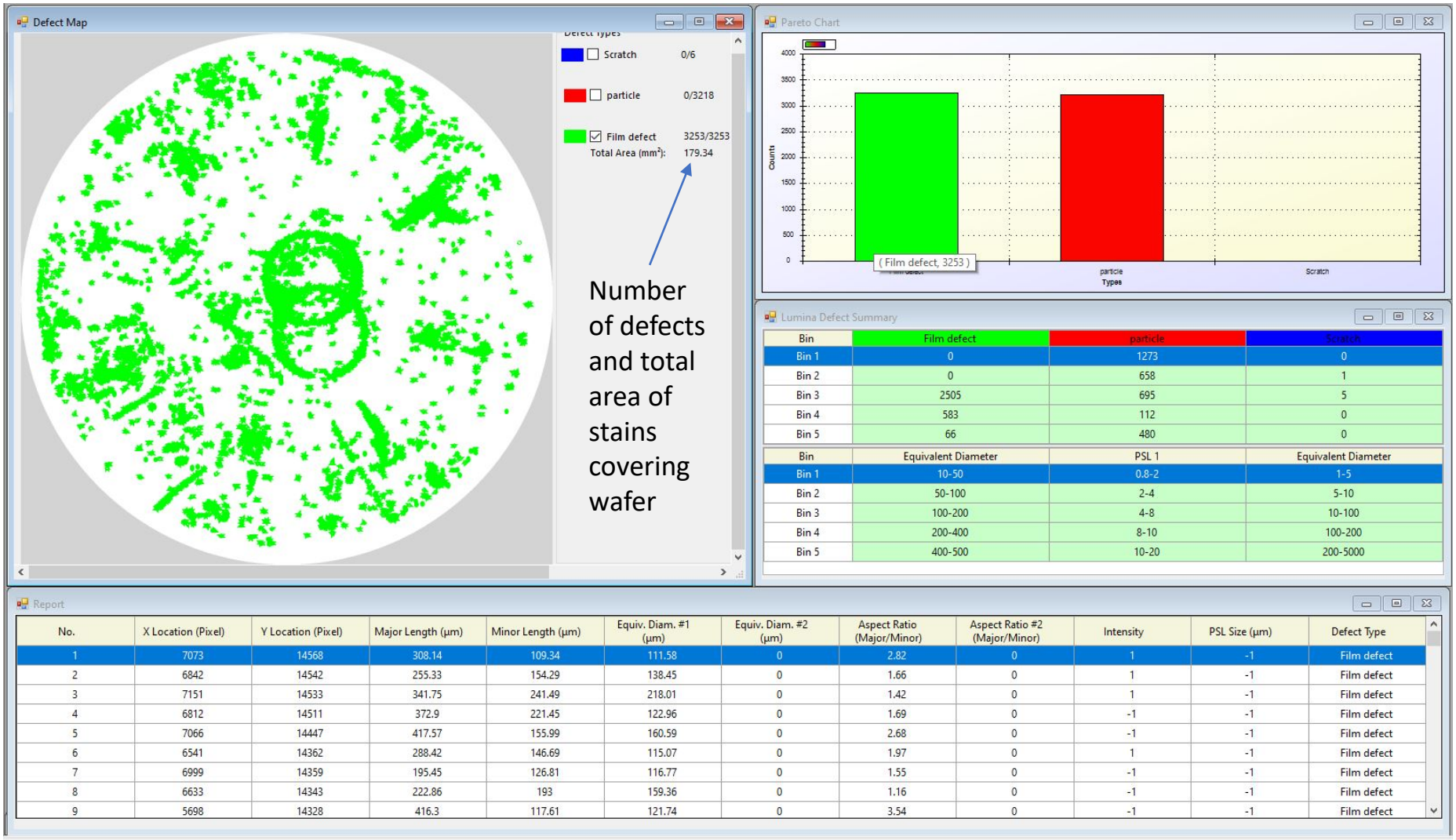
Key findings

- Contamination which is invisible via other techniques is easily visible with this optical scanning process

150 mm glass wafer

- Images showing before and after cleaning of a 150 mm glass wafer
- The purpose of this experiment was to demonstrate the effectiveness (or lack thereof) of the cleaning process

150 mm glass wafer before cleaning (contamination only)

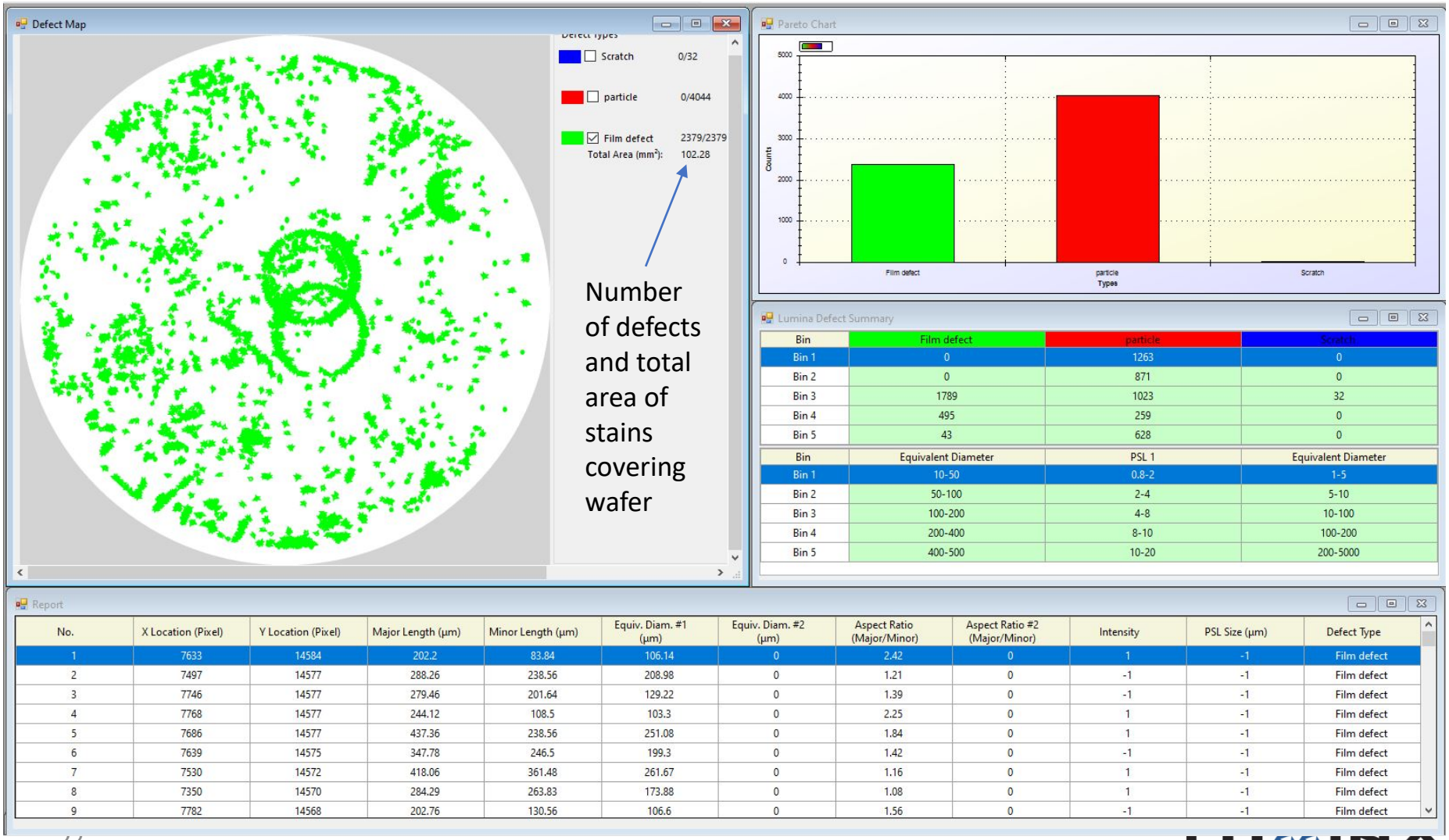


Bin	Film defect	particle	Scratch
Bin 1	0	1273	0
Bin 2	0	658	1
Bin 3	2505	695	5
Bin 4	583	112	0
Bin 5	66	480	0

Bin	Equivalent Diameter	PSL 1	Equivalent Diameter
Bin 1	10-50	0.8-2	1-5
Bin 2	50-100	2-4	5-10
Bin 3	100-200	4-8	10-100
Bin 4	200-400	8-10	100-200
Bin 5	400-500	10-20	200-5000

No.	X Location (Pixel)	Y Location (Pixel)	Major Length (µm)	Minor Length (µm)	Equiv. Diam. #1 (µm)	Equiv. Diam. #2 (µm)	Aspect Ratio (Major/Minor)	Aspect Ratio #2 (Major/Minor)	Intensity	PSL Size (µm)	Defect Type
1	7073	14568	308.14	109.34	111.58	0	2.82	0	1	-1	Film defect
2	6842	14542	255.33	154.29	138.45	0	1.66	0	1	-1	Film defect
3	7151	14533	341.75	241.49	218.01	0	1.42	0	1	-1	Film defect
4	6812	14511	372.9	221.45	122.96	0	1.69	0	-1	-1	Film defect
5	7066	14447	417.57	155.99	160.59	0	2.68	0	-1	-1	Film defect
6	6541	14362	288.42	146.69	115.07	0	1.97	0	1	-1	Film defect
7	6999	14359	195.45	126.81	116.77	0	1.55	0	-1	-1	Film defect
8	6633	14343	222.86	193	159.36	0	1.16	0	-1	-1	Film defect
9	5698	14328	416.3	117.61	121.74	0	3.54	0	-1	-1	Film defect

150 mm glass wafer after cleaning (contamination only)



Bin	Film defect	particle	Scratch
Bin 1	0	1263	0
Bin 2	0	871	0
Bin 3	1789	1023	32
Bin 4	495	259	0
Bin 5	43	628	0

Bin	Equivalent Diameter	PSL 1	Equivalent Diameter
Bin 1	10-50	0.8-2	1-5
Bin 2	50-100	2-4	5-10
Bin 3	100-200	4-8	10-100
Bin 4	200-400	8-10	100-200
Bin 5	400-500	10-20	200-5000

No.	X Location (Pixel)	Y Location (Pixel)	Major Length (µm)	Minor Length (µm)	Equiv. Diam. #1 (µm)	Equiv. Diam. #2 (µm)	Aspect Ratio (Major/Minor)	Aspect Ratio #2 (Major/Minor)	Intensity	PSL Size (µm)	Defect Type
1	7633	14584	202.2	83.84	106.14	0	2.42	0	1	-1	Film defect
2	7497	14577	288.26	238.56	208.98	0	1.21	0	-1	-1	Film defect
3	7746	14577	279.46	201.64	129.22	0	1.39	0	-1	-1	Film defect
4	7768	14577	244.12	108.5	103.3	0	2.25	0	1	-1	Film defect
5	7686	14577	437.36	238.56	251.08	0	1.84	0	1	-1	Film defect
6	7639	14575	347.78	246.5	199.3	0	1.42	0	-1	-1	Film defect
7	7530	14572	418.06	361.48	261.67	0	1.16	0	1	-1	Film defect
8	7350	14570	284.29	263.83	173.88	0	1.08	0	1	-1	Film defect
9	7782	14568	202.76	130.56	106.6	0	1.56	0	-1	-1	Film defect

Key Findings

- This cleaning process results in a reduction of the surface contamination by 43% on an area basis

Summary

The Lumina AT1/AT2 is an innovative technology in laser scanning with:

- Exceptional sensitivity (sub nm) to film defects or contamination on glass, silicon substrates or patterned silicon
- Ability to inspect any flat shape (rectangular, round, irregular or very fragile)
- Ability to separate top, bottom and internal defects on glass substrates
- 100 nm PSL sensitivity on silicon substrates

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