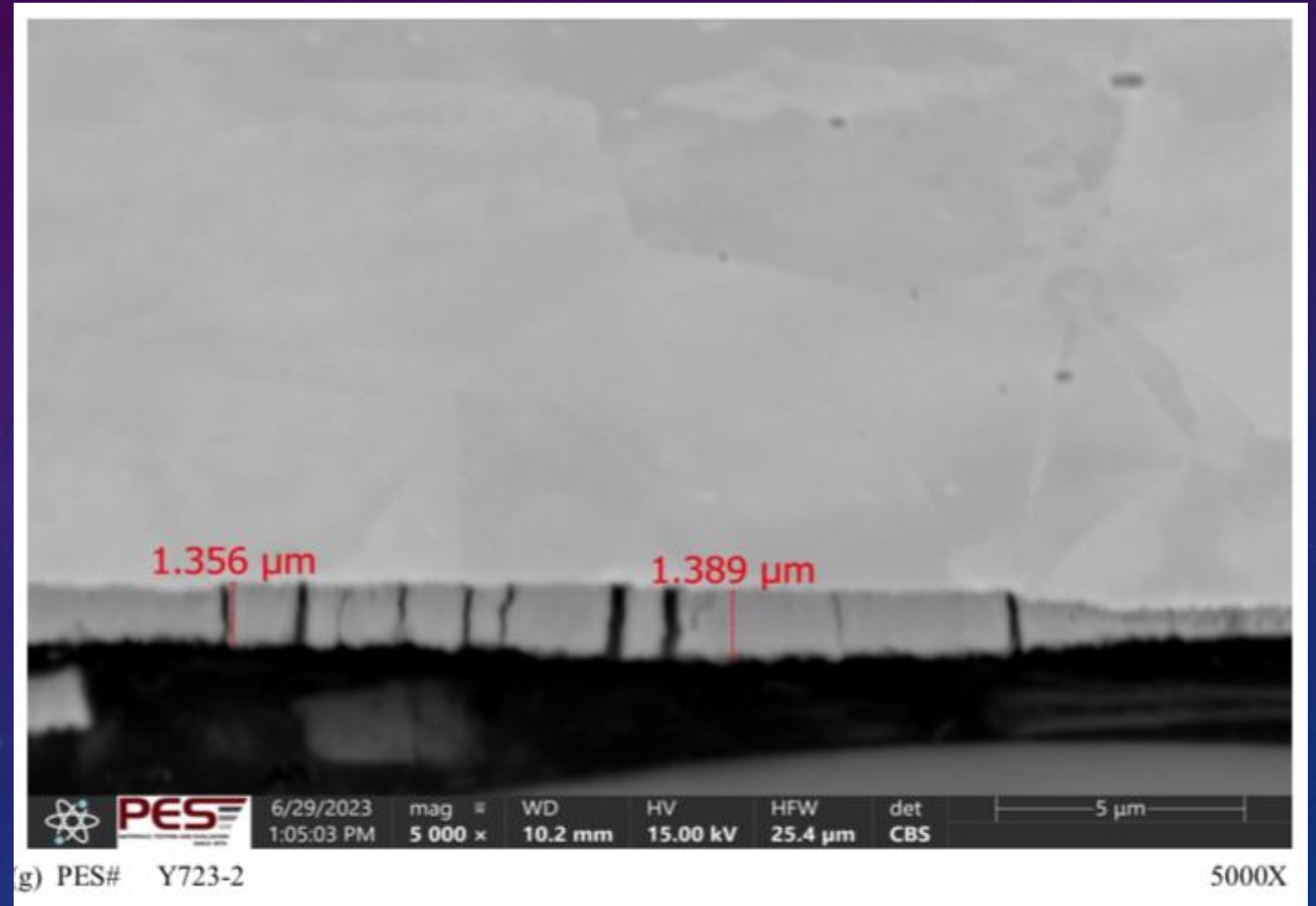
The background features a dark blue gradient with faint, light blue technical drawings. These include several concentric circles, some with arrows indicating rotation, and a large circular scale with degree markings ranging from 140 to 260. The overall aesthetic is scientific and technical.

Metallography, Laser Scanning Microscopy and White Light Profilometry of Steel Pipe Surfaces

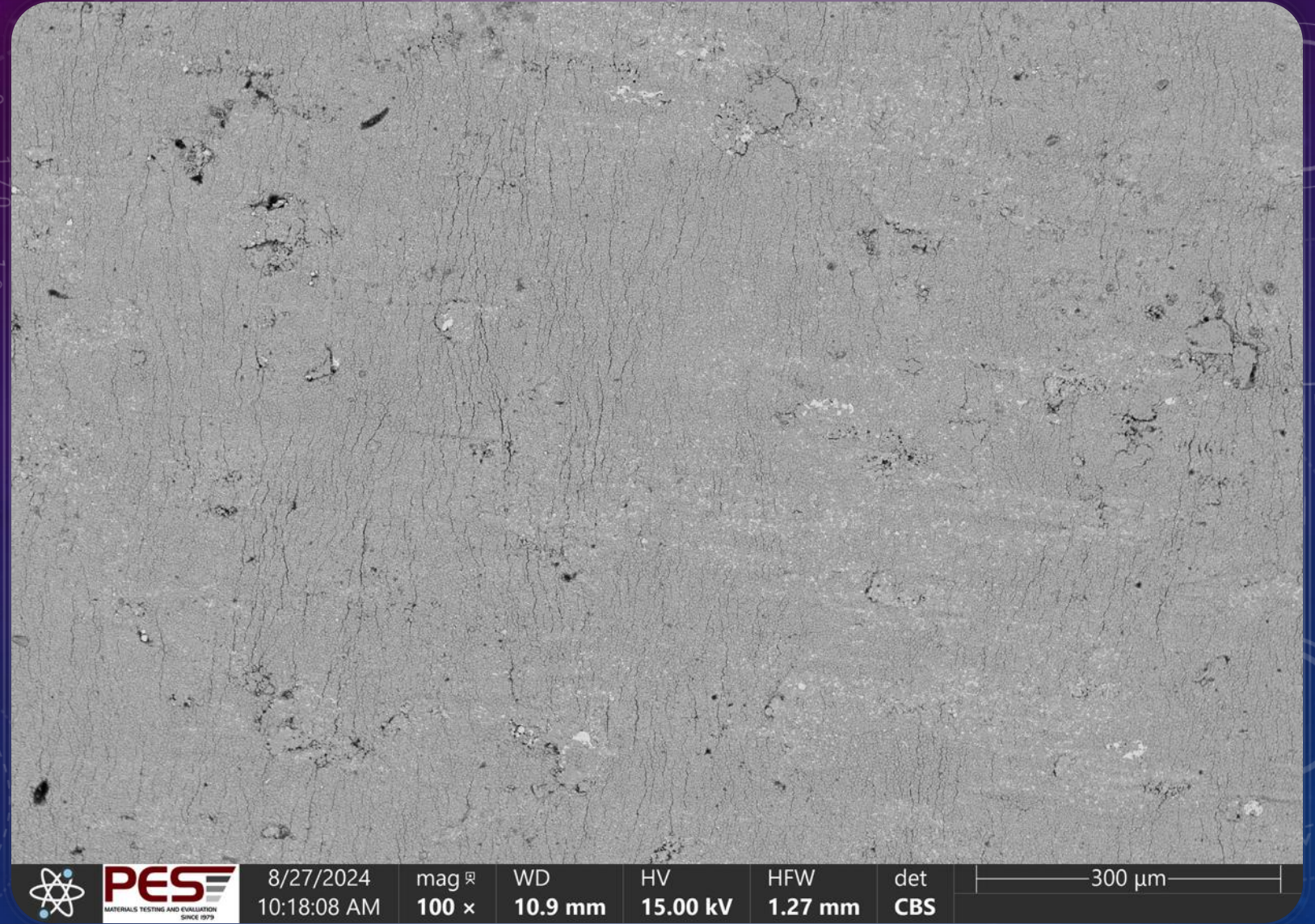
DAN HENKEL

October 1, 2025

Magnetite Thickness Caltech Steel

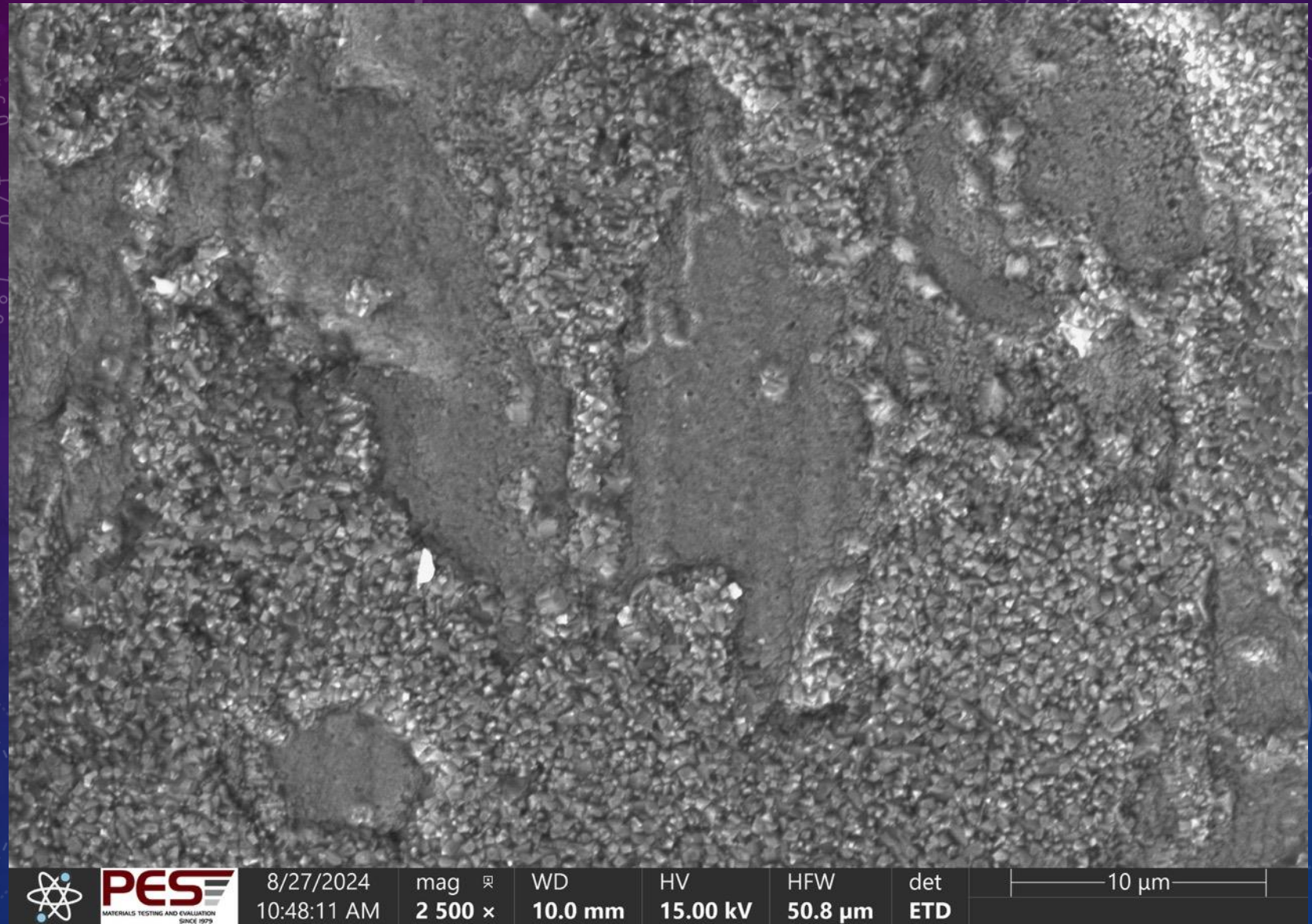


SURFACE OF CALTECH STEEL 100X



MATERIAL FORENSICS LLC

SURFACE OF
CALTECH STEEL
2,500X



PES
MATERIALS TESTING AND EVALUATION
SINCE 1979

8/27/2024
10:48:11 AM

mag 2 500 x

WD
10.0 mm

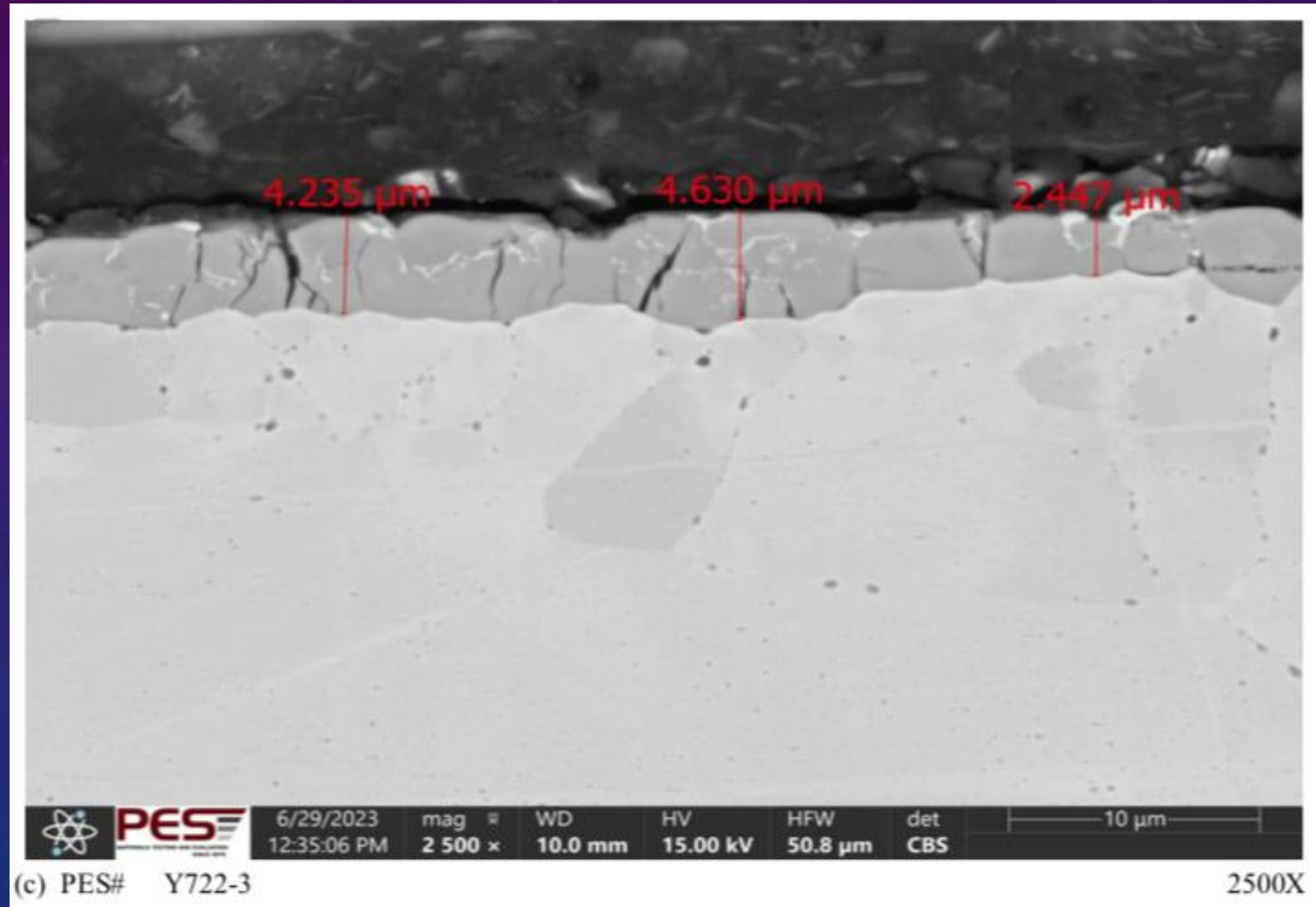
HV
15.00 kV

HFW
50.8 μm

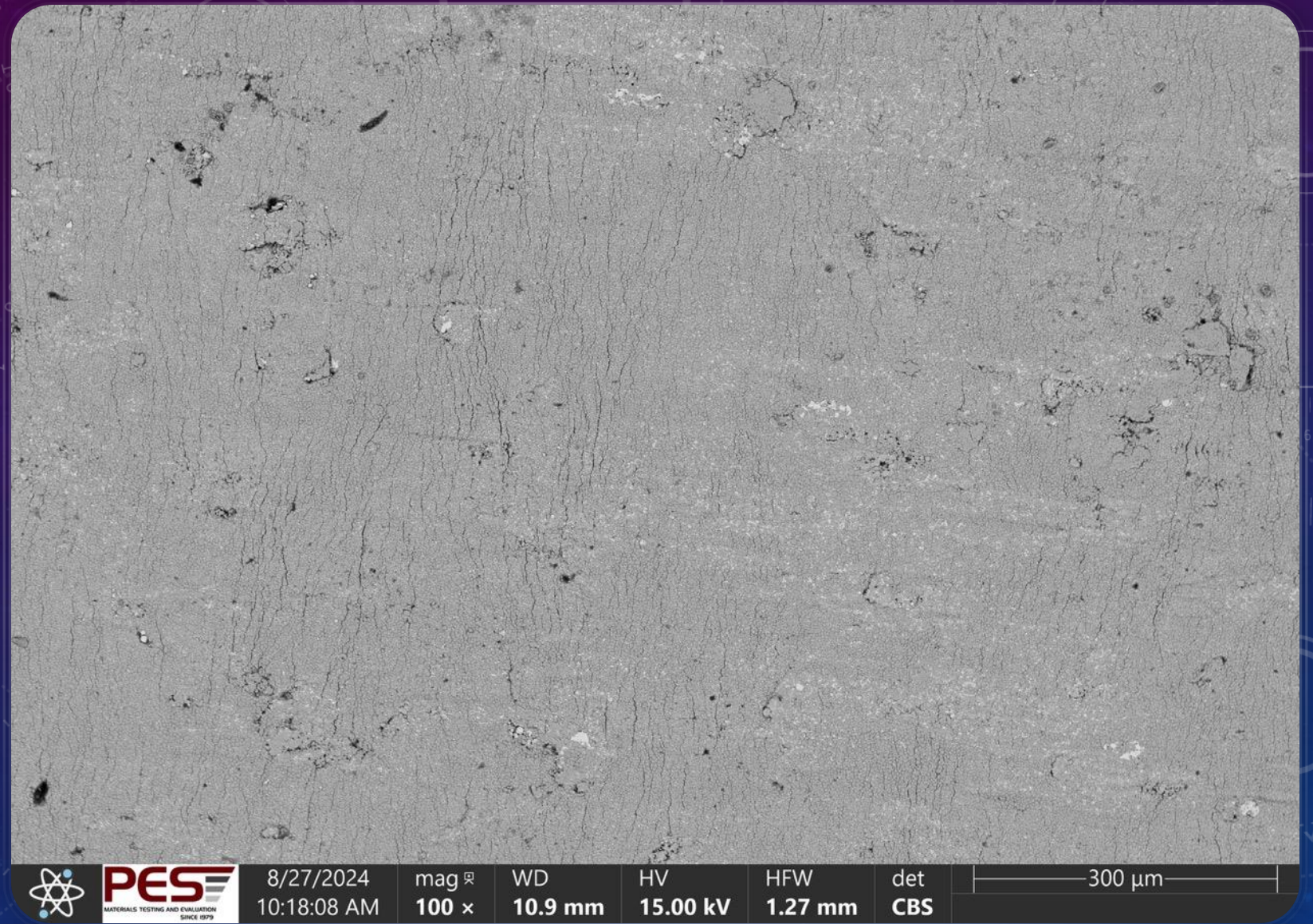
det
ETD

10 μm

Magnetite Thickness CERN Steel



SURFACE OF
CERN STEEL
100X



PES
MATERIALS TESTING AND EVALUATION
SINCE 1979

8/27/2024
10:18:08 AM

mag 100 ×

WD
10.9 mm

HV
15.00 kV

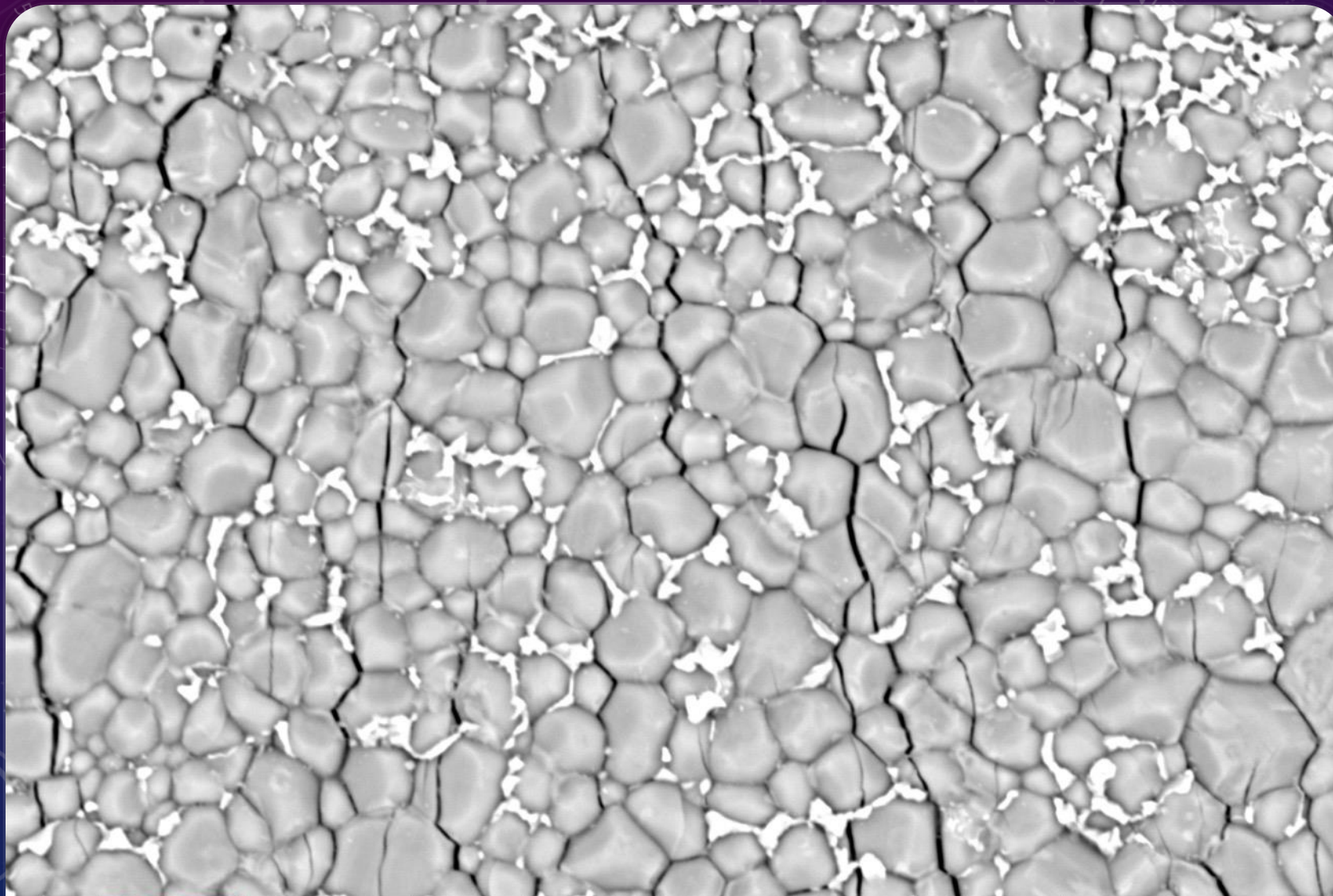
HFW
1.27 mm

det
CBS

300 μm

MATERIAL FORENSICS LLC

SURFACE OF
CERN STEEL
2,000X



PES
MATERIALS TESTING AND EVALUATION
SINCE 1979

8/27/2024
10:24:20 AM

mag 2 000 x

WD 10.9 mm

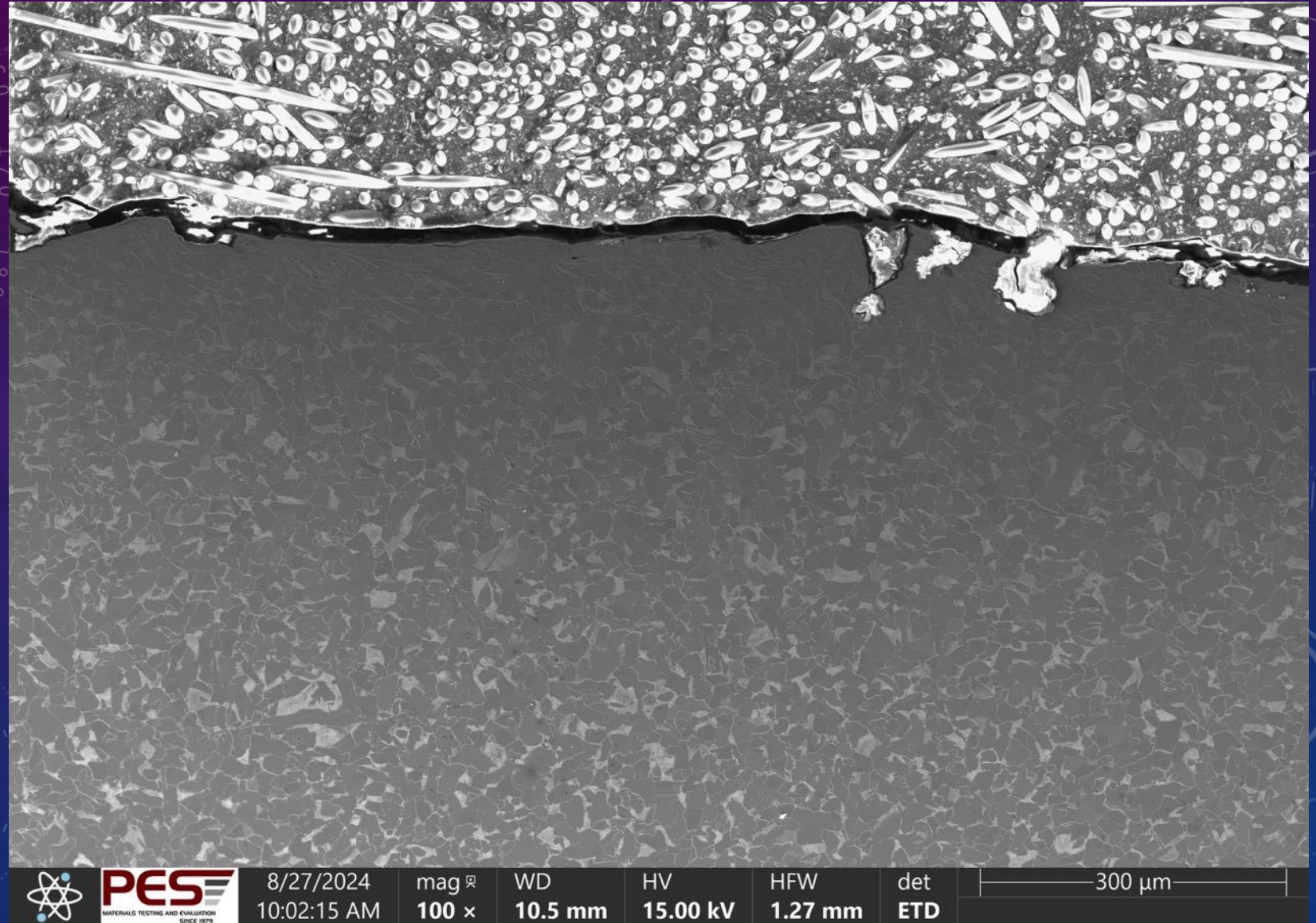
HV 15.00 kV

HFW 63.5 μm

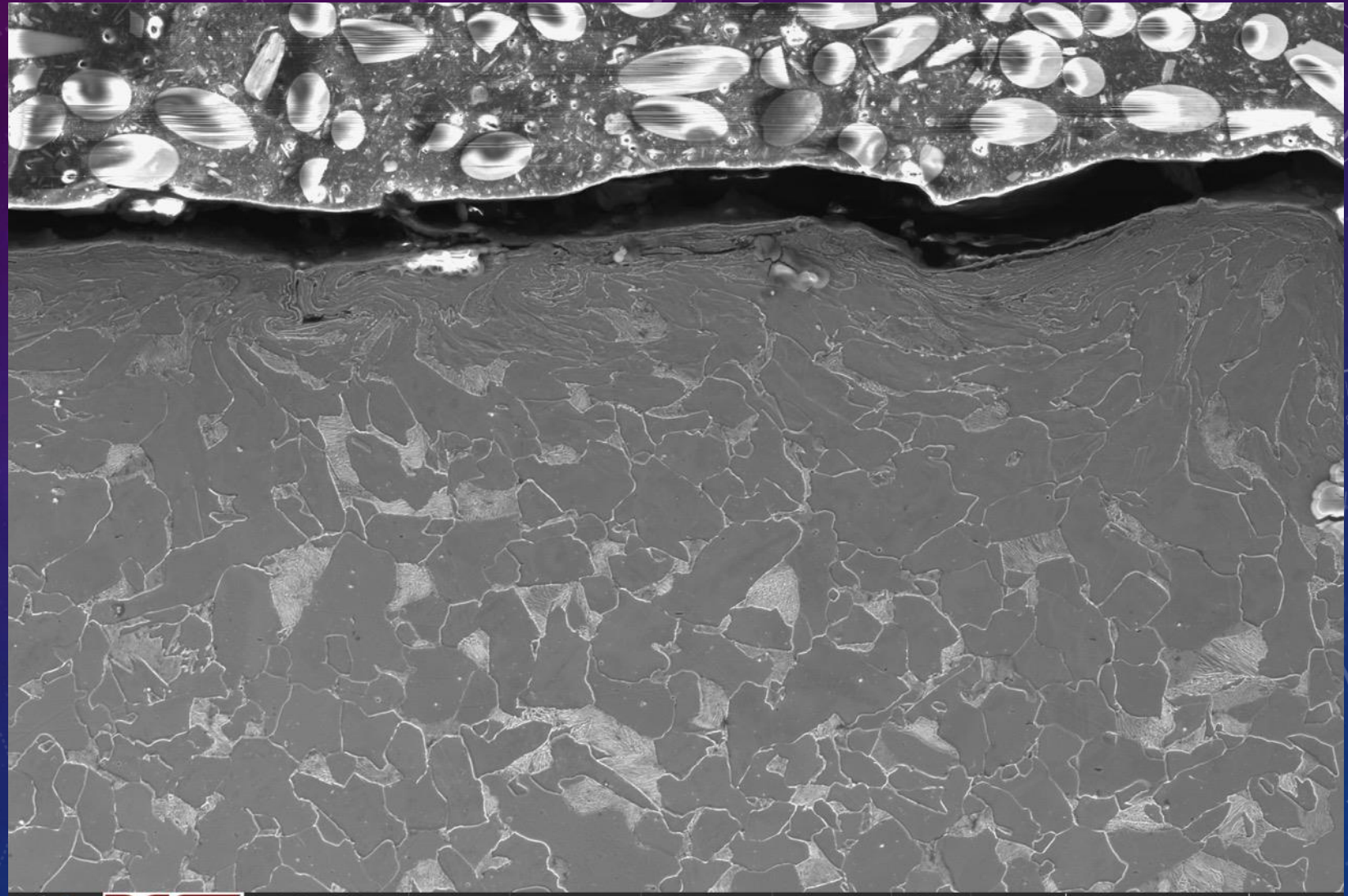
det CBS

10 μm

CROSS SECTION OF DURA-BOND STEEL 100X



CROSS SECTION OF DURA-BOND STEEL 350X



PES
MATERIALS TESTING AND EVALUATION
SINCE 1979

8/27/2024
10:00:42 AM

mag 350 ×

WD
10.5 mm

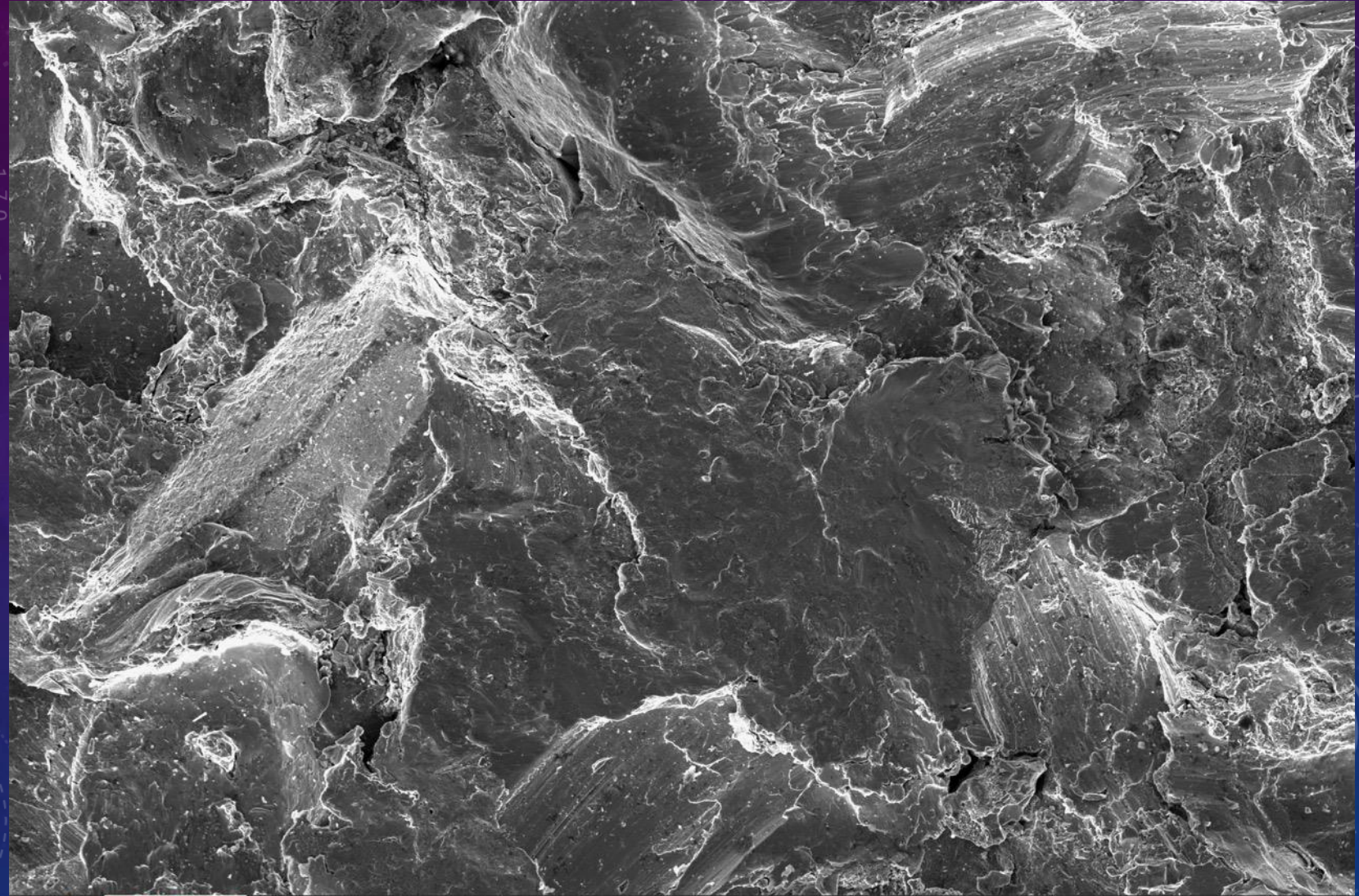
HV
15.00 kV

HFW
363 μm

det
ETD

50 μm

SURFACE OF DURA-BOND STEEL 200X



PES
MATERIALS TESTING AND EVALUATION
SINCE 1979

8/27/2024
9:36:41 AM

mag 200 ×

WD
10.8 mm

HV
15.00 kV

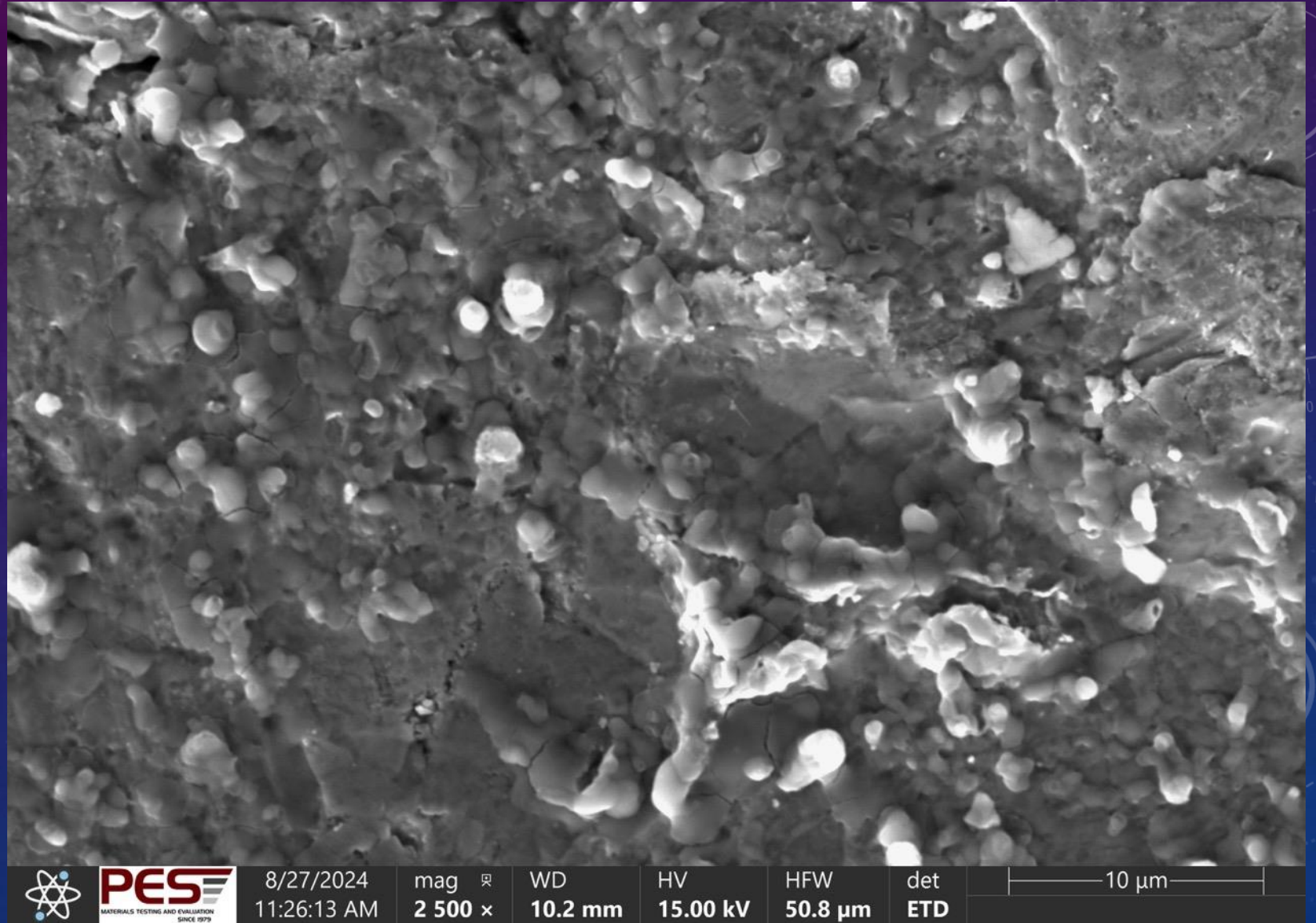
HFW
635 μm

det
ETD

100 μm

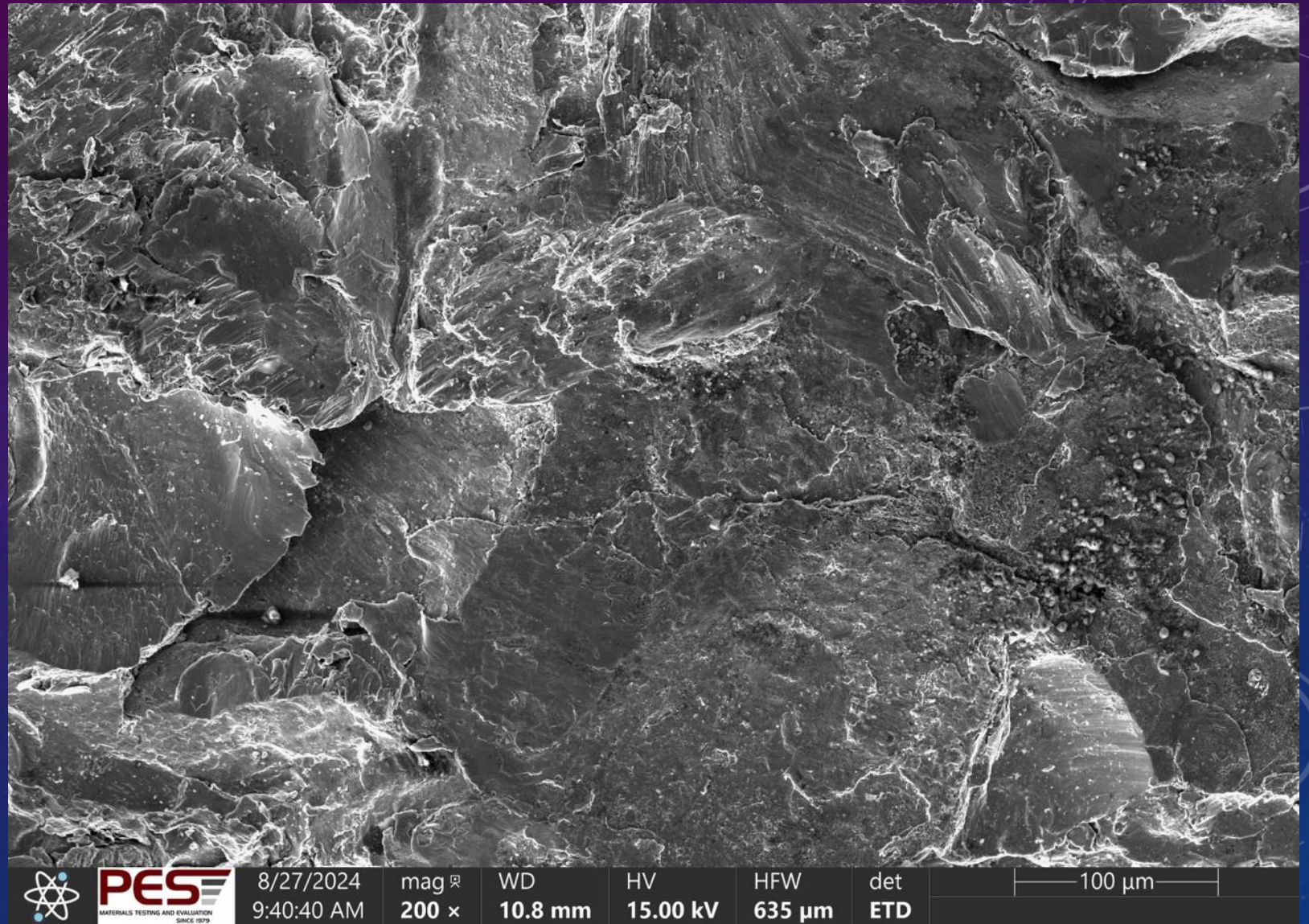
MATERIAL FORENSICS LLC

SURFACE OF
DURA-BOND STEEL
2,500X

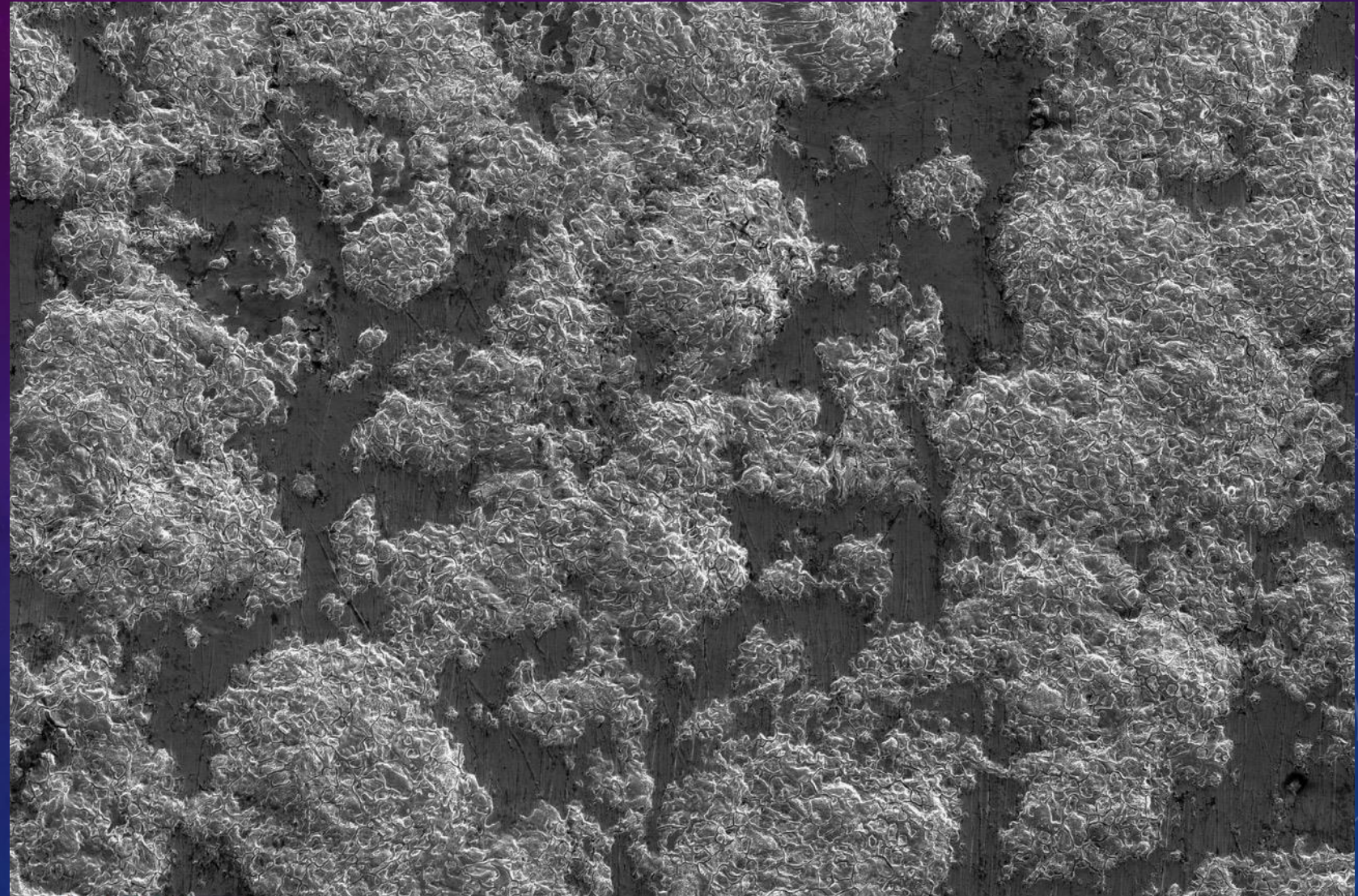


MATERIAL FORENSICS LLC

SURFACE OF DURA-BOND STEEL 200X



SURFACE OF LIGO STAINLESS STEEL 100X



PES
MATERIALS TESTING AND EVALUATION
SINCE 1979

9/11/2024
10:20:04 AM

mag 100 ×

WD 11.0 mm

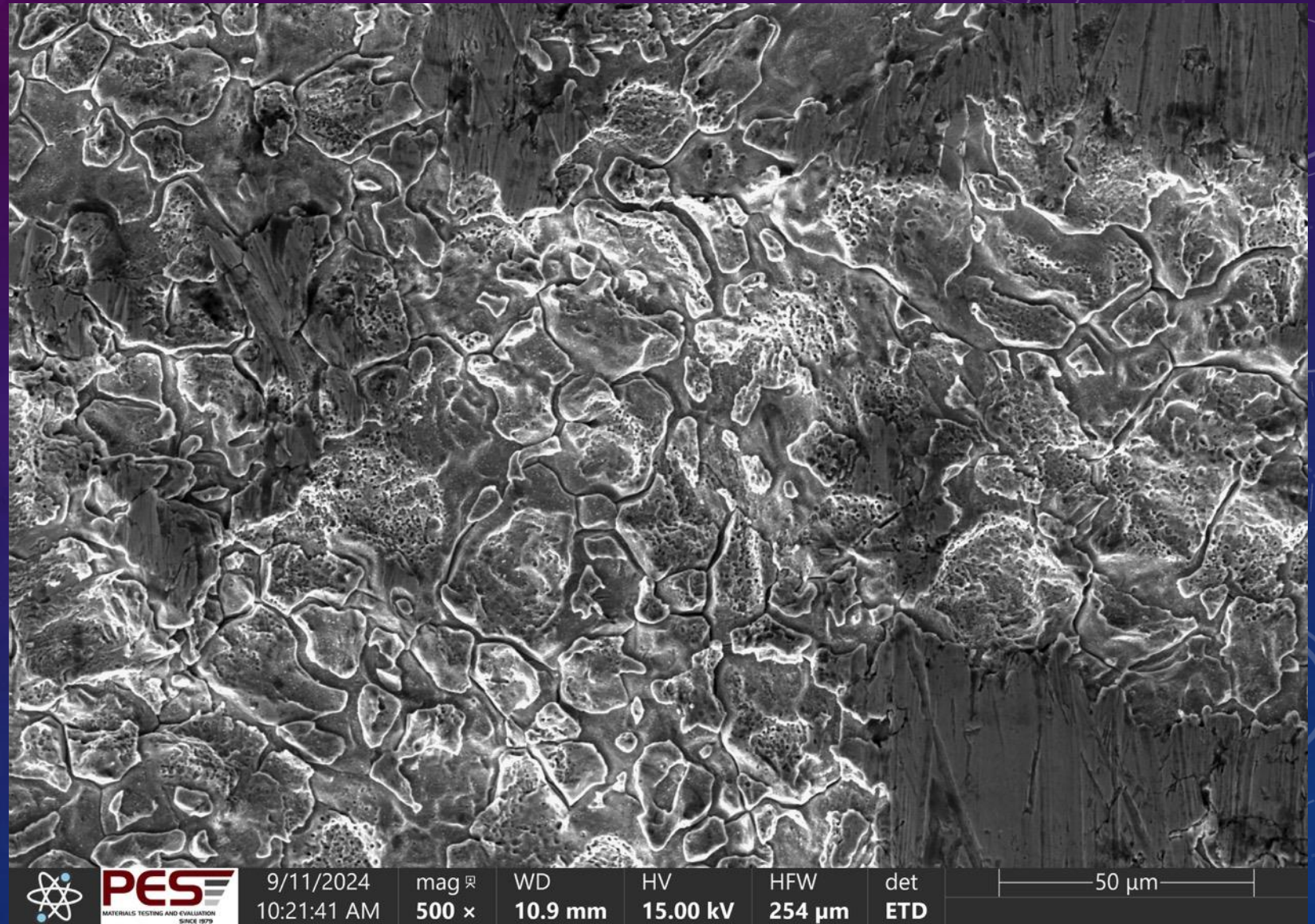
HV 15.00 kV

HFW 1.27 mm

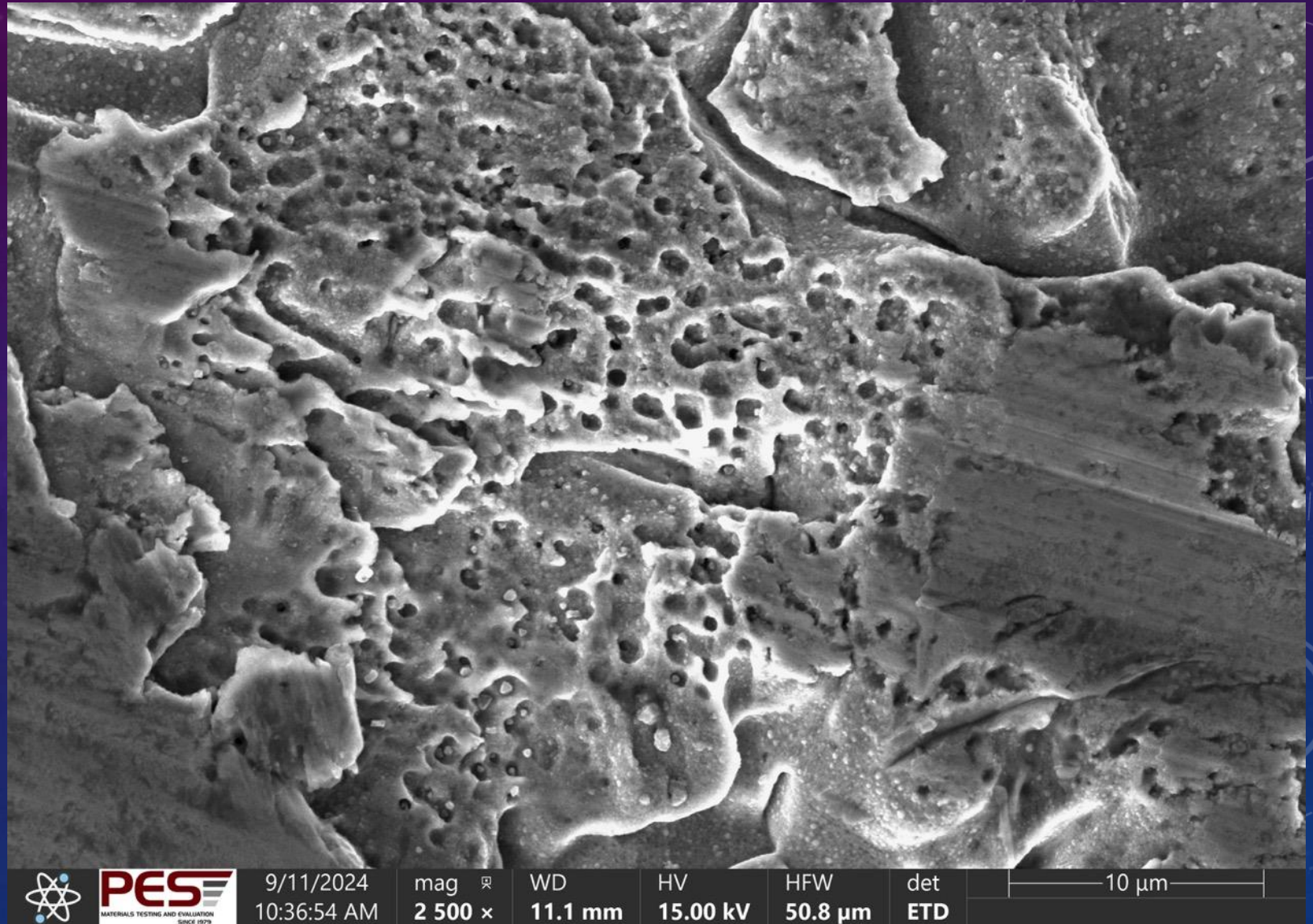
det ETD

300 μm

SURFACE OF LIGO STAINLESS STEEL 500X



SURFACE OF LIGO STAINLESS STEEL 2,500X

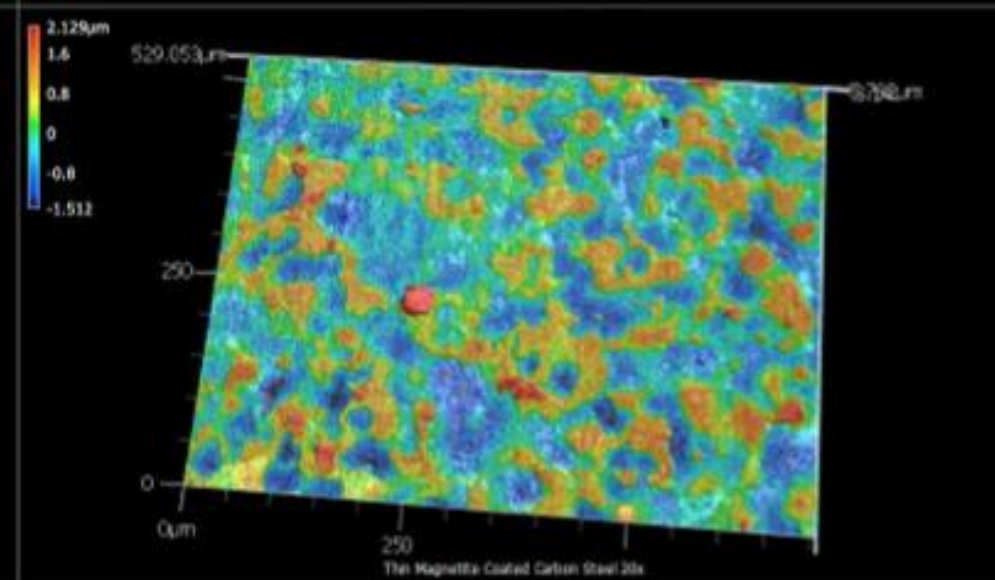
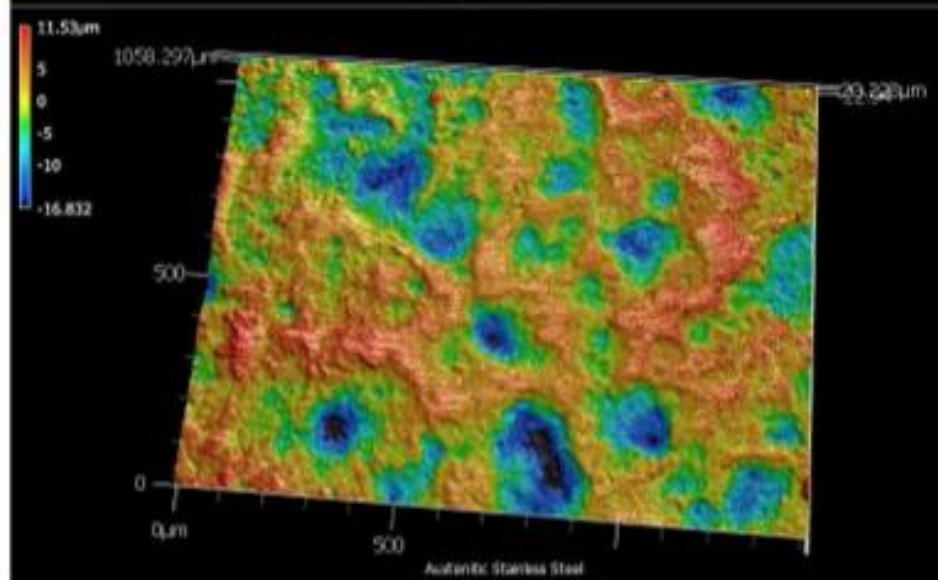
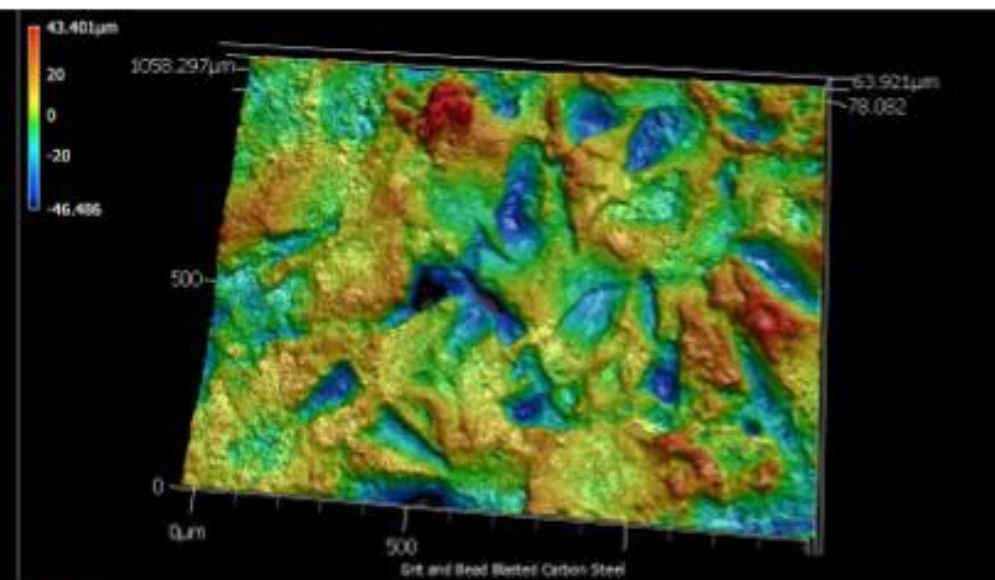
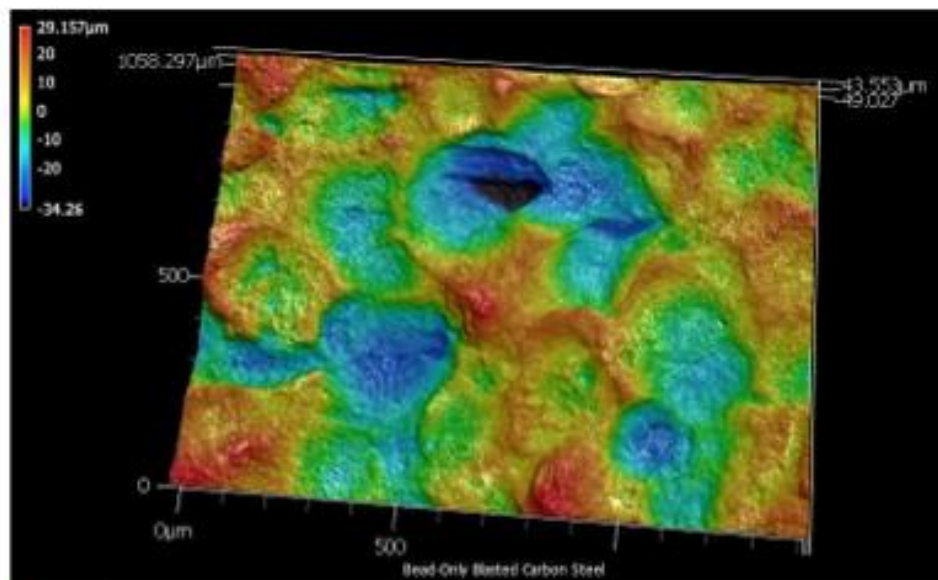


LASER SCANNING MICROSCOPY

(KEYENCE VK-X3000)



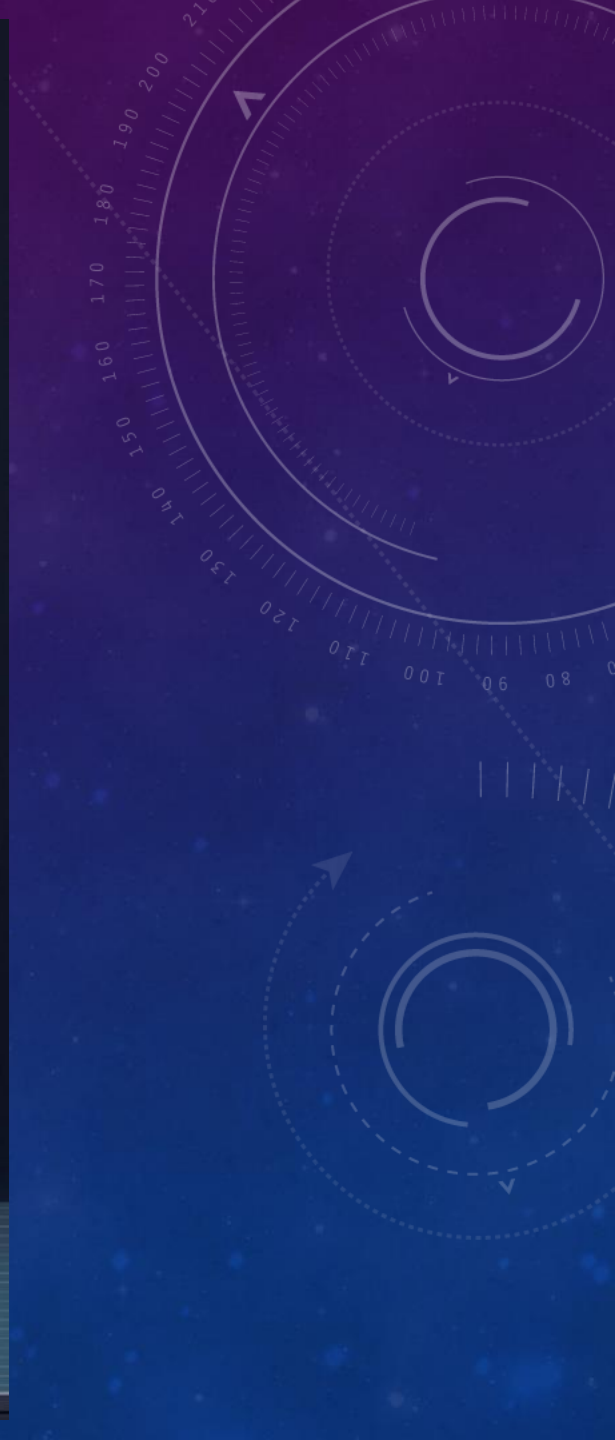
VK-X3000 3D Images



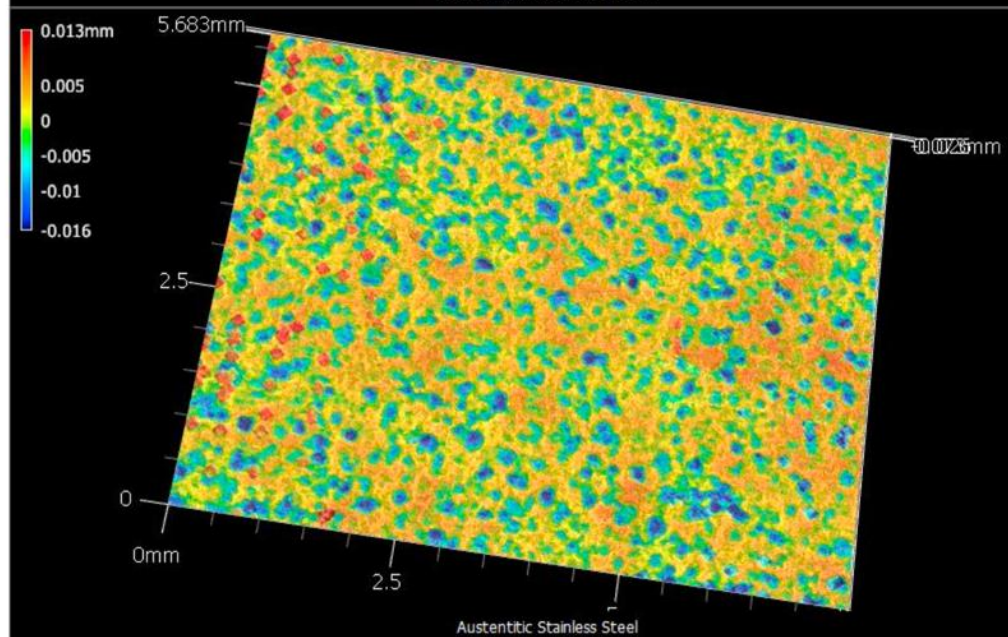
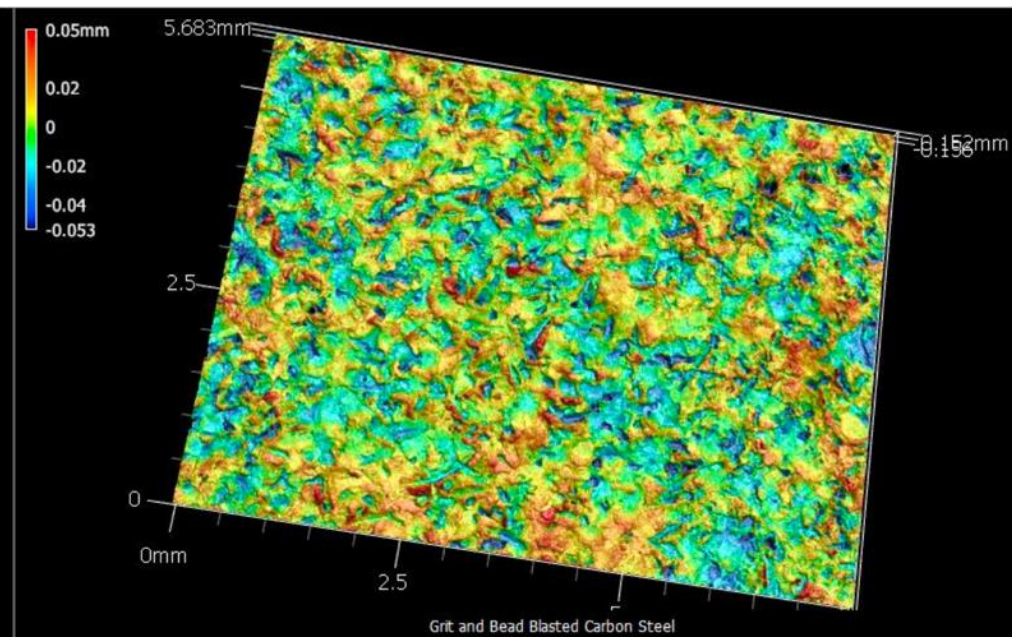
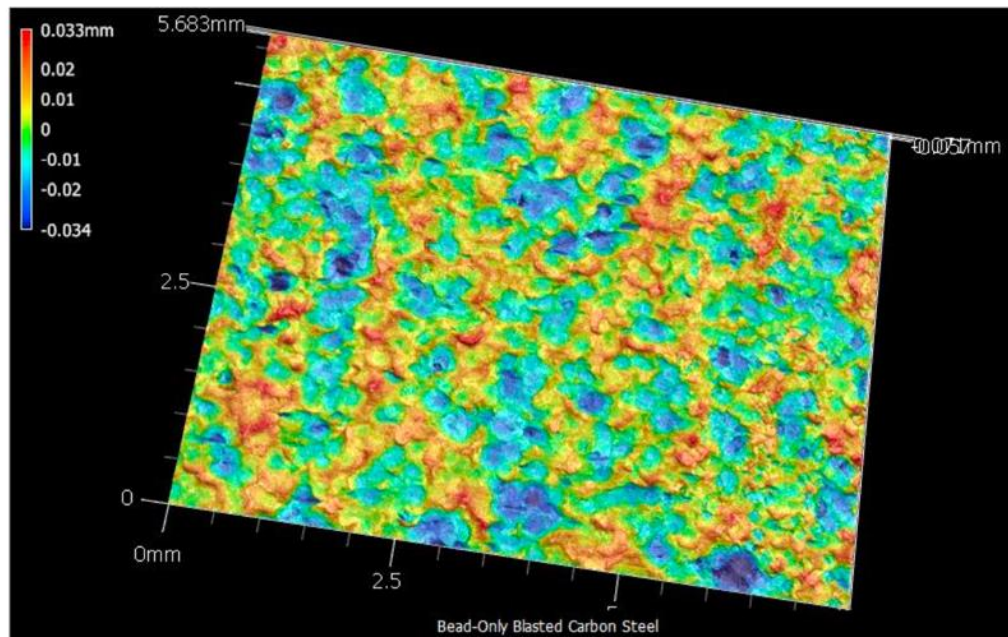
WHITE LIGHT PROFILOMETRY (KEYENCE VR-6000)



3D Optical Profilometer
VR-6000 Series



VR-6000 3D Images

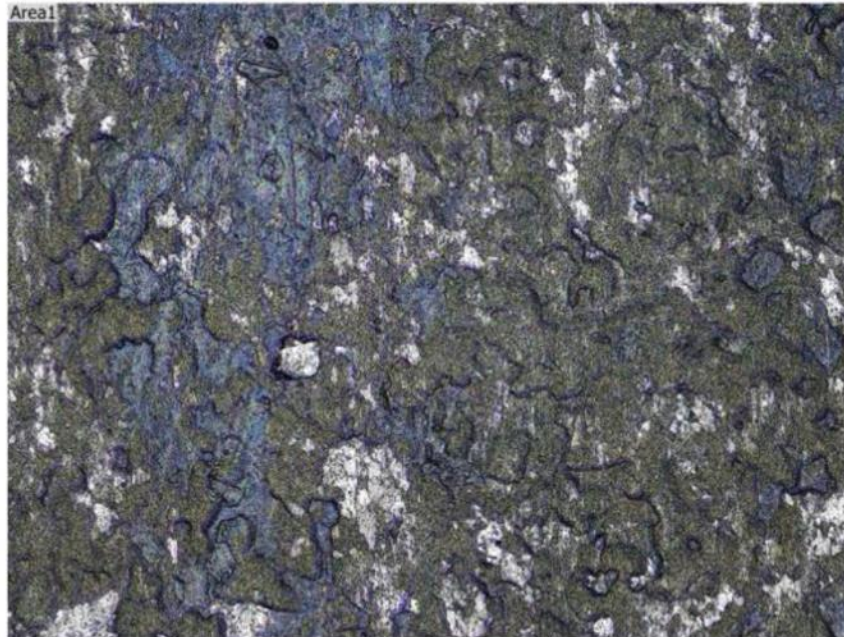


VK-X3000 Roughness Data

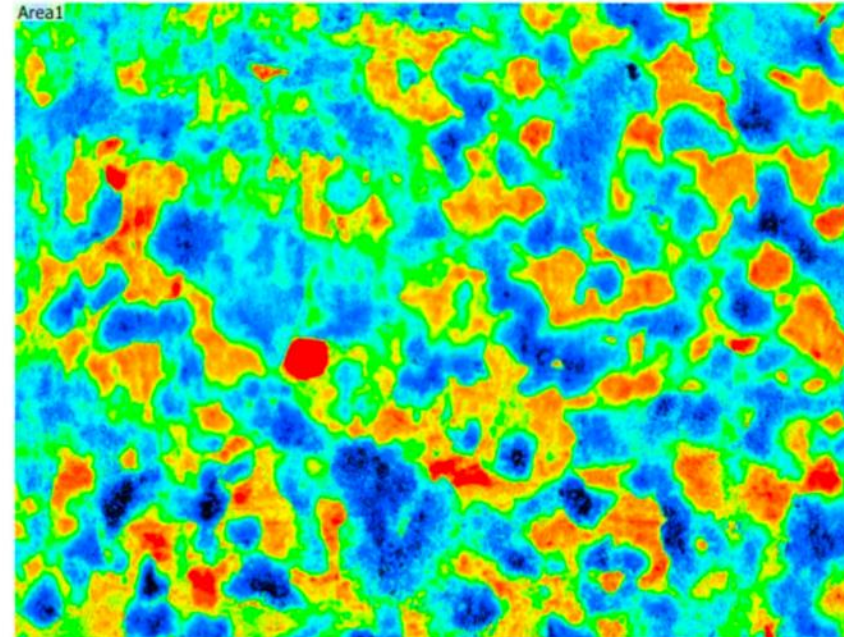
Surface roughness measurement Thin Magnetite Coated Carbon Steel 20x

KEYENCE VK-X3000 Series

Main image



Scale-limited surface



Analysis condition

Roughness standard	ISO 25178-2:2012
Filter type	Gaussian
S-filter	None
F-operation	None
L-filter	None
End effect correction	Enabled

Measurement result

	Sa	Sz	Sq
	μm	μm	μm
Max.	0.622	8.922	0.764
Min.	0.622	8.922	0.764
Ave.	0.622	8.922	0.764
Std. DV	0.000	0.000	0.000
Area1	0.622	8.922	0.764

Measured date : 2/10/2025 1:07:47 PM

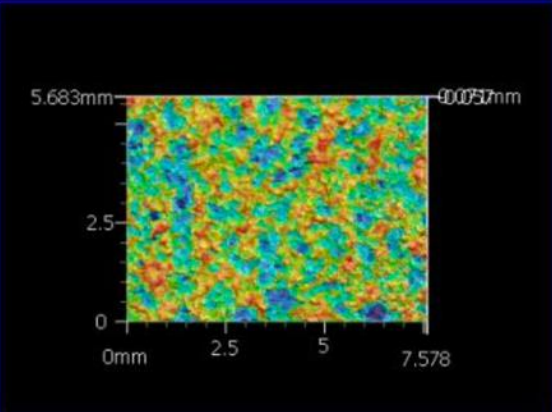
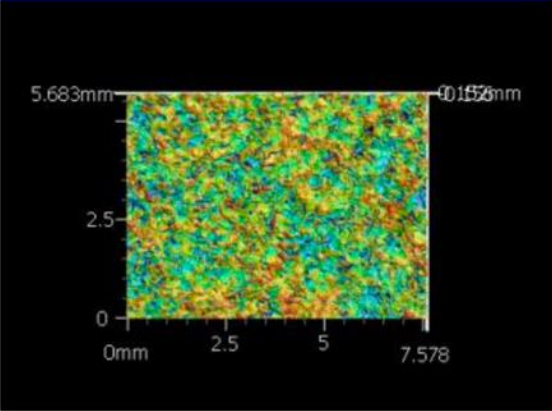
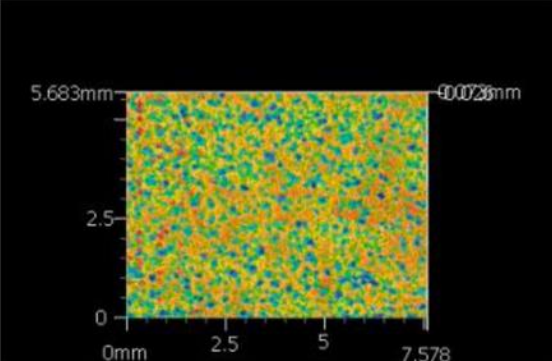
Objective Lens Power : 20X

The background is a dark blue gradient with faint, light blue technical drawing elements. These include several concentric circles, some with dashed lines and arrows indicating rotation or movement. There are also circular scales with numerical markings, such as one on the right side showing values from 80 to 210. The overall aesthetic is that of a technical or engineering blueprint.

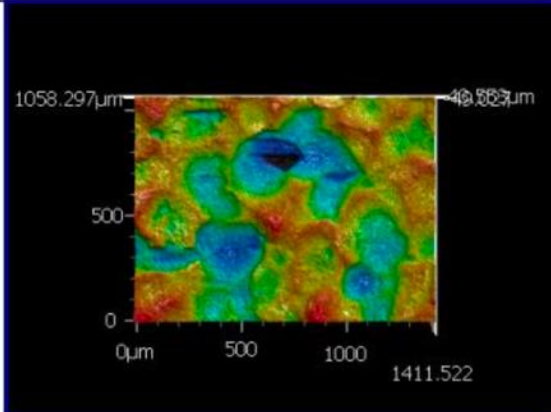
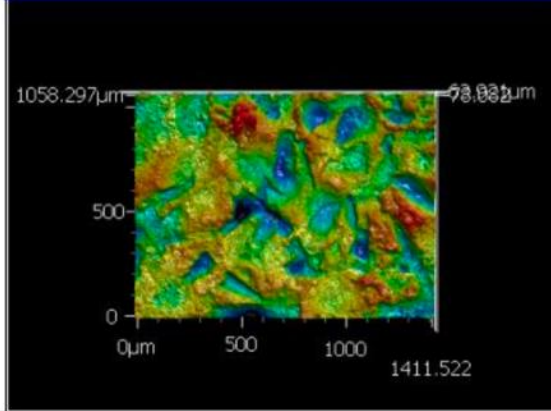
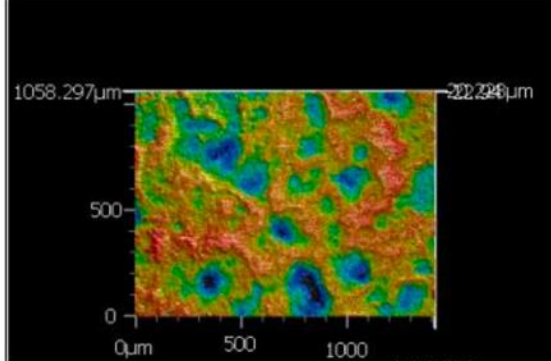
SURFACE ROUGHNESS

PROFILES, FLATNESS, AND ROUGHNESS IN AS LITTLE AS 1 SECOND

VR-6000 Roughness Data

Measurement data name	3D image	Surface roughness		
		Area1		
		Sa μm	Sz μm	Sq μm
Bead-Only Blasted Carbon Steel		9.948	128.260	12.513
Grit and Bead Blasted Carbon Steel		13.191	307.810	17.261
Austenitic Stainless Steel		3.712	98.850	4.842


VK-X3000 Roughness Data


Measurement data name	3D image	Surface roughness		
		Area1		
		Sa μm	Sz μm	Sq μm
Bead-Only Blasted Carbon Steel		9.386	92.580	11.790
Grit and Bead Blasted Carbon Steel		10.414	142.002	14.187
Austenitic Stainless Steel		4.470	43.168	5.626

The background of the slide features a series of horizontal, jagged lines representing surface roughness profiles. These lines are rendered in a lighter shade of blue against a darker blue gradient. In the upper right corner, there are technical diagrams including a circular scale with numerical markings (150, 160, 170, 180, 190, 200) and arrows, and a circular arrow indicating a clockwise direction. In the lower right corner, there are concentric circles and a dashed line with an arrow pointing towards the center. The overall aesthetic is technical and scientific.

ROUGHNESS PARAMETERS



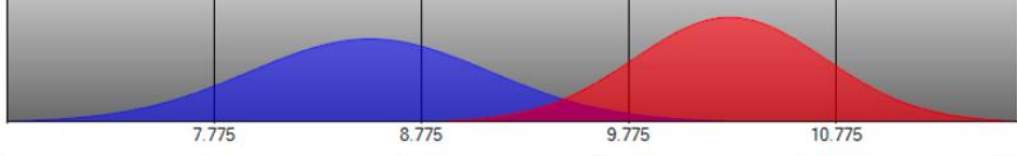

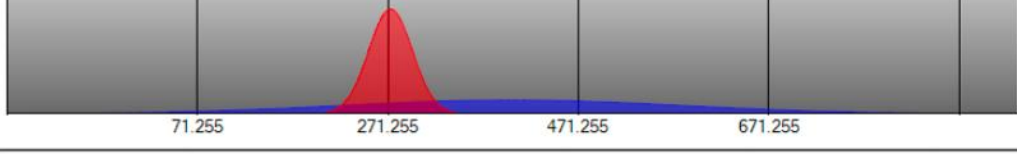
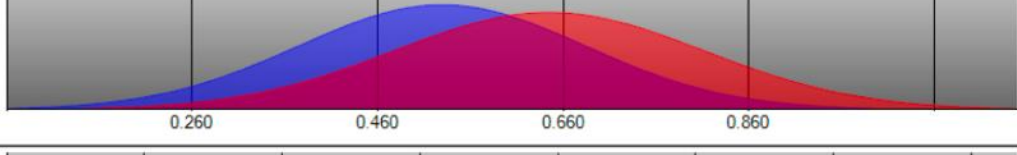

Measurement data

Measurement data name	Image	Area settings
Bead-Only Blasted Carbon Steel		All areas

Measurement data name	Image	Area settings
Grit and Bead Blasted Carbon Steel		All areas

Analysis result

Parameters are ordered by degree of separation.
Select parameters to be added to a report.

Separation ?	Parameter	Name	Desc	Distribution	Ave.	Std. DV
★★★★	Sdr	Developed interfacial area ratio (degree of increase of surface area when compared with a flat surface) * This value is 0.1 when the surface area increases by 10%.	?		Group 1 0.0805 Group 2 0.3686	Group 1 0.0157 Group 2 0.0322
★★★★	Spc	Arithmetic mean peak curvature (peakedness) * The larger the value, the higher the peakedness.	?		Group 1 210.230 Group 2 481.605	Group 1 28.389 Group 2 30.922
★★★	Sa	Arithmetic mean height of the surface	?		Group 1 8.525 Group 2 10.259	Group 1 0.502 Group 2 0.398
★★★	Sz	Maximum height of the surface	?		Group 1 63.682 Group 2 95.806	Group 1 2.128 Group 2 14.677
★★★	RSm	Mean width of the profile elements (average of peak and valley cycle lengths)	?		Group 1 401.883 Group 2 274.150	Group 1 158.042 Group 2 20.542
★★★	Str	Aspect ratio of the surface texture (presence of systematic creases) * This is a value from 0 to 1. The smaller the value, the more clear are the creases.	?		Group 1 0.529 Group 2 0.644	Group 1 0.134 Group 2 0.145
★★★	Ra	Arithmetic mean height of the profile	?		Group 1 6.298 Group 2 7.627	Group 1 1.817 Group 2 2.135

The background of the slide features a dense, horizontal pattern of seismic waveforms in various shades of blue and purple. Overlaid on these waveforms are several faint, white technical diagrams. These include circular arcs with arrows indicating a clockwise direction, and a larger circular scale with numerical markings ranging from 100 to 200. The overall aesthetic is scientific and technical.

CROSS-SECTIONAL MEASUREMENTS

