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Post-flight MMOD Impact Feature Survey of the Hubble Space Telescope WFPC2 Radiator

John N. Opiela[1], J.-C. Liou[2], and Phillip D. Anz-Meador[1]

[1]*ESC Group/Jacobs*
Houston, TX 77058

[2]*National Aeronautics and Space Administration*
Johnson Space Center
Houston, TX 77058

National Aeronautics and
Space Administration

Johnson Space Center
Houston, TX 77058

March 2012

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National Aeronautics and
Space Administration

Johnson Space Center
Houston, TX 77058

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1.0 Introduction

This document describes the micrometeoroid and orbital debris (MMOD) impact survey conducted upon the radiator panel of the Hubble Space Telescope's (HST's) Wide Field Planetary Camera 2 (WFPC2). Sections 1.0 – 4.0 introduce the project, explain the methods used, and describe typical results. Appendix A provides information about the WFPC2 radiator and describes the coordinate frame used. Appendix B contains a table listing the measurement results. Appendix C consists of reduced images of each recorded impact feature.

The STS-125 Atlantis astronauts retrieved the HST WFPC2 during a very successful and final servicing mission to the HST in May 2009. The radiator attached to WFPC2 (Figure 1) has dimensions of 2.2 by 0.8 meters. Its outermost layer is a 4-mm-thick aluminum, curved plate coated with white thermal paint. This radiator had been exposed to space since the deployment of WFPC2 in 1993. Due to its large surface area and long exposure time, the radiator served as a unique witness plate for the MMOD environment between 560 and 620 km altitude for more than 15 years.

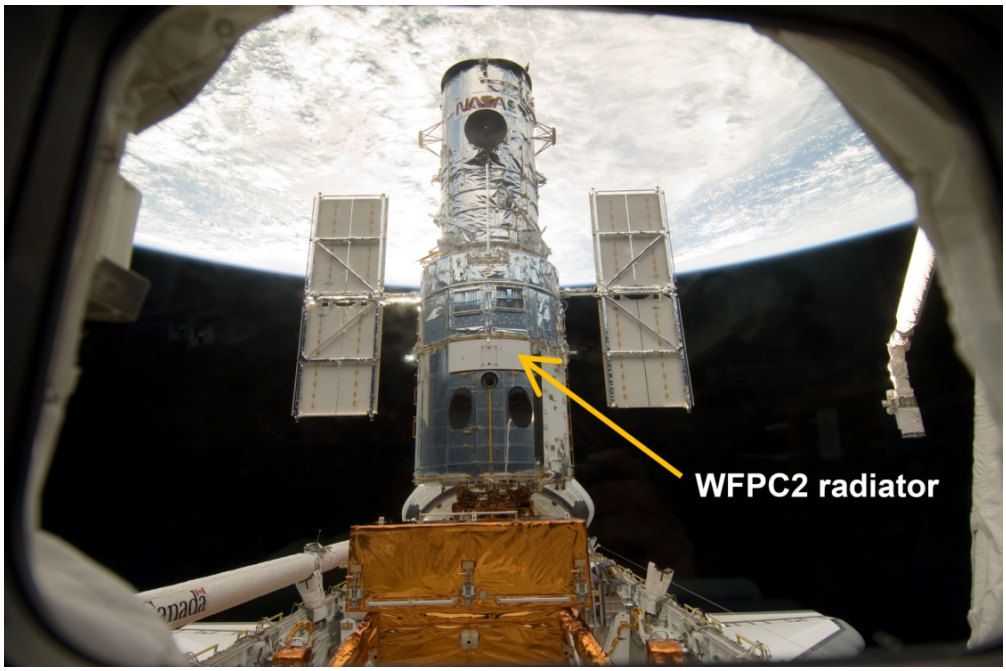


Figure 1. A view of the HST after it was captured and docked to the Atlantis cargo bay during the 2009 servicing mission. (NASA Photo s125e007066)

2.0 Inspection Overview

The NASA Orbital Debris Program Office (ODPO) led an effort, with full support from the NASA Hypervelocity Impact Technology (HVIT) group, the NASA Meteoroid Environment Office, and the NASA Astromaterials Acquisition and Curation Office, to conduct an MMOD impact survey of the WFPC2 radiator during the summer of 2009. This effort also was supported by the HST Program Office located at the NASA Goddard Space Flight Center (GSFC). The ultimate goal is to use the survey data to validate or improve the near-Earth MMOD environment definition. During the initial inspection, completed in September 2009 at GSFC, the survey team found a total of 675 impact craters caused by MMOD particles in the size regime that is important to satellite impact risk assessments. Figure 2 highlights 20 of the largest impact features.

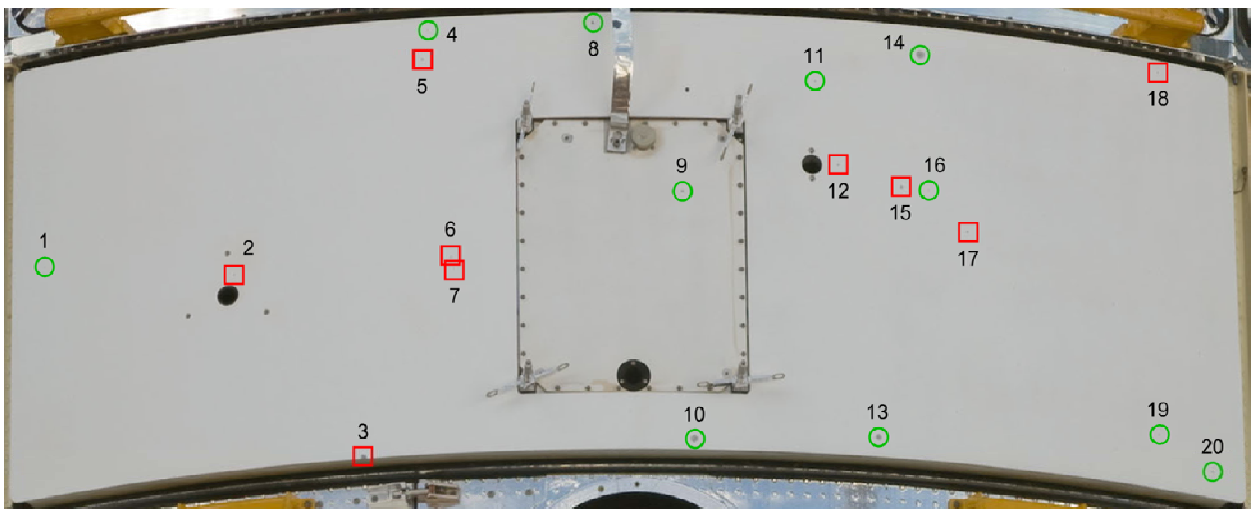


Figure 2. Large, visible MMOD impacts on the WFPC2 radiator. The largest damage area is about 1 cm across. Red squares indicate features identified from the 2002 HST Servicing Mission 3B image survey. Green circles indicate features identified from the 2009 HST Servicing Mission 4 image survey. (From NASA Photo s125e006995)

Two instruments were used during the 6-week inspection at GSFC: a laser scanner for a quick map of the distribution of impact features on the surface, and a digital microscope for detailed two- and three-dimensional imagery of individual impacts. In addition, a laser template projector was programmed and set up to establish the coordinates of individual impact features. The inspection was limited to features larger than about 300 µm across, because this is approximately the threshold for the smallest MMOD particles that are important for satellite impact risk assessments. The outermost layer of the radiator is a 4-mm-thick aluminum plate coated with thermal control paint with a thickness of 100 to 300 µm. See Appendix A for a description of the coordinate reference frame and a brief description of the radiator.

By the end of the inspection, a total of 675 MMOD impact features were identified and documented. An additional 187 non-impact features, such as surface contamination and tool marks, were also observed and documented. The largest impact feature has a crater diameter of 1.5 mm with a surrounding spall zone about 1.5 cm across (on the painted radiator surface). The majority of the documented impacts did not penetrate the paint layer. The crater on the left in Figure 3 is a typical example of a particle not penetrating through the paint layer. The crater on the right in Figure 3 shows a different type of impact where the projectile went through the paint and damaged the metal substrate of the radiator. (See Appendix A for a description of the crater identification labels listed in the figure caption.)

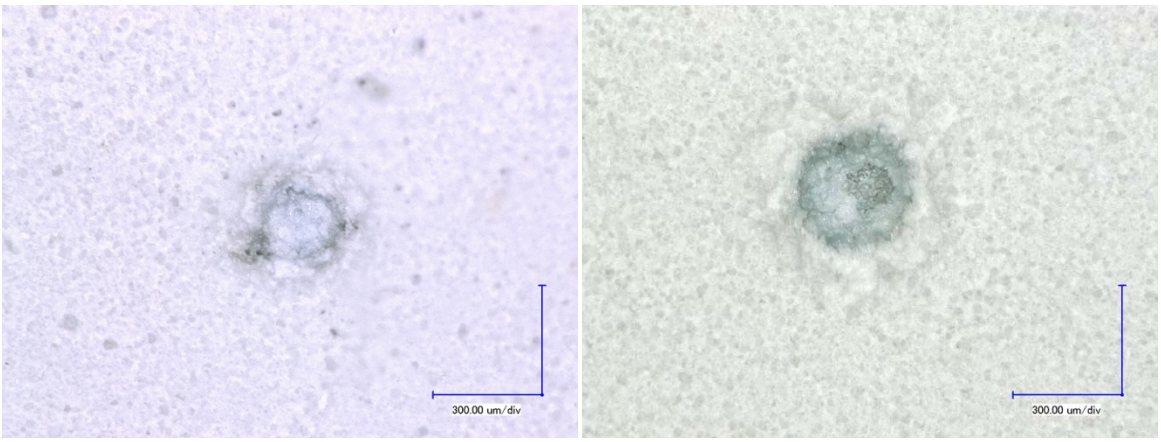


Figure 3. On the left is a typical impact crater (H1-40-29) on the WFPC2, where the impacting particle did not penetrate the paint layer. The crater on the right (C3-97-92) resulted when a particle passed through the paint and damaged the metal part of the radiator.

3.0 Data Extraction

The data that were collected by the inspection team included over 26,000 digital images of more than 800 features. For each impact feature, and for some other interesting features, the inspectors used the digital microscope to semi-automatically capture a series of anywhere from 5 to 50 images at precise "depth" intervals (yielding the large total number of images). Given the lens and depth-interval settings, the microscope's internal software constructs a three-dimensional (3-D) representation of the feature, and then allows the operator to measure the distance between points. The microscope includes software tools for measuring depth, diameter, and many other quantities.

3.1 Measurement

Taking depth measurements after completion of the photographic survey involved loading each feature's series of images, setting the microscope parameters to those used when capturing the original images, and commanding the software to create the 3-D representation. The microscope operator then positioned a reference line across an image of the crater (as shown in the upper part

of Figure 4), sweeping the line back and forth to find the deepest part of the crater (as shown by the red profile line in the lower part of Figure 4). The depth values then were determined by positioning two horizontal reference lines over the profile line; the software reported the distance between the reference lines. When craters did not reach the underlying metal surface, the analyst measured the depth from the undisturbed paint surface to the lowest point in the crater. When craters did reach the metal, the analyst recorded both the paint thickness (measured from the undisturbed paint surface to the uppermost level of radiator metal) and the deepest penetration into the metal.

For the sample shown in Figure 4, the damage shown is ~1.4 mm across with a spall zone (the area between the vertical lines "C" and "D") about twice as big. The horizontal green line labeled "B" defines the top surface of the paint while the horizontal green line labeled "A" indicates the top of the aluminum surface (under the paint). The distance from "A" to "B" is about 0.38 mm. The thickness of the undisturbed paint at this particular location can also be estimated from the image to be about 0.28 mm.

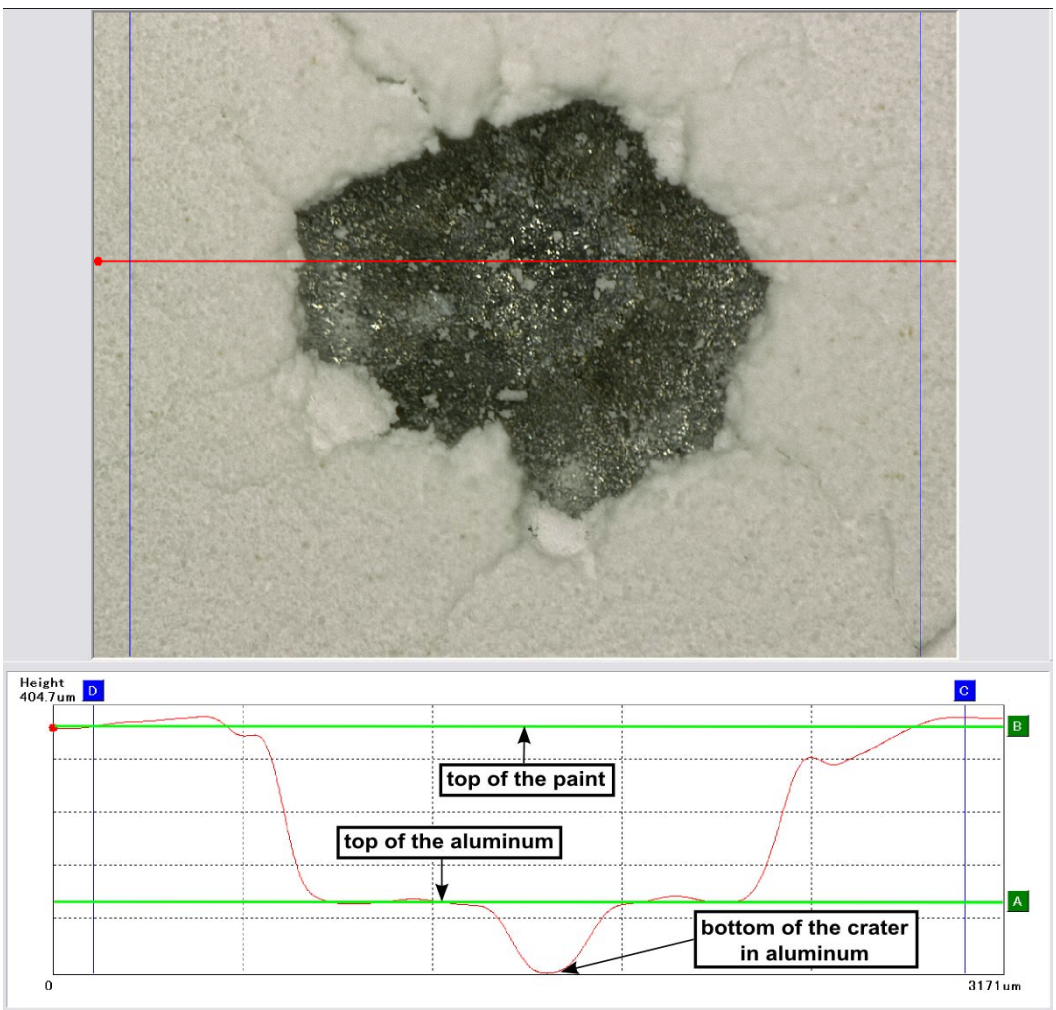


Figure 4. Digital microscope depth profile measurement (crater B5-76-81).

After completing the depth measurements, the analyst would command the microscope software to flatten the image series into a composite, “all-in-focus” two-dimensional (2-D) image. Diameter measurements were taken from the 2-D images (Figure 5). Depending on the crater morphology, up to four diameters were recorded: the spall zone, the bare metal, the colored or “burned” metal, and the lips or center. All the craters typically had a spall zone, regardless of whether the metal was exposed. The boundary of this zone was formed of chipped and fractured paint (Figure 6). The area of bare metal was usually obvious, though sometimes interrupted by paint residue. The larger craters with a bare metal zone usually had a smaller “burned” area radiating from the central area (Figure 5). Craters with bare metal but no clear central pit often had patchy or mottled areas of darker color (Figure 7). The central diameter of craters with no exposed metal were formed by the shoulder of the crater, between the spall zone and the central pit. The central diameter of craters with exposed metal was measured either across the uplifted ridge surrounding the central pit, where it existed, or across the best-defined, lowest depression within the crater. Defining the central diameter was most difficult on the smaller craters with exposed metal because of the irregularity of the floors of those craters.

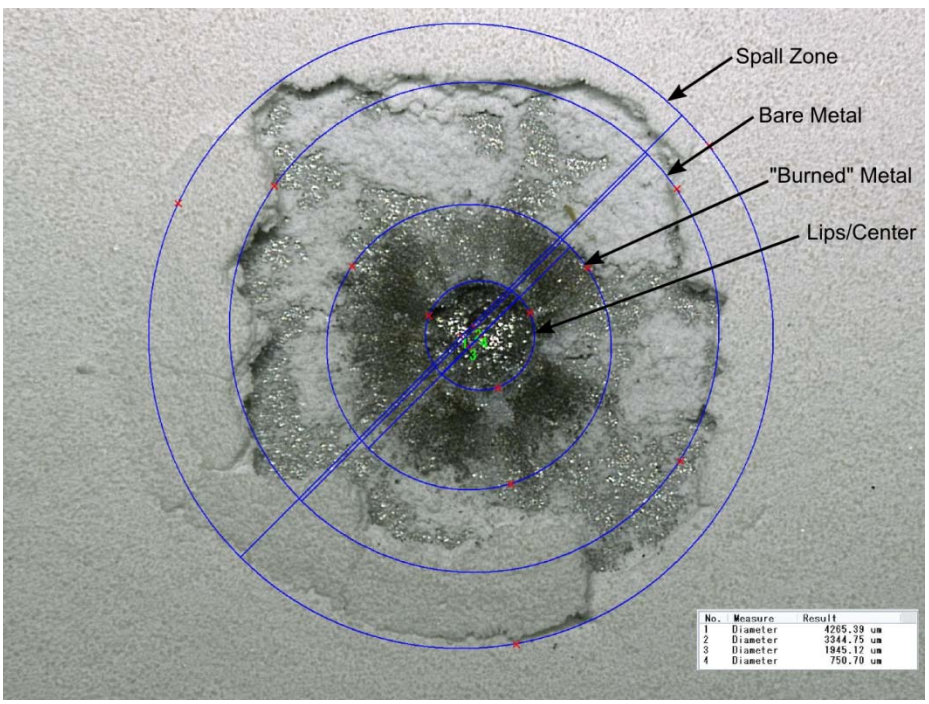


Figure 5. Digital microscope diameter measurement function (crater E4-25-89). (NASA image JSC2010E054443)

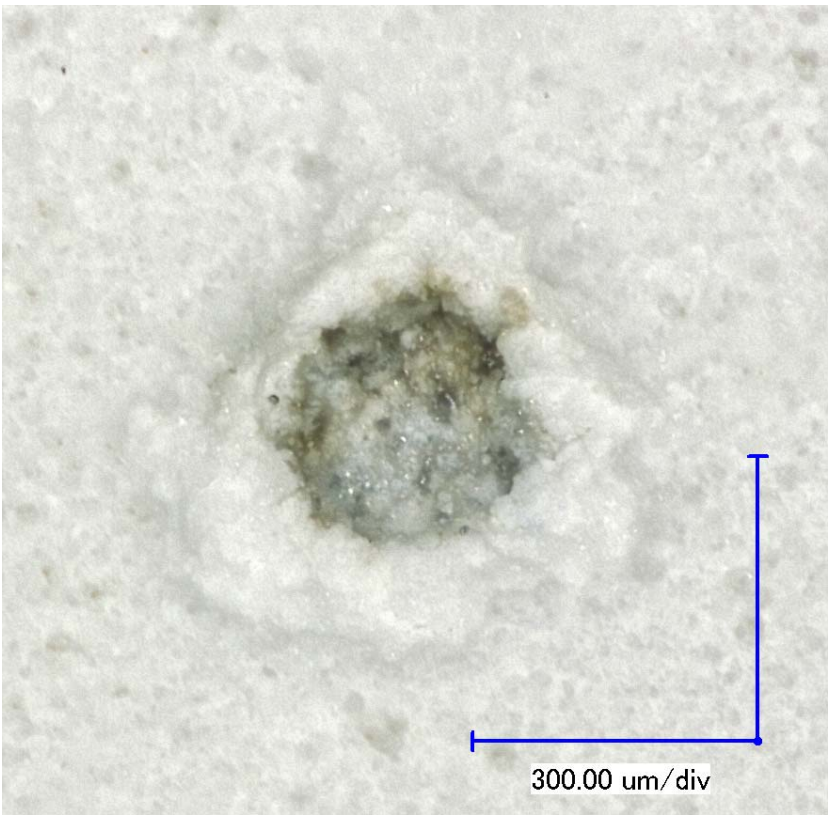


Figure 6. A typical crater (G2-50-26), which does not penetrate the paint layer.

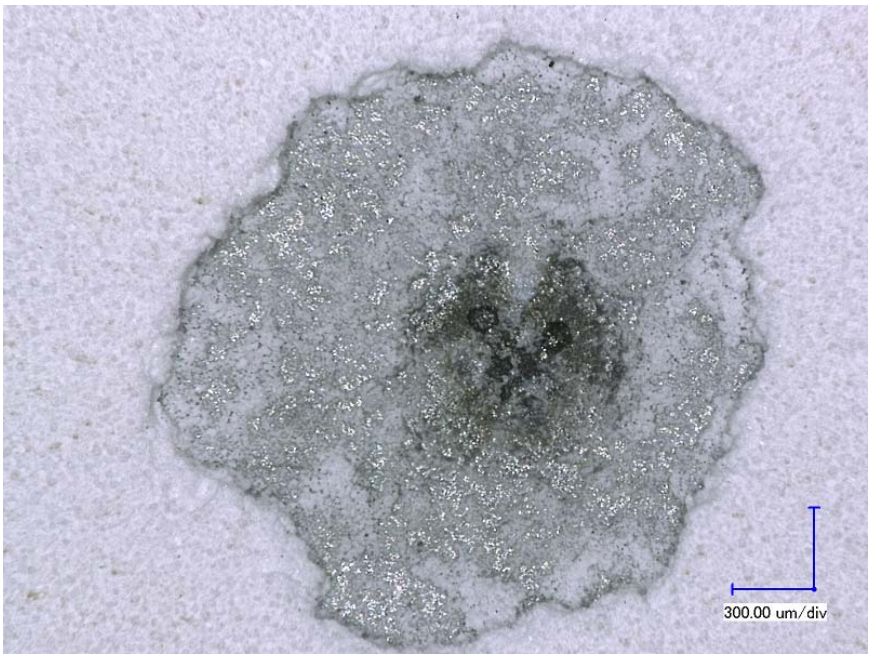


Figure 7. This larger impact (V1-65-47) has no well-defined central pit, but rather an irregular darkened area that is somewhat deeper than the surrounding exposed surface.

The 3-D capabilities of the digital microscope were crucial to estimating the central diameters of the craters. The combination of low contrast and ill-defined features often made it difficult to locate the "shoulder" in a small crater, or the central depression in a larger crater, by using the straight-down 2-D image. The digital microscope allowed the analyst to rotate and translate the image of the surface in three dimensions, to exaggerate the vertical relief, and to add relief shading to the image. These features allowed the analyst to select locations for the diameter measurements.

3.2 Crater Characteristics

All measurements of the impact features were both written onto worksheets and stored as images on the microscope's hard drive. The measurements were then transferred into a computer spreadsheet for cataloging and analysis. Figures 8 to 10 show the locations of the recorded impacts, separated by crater size. Figure 8 shows locations of the 45 largest features, which are visible in large-scale photographs of the radiator. Figure 9 shows locations of smaller impacts that exposed the radiator metal. Figure 10 shows locations of impacts that did not penetrate the paint. The spatial distribution of large and paint-penetrating impacts appears asymmetrical. The probability of this being a random distribution is calculated as only 0.98%. This characteristic is being investigated and will be one subject of future work.

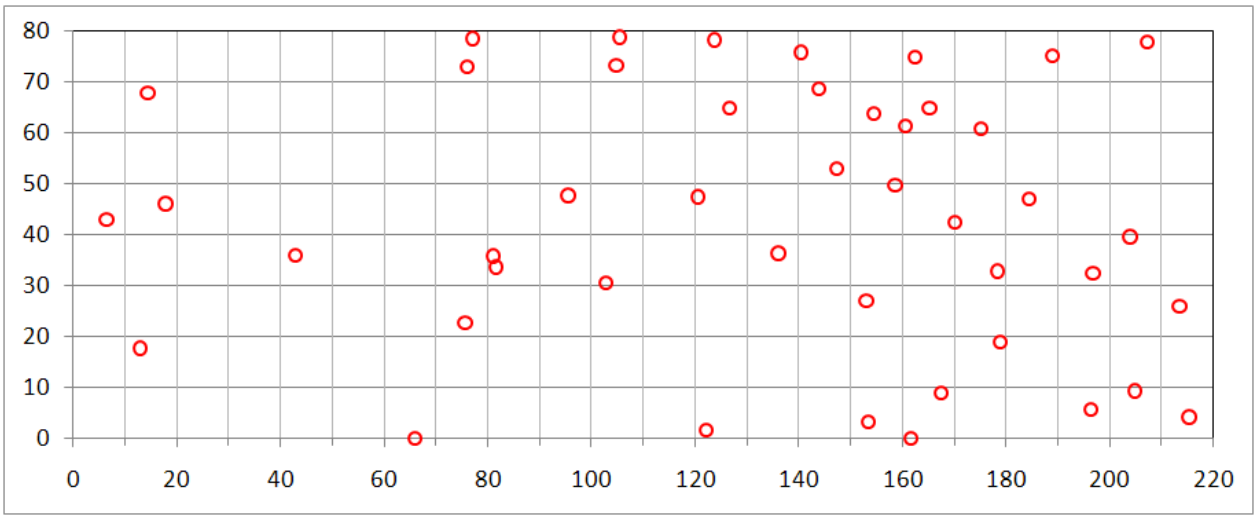


Figure 8. Locations of the 45 largest impact features. These are typically visible to the naked eye from a distance of 2 meters. (Axis units are cm.)

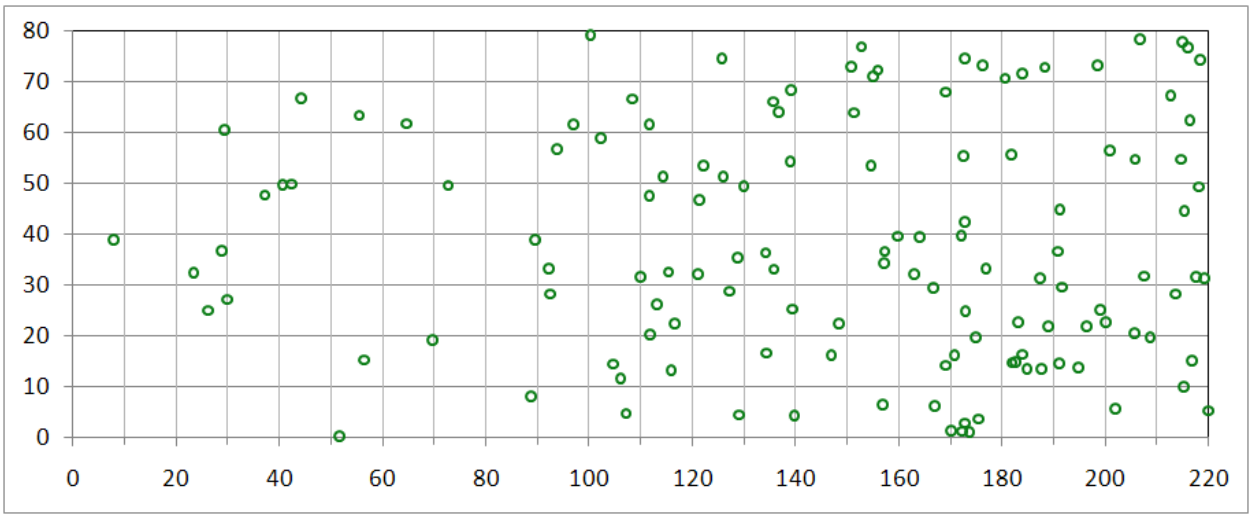


Figure 9. Locations of the 129 impacts that penetrated the paint, not including the 45 largest. (Axis units are cm.)

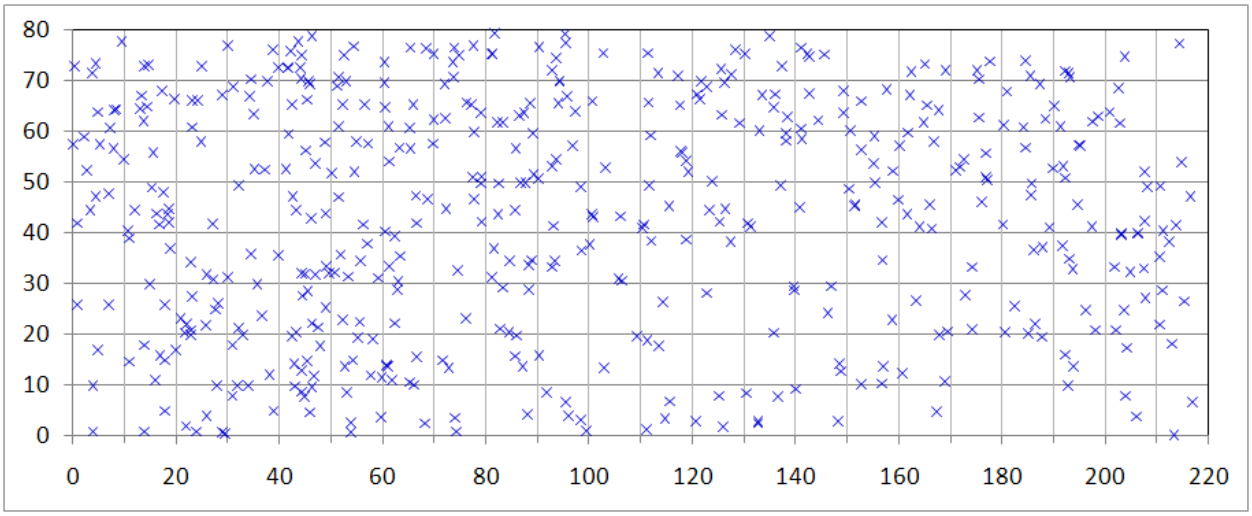


Figure 10. Locations of the 503 impact features that did not penetrate the paint. (Axis units are cm.)

Figure 11 shows the cumulative size distribution of the impact features, both in depth and in diameter. As expected, all three curves follow a power-law distribution. The dashed "spall" line in the figure flattens out between 200 and 300 µm as a result of the 300-µm inspection threshold. The largest impact has a central crater diameter of 1.5 mm and a surrounding paint spall zone about 1.5 cm across. This same impact has the deepest crater, at 0.74 mm (0.59 mm in the radiator metal). Measured where it is broken by impacts, the layer of white thermal paint does not have a uniform thickness. Figure 12 shows a histogram (using 10-µm bins) of paint thicknesses measured in crater walls. The paint thickness varies from 13 to 270 µm in the crater walls. This variation may result from space weathering or from non-uniform application.

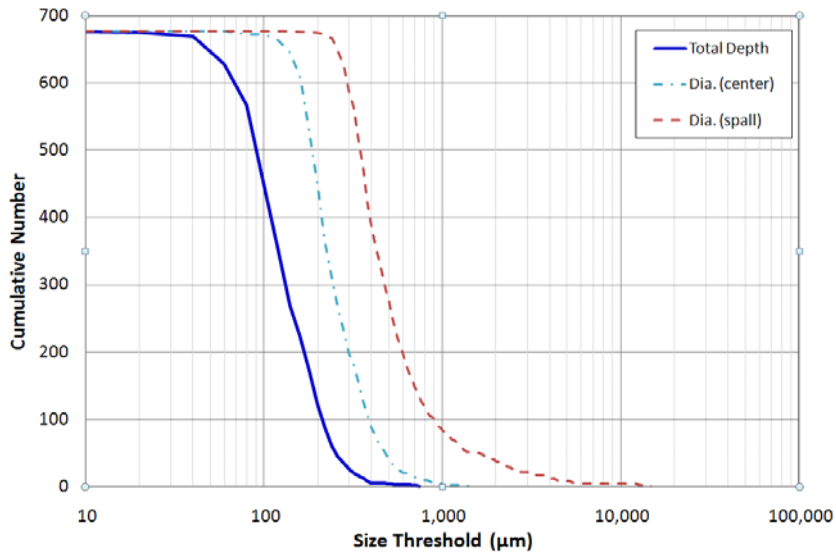


Figure 11. Size (both diameter and depth) distributions of the WFPC-2 impact features.

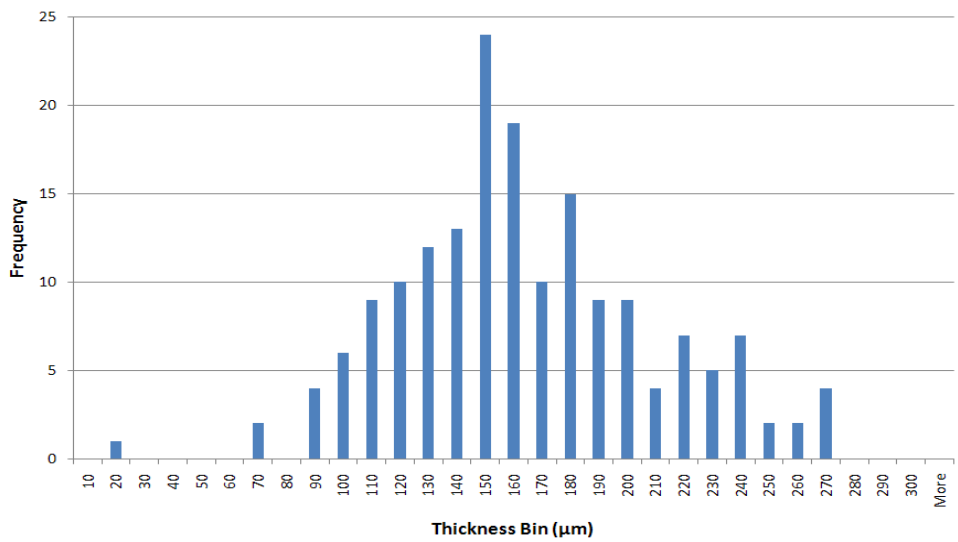


Figure 12. Histogram of paint thicknesses, as measured in crater walls, binned in 10-µm intervals.

4.0 Summary

The survey of the HST WFPC2 radiator using optical microscopy has yielded a wealth of information. These data will be compared with a similar analysis of ground-based hypervelocity impact (HVI) test results to validate or improve the MMOD environment in low Earth orbit. The HVI test results will be used to relate the observed feature dimensions to the characteristics of the impacting particles and to estimate the impact condition. This will also include classifying the impacts by common morphology. An effort to use the HST attitude-time history to model the observed impacts also has been initiated. Among other issues, this "pointing history" may help explain the asymmetry in the spatial distribution of larger impact features seen in Figures 8 and 9.

This and other studies of the WFPC2 radiator continue to move forward. The next phase is an attempt to identify the impacting particles. Select craters were sampled using Kapton tape pulls, similar to the technique historically used to survey impacts on the Space Shuttle orbiter windows. These results were ambiguous and motivated an effort to directly examine the crater residue – and thereby classify the residue as either micrometeoroid or orbital debris – by coring and subsequent laboratory inspection of the features. The WFPC2 radiator continues to provide information about the orbital debris environment.

Appendix A:
The WFPC2 Radiator Survey Coordinate System

1.0 Introduction

A reference coordinate system must be defined for the microscopic survey of the Hubble Space Telescope (HST) Wide Field Planetary Camera 2 (WFPC2) radiator assembly. Given the geometry of the surface, a Cartesian frame has been adopted.

2.0 Coordinate Frame

The overall dimensions of the radiator (see Figure A-1) are a height of 79.4 cm and a length (measured along the curved surface) of 219.0 cm. Hereafter, "length" shall be understood to indicate "length-over-surface." The size of the radiator's surface indicates a "natural" coordinate space of size 80 cm high by 220 cm long. The radiator is placed in the first quadrant of a Cartesian coordinate system so that all values for x (length) and y (height) will be positive. The origin is slightly outside the lower-left physical boundary of the radiator surface.

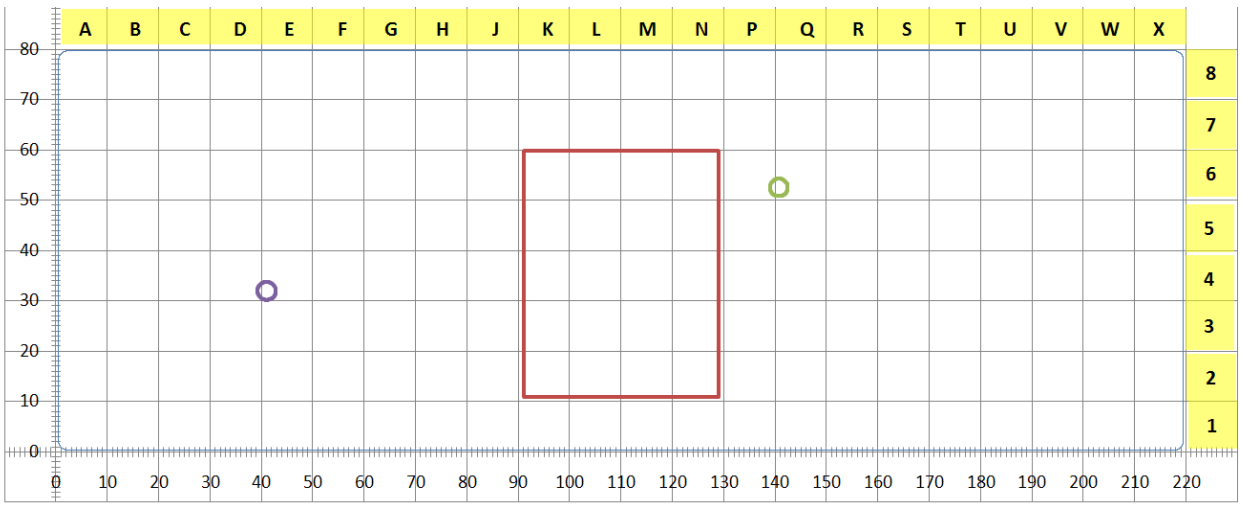


Figure A-1. Radiator outline and 10-cm grid labels (along top and right edges) and distance marks (cm) from origin at lower left corner. (Axis units are cm.) The rectangle near the center of the figure shows the location of an electronics radiator. The circles show locations of two other access ports through the radiator.

The surface is divided into major divisions (or "grid squares") of 10 by 10 cm. Each grid square is subdivided into 1 by 1 cm grid elements. The grid elements can be further subdivided into 1 by 1 mm sub-elements by visual estimation.

For ease of general location and mapping, the length dimension is broken by major division into 22 "columns" A through X (here, the letters "I" and "O" are excluded for their similarity to the numerals "1" and "0", respectively), and the height dimension into "rows" 1 through 8. Grid

squares are referred to with the notation <alphabetic column><numeric row>. The lower left grid square is therefore "A1" while the upper right grid square is "X8". A total of 176 10-cm grid squares completely cover the radiator surface. The 1-cm grid elements and 1-mm sub-elements (see Figure A-2) are numbered 0 through 9 in both the horizontal and vertical directions. The notation "<column><row>" is preferred, so that the lower left corner is "00" and the upper right corner is "99". Other notations (e.g., "0,0", "(0,0)") are possible, though not preferred.

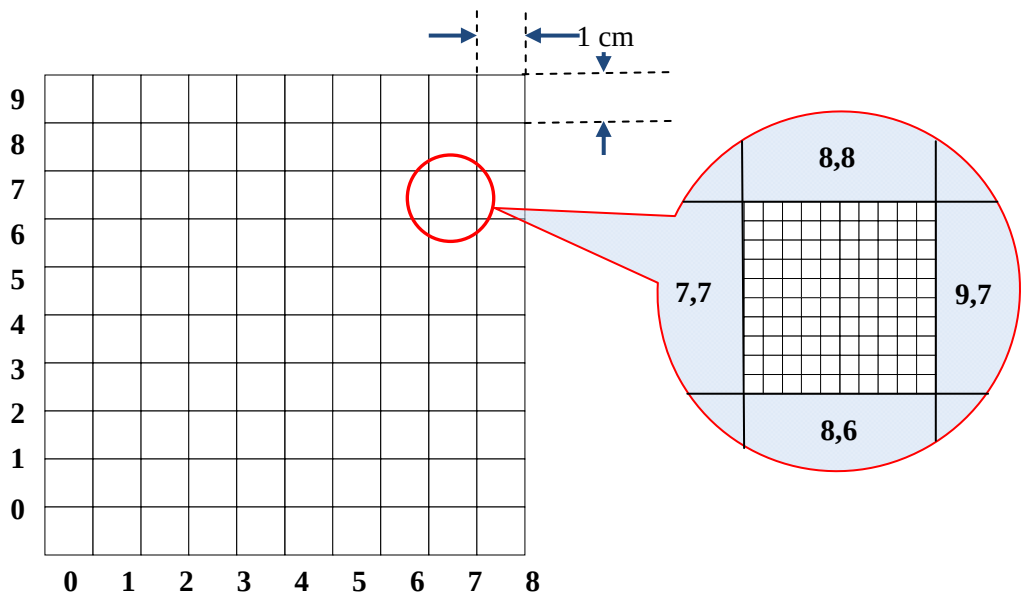


Figure A-2: The 10-cm grid (left) is divided into 1-cm elements and 1-mm sub-elements (right).

Although the grid square and element coordinates will almost always be enough to uniquely locate a given impact feature on the radiator's surface, the occasion of two or more features occupying the same element requires that the sub-element nomenclature also be utilized. For feature sizes larger than a given 1 by 1 millimeter sub-element, the approximate center of the feature, usually a crater, should be indicated by the observer. The complete location notation is "GG-EE-SS", providing both X and Y coordinates at the grid (10 cm), element (1 cm), and sub-element (1 mm) levels. This nomenclature is used in file name definition for surface feature imagery.

2.1 Positional Awareness Aids

Aids are required to place the coordinate frame on the radiator's curved surface in a manner meaningful to the observer. Several non-contact methods were examined, and an opto-mechanical laser system was selected for this project. The system uses a LAP "CAD-Pro 3D" laser template projector to project the grid/element/sub-element template onto the surface with a 635-nm (red) eye-safe (Class IIIa/2M) laser.

3.0 Technical Description

3.1 General Structure

The WFPC2 radiator consists of a rectangular section of the lateral surface of a right circular cylinder. The long axis is considered the length or width, the perpendicular surface axis is considered the height, and the third axis/direction is considered the depth. See Figure A-3.

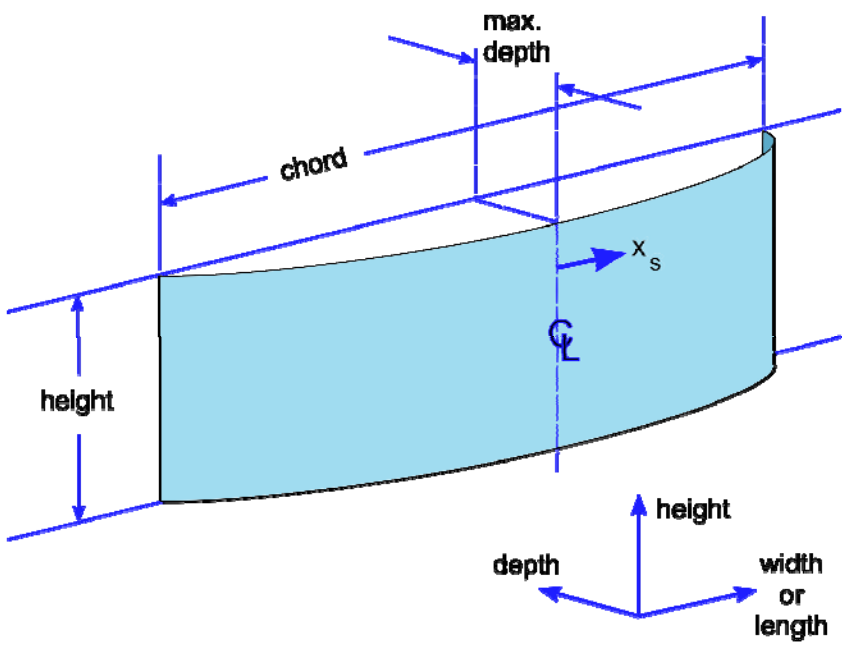


Figure A-3. Radiator directional nomenclature and axis definitions.

The original was fabricated from 4-mm-thick 6061-T651 Al alloy sheet. The inner radius is 218.8 cm, for an outer radius of 219.3 cm. Length over this surface is 219.0 cm with an attendant, derived chord length of 210.0 cm. Maximum derived depth (measured chord/flat to outer surface) is 26.8 cm. The height of the rectangular surface is 79.4 cm. The four corners are finished with a radius of 1.9 cm. The surface of the radiator is finished to a surface finish standard of 63.

The original blueprint PDFs supplied by NASA Jet Propulsion Laboratory (JPL) express all lengths as measured along the chord, *i.e.*, "along the flat." In order to relate these drafting lengths with lengths measured *along* the surface, we may use:

—,

where x is a distance measured on the flat/blueprint, x_s is the corresponding distance measured along the surface, and r_o is the outer radius of the surface (219.3 cm). Required units of the *arcsine* function are radians.

3.2 Surface Details

The primary surface feature is the central access panel, which also serves as a radiator for the electronics package behind this panel. Using the same length/height/width nomenclature as before, the access panel is 37.8 cm wide and 48.9 cm high. Though centered on the radiator's long axis centerline, the bottom (toward HST "aft") side of the panel is 10.5 cm from the bottom of the radiator panel.

There are two secondary surface features, both access ports. The PURGE/VENT TUBE port center is located 140.1 cm from the left edge of the radiator (looking at the outer surface) and 52.2 cm from the bottom. The port is 3.5 cm in diameter and oriented perpendicularly to the surface. Two flat-head screws are located 2.5 cm above/below the port centerline. The second port is the blind CONNECTOR JACKING ROD ASSY port. This port is located 67.8 cm to the left of the center (looking at the outer surface) and 31.7 cm from the radiator bottom edge. The port diameter is 3.6 cm and is oriented perpendicularly to the chord/flat. Three flat-head screws are equally spaced along a 7.6 cm radius circle centered on this port. All screws are flush with the surface and unpainted.

3.3 Paint

The radiator is painted with YB-71 white thermal control paint. This paint is composed of a Zinc Orthotitanate (ZOT, Zn_2TiO_4) pigment in a Potassium Silicate (PS-7) binder. The specified paint thickness is 4 to 8 mil (about 102 to 203 µm). The post-flight paint thickness, as measured in crater walls, is 100 to 300 µm.

4.0 Resources

Three JPL blueprint PDFs are the primary sources for this technical memo. These are JPL drawings 10085122, 10085120 (p. 2 of 4), and 10085120 (p. 3 of 4).

Appendix B:
Impact Measurements

The table below lists all measured impact features, their depths and diameters. Figures B-1 and B-2 show how the measured dimensions correspond to typical large and small impact features, respectively. Note that two duplicate entries exist within the data; the erroneous entries will be removed upon reexamination of the WFPC2 radiator.

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter			
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(μm)	(μm)	(μm)	Dia (μm)	Dia (μm)	Dia (μm)	Dia (μm)
444	Q	6	147.4	53.0	1	91.5	144.1	235.4	4437.37	4280.85	1295.27	591.97
445	Q	7	141.1	60.5	0	133.6	0.0	133.6	369.75			215.41
446	Q	7	142.7	67.5	0	87.6	0.0	87.6	276.73			179.33
447	Q	7	143.8	68.6	1	218.8	126.3	345.1	3944.01	3206.43	1260.15	538.75

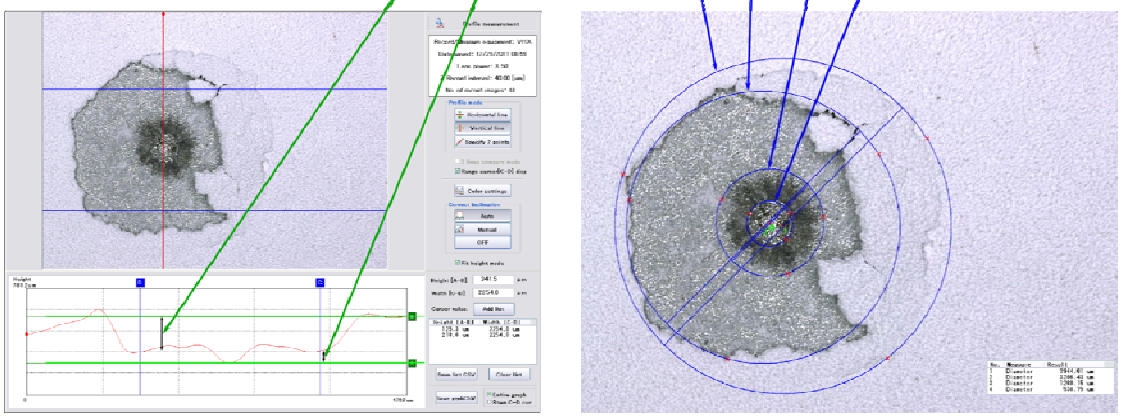


Figure B-1. Crater dimensions and corresponding characteristics of a large impact feature.

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter			
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(μm)	(μm)	(μm)	Dia (μm)	Dia (μm)	Dia (μm)	Dia (μm)
201	G	2	61.9	10.9	0	119.5	0.0	119.5	465.51			261.56
202	G	2	65.2	10.6	0	167.1	0.0	167.1	574.75			317.14
203	G	2	66.1	10.0	0	183.5	0.0	183.5	615.74			421.40
204	G	2	66.6	15.6	0	117.4	0.0	117.4	602.21			390.35

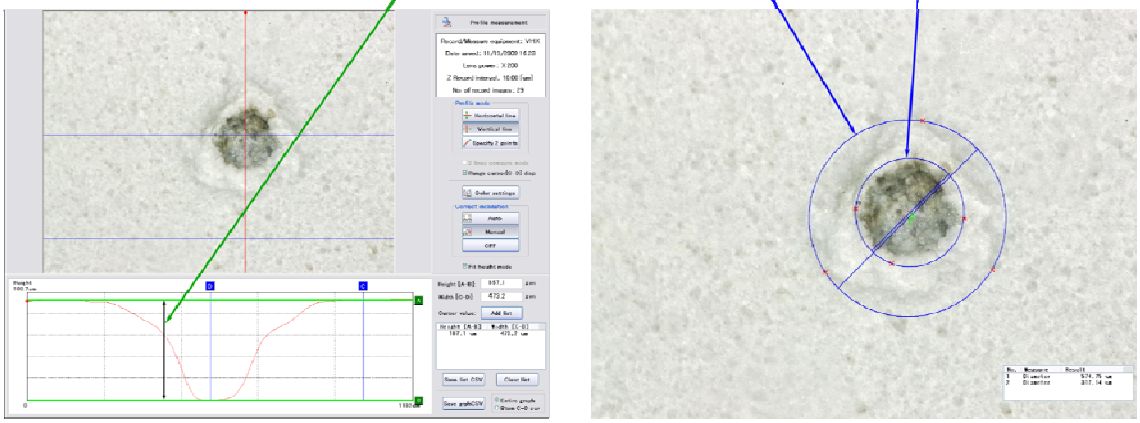


Figure B-2. Crater dimensions and corresponding characteristics of a small impact feature.

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter				Notes
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center	Dia = diameter of the best-fit circle
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(µm)	(µm)	(µm)	Dia (µm)	Dia (µm)	Dia (µm)	Dia (µm)	Depth = from surface to the deepest point
1	A	1	3.9	0.9	0	173.8	0.0	173.8	601.04			382.18	
2	A	1	3.9	9.9	0	146.5	0.0	146.5	602.36			271.68	
3	A	2	4.9	16.9	0	153.2	0.0	153.2	636.57			325.94	
4	A	3	0.9	25.9	0	162.2	0.0	162.2	755.72			324.78	
5	A	3	6.9	25.9	0	169.6	0.0	169.6	534.71			271.58	
6	A	4	7.9	38.9	3	150.0	88.0	238.0	813.77			485.17	total depth 238.0; assume thickness 150
7	A	5	0.8	41.9	0	45.7	0.0	45.7	258.36			161.09	
8	A	5	3.4	44.4	0	67.3	0.0	67.3	375.94			230.16	oblong center (230.16 x 161.90); brown area
9	A	5	4.4	47.1	0	71.6	0.0	71.6	219.43			142.38	
10	A	5	6.4	43.0	1	12.7	29.2	41.9	2175.28	1648.37	1203.63	510.22	big 1
11	A	5	6.9	47.7	0	107.3	0.0	107.3	383.15			230.80	
12	A	6	0.0	57.5	0	66.3	0.0	66.3	405.44			170.34	
13	A	6	2.2	58.9	0	108.9	0.0	108.9	299.08			209.57	dark crater
14	A	6	2.7	52.3	0	86.2	0.0	86.2	421.16			208.02	oblique?
15	A	6	5.2	57.4	0	156.3	0.0	156.3	573.17			325.29	dark material in crater
16	A	6	7.9	56.6	0	97.3	0.0	97.3	452.99			268.26	dark material in crater
17	A	6	9.8	54.4	0	197.4	0.0	197.4	607.15			368.94	
18	A	7	4.9	63.8	0	112.8	0.0	112.8	484.15			258.16	
19	A	7	7.2	60.7	0	57.3	0.0	57.3	286.81			159.05	
20	A	7	8.0	64.2	0	62.2	0.0	62.2	250.71			114.14	dark crater bottom
21	A	7	8.4	64.3	0	95.9	0.0	95.9	284.25			151.59	
22	A	8	0.3	72.8	0	63.9	0.0	63.9	277.16			159.76	non-circular center
23	A	8	3.8	71.4	0	33.0	0.0	33.0	227.49			132.40	
24	A	8	4.4	73.4	0	104.4	0.0	104.4	382.60			208.48	white center, dark on one side
25	A	8	9.5	77.7	0	68.7	0.0	68.7	342.52			194.55	oblique
26	B	1	13.9	0.9	0	186.8	0.0	186.8	692.09			430.73	
27	B	1	17.9	4.9	0	187.9	0.0	187.9	643.18			405.41	
28	B	2	11.0	14.6	0	69.0	0.0	69.0	267.17			149.98	
29	B	2	12.9	17.7	1	269.5	103.1	372.6	2180.33	1319.41	1319.32	445.37	cracked paint 3558.73 dia big 23
30	B	2	13.9	17.9	0	81.7	0.0	81.7	297.86			166.36	
31	B	2	15.9	10.9	0	183.9	0.0	183.9	590.13			347.59	
32	B	2	16.9	15.9	0	180.6	0.0	180.6	751.55			440.30	
33	B	2	17.9	14.9	0	75.1	0.0	75.1	374.29			203.40	
34	B	2	19.9	16.9	0	79.7	0.0	79.7	436.76			213.70	
35	B	3	14.9	29.9	0	199.6	0.0	199.6	620.89			392.45	

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter				Notes
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center	Dia = diameter of the best-fit circle
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(µm)	(µm)	(µm)	Dia (µm)	Dia (µm)	Dia (µm)	Dia (µm)	Depth = from surface to the deepest point
36	B	3	17.9	25.9	0	124.2	0.0	124.2	510.40			329.73	
37	B	4	10.9	38.9	0	179.6	0.0	179.6	644.46			401.83	Dark material in crater
38	B	4	18.9	36.9	0	212.1	0.0	212.1	745.37			440.09	
39	B	5	10.6	40.5	0	41.3	0.0	41.3	248.13			127.04	
40	B	5	12.0	44.4	0	75.6	0.0	75.6	265.32			142.09	
41	B	5	15.3	48.9	0	109.8	0.0	109.8	357.61			211.19	
42	B	5	16.2	43.8	0	213.3	0.0	213.3	768.83			376.74	brown area in side of crater
43	B	5	16.8	41.6	0	61.2	0.0	61.2	268.37			155.30	
44	B	5	17.6	48.0	0	116.6	0.0	116.6	419.64			234.57	
45	B	5	17.8	46.1	1	264.7	109.4	374.1	2332.62	1626.12	1535.82	488.76	big 22
46	B	5	18.3	43.6	0	134.6	0.0	134.6	382.80			202.05	
47	B	5	18.6	42.1	0	65.3	0.0	65.3	338.24			170.77	
48	B	5	18.6	44.7	0	52.9	0.0	52.9	283.80			124.35	
49	B	6	15.6	55.9	0	109.1	0.0	109.1	369.14			225.81	
50	B	7	13.1	64.4	0	55.4	0.0	55.4	252.52			115.65	black material in crater
51	B	7	13.3	67.0	0	164.4	0.0	164.4	516.27			293.79	
52	B	7	13.7	62.0	0	77.0	0.0	77.0	307.07			193.01	
53	B	7	14.4	64.9	0	88.6	0.0	88.6	329.39			180.90	dark area near bottom
54	B	7	14.4	67.8	1	213.4	76.4	289.8	1758.04	1071.56	1071.56	389.94	big 21
55	B	7	17.2	67.9	0	184.0	0.0	184.0	643.56			340.81	
56	B	7	19.7	66.3	0	65.6	0.0	65.6	225.57			108.10	dark material in crater
57	B	8	13.8	72.9	0	149.7	0.0	149.7	488.51			297.42	
58	B	8	14.7	73.1	0	98.1	0.0	98.1	286.37			149.65	
59	C	1	21.9	1.9	0	164.7	0.0	164.7	533.65			347.01	
60	C	1	23.9	0.9	0	98.7	0.0	98.7	402.82			231.58	
61	C	1	25.9	3.9	0	111.6	0.0	111.6	432.69			200.67	
62	C	1	27.9	9.9	0	146.1	0.0	146.1	488.16			283.16	
63	C	1	29.0	0.7	0	61.3	0.0	61.3	354.17			204.52	
64	C	1	29.4	0.5	0	107.1	0.0	107.1	399.05			234.85	
65	C	2	22.9	19.9	0	77.7	0.0	77.7	320.39			188.18	
66	C	3	20.9	23.2	0	57.7	0.0	57.7	329.71			195.65	
67	C	3	21.7	20.3	0	143.2	0.0	143.2	313.86			239.11	
68	C	3	22.1	22.1	0	208.5	0.0	208.5	587.32			336.41	dark & brown material in crater; oblong
69	C	3	22.8	20.8	0	149.5	0.0	149.5	460.50			268.07	
70	C	3	23.1	27.5	0	91.7	0.0	91.7	361.47			188.74	

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter				Notes
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center	Dia = diameter of the best-fit circle
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(µm)	(µm)	(µm)	Dia (µm)	Dia (µm)	Dia (µm)	Dia (µm)	Depth = from surface to the deepest point
71	C	3	25.7	21.8	0	203.7	0.0	203.7	756.26			429.41	crater almost rectangular
72	C	3	26.2	25.0	2	233.7	18.2	251.9	536.55	129.36	65.47	65.47	large (904.13 um) depression in paint, brown speckles at rim
73	C	3	27.6	24.9	0	86.6	0.0	86.6	364.04			220.89	duplicate of C3-86-21
74	C	3	28.2	26.1	0	86.6	0.0	86.6	364.04			220.89	duplicate of C3-74-69
75	C	3	29.9	27.2	3	234.6	22.3	256.9	675.33	118.14	118.14	367.51	small patch of metal visible
76	C	4	22.9	34.3	0	87.2	0.0	87.2	394.64			172.05	dark material in crater; crater almost triangular
77	C	4	23.4	32.4	1	265.4	58.2	323.6	1196.48	549.31	6449.31	219.00	
78	C	4	25.9	31.8	0	117.0	0.0	117.0	511.61			247.66	
79	C	4	27.2	30.8	0	82.6	0.0	82.6	457.32			277.59	oblong
80	C	4	28.9	36.8	2	258.8	9.6	268.4	805.42	121.37	64.81	422.04	small patch of metal visible
81	C	5	27.1	41.8	0	166.0	0.0	166.0	267.72			144.08	sinkhole
82	C	6	24.8	58.0	0	76.6	0.0	76.6	314.36			154.03	
83	C	7	23.2	60.8	0	111.6	0.0	111.6	346.21			171.08	
84	C	7	23.2	66.0	0	43.7	0.0	43.7	253.17			121.64	brown material on side of crater
85	C	7	24.2	66.1	0	102.3	0.0	102.3	389.24			205.03	
86	C	7	28.9	67.1	0	88.7	0.0	88.7	353.36			208.66	
87	C	7	29.4	60.5	3	226.8	13.0	239.8	535.23	112.72	167.34	167.34	SE dark patch likely radiator metal; complex spall levels
88	C	8	25.0	72.8	0	54.6	0.0	54.6	296.49			167.30	
89	D	1	30.9	7.9	0	103.2	0.0	103.2	451.96			250.38	
90	D	1	31.9	9.9	0	53.9	0.0	53.9	341.36			167.38	
91	D	1	33.9	9.9	0	75.4	0.0	75.4	371.21			207.87	
92	D	1	38.9	4.9	0	98.4	0.0	98.4	306.82			161.52	
93	D	2	30.9	17.9	0	43.5	0.0	43.5	284.14			182.68	
94	D	2	32.9	19.9	0	172.1	0.0	172.1	566.27			362.21	
95	D	2	38.1	12.0	0	208.6	0.0	208.6	685.95			434.57	
96	D	3	32.2	21.3	0	72.1	0.0	72.1	367.20			212.64	
97	D	3	35.7	29.9	0	48.7	0.0	48.7	340.05			155.53	oblong (155.53 x 224.02) with ramp; gray color
98	D	3	36.7	23.6	0	84.8	0.0	84.8	309.64			183.56	
99	D	4	30.0	31.2	0	246.1	0.0	246.1	555.86			310.17	maybe hole through paint at deepest point
100	D	4	34.6	35.9	0	97.3	0.0	97.3	364.03			168.35	crack in bottom
101	D	4	39.8	35.6	0	91.6	0.0	91.6	523.04			298.60	dark material in crater; irregular crater, elongated spall
102	D	5	32.1	49.4	0	182.1	0.0	182.1	689.77			357.19	
103	D	5	37.2	47.7	1	192.3	39.2	231.5	339.64	205.73		233.06	sinkhole; crack in bare metal
104	D	6	35.2	52.6	0	84.3	0.0	84.3	290.08			164.45	
105	D	6	37.2	52.4	0	96.1	0.0	96.1	402.07			249.05	

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter				Notes
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center	Dia = diameter of the best-fit circle
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(µm)	(µm)	(µm)	Dia (µm)	Dia (µm)	Dia (µm)	Dia (µm)	Depth = from surface to the deepest point
106	D	7	31.1	68.8	0	66.5	0.0	66.5	298.44			148.99	
107	D	7	34.2	66.8	0	200.6	0.0	200.6	601.37			345.59	
108	D	7	35.0	63.4	0	198.7	0.0	198.7	733.85			295.95	dark areas in crater bottom (can't see metal)
109	D	7	37.7	69.9	0	119.0	0.0	119.0	397.82			242.33	
110	D	8	30.0	76.8	0	40.7	0.0	40.7	242.84			140.52	
111	D	8	34.6	70.3	0	68.1	0.0	68.1	292.95			185.26	
112	D	8	38.8	76.1	0	75.1	0.0	75.1	285.24			143.18	
113	D	8	39.8	72.6	0	103.8	0.0	103.8	335.56			186.53	
114	E	1	43.0	9.8	0	46.1	0.0	46.1	432.94			208.55	
115	E	1	44.3	8.7	0	94.0	0.0	94.0	368.80			185.64	
116	E	1	44.9	7.7	0	202.5	0.0	202.5	754.90			398.75	
117	E	1	45.9	4.6	0	216.2	0.0	216.2	812.92			426.73	Difficult depth
118	E	1	46.3	9.6	0	150.0	0.0	150.0	372.27			194.59	Dark spot in crater
119	E	2	42.5	19.6	0	60.7	0.0	60.7	319.01			179.59	
120	E	2	42.9	14.2	0	92.9	0.0	92.9	328.00			184.27	
121	E	2	44.4	12.9	0	113.6	0.0	113.6	464.88			281.55	nice cone
122	E	2	45.3	14.7	0	90.2	0.0	90.2	373.92			228.31	
123	E	2	46.7	11.8	0	216.2	0.0	216.2	710.86			464.54	
124	E	2	47.9	17.8	0	82.9	0.0	82.9	303.27			149.83	dark spots in crater
125	E	3	43.3	20.4	0	120.7	0.0	120.7	500.06			279.62	oblong (279.62 x 181.98)
126	E	3	44.5	27.6	0	111.8	0.0	111.8	478.93			241.99	
127	E	3	45.5	28.5	0	167.3	0.0	167.3	537.49			380.40	oblong/bean-shaped (380.40 x 246.15); brown on one side of crater
128	E	3	46.3	22.2	0	187.5	0.0	187.5	628.81			337.20	
129	E	3	47.5	21.4	0	120.3	0.0	120.3	453.04			250.38	
130	E	3	49.0	25.3	0	88.0	0.0	88.0	358.81			223.33	cracks in bottom
131	E	4	42.8	35.9	1	218.1	166.9	385.0	4265.39	3344.75	1945.12	750.70	big 2
132	E	4	44.4	32.0	0	84.2	0.0	84.2	313.28			153.36	
133	E	4	45.0	31.9	0	111.7	0.0	111.7	378.29			259.49	
134	E	4	46.9	31.7	0	141.6	0.0	141.6	409.48			223.55	
135	E	4	49.1	33.4	0	124.5	0.0	124.5	538.61			297.80	
136	E	4	49.6	32.1	0	82.1	0.0	82.1	298.21			169.18	
137	E	5	40.6	49.8	3	227.1	0.0	227.1	814.89	36.64		375.64	patches of metal visible around bottom of crater
138	E	5	42.3	49.9	3	233.4	6.3	239.7	788.63	172.93		339.67	no spall; large, bowl-shaped depression; metal vis. through cracks
139	E	5	42.6	47.2	0	126.8	0.0	126.8	524.35			273.78	
140	E	5	43.2	44.5	0	177.1	0.0	177.1	613.95			320.65	

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter				Notes
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center	Dia = diameter of the best-fit circle
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(µm)	(µm)	(µm)	Dia (µm)	Dia (µm)	Dia (µm)	Dia (µm)	Depth = from surface to the deepest point
141	E	5	46.2	42.8	0	142.0	0.0	142.0	414.93			221.49	dark material in crater
142	E	5	49.0	43.8	0	128.4	0.0	128.4	363.82			218.85	
143	E	6	41.3	52.6	0	81.9	0.0	81.9	404.37			227.35	
144	E	6	41.8	59.5	0	135.6	0.0	135.6	562.51			288.69	
145	E	6	45.1	56.2	0	160.6	0.0	160.6	618.56			296.93	
146	E	6	46.9	53.7	0	140.6	0.0	140.6	556.93			237.89	
147	E	6	48.8	57.8	0	219.3	0.0	219.3	683.98			369.71	
148	E	7	42.4	65.2	0	88.1	0.0	88.1	296.41			142.30	brown patch on side of crater
149	E	7	44.2	66.7	3	204.0	12.9	216.9	638.04	56.77		347.51	patch of metal visible at deepest point
150	E	7	45.3	66.2	0	107.1	0.0	107.1	321.59			195.92	g center (195.92 x 134.40); dark mater. in crater; also has 5 µm profile
151	E	7	45.6	69.9	0	123.8	0.0	123.8	413.35			209.64	
152	E	7	46.0	69.4	0	83.1	0.0	83.1	348.79			187.64	
153	E	8	41.6	72.4	0	55.5	0.0	55.5	254.06			125.61	oblique?
154	E	8	41.6	72.6	0	91.3	0.0	91.3	314.72			195.55	dark patch near bottom of crater
155	E	8	42.2	75.8	0	48.1	0.0	48.1	283.75			161.45	
156	E	8	43.7	77.7	0	58.4	0.0	58.4	236.53			163.05	
157	E	8	44.1	72.5	0	138.5	0.0	138.5	367.43			180.20	
158	E	8	44.2	70.4	0	123.3	0.0	123.3	502.01			250.04	
159	E	8	44.3	75.0	0	81.6	0.0	81.6	308.14			174.81	dark material in crater
160	E	8	46.3	78.7	0	70.8	0.0	70.8	262.31			156.79	
161	F	1	51.6	0.4	3	150.0	97.9	247.9	955.25	321.79		533.27	total depth 247.9; assume thickness 150
162	F	1	53.1	8.5	0	139.5	0.0	139.5	444.13			267.24	
163	F	1	53.8	0.7	0	111.5	0.0	111.5	457.68			245.03	dark material in crater
164	F	1	53.9	2.6	0	68.9	0.0	68.9	269.00			189.20	
165	F	1	59.7	3.7	0	122.5	0.0	122.5	507.10			324.27	
166	F	2	52.7	13.7	0	126.0	0.0	126.0	327.26			263.18	
167	F	2	54.3	14.9	0	126.8	0.0	126.8	389.61			290.91	
168	F	2	55.2	19.4	0	68.7	0.0	68.7	344.95			207.78	
169	F	2	56.4	15.3	3	150.0	111.8	261.8	1028.76	497.77		627.55	total depth 261.8; assume thickness 150
170	F	2	57.7	11.9	0	110.6	0.0	110.6	376.78			243.02	
171	F	2	58.1	19.1	0	227.1	0.0	227.1	647.11			411.05	
172	F	2	59.8	11.5	0	34.3	0.0	34.3	203.73			116.99	dark crater
173	F	3	52.2	22.9	0	102.2	0.0	102.2	291.36			177.48	black & brown in crater; **duplicate of F3-52-65**
174	F	3	55.6	22.5	0	102.2	0.0	102.2	291.36			177.48	black & brown in crater; **duplicate of F3-22-29**
175	F	4	50.7	32.2	0	128.2	0.0	128.2	352.13			200.62	bullseye with steep, dark sides

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter				Notes
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center	Dia = diameter of the best-fit circle
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(µm)	(µm)	(µm)	Dia (µm)	Dia (µm)	Dia (µm)	Dia (µm)	Depth = from surface to the deepest point
176	F	4	51.9	35.7	0	190.8	0.0	190.8	606.69			363.84	
177	F	4	53.3	31.4	0	90.6	0.0	90.6	294.74			176.96	irregular bottom
178	F	4	55.8	34.4	0	68.5	0.0	68.5	350.93			185.61	
179	F	4	57.1	37.9	0	83.0	0.0	83.0	401.38			193.02	
180	F	4	59.1	31.1	0	88.1	0.0	88.1	335.21			182.72	
181	F	5	51.5	47.0	0	100.7	0.0	100.7	561.30			335.65	
182	F	5	56.3	41.6	0	85.7	0.0	85.7	372.31			197.39	
183	F	6	50.2	51.8	0	90.0	0.0	90.0	399.87			182.48	dark material in crater
184	F	6	54.5	52.1	0	152.8	0.0	152.8	591.63			353.95	oblong.: center (353.95 x 246.48)
185	F	6	55.0	58.0	0	192.6	0.0	192.6	654.52			345.21	
186	F	6	57.2	57.6	0	114.1	0.0	114.1	349.68			186.53	dark material in crater
187	F	7	51.2	68.9	0	79.4	0.0	79.4	285.87			163.67	brown material in crater
188	F	7	51.4	60.9	0	81.8	0.0	81.8	331.75			176.75	
189	F	7	52.2	65.3	0	132.4	0.0	132.4	443.55			289.73	
190	F	7	52.9	69.8	0	83.7	0.0	83.7	370.35			207.85	
191	F	7	55.5	63.4	2	204.0	35.0	239.0	919.36	443.13	322.87	322.87	much paint attached to bottom of crater
192	F	7	56.5	65.2	0	146.0	0.0	146.0	444.14			278.16	
193	F	8	51.4	70.6	0	50.5	0.0	50.5	263.21			160.62	
194	F	8	52.6	75.0	0	100.1	0.0	100.1	325.52			178.49	
195	F	8	54.4	76.7	0	91.9	0.0	91.9	381.34			249.32	11); double impact, small/left spall=129.95, center=63.21, depth=85.1
196	G	1	65.9	0.1	1	150.0	156.3	306.3	12245.71	10003.91	2082.35	1021.96	paint boundary outside FOV; assume thickness 150 big 3
197	G	1	68.2	2.5	0	55.1	0.0	55.1	337.46			202.89	
198	G	2	60.7	13.8	0	42.9	0.0	42.9	262.94			146.16	
199	G	2	60.7	14.0	0	87.3	0.0	87.3	279.15			185.61	
200	G	2	61.0	13.7	0	19.6	0.0	19.6	159.87			103.31	nearly flat
201	G	2	61.9	10.9	0	119.5	0.0	119.5	465.51			261.56	
202	G	2	65.2	10.6	0	167.1	0.0	167.1	574.75			317.14	
203	G	2	66.1	10.0	0	183.5	0.0	183.5	615.74			421.40	
204	G	2	66.6	15.6	0	117.4	0.0	117.4	602.21			390.35	very elongated
205	G	2	69.6	19.2	2	150.0	98.0	248.0	1081.00	564.06		711.26	total depth 248.0; assume thickness 150
206	G	3	62.4	22.2	0	154.1	0.0	154.1	464.53			266.84	
207	G	3	62.9	28.8	0	232.6	0.0	232.6	704.98			368.95	
208	G	4	61.3	33.4	0	121.7	0.0	121.7	516.14			305.87	
209	G	4	62.4	39.4	0	142.7	0.0	142.7	416.60			268.71	
210	G	4	63.0	30.5	0	91.3	0.0	91.3	321.51			192.80	dark material in crater; uneven coloring

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter				Notes
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center	Dia = diameter of the best-fit circle
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(µm)	(µm)	(µm)	Dia (µm)	Dia (µm)	Dia (µm)	Dia (µm)	Depth = from surface to the deepest point
211	G	4	63.5	35.4	0	187.3	0.0	187.3	906.92			321.86	large, irregular spall
212	G	5	60.5	40.3	0	201.2	0.0	201.2	779.76			388.29	
213	G	5	66.5	47.3	0	74.4	0.0	74.4	414.08			211.38	brown material in crater
214	G	5	66.6	41.9	0	181.7	0.0	181.7	483.95			321.71	
215	G	5	68.7	46.6	0	178.7	0.0	178.7	456.90			299.03	brown on side of crater
216	G	6	61.3	54.1	0	80.7	0.0	80.7	339.40			179.86	
217	G	6	63.3	56.8	0	105.7	0.0	105.7	440.27			258.75	dark patches on crater walls
218	G	6	65.4	56.6	0	201.3	0.0	201.3	648.86			347.29	
219	G	6	69.8	57.6	0	174.0	0.0	174.0	565.01			319.76	
220	G	7	60.4	69.6	0	88.1	0.0	88.1	292.15			151.86	brown material in crater
221	G	7	60.5	64.7	0	96.5	0.0	96.5	337.47			176.16	
222	G	7	61.2	60.9	0	54.3	0.0	54.3	342.16			149.16	
223	G	7	64.6	61.8	2	188.7	53.2	241.9	2669.65	384.90	384.90	471.05	spall still attached
224	G	7	65.2	60.7	0	77.9	0.0	77.9	314.05			216.02	
225	G	7	65.9	65.2	0	55.3	0.0	55.3	266.44			166.89	somewhat triangular
226	G	7	69.9	62.3	0	54.6	0.0	54.6	266.58			172.26	dark material in crater
227	G	8	60.4	73.6	0	71.2	0.0	71.2	339.00			174.99	
228	G	8	65.4	76.5	0	195.0	0.0	195.0	479.74			283.85	
229	G	8	68.5	76.4	0	222.2	0.0	222.2	786.60			439.81	irregular; no metal visible
230	G	8	69.9	75.3	0	79.6	0.0	79.6	336.48			164.00	
231	H	1	74.1	3.6	0	171.4	0.0	171.4	540.09			149.96	
232	H	1	74.2	0.9	0	102.1	0.0	102.1	393.93			205.30	
233	H	2	71.6	14.9	0	136.7	0.0	136.7	234.35			162.39	
234	H	2	72.8	13.5	0	47.2	0.0	47.2	359.79			206.86	
235	H	3	75.6	22.8	1	150.0	75.7	225.7	3379.73	941.73	941.73	594.94	crater bottom to top of paint is 225.7; assume thickness 150 big 24
236	H	3	76.1	23.2	0	210.5	0.0	210.5	663.31			389.28	
237	H	4	74.5	32.6	0	37.4	0.0	37.4	266.72			207.72	207.72 x 146.74), shallow & irregular; appears to be 200X (no PRO file)
238	H	5	72.3	44.8	0	215.9	0.0	215.9	675.44			426.48	side of crater; oblong: spall (675.44 x 475.76), center (426.48 x 323.36)
239	H	5	72.7	49.6	2	248.9	37.9	286.8	1026.40	169.06	169.06	465.16	tal vis. through gap at lowest pt.; blue-gr. tint to paint in crater bottom
240	H	5	77.7	46.7	0	172.5	0.0	172.5	457.01			276.18	
241	H	5	79.0	49.7	0	174.0	0.0	174.0	573.46			384.78	
242	H	5	79.2	42.2	0	70.9	0.0	70.9	301.70			166.41	
243	H	6	77.4	50.9	0	127.7	0.0	127.7	455.52			265.08	
244	H	6	77.8	59.9	0	88.2	0.0	88.2	401.07			280.07	irreg./extended: center (280.07 x 180.10)
245	H	6	79.2	51.1	0	124.0	0.0	124.0	427.84			228.67	

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter				Notes
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center	Dia = diameter of the best-fit circle
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(µm)	(µm)	(µm)	Dia (µm)	Dia (µm)	Dia (µm)	Dia (µm)	Depth = from surface to the deepest point
246	H	7	72.0	69.3	0	285.4	0.0	285.4	952.12			511.77	no metal visible
247	H	7	72.1	62.6	0	221.1	0.0	221.1	782.59			406.65	no metal visible
248	H	7	76.3	65.7	0	208.4	0.0	208.4	478.22			286.21	
249	H	7	77.2	65.2	0	191.9	0.0	191.9	471.54			252.00	black spot at lowest point
250	H	7	79.1	63.7	0	170.9	0.0	170.9	510.42			300.95	
251	H	8	73.6	73.7	0	126.0	0.0	126.0	421.01			231.25	dark material in crater
252	H	8	73.7	70.7	0	108.8	0.0	108.8	415.77			200.80	
253	H	8	73.9	76.5	0	116.7	0.0	116.7	291.32			209.94	dark material in crater
254	H	8	74.9	74.9	0	95.5	0.0	95.5	377.12			215.69	
255	H	8	76.0	73.0	1	244.2	242.2	486.4	4325.23	3493.31	1807.16	909.04	big 5
256	H	8	77.0	78.5	1	150.0	140.5	290.5	3409.81	2452.71	1427.11	490.20	paint boundary outside FOV; assume thickness 150 big 4
257	H	8	77.6	76.9	0	161.8	0.0	161.8	582.53			324.10	brown material in crater
258	J	1	88.1	4.2	0	145.1	0.0	145.1	464.98			323.71	
259	J	1	88.8	8.1	3	263.3	37.9	301.2	1316.90	485.59	225.17	180.57	
260	J	2	85.6	15.7	0	95.3	0.0	95.3	399.29			218.36	
261	J	2	85.9	19.8	0	105.7	0.0	105.7	363.57			176.53	
262	J	2	87.1	13.7	0	114.1	0.0	114.1	463.59			224.73	
263	J	3	82.7	21.1	0	197.4	0.0	197.4	654.67			345.84	
264	J	3	83.3	29.2	0	145.4	0.0	145.4	458.61			244.70	
265	J	3	84.5	20.5	0	89.9	0.0	89.9	323.50			216.27	
266	J	3	88.3	28.8	0	269.5	0.0	269.5	914.81			430.09	two small holes through paint, dia, 88.26 & 58.94
267	J	4	81.0	35.8	1	102.6	50.2	152.8	3831.93	3398.98	1442.99	595.09	big 6
268	J	4	81.2	31.3	0	94.4	0.0	94.4	278.55			148.59	
269	J	4	81.5	33.7	1	80.8	149.7	230.5	3984.41	2143.49	1473.46	552.34	difficult paint thickness big 7
270	J	4	81.6	36.9	0	98.8	0.0	98.8	541.20			393.59	oblong (393.59 x 203.07)
271	J	4	84.7	34.4	0	92.0	0.0	92.0	388.43			194.18	
272	J	4	88.4	33.6	0	189.8	0.0	189.8	508.91			330.37	
273	J	4	88.9	34.6	0	185.3	0.0	185.3	638.77			412.66	irregular
274	J	4	89.5	39.0	3	152.6	41.2	193.8	696.07	164.94	145.26	378.92	metal visible in hole at lowest point
275	J	5	82.4	43.7	0	85.9	0.0	85.9	327.26			164.15	
276	J	5	82.5	49.7	0	172.2	0.0	172.2	510.42			254.25	
277	J	5	85.6	44.5	0	87.6	0.0	87.6	329.80			173.44	
278	J	5	86.8	49.8	0	36.5	0.0	36.5	303.36			191.58	
279	J	5	87.7	49.8	0	141.6	0.0	141.6	357.94			199.97	"sinkhole" (no spall); gaps in crater and nearby surface
280	J	6	85.8	56.7	0	83.7	0.0	83.7	247.41			147.93	

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter				Notes
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center	Dia = diameter of the best-fit circle
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(µm)	(µm)	(µm)	Dia (µm)	Dia (µm)	Dia (µm)	Dia (µm)	Depth = from surface to the deepest point
281	J	6	89.2	59.6	0	153.4	0.0	153.4	511.31			259.67	dark material in crater
282	J	6	89.3	51.5	0	182.4	0.0	182.4	612.35			378.17	surr. by field of small "sinkhole" craters.
283	J	7	82.2	61.7	0	86.1	0.0	86.1	283.10			174.42	
284	J	7	83.3	61.7	0	140.6	0.0	140.6	422.48			201.56	dark material in crater
285	J	7	86.5	63.1	0	85.0	0.0	85.0	365.29			177.36	dark material in crater
286	J	7	87.4	63.7	0	120.5	0.0	120.5	360.76			210.15	
287	J	7	88.6	65.5	0	89.0	0.0	89.0	328.88			175.75	dark spot/crack in crater
288	J	8	81.2	75.2	0	223.8	0.0	223.8	906.54			445.14	
289	J	8	81.3	75.3	0	193.6	0.0	193.6	733.86			324.72	
290	J	8	81.7	79.3	0	154.3	0.0	154.3	463.06			257.60	black material in crater; lumpy surroundings
291	K	1	91.8	8.5	0	54.7	0.0	54.7	374.70			227.05	
292	K	1	95.5	6.7	0	67.6	0.0	67.6	282.37			165.64	steep sides
293	K	1	96.1	3.9	0	100.6	0.0	100.6	382.78			216.65	
294	K	1	98.4	3.1	0	129.3	0.0	129.3	494.50			289.99	dark material in crater
295	K	1	99.5	1.0	0	130.8	0.0	130.8	602.14			428.79	oblong; large uplift on N. side of crater
296	K	2	90.3	15.8	0	283.5	0.0	283.5	852.12			376.19	inner pit dia. 187.44
297	K	3	92.5	28.3	2	105.7	5.0	110.7	415.65	155.51	155.51	155.51	
298	K	4	92.2	33.3	1	100.7	269.3	370.0	730.82	524.80	524.80	134.09	irreg.; metal appears tilted rel. to paint surface
299	K	4	92.9	33.3	0	42.4	0.0	42.4	286.80			195.87	
300	K	4	93.3	34.4	0	77.3	0.0	77.3	393.58			179.80	
301	K	4	98.5	36.5	0	72.2	0.0	72.2	259.61			167.46	dark material in crater
302	K	5	93.1	41.4	0	68.2	0.0	68.2	288.92			160.56	dark material in crater
303	K	5	95.5	47.7	1	237.0	154.4	391.4	2103.17	2671.74	1219.45	514.10	uncertain paint thickness big 16
304	K	5	98.4	49.0	0	75.8	0.0	75.8	467.18			343.97	edge-shaped, oblong center (343.97 x 149.91); brown material at point
305	K	6	90.2	50.6	0	178.4	0.0	178.4	584.63			357.55	
306	K	6	92.9	53.2	0	96.6	0.0	96.6	346.87			214.28	
307	K	6	93.6	54.5	0	60.9	0.0	60.9	312.67			187.76	
308	K	6	93.8	56.7	1	96.5	29.4	125.9	580.05	375.87		340.07	black spot near center; patches of paint attached in bare metal zone
309	K	6	96.8	57.2	0	92.6	0.0	92.6	318.63			203.94	
310	K	7	94.0	65.5	0	85.0	0.0	85.0	327.05			188.07	oblong center (188.07 x 127.77)
311	K	7	94.3	69.9	0	199.2	0.0	199.2	573.04			359.68	black material in crater
312	K	7	95.7	66.8	0	178.0	0.0	178.0	525.40			335.60	dark spot near bottom of crater
313	K	7	97.0	61.6	3	189.1	37.8	226.9	538.05	97.54	97.54	332.72	patch of metal visible at deepest point; dirty/debris
314	K	7	97.4	64.0	0	76.0	0.0	76.0	245.75			135.66	dark & brown areas in crater
315	K	8	90.3	76.6	0	132.6	0.0	132.6	362.97			211.00	dark crater

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter				Notes
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center	Dia = diameter of the best-fit circle
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(µm)	(µm)	(µm)	Dia (µm)	Dia (µm)	Dia (µm)	Dia (µm)	Depth = from surface to the deepest point
316	K	8	92.9	72.1	0	131.6	0.0	131.6	362.45			233.92	
317	K	8	93.6	74.5	0	105.6	0.0	105.6	409.10			251.57	dark material in crater
318	K	8	94.3	70.0	0	192.2	0.0	192.2	566.19			374.20	dark material in crater; somewhat triangular
319	K	8	95.4	79.2	0	104.9	0.0	104.9	416.32			223.41	
320	K	8	95.5	77.5	0	113.7	0.0	113.7	361.19			191.65	
321	L	1	107.2	4.8	1	212.4	28.5	240.9	1284.98	666.15	666.15	403.78	irregular bottom; possible debris SW of crater
322	L	2	102.9	13.4	0	47.3	0.0	47.3	341.73			162.45	
323	L	2	104.6	14.5	1	94.7	42.5	137.2	1201.99	1049.81	724.38	487.19	
324	L	2	106.1	11.6	2	87.2	23.2	110.4	364.57	257.17	217.89	217.89	
325	L	2	109.3	19.6	0	112.2	0.0	112.2	523.64			308.00	
326	L	4	100.1	37.7	0	113.7	0.0	113.7	513.91			281.51	
327	L	4	102.7	30.6	1	64.7	75.9	140.6	2564.44	1493.79	1020.67	516.64	big 26
328	L	4	105.7	31.0	0	80.6	0.0	80.6	361.35			220.24	dark line in crater
329	L	4	106.3	30.6	0	85.4	0.0	85.4	344.78			194.36	
330	L	4	109.9	31.6	3	160.6	25.8	186.4	698.13	216.90	216.90	357.03	metal visiblel through cracks
331	L	5	100.6	43.7	0	81.3	0.0	81.3	330.59			230.69	dark material in crater
332	L	5	100.8	43.2	0	57.8	0.0	57.8	331.22			188.88	
333	L	5	106.1	43.3	0	95.6	0.0	95.6	326.50			216.98	
334	L	6	102.3	59.0	1	158.6	83.7	242.3	1975.68	1820.26	970.29	408.31	overlaps an unpainted area; paint thickness 231.5 by unpainted area
335	L	6	103.1	52.9	0	140.9	0.0	140.9	541.62			243.93	
336	L	7	100.7	65.9	0	140.0	0.0	140.0	497.03			277.17	
337	L	7	108.3	66.6	2	206.7	12.5	219.2	1110.28	600.68	91.63	120.32	paint attached around lowest area
338	L	8	100.3	79.1	3	126.3	33.0	159.3	477.18	216.01		311.72	metal visible through cracks
339	L	8	102.8	75.4	0	34.6	0.0	34.6	194.87			124.77	dark mater. in oblong pie-slice crater (124.77 x 83.00)
340	L	8	104.8	73.3	1	204.5	94.9	299.4	1704.02	1181.92	1181.92	437.67	big 25
341	L	8	105.5	78.8	1	150.0	208.7	358.7	5952.38	5952.38	1718.52	879.61	paint boundary outside FOV; assume thickness 150 big 8
342	M	1	111.2	1.2	0	66.2	0.0	66.2	320.59			177.81	
343	M	1	114.7	3.4	0	96.5	0.0	96.5	347.19			182.67	
344	M	1	115.7	6.8	0	133.0	0.0	133.0	601.85			291.93	
345	M	2	111.3	18.9	0	78.7	0.0	78.7	324.51			209.31	
346	M	2	113.6	17.7	0	104.5	0.0	104.5	324.97			185.46	dark area (hole?) near bottom
347	M	2	115.9	13.2	1	102.9	14.3	117.2	368.98	182.65	156.36	125.93	bare metal are is oblong
348	M	3	111.8	20.3	1	123.8	65.2	189.0	1044.35	736.22	681.18	361.77	
349	M	3	113.1	26.2	1	147.5	45.6	193.1	895.37	390.92	390.92	237.73	
350	M	3	114.3	26.4	0	123.6	0.0	123.6	558.68			276.94	

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter				Notes
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center	Dia = diameter of the best-fit circle
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(µm)	(µm)	(µm)	Dia (µm)	Dia (µm)	Dia (µm)	Dia (µm)	Depth = from surface to the deepest point
351	M	3	116.5	22.5	1	136.0	46.0	182.0	1136.88	751.16	751.16	446.11	
352	M	4	112.1	38.4	0	99.4	0.0	99.4	402.13			255.32	
353	M	4	115.4	32.6	1	166.5	41.0	207.5	706.71	505.34	505.34	251.14	oblong burned area (503.34 x 339.78); irreg. bottom
354	M	4	118.9	38.7	0	88.9	0.0	88.9	385.97			281.20	ble (281.20 x 176.31) L: 180.46 dia, 62.1 dpth, R: 176.31 dia, 88.9 dpth
355	M	5	110.4	40.9	0	67.5	0.0	67.5	280.06			203.26	oblong (203.26 x 160.17); dark material in crater
356	M	5	110.6	41.6	0	71.4	0.0	71.4	552.58			509.85	spall (552.58 x 415.40), center (509.85 x 260.57); irregular; brown area
357	M	5	111.6	49.3	0	88.4	0.0	88.4	368.74			198.94	lopsided dark area
358	M	5	111.7	47.5	1	212.9	42.8	255.7	800.04	567.03	497.73	200.24	
359	M	5	115.5	45.2	0	62.6	0.0	62.6	256.62			189.16	
360	M	6	111.9	59.2	0	81.5	0.0	81.5	298.59			183.51	dark material in crater
361	M	6	114.3	51.3	3	105.4	34.1	139.5	582.25	122.34		317.27	metal vis. through hole in side of crater (122.34 x 48.68); double slope
362	M	6	117.7	56.0	0	45.5	0.0	45.5	302.89			163.01	
363	M	6	118.0	55.9	0	64.8	0.0	64.8	285.01			160.67	
364	M	6	118.9	54.2	0	109.3	0.0	109.3	400.93			262.27	
365	M	6	119.2	52.0	0	87.2	0.0	87.2	301.15			189.75	dark center
366	M	7	111.5	65.7	0	87.5	0.0	87.5	362.29			233.24	
367	M	7	111.7	61.6	1	221.4	58.4	279.8	1287.06	842.30	842.30	469.28	
368	M	7	117.6	65.1	0	114.7	0.0	114.7	373.12			188.96	
369	M	8	111.4	75.4	0	58.0	0.0	58.0	235.59			151.34	shiny debris on surface
370	M	8	113.4	71.5	0	117.9	0.0	117.9	419.97			228.79	
371	M	8	117.3	71.0	0	55.8	0.0	55.8	246.75			132.90	dark area/cracks in side of crater
372	N	1	120.7	2.9	0	70.6	0.0	70.6	376.09			196.54	
373	N	1	122.1	1.6	1	150.0	539.4	689.4	13417.38	12775.77	2878.09	1282.94	paint boundary outside FOV; assume thickness 150 big 10
374	N	1	125.2	7.9	0	83.8	0.0	83.8	353.36			190.90	
375	N	1	125.9	1.8	0	118.7	0.0	118.7	389.49			214.68	
376	N	1	129.0	4.5	1	237.0	52.3	289.3	1023.90	643.66	282.58	206.68	
377	N	3	122.8	28.1	0	92.0	0.0	92.0	298.84			187.09	
378	N	3	127.1	28.8	1	134.2	57.0	191.2	994.74	688.73	661.07	380.16	lopsided burned area
379	N	4	121.1	32.2	1	122.2	39.3	161.5	1190.36	893.98	588.24	383.52	irreg. center
380	N	4	127.4	38.3	0	131.4	0.0	131.4	494.80			301.81	dark crater; dark line on crater edge
381	N	4	128.8	35.4	3	64.1	19.1	83.2	549.15	147.91	256.53	147.91	paint mostly attached
382	N	5	120.6	47.4	1	138.5	124.6	263.1	5303.32	4473.85	1585.92	699.51	big 9
383	N	5	121.3	46.7	1	153.2	34.5	187.7	688.14	420.23	283.75	214.72	
384	N	5	123.4	44.5	0	78.7	0.0	78.7	364.86			195.82	
385	N	5	125.3	42.2	0	141.2	0.0	141.2	554.32			346.94	dark material in crater; oblong center (346.94 x 260.11)

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter				Notes
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center	Dia = diameter of the best-fit circle
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(µm)	(µm)	(µm)	Dia (µm)	Dia (µm)	Dia (µm)	Dia (µm)	Depth = from surface to the deepest point
386	N	5	126.4	44.8	0	94.0	0.0	94.0	338.42			234.60	
387	N	6	122.1	53.6	2	103.7	26.4	130.1	627.58	354.17	189.45	189.45	much paint still attached; black spot at center
388	N	6	123.9	50.2	0	138.3	0.0	138.3	457.73			297.98	dark gray center
389	N	6	126.0	51.3	1	144.5	41.6	186.1	823.84	554.46	440.55	266.91	
390	N	7	121.0	67.3	0	124.4	0.0	124.4	420.54			217.26	dark & irregular area in side of crater
391	N	7	121.4	66.4	0	102.5	0.0	102.5	388.37			202.25	
392	N	7	121.8	69.8	0	88.6	0.0	88.6	324.61			194.39	oblong center (194.39 x 105.31)
393	N	7	122.8	68.7	0	90.5	0.0	90.5	251.45			145.60	dark crater
394	N	7	125.8	63.2	0	133.0	0.0	133.0	360.30			166.99	
395	N	7	126.2	69.5	0	103.9	0.0	103.9	470.98			228.65	somewhat diagonal
396	N	7	126.6	64.9	1	197.3	102.7	300.0	2076.32	1107.05	1107.05	532.11	big 28
397	N	7	129.2	61.6	0	126.6	0.0	126.6	468.60			248.53	
398	N	8	123.8	78.2	1	150.5	50.7	201.2	1745.45	1376.27	621.25	850.73	big 27
399	N	8	125.6	72.2	0	86.0	0.0	86.0	371.30			212.95	
400	N	8	125.7	74.6	1	190.1	50.9	241.0	1706.11	868.95	679.23	291.59	
401	N	8	127.5	71.2	0	136.6	0.0	136.6	507.90			376.96	dark mater. in crater; oblong center (376.96 x 207.06)
402	N	8	128.3	76.1	0	110.0	0.0	110.0	453.03			255.32	brown area in side of crater
403	P	1	130.5	8.4	0	110.1	0.0	110.1	371.01			277.76	
404	P	1	132.7	2.5	0	63.5	0.0	63.5	399.29			219.28	
405	P	1	132.7	2.9	0	96.8	0.0	96.8	335.70			195.53	
406	P	1	136.5	7.8	0	99.9	0.0	99.9	330.71			176.55	
407	P	1	139.8	4.4	1	161.8	49.5	211.3	960.26	677.14	320.41	320.41	
408	P	2	134.3	16.7	1	181.3	44.4	225.7	981.14	693.70	543.57	380.32	
409	P	3	135.8	20.3	0	118.4	0.0	118.4	355.07			187.12	
410	P	3	139.4	25.3	1	103.9	25.7	129.6	708.40	350.04	350.04	228.40	
411	P	3	139.6	29.5	0	87.4	0.0	87.4	348.01			170.93	oblong; brown color in crater
412	P	3	139.8	28.7	0	148.8	0.0	148.8	393.89			198.44	dark material or hole in crater
413	P	4	134.2	36.4	1	186.3	89.6	275.9	1220.78	867.93	867.93	413.13	some cracks beyond spall
414	P	4	135.8	33.1	1	151.4	43.3	194.7	977.83	544.03	212.93	260.97	long cracks beyond spall; oblong bare metal (544.03 x 353.34)
415	P	4	136.1	36.4	1	210.8	60.7	271.5	1316.14	917.48	917.48	383.77	big 45
416	P	5	130.0	49.4	1	166.5	16.1	182.6	802.97	551.87		79.95	oblong: spall (802.97 x 627.02), bare metal (551.87 x 392.65)
417	P	5	130.8	41.9	0	74.5	0.0	74.5	294.50			165.76	dark material in crater
418	P	5	131.3	41.3	0	70.3	0.0	70.3	330.82			151.37	
419	P	5	137.2	49.4	0	83.1	0.0	83.1	336.56			199.84	
420	P	6	138.1	59.6	0	106.3	0.0	106.3	359.97			186.13	possibly radiating 3 cracks

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter				Notes
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center	Dia = diameter of the best-fit circle
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(µm)	(µm)	(µm)	Dia (µm)	Dia (µm)	Dia (µm)	Dia (µm)	Depth = from surface to the deepest point
421	P	6	138.2	58.1	0	95.8	0.0	95.8	329.48			191.60	
422	P	6	139.0	54.4	1	177.0	29.4	206.4	1036.39	730.28	190.76	256.74	black patch in center
423	P	7	133.0	60.2	0	70.2	0.0	70.2	270.59			171.30	dark patches in crater
424	P	7	133.5	67.2	0	90.2	0.0	90.2	418.83			232.41	
425	P	7	135.7	66.1	2	119.3	11.6	130.9	533.86	162.24	78.46	271.60	
426	P	7	135.8	64.7	0	105.8	0.0	105.8	338.31			196.02	dark patch in side of crater
427	P	7	136.1	67.3	0	102.4	0.0	102.4	437.94			228.26	
428	P	7	136.7	64.0	1	128.7	18.8	147.5	667.61	255.36		134.77	
429	P	7	138.4	62.8	0	92.6	0.0	92.6	294.27			160.02	
430	P	7	139.1	68.3	1	153.0	100.1	253.1	917.73	580.00	580.00	272.35	
431	P	8	130.2	75.2	0	112.0	0.0	112.0	404.21			228.95	brown patch on side of crater
432	P	8	135.0	78.7	0	103.4	0.0	103.4	500.00			216.09	dark, irregular bottom
433	P	8	137.3	72.9	0	155.6	0.0	155.6	515.00			206.21	dark material in crater bottom
434	Q	1	140.0	9.2	0	41.9	0.0	41.9	275.69			160.08	
435	Q	1	148.3	2.8	0	55.0	0.0	55.0	298.81			182.32	
436	Q	2	146.9	16.2	2	160.9	6.7	167.6	719.29	233.72	233.72	158.88	metal partially exposed
437	Q	2	148.5	14.2	0	109.9	0.0	109.9	497.30			226.44	
438	Q	2	148.8	12.7	0	148.1	0.0	148.1	572.85			312.22	
439	Q	3	146.3	24.2	0	90.8	0.0	90.8	388.97			216.40	
440	Q	3	146.9	29.5	0	137.6	0.0	137.6	502.09			222.22	oblong: 222.22 x 309.98
441	Q	3	148.3	22.4	1	167.8	26.3	194.1	1009.76	551.55	403.47	193.48	dark area is NOT deepest point
442	Q	5	140.9	45.1	0	85.9	0.0	85.9	429.71			255.85	
443	Q	6	141.2	58.6	0	164.6	0.0	164.6	434.01			256.88	
444	Q	6	147.4	53.0	1	91.3	144.1	235.4	4437.37	4280.85	1295.27	591.97	big 12
445	Q	7	141.1	60.5	0	133.6	0.0	133.6	369.75			215.41	
446	Q	7	142.7	67.5	0	87.6	0.0	87.6	276.73			179.33	dark crater
447	Q	7	143.8	68.6	1	218.8	126.3	345.1	3944.01	3206.43	1260.15	538.75	big 11
448	Q	7	144.4	62.2	0	96.9	0.0	96.9	334.53			173.55	metal debris on nearby surface
449	Q	7	149.4	63.7	0	112.5	0.0	112.5	420.11			230.77	dark material in crater
450	Q	7	149.4	67.9	0	80.3	0.0	80.3	372.17			180.45	
451	Q	8	140.5	75.8	1	174.5	35.7	210.2	2009.06	1566.21	1121.61	464.50	elliptical spall big 29
452	Q	8	141.1	76.5	0	123.6	0.0	123.6	546.51			316.73	
453	Q	8	142.3	75.2	0	98.9	0.0	98.9	317.17			174.68	
454	Q	8	142.7	74.7	0	95.9	0.0	95.9	323.17			197.07	larger of double crater (smaller to SW), 248.81 between centers
455	Q	8	142.7	74.7	0	40.7	0.0	40.7	241.26			165.29	smaller of double crater (larger to NE), 248.81 between centers

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter				Notes
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center	Dia = diameter of the best-fit circle
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(µm)	(µm)	(µm)	Dia (µm)	Dia (µm)	Dia (µm)	Dia (µm)	Depth = from surface to the deepest point
456	Q	8	145.6	75.1	0	106.6	0.0	106.6	352.49			183.03	
457	R	1	153.4	3.3	1	150.0	516.1	666.1	12541.68	11452.39	2686.91	1062.19	paint boundary outside FOV; assume thickness 150 big 13
458	R	1	156.9	6.6	1	117.3	9.6	126.9	829.75	501.51	284.66	118.57	oblong, irregular
459	R	2	152.8	10.2	0	125.6	0.0	125.6	488.21			251.25	
460	R	2	156.8	10.3	0	106.8	0.0	106.8	393.22			215.31	
461	R	2	157.0	13.6	0	104.9	0.0	104.9	360.30			163.87	
462	R	3	153.0	27.0	1	183.5	84.4	267.9	1650.51	1109.91	1001.45	496.57	big 30
463	R	3	158.7	22.8	0	86.7	0.0	86.7	312.87			192.03	
464	R	4	156.9	34.6	0	157.7	0.0	157.7	403.51			234.64	dark material in crater
465	R	4	157.1	34.3	2	125.3	89.7	215.0	625.26	259.98	259.98	259.98	notched, semi-circular indentation, burned & center (259.98 x 139.98)
466	R	4	157.3	36.6	1	153.3	88.1	241.4	1577.35	902.06	902.06	403.57	
467	R	4	159.8	39.6	1	189.7	47.2	236.9	893.47	317.60	317.60	233.73	dark crater; steep sides
468	R	5	150.3	48.7	0	81.7	0.0	81.7	357.57			198.92	
469	R	5	151.5	45.2	0	122.9	0.0	122.9	378.51			264.49	
470	R	5	151.6	45.6	0	85.7	0.0	85.7	240.52			166.20	horizontal fiber on crater (no thickness)
471	R	5	155.5	49.8	0	119.1	0.0	119.1	421.38			249.38	
472	R	5	156.8	42.0	0	109.8	0.0	109.8	338.53			225.68	
473	R	5	158.6	49.7	1	258.6	276.6	535.2	7977.52	6872.82	1908.42	890.66	big 15
474	R	6	152.7	56.3	0	169.3	0.0	169.3	465.22			241.75	oblique?; dark area at deepest point
475	R	6	154.6	53.6	3	179.8	4.7	184.5	697.86	123.09	123.09	322.29	small patches of metal visible
476	R	6	155.2	53.6	0	174.0	0.0	174.0	701.76			360.83	
477	R	6	155.3	59.0	0	126.2	0.0	126.2	239.50			155.21	
478	R	6	158.8	52.2	0	112.7	0.0	112.7	386.97			244.56	
479	R	7	150.7	60.2	0	110.1	0.0	110.1	323.13			157.87	
480	R	7	151.3	63.9	1	173.8	48.9	222.7	902.10	559.99	440.62	180.80	
481	R	7	152.7	65.9	0	104.3	0.0	104.3	442.46			274.67	
482	R	7	154.4	63.7	1	144.0	60.6	204.6	2750.36	1241.73	1190.86	461.77	big 34
483	R	7	157.7	68.2	0	107.4	0.0	107.4	371.03			198.61	
484	R	8	150.7	73.0	2	121.5	21.9	143.4	666.45	233.65	102.42	209.19	paint on most of crater bottom; oblong inner spall (479.35 x 322.66)
485	R	8	152.8	76.9	3	118.9	19.3	138.2	479.09	779.62		227.36	patch of metal visible in side of crater
486	R	8	155.1	71.0	1	134.8	22.2	157.0	732.10	459.37	459.37	247.05	irrgeular bottom; oblong burned area (459.37 x 251.95)
487	R	8	155.9	72.3	3	100.0	10.1	110.1	304.72	92.22	71.47	182.38	patch of metal at lowest point
488	S	1	161.7	0.0	1	94.8	65.9	160.7	2423.94	2170.65	957.26	503.39	big 31
489	S	1	166.9	6.2	1	160.9	60.6	221.5	1235.94	864.19	573.09	455.59	
490	S	1	167.3	4.7	0	131.4	0.0	131.4	528.07			375.39	

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter				Notes
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center	Dia = diameter of the best-fit circle
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(µm)	(µm)	(µm)	Dia (µm)	Dia (µm)	Dia (µm)	Dia (µm)	Depth = from surface to the deepest point
491	S	1	167.4	8.9	1	172.3	140.3	312.6	2268.70	1979.93	1155.21	549.81	big 32
492	S	2	160.7	12.4	0	84.1	0.0	84.1	331.90			177.13	dark material in crater
493	S	2	167.8	19.9	0	119.9	0.0	119.9	347.12			270.29	
494	S	2	168.9	10.8	0	95.7	0.0	95.7	404.46			199.69	
495	S	2	169.1	14.2	1	158.3	59.2	217.5	1139.25	832.73	781.56	410.75	
496	S	3	163.3	26.6	0	111.9	0.0	111.9	516.74			223.34	
497	S	3	166.6	29.4	1	151.2	11.2	162.4	1267.62	739.62	610.52	112.58	very flat bottom
498	S	3	169.4	20.6	0	164.4	0.0	164.4	452.97			258.45	dark material or hole in crater (dia. 85.06)
499	S	4	163.0	32.1	1	141.9	52.7	194.6	1318.48	882.89	300.34	369.56	
500	S	4	164.1	39.5	1	165.8	39.7	205.5	1111.35	730.79	450.07	243.38	irregular bottom
501	S	5	160.0	46.5	0	114.6	0.0	114.6	363.69			237.41	dark patch or hole in side of crater
502	S	5	161.6	43.7	0	133.1	0.0	133.1	459.32			258.72	
503	S	5	164.0	41.3	0	102.7	0.0	102.7	437.16			227.84	
504	S	5	166.1	45.6	0	120.6	0.0	120.6	342.36			186.34	
505	S	5	166.4	40.8	0	75.1	0.0	75.1	284.97			170.79	dark material in crater
506	S	6	160.2	57.2	0	93.9	0.0	93.9	258.76			166.71	
507	S	6	161.7	59.7	0	125.6	0.0	125.6	386.24			191.85	
508	S	6	166.9	58.0	0	98.1	0.0	98.1	329.68			203.18	
509	S	7	160.6	61.3	1	126.5	120.9	247.4	2139.17	1129.19	765.63	475.74	cracked paint 2441.16 dia big 36
510	S	7	162.2	67.1	0	95.1	0.0	95.1	316.44			176.38	
511	S	7	164.8	61.8	0	123.9	0.0	123.9	418.47			230.98	
512	S	7	165.2	64.8	1	137.8	56.1	193.9	1747.36	1293.21	1188.13	562.46	big 35
513	S	7	165.5	65.1	0	77.0	0.0	77.0	346.58			201.97	
514	S	7	167.7	64.2	0	77.5	0.0	77.5	438.08			347.65	very oblong.; spall (438.08 x 187.71), center (347.65 x 122.41)
515	S	7	169.0	68.0	1	199.1	37.5	236.6	1022.42	699.39	358.57	358.57	outer crack ring at 1046.39
516	S	8	162.4	71.8	0	95.5	0.0	95.5	292.52			172.93	
517	S	8	162.4	74.9	1	150.0	588.8	738.8	14706.43	14706.43	3789.97	1524.69	reg/double; paint boundary outside FOV; assume thickness 150 big 14
518	S	8	165.1	73.2	0	55.2	0.0	55.2	391.16			233.02	soot extends to NE
519	S	8	169.1	72.1	0	83.7	0.0	83.7	264.10			138.13	dark ring in crater
520	T	1	170.1	1.4	3	146.8	7.0	153.8	418.57	145.65	145.65	67.53	
521	T	1	172.2	1.3	1	126.8	14.9	141.7	728.79	501.54		307.51	no colored metal; paint covers crater bottom
522	T	1	172.8	2.9	1	156.0	136.5	292.5	914.45	710.89	556.88	307.79	
523	T	1	173.7	1.2	1	137.9	66.2	204.1	1340.60	976.22	536.17	471.72	
524	T	1	175.5	3.7	1	171.5	14.3	185.8	697.98	383.25	325.34	137.72	
525	T	2	170.8	16.3	1	163.8	57.3	221.1	1005.58	709.93	709.93	332.94	

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter				Notes
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center	Dia = diameter of the best-fit circle
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(µm)	(µm)	(µm)	Dia (µm)	Dia (µm)	Dia (µm)	Dia (µm)	Depth = from surface to the deepest point
526	T	2	174.9	19.7	3	138.8	0.0	138.8	854.29	141.54		323.38	irregular
527	T	2	178.9	18.9	1	113.0	136.2	249.2	2234.96	1593.25	1090.25	645.50	big 33
528	T	3	172.9	24.9	2	173.2	16.9	190.1	786.98	228.18	228.18	228.18	dark material in crater
529	T	3	172.9	27.7	0	105.3	0.0	105.3	568.97			256.09	oblong.; center is 256.09 x 416.27
530	T	3	174.3	20.9	0	127.9	0.0	127.9	394.75			236.25	
531	T	4	172.1	39.8	1	147.7	66.7	214.4	1971.39	1128.64	752.44	543.59	much spall still attached
532	T	4	174.2	33.3	0	114.9	0.0	114.9	288.32			206.50	crack in bottom
533	T	4	176.9	33.3	2	119.2	11.2	130.4	534.49	135.42	135.42	246.25	oblong (246.25 x 135.42); brown color & line
534	T	4	178.3	32.9	1	83.6	94.7	178.3	3262.01	1661.57	1113.99	733.36	big 38
535	T	5	170.1	42.4	1	145.6	188.3	333.9	4340.07	3986.55	1617.22	658.34	min paint thickness of 85.2 big 17
536	T	5	172.7	42.5	1	173.1	37.9	211.0	931.90	506.13	254.22	333.86	
537	T	5	176.1	46.1	0	118.6	0.0	118.6	468.04			267.68	
538	T	6	171.1	52.3	0	51.0	0.0	51.0	322.93			181.07	brown patch on side of crater
539	T	6	171.9	53.0	0	86.7	0.0	86.7	359.22			209.51	
540	T	6	172.5	55.4	1	197.6	39.2	236.8	1829.55	1100.74	372.82	356.58	much spall still attached
541	T	6	172.7	54.4	0	96.9	0.0	96.9	261.37			164.46	
542	T	6	176.8	50.9	0	78.4	0.0	78.4	388.27			240.86	oblong center (240.86 x 142.79)
543	T	6	176.9	55.7	0	85.0	0.0	85.0	358.03			198.98	
544	T	6	177.2	50.5	0	107.2	0.0	107.2	389.53			215.84	
545	T	7	175.2	60.8	1	84.8	80.8	165.6	1810.18	1533.56	1112.84	391.54	big 37
546	T	7	175.6	62.7	0	92.9	0.0	92.9	365.01			205.18	
547	T	8	172.7	74.6	1	120.7	27.7	148.4	634.09	427.38	105.85	178.48	
548	T	8	175.2	72.1	0	118.5	0.0	118.5	353.49			165.06	black crater bottom
549	T	8	175.5	70.3	0	104.0	0.0	104.0	360.42			222.60	dark crater
550	T	8	176.3	73.2	2	119.7	95.0	214.7	488.28	230.29	158.87	73.11	
551	T	8	177.7	73.8	0	91.0	0.0	91.0	372.31			261.47	
552	U	2	181.9	14.8	1	116.5	53.1	169.6	746.56	475.75	475.75	158.12	
553	U	2	182.5	14.9	3	176.4	0.0	176.4	672.96	352.23		487.51	odd pit, shiny "icy" bottom; no spall; "Z"?
554	U	2	183.9	16.4	1	157.9	28.3	186.2	671.89	333.41	333.41	179.66	
555	U	2	184.8	13.5	3	126.5	0.0	126.5	731.83	285.82		488.53	odd pit, shiny "icy" bottom; no spall; "Z"?
556	U	2	187.6	13.6	2	137.3	0.0	137.3	274.74	161.56		199.63	sinkhole; no spall
557	U	2	187.7	19.5	0	124.9	0.0	124.9	586.16			271.23	
558	U	3	180.6	20.4	0	128.7	0.0	128.7	245.97			164.94	narrow w/ steep sides; maybe crack in bottom
559	U	3	182.4	25.5	0	174.3	0.0	174.3	558.08			284.49	
560	U	3	183.2	22.7	2	159.6	44.4	204.0	499.44	295.86	227.65	163.91	shiny cellophane rim; circle with no spall

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter				Notes
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center	Dia = diameter of the best-fit circle
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(µm)	(µm)	(µm)	Dia (µm)	Dia (µm)	Dia (µm)	Dia (µm)	Depth = from surface to the deepest point
561	U	3	185.1	20.1	0	121.0	0.0	121.0	585.75			249.47	
562	U	3	186.5	22.1	0	124.1	0.0	124.1	460.73			214.91	
563	U	3	188.9	21.9	2	142.7	30.6	173.3	621.44	186.07	110.51	124.29	crater edge dia. 321.23
564	U	4	186.2	36.6	0	97.3	0.0	97.3	384.61			196.91	
565	U	4	187.3	31.4	3	164.9	6.1	171.0	632.73	91.75		273.58	metal visible through cracks
566	U	4	187.9	37.2	0	169.8	0.0	169.8	550.50			292.91	crack/gap in bottom
567	U	5	180.2	41.6	0	110.7	0.0	110.7	410.25			277.80	
568	U	5	184.4	47.1	1	146.9	54.7	201.6	2405.78	2069.41	834.01	540.51	big 39
569	U	5	185.7	47.4	0	113.9	0.0	113.9	395.88			209.89	
570	U	5	185.8	49.7	0	67.3	0.0	67.3	299.42			131.17	nearby fiber shows VHX depth smoothing
571	U	5	189.2	41.1	0	127.8	0.0	127.8	409.55			255.38	bullseye
572	U	6	181.8	55.7	3	136.9	9.5	146.4	718.28	105.42		340.81	metal visible through gap at deepest point
573	U	6	184.6	56.8	0	122.2	0.0	122.2	550.03			281.02	
574	U	6	189.9	52.7	0	92.1	0.0	92.1	310.09			168.84	dark material in crater
575	U	7	180.3	61.2	0	32.1	0.0	32.1	203.36			132.77	amber, non-metallic debris on nearby surface
576	U	7	181.0	67.8	0	49.4	0.0	49.4	334.01			159.56	dark patch in side of crater
577	U	7	184.2	60.8	0	98.1	0.0	98.1	364.56			179.68	
578	U	7	187.4	69.4	0	115.2	0.0	115.2	329.92			228.64	
579	U	7	188.4	62.4	0	106.5	0.0	106.5	471.31			314.37	
580	U	8	180.6	70.7	1	117.4	29.0	146.4	580.75	323.75	239.71	225.05	
581	U	8	183.9	71.6	1	127.9	38.2	166.1	756.16	426.13	380.39	322.05	
582	U	8	184.5	73.9	0	90.7	0.0	90.7	250.63			155.89	dark ring in crater
583	U	8	185.5	70.9	0	46.5	0.0	46.5	241.38			152.71	dark patch in side of crater
584	U	8	188.3	72.8	3	115.5	17.9	133.4	527.31	112.65		307.53	metal vis. in side of crater; oblong center (307.53 x 210.62)
585	U	8	189.0	75.2	1	124.3	108.8	233.1	3159.54	2442.28	1453.62	822.18	big 40
586	V	1	192.8	9.9	0	70.8	0.0	70.8	389.63			207.90	
587	V	1	196.4	5.7	1	156.2	38.4	194.6	2516.59	2143.85	972.13	521.97	big 42
588	V	2	191.1	14.7	2	137.4	6.6	144.0	783.59	452.65		174.34	"icy" bottom; sinkhole; dark spot on side
589	V	2	192.2	16.0	0	113.7	0.0	113.7	494.36			281.19	
590	V	2	193.9	13.7	0	80.3	0.0	80.3	609.68			344.98	wrinkled, shiny object in crater; little chipping
591	V	2	194.8	13.8	1	196.7	38.8	235.5	1359.33	1018.08	658.46	496.17	
592	V	3	191.6	29.6	3	136.4	27.8	164.2	548.17	147.87	147.87	125.63	metal visible through cracks; crater edge dia. 342.23
593	V	3	196.2	24.7	0	130.9	0.0	130.9	535.54			273.03	brown material in crater
594	V	3	196.4	21.9	3	172.0	0.0	172.0	685.07	136.28	68.12	73.47	metal visible through cracks; crater edge dia. 286.21
595	V	3	198.1	20.8	0	138.4	0.0	138.4	540.05			283.55	

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter				Notes
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center	Dia = diameter of the best-fit circle
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(µm)	(µm)	(µm)	Dia (µm)	Dia (µm)	Dia (µm)	Dia (µm)	Depth = from surface to the deepest point
596	V	3	199.0	25.2	1	144.7	16.6	161.3	810.72	530.94	348.21	215.96	
597	V	4	190.8	36.6	2	157.3	8.7	166.0	1064.76	232.88	454.08	454.08	some spall removed (dia. 754.55); oblong (454.08 x 336.33)
598	V	4	191.8	37.5	0	123.4	0.0	123.4	399.77			226.82	
599	V	4	193.0	34.9	0	125.9	0.0	125.9	494.28			246.03	
600	V	4	193.7	32.8	0	86.5	0.0	86.5	390.77			229.28	
601	V	4	196.8	32.4	1	100.9	187.8	288.7	3212.90	2761.52	1459.30	777.59	big 41
602	V	5	191.2	44.8	3	177.4	15.4	192.8	435.77	191.36	116.41	361.16	rounded rim (no spall); metal visible through gaps
603	V	5	194.6	45.6	0	176.7	0.0	176.7	478.99			317.61	
604	V	5	197.4	41.2	0	56.9	0.0	56.9	391.85			194.47	ye with central pit; spall area seem suplifted (13.1); profile incomplete
605	V	6	191.9	53.2	0	145.5	0.0	145.5	493.88			258.54	
606	V	6	192.3	50.8	0	133.8	0.0	133.8	322.53			200.68	
607	V	6	195.0	57.3	0	129.5	0.0	129.5	424.83			293.87	
608	V	6	195.2	57.2	0	116.5	0.0	116.5	346.93			226.21	
609	V	7	190.2	65.0	0	95.4	0.0	95.4	314.11			168.33	
610	V	7	191.3	61.0	0	122.5	0.0	122.5	432.76			215.92	
611	V	7	197.5	61.9	0	71.3	0.0	71.3	372.82			208.48	
612	V	7	198.7	63.0	0	79.3	0.0	79.3	307.89			183.09	dirty surroundings
613	V	8	192.2	71.9	0	77.3	0.0	77.3	448.55			210.56	dark patch on S. side, small companion impact on N. side
614	V	8	192.9	71.5	0	130.2	0.0	130.2	512.27			280.91	
615	V	8	193.2	70.7	0	102.7	0.0	102.7	344.51			172.72	
616	V	8	198.5	73.3	1	159.2	35.2	194.4	833.34	492.25	401.91	249.76	irregular crater bottom
617	W	1	202.0	5.7	1	196.8	104.0	300.8	1612.74	1326.36	995.76	535.99	
618	W	1	203.9	7.9	0	138.1	0.0	138.1	414.76			271.65	
619	W	1	204.8	9.4	1	108.9	263.7	372.6	387.01	2045.38	1495.52	690.01	big 19
620	W	1	206.1	3.8	0	183.9	0.0	183.9	533.02			340.56	dark crater
621	W	2	204.2	17.3	0	133.4	0.0	133.4	509.81			294.68	
622	W	2	208.7	19.8	1	190.1	63.4	253.5	1090.59	696.98	538.67	378.48	**Duplicate of W3-50-76**
623	W	3	200.0	22.7	1	150.7	28.2	178.9	873.12	453.06	132.64	163.66	lopsided spall
624	W	3	202.1	20.8	0	102.4	0.0	102.4	319.15			182.44	
625	W	3	203.6	24.8	0	112.7	0.0	112.7	484.04			216.63	wide crater
626	W	3	205.7	20.6	1	175.0	71.1	246.1	1200.81	701.97	500.95	390.13	**Duplicate of W2-89-78**
627	W	3	207.8	27.2	0	133.5	0.0	133.5	444.87			238.79	oblong
628	W	4	201.8	33.3	0	88.2	0.0	88.2	267.91			140.51	
629	W	4	203.1	39.8	0	45.0	0.0	45.0	285.17			178.09	surrounding paint very uneven & sloping
630	W	4	203.2	39.7	0	163.4	0.0	163.4	590.79			314.21	surrounding paint very uneven & sloping

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter				Notes
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center	Dia = diameter of the best-fit circle
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(µm)	(µm)	(µm)	Dia (µm)	Dia (µm)	Dia (µm)	Dia (µm)	Depth = from surface to the deepest point
631	W	4	203.9	39.6	1	219.1	112.4	331.5	2438.31	1778.36	1187.39	586.17	big 44
632	W	4	204.9	32.3	0	89.8	0.0	89.8	282.17			189.02	
633	W	4	206.3	39.9	0	107.7	0.0	107.7	375.91			196.91	surrounding paint uneven
634	W	4	207.5	31.8	2	149.9	24.5	174.4	781.42	228.55	193.87	381.52	dark material in crater
635	W	4	207.5	33.0	0	106.7	0.0	106.7	535.94			205.19	dark material in crater
636	W	5	206.4	40.0	0	108.8	0.0	108.8	325.50			168.62	
637	W	5	207.6	42.4	0	100.8	0.0	100.8	389.69			200.92	
638	W	5	208.2	49.0	0	122.1	0.0	122.1	463.71			221.75	
639	W	6	200.9	56.5	3	173.6	9.8	183.4	842.67	192.68	90.53	347.53	metal visible through gaps
640	W	6	205.8	54.7	2	175.8	14.5	190.3	762.01	314.43		170.54	oblong spall (762.01 x 438.46), floor (573.61 x 295.79)
641	W	6	207.6	52.1	0	357.9	0.0	357.9	682.62			398.86	dark spot on bottom
642	W	7	200.9	63.8	0	212.5	0.0	212.5	703.19			409.91	dark crater
643	W	7	202.6	68.5	0	124.0	0.0	124.0	459.81			220.13	dark border of center
644	W	7	202.8	61.6	0	172.1	0.0	172.1	617.88			283.30	dark center
645	W	8	203.8	74.7	0	148.6	0.0	148.6	506.10			300.75	
646	W	8	206.7	78.3	1	175.8	28.4	204.2	993.86	637.44	464.78	168.75	irreg. bottom with a peak; oblong burned area (464.78 x 302.70)
647	W	8	207.2	77.8	1	231.4	152.4	383.8	4053.83	3525.92	1487.48	642.46	irreg/mulitiple big 18
648	X	1	213.3	0.1	0	79.7	0.0	79.7	357.79			198.58	
649	X	1	215.3	4.2	1	150.0	116.3	266.3	5226.57	3719.46	1416.08	552.89	big 20
650	X	1	216.9	6.7	0	27.7	0.0	27.7	338.17			169.29	incomplete profile; estimated depth
651	X	1	219.9	5.3	1	196.0	67.2	263.2	1221.65	731.44	544.95	377.53	
652	X	2	213.0	18.1	0	88.3	0.0	88.3	336.77			216.59	
653	X	2	215.2	10.1	1	150.9	71.3	222.2	956.42	628.42	612.24	214.05	
654	X	2	216.8	15.2	1	184.7	32.9	217.6	905.55	544.33	544.33	398.75	irregular bottom
655	X	3	210.6	21.9	0	129.6	0.0	129.6	525.98			280.42	
656	X	3	211.0	28.7	0	150.1	0.0	150.1	592.44			296.27	dark area (hole?) near bottom
657	X	3	213.5	26.0	1	224.7	122.0	346.7	2479.85	1988.82	1537.65	777.30	big 43
658	X	3	213.6	28.3	2	151.6	9.9	161.5	500.98	192.47	192.47	104.69	very dark crater
659	X	3	215.3	26.5	0	127.2	0.0	127.2	460.23			424.30	slightly oblong
660	X	4	210.6	35.3	0	110.8	0.0	110.8	372.11			202.07	
661	X	4	212.4	38.3	0	128.6	0.0	128.6	366.25			208.83	
662	X	4	217.6	31.6	1	158.4	39.6	198.0	759.43	456.99	437.59	172.77	
663	X	4	219.2	31.4	1	95.5	16.3	111.8	1525.95	1228.17	532.81	336.02	some spall still attached; not a good image
664	X	5	210.7	49.2	0	95.7	0.0	95.7	337.69			167.10	dark material in crater
665	X	5	211.2	40.4	0	97.3	0.0	97.3	385.05			227.09	

Line	Location				Radiator metal visible in crater?	Crater Depth			Crater Diameter				Notes
						Depth in Paint	Depth in Metal	Total Depth	Spall Zone	Bare Metal	Colored/ "Burned" Metal	Lips/ Center	Dia = diameter of the best-fit circle
	Grid X	Grid Y	X (cm)	Y (cm)	0=NO 1=YES	(µm)	(µm)	(µm)	Dia (µm)	Dia (µm)	Dia (µm)	Dia (µm)	Depth = from surface to the deepest point
666	X	5	213.8	41.5	0	117.8	0.0	117.8	321.26			211.44	
667	X	5	215.3	44.6	3	138.4	16.7	155.1	594.37	166.58		322.84	
668	X	5	216.5	47.1	0	83.5	0.0	83.5	403.39			213.25	
669	X	5	218.1	49.3	1	115.4	65.1	180.5	1968.86	1362.86	586.70	157.15	; estimated paint thickness; dark center; bare metal 1700.21 x 1277.07
670	X	6	214.6	54.7	2	184.4	184.4	184.4	408.70	408.70		284.89	near division between dark/paint & bare metal; metal 284.89 x 191.64
671	X	6	214.8	53.9	0	157.8	0.0	157.8	371.94			234.68	dark material in crater
672	X	7	212.7	67.3	3	144.5	35.2	179.7	495.92	138.78		343.20	oblong: spall (495.92 x 312.05), center (343.20 x 168.71)
673	X	7	216.4	62.5	1	226.9	58.7	285.6	1176.48	839.76	595.60	131.66	ottom; oblong: spall (1176.49 x 969.33), burned area (595.60 x 436.88)
674	X	8	214.4	77.3	0	221.5	0.0	221.5	583.78			391.92	cracks in bottom
675	X	8	214.9	77.8	1	239.2	85.2	324.4	1209.51	918.14	646.56	200.63	oblong bare metal (918.14 x 551.88)
676	X	8	216.0	76.8	3	182.5	16.2	198.7	440.77	203.06		350.91	metal visible through gaps
677	X	8	218.3	74.3	3	134.9	12.2	147.1	434.57	75.06		320.71	metal visible through gap at deepest point

Appendix C:
Impact Depth Profile Images

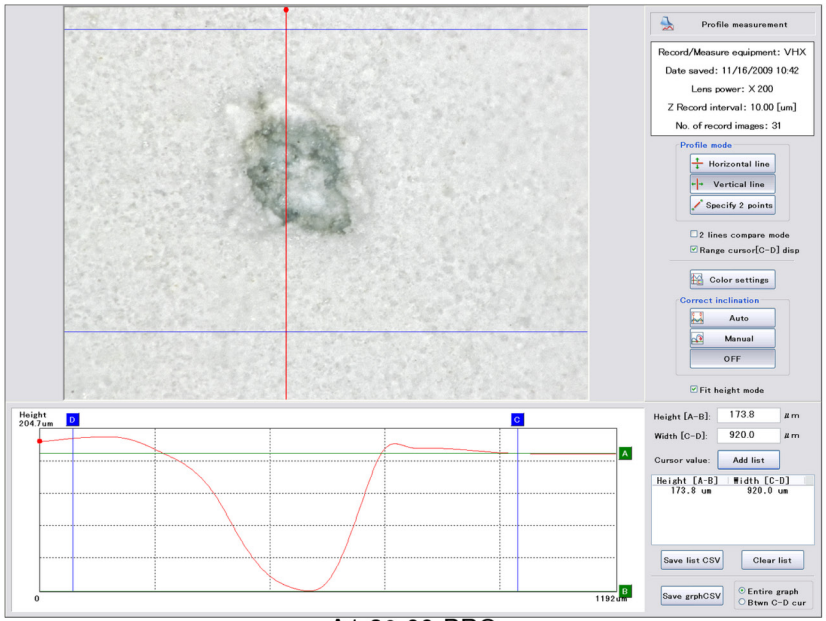
The following pages contain reduced-size images of all impact features recorded in the WFPC-2 MMOD survey. The image labels are based on the original image file names, which contain a grid code for the first position coordinate. (See Appendix A for a description of the crater identification labels.) The suffix "-PRO" indicates that the image is a depth profile. Table C-1 lists the 10-cm grid codes and corresponding grid locations. To calculate the location (as listed in Appendix B), sum the coordinates encoded in the impact feature name. For example, using the impact shown in image "B5-58-39-PRO",

- Add 9 mm to Y
- Add 3 mm to X
- Add 8 cm to Y
- Add 5 cm to X
- Fifth Y grid, add 40 cm to Y
- Second X grid, add 10 cm to X

Thus the location of the impact is X = 10 + 5 + 0.3 =1 5.3 cm and Y = 40 + 8 + 0.9 = 48.9 cm.

Table C-1. 10-cm grid labels and the corresponding distance from the origin to the left (for X) or bottom (for Y) edge of the 10-cm grid.

X Grid Label	X Grid Location (cm)	Y Grid Label	Y Grid Location (cm)
A	0	1	0
B	10	2	10
C	20	3	20
D	30	4	30
E	40	5	40
F	50	6	50
G	60	7	60
H	70	8	70
J	80		
K	90		
L	100		
M	110		
N	120		
P	130		
Q	140		
R	150		
S	160		
T	170		
U	180		
V	190		
W	200		
X	210		



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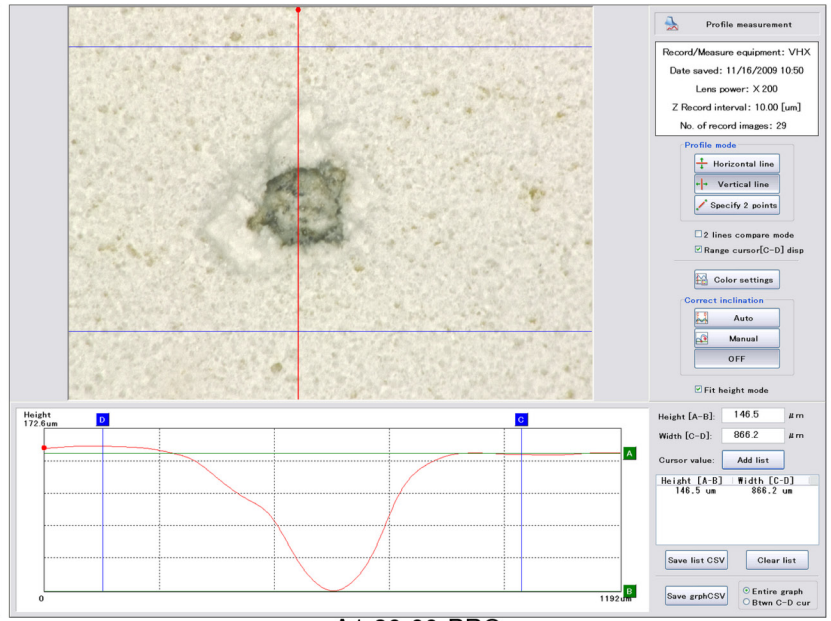

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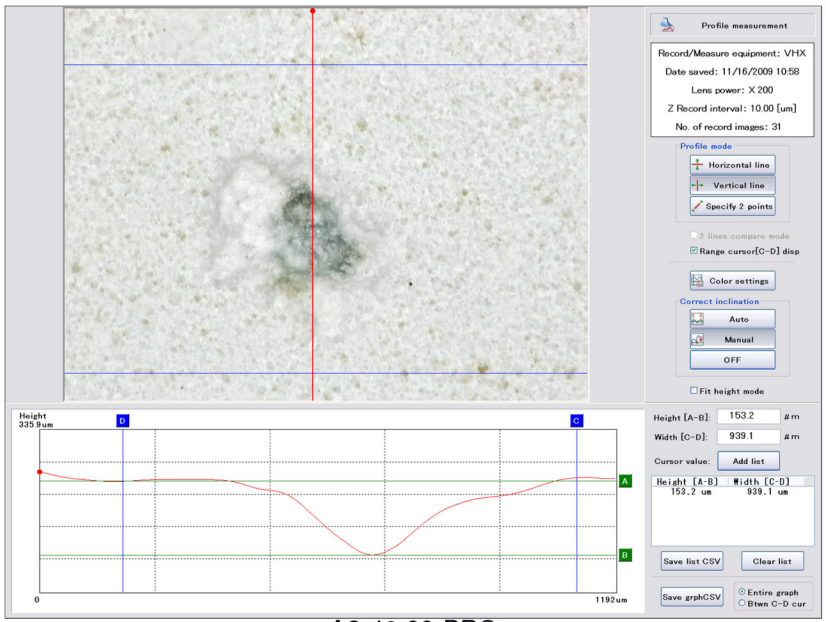

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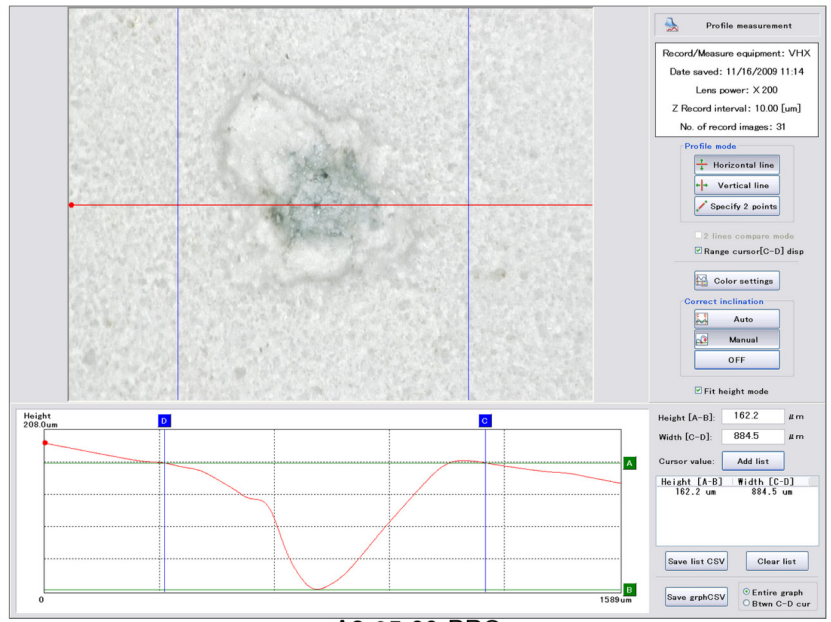

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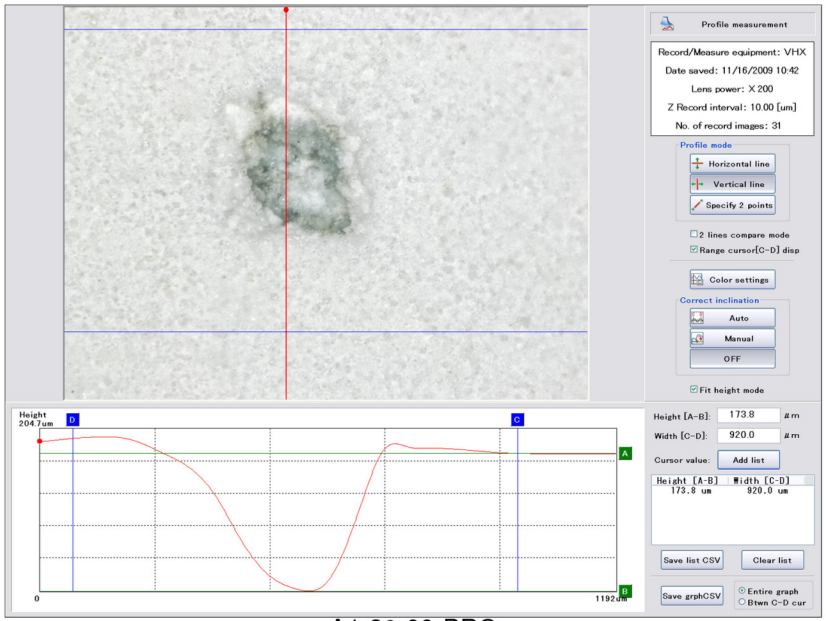

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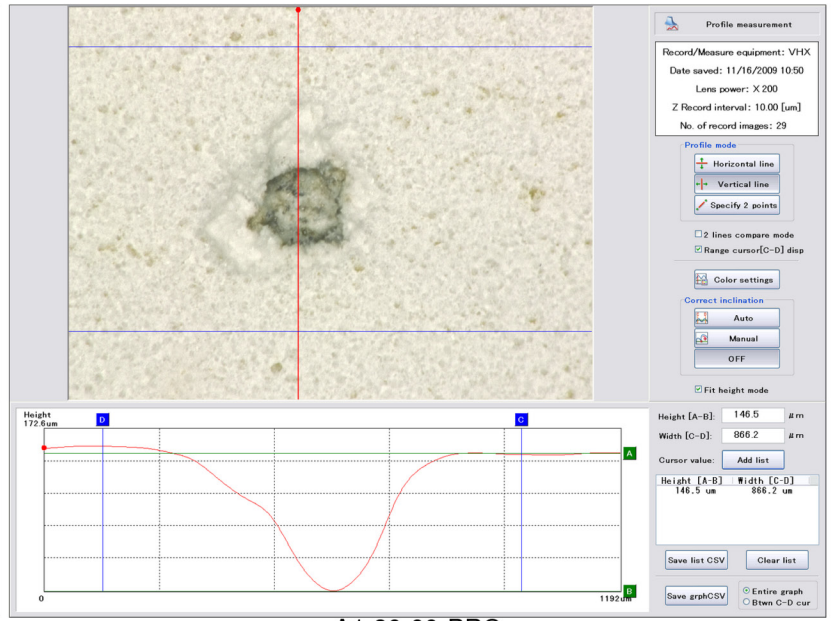

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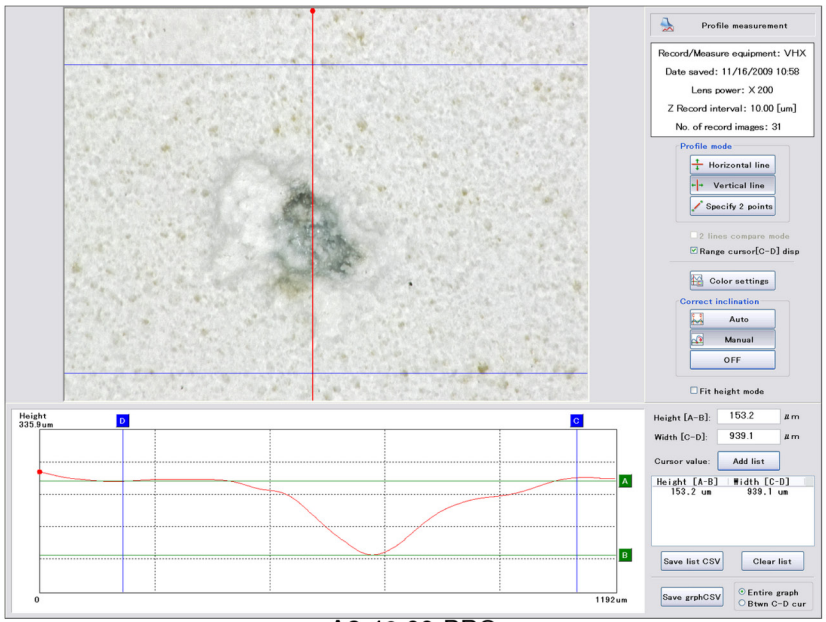

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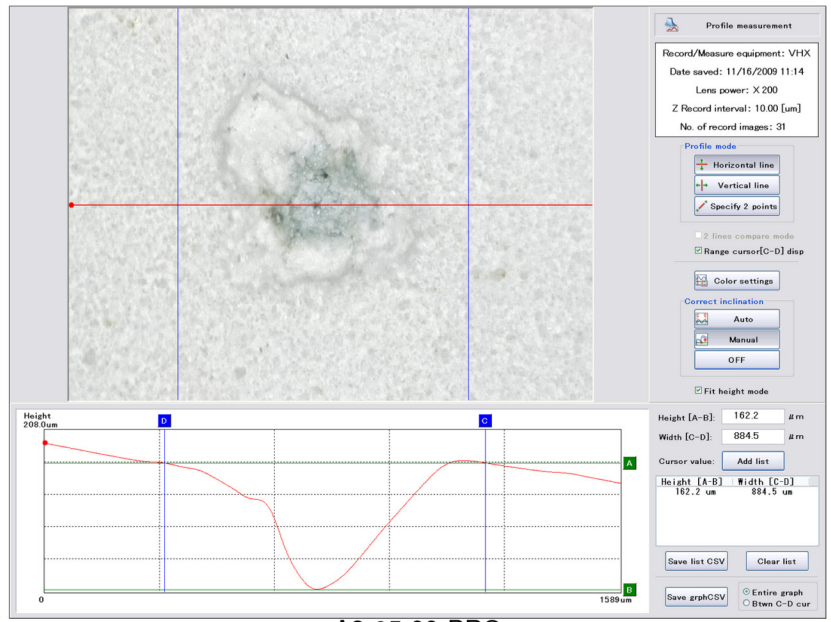

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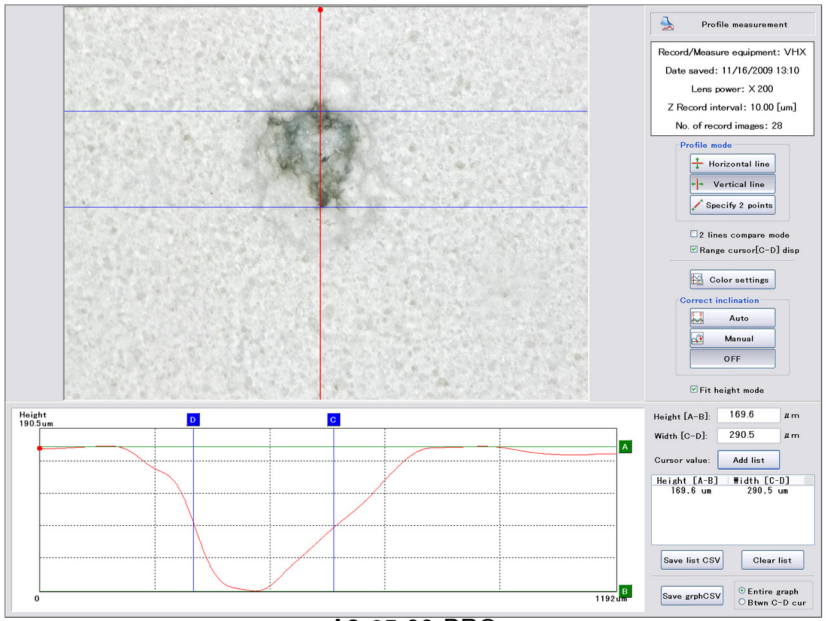

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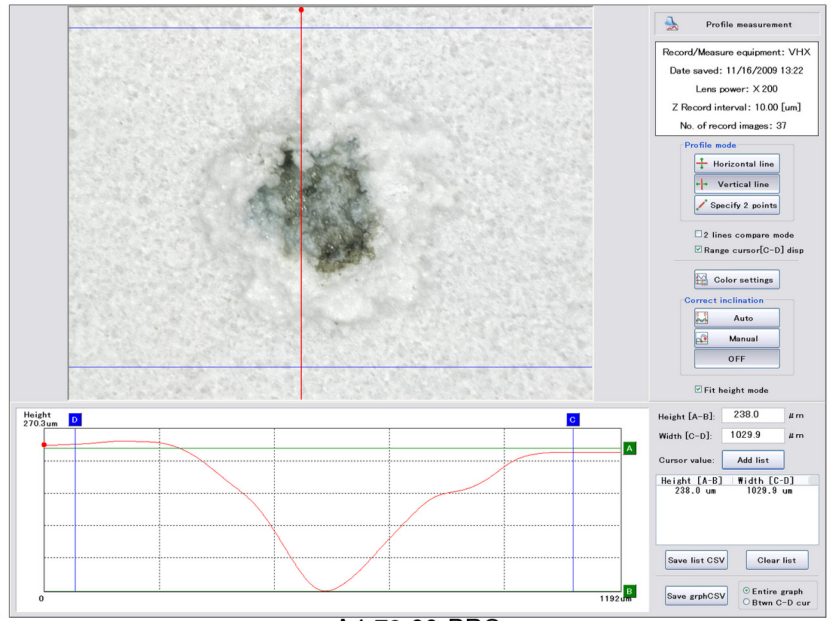

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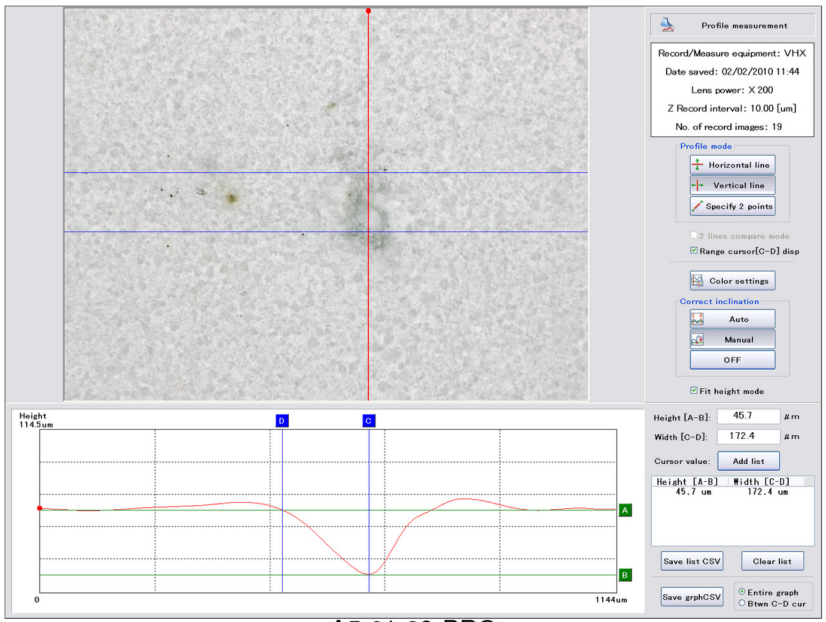

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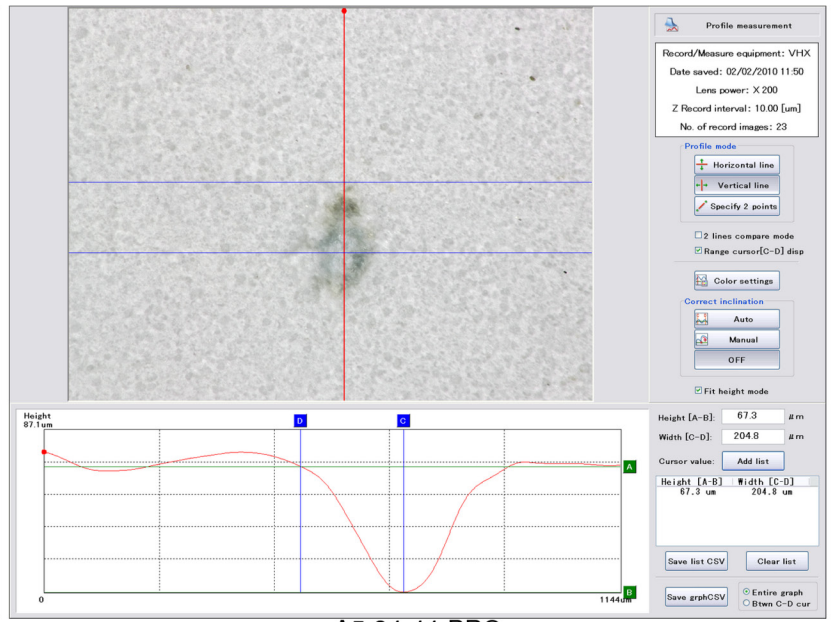

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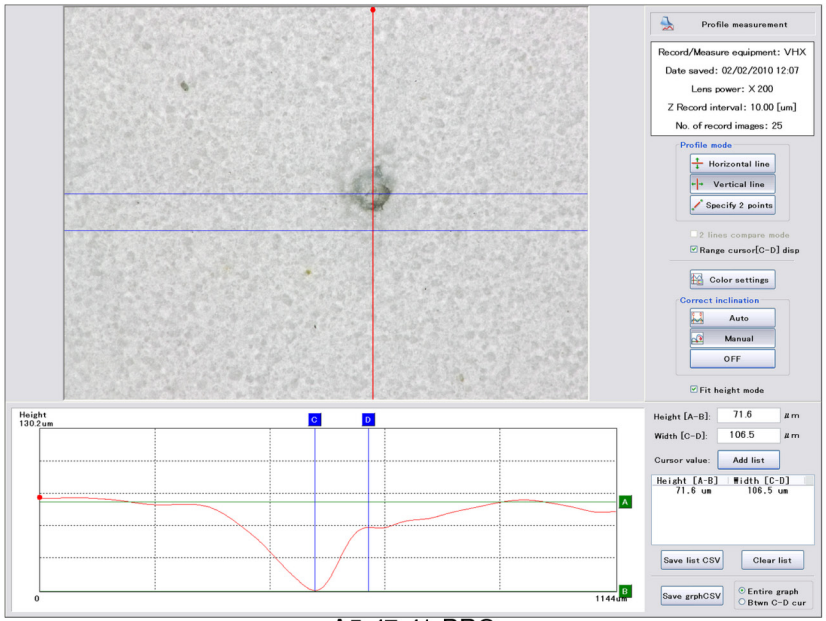

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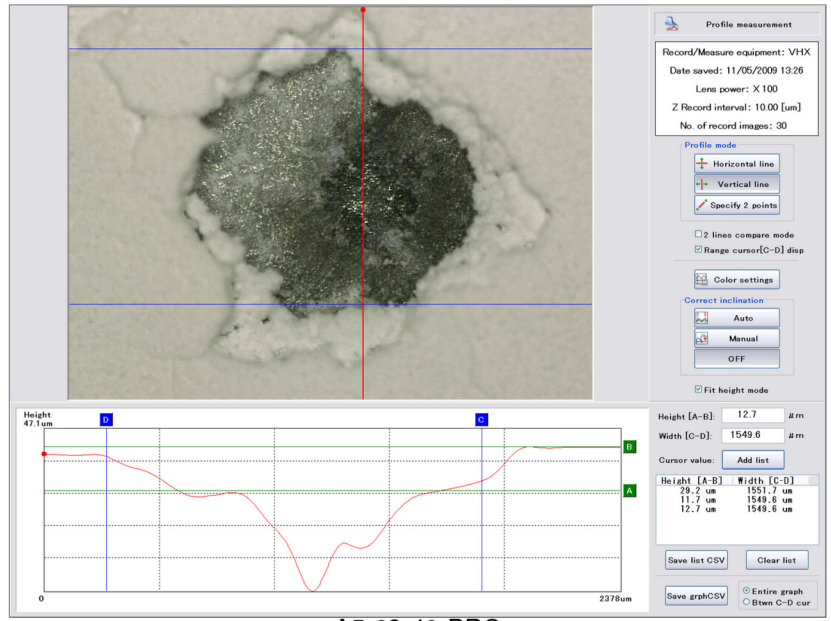

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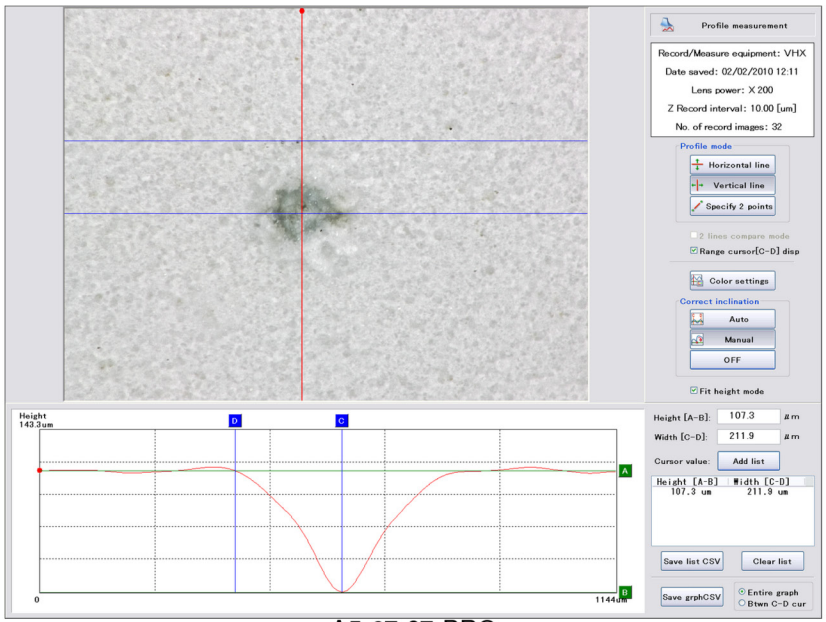

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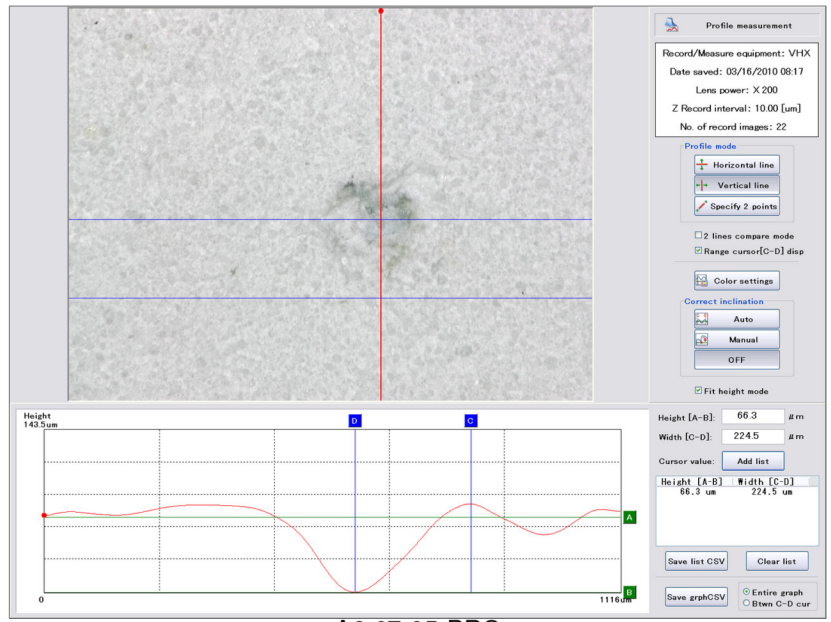

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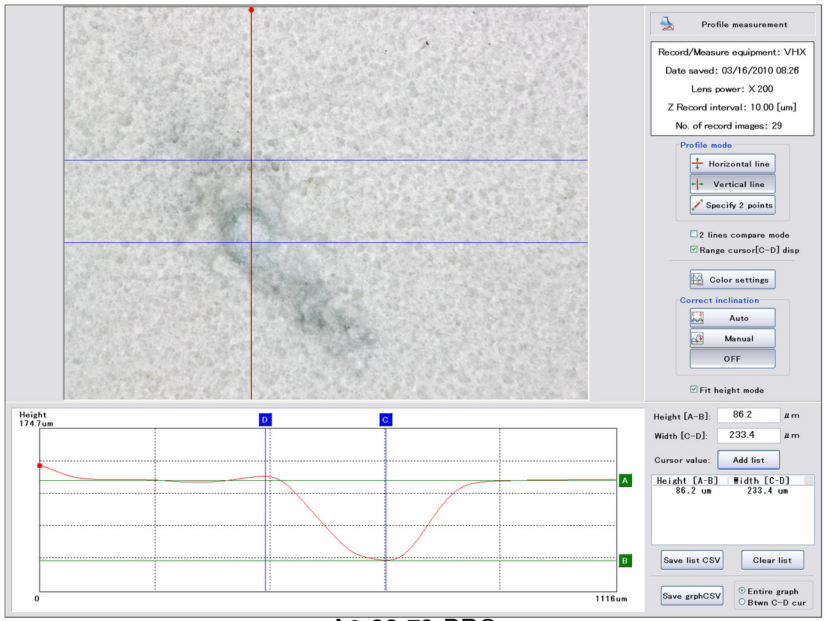

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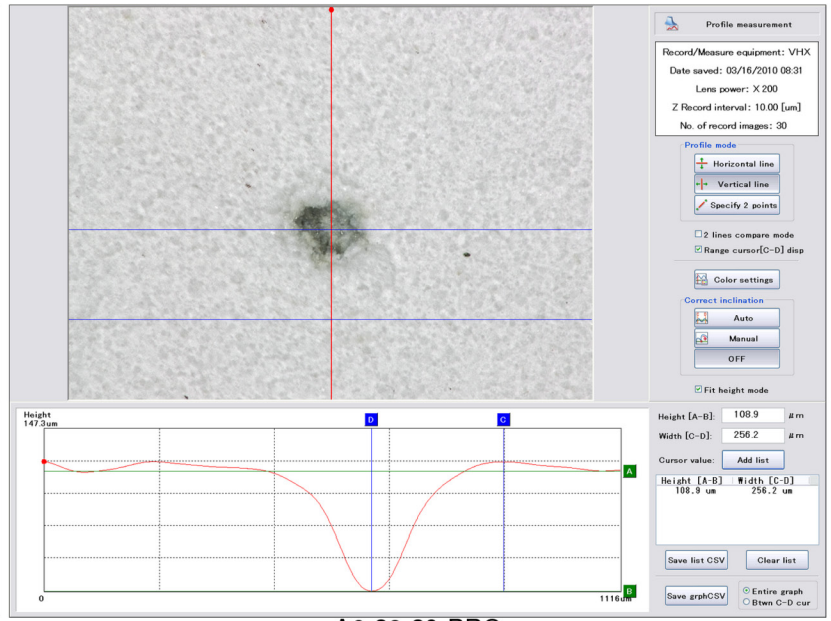

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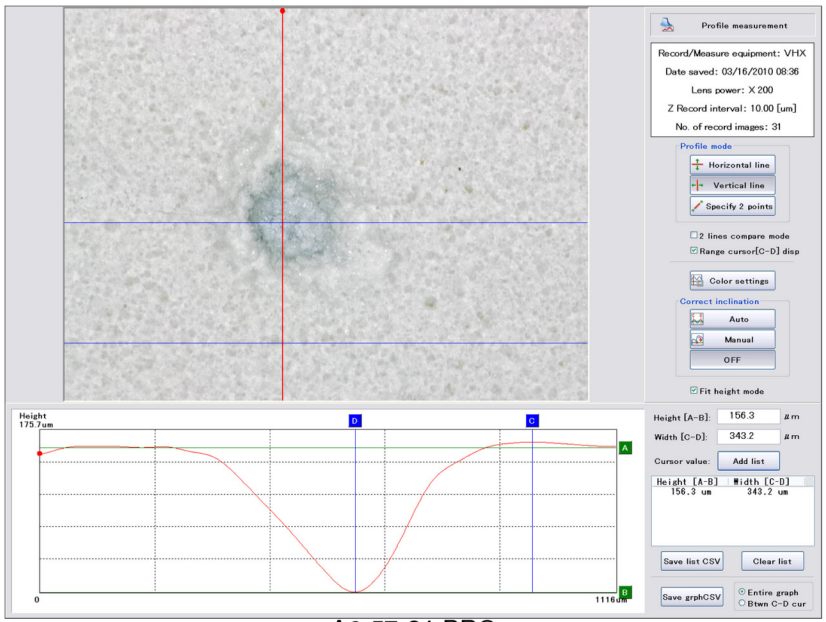

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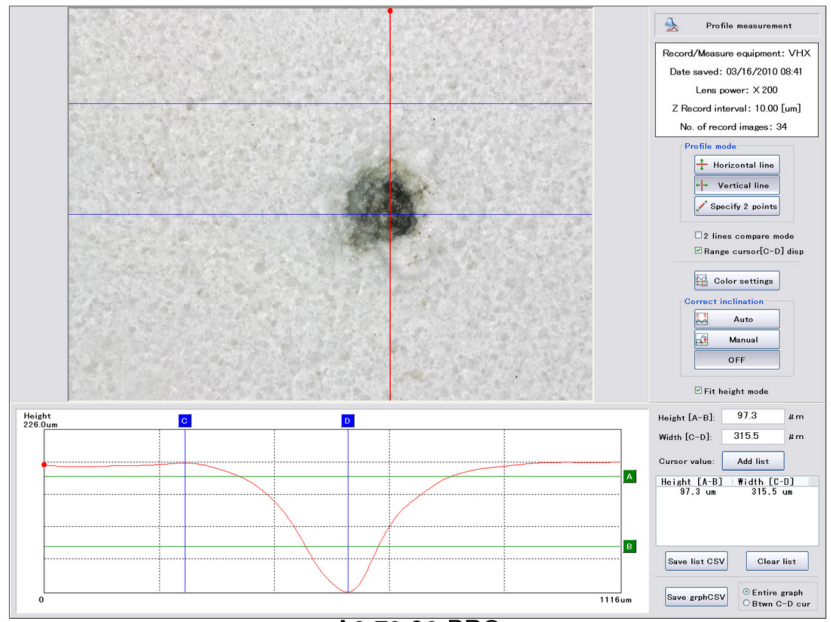

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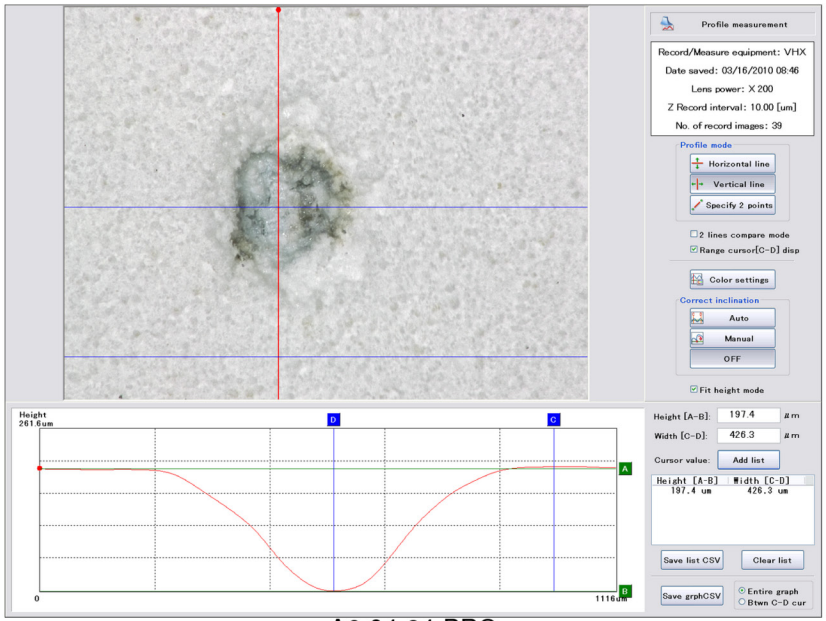

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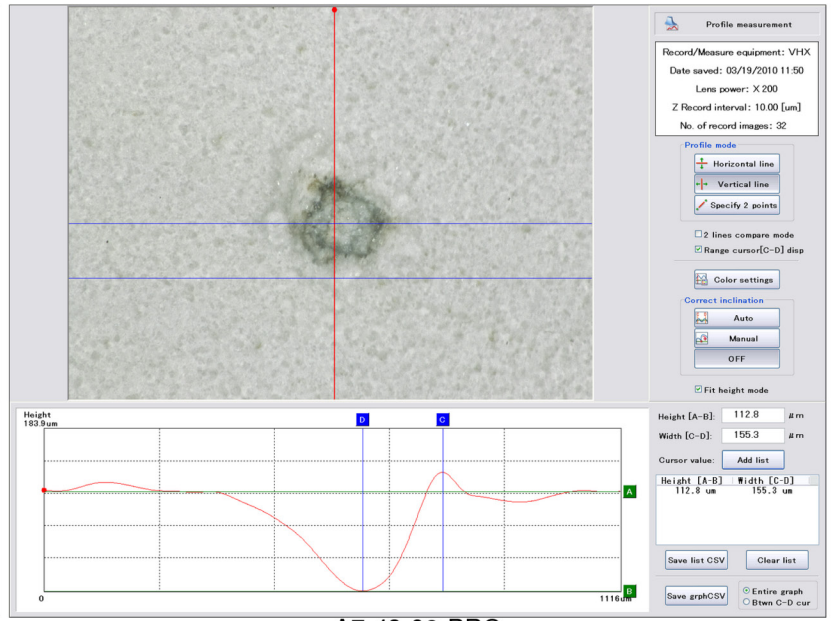

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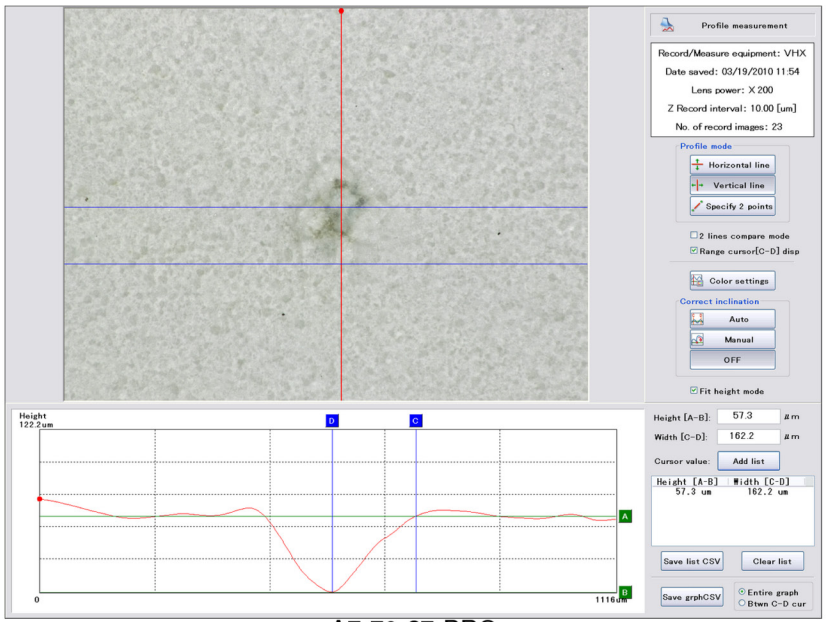

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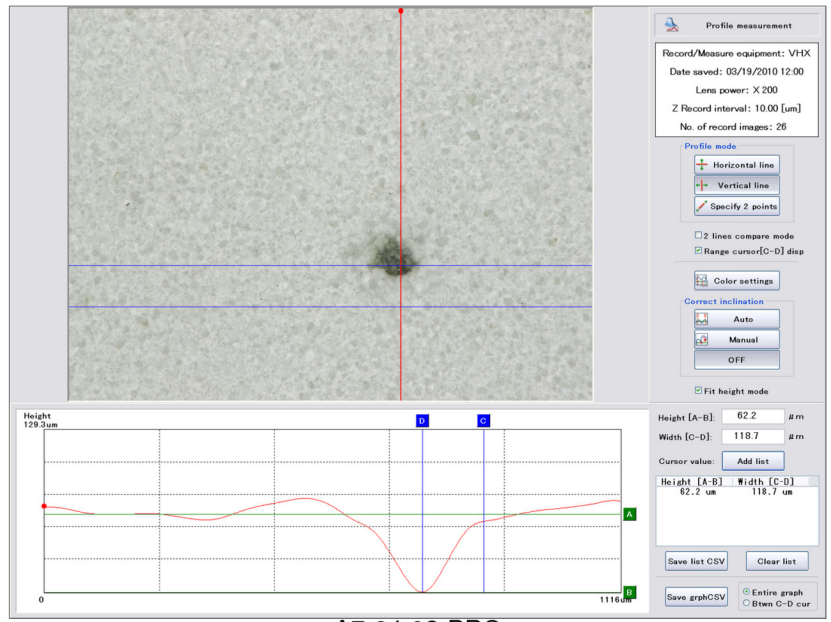

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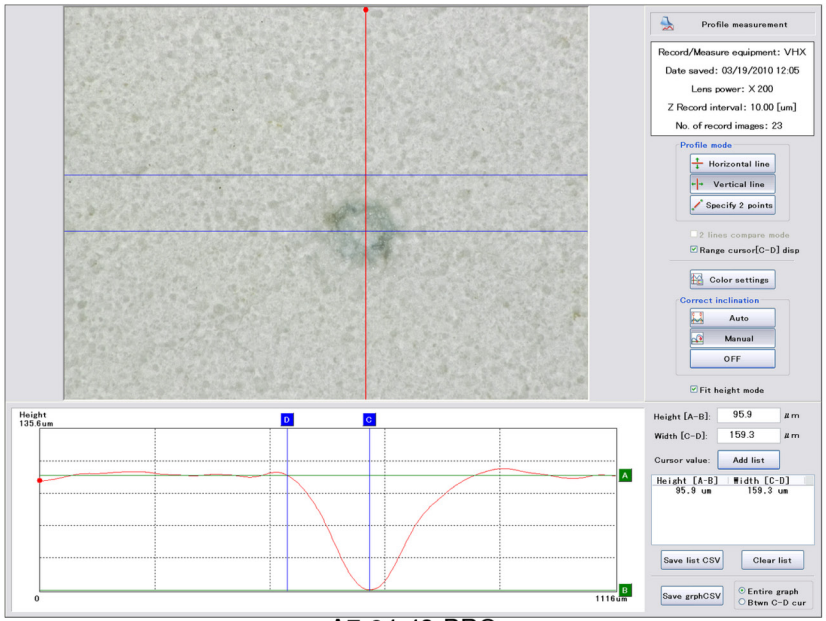

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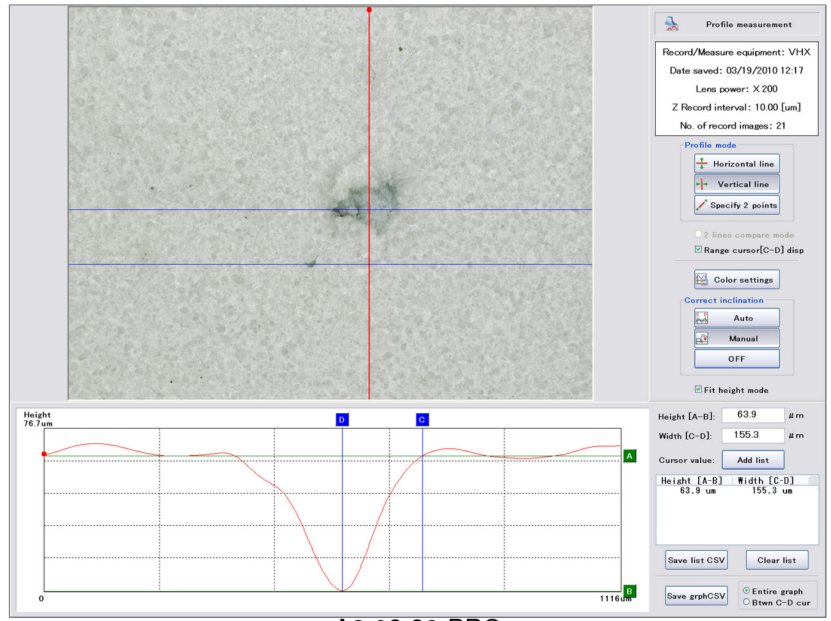

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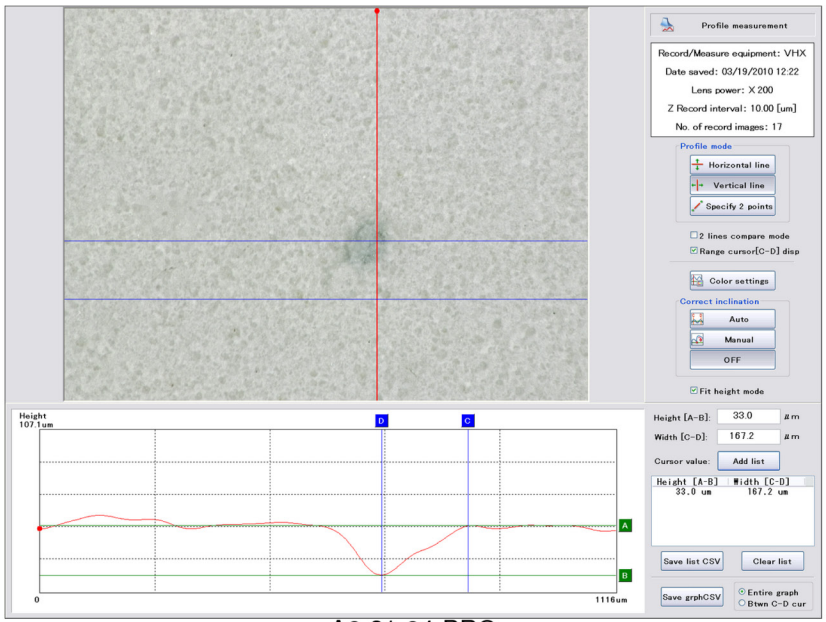

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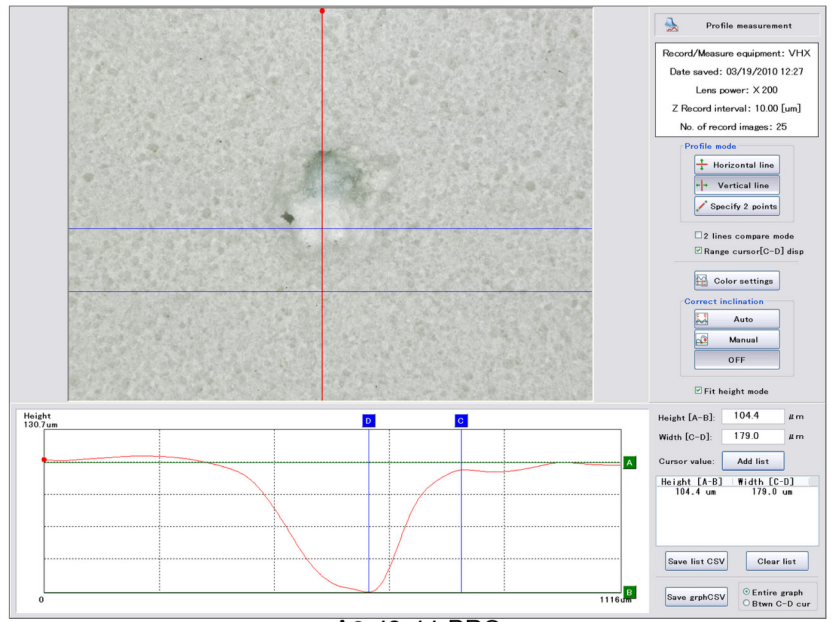

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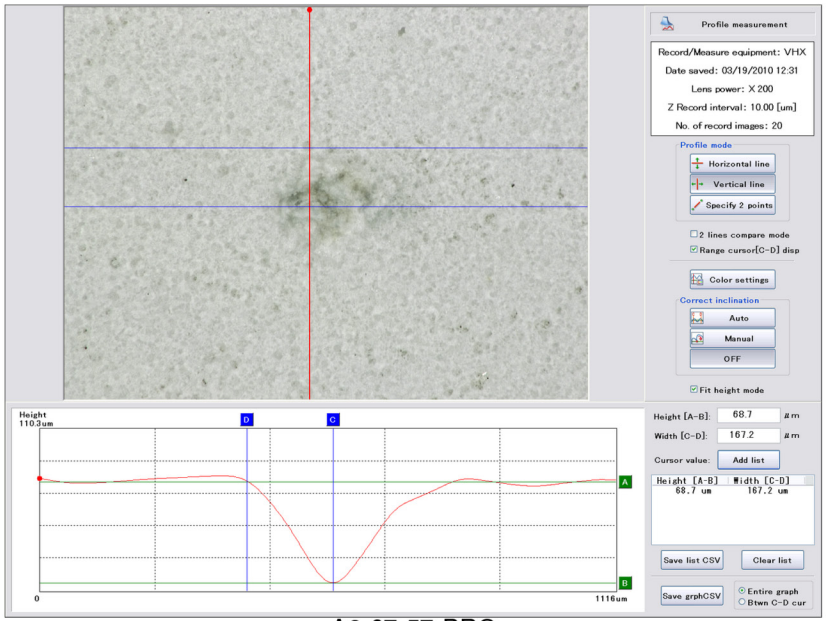
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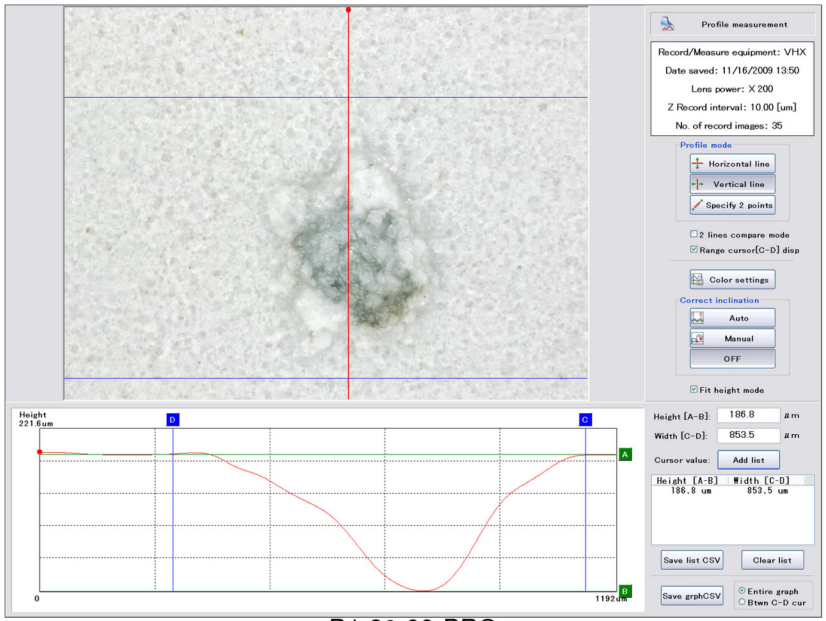

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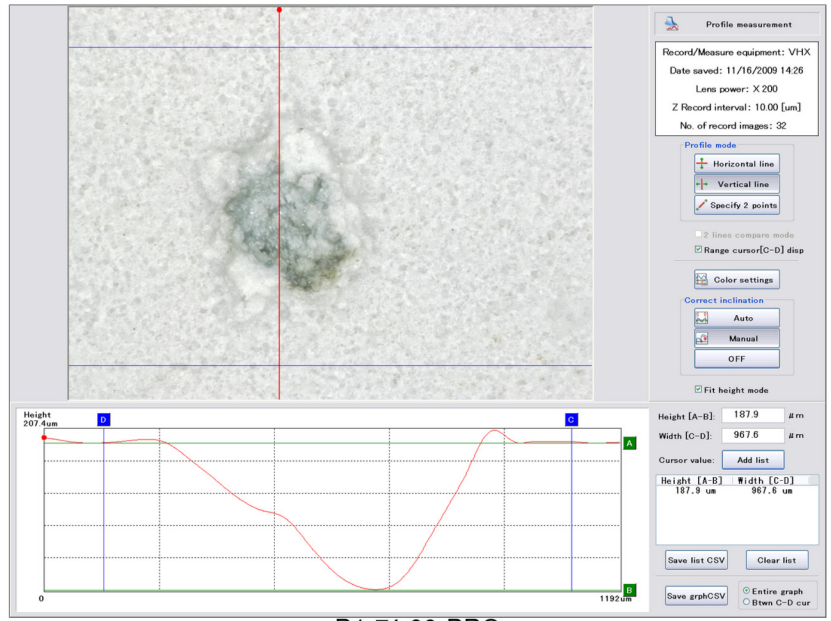

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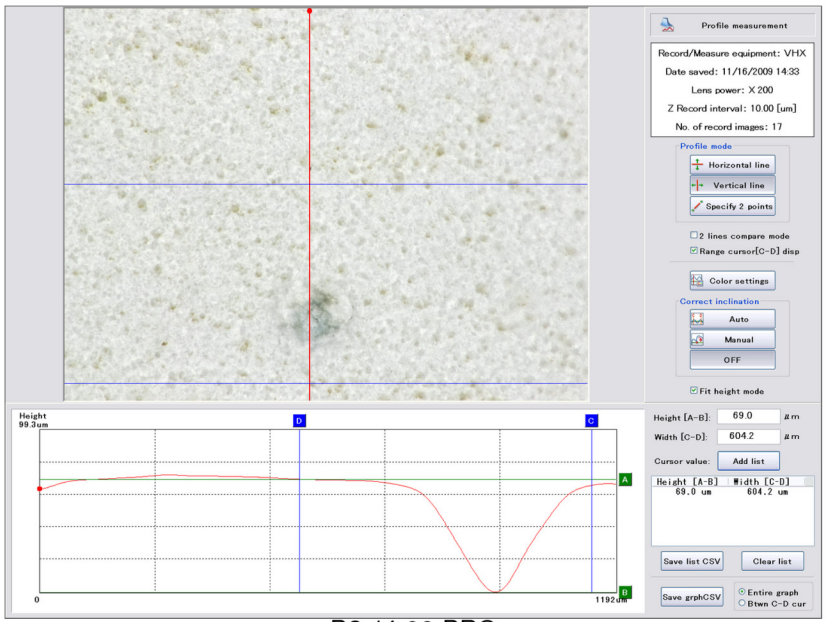

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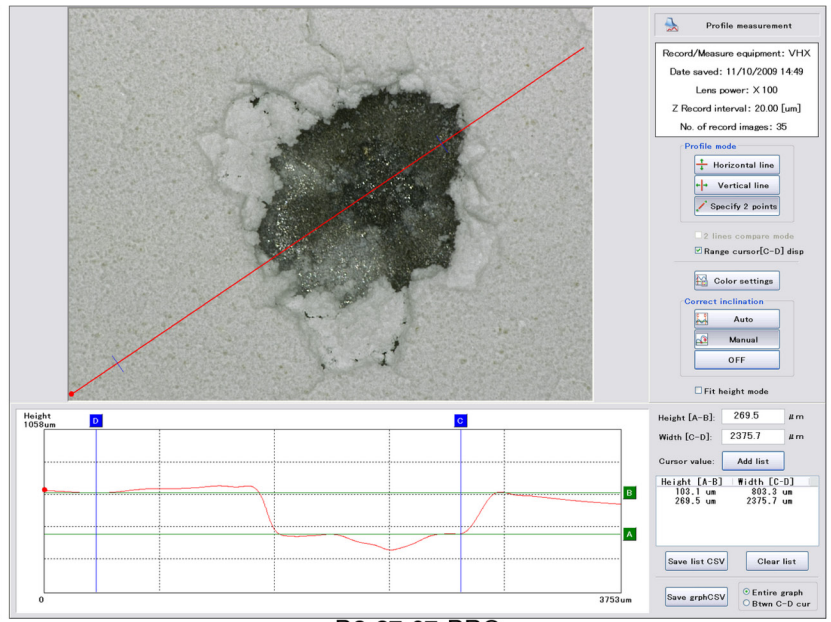

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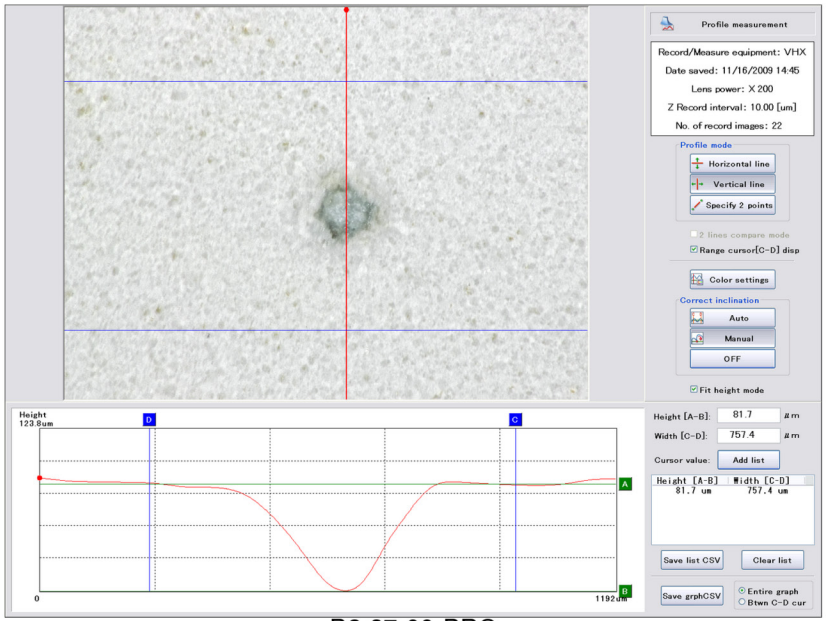

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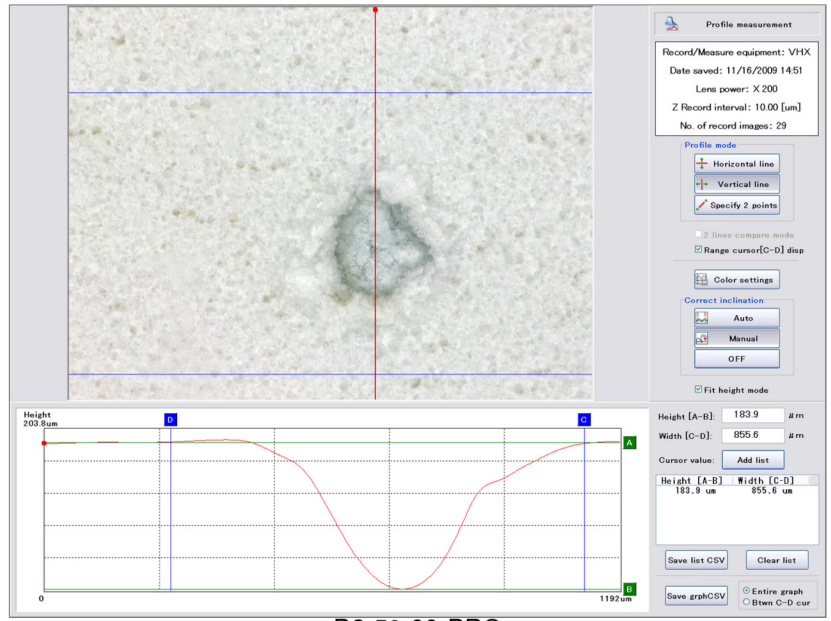

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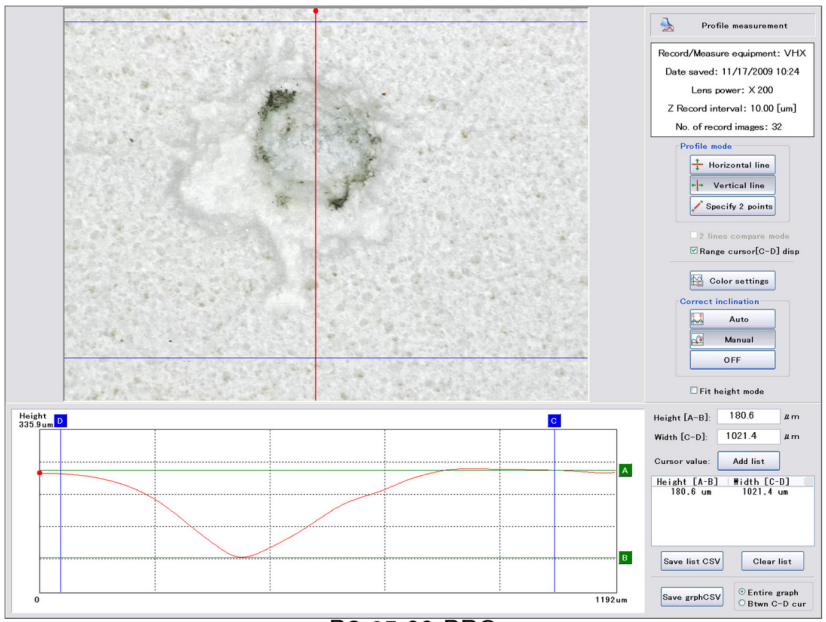

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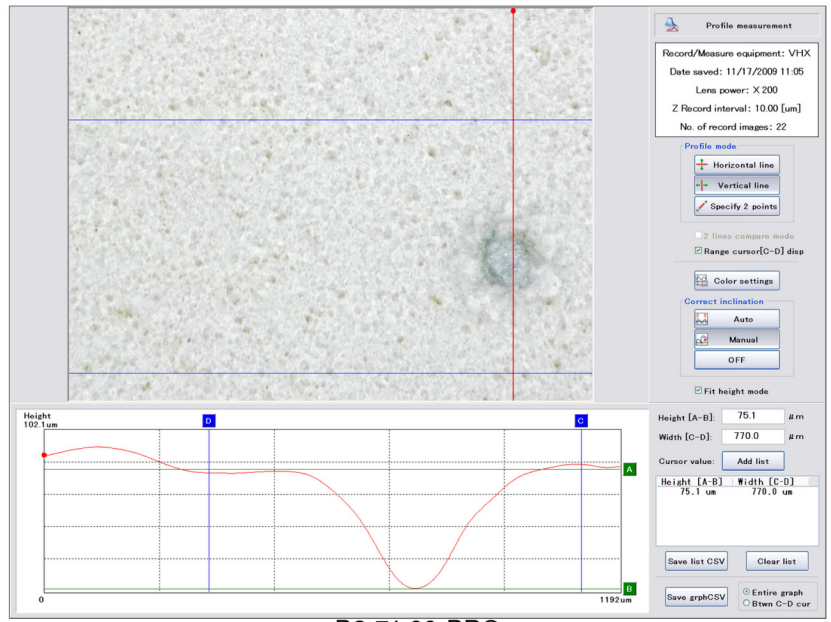

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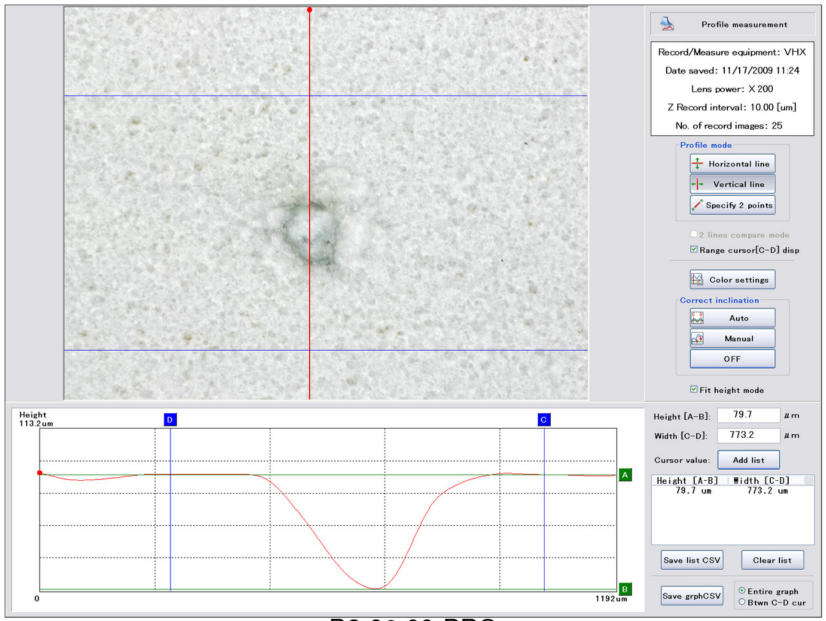

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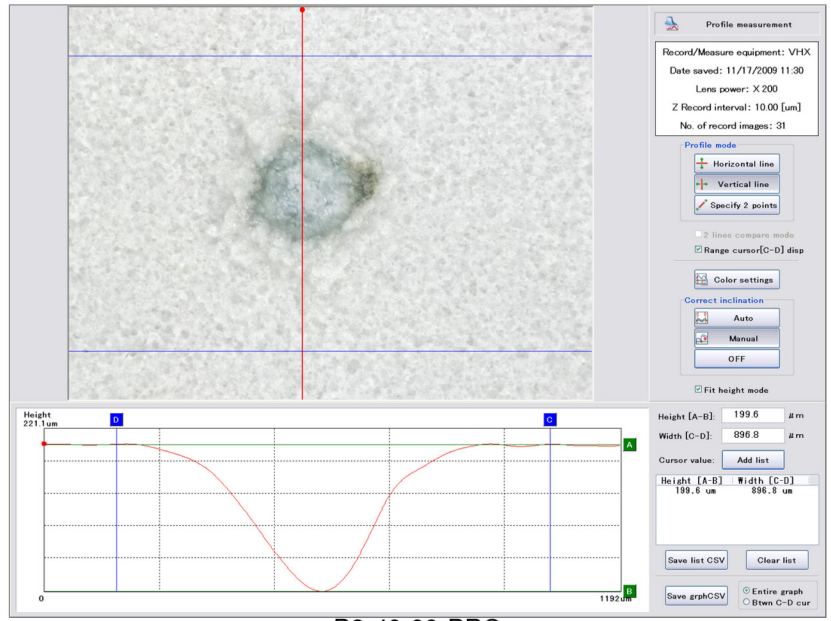

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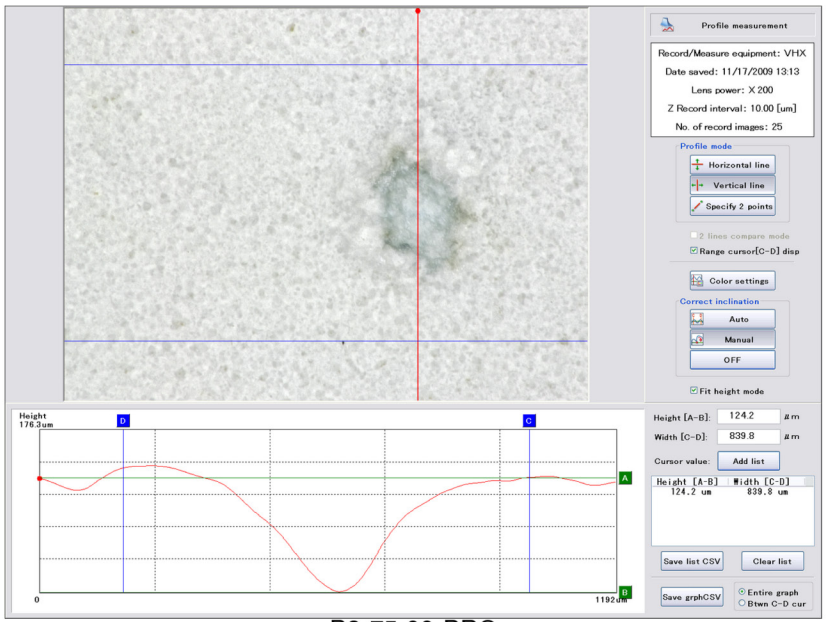

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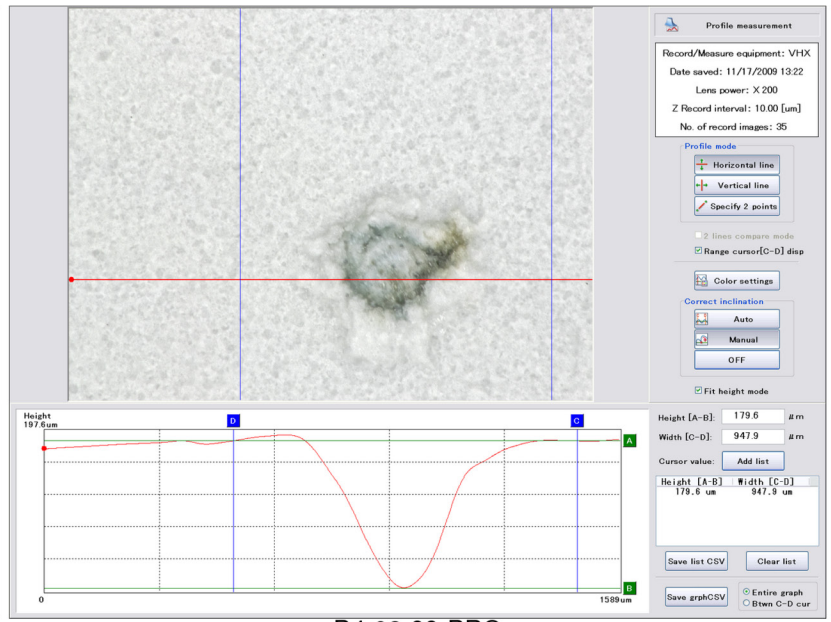

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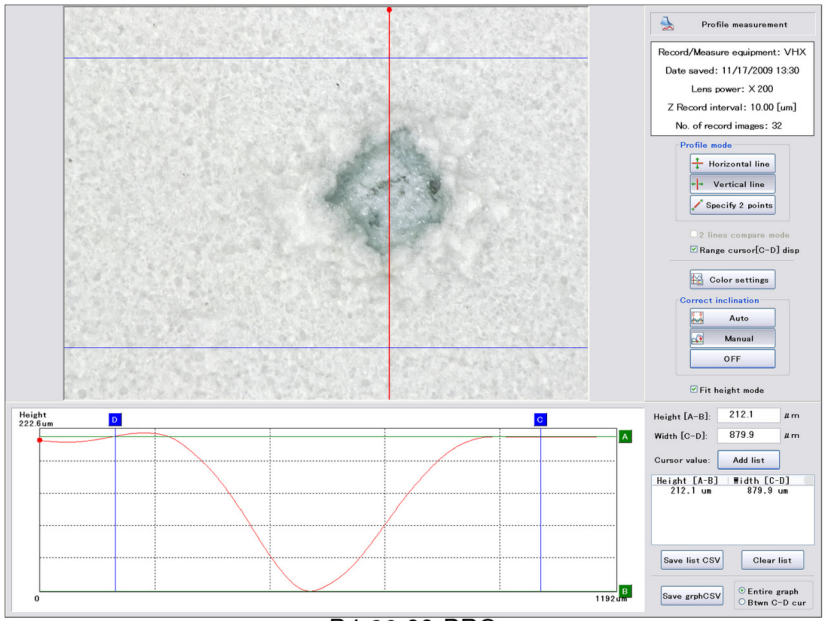
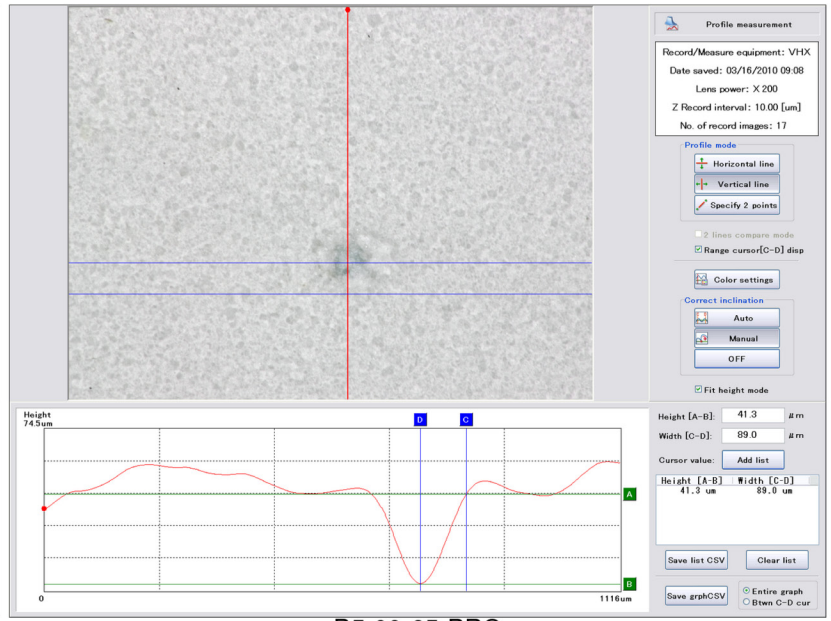
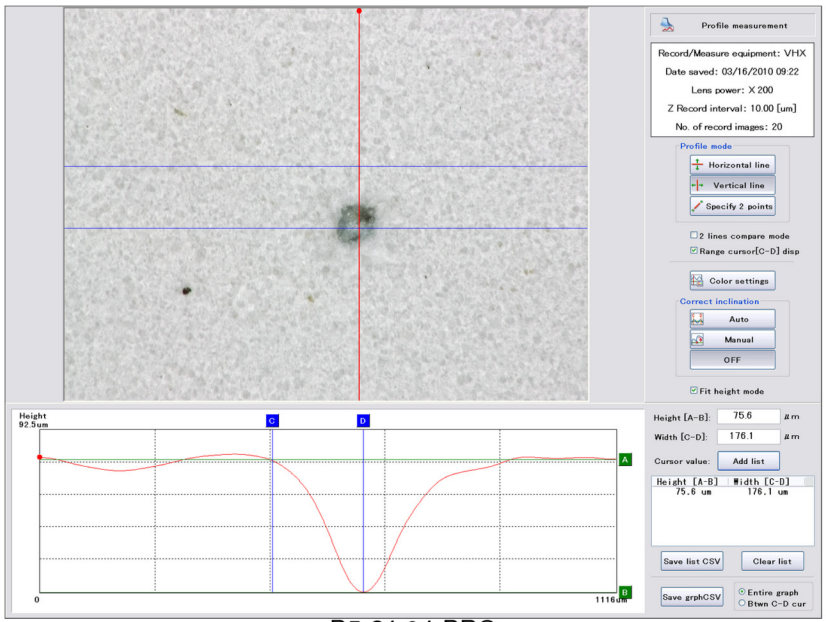


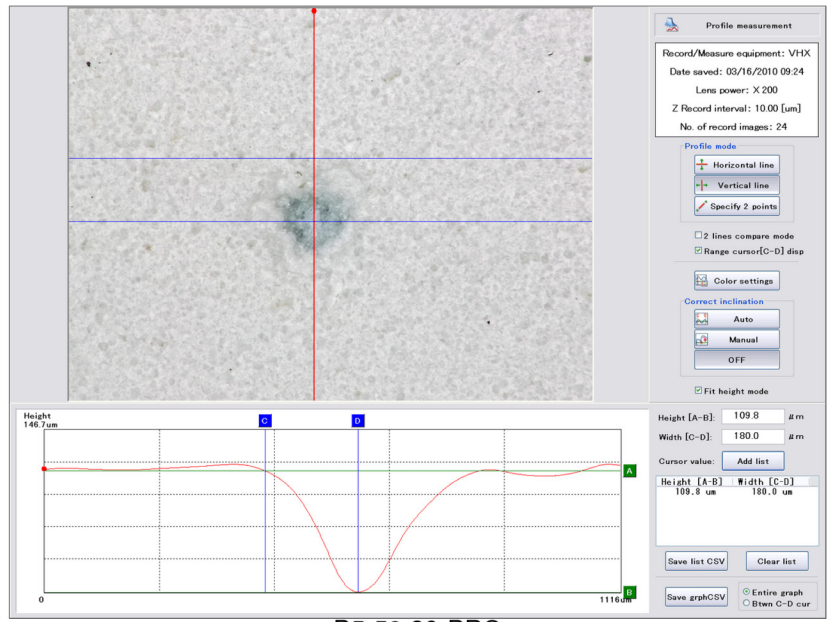
B4-86-99-PRO



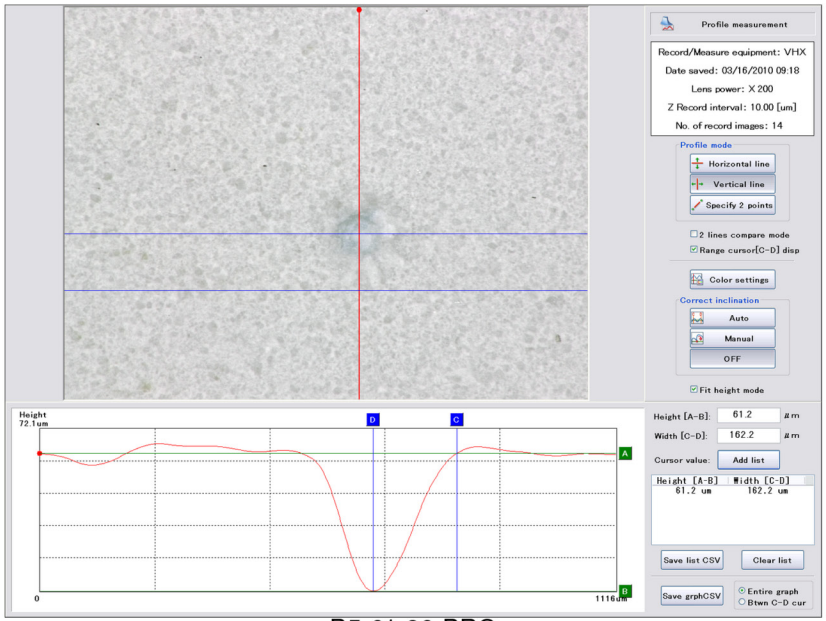
B5-00-65-PRO



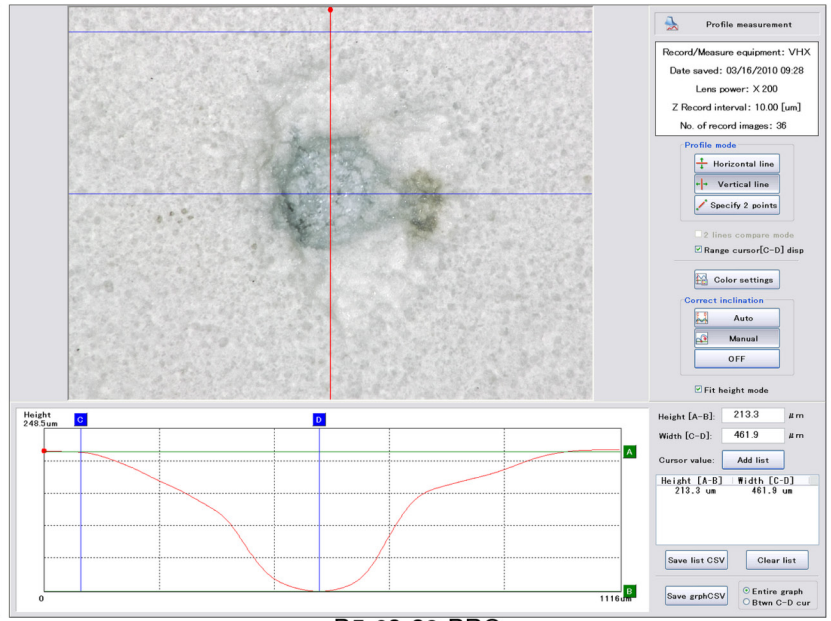
B5-24-04-PRO



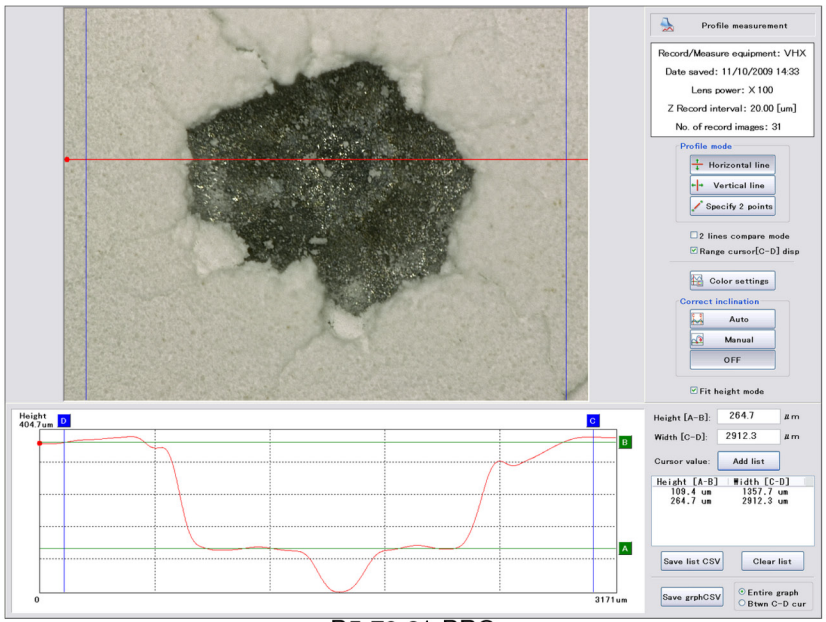
B5-58-39-PRO



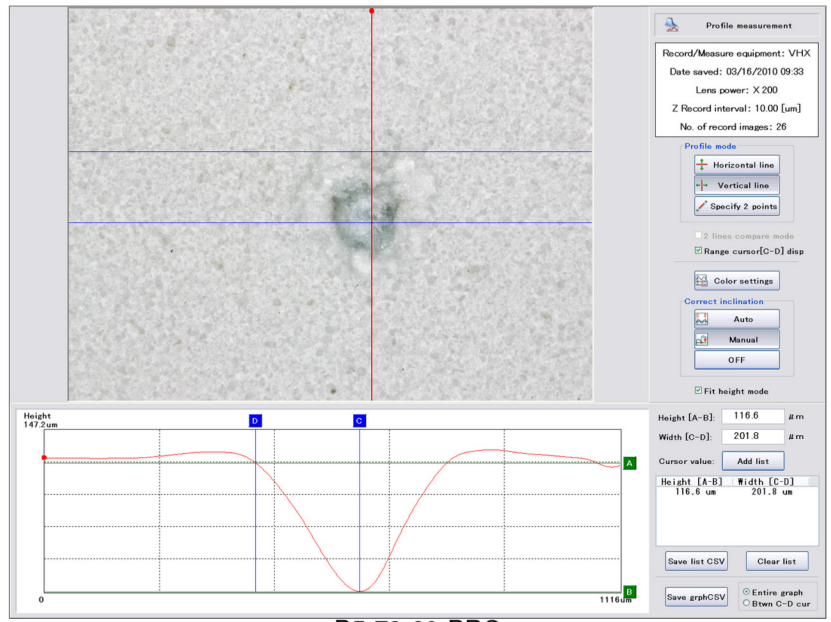
B5-61-86-PRO



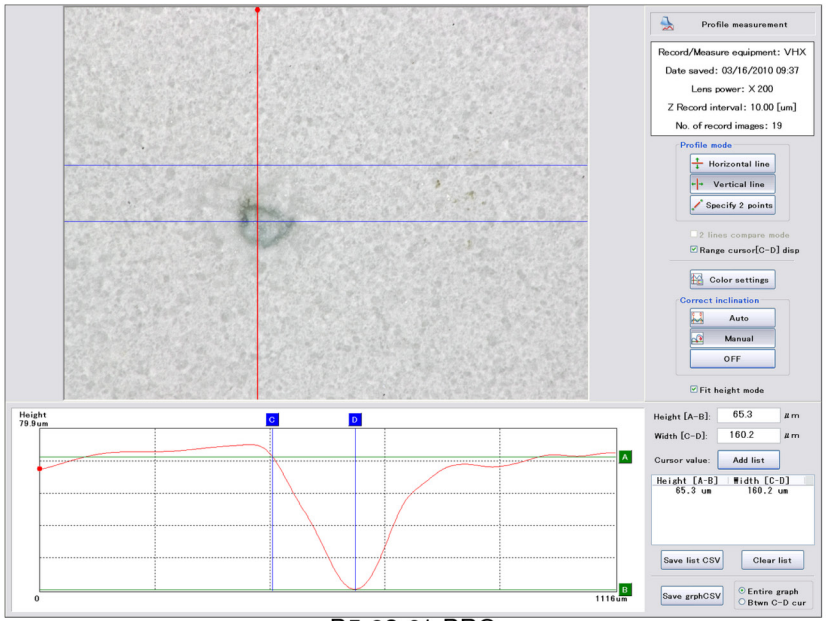
B5-63-28-PRO



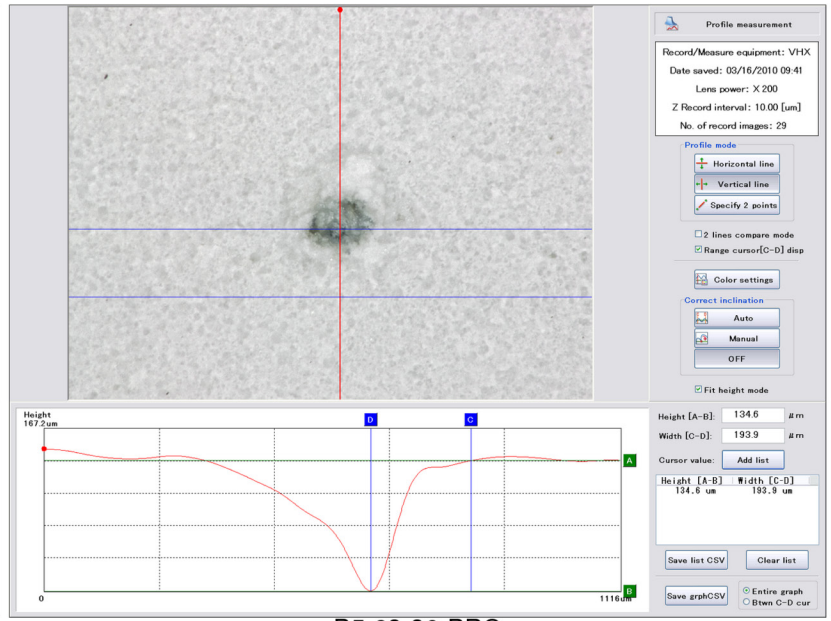
B5-76-81-PRO



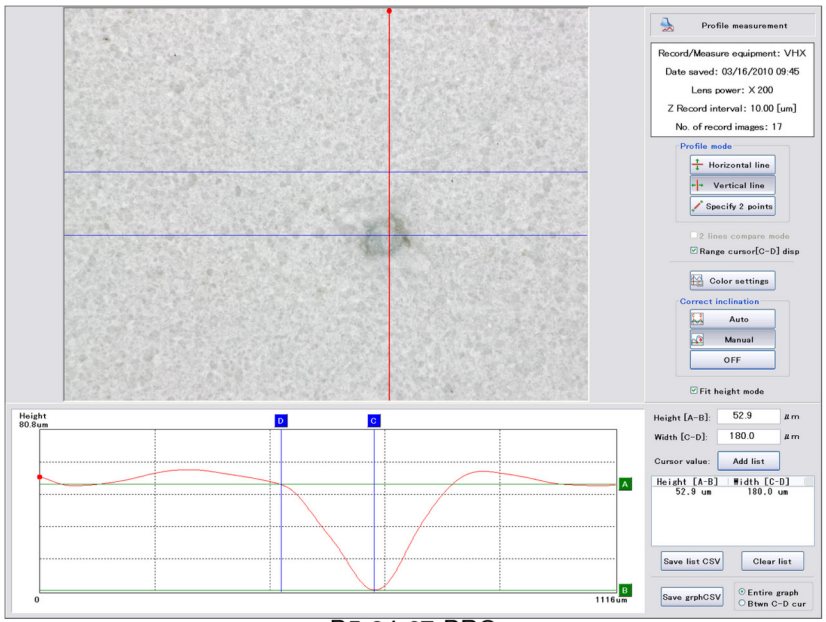
B5-78-60-PRO



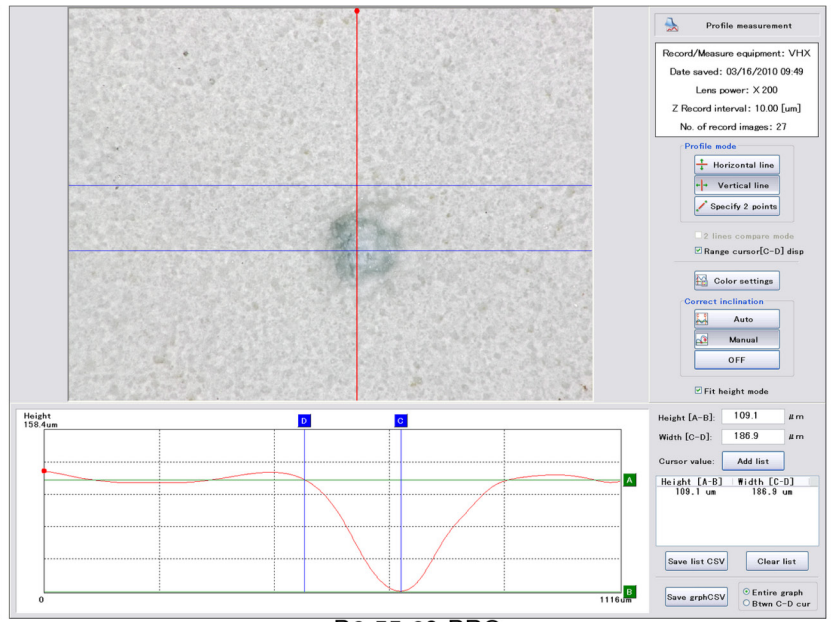
B5-82-61-PRO



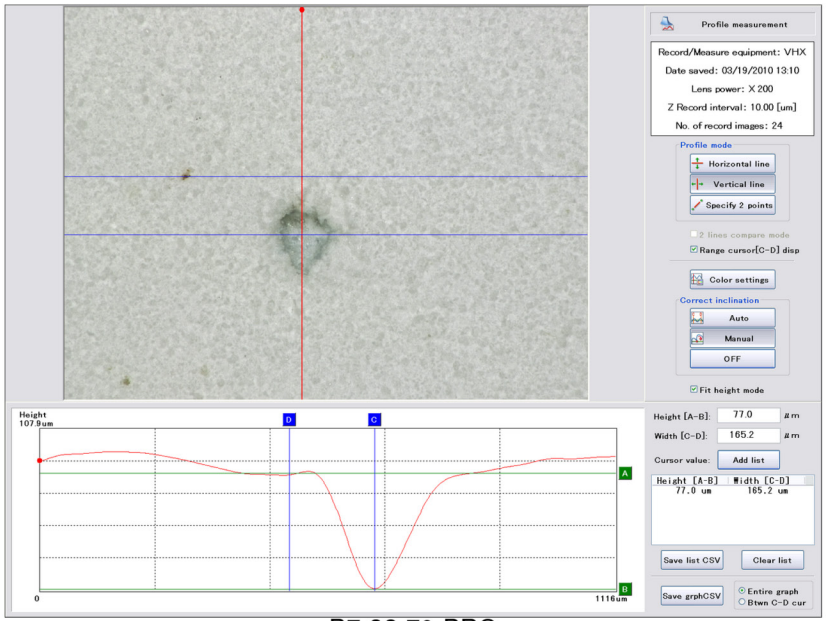
B5-83-36-PRO



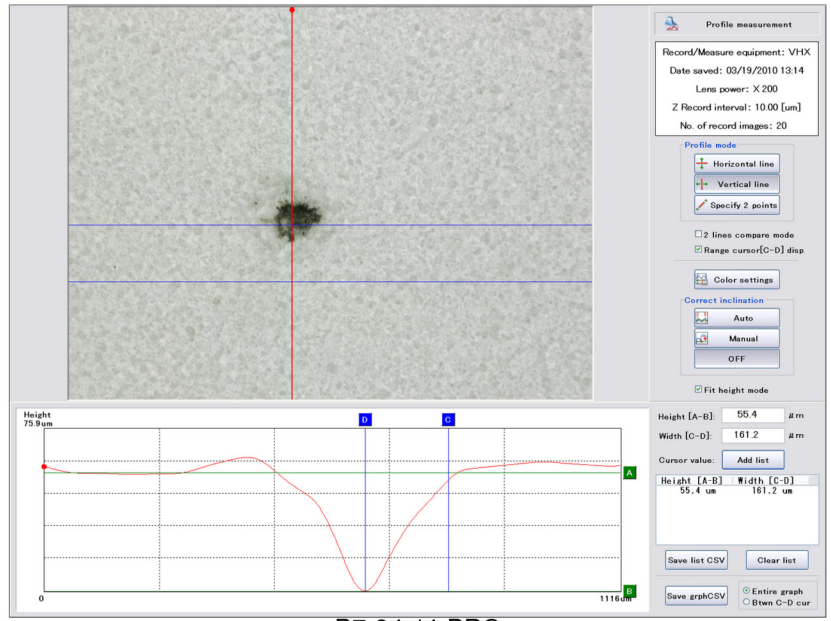
B5-84-67-PRO



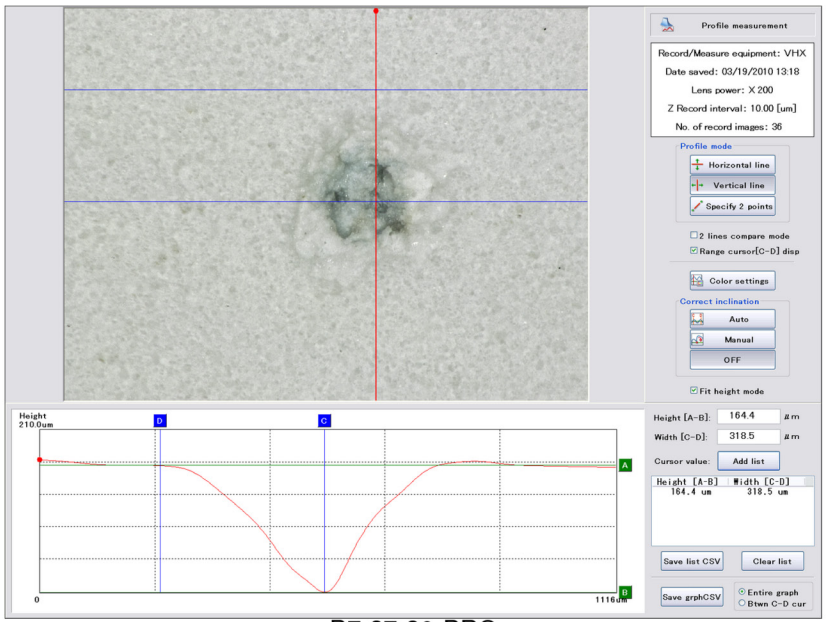
B6-55-69-PRO



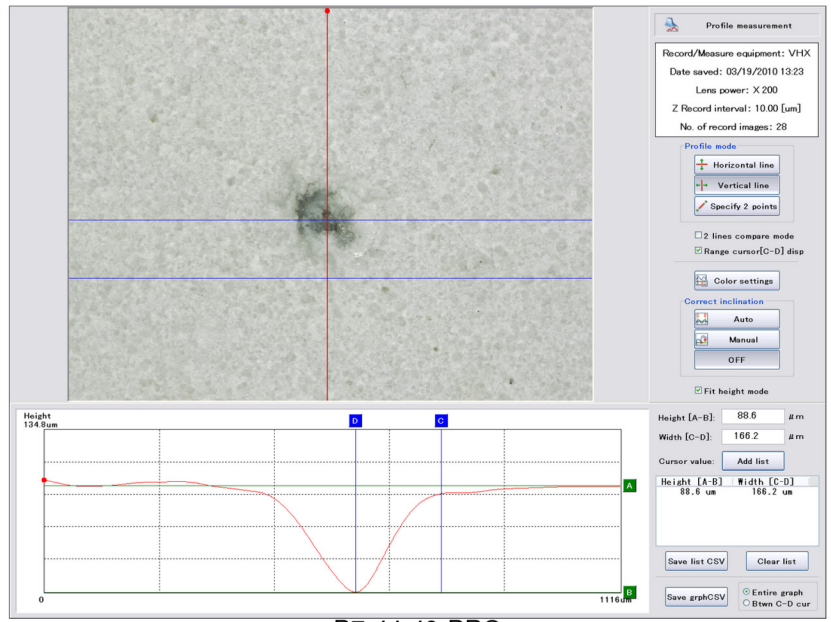
B7-32-70-PRO



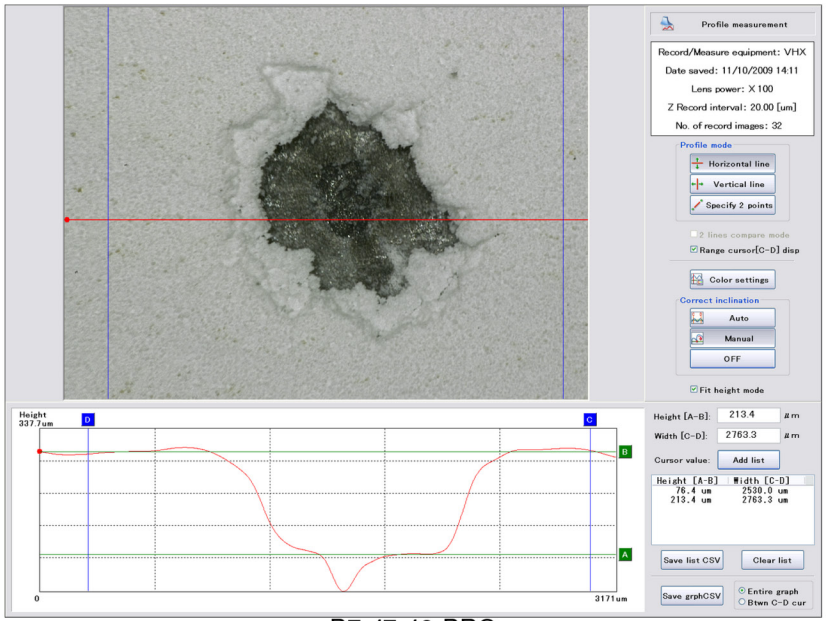
B7-34-14-PRO



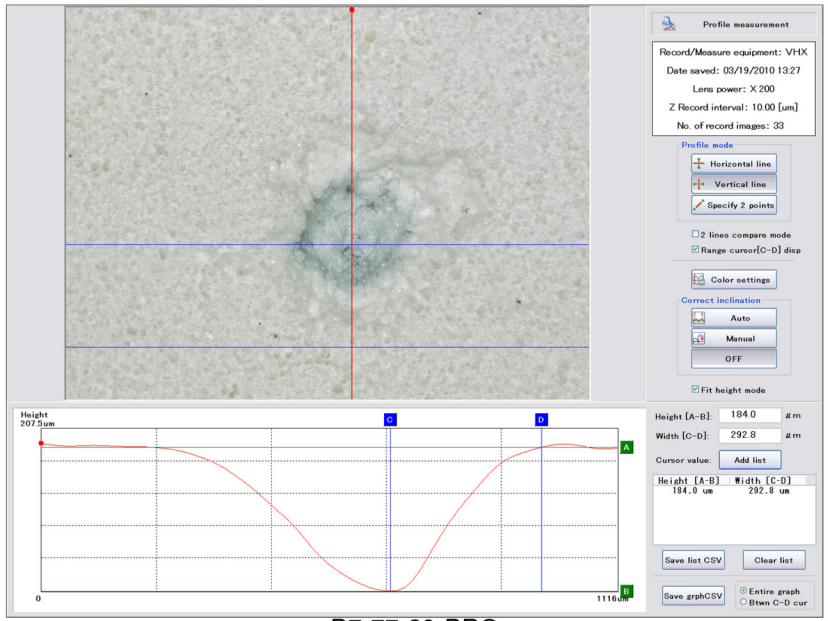
B7-37-30-PRO



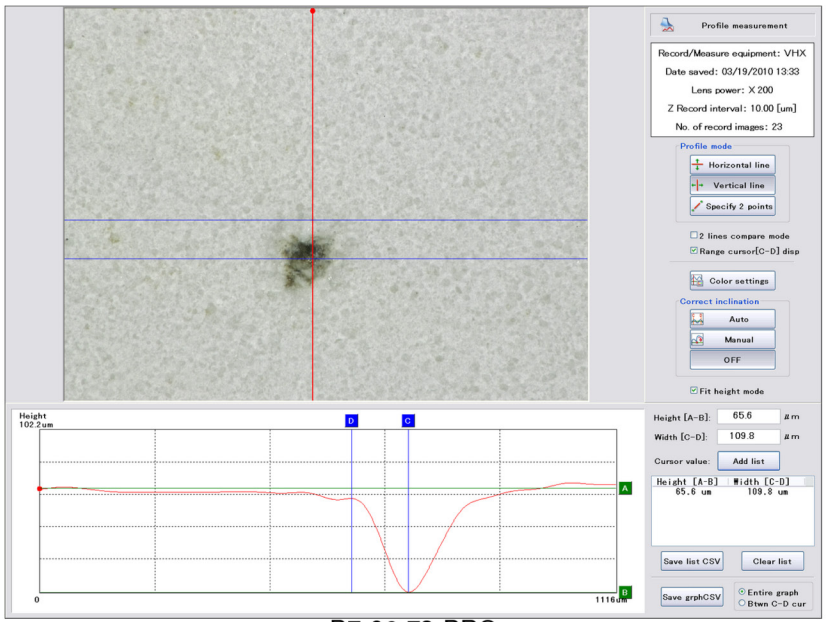
B7-44-49-PRO



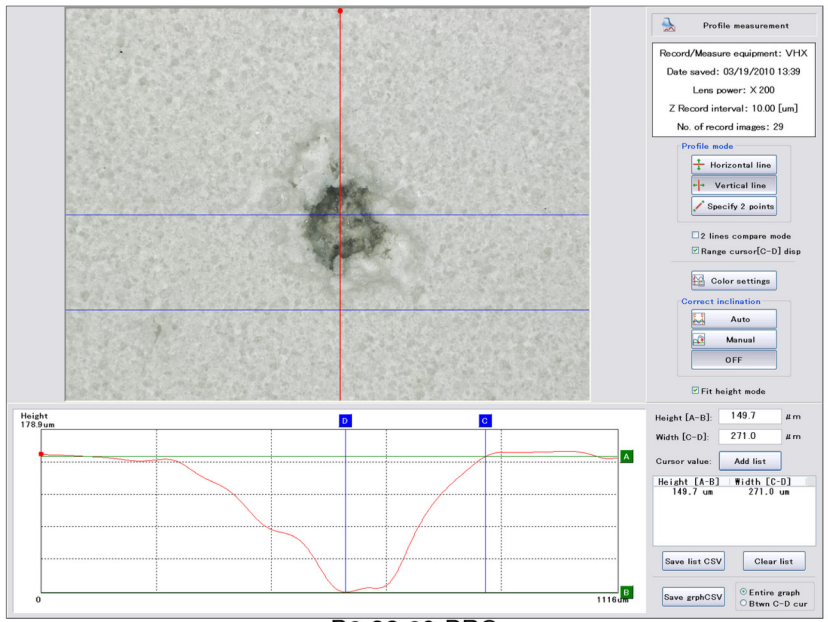
B7-47-48-PRO



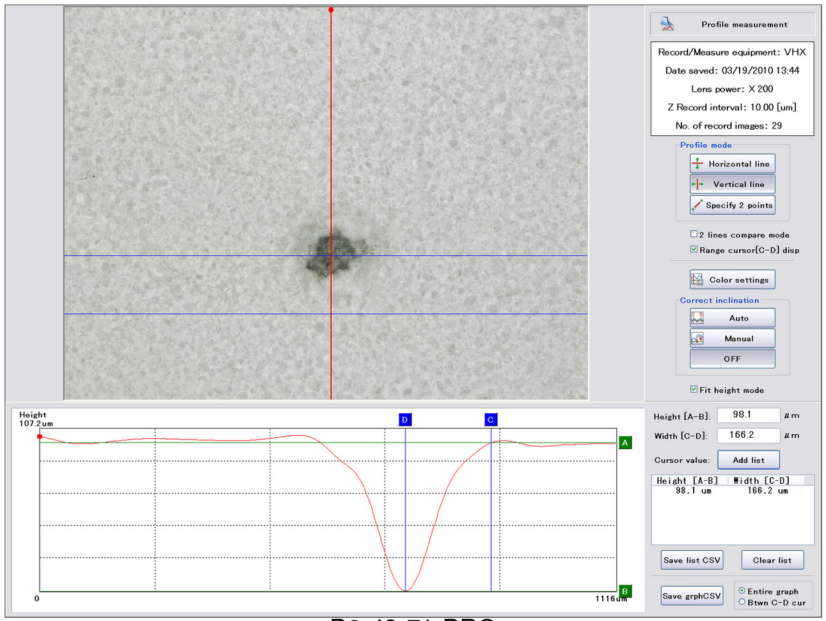
B7-77-29-PRO



B7-96-73-PRO



B8-32-89-PRO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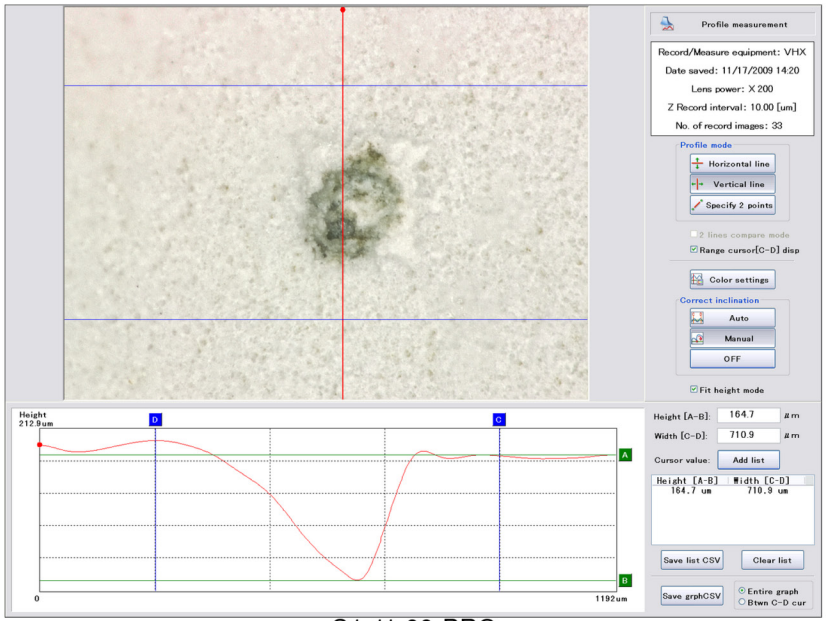
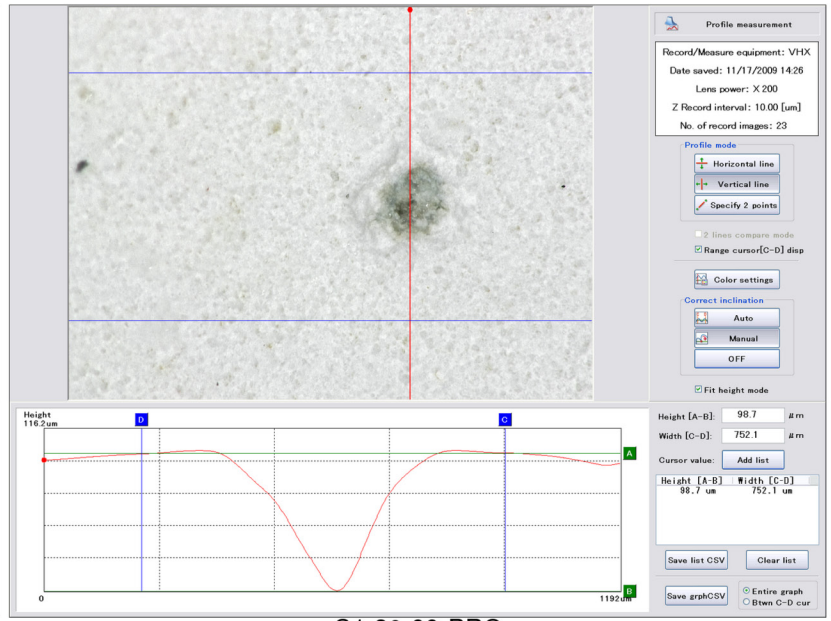
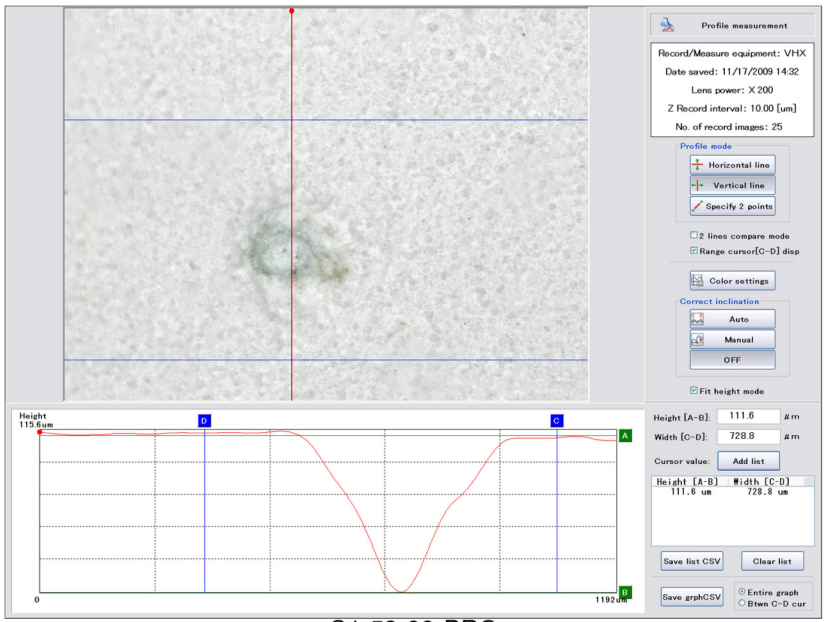
B8-43-71-PRO



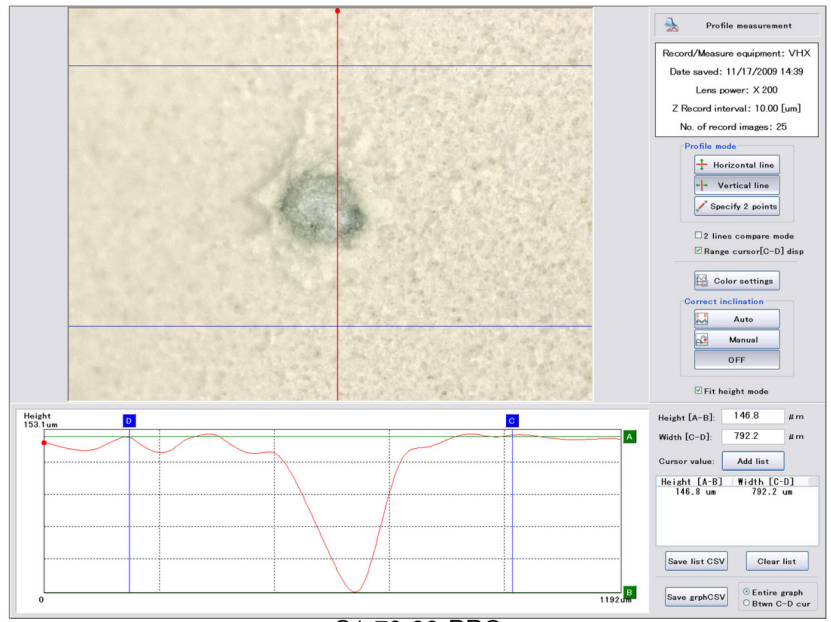
C1-11-99-PRO



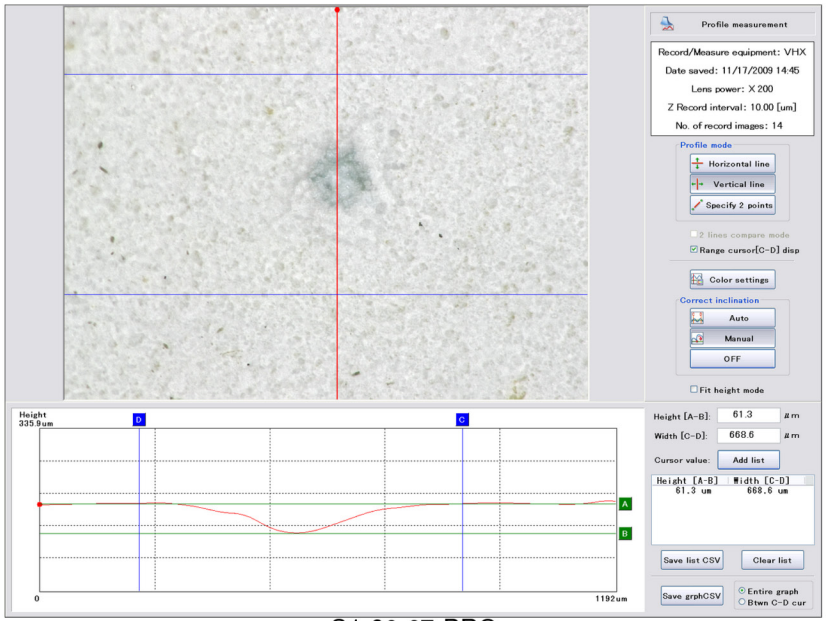
C1-30-99-PRO



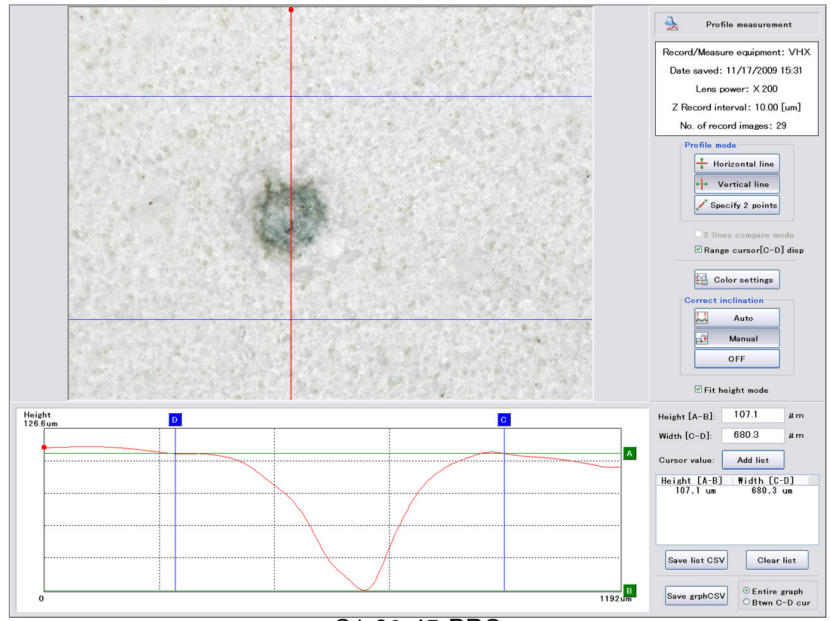
C1-53-99-PRO



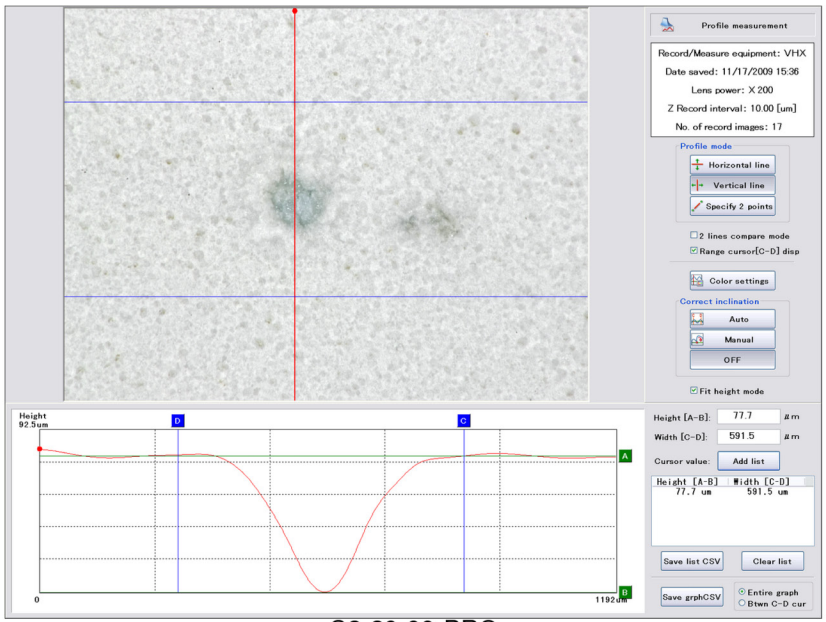
C1-79-99-PRO



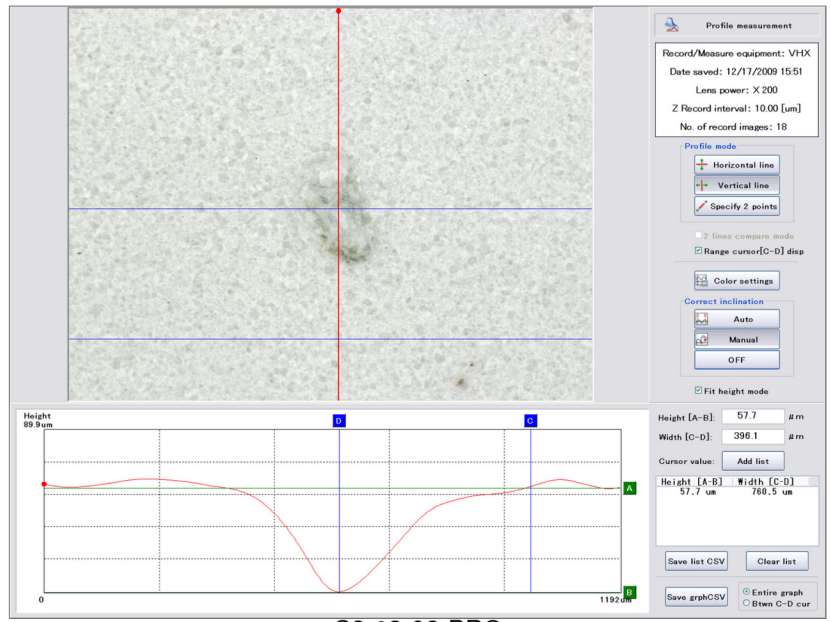
C1-90-07-PRO



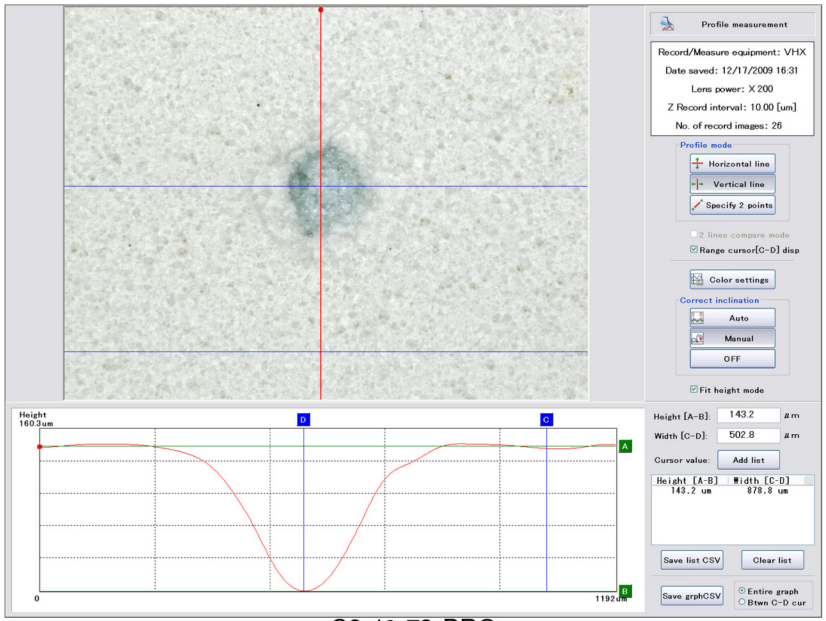
C1-90-45-PRO



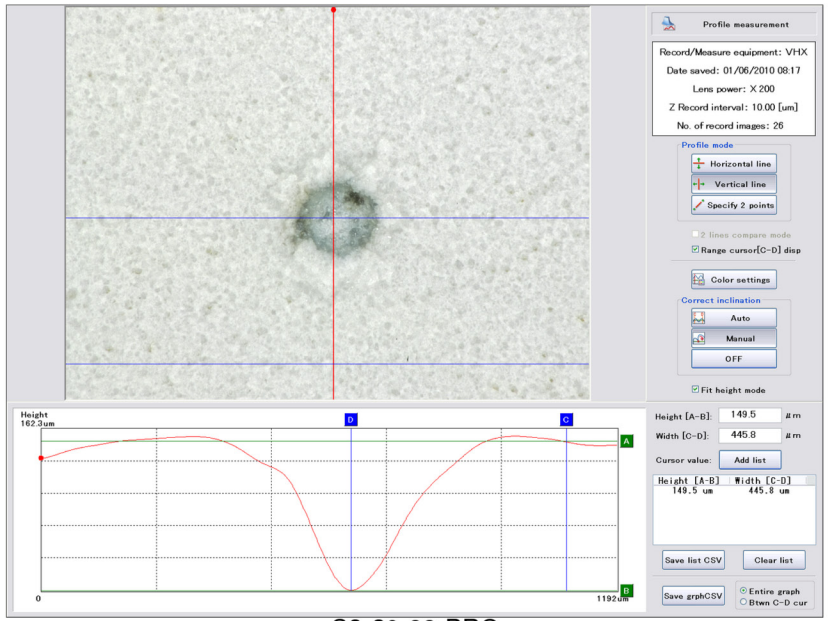
C2-29-99-PRO



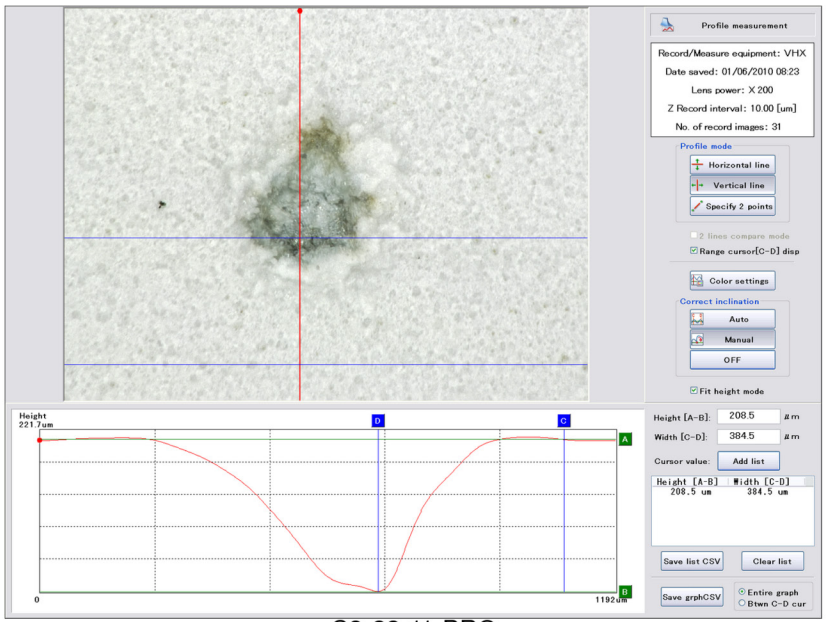
C3-03-92-PRO



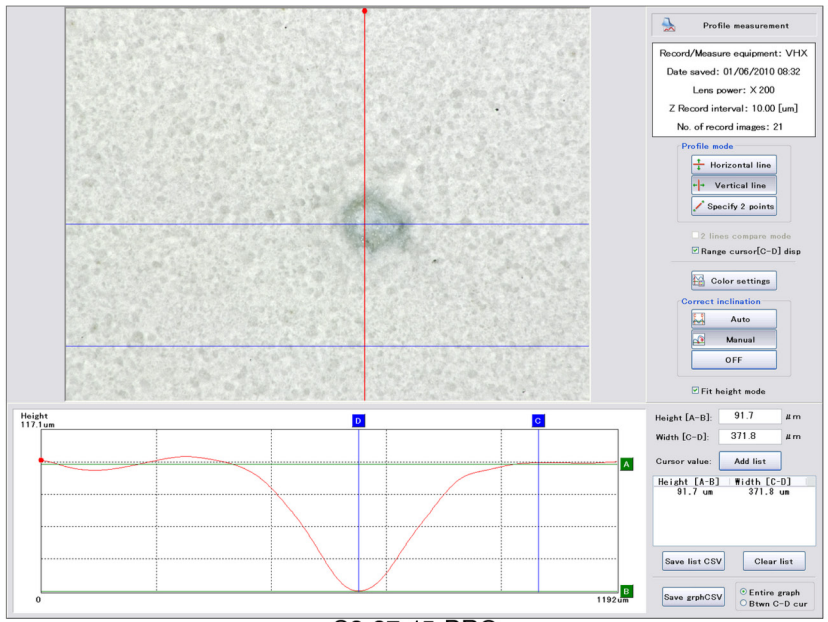
C3-10-73-PRO



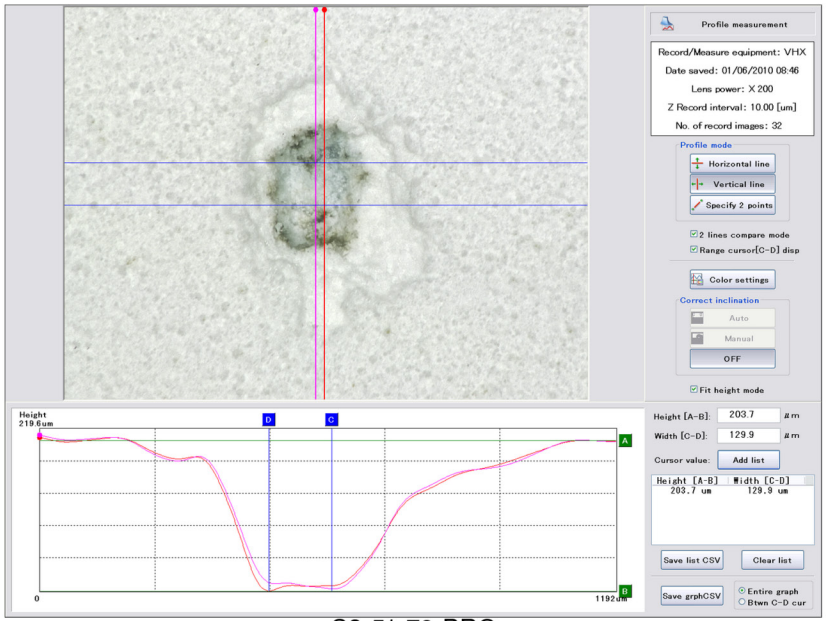
C3-20-88-PRO



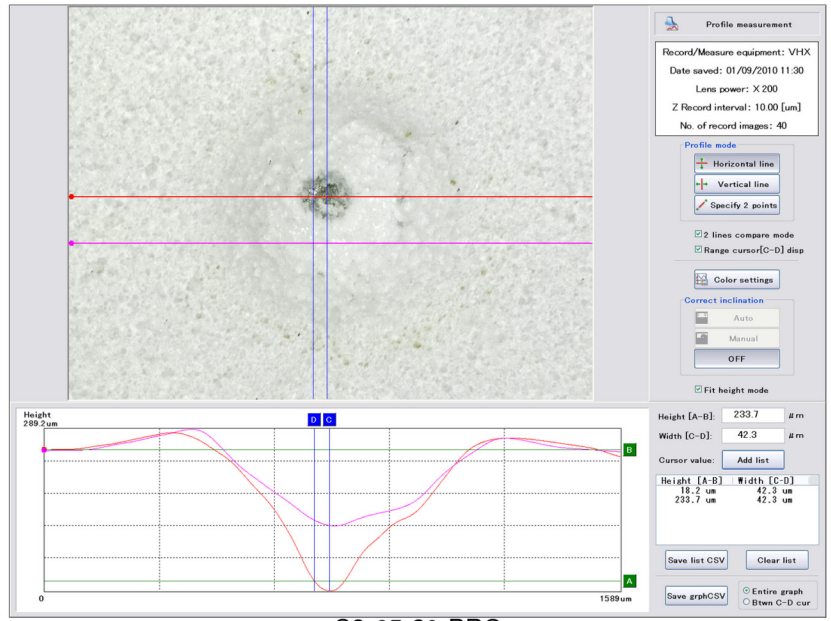
C3-22-11-PRO



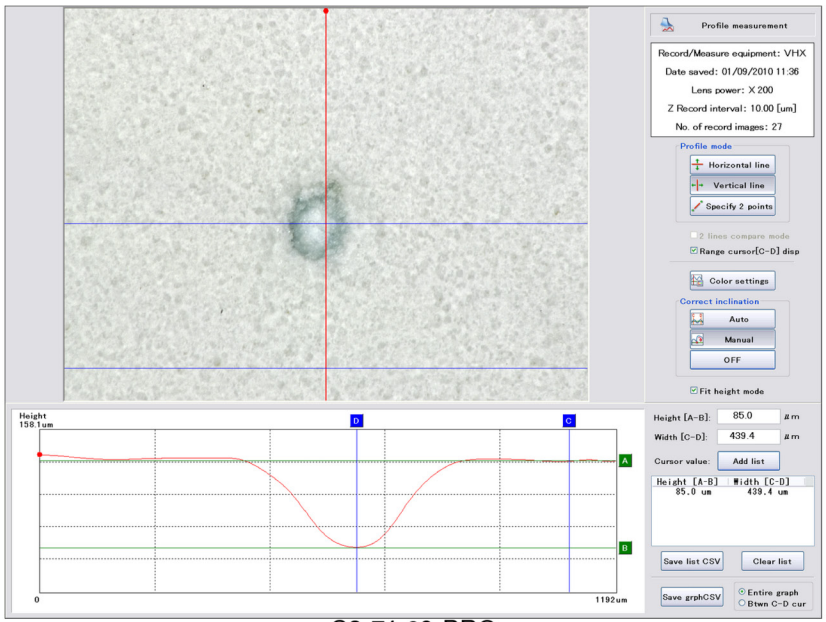
C3-37-15-PRO



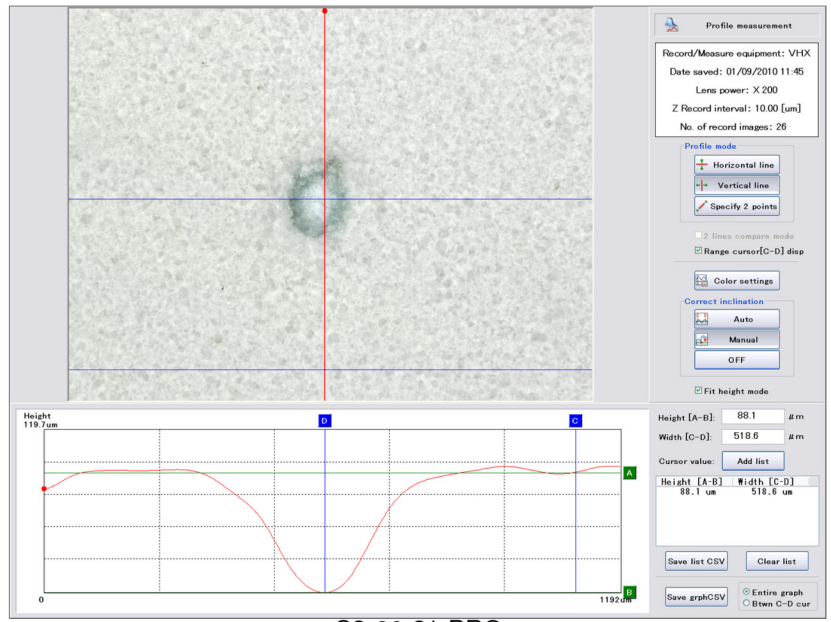
C3-51-78-PRO



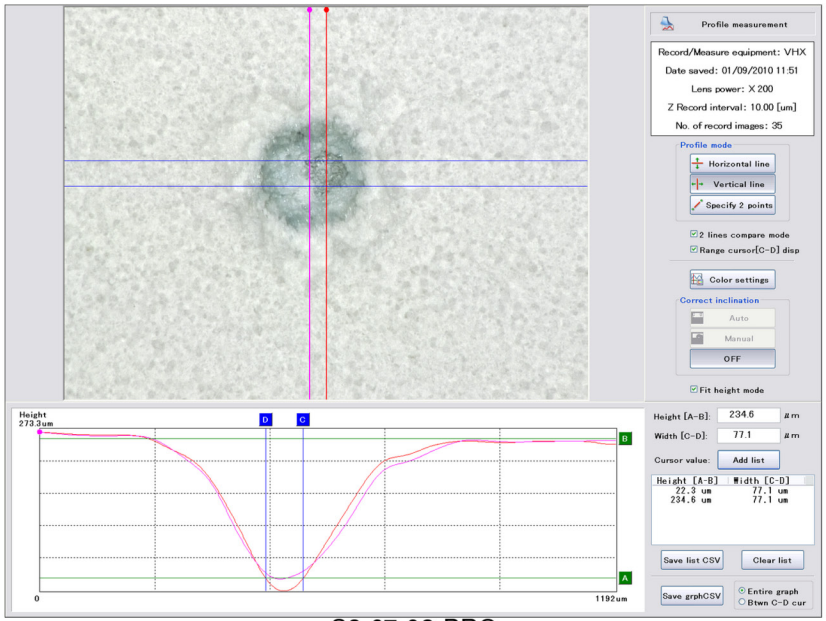
C3-65-20-PRO



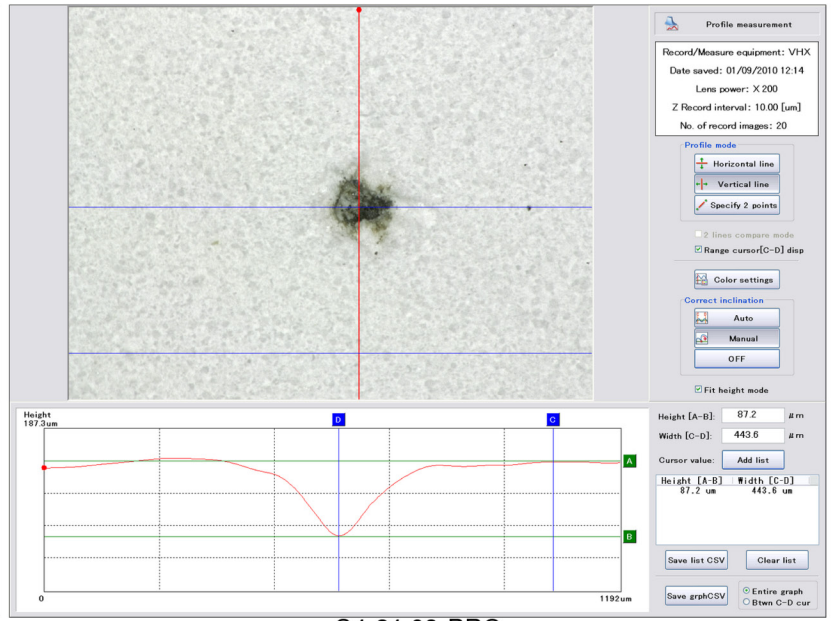
C3-74-69-PRO



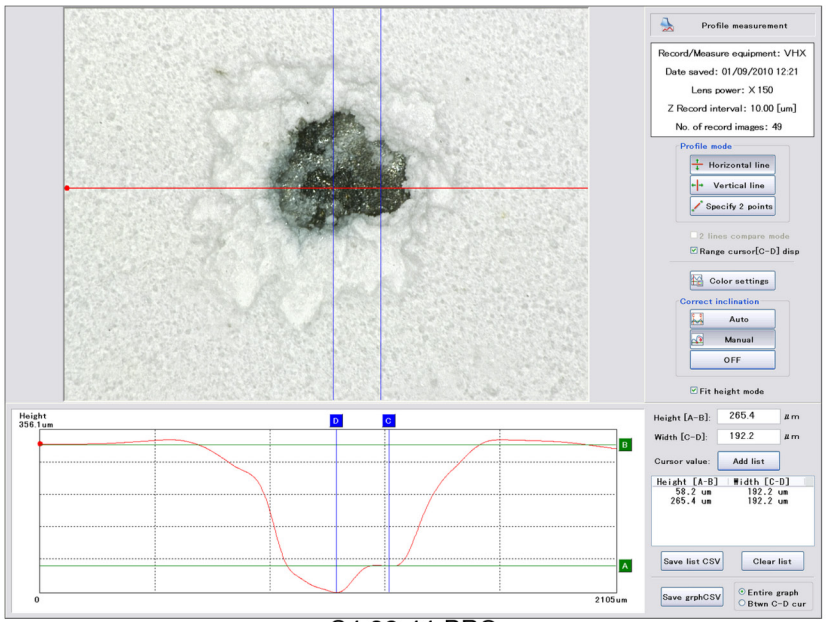
C3-86-21-PRO



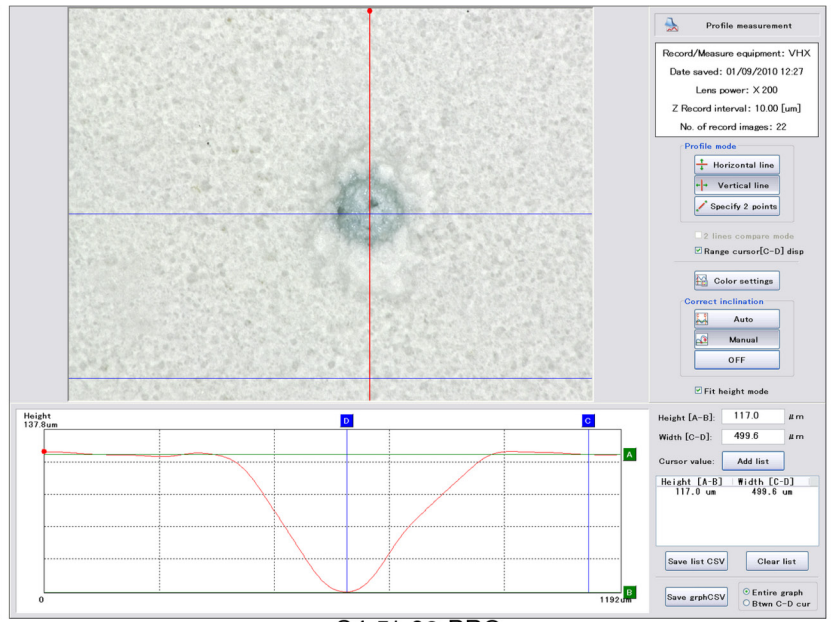
C3-97-92-PRO



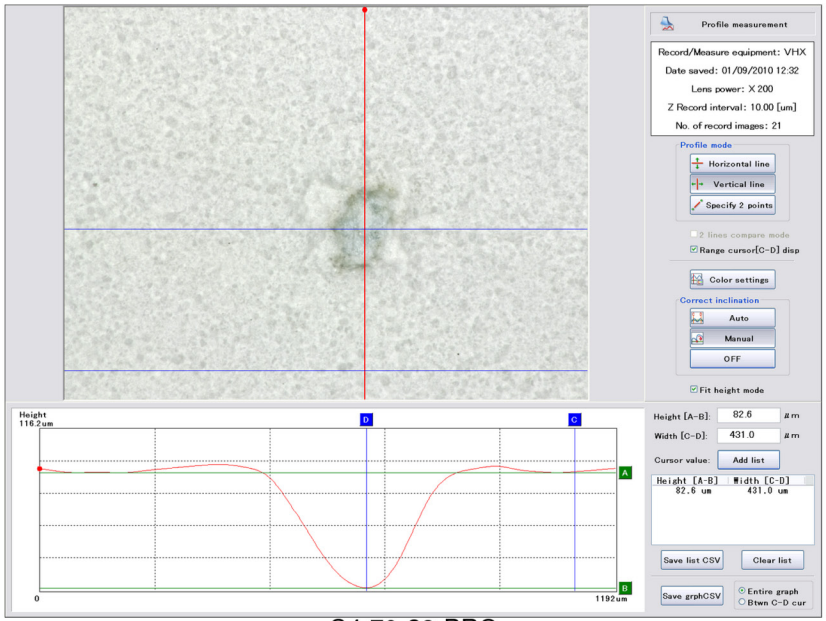
C4-24-93-PRO



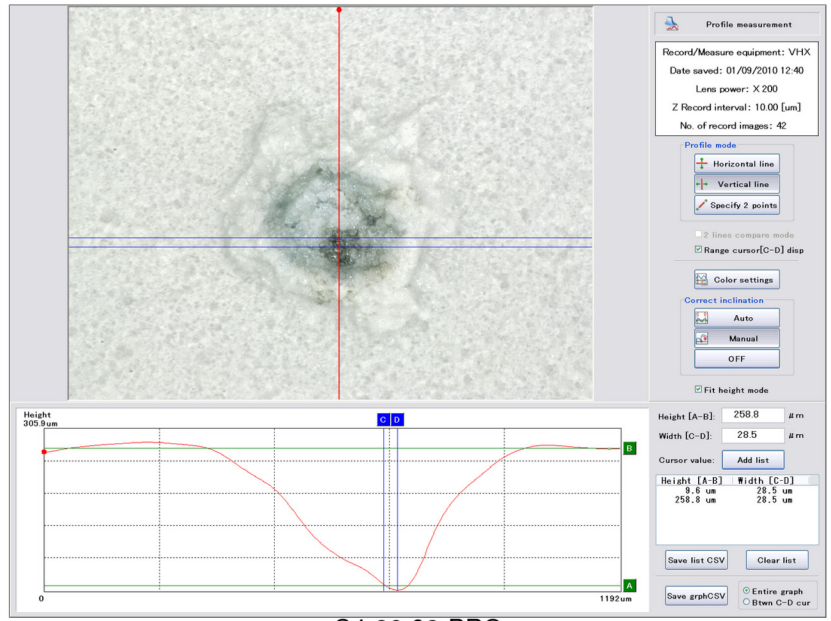
C4-32-44-PRO



C4-51-98-PRO



C4-70-28-PRO



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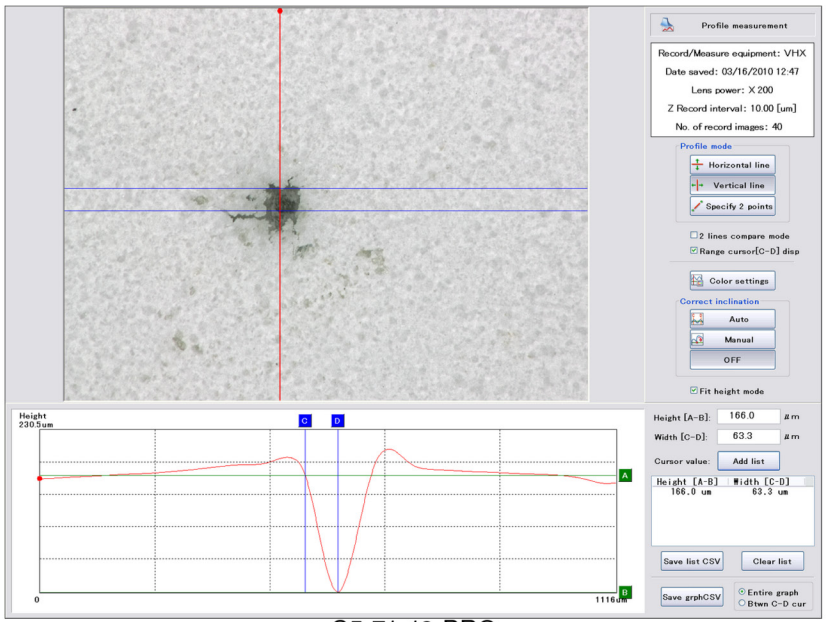
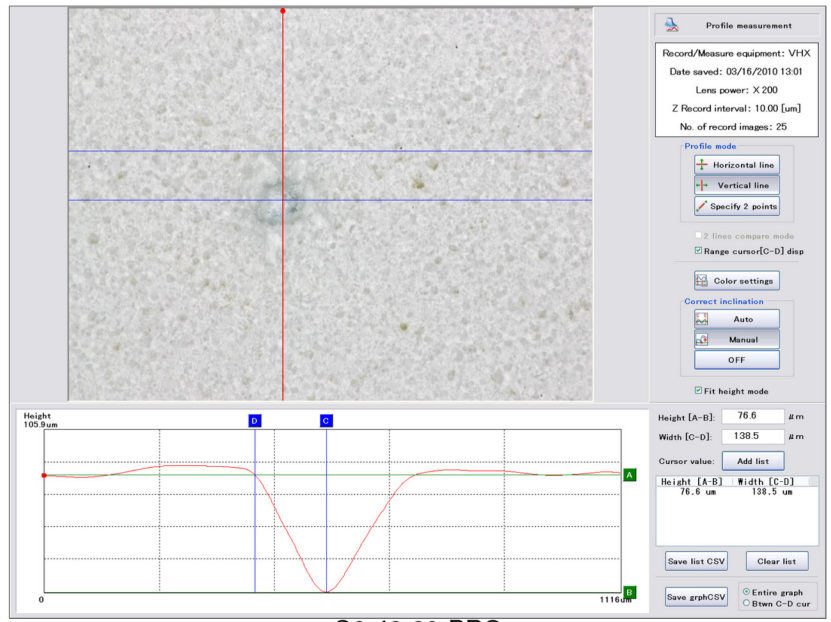
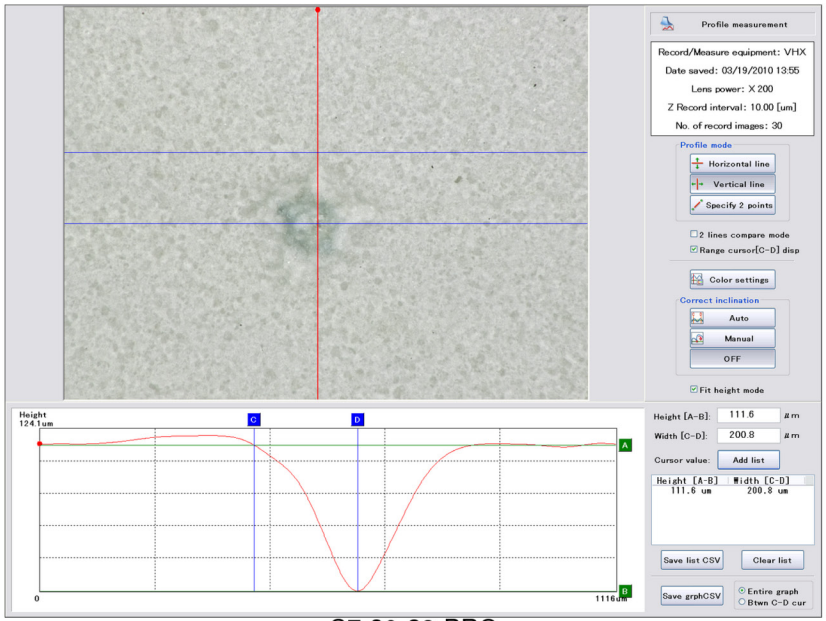


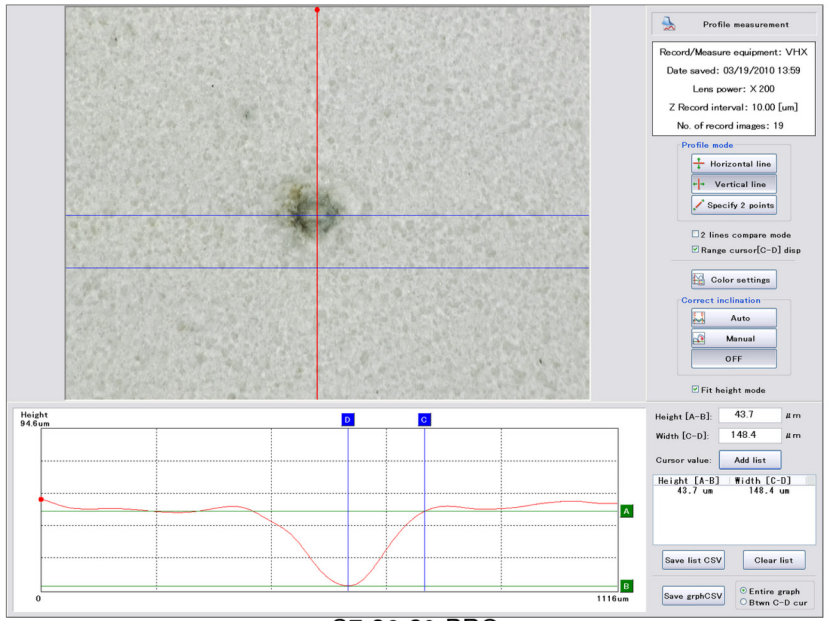
C5-71-18-PRO



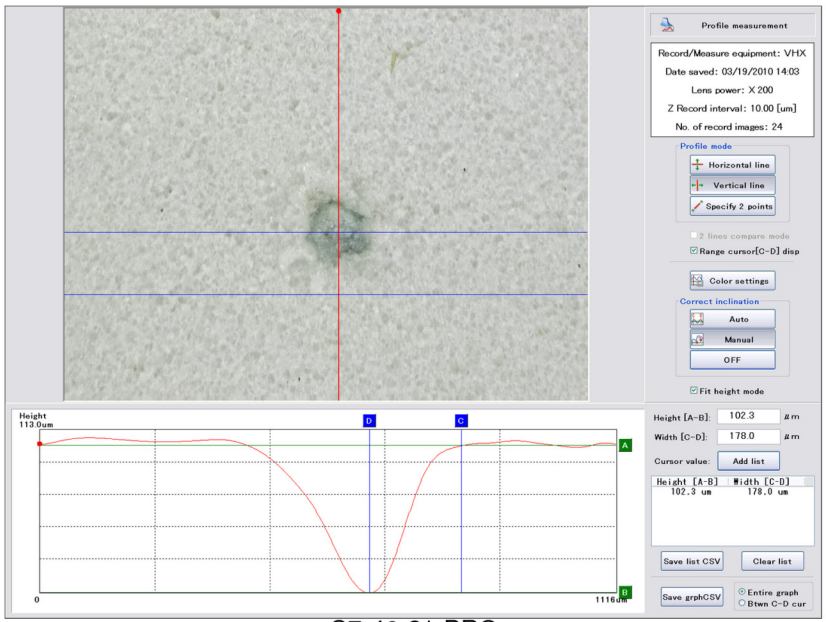
C6-48-80-PRO



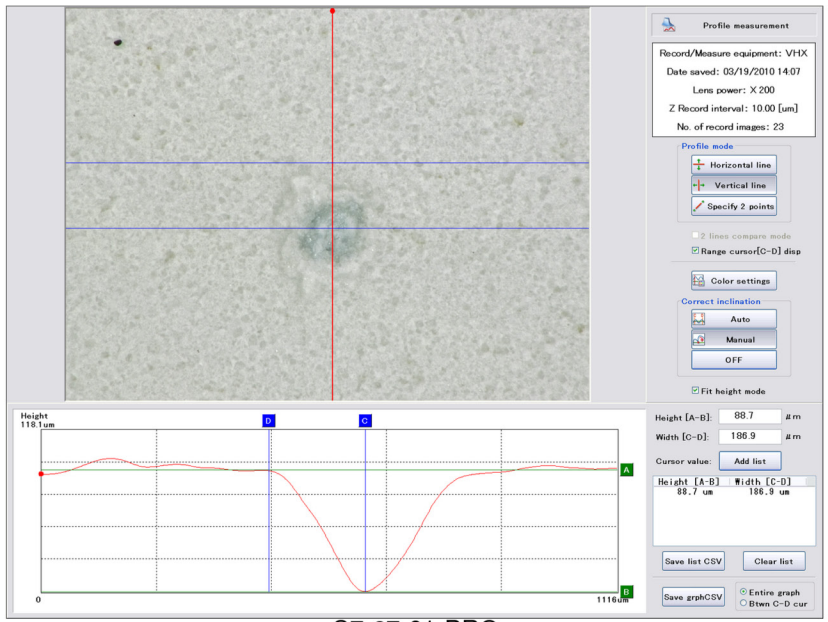
C7-30-28-PRO



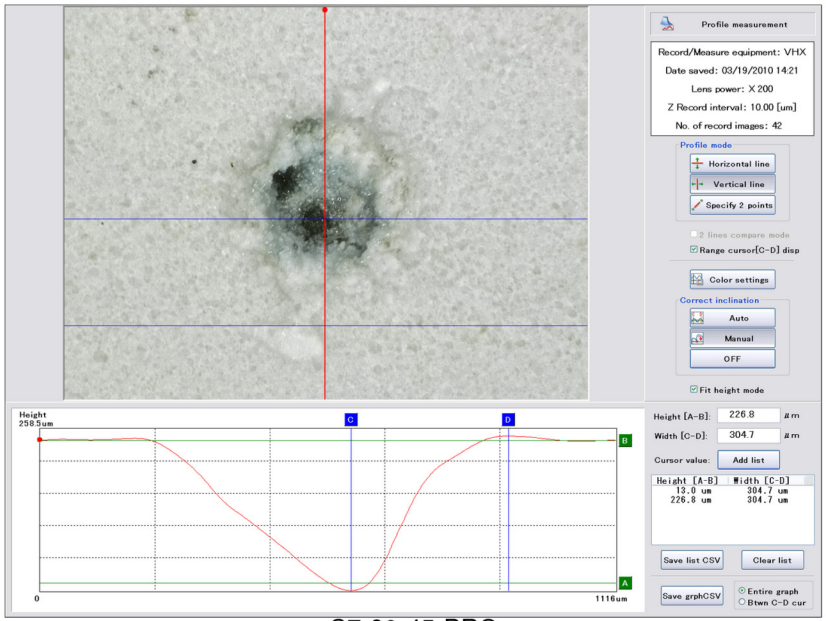
C7-36-20-PRO



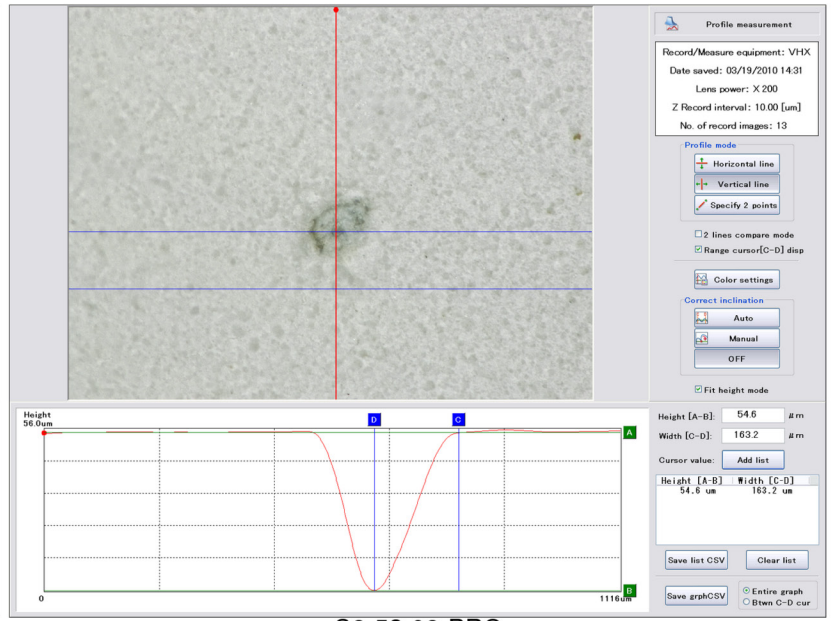
C7-46-21-PRO



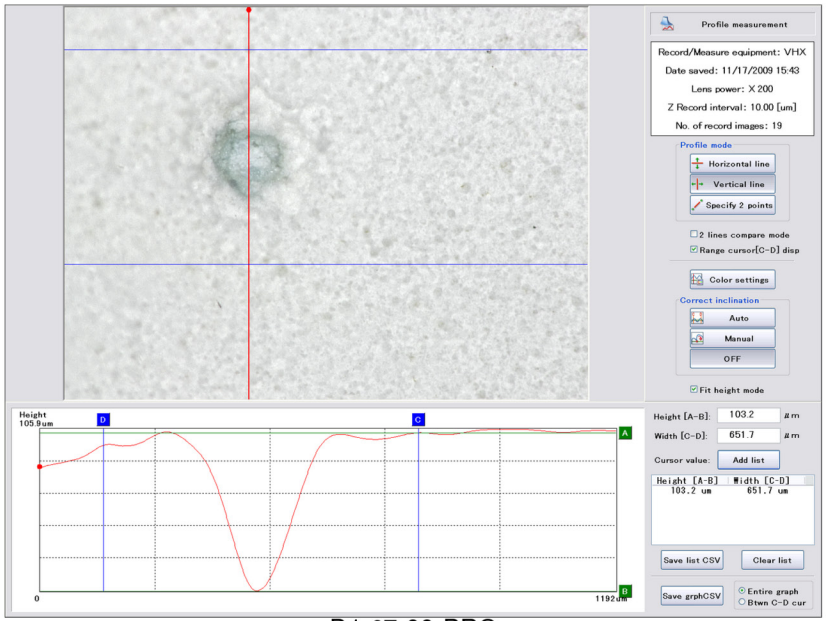
C7-87-91-PRO



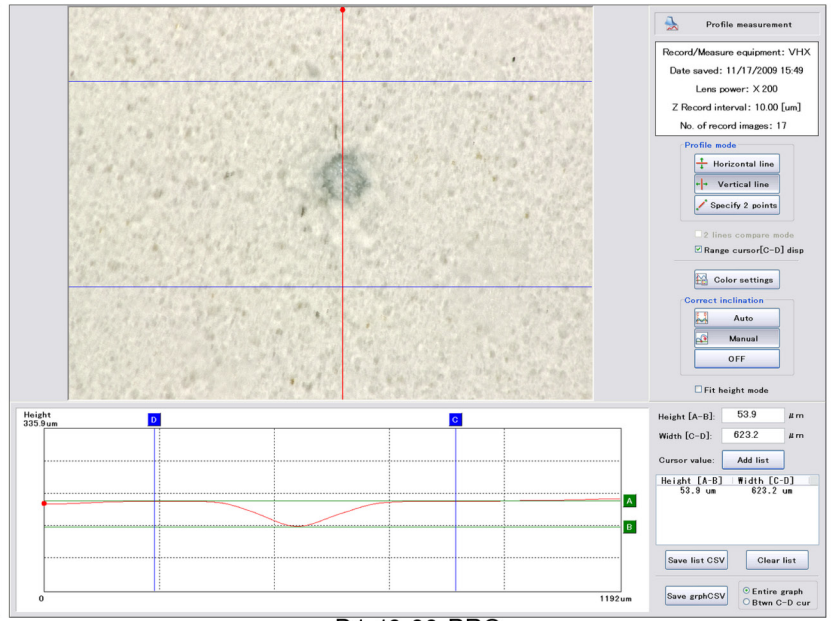
C7-90-45-PRO



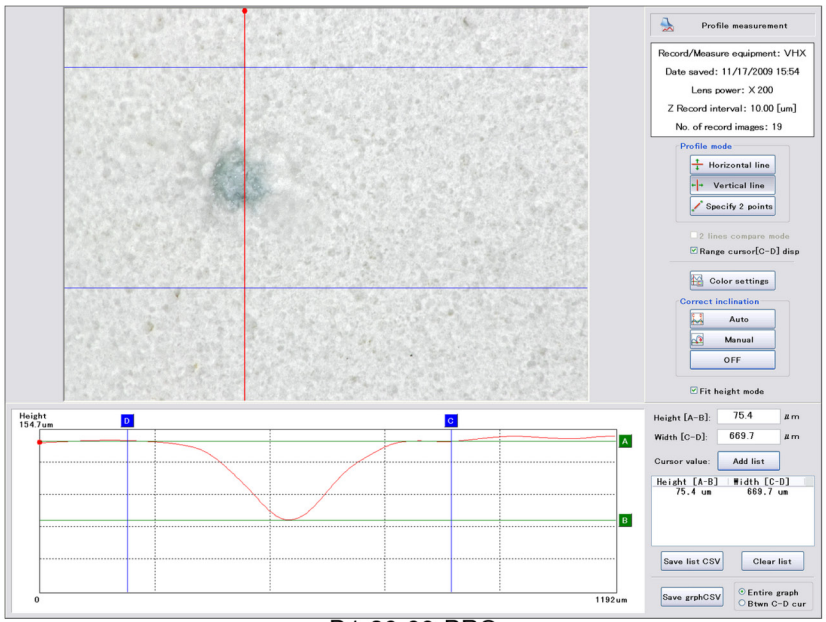
C8-52-08-PRO



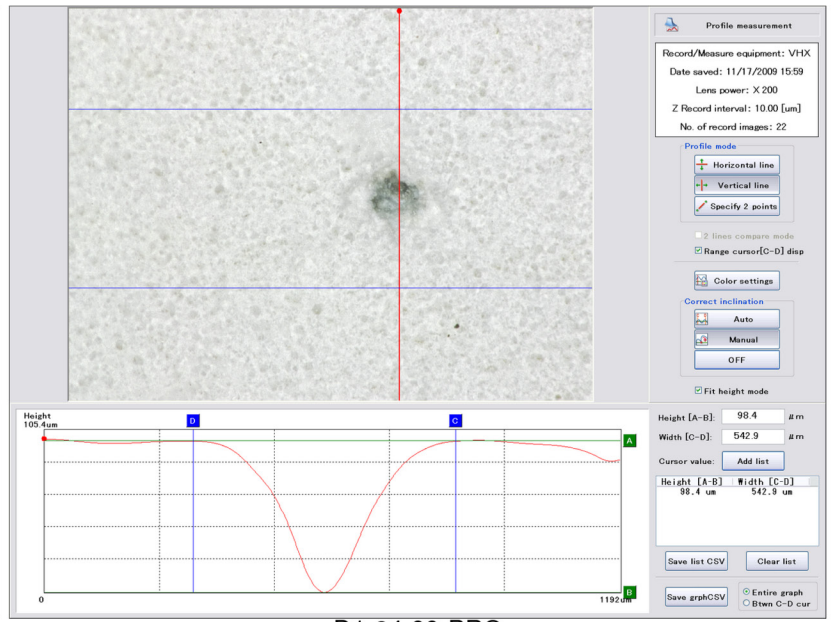
D1-07-99-PRO



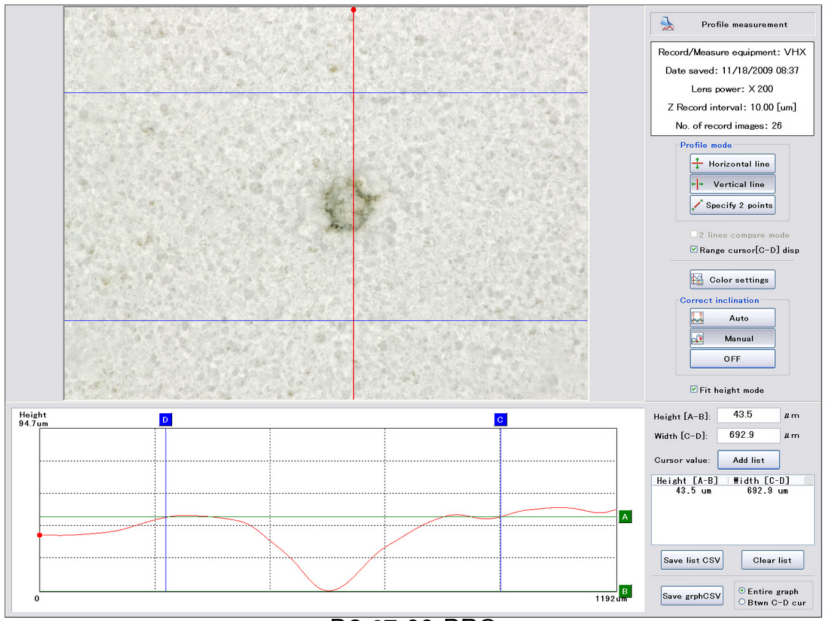
D1-19-99-PRO



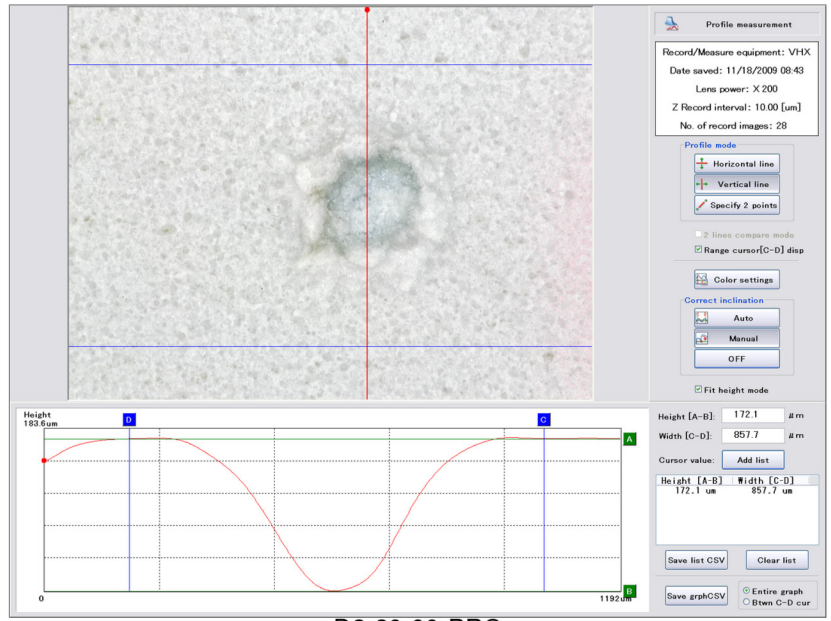
D1-39-99-PRO



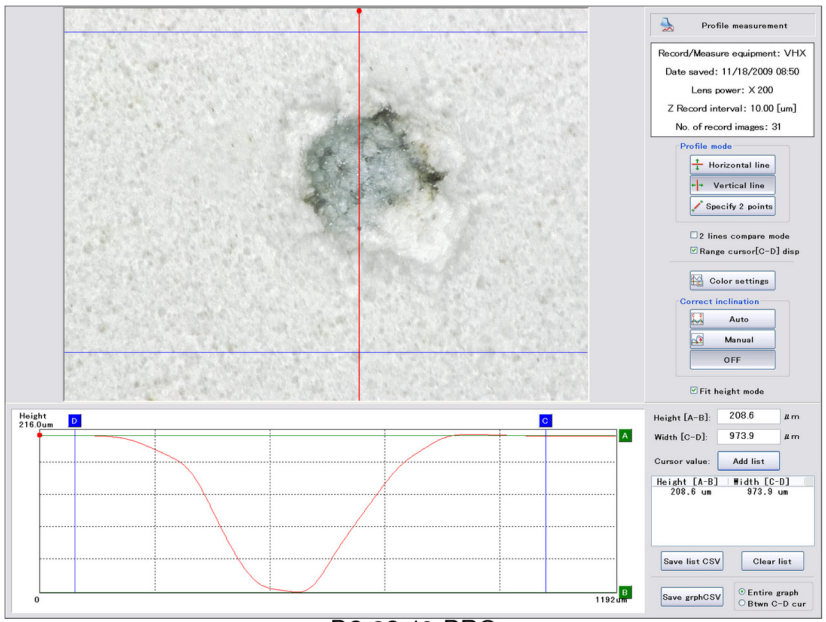
D1-84-99-PRO



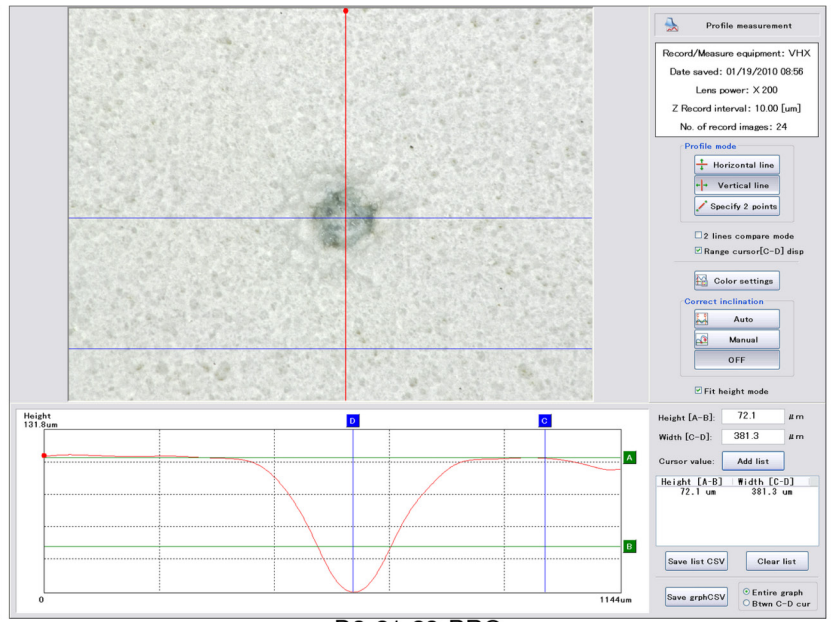
D2-07-99-PRO



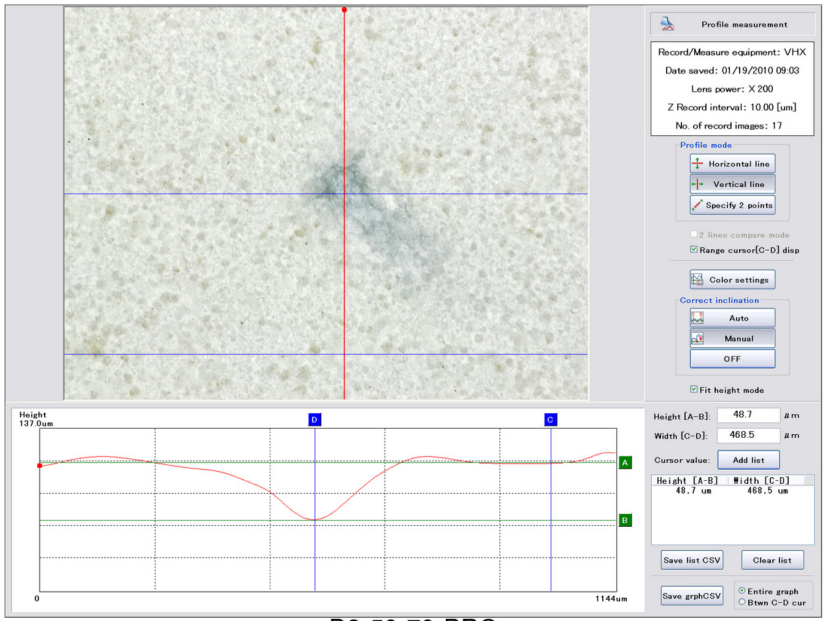
D2-29-99-PRO



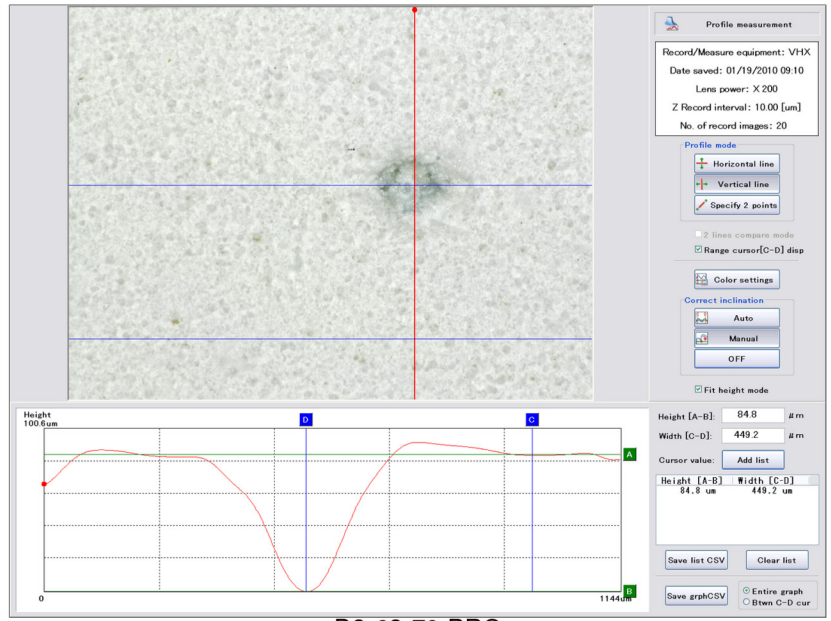
D2-82-10-PRO



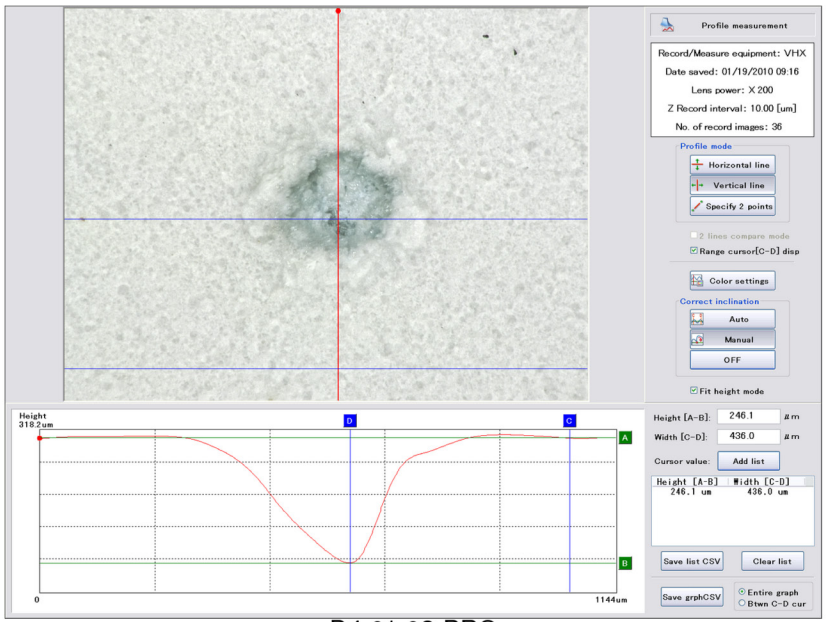
D3-21-23-PRO



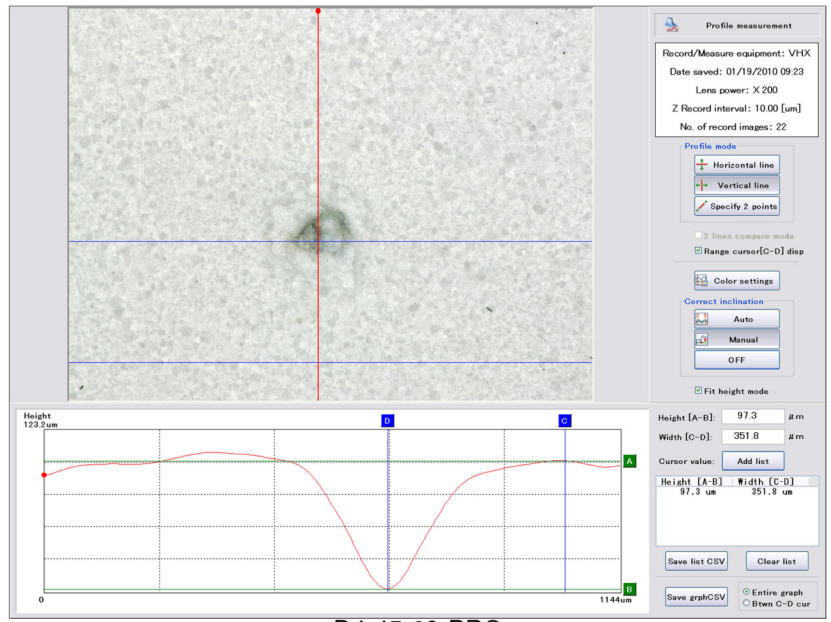
D3-59-79-PRO



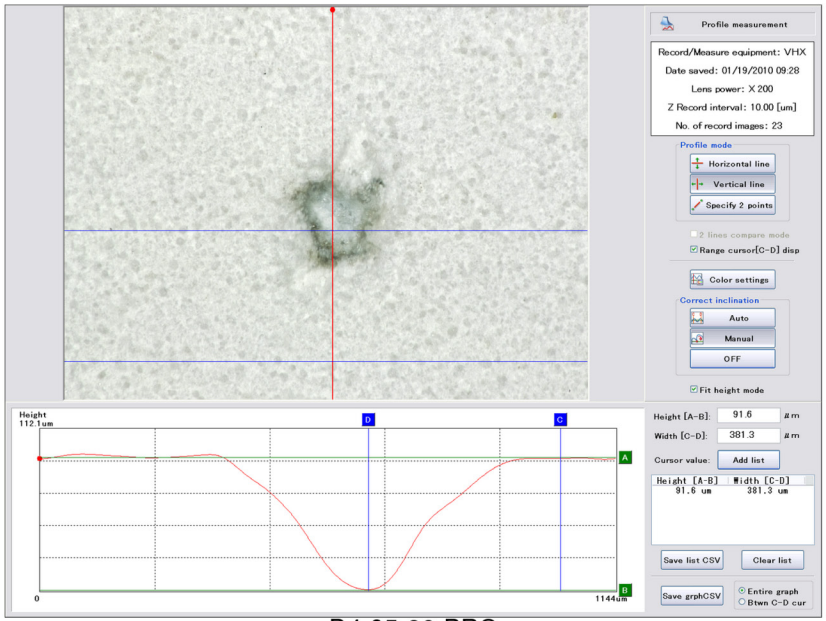
D3-63-76-PRO



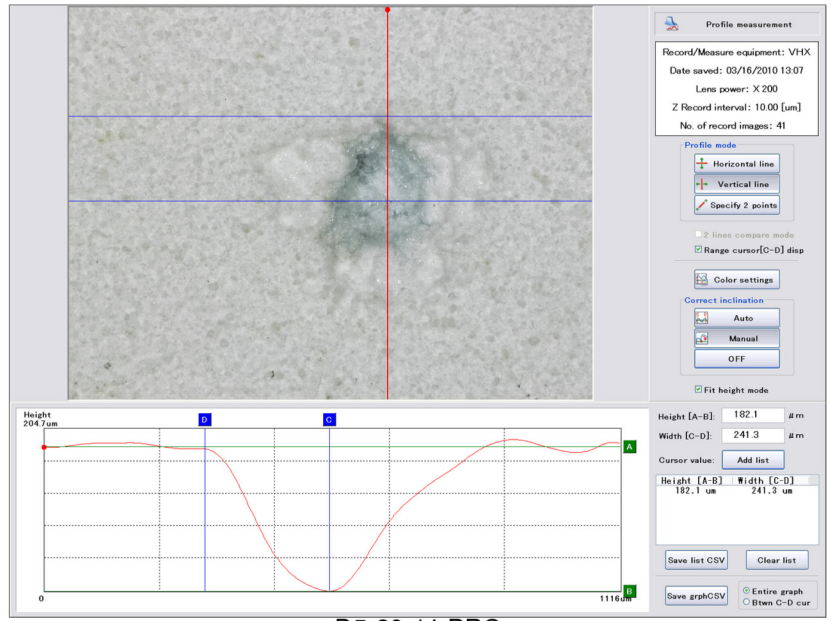
D4-01-02-PRO



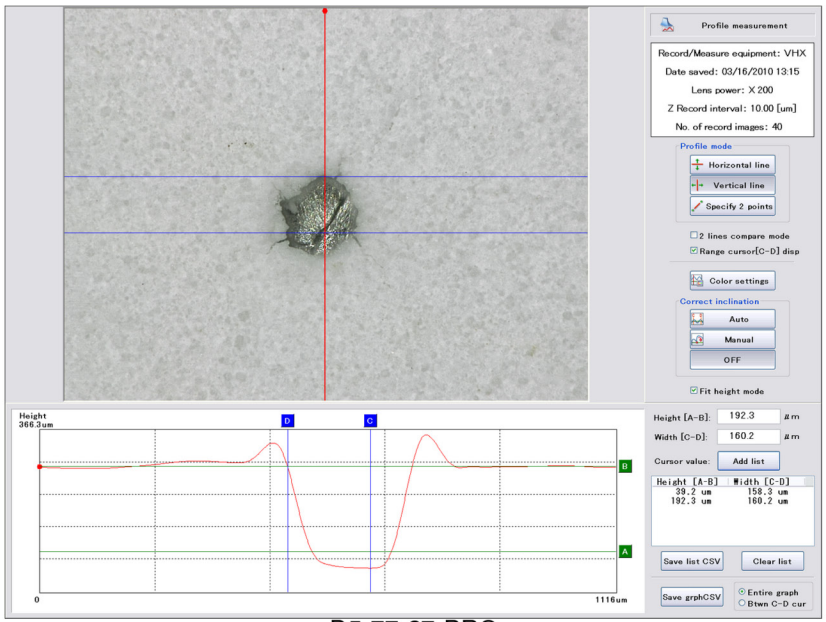
D4-45-69-PRO



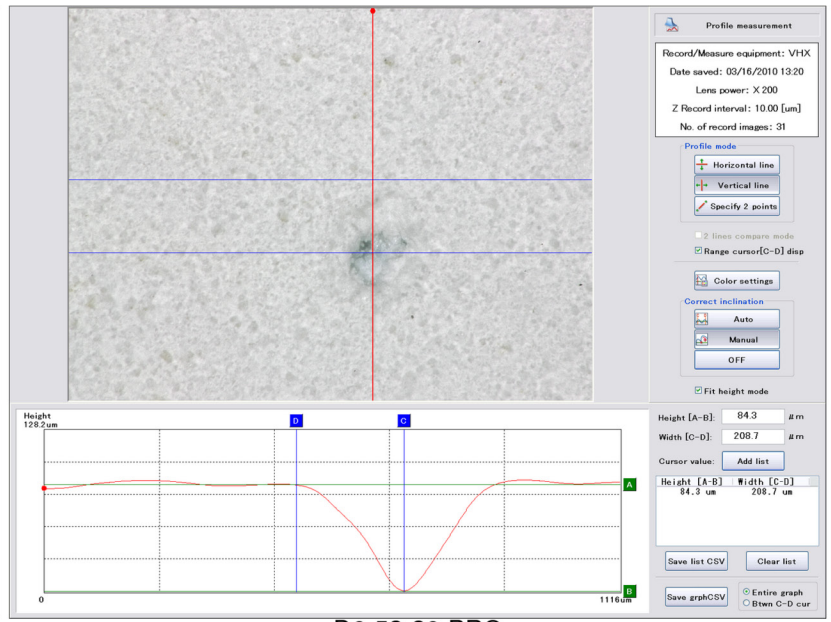
D4-95-86-PRO



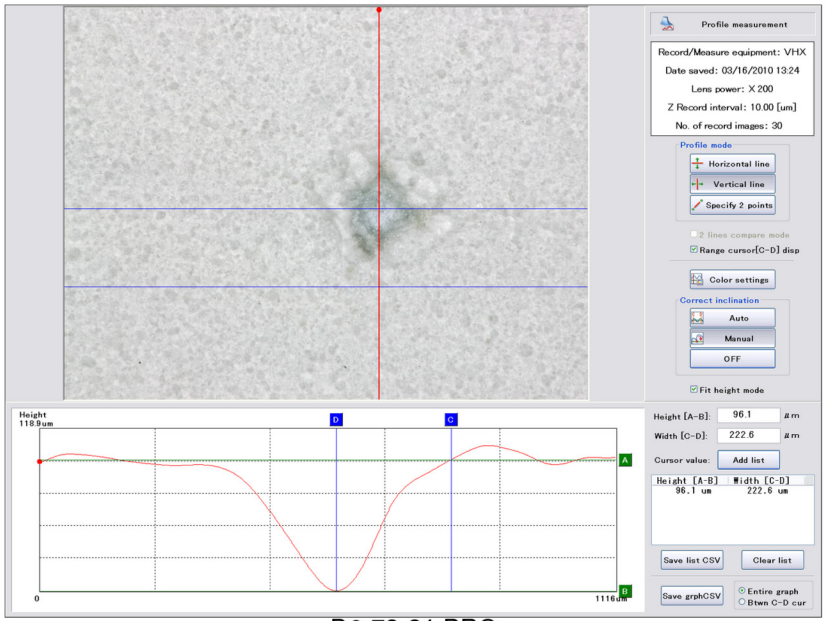
D5-29-14-PRO



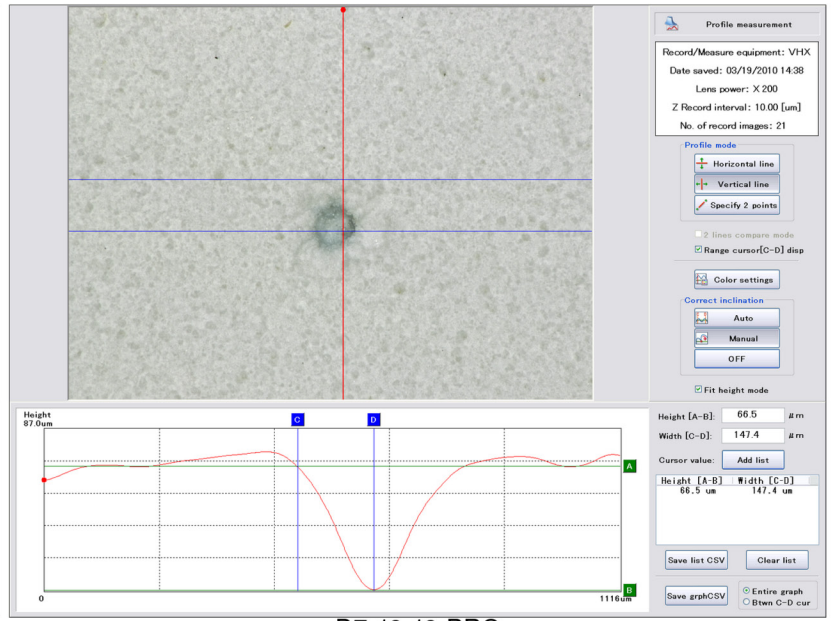
D5-77-27-PRO



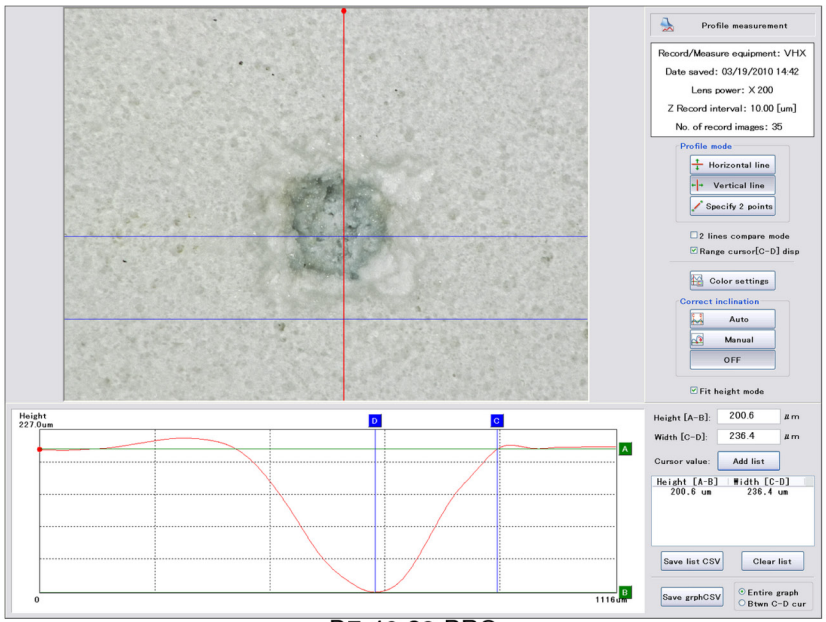
D6-52-26-PRO



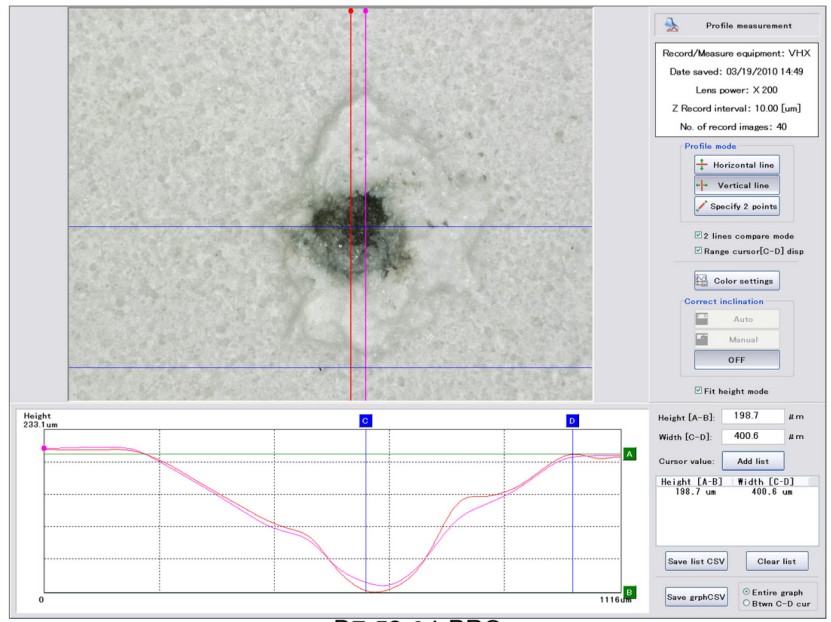
D6-72-24-PRO



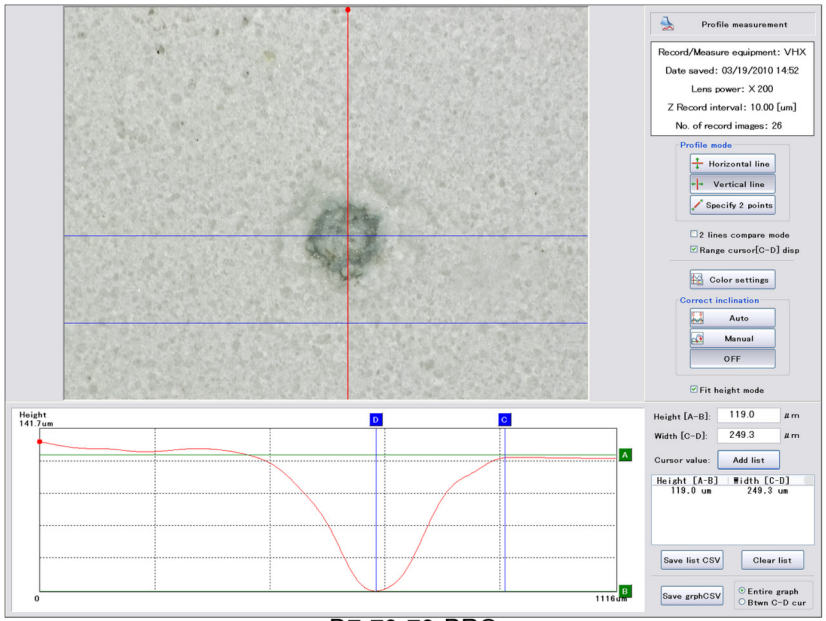
D7-18-18-PRO



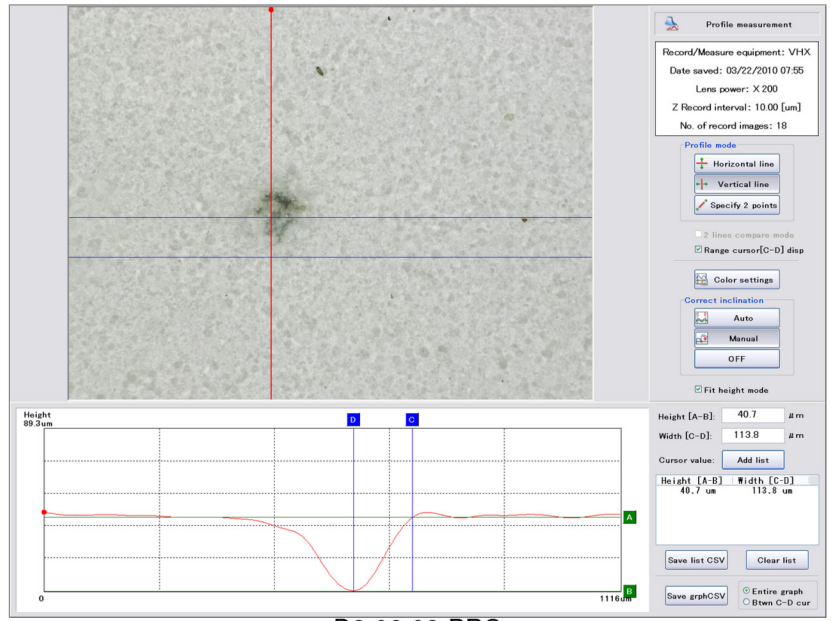
D7-46-28-PRO



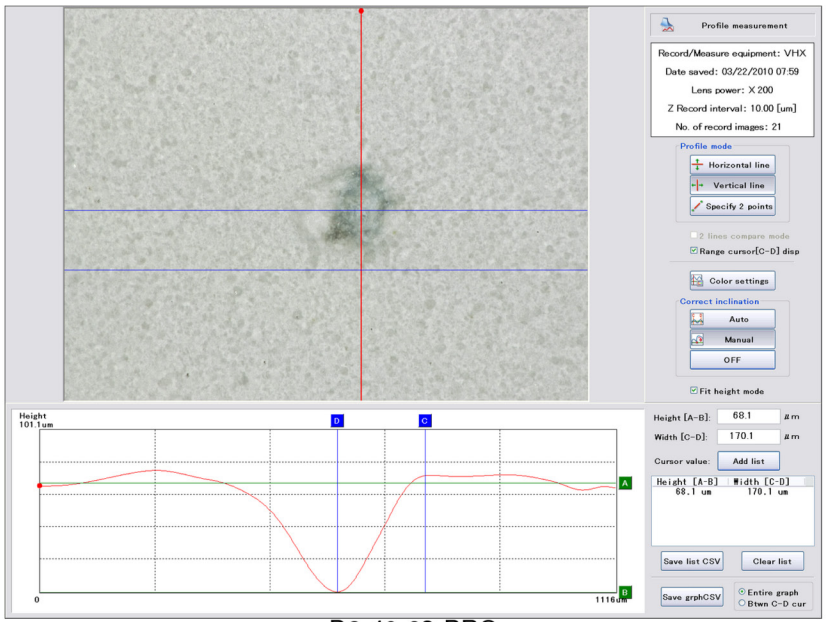
D7-53-04-PRO



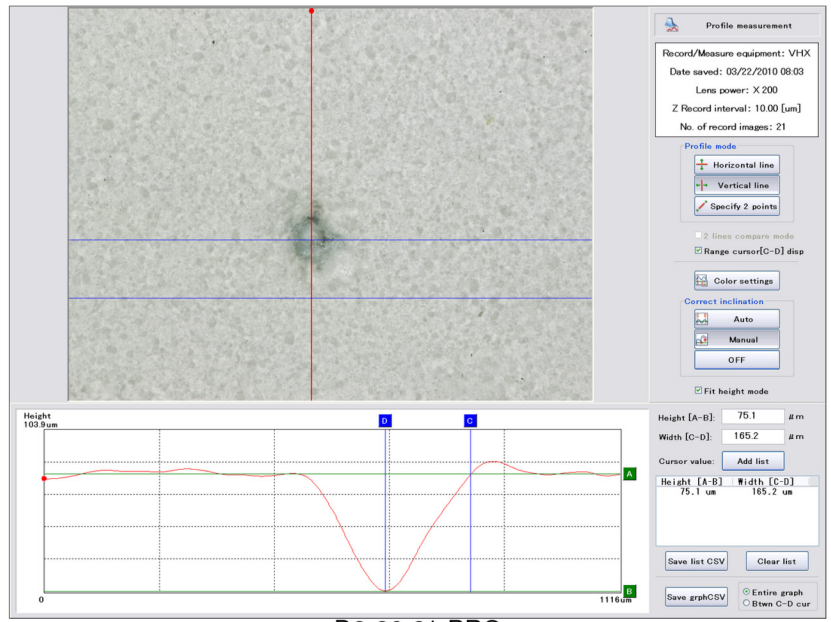
D7-79-79-PRO



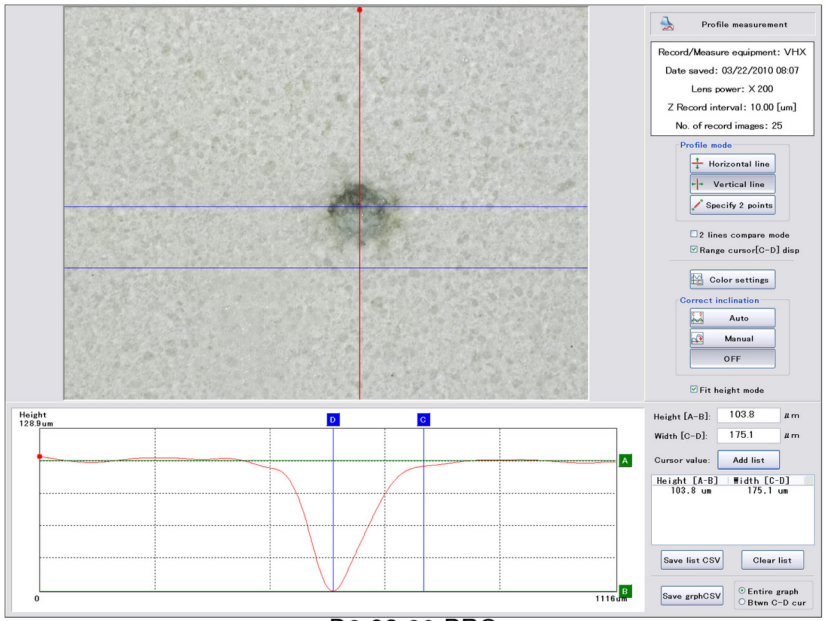
D8-06-08-PRO



D8-40-63-PRO



D8-86-81-PRO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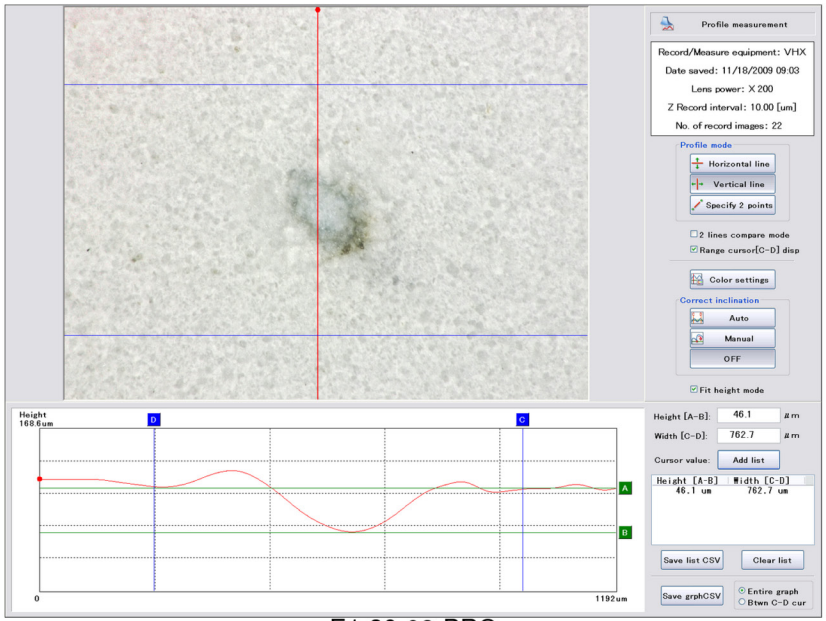
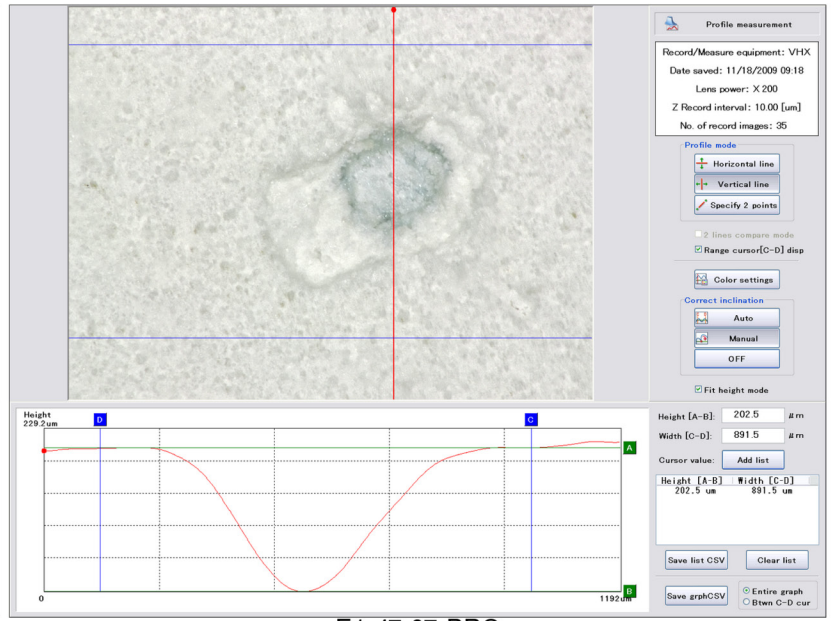
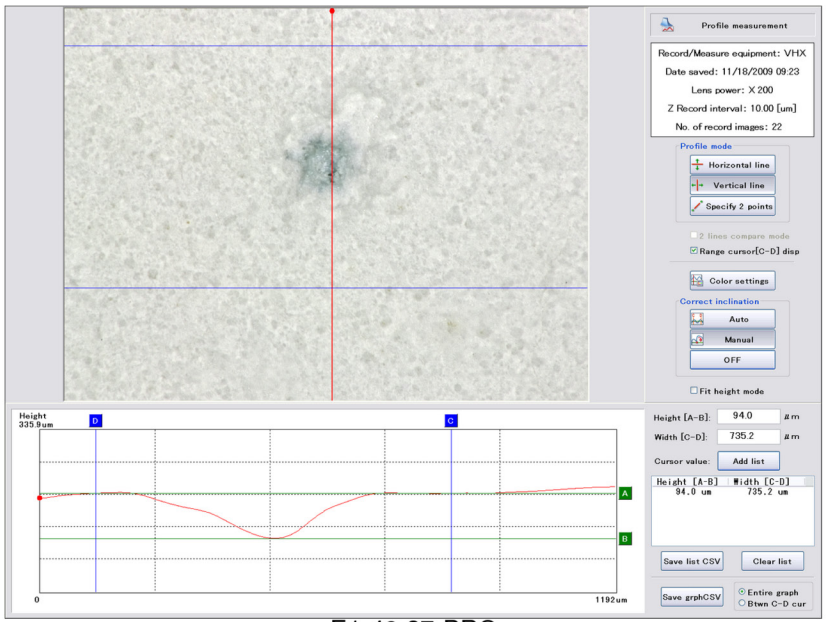
D8-92-86-PRO



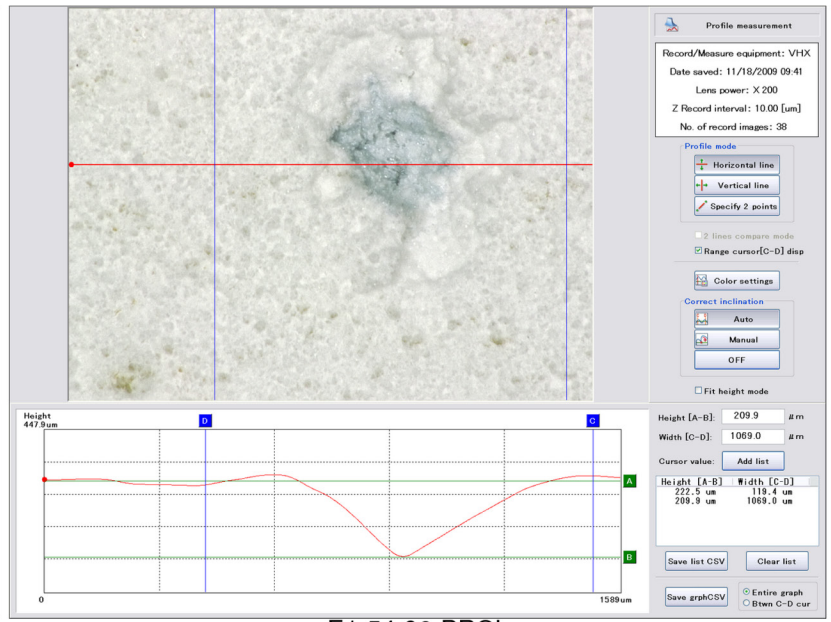
E1-39-08-PRO



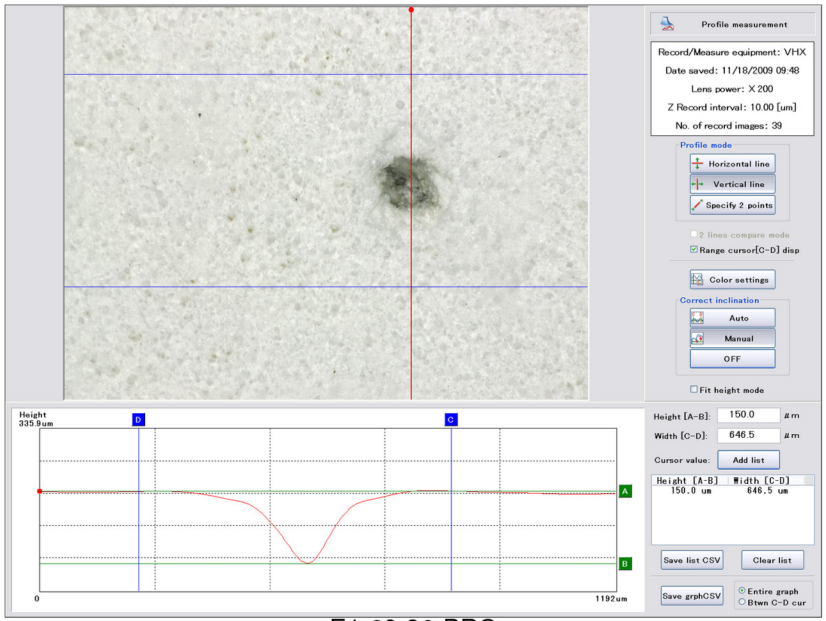
E1-47-97-PRO



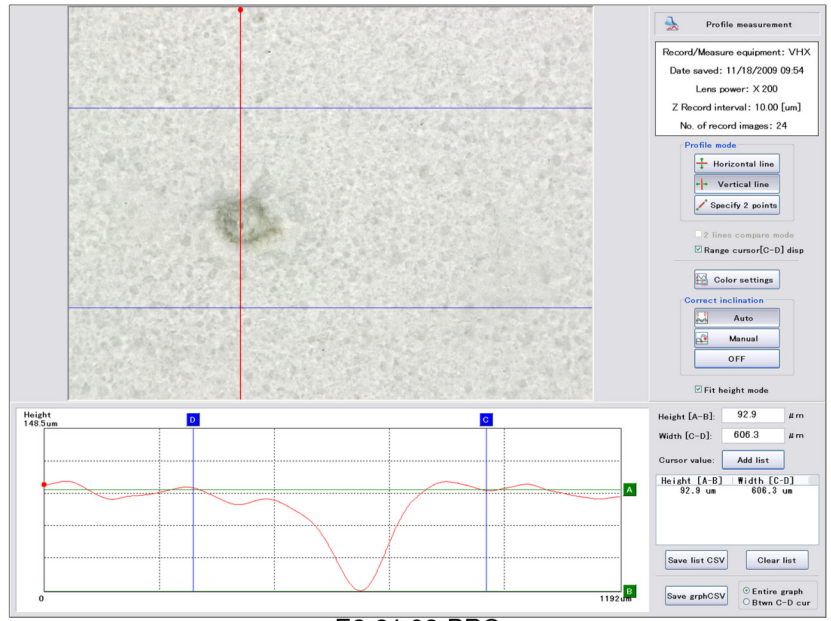
E1-48-37-PRO



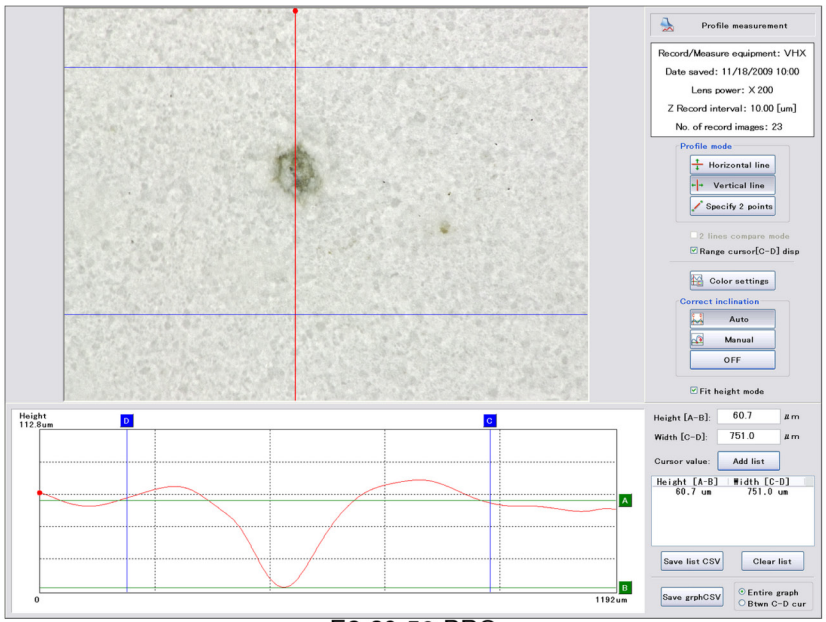
E1-54-96-PROh



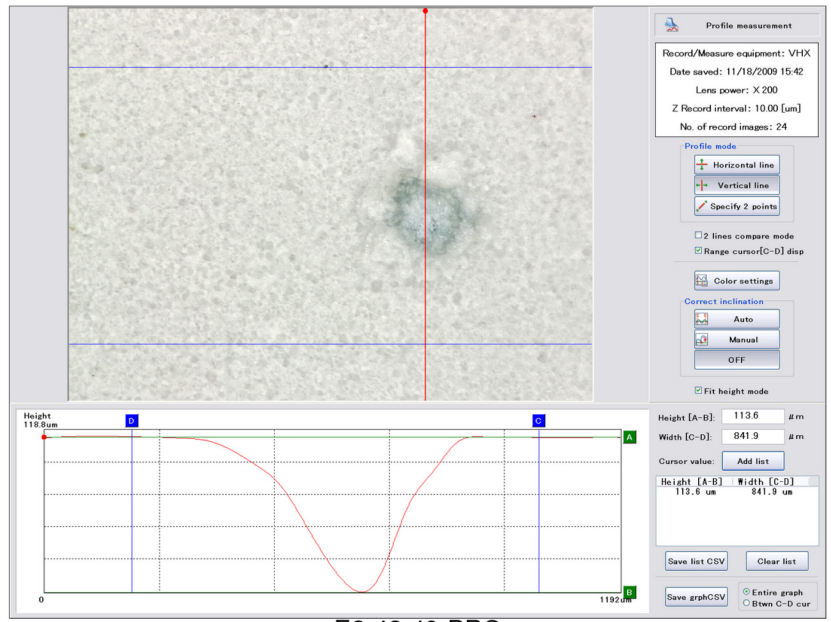
E1-69-36-PRO



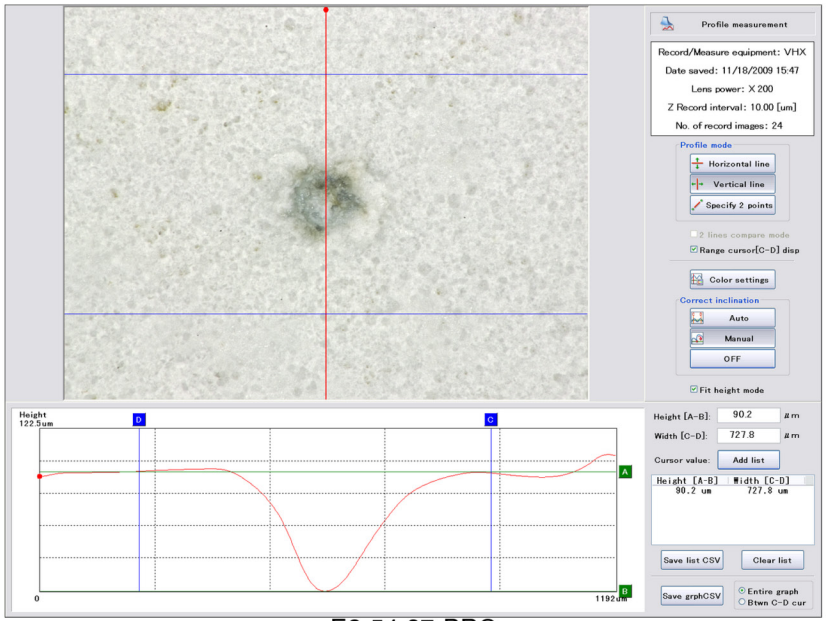
E2-24-92-PRO



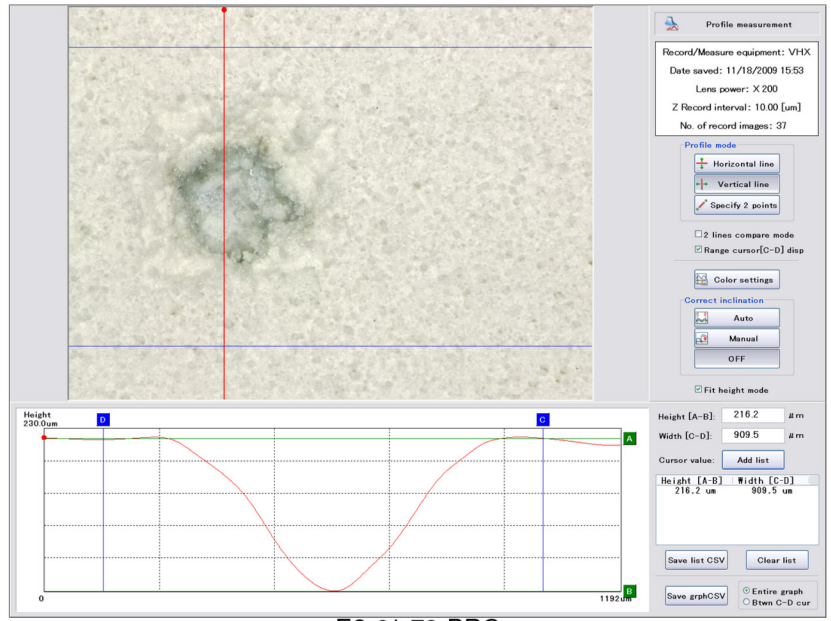
E2-29-56-PRO



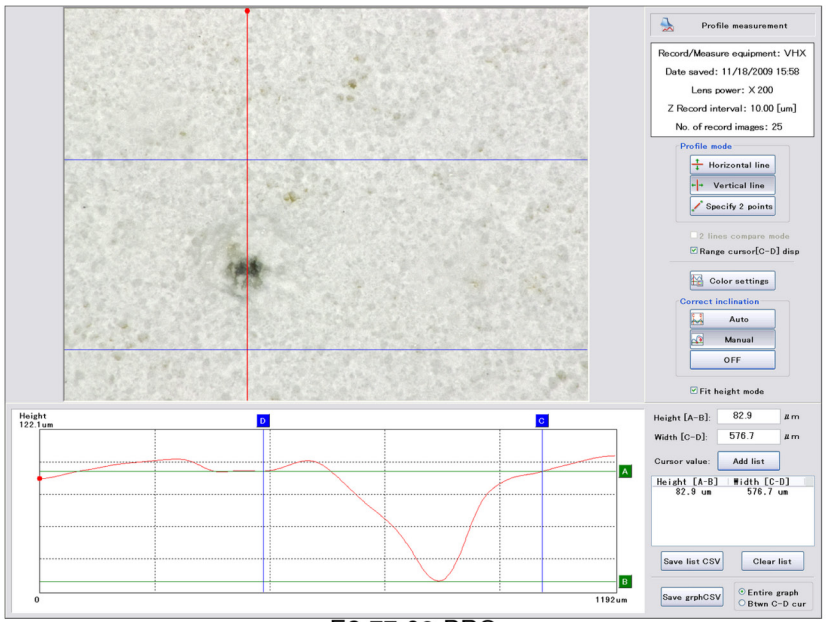
E2-42-49-PRO



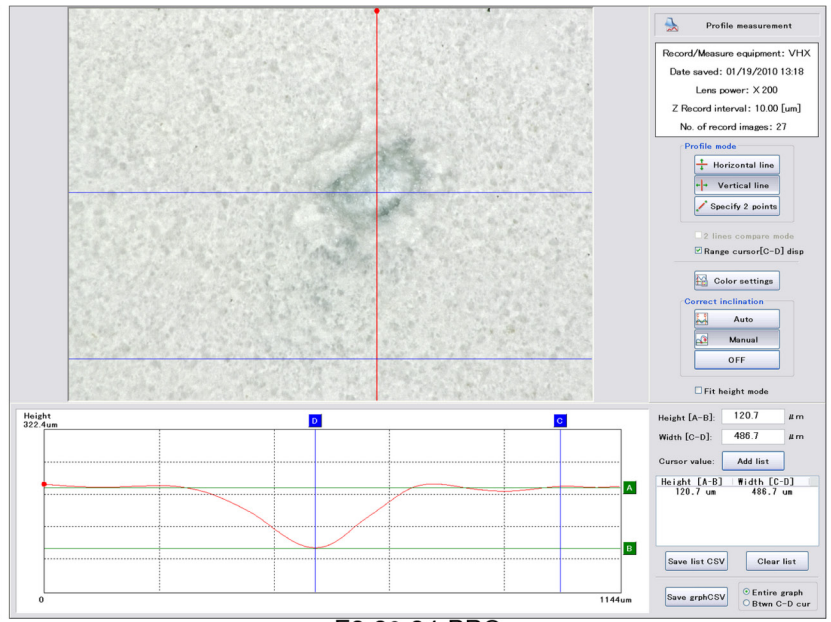
E2-54-37-PRO



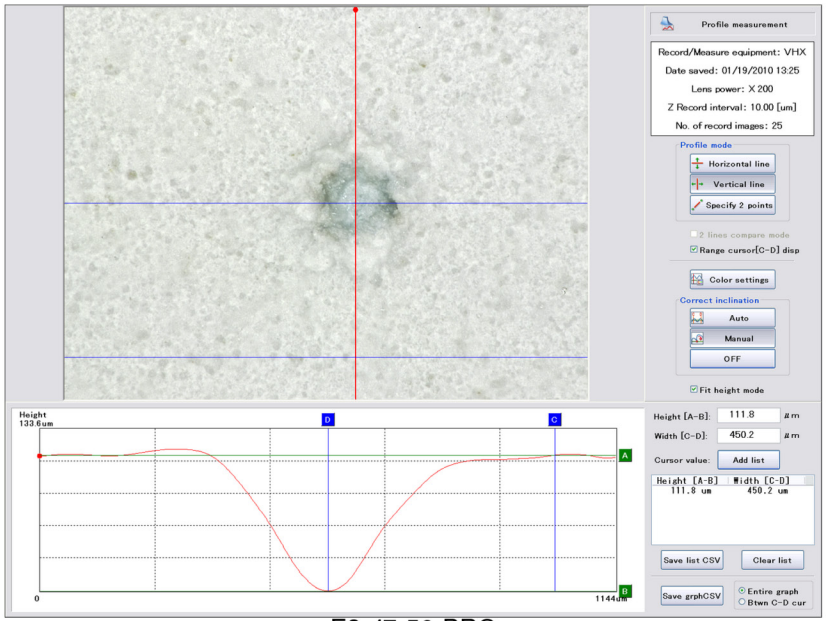
E2-61-78-PRO



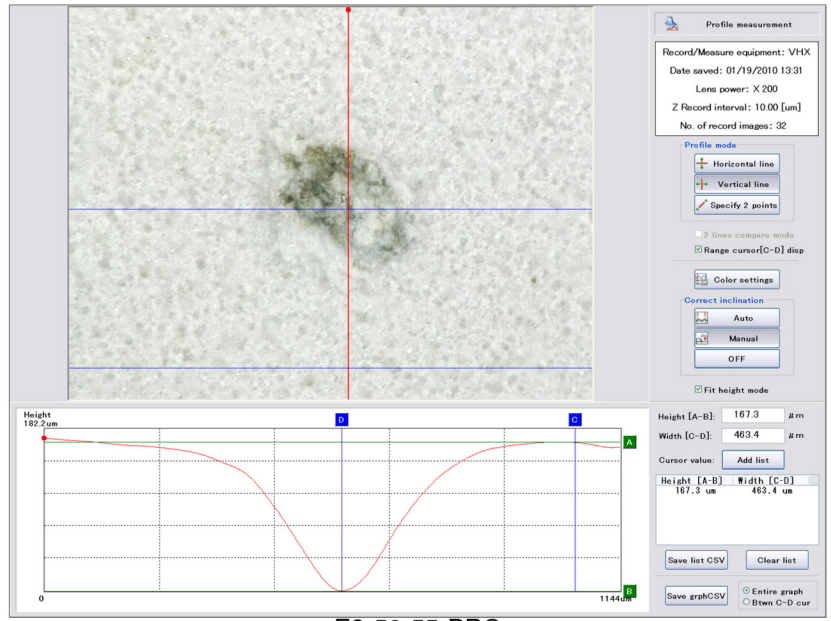
E2-77-98-PRO



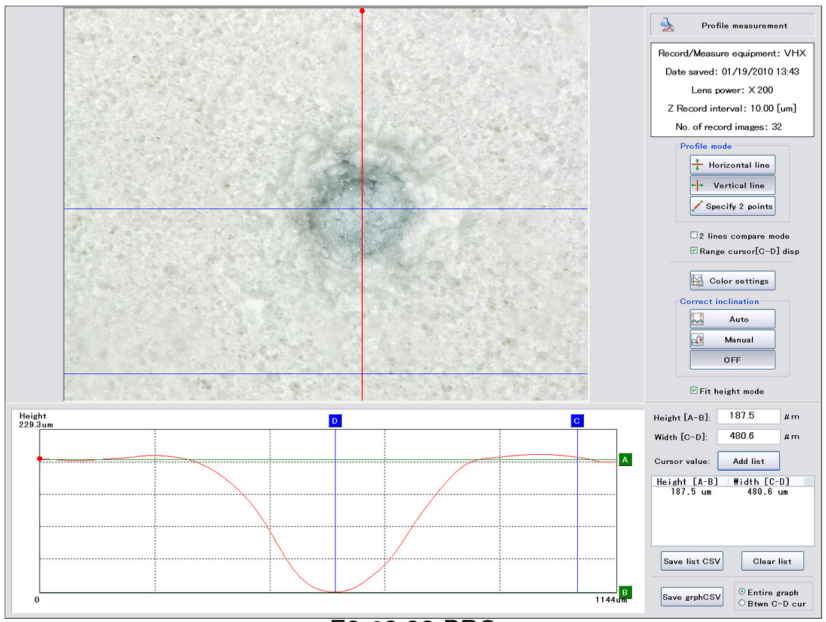
E3-30-34-PRO



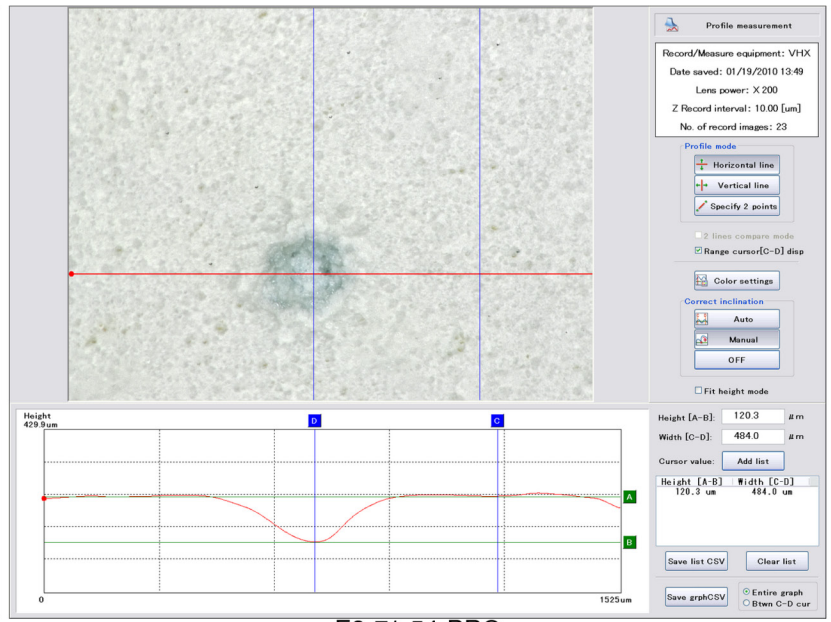
E3-47-56-PRO



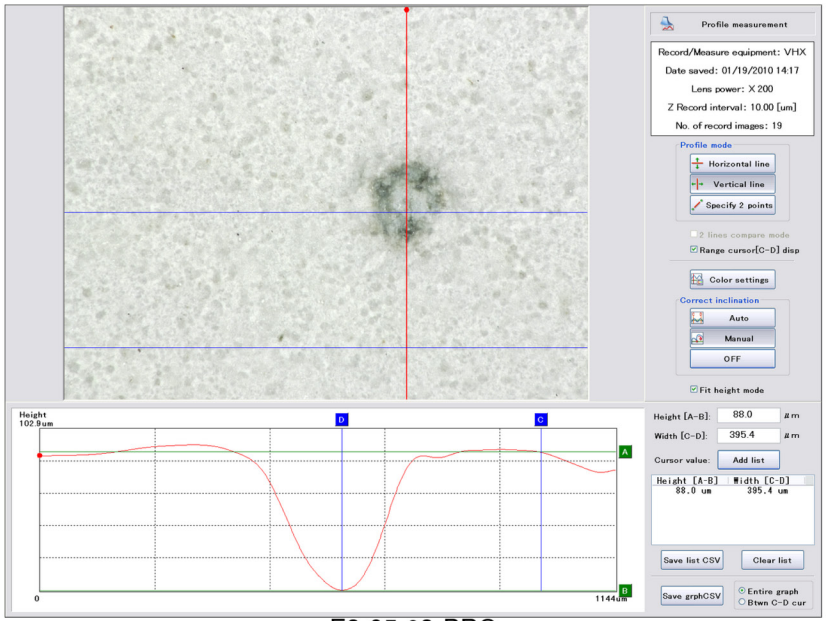
E3-58-55-PRO



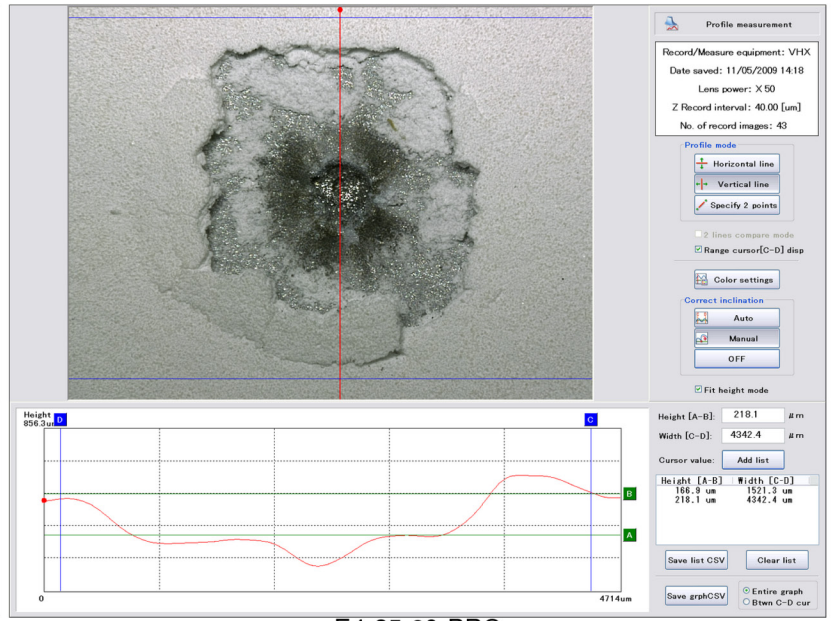
E3-62-32-PRO



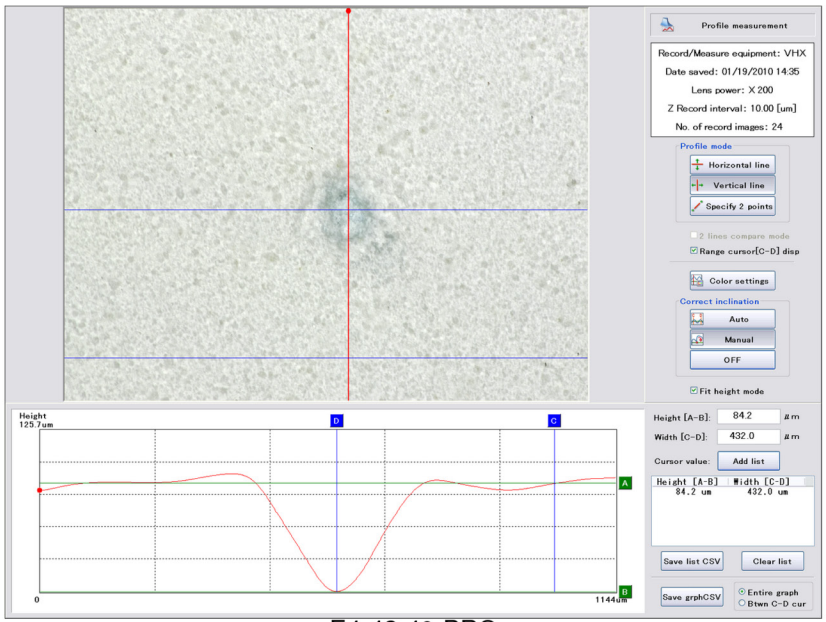
E3-71-54-PRO



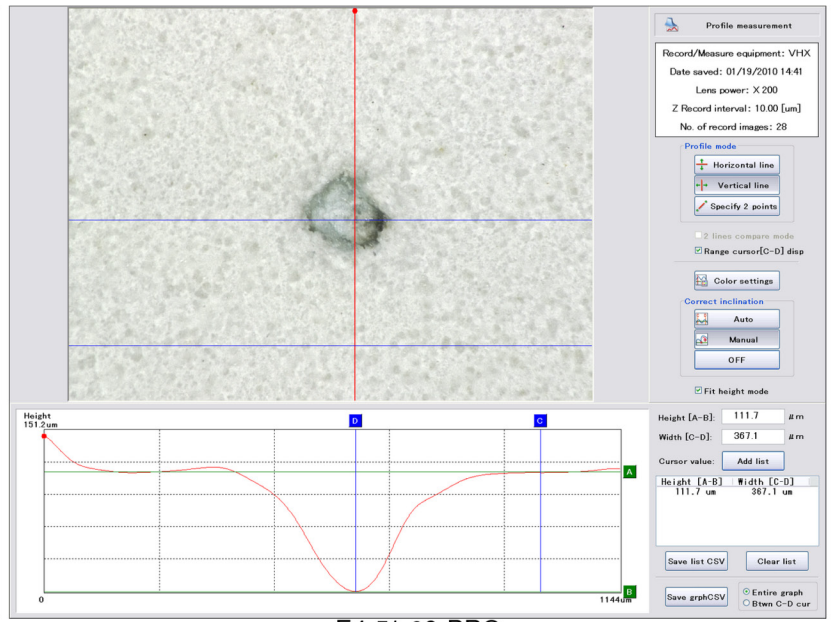
E3-95-03-PRO



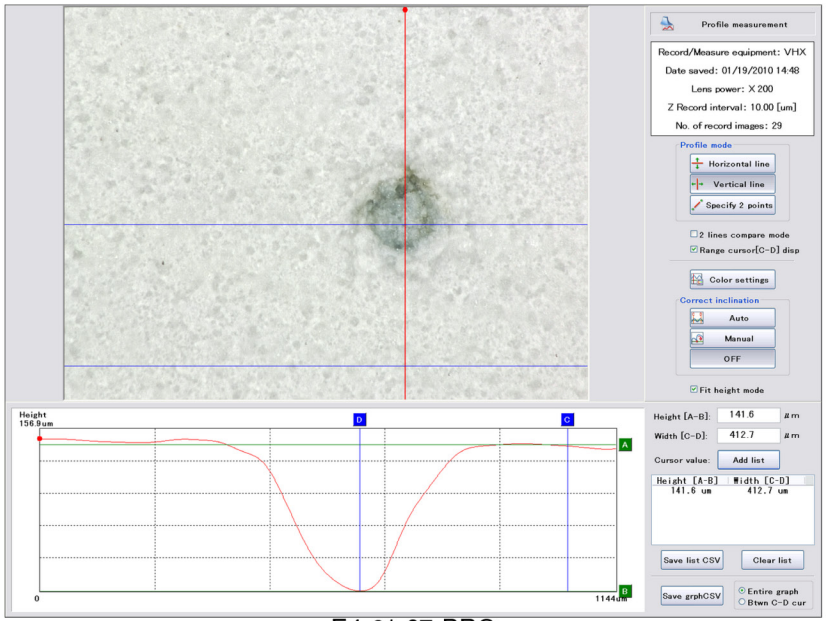
E4-25-89-PRO



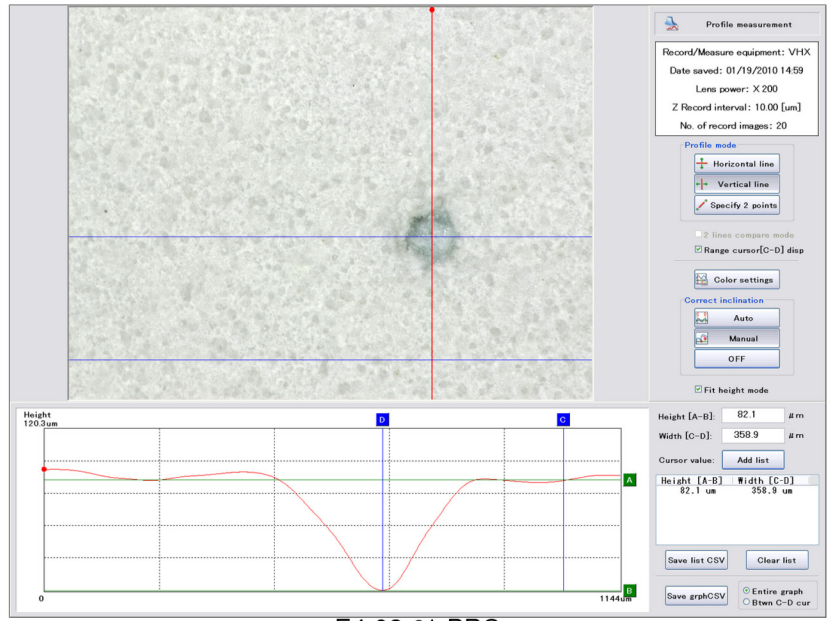
E4-42-40-PRO



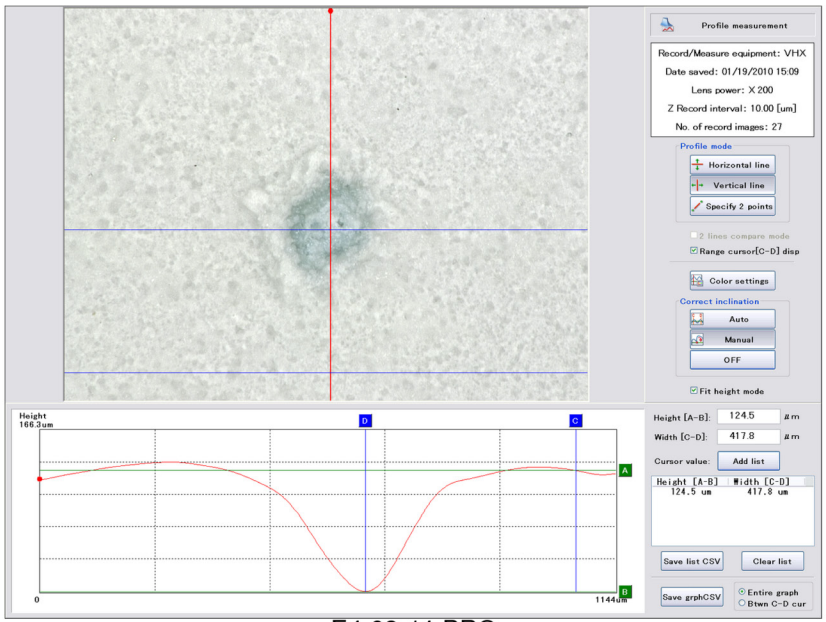
E4-51-09-PRO



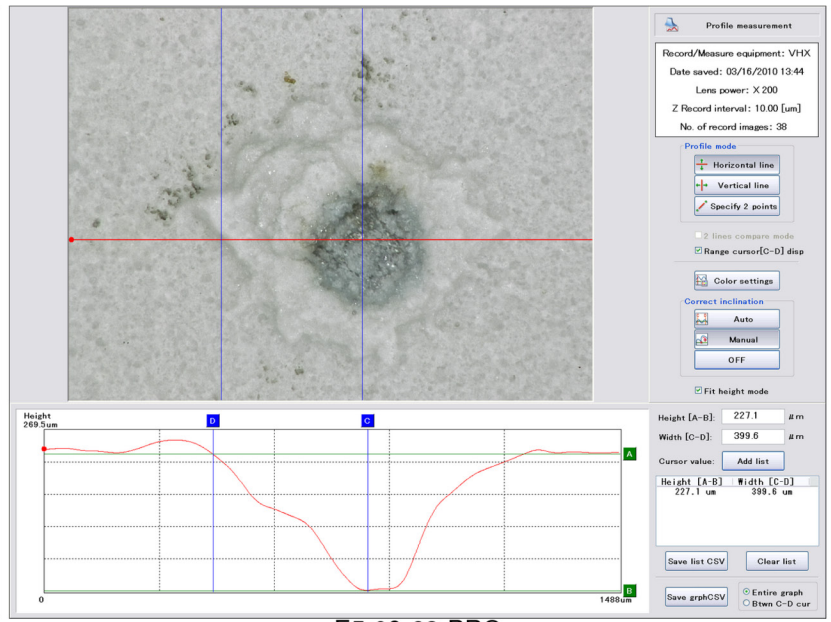
E4-61-97-PRO



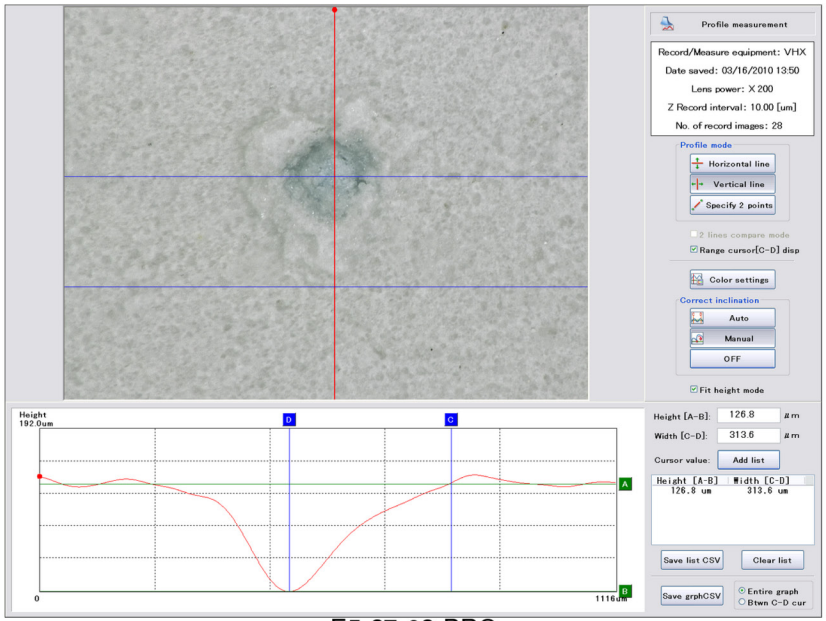
E4-92-61-PRO



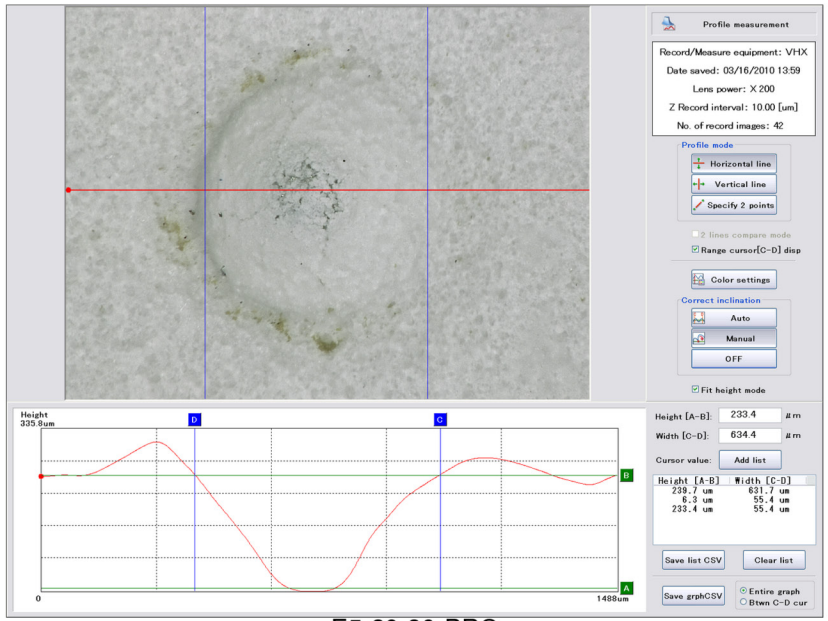
E4-93-14-PRO



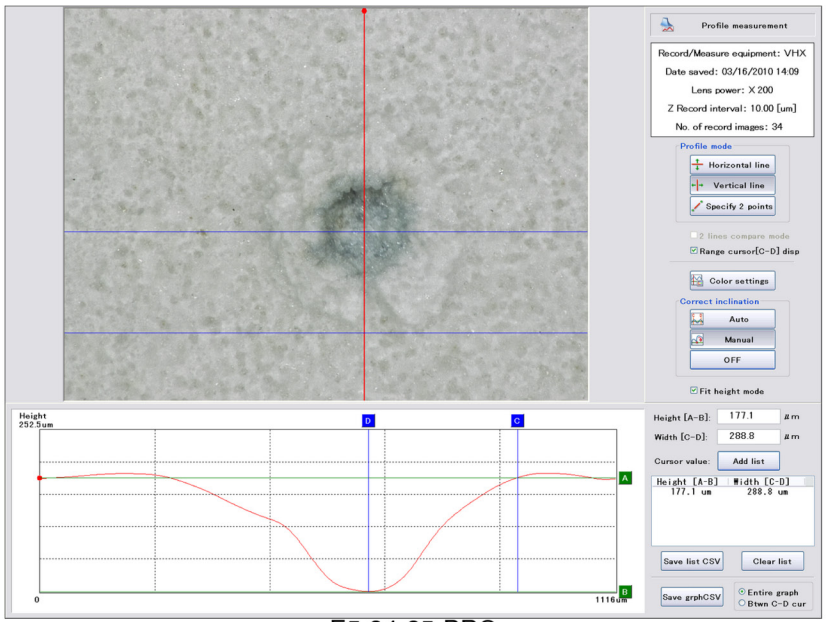
E5-09-68-PRO



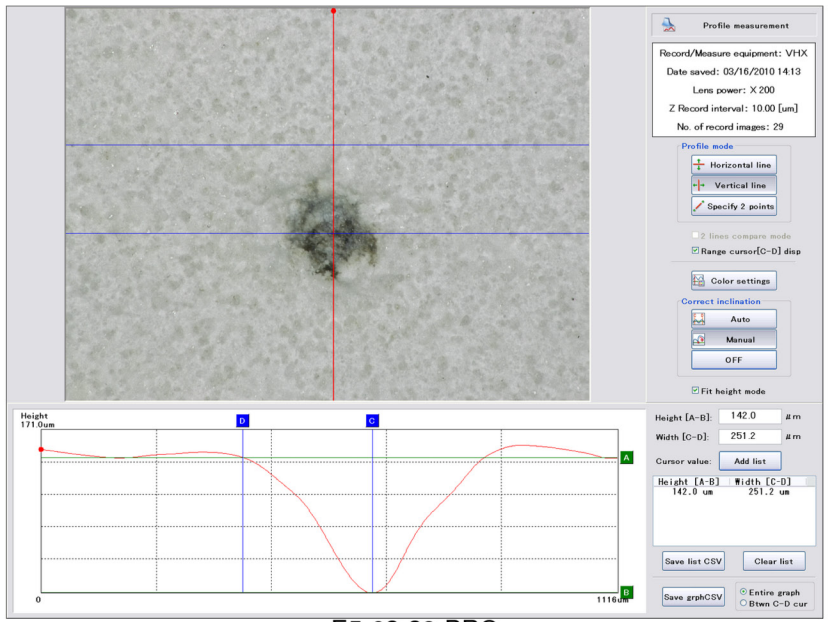
E5-27-62-PRO



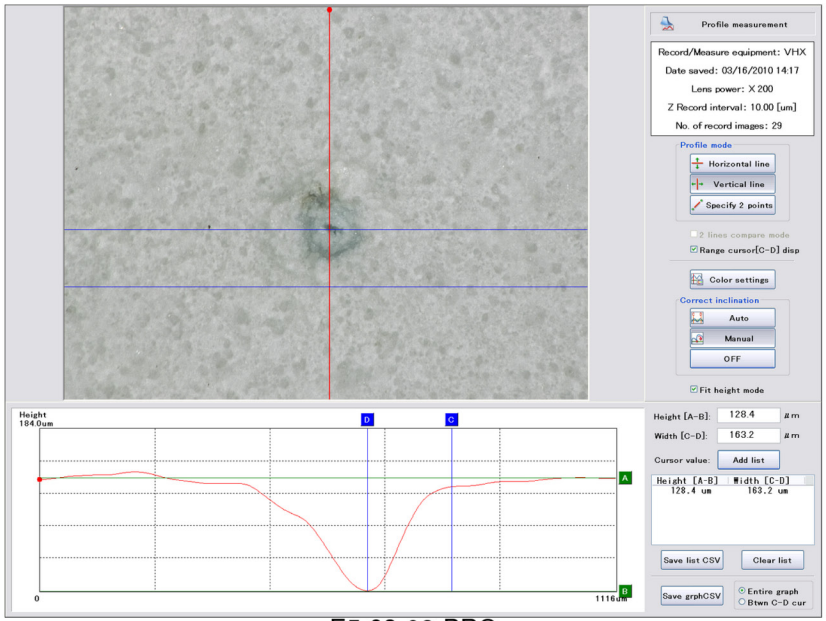
E5-29-39-PRO



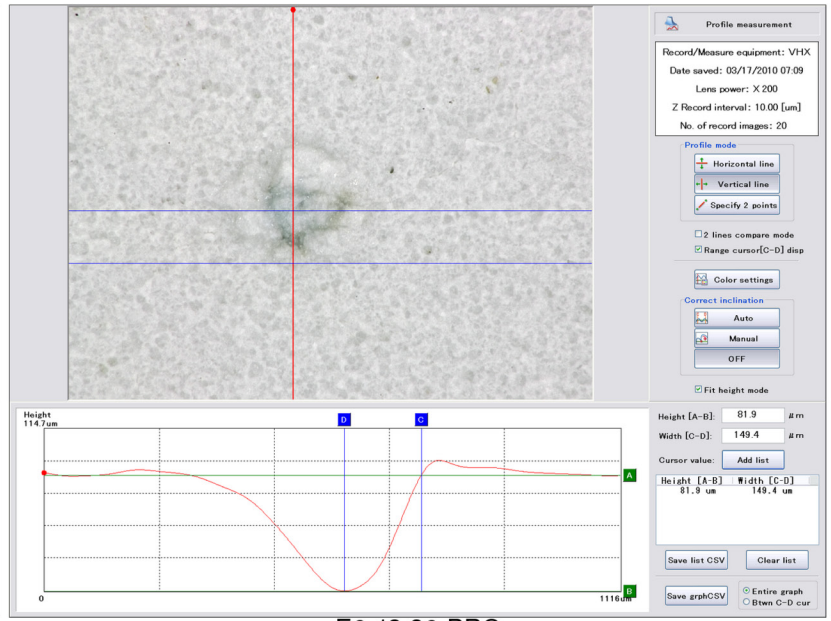
E5-34-25-PRO



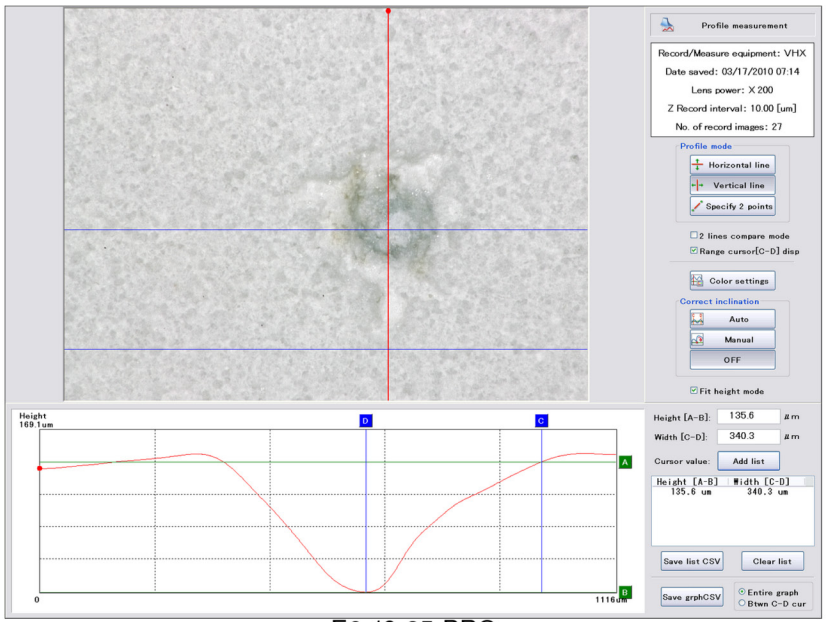
E5-62-28-PRO



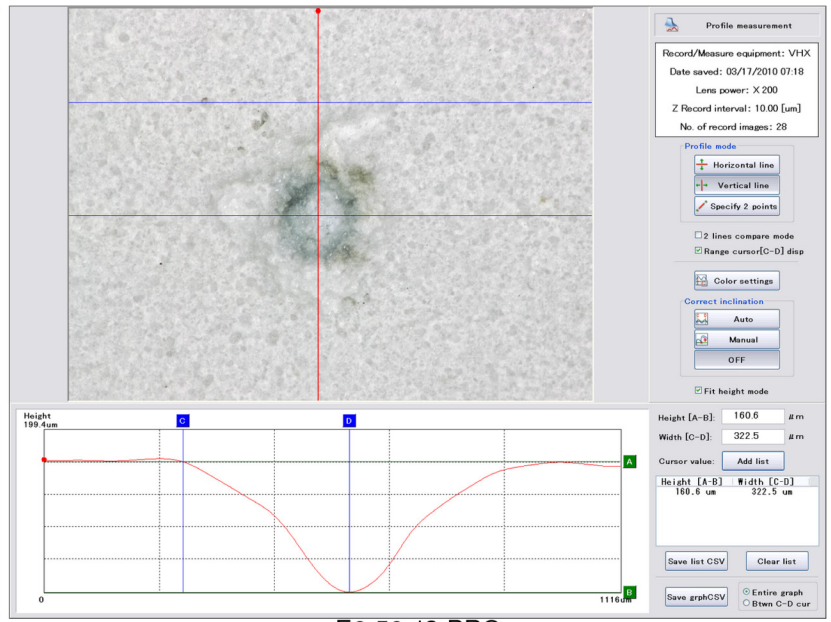
E5-93-08-PRO



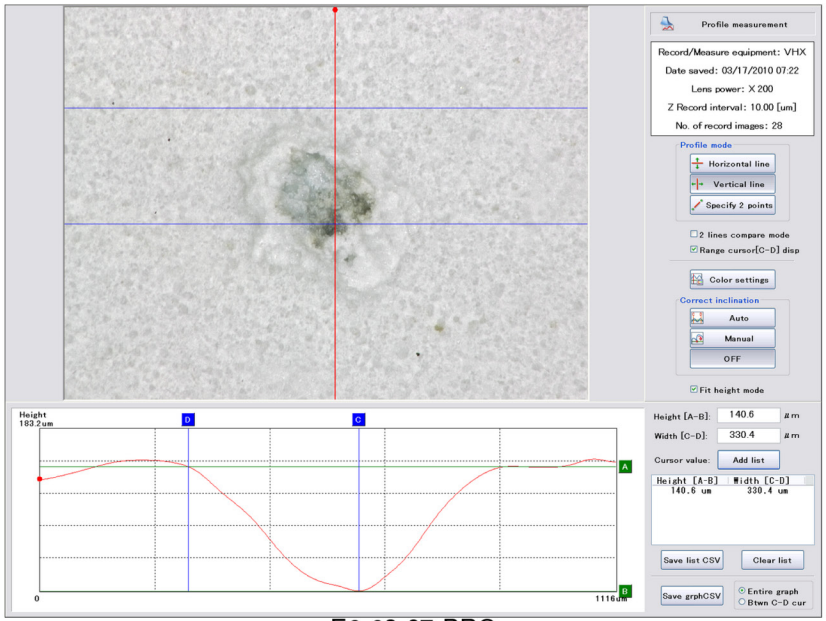
E6-12-36-PRO



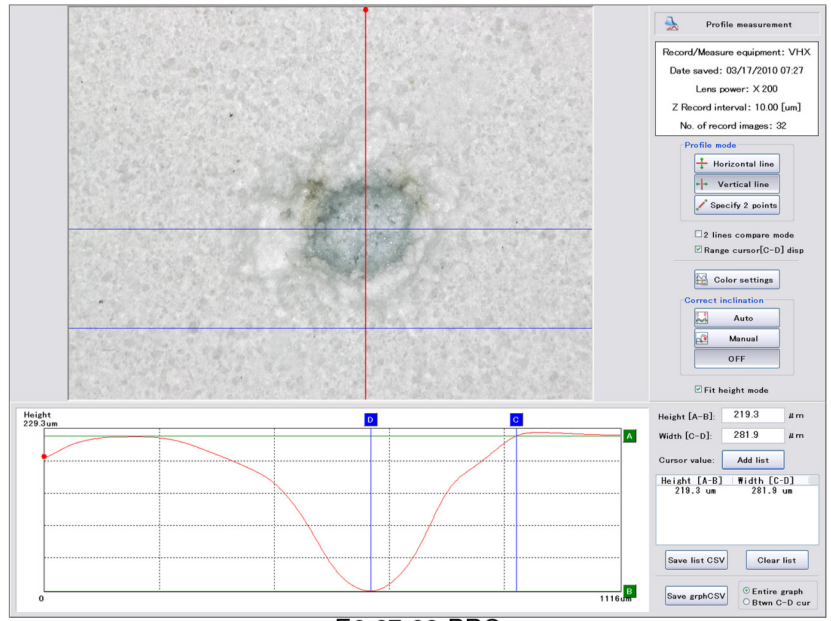
E6-19-85-PRO



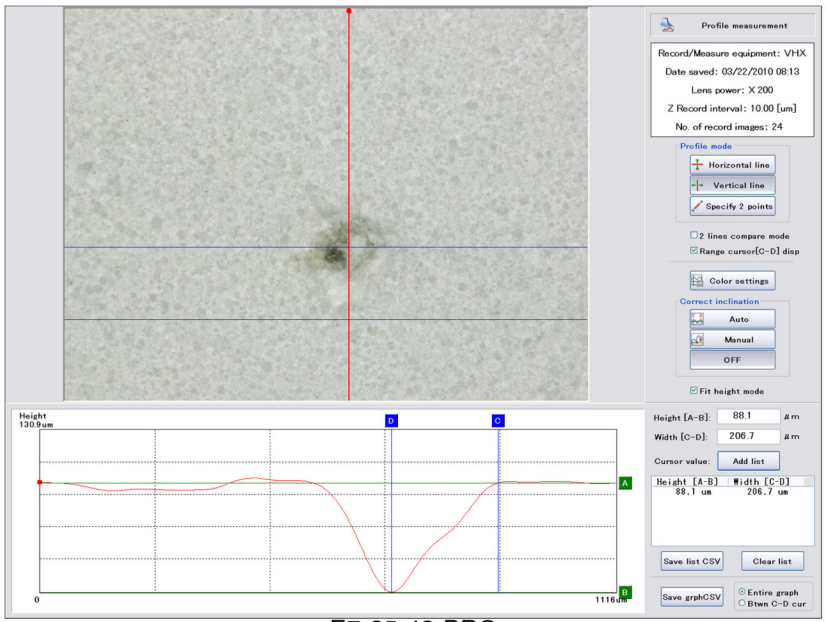
E6-56-12-PRO



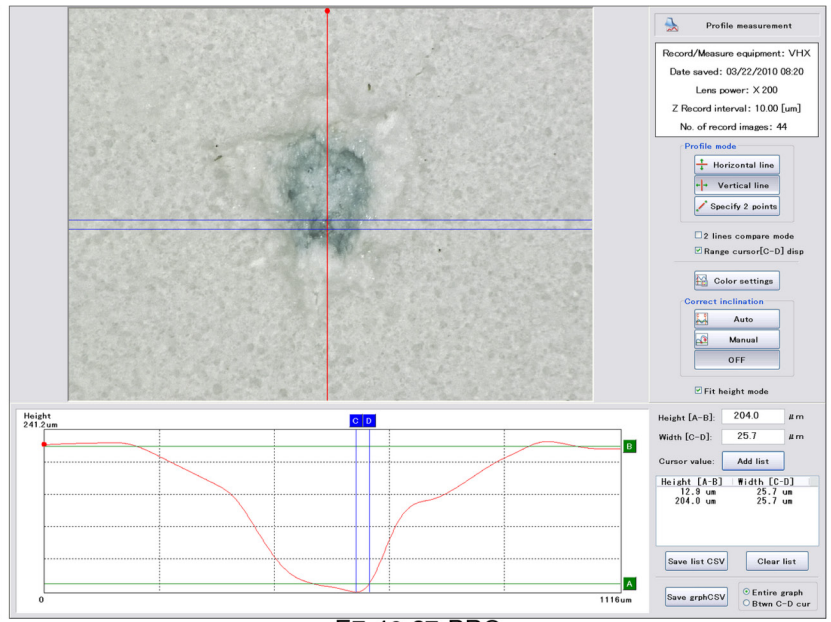
E6-63-97-PRO



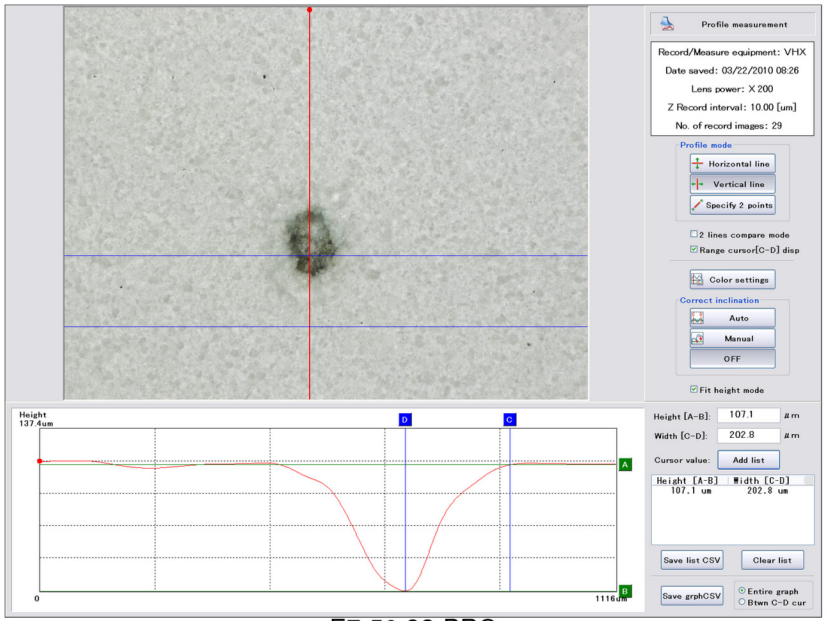
E6-87-88-PRO



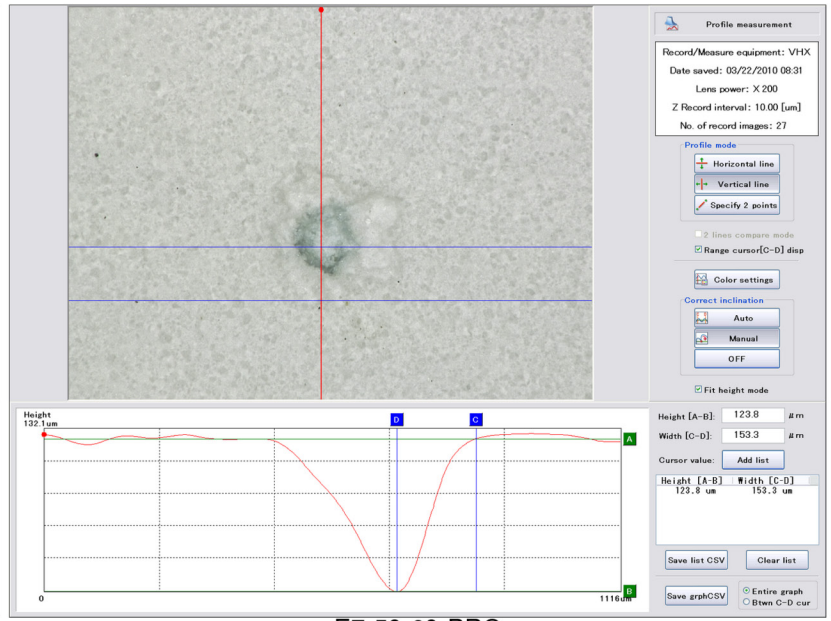
E7-25-42-PRO



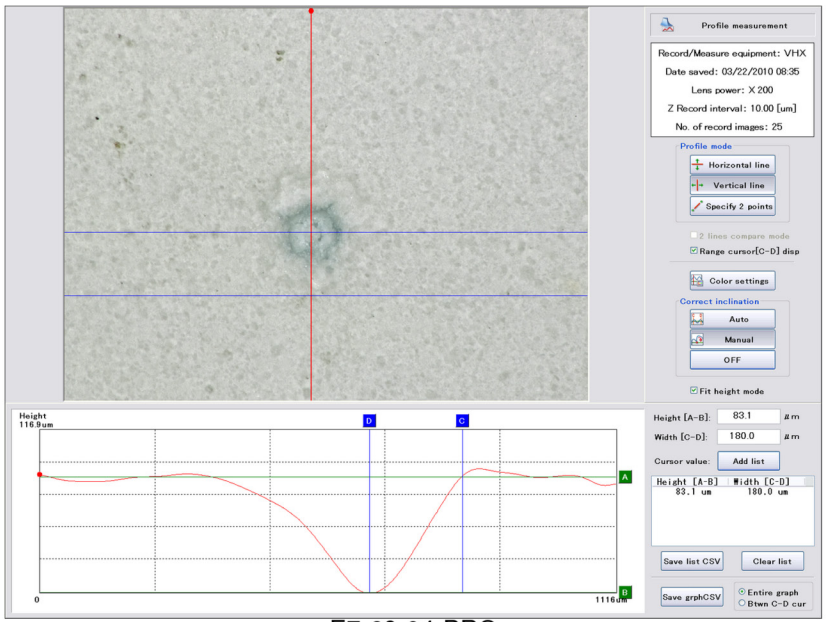
E7-46-27-PRO



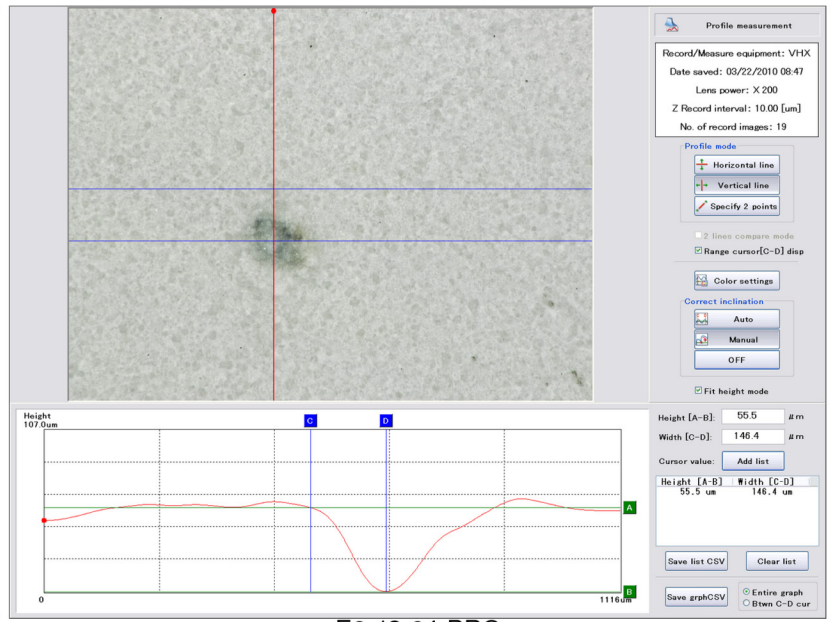
E7-56-32-PRO



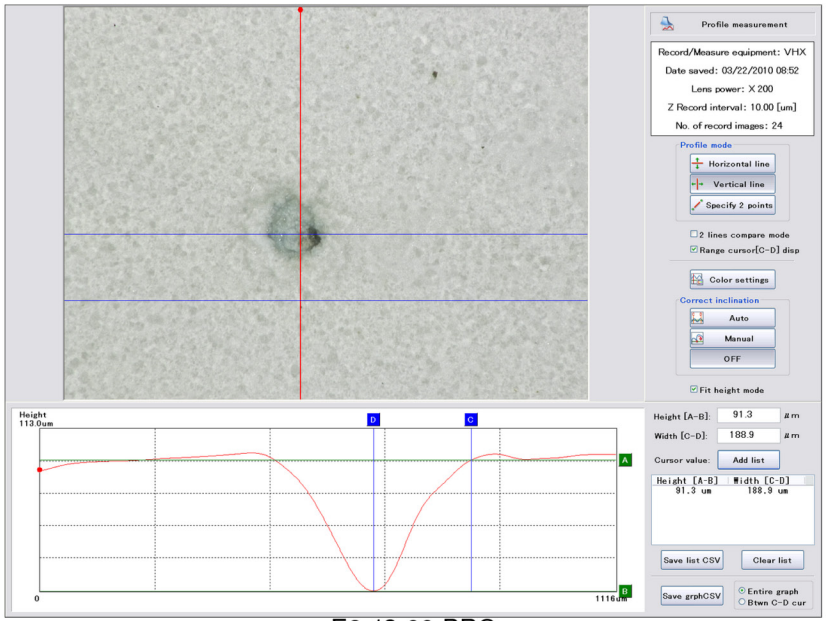
E7-59-69-PRO



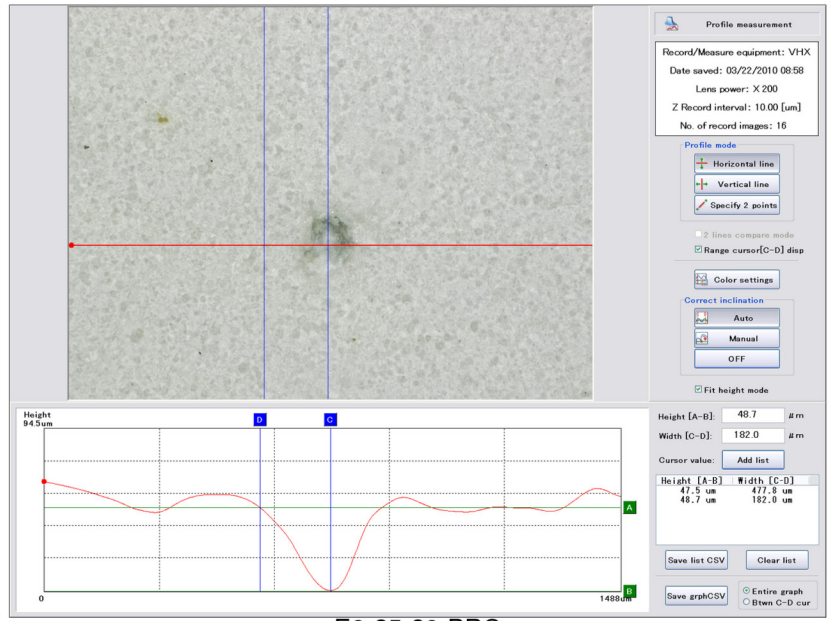
E7-69-04-PRO



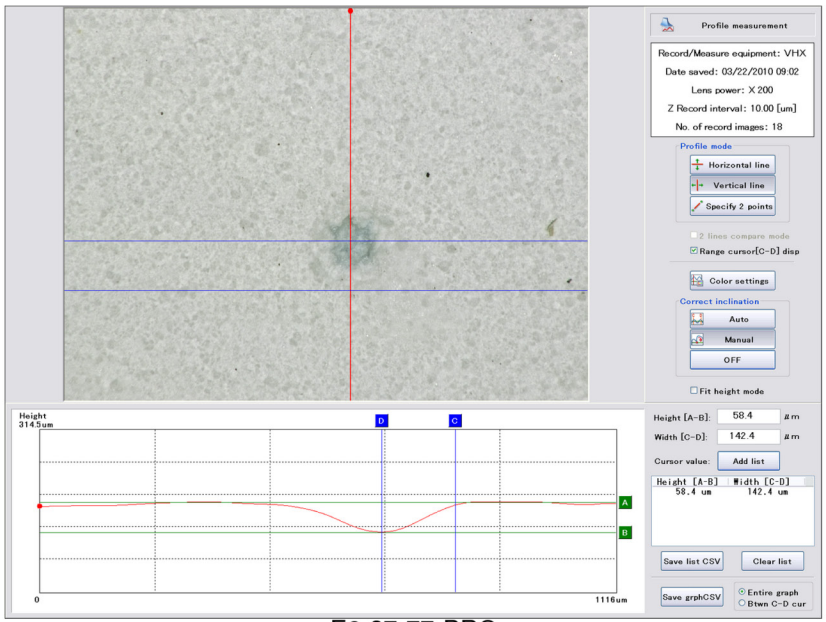
E8-12-64-PRO



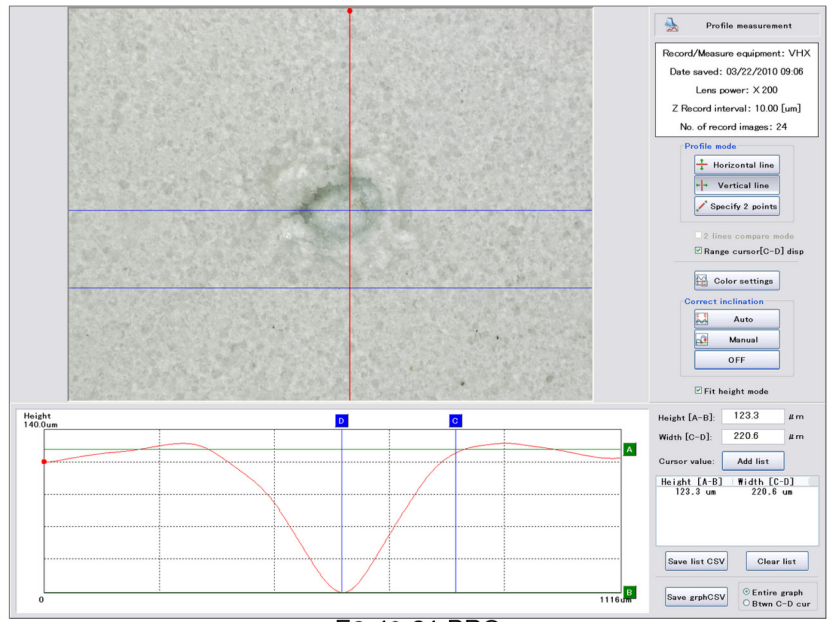
E8-12-66-PRO



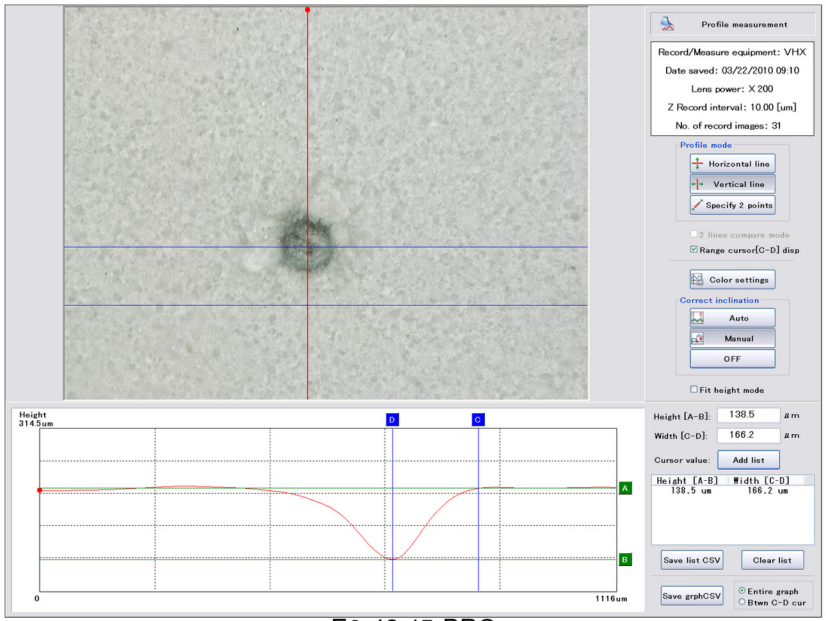
E8-25-28-PRO



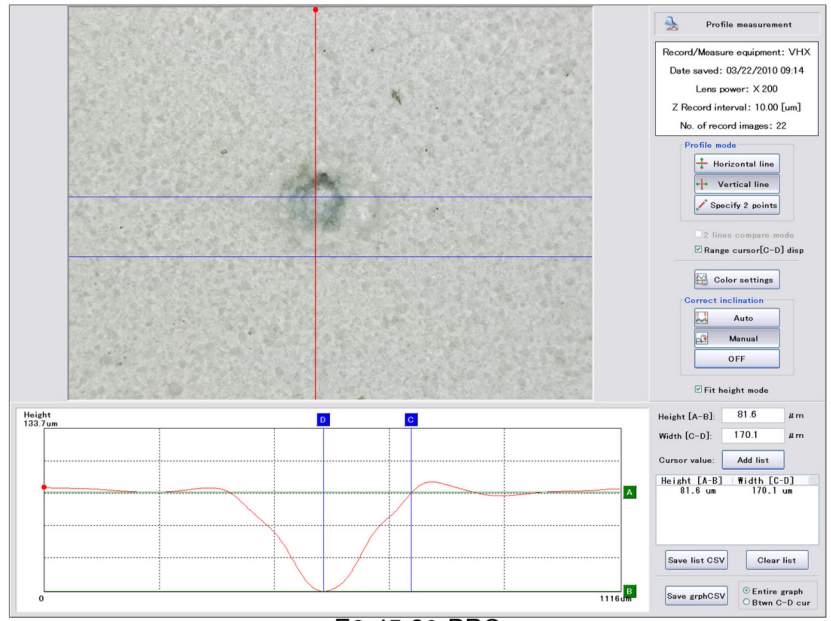
E8-37-77-PRO



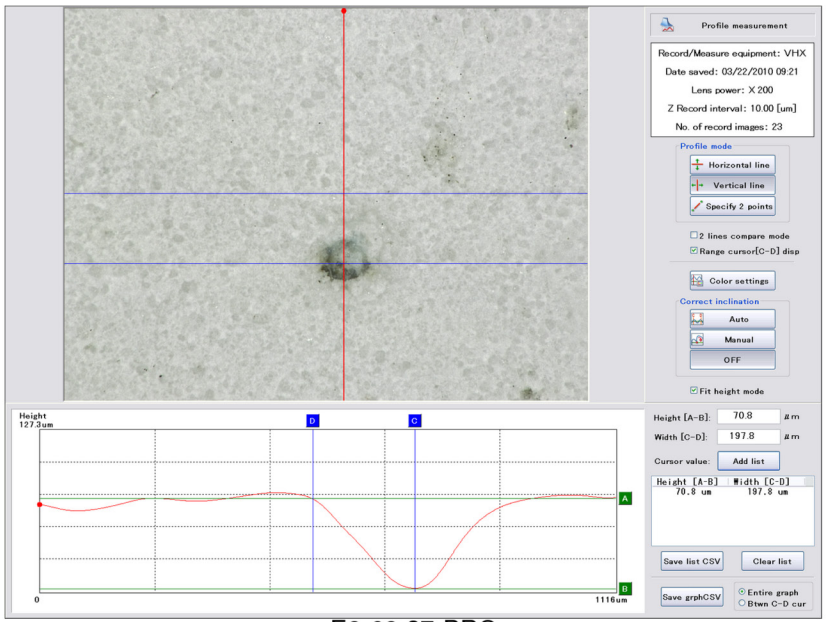
E8-40-24-PRO



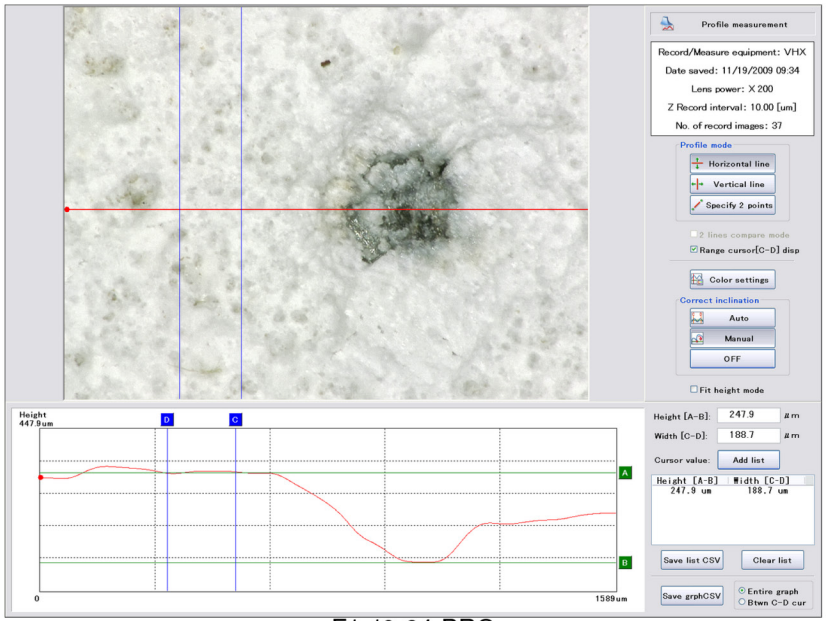
E8-42-15-PRO



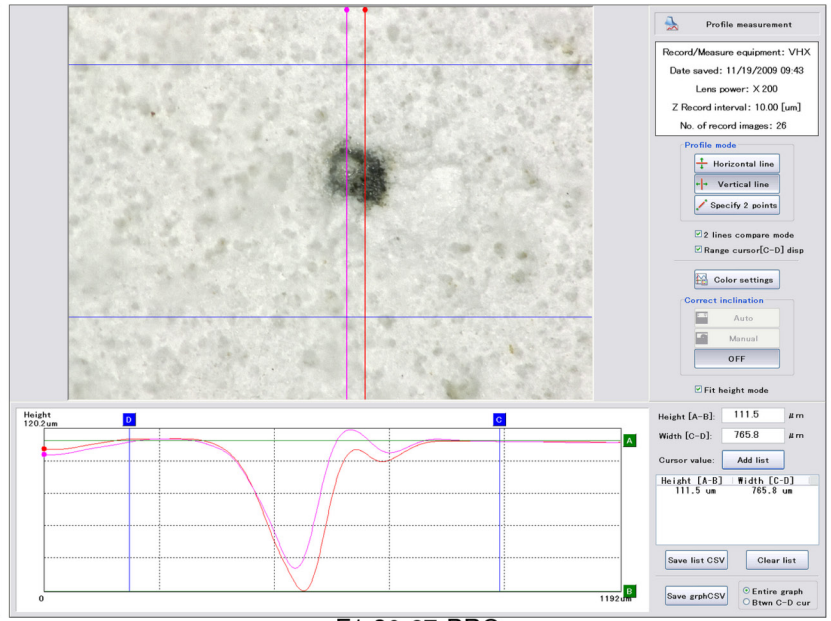
E8-45-30-PRO



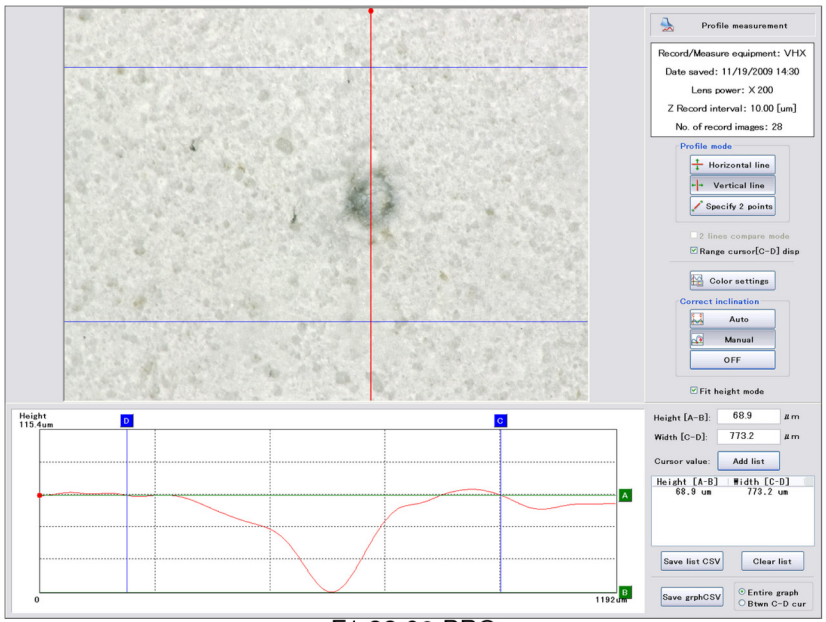
E8-68-37-PRO



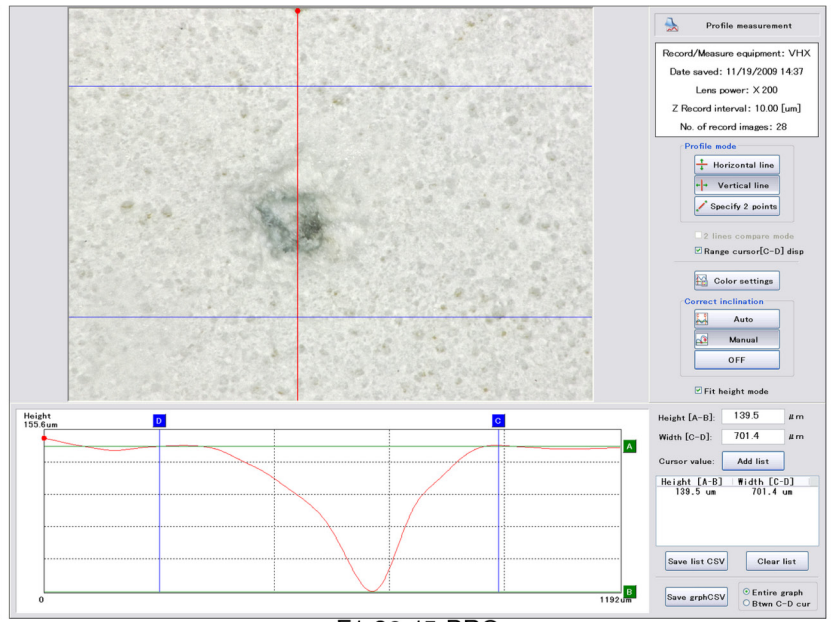
F1-10-64-PRO



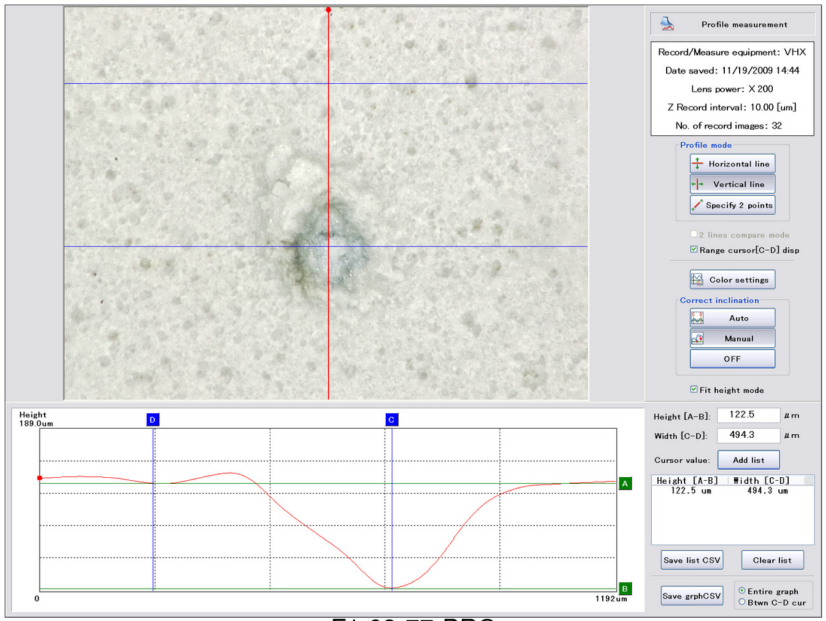
F1-30-87-PRO



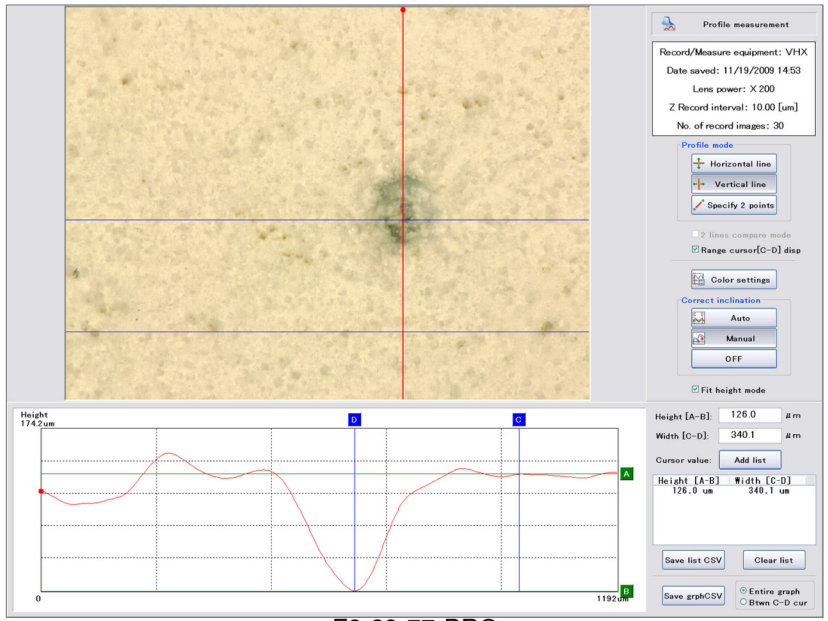
F1-32-96-PRO



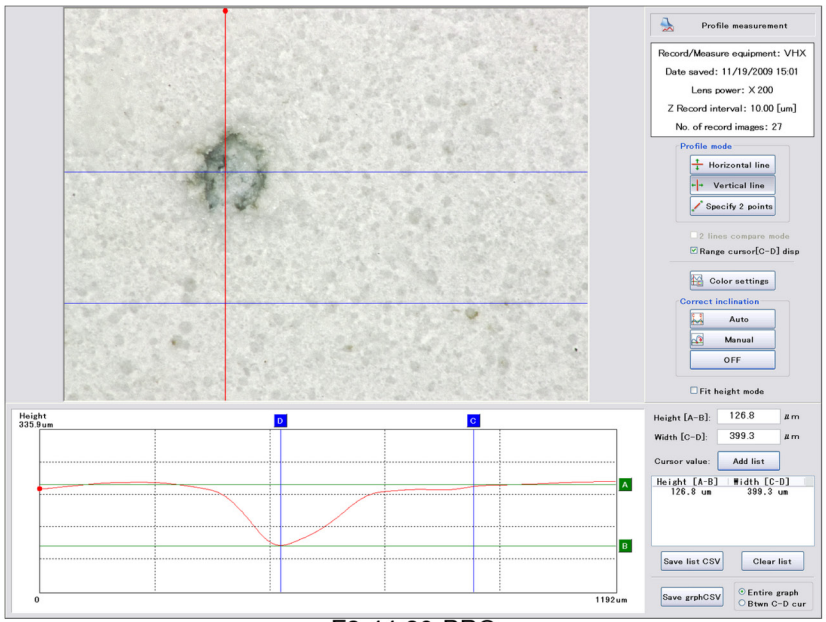
F1-38-15-PRO



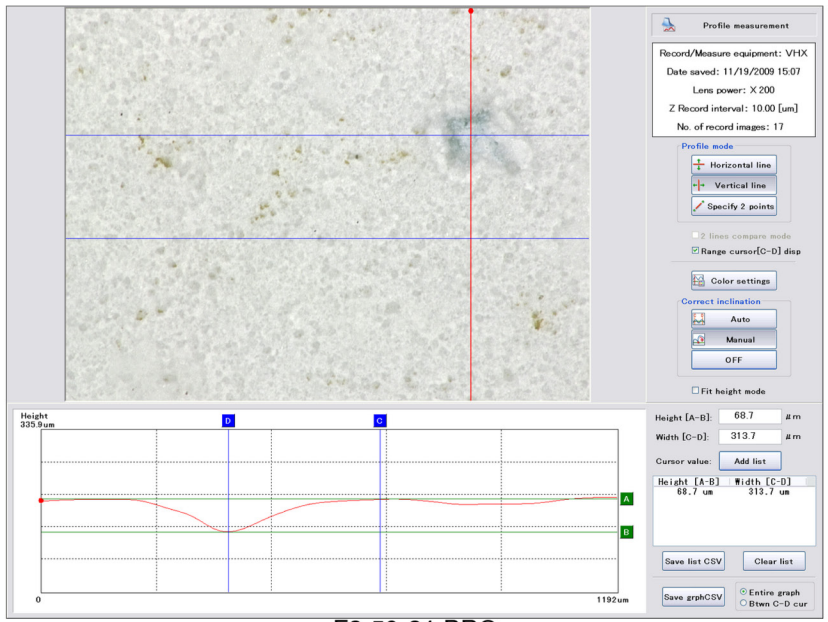
F1-93-77-PRO



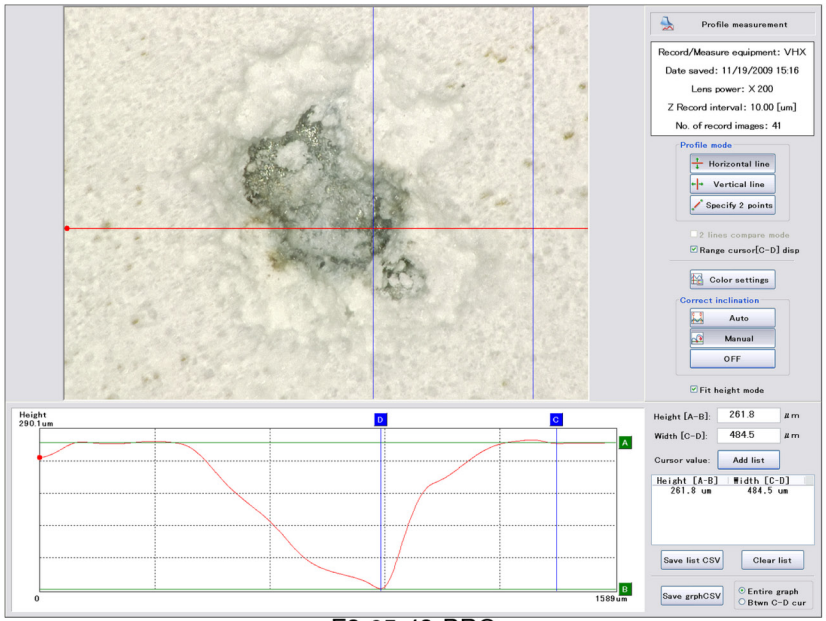
F2-23-77-PRO



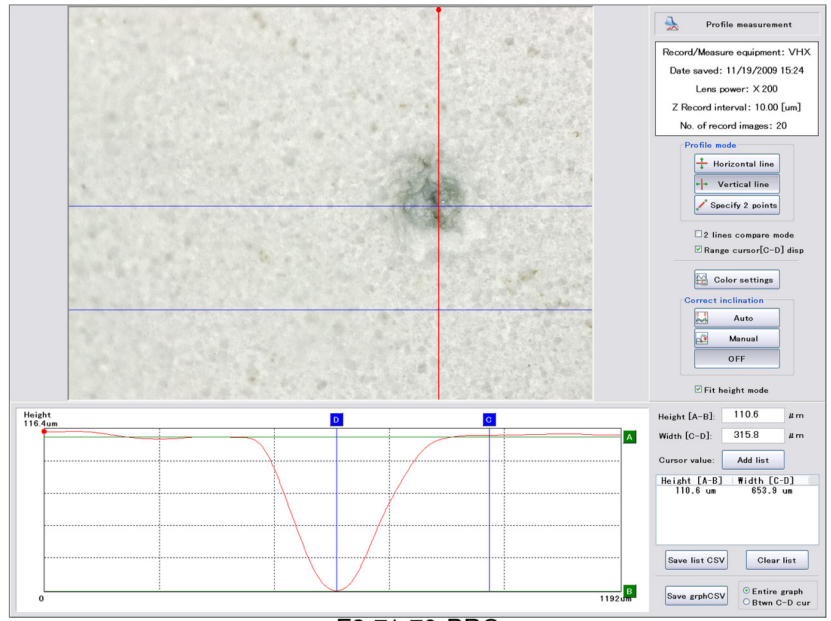
F2-44-39-PRO



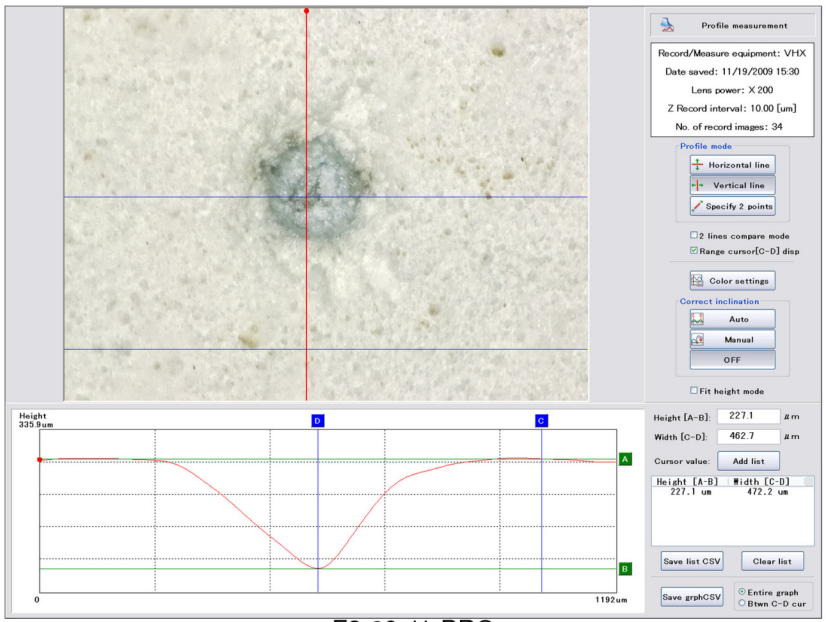
F2-59-24-PRO



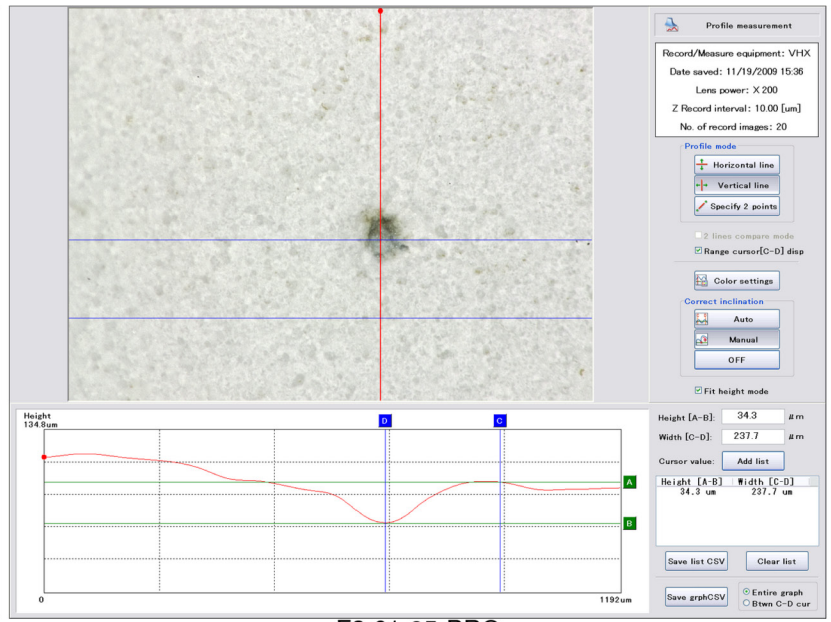
F2-65-43-PRO



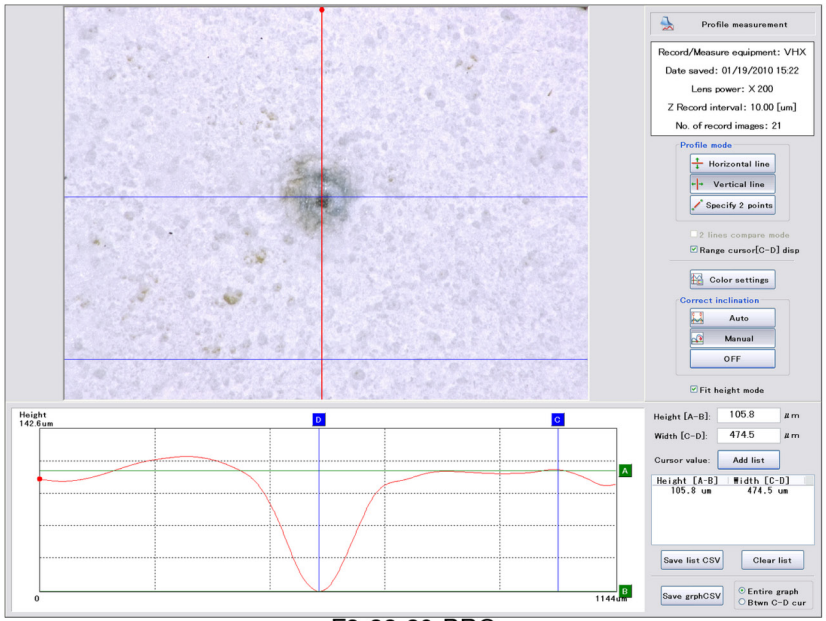
F2-71-79-PRO



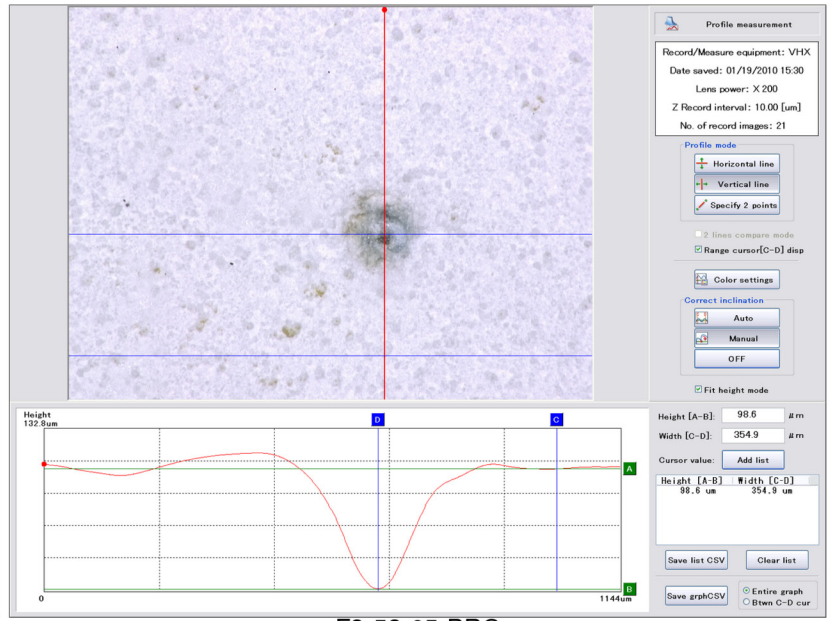
F2-89-11-PRO



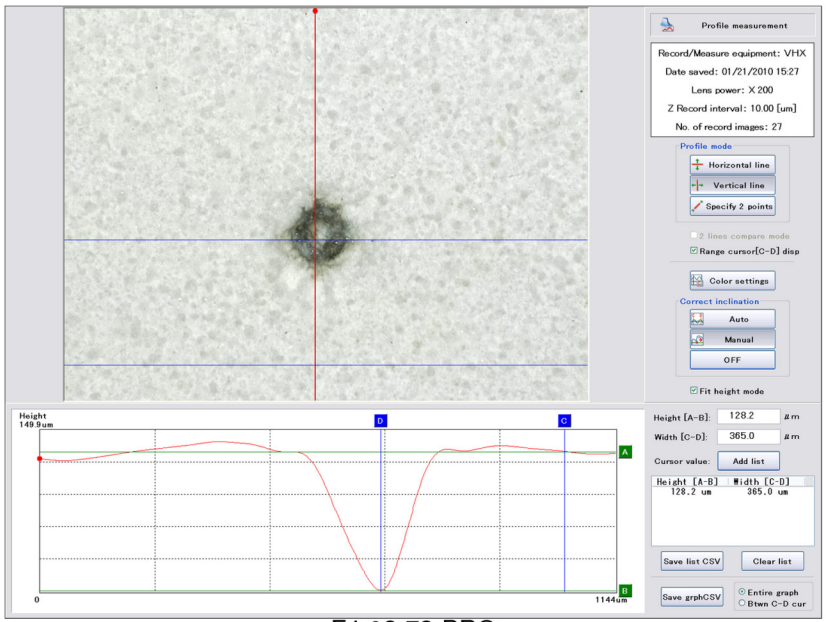
F2-91-85-PRO



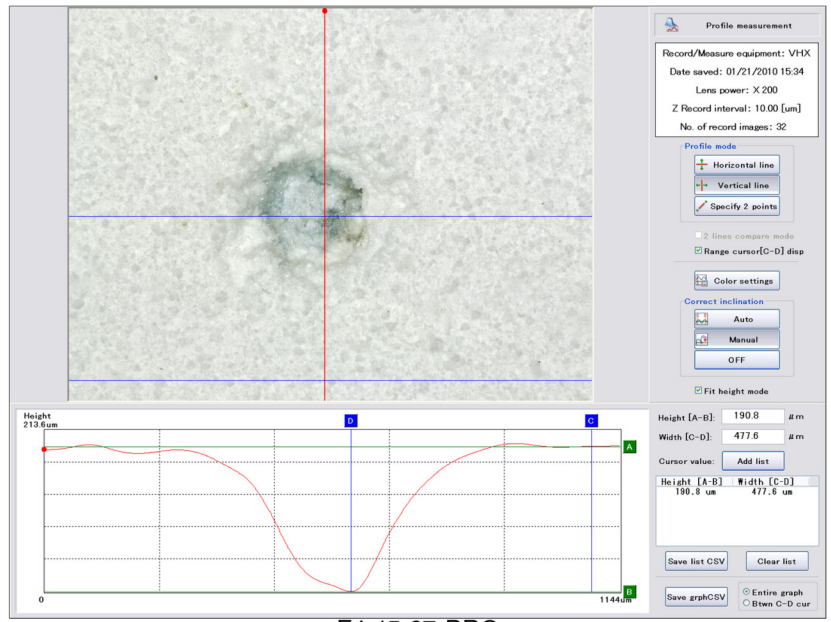
F3-22-29-PRO



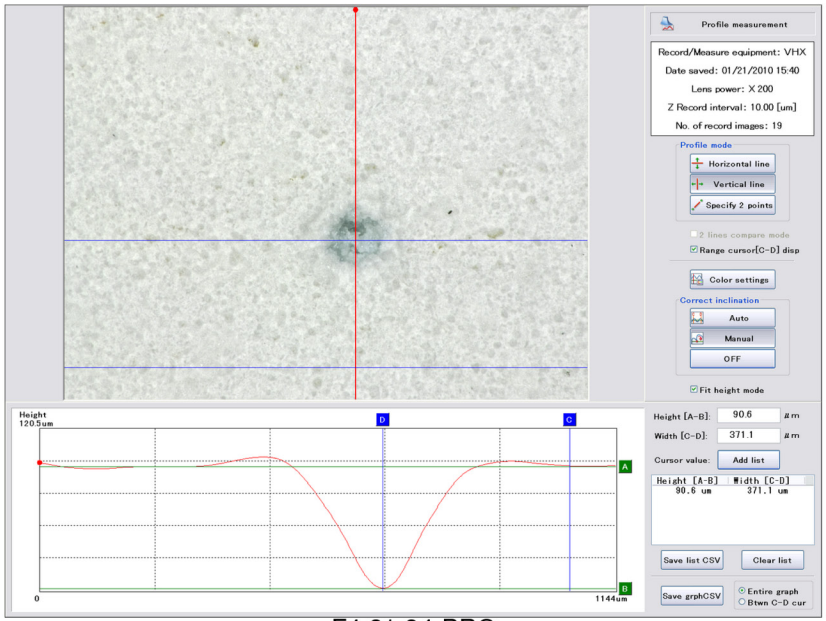
F3-52-65-PRO



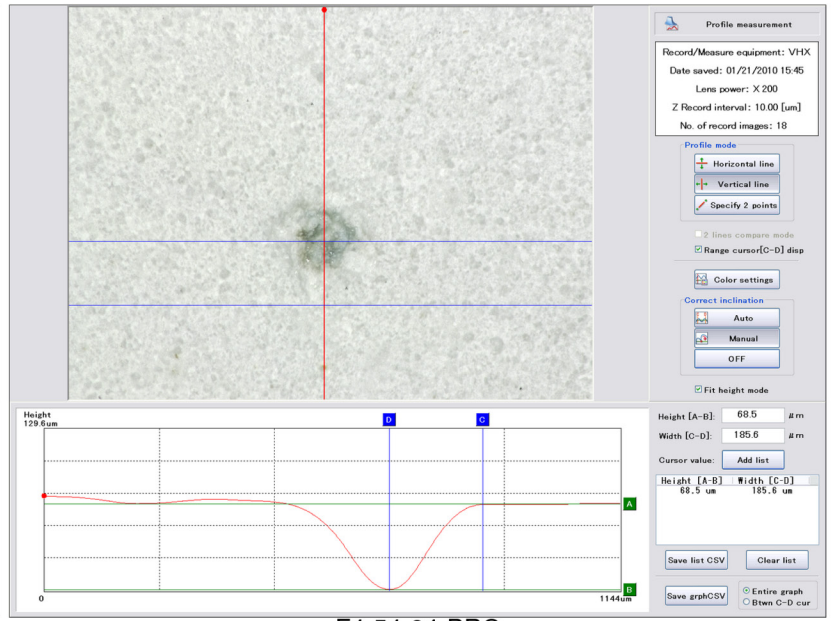
F4-02-72-PRO



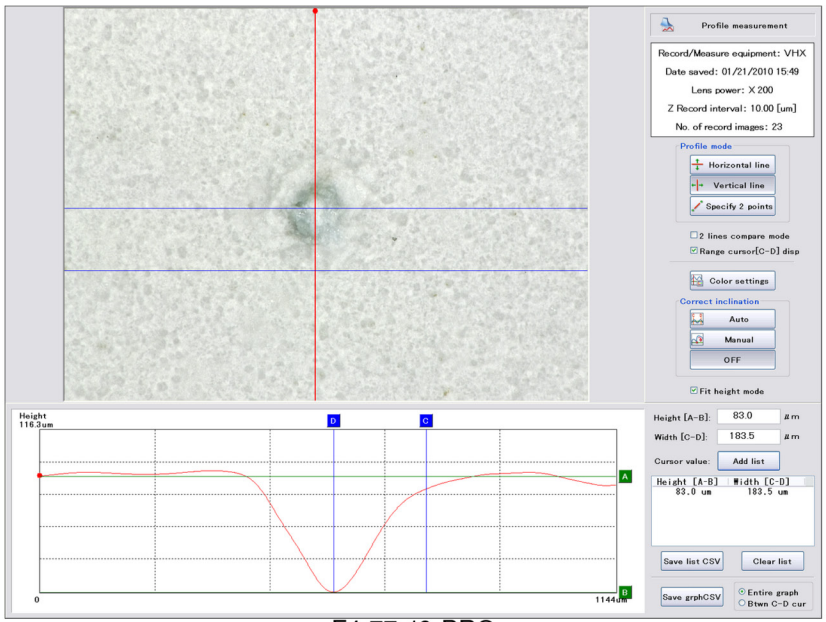
F4-15-97-PRO



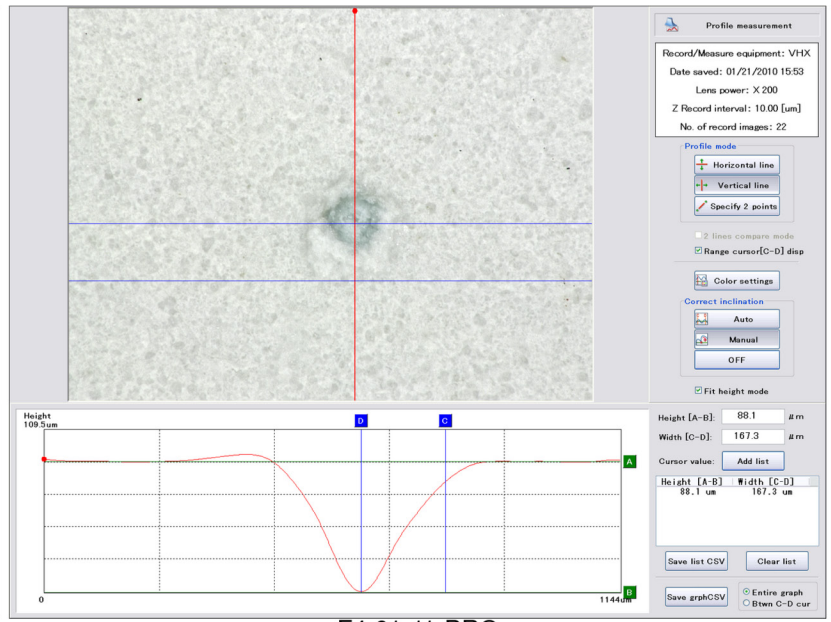
F4-31-34-PRO



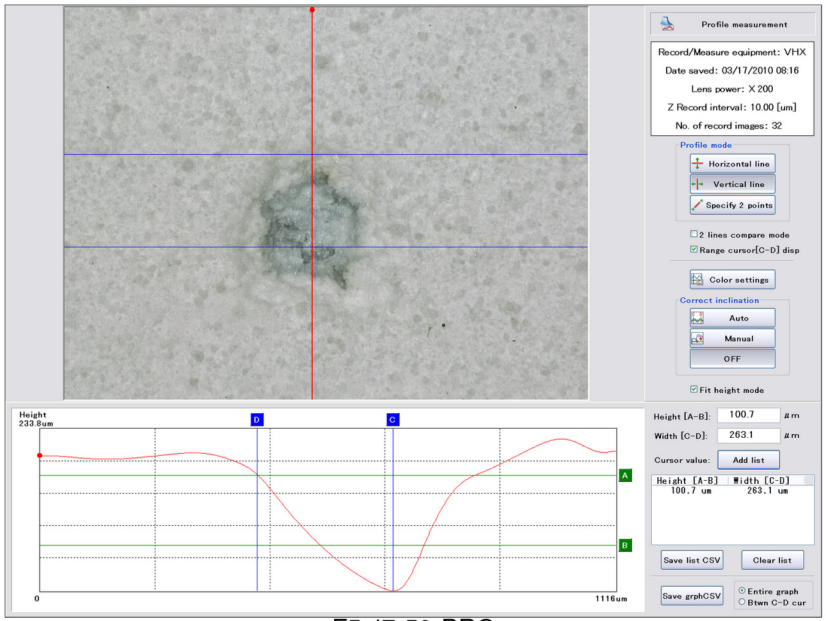
F4-54-84-PRO



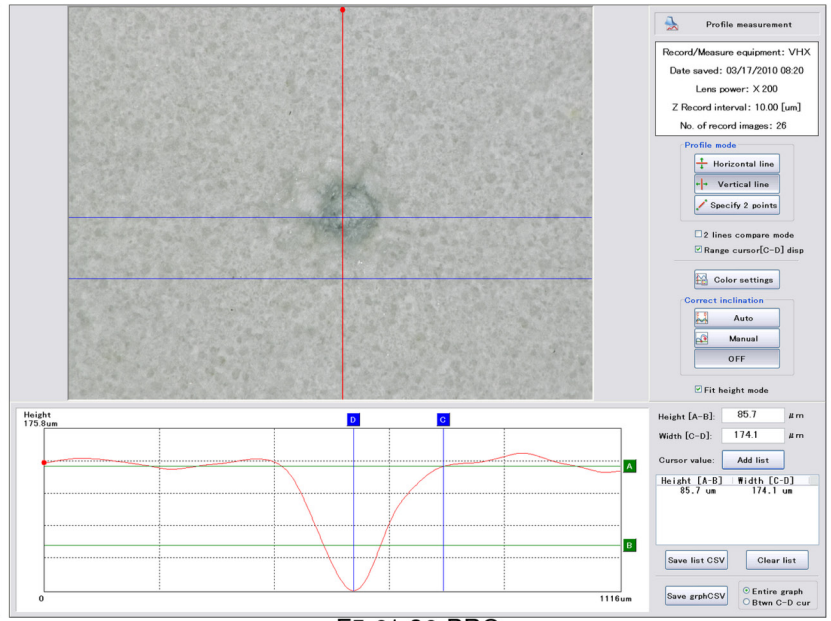
F4-77-19-PRO



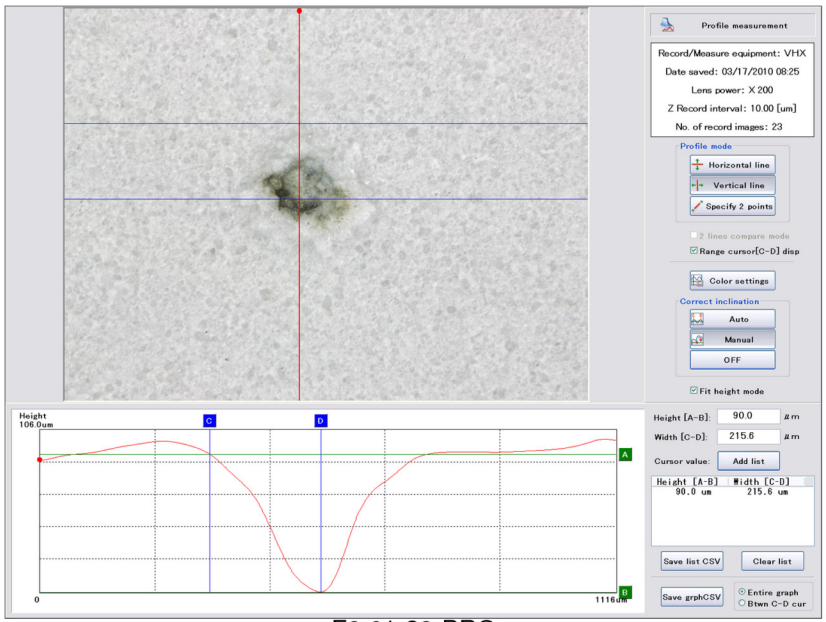
F4-91-11-PRO



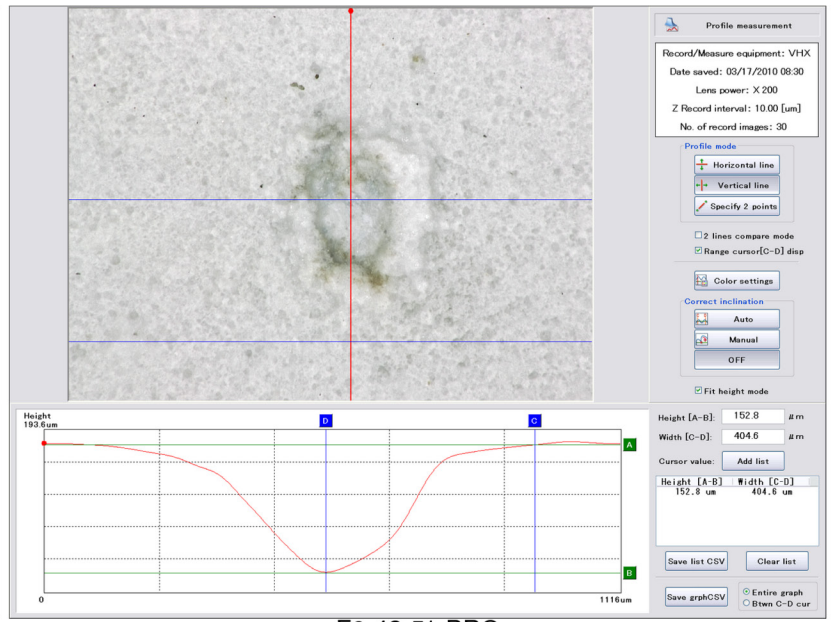
F5-17-50-PRO



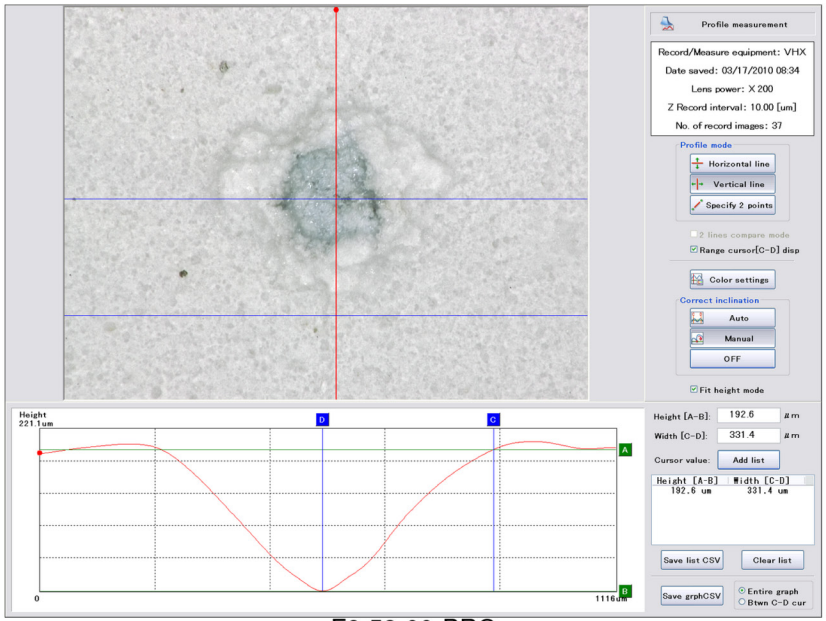
F5-61-36-PRO



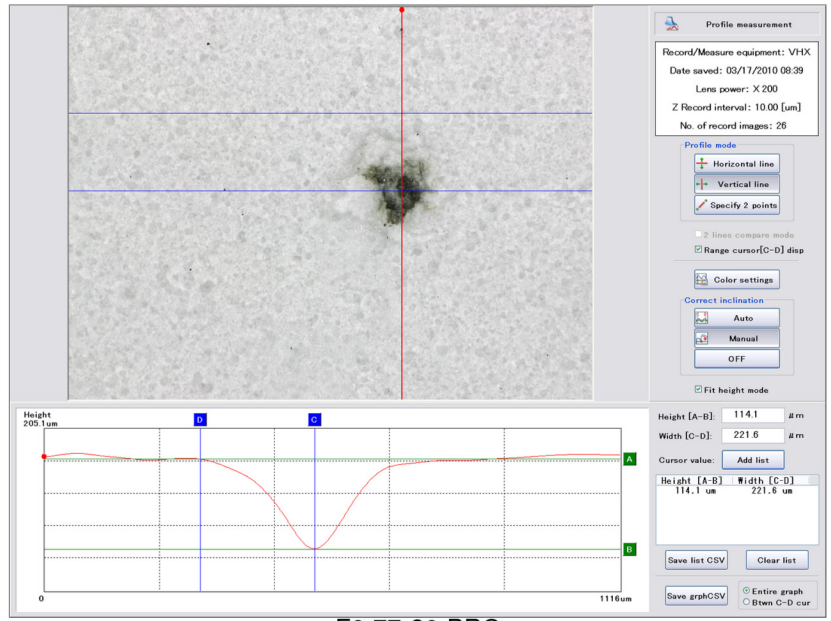
F6-01-28-PRO



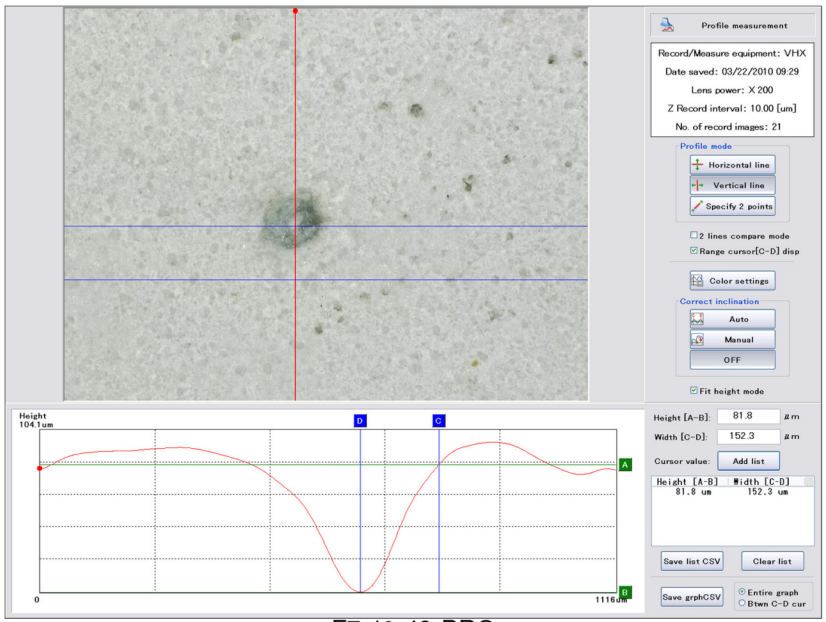
F6-42-51-PRO



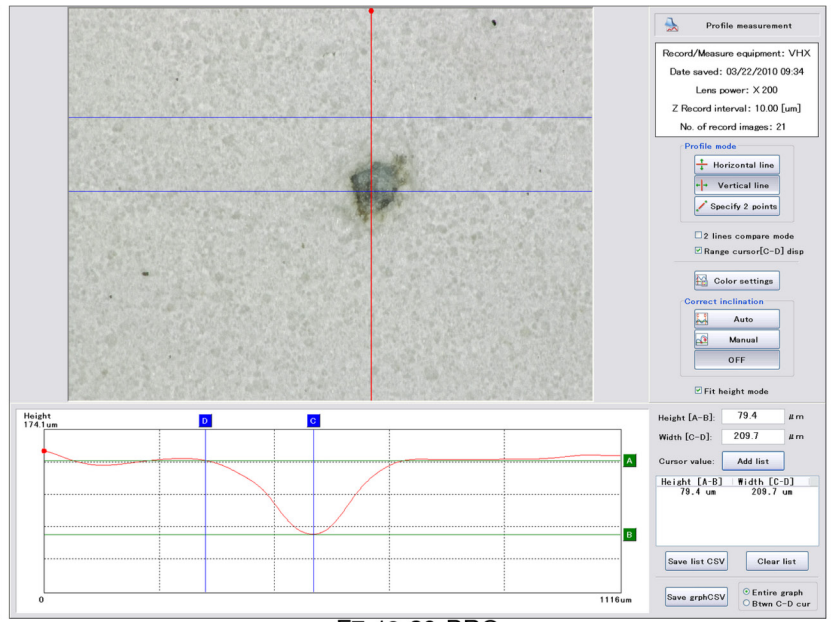
F6-58-00-PRO



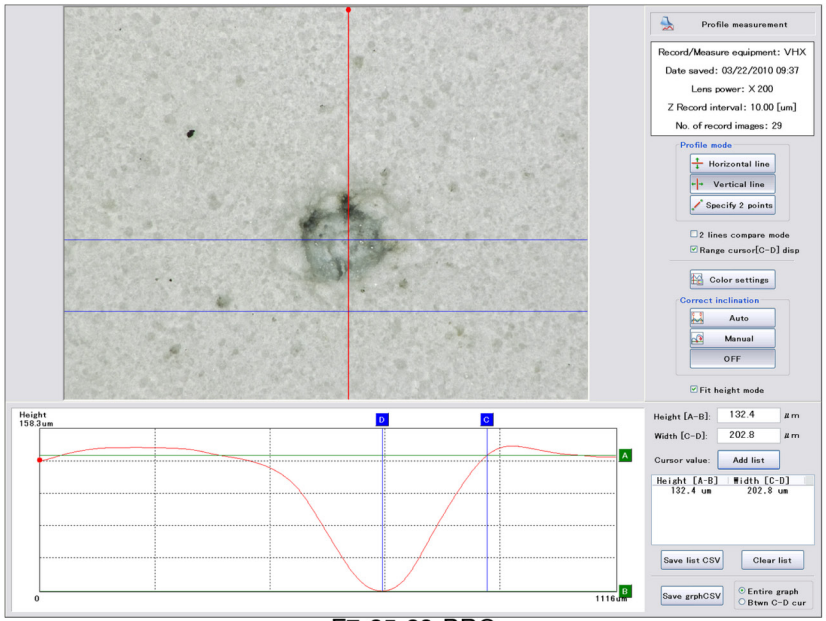
F6-77-26-PRO



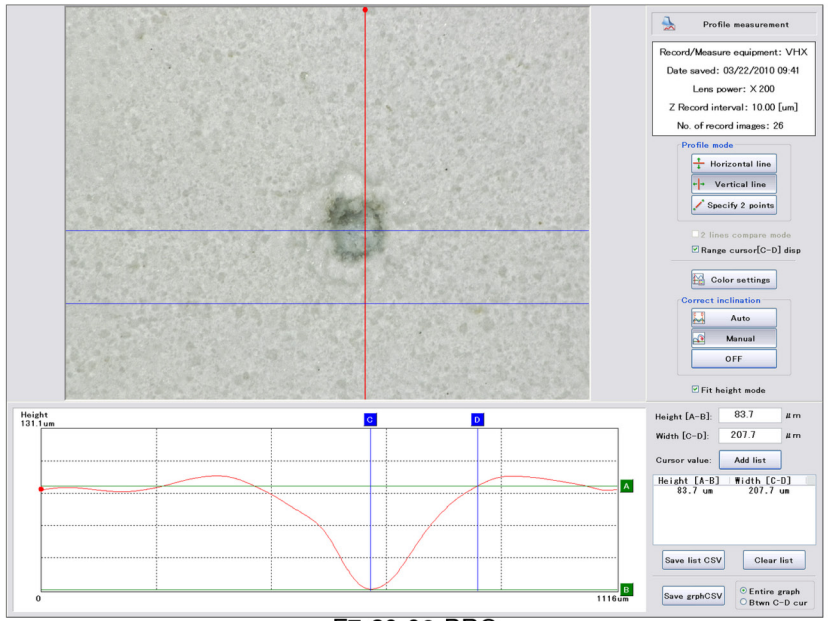
F7-10-49-PRO



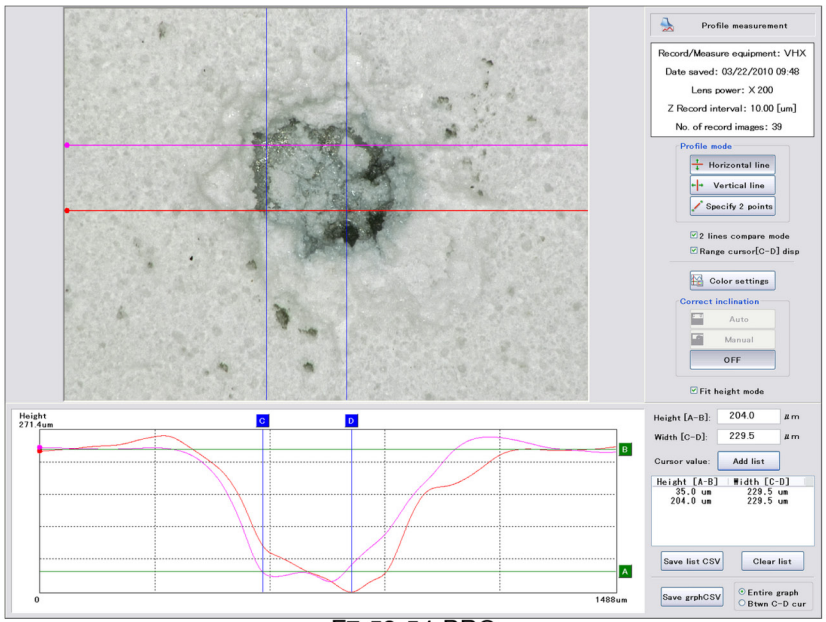
F7-18-29-PRO



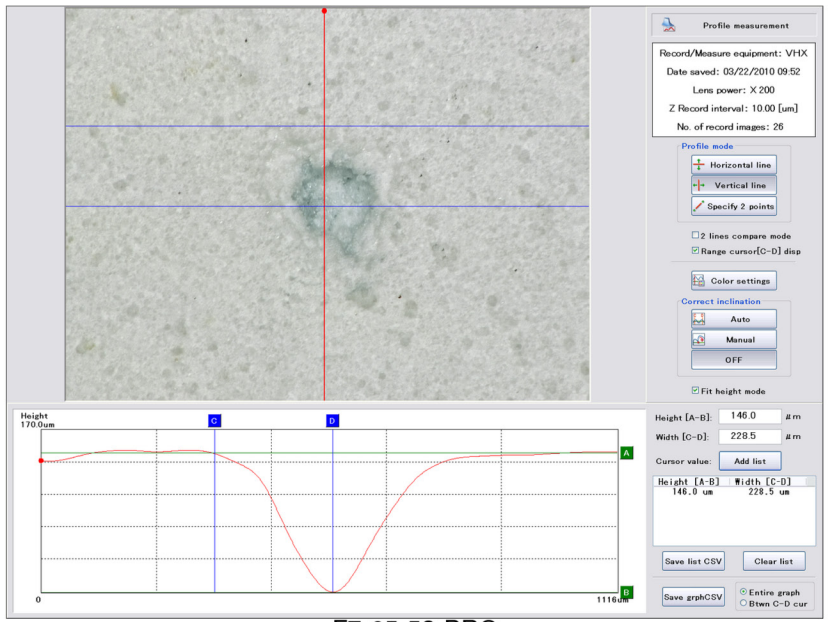
F7-25-23-PRO



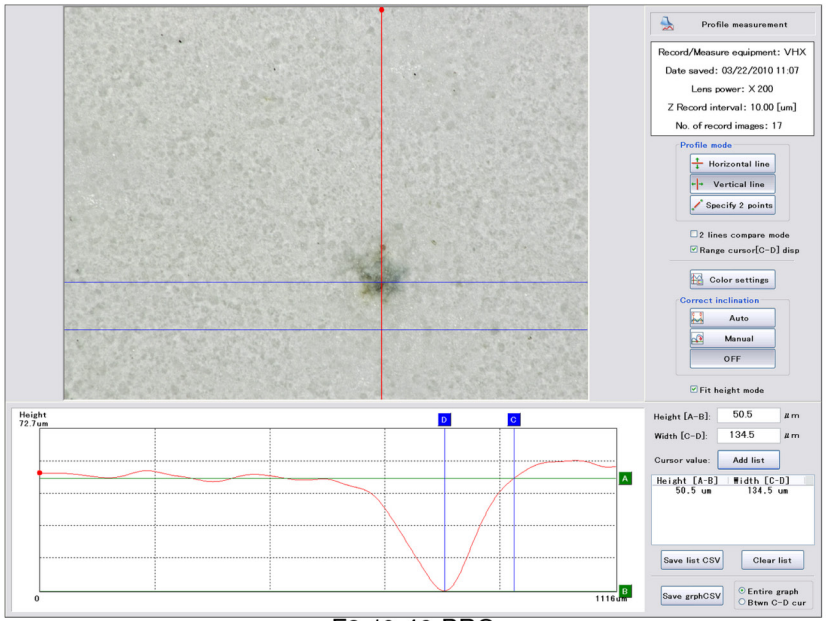
F7-29-98-PRO



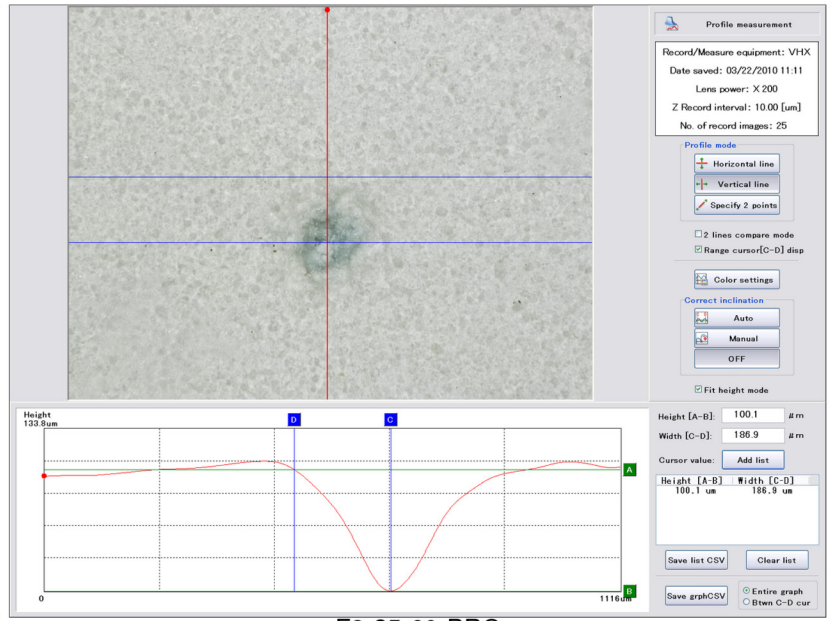
F7-53-54-PRO



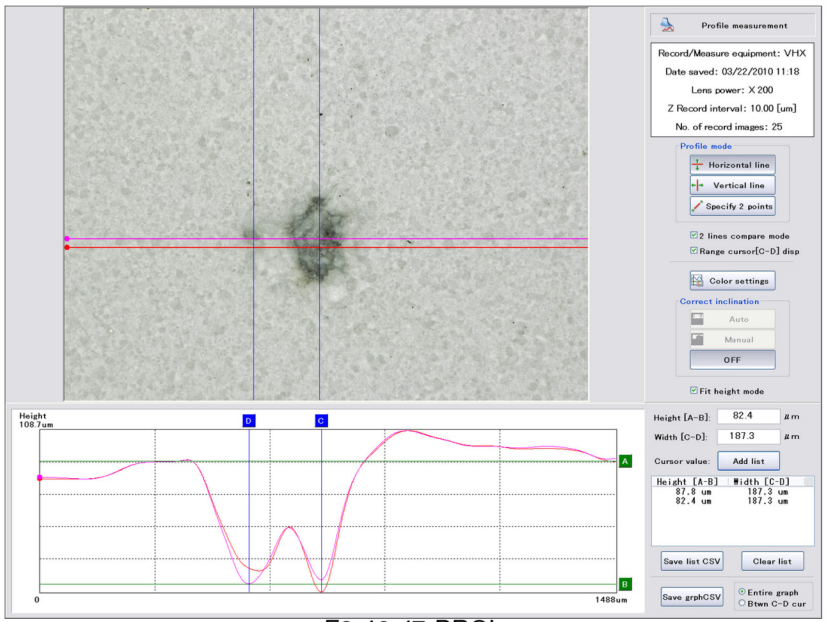
F7-65-52-PRO



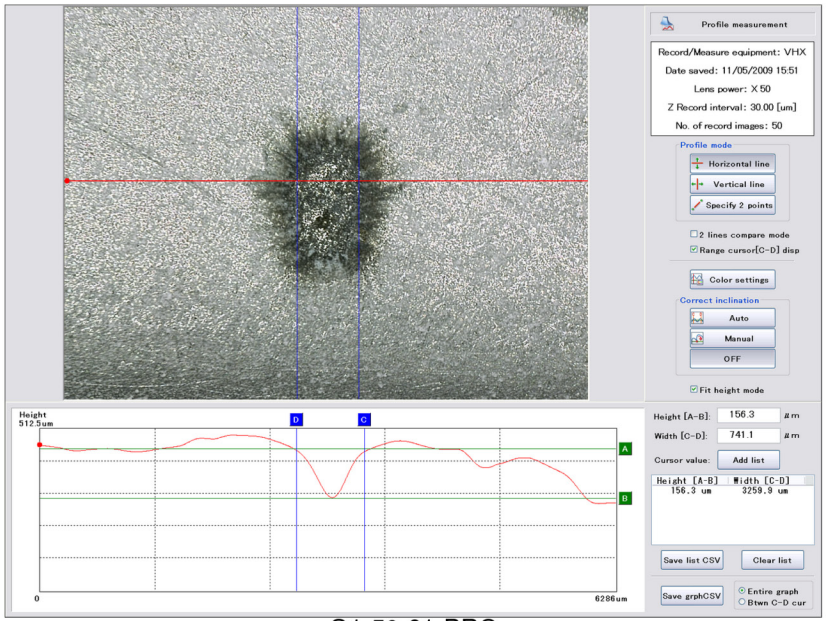
F8-10-46-PRO



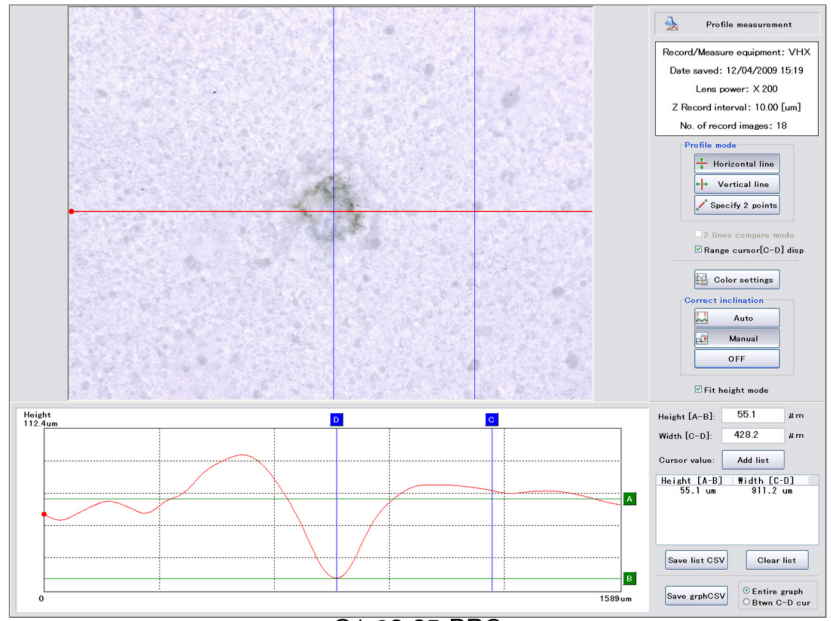
F8-25-60-PRO



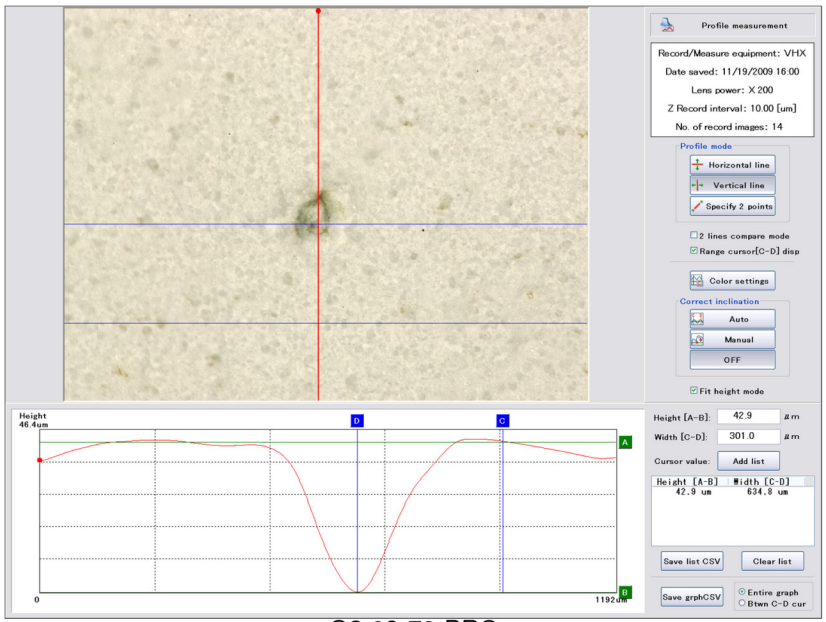
F8-46-47-PROh



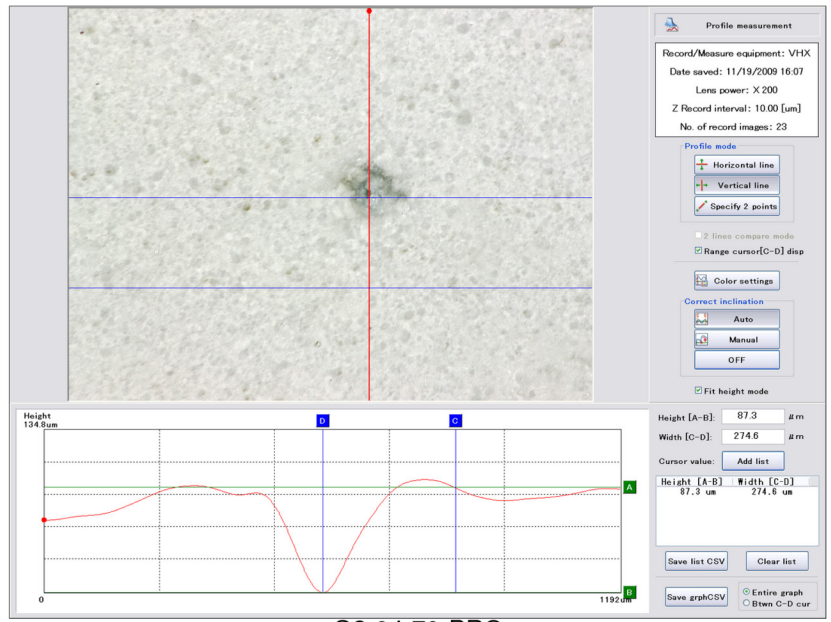
G1-50-91-PRO



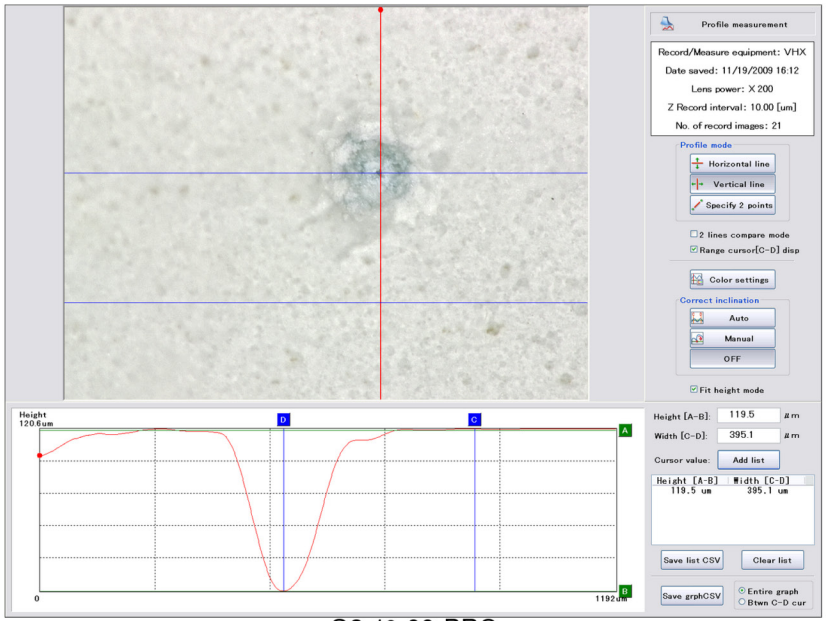
G1-82-25-PRO



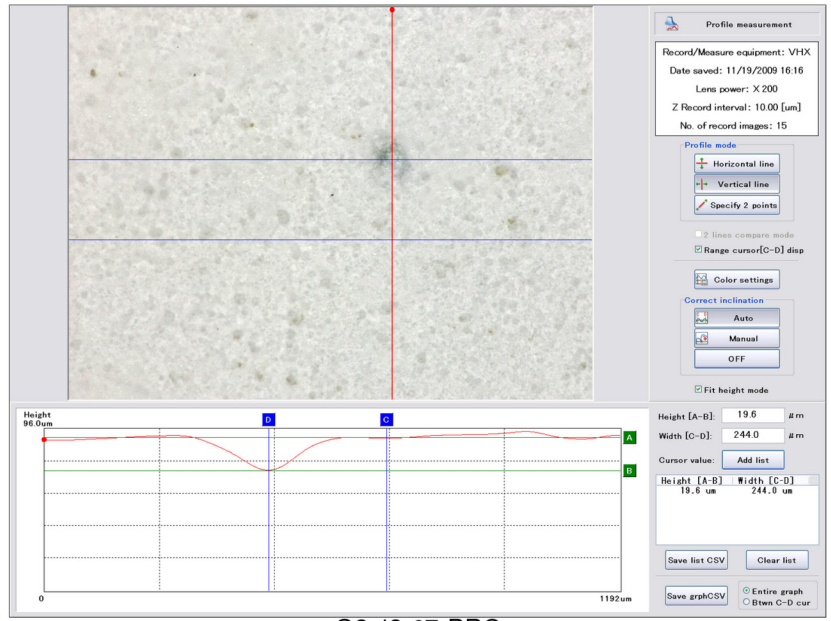
G2-03-78-PRO



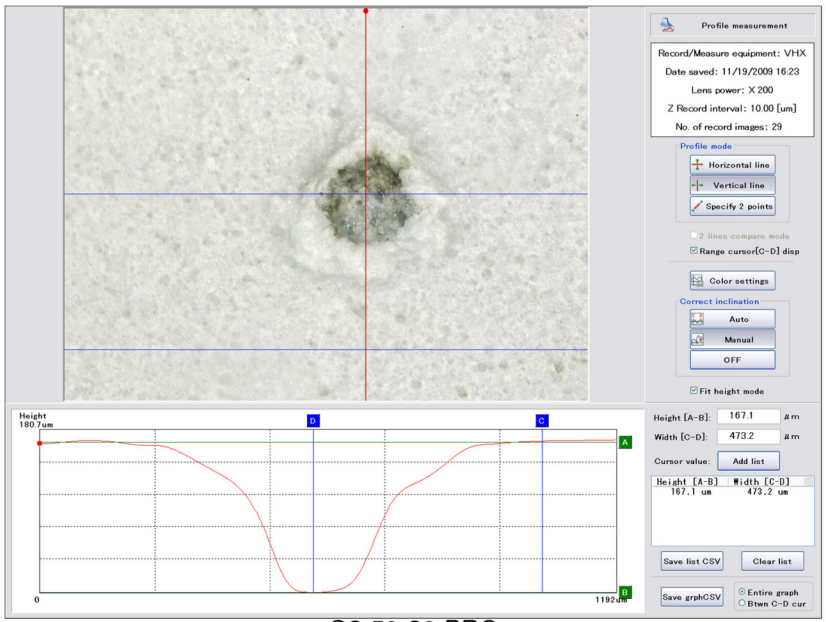
G2-04-70-PRO



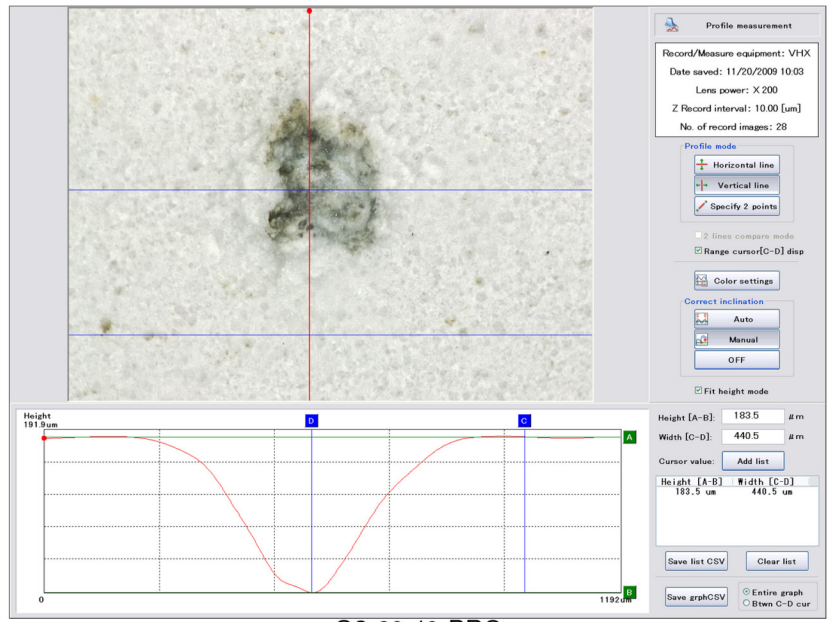
G2-10-99-PRO



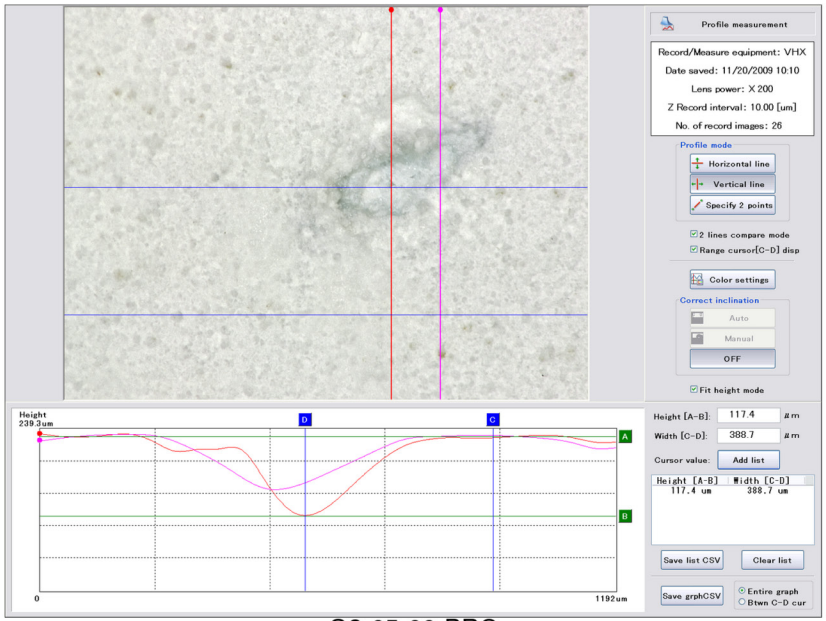
G2-13-07-PRO



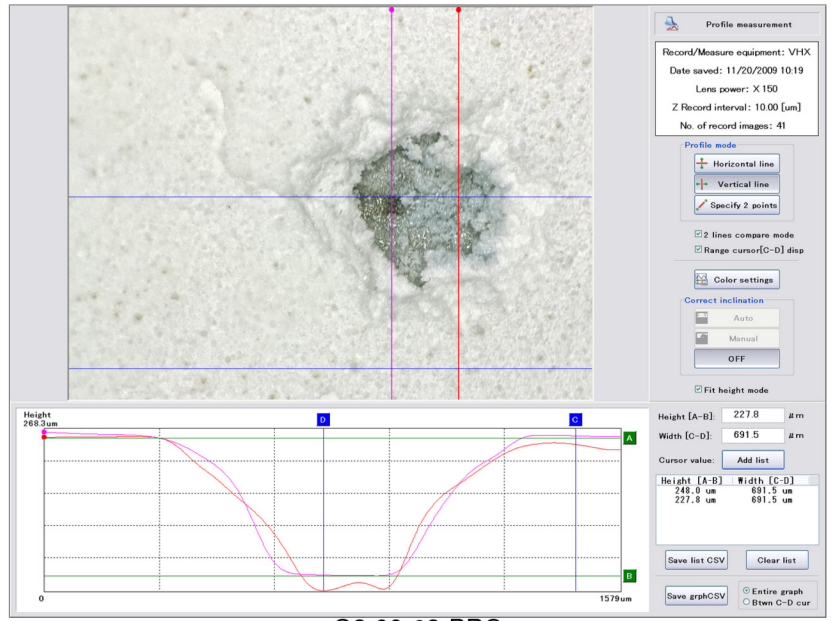
G2-50-26-PRO



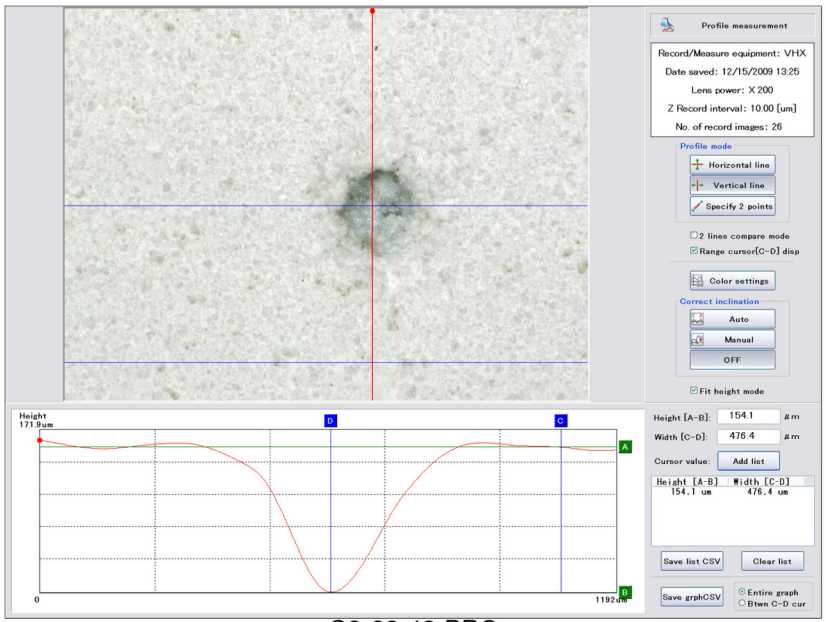
G2-60-10-PRO



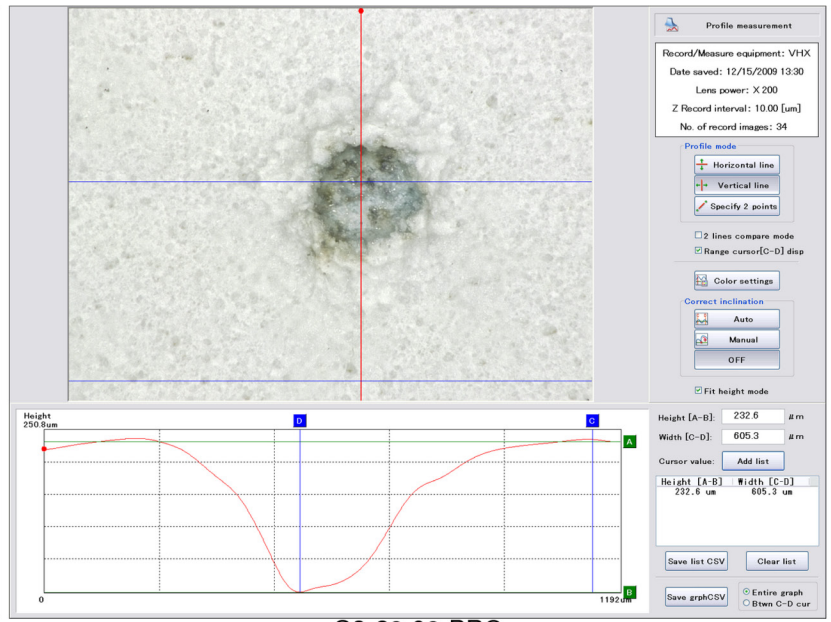
G2-65-66-PRO



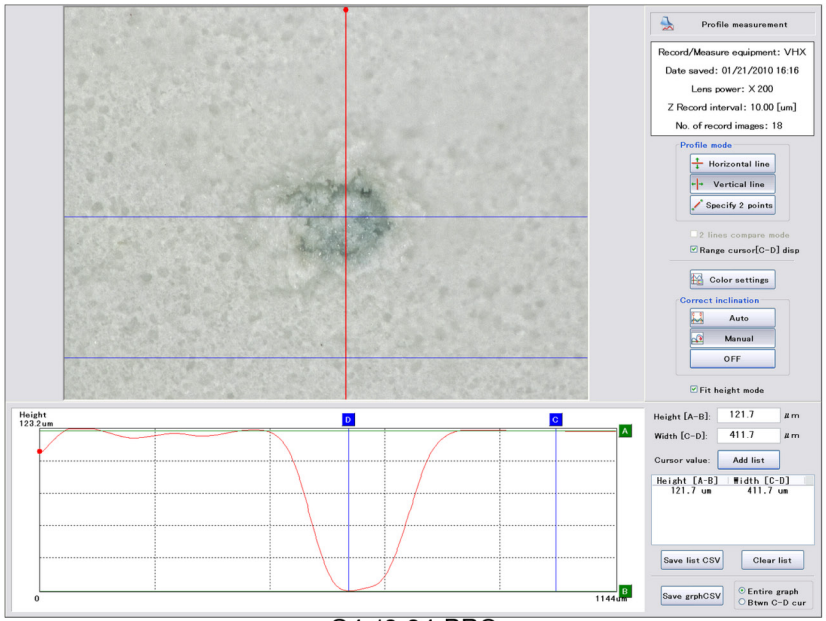
G2-99-62-PRO



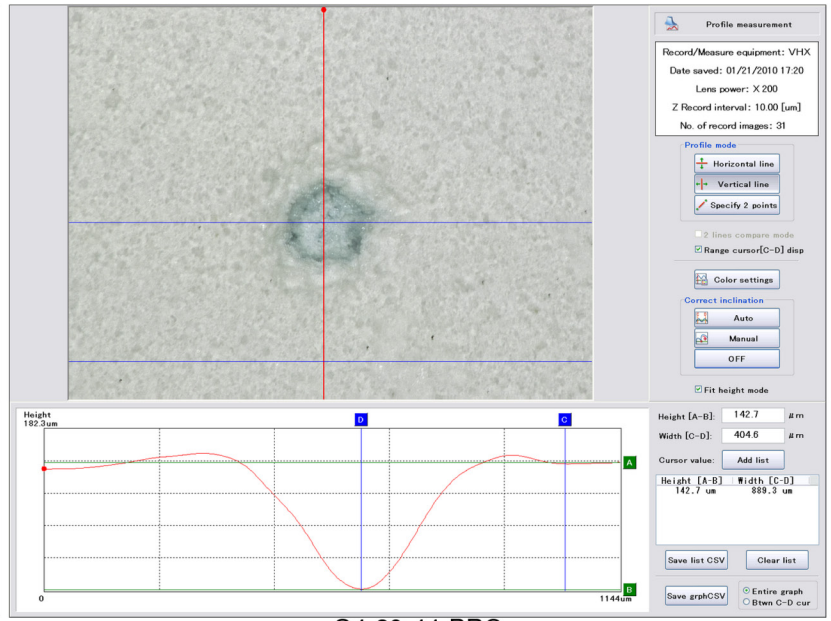
G3-22-42-PRO



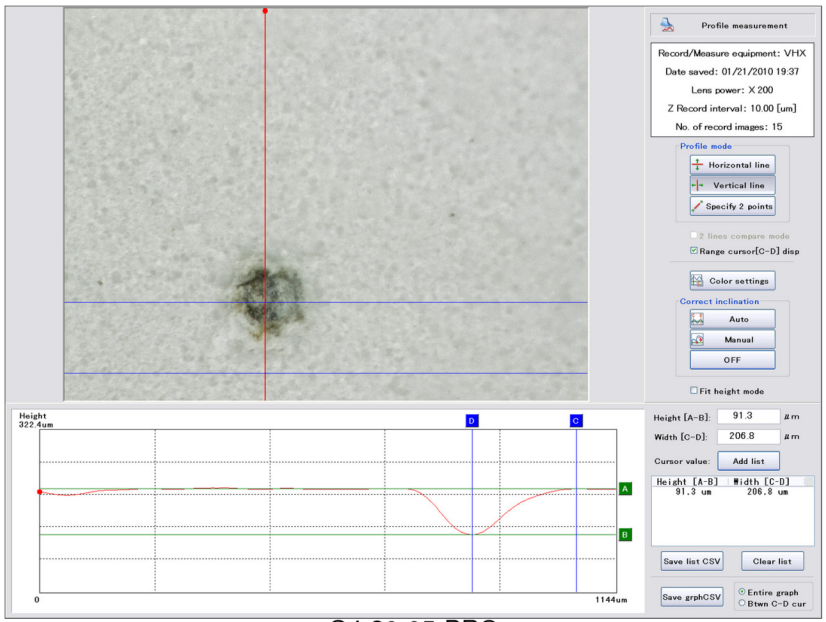
G3-28-98-PRO



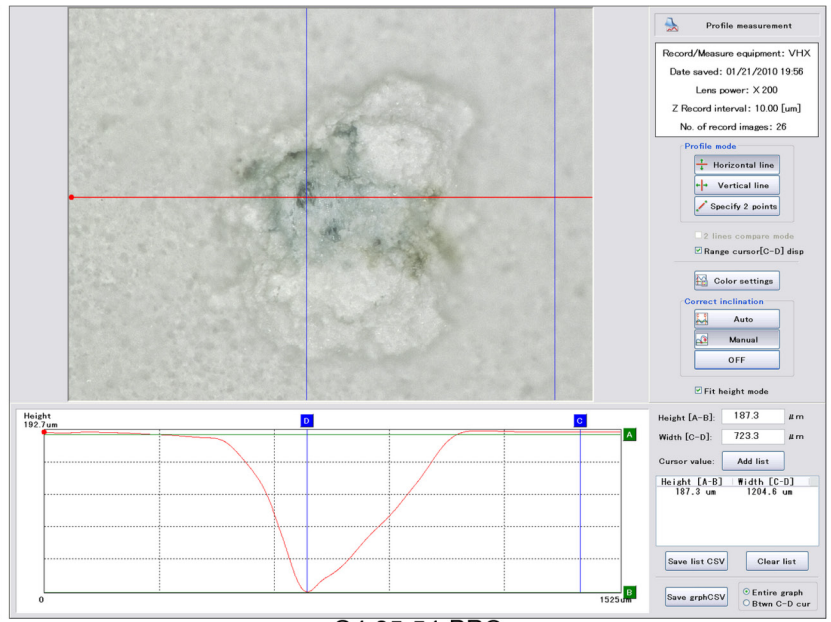
G4-13-34-PRO



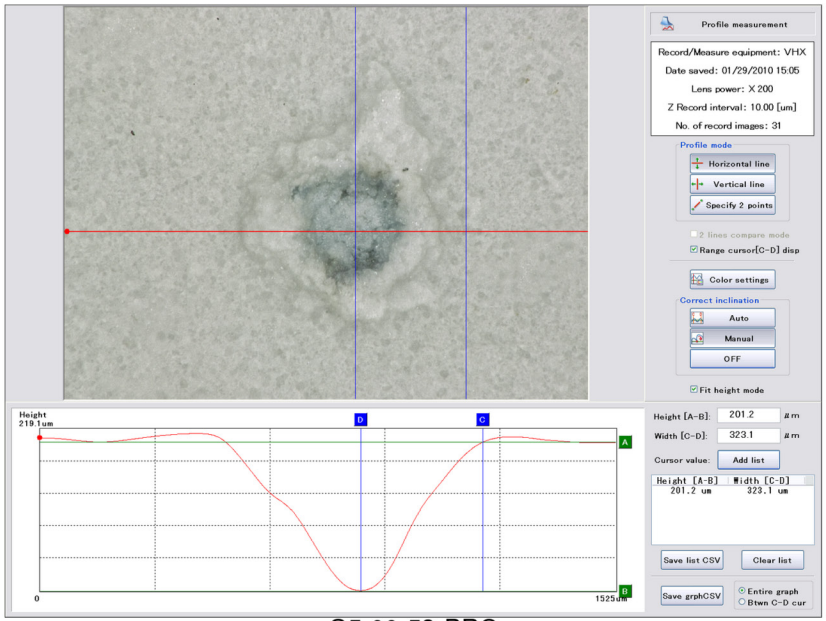
G4-29-44-PRO



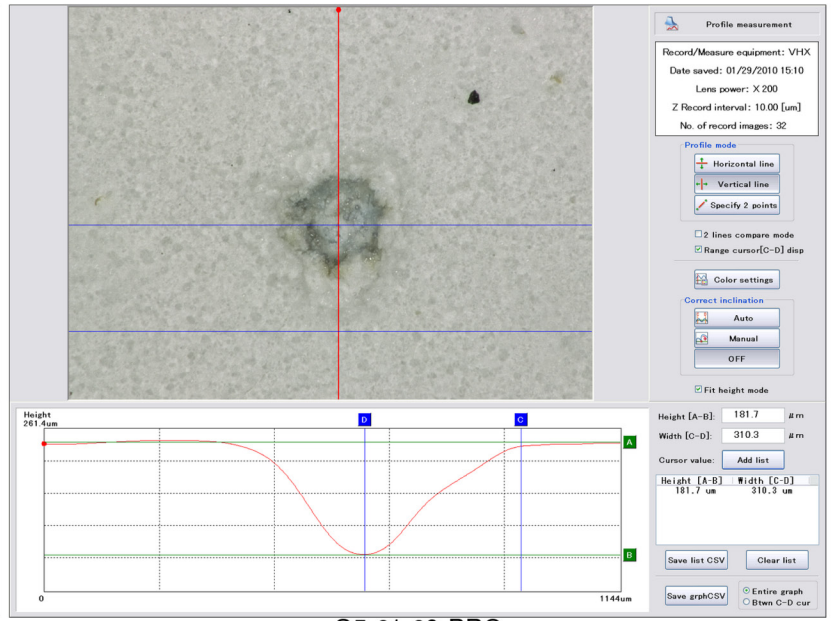
G4-30-05-PRO



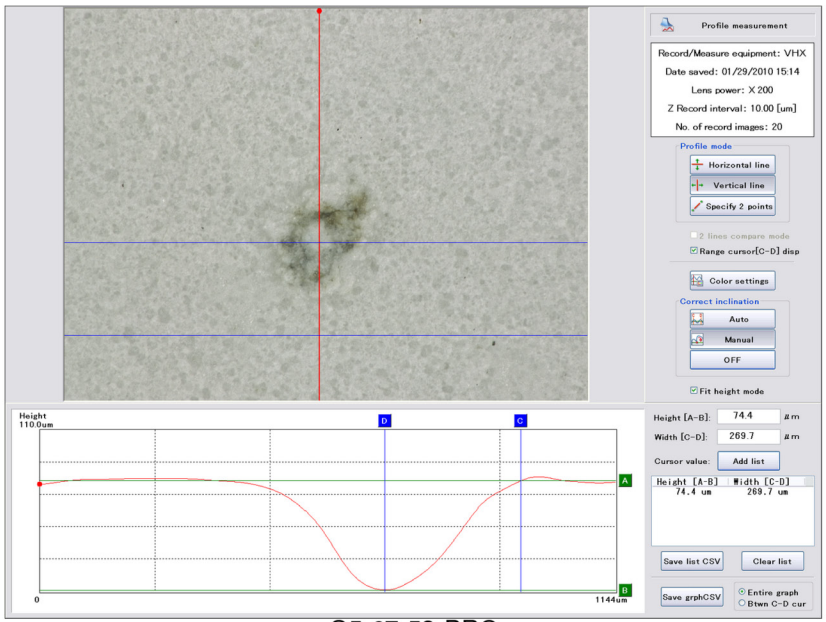
G4-35-54-PRO



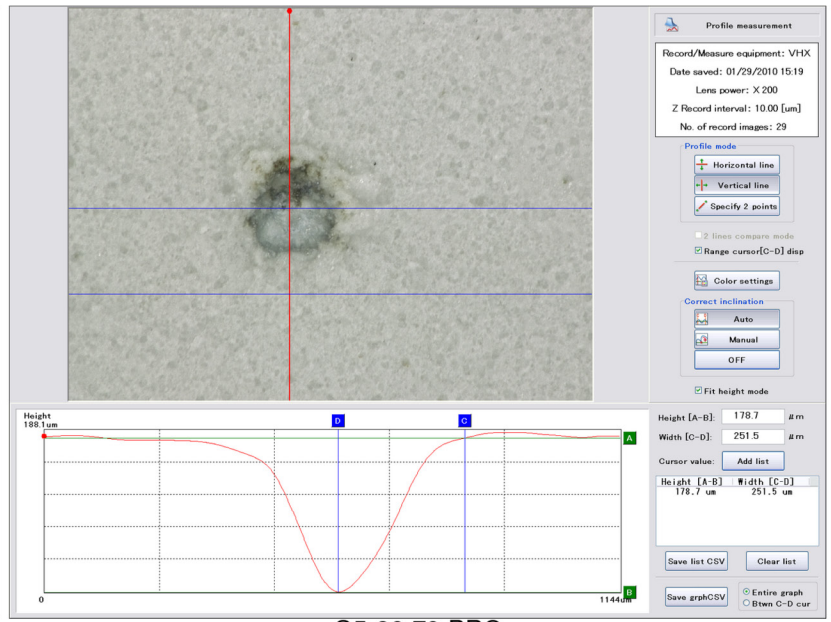
G5-00-53-PRO



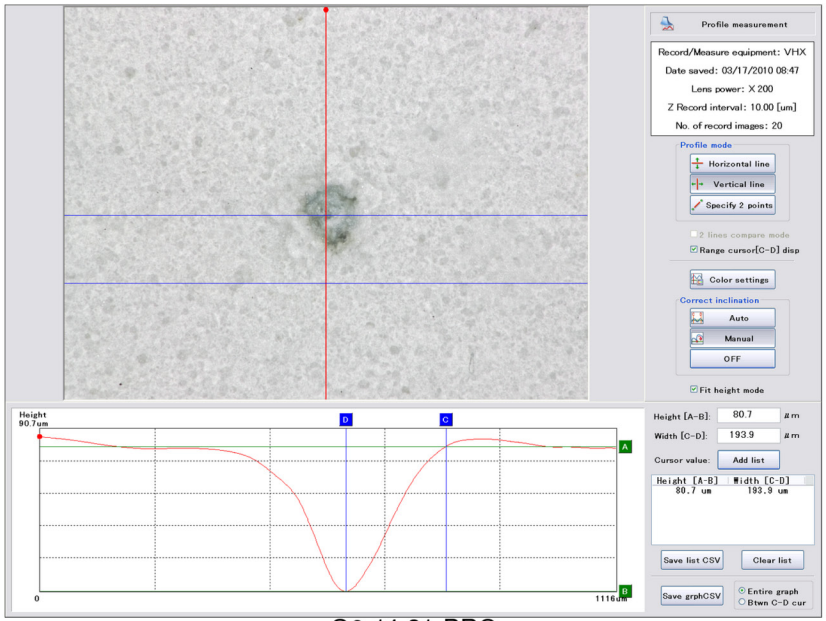
G5-61-69-PRO



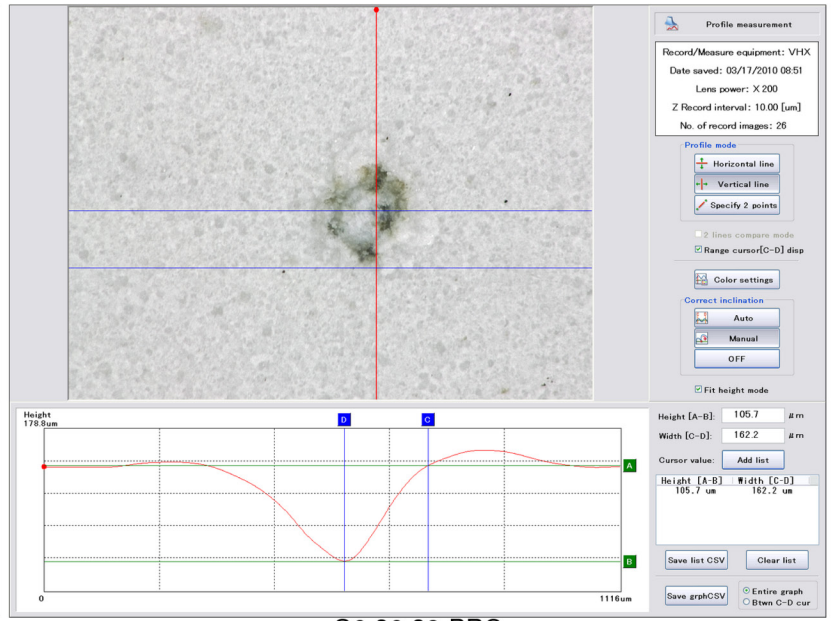
G5-67-53-PRO



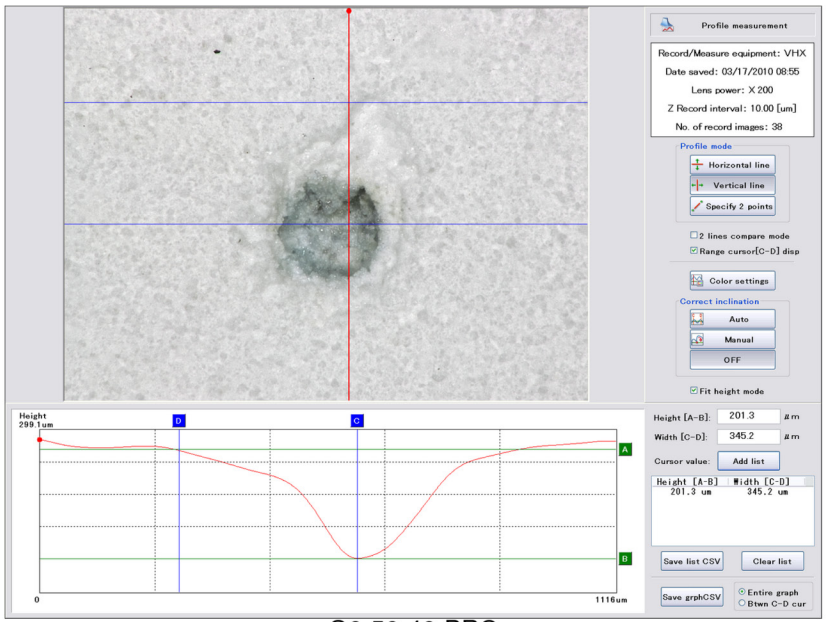
G5-86-76-PRO



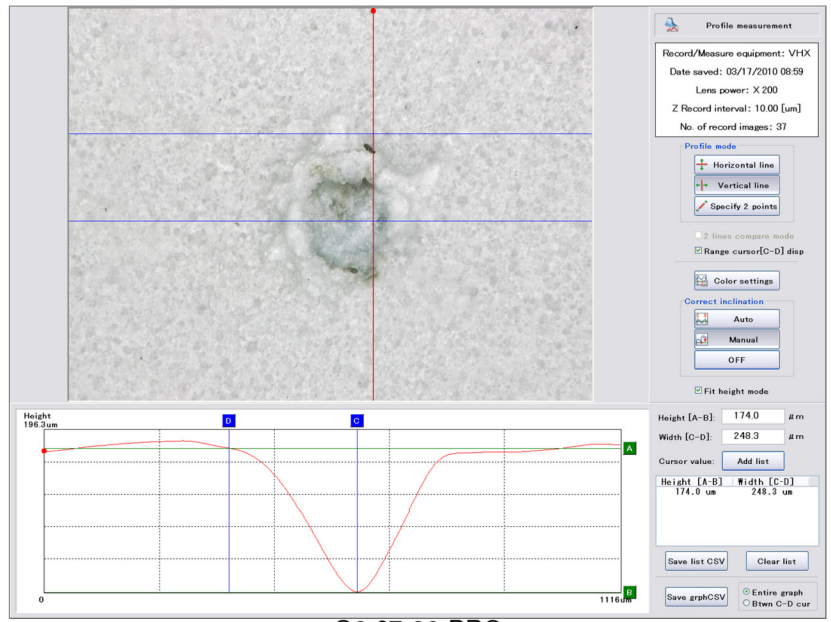
G6-14-31-PRO



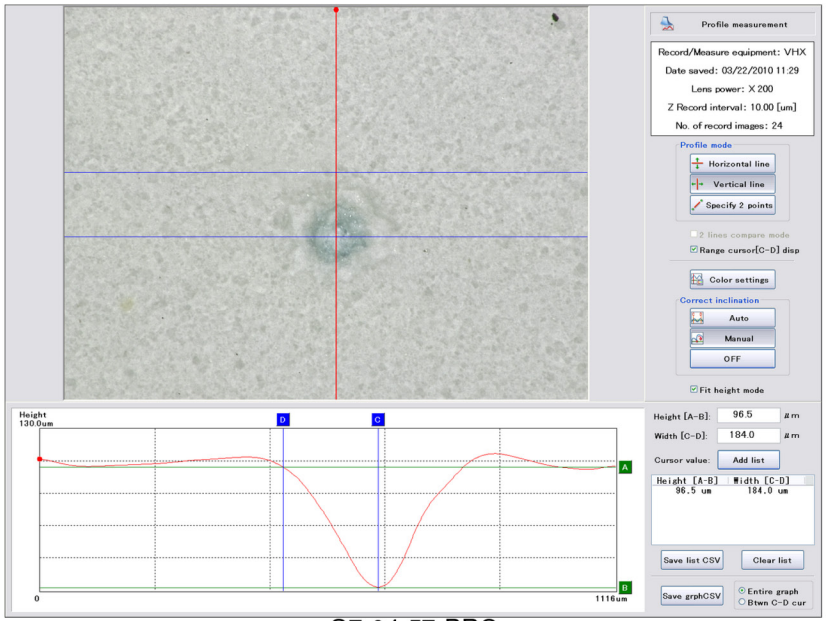
G6-36-38-PRO



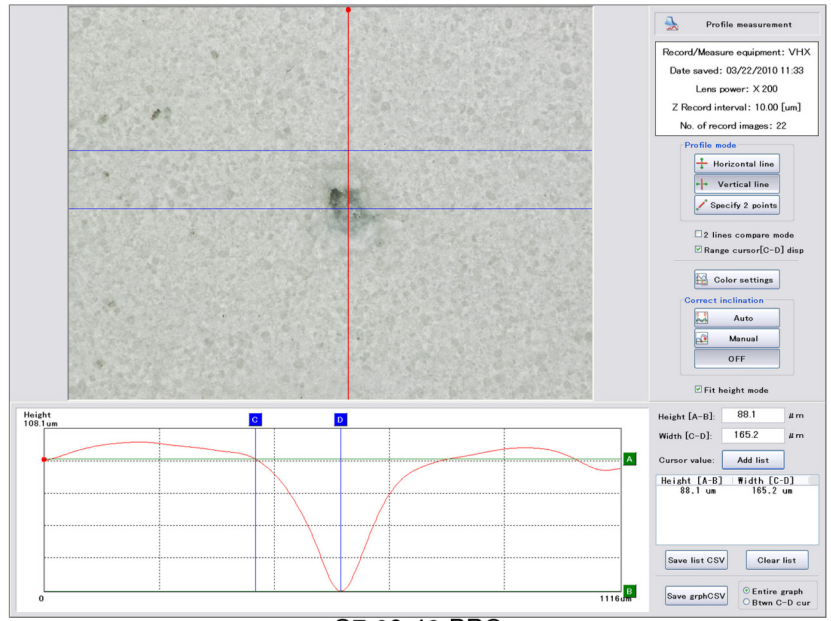
G6-56-46-PRO



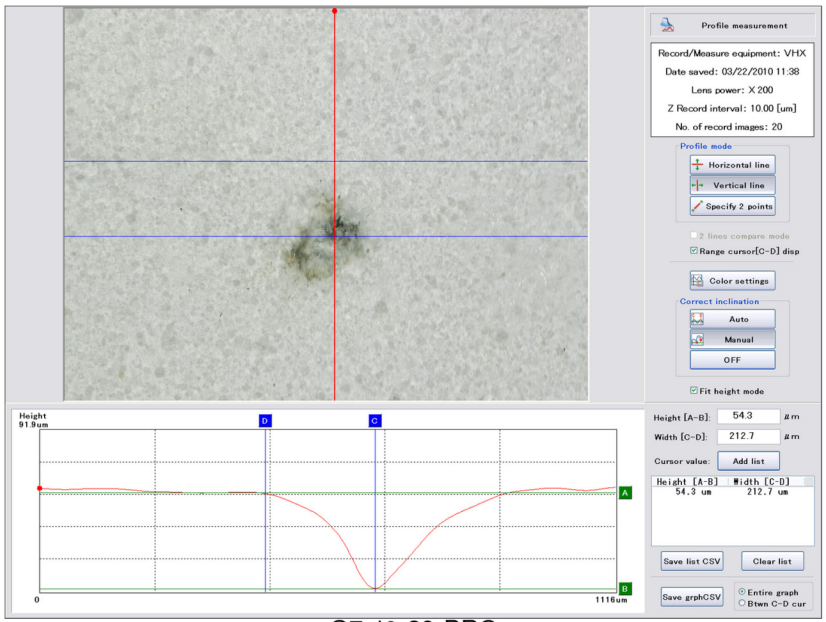
G6-97-86-PRO



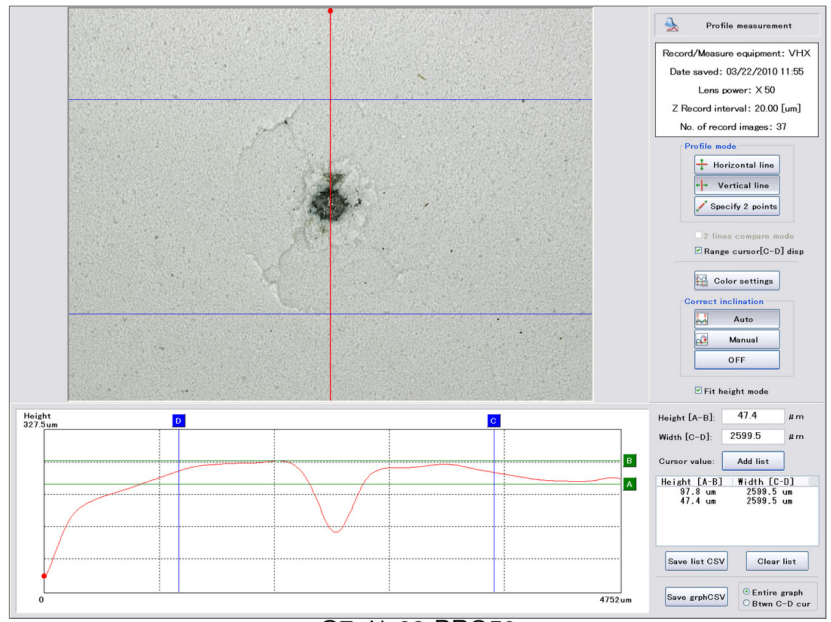
G7-04-57-PRO



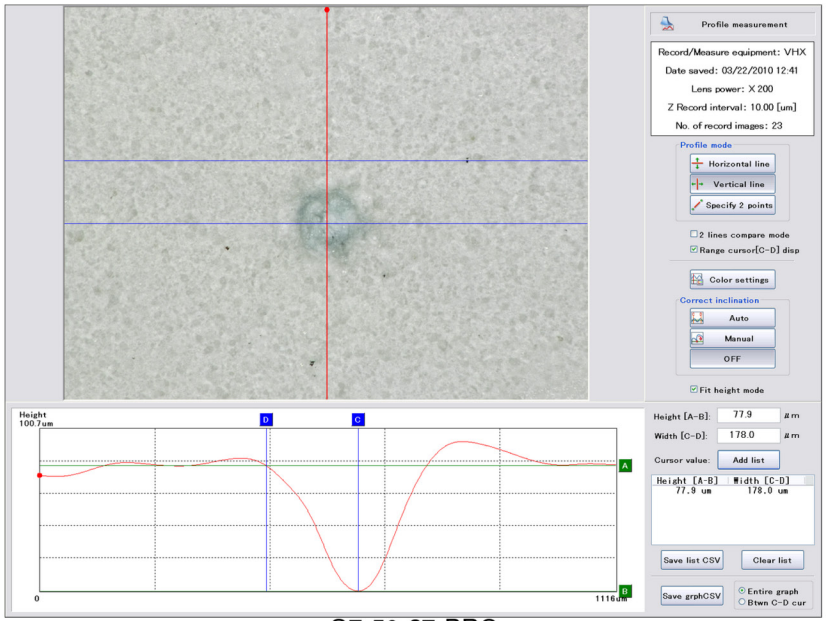
G7-09-46-PRO



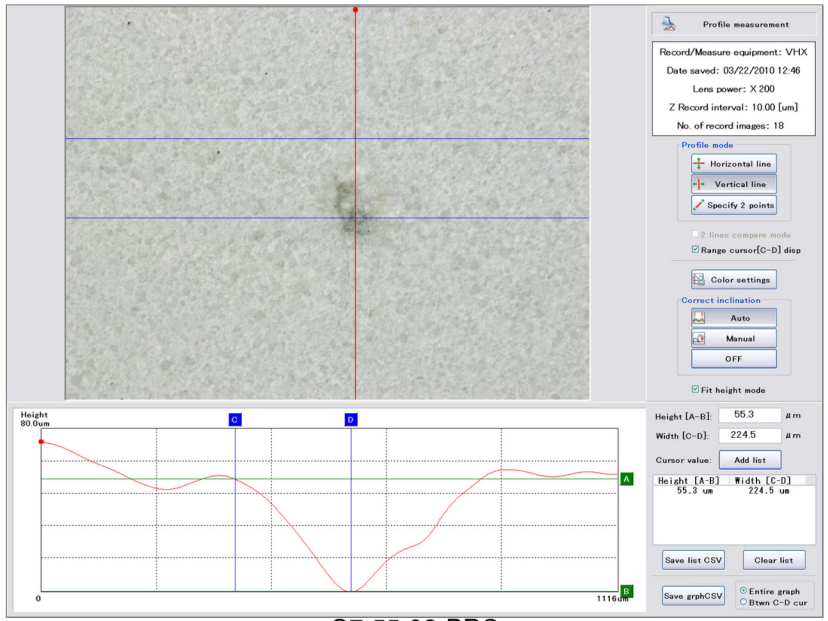
G7-10-29-PRO



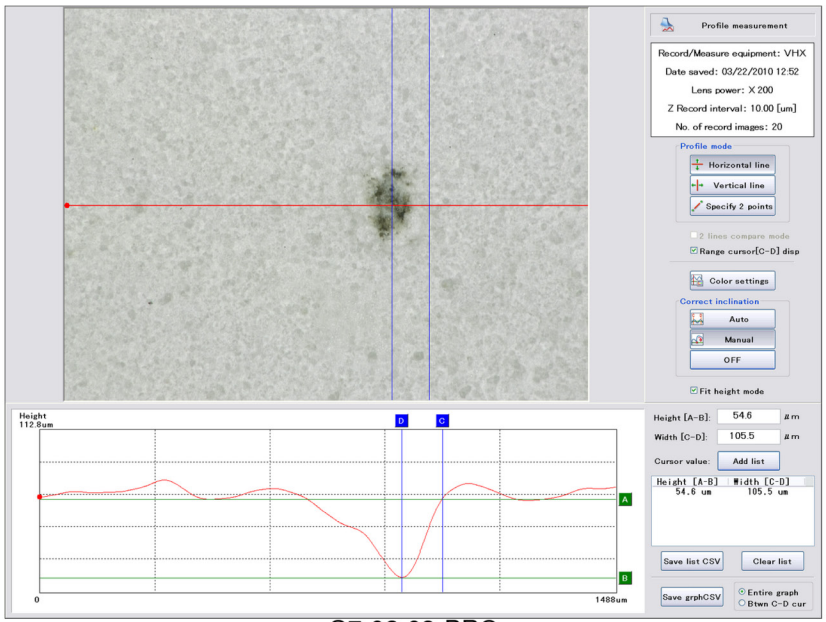
G7-41-68-PRO50



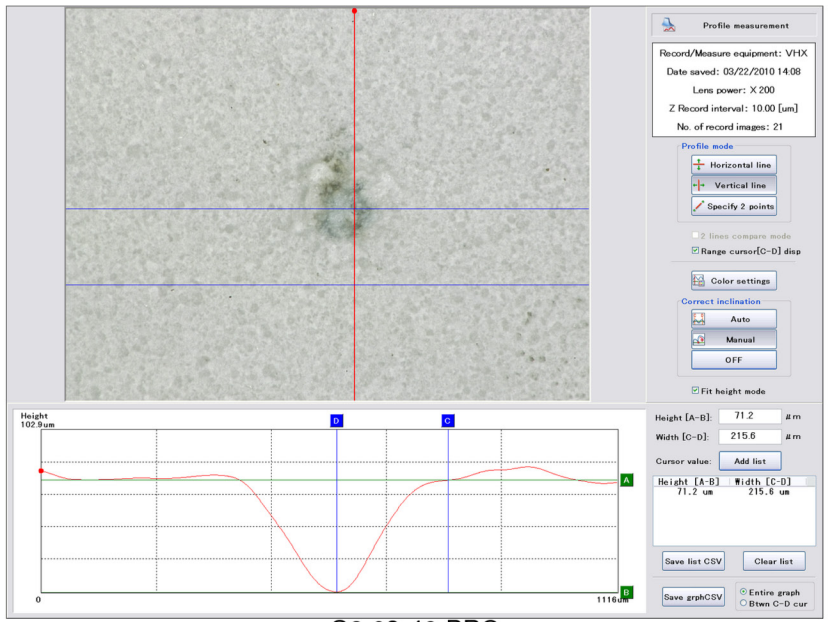
G7-50-27-PRO



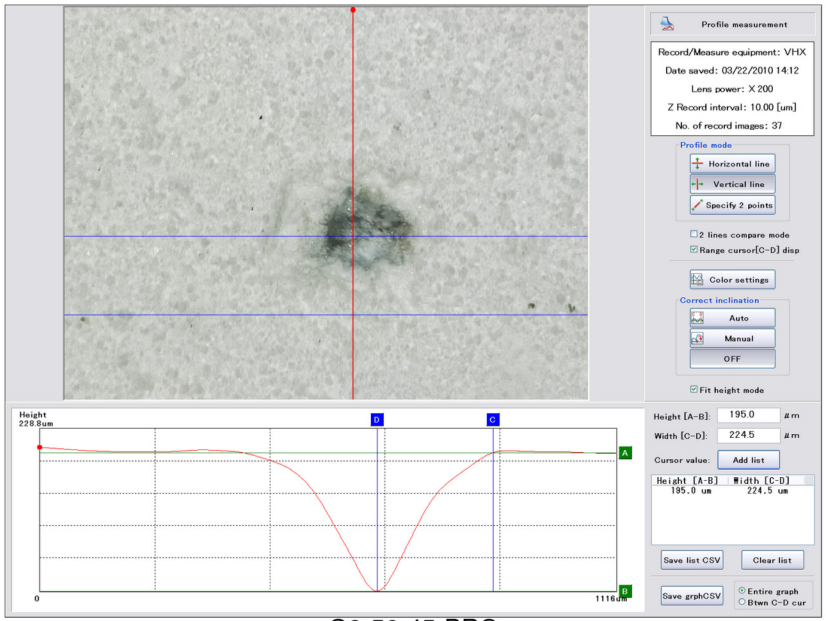
G7-55-92-PRO



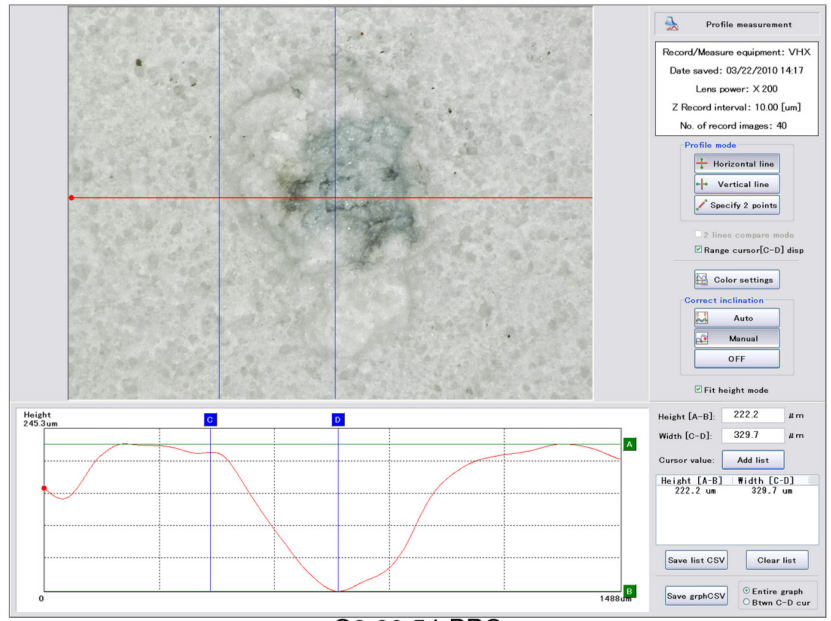
G7-92-93-PRO



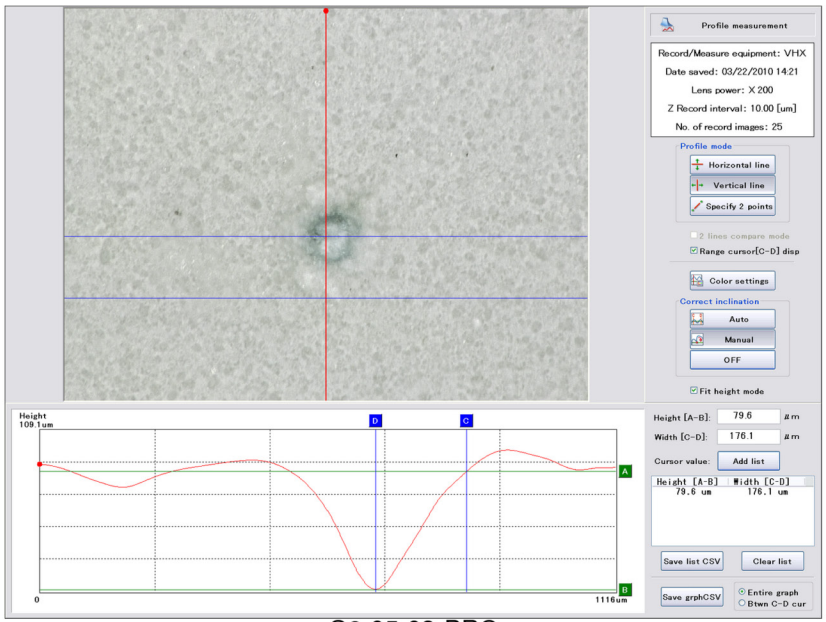
G8-03-46-PRO



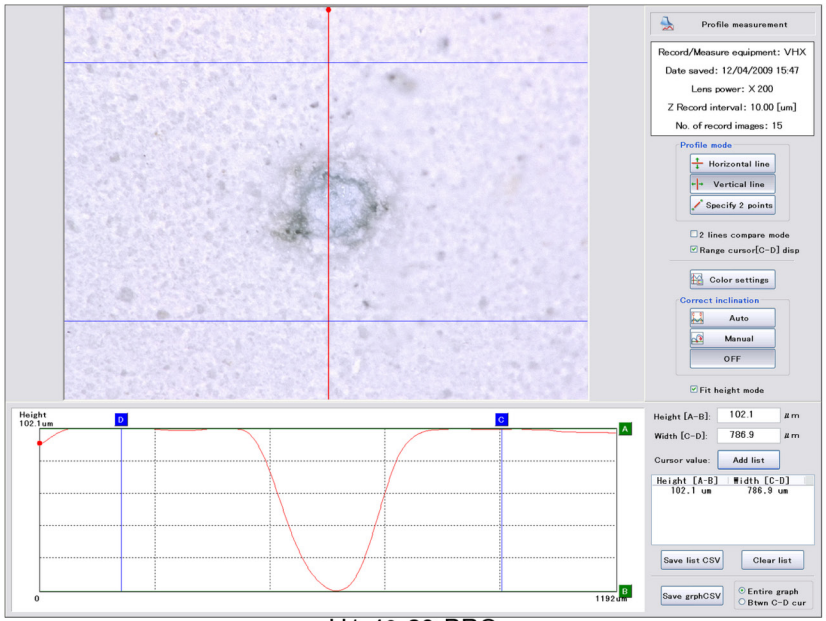
G8-56-45-PRO



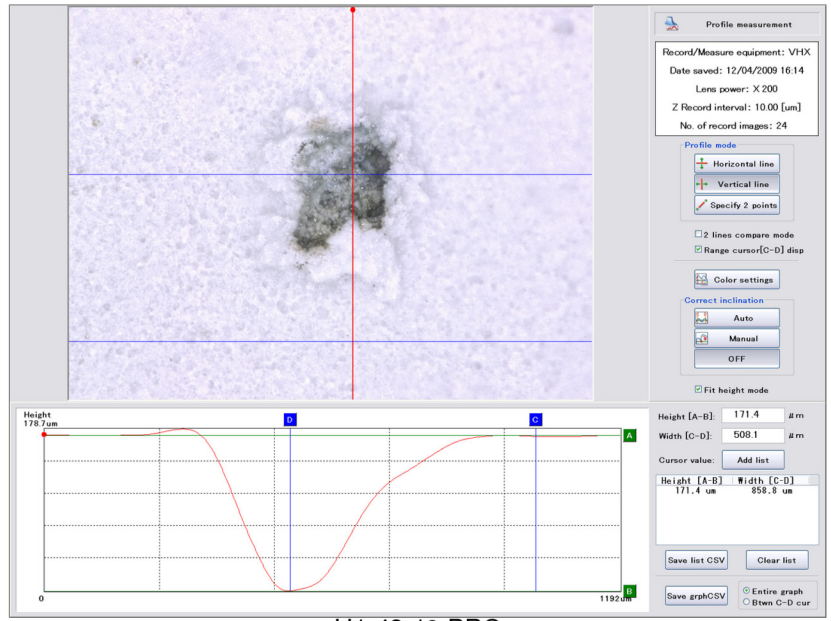
G8-86-54-PRO



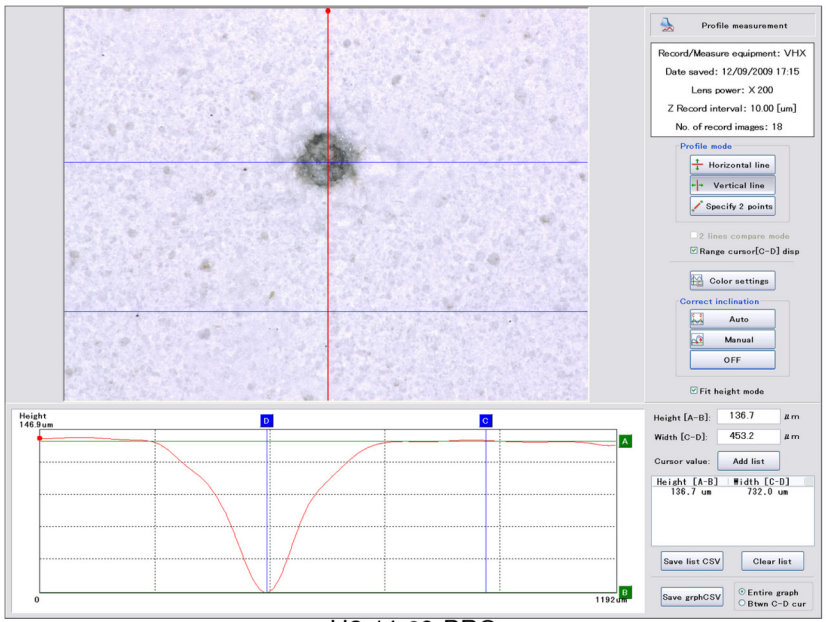
G8-95-93-PRO



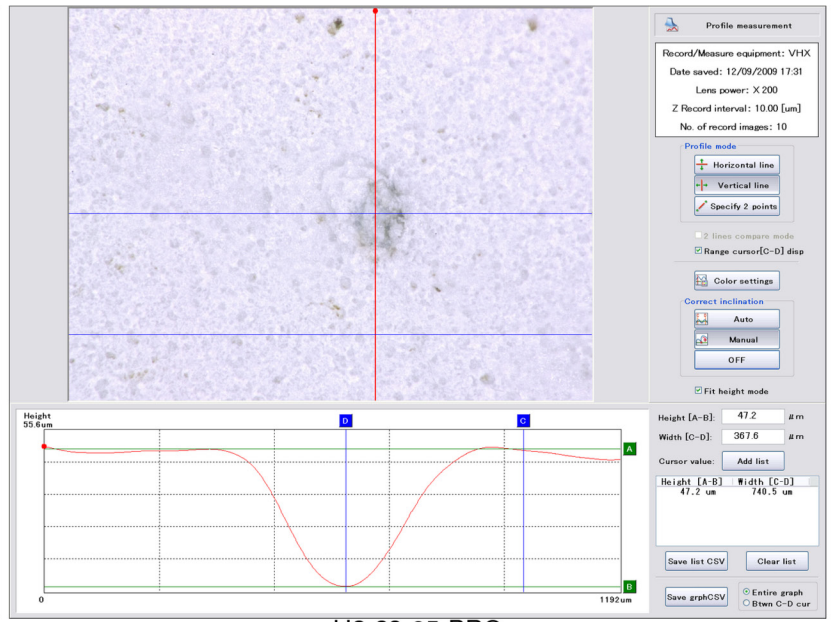
H1-40-29-PRO



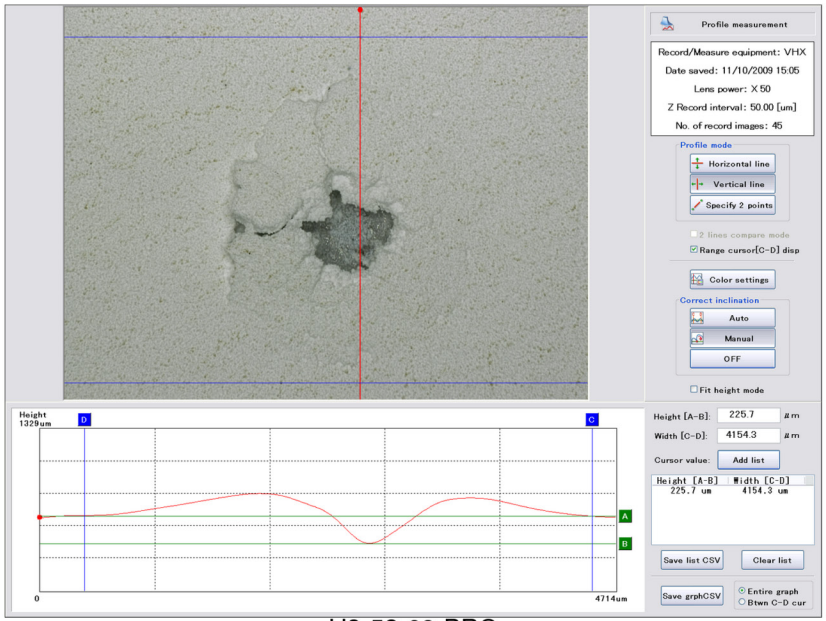
H1-43-16-PRO



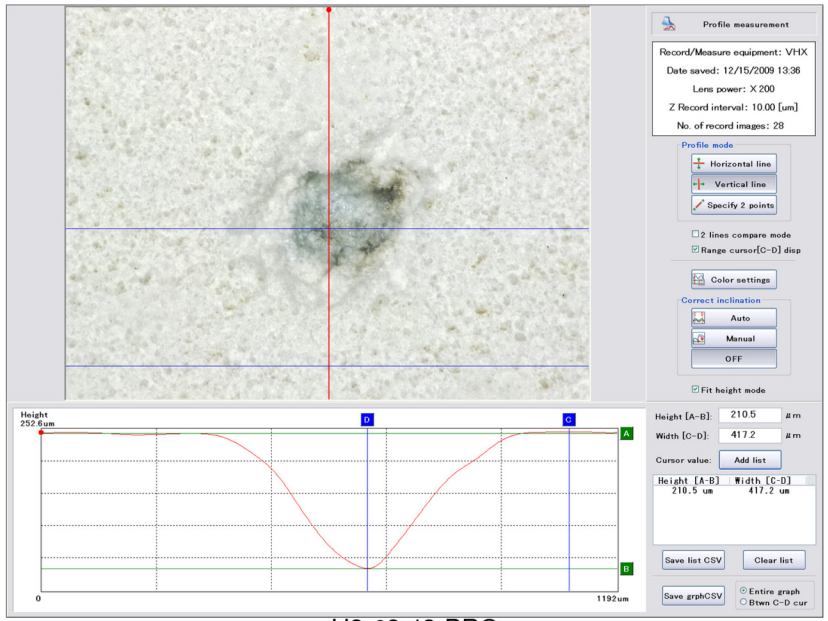
H2-14-69-PRO



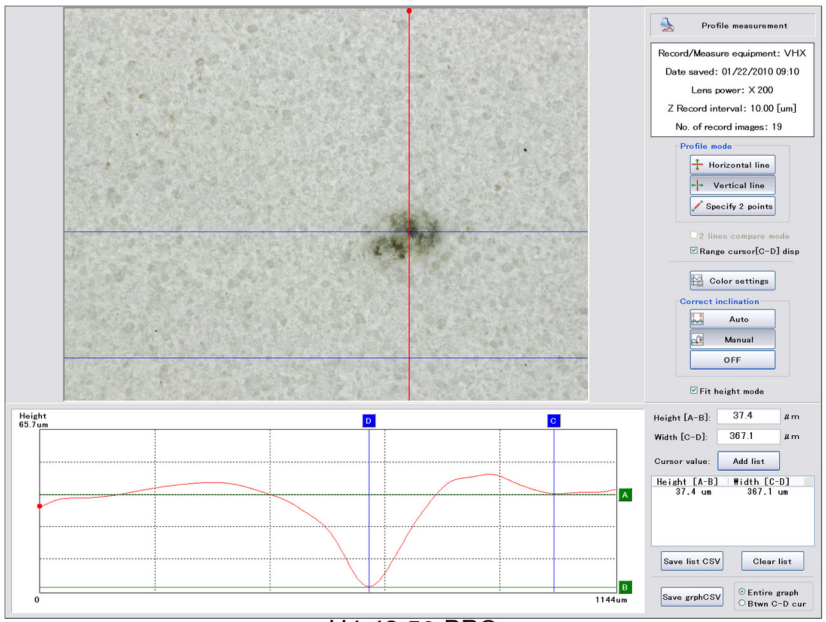
H2-23-85-PRO



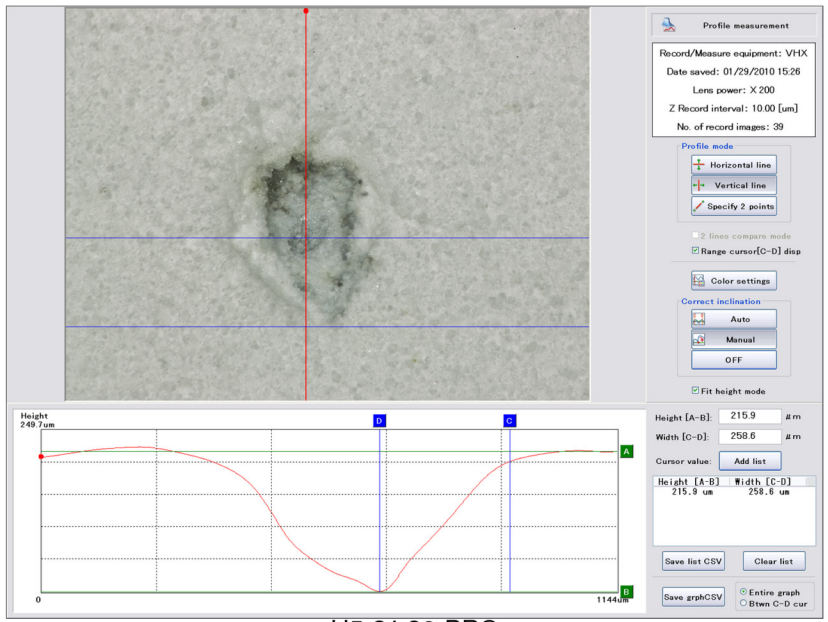
H3-52-68-PRO



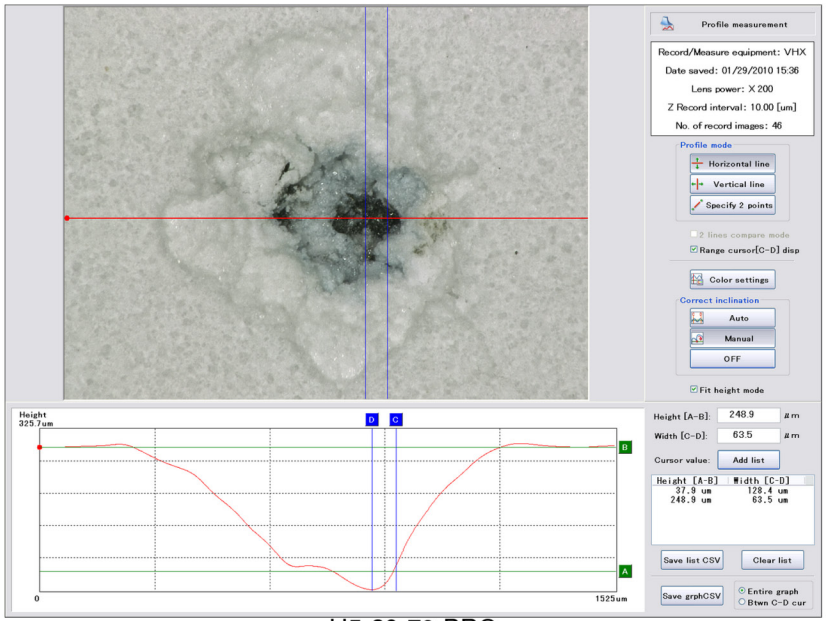
H3-63-12-PRO



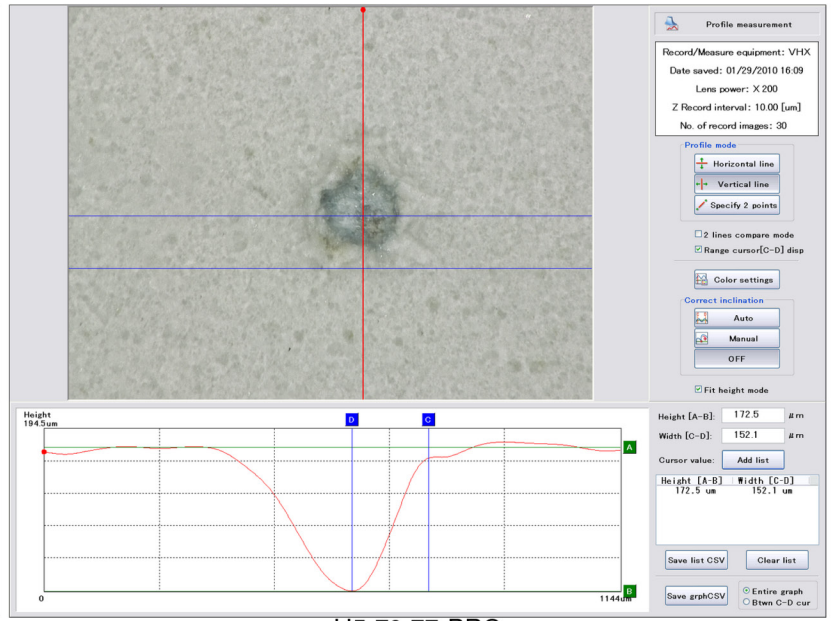
H4-42-56-PRO



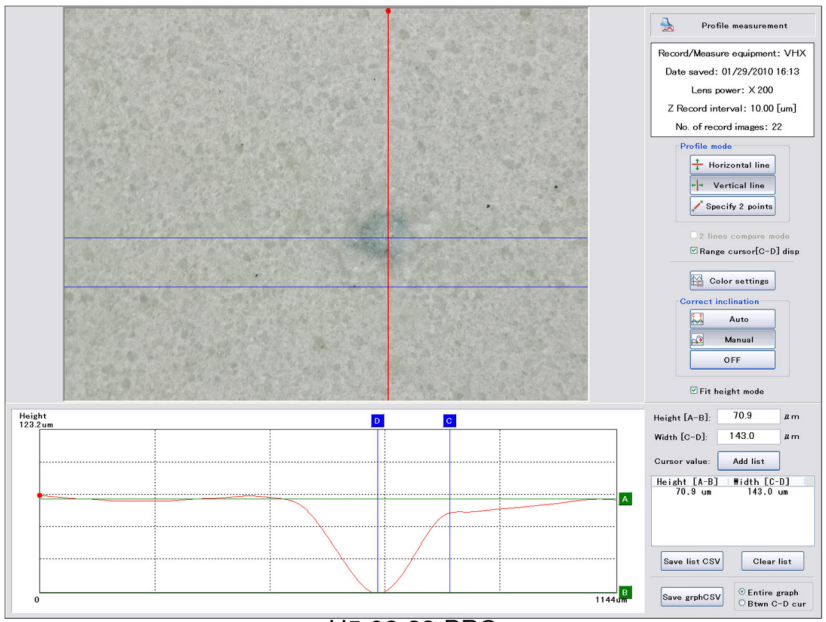
H5-24-38-PRO



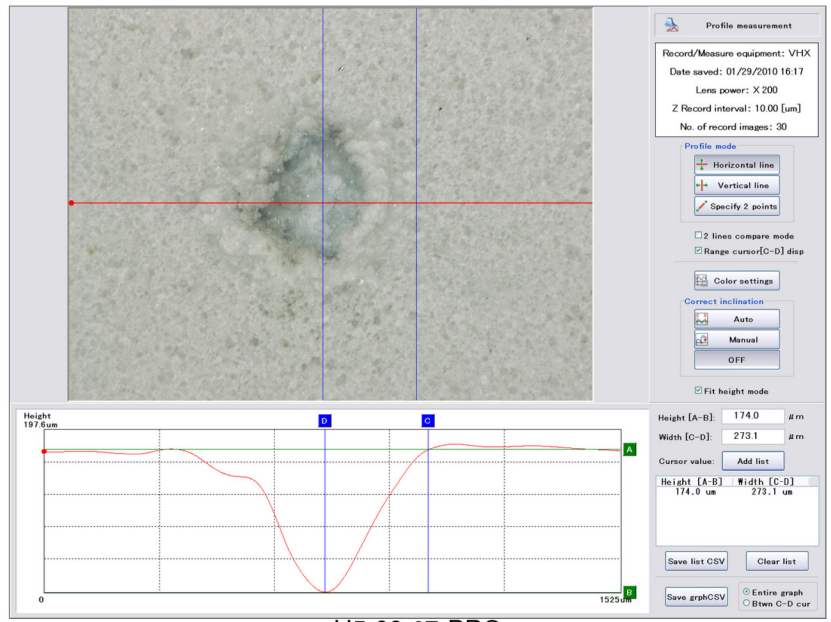
H5-29-76-PRO



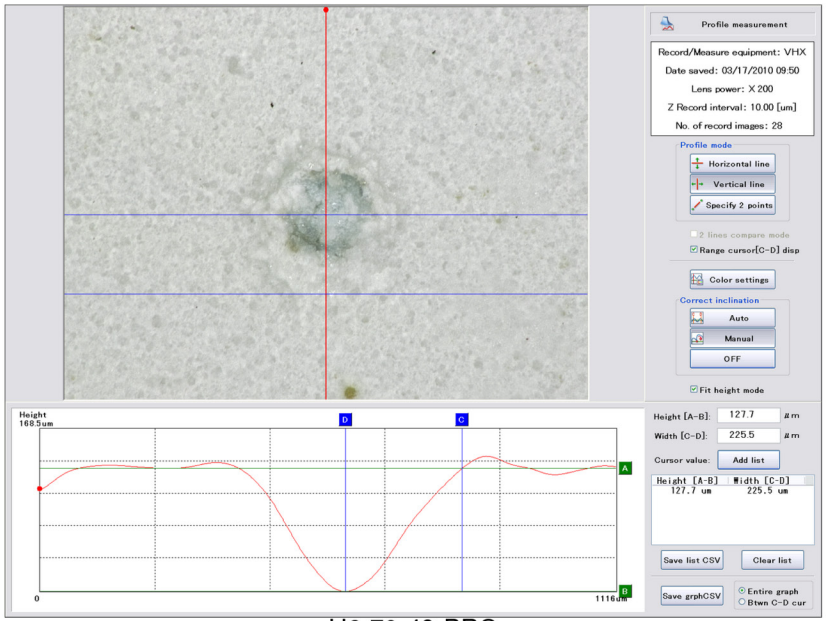
H5-76-77-PRO



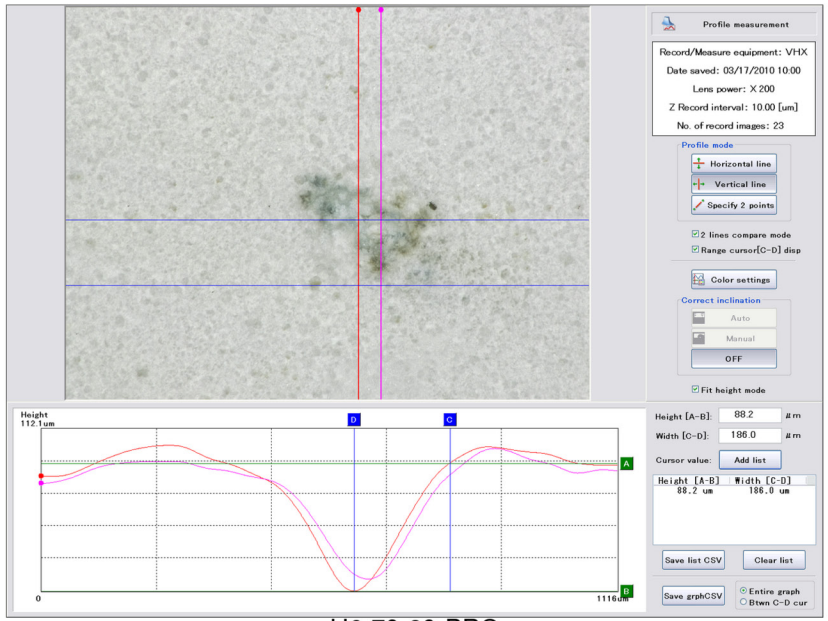
H5-92-22-PRO



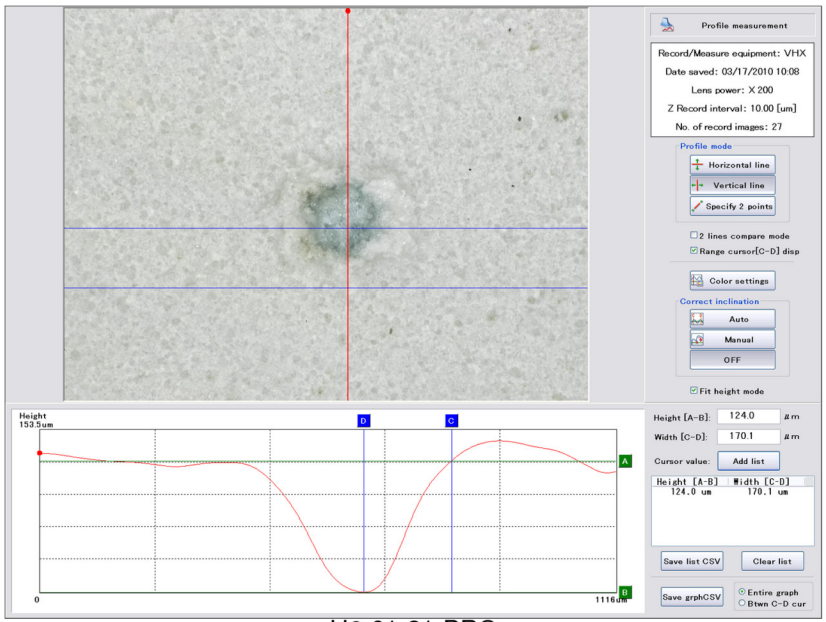
H5-99-07-PRO



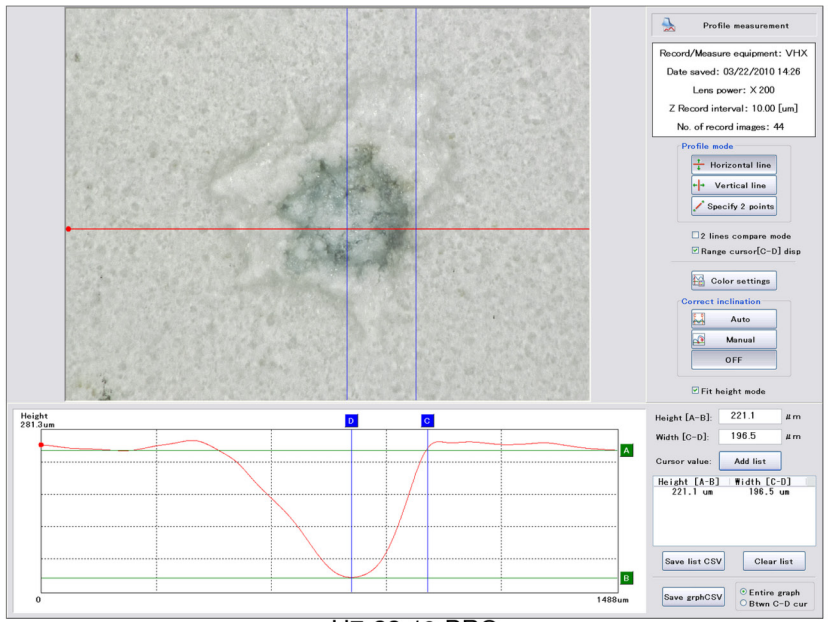
H6-70-49-PRO



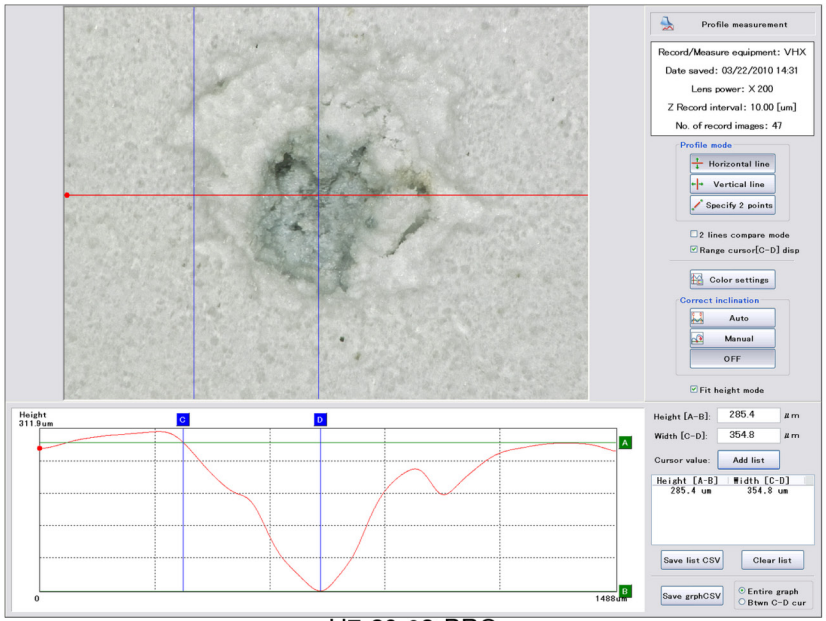
H6-79-89-PRO



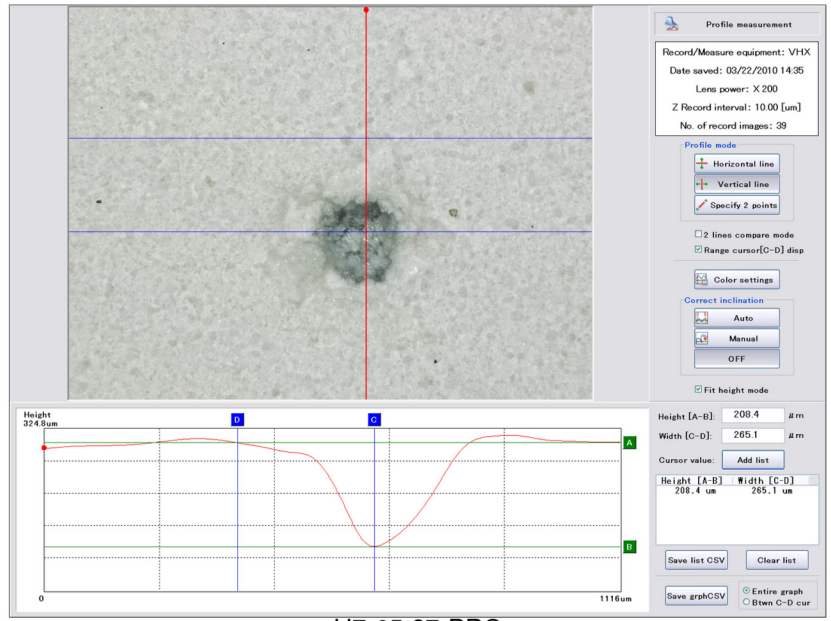
H6-91-21-PRO



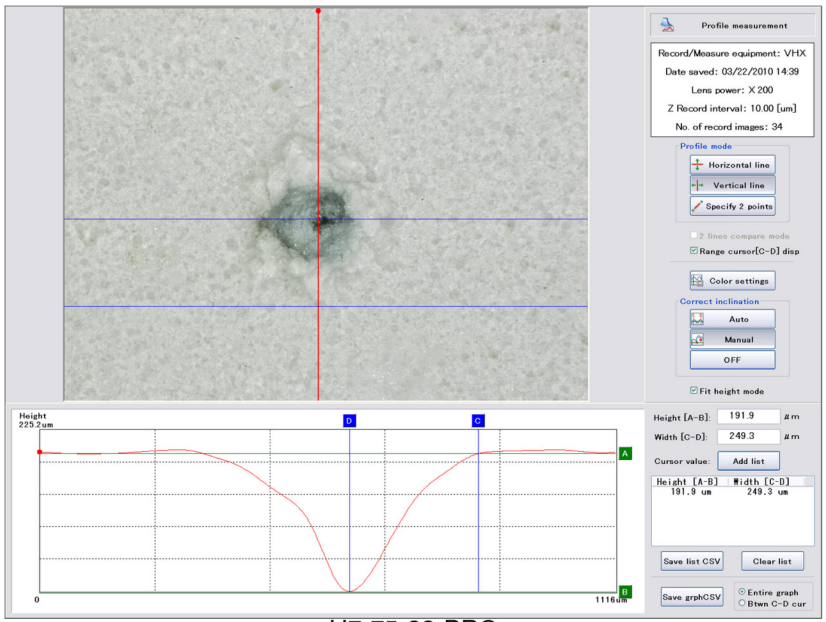
H7-22-16-PRO



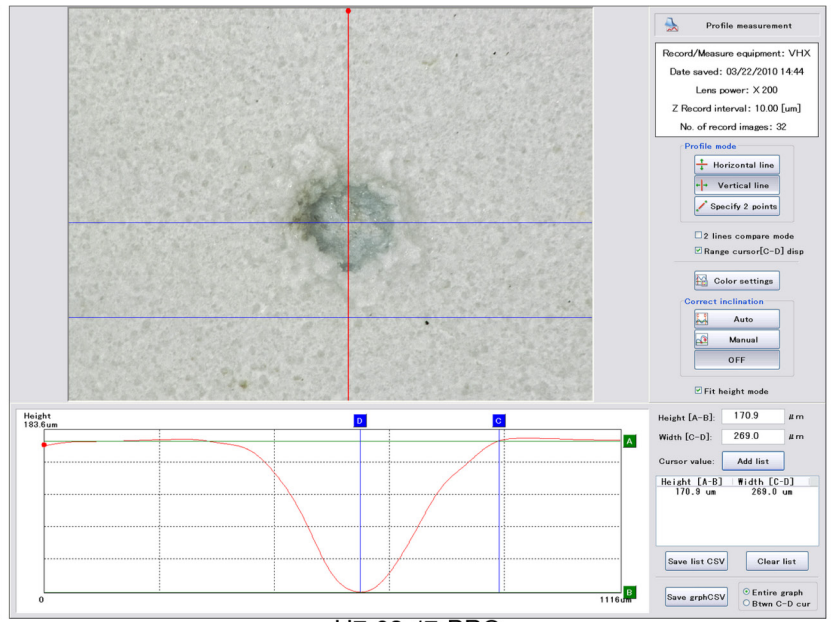
H7-29-03-PRO



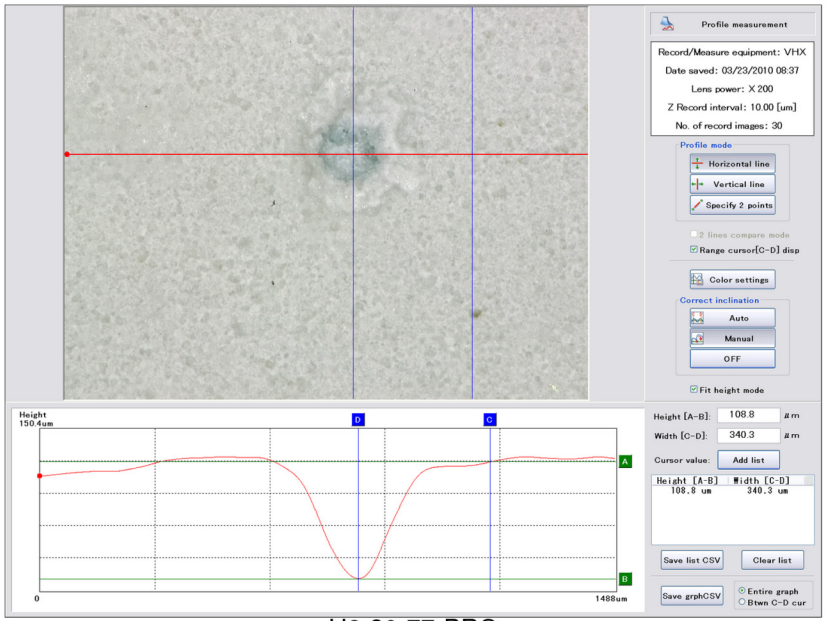
H7-65-37-PRO



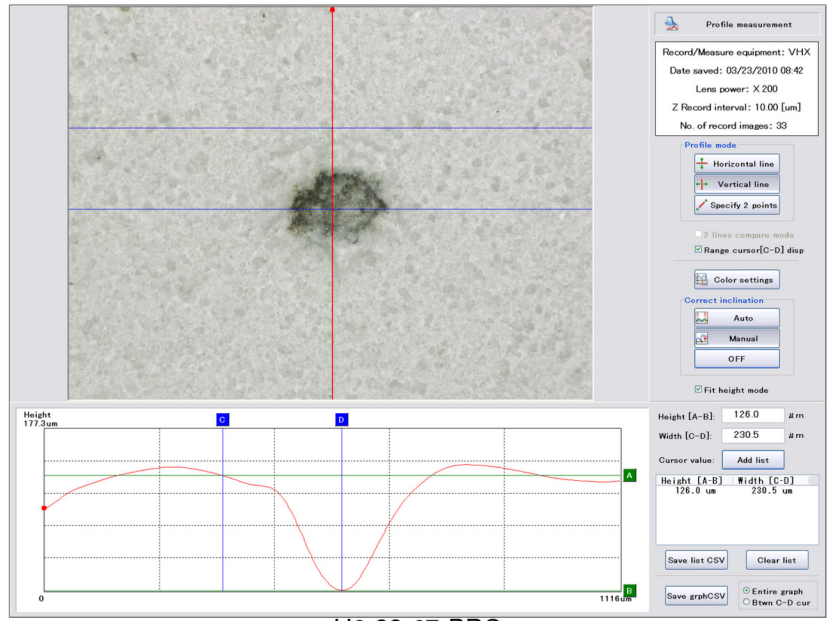
H7-75-22-PRO



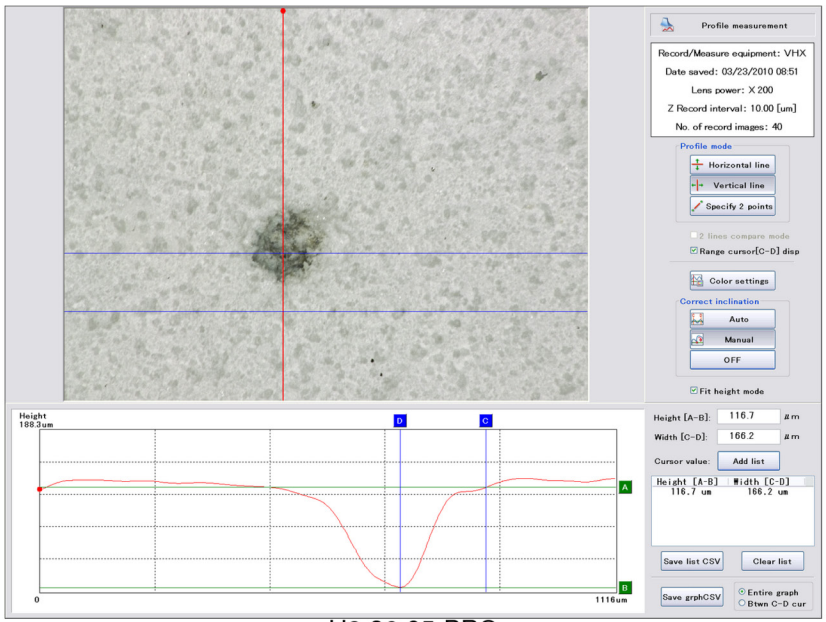
H7-93-17-PRO



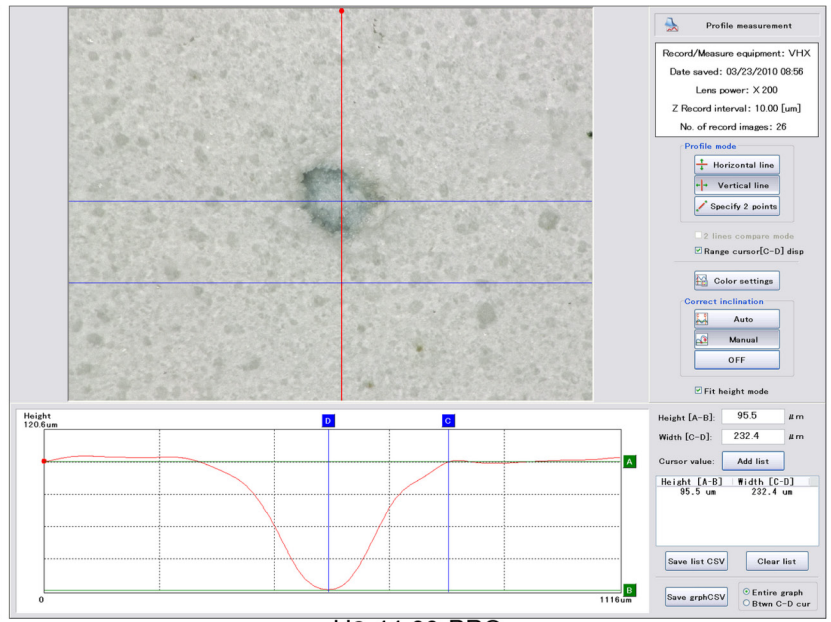
H8-30-77-PRO



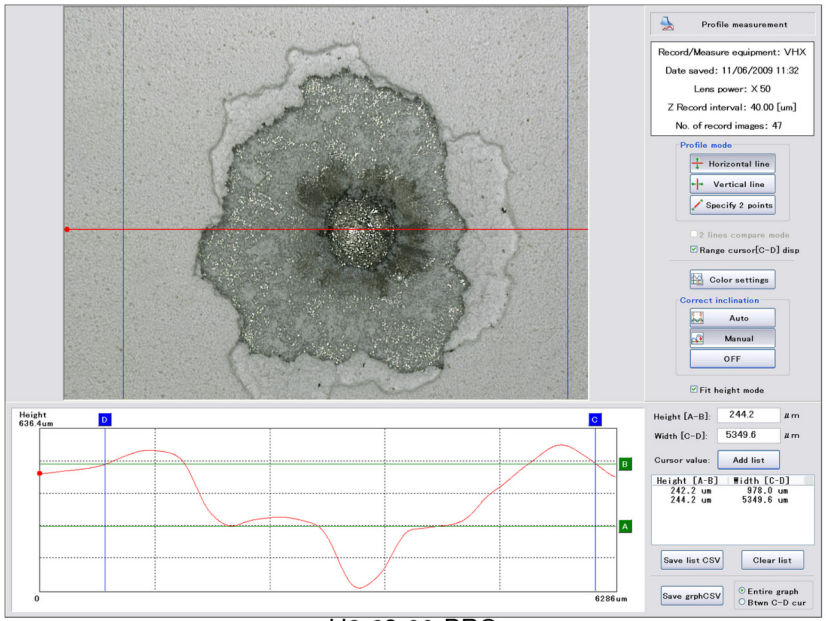
H8-33-67-PRO



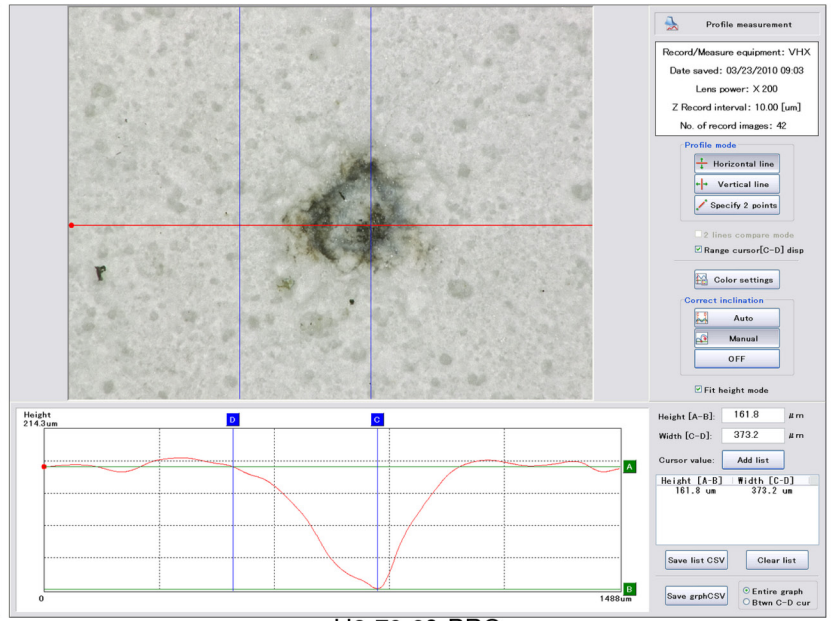
H8-36-95-PRO



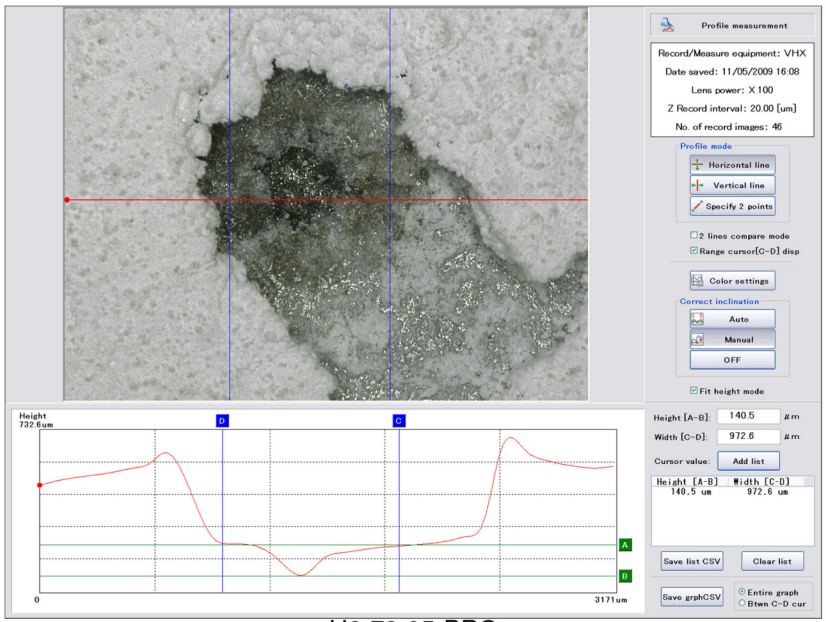
H8-44-99-PRO



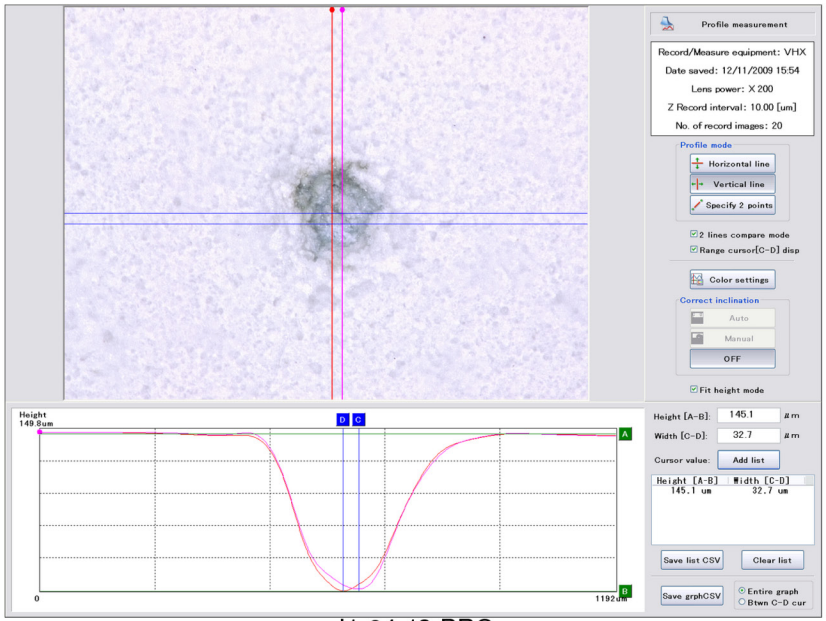
H8-63-00-PRO



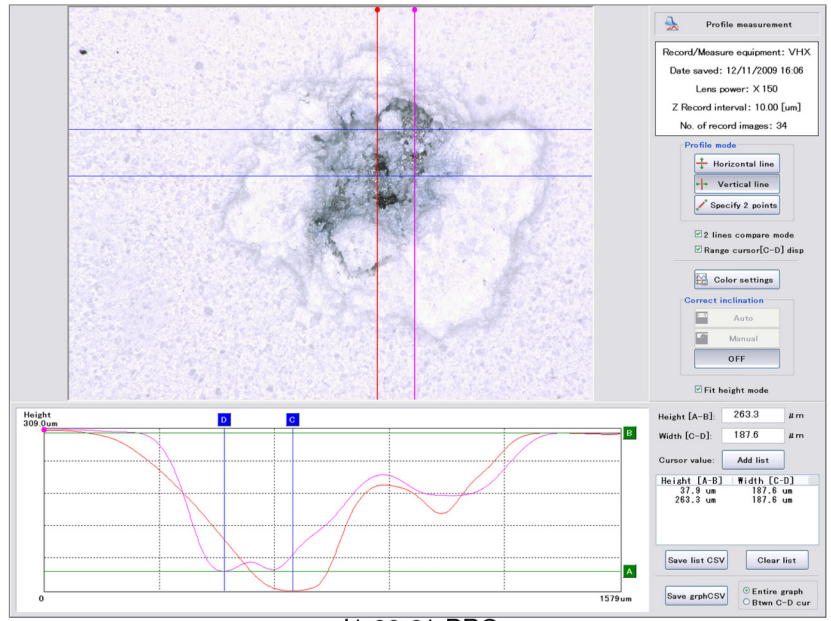
H8-76-69-PRO



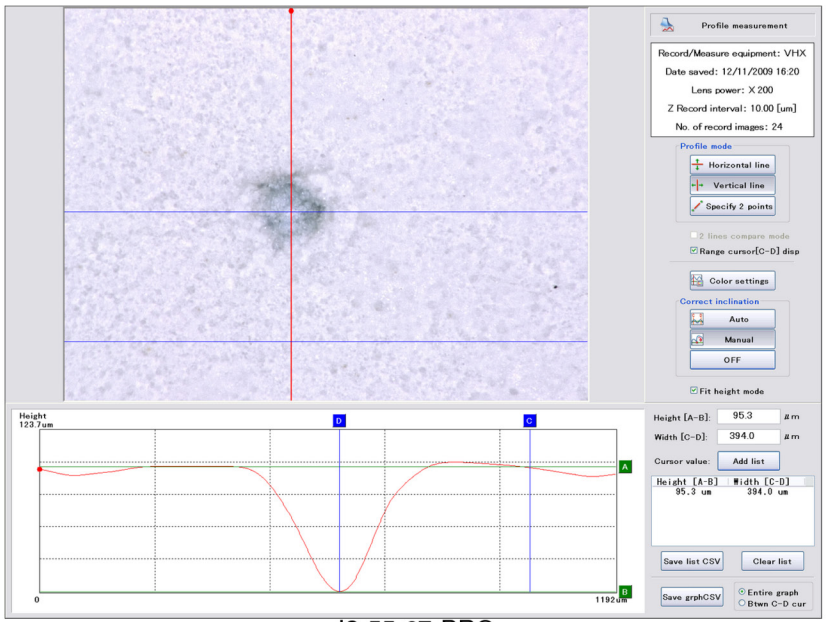
H8-78-05-PRO



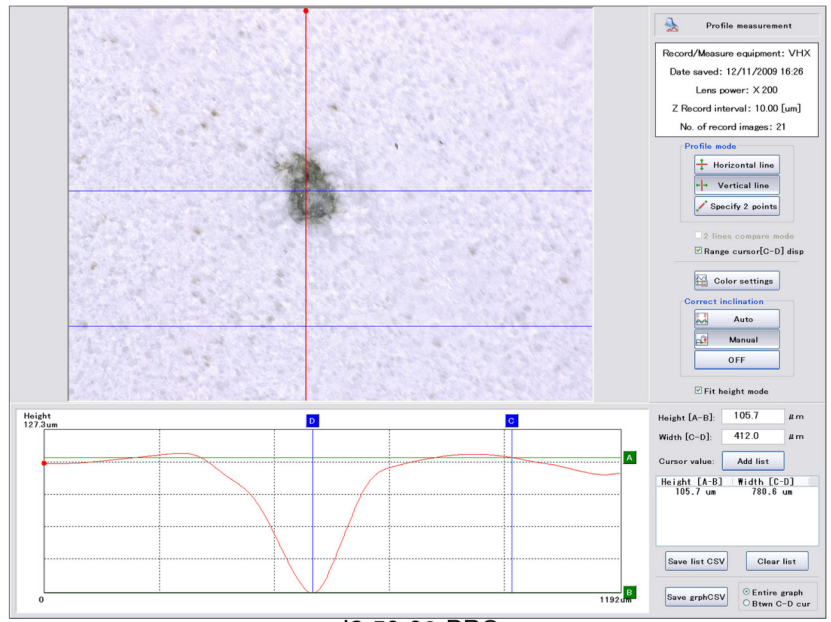
J1-84-12-PRO



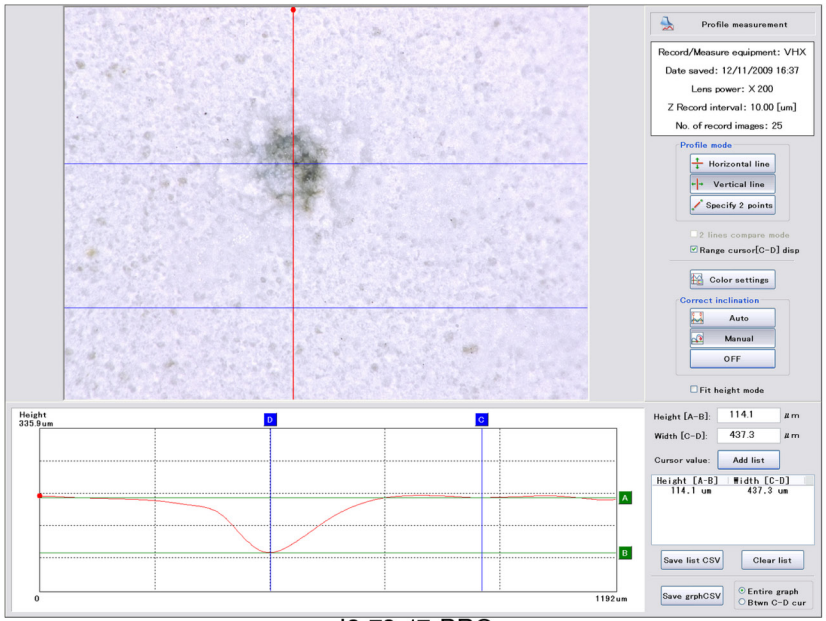
J1-88-81-PRO



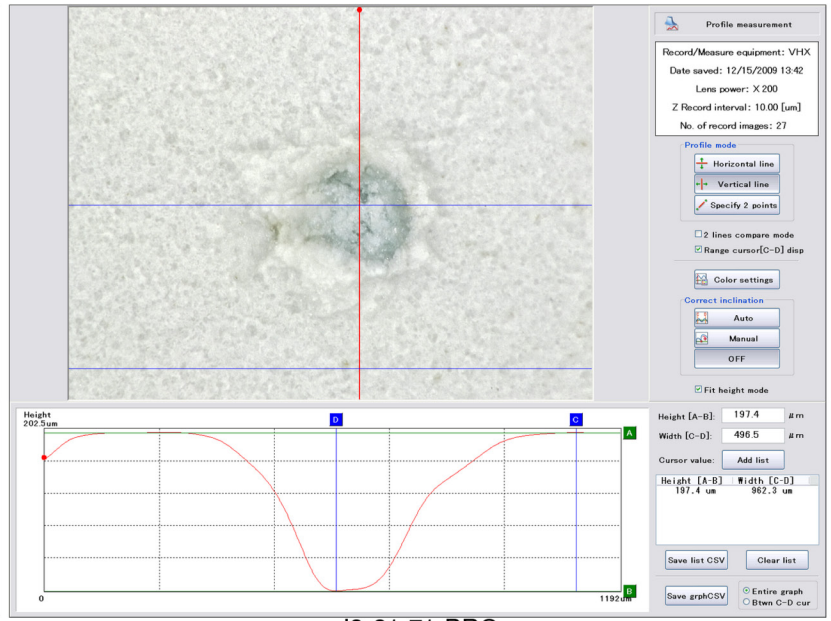
J2-55-67-PRO



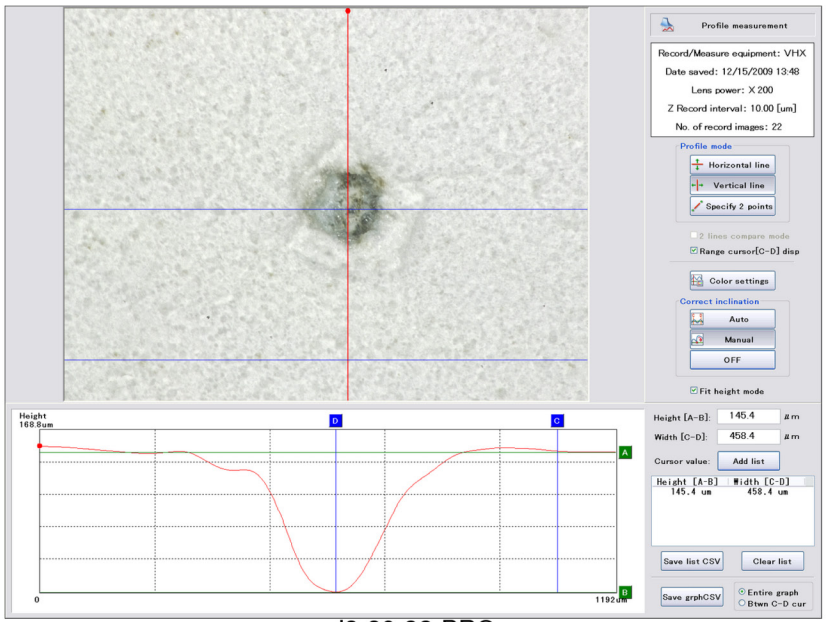
J2-59-98-PRO



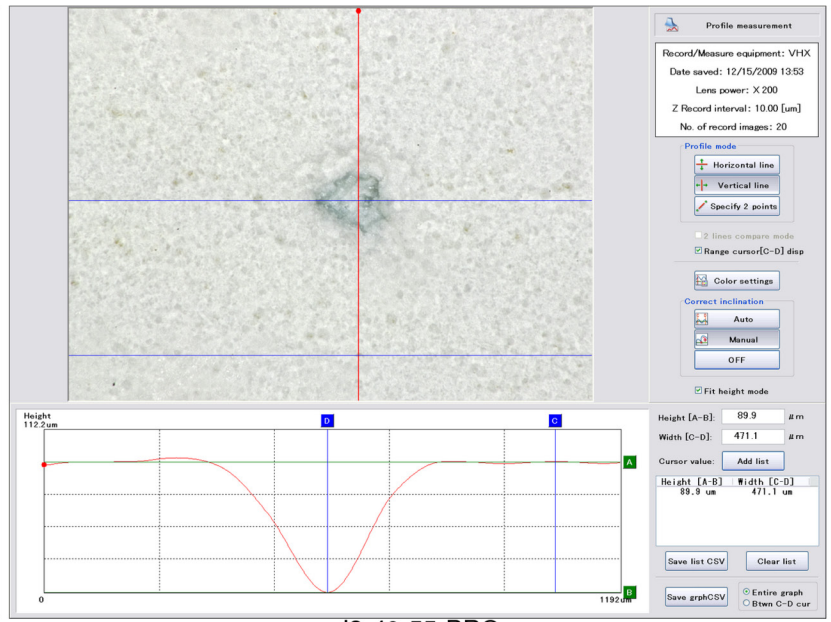
J2-73-17-PRO



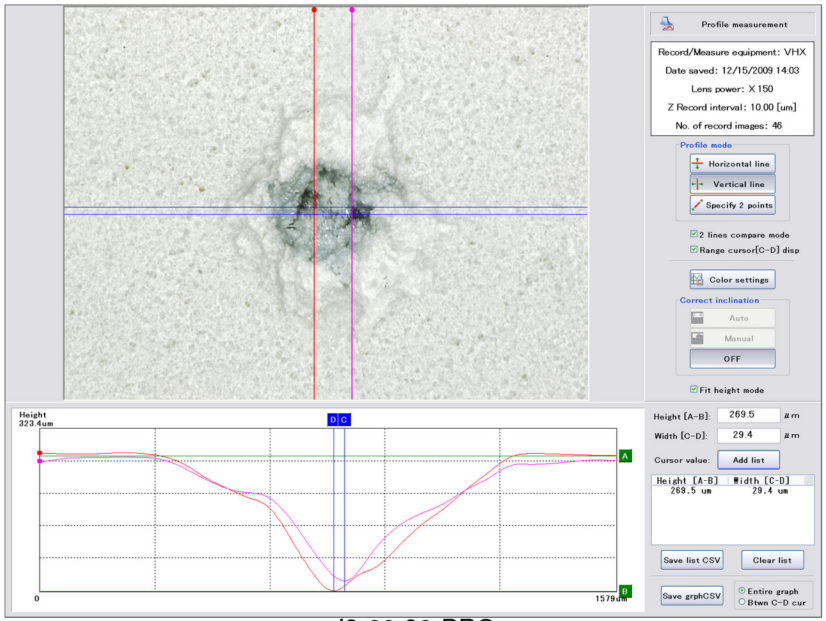
J3-21-71-PRO



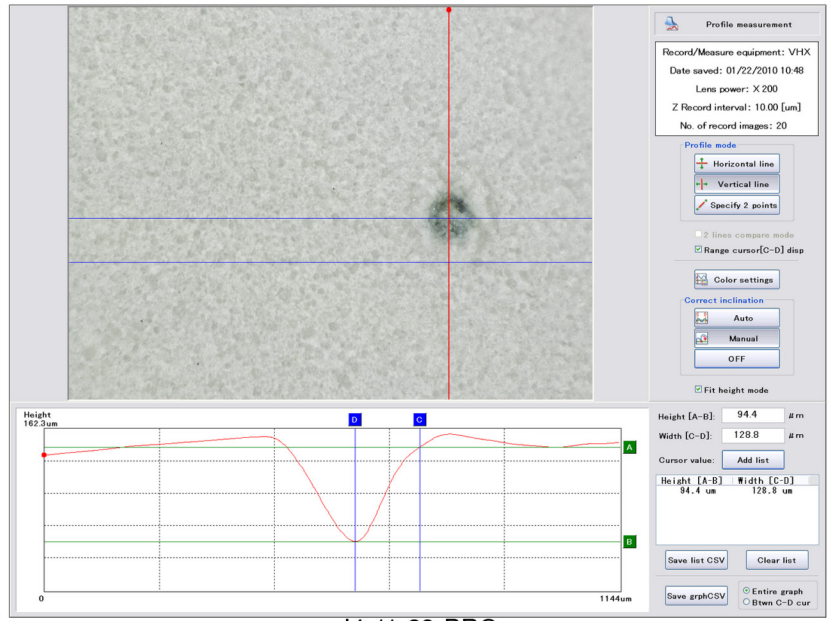
J3-39-32-PRO



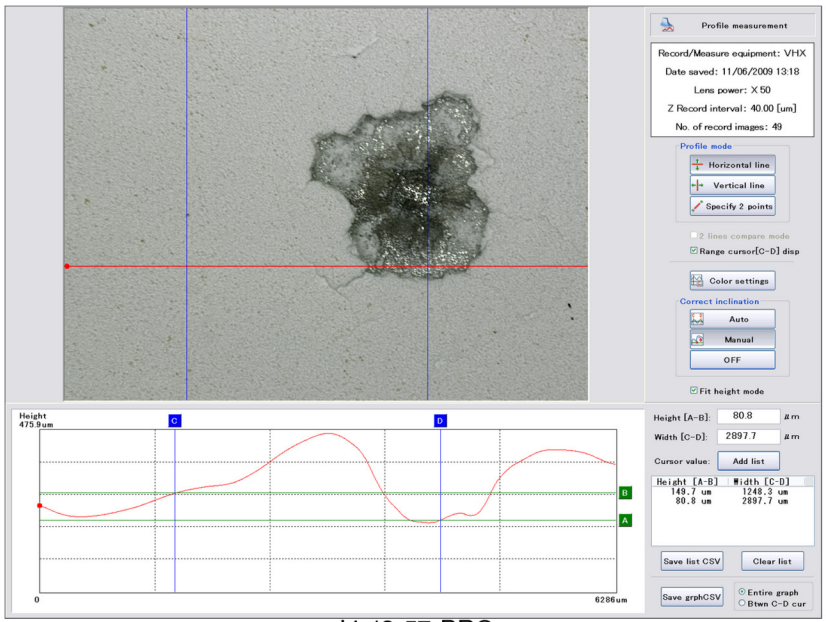
J3-40-55-PRO



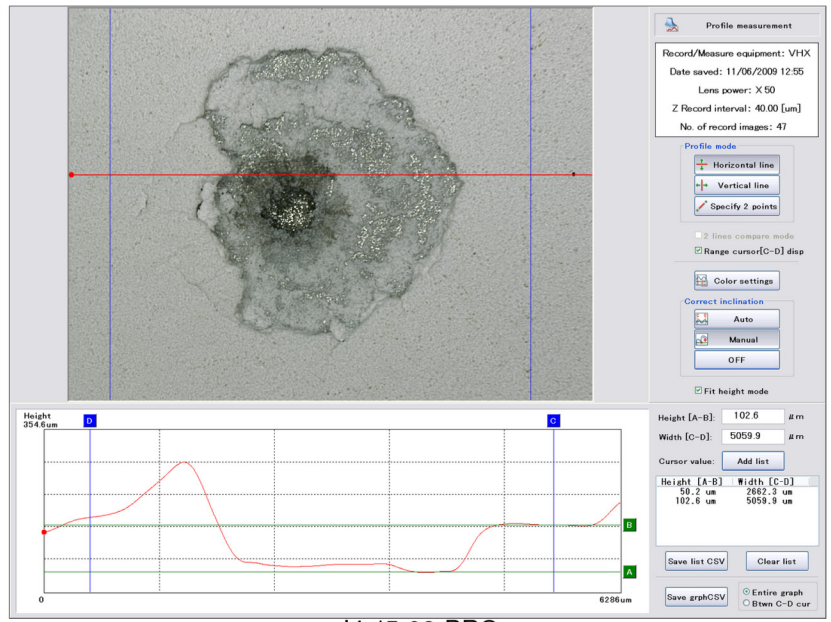
J3-88-38-PRO



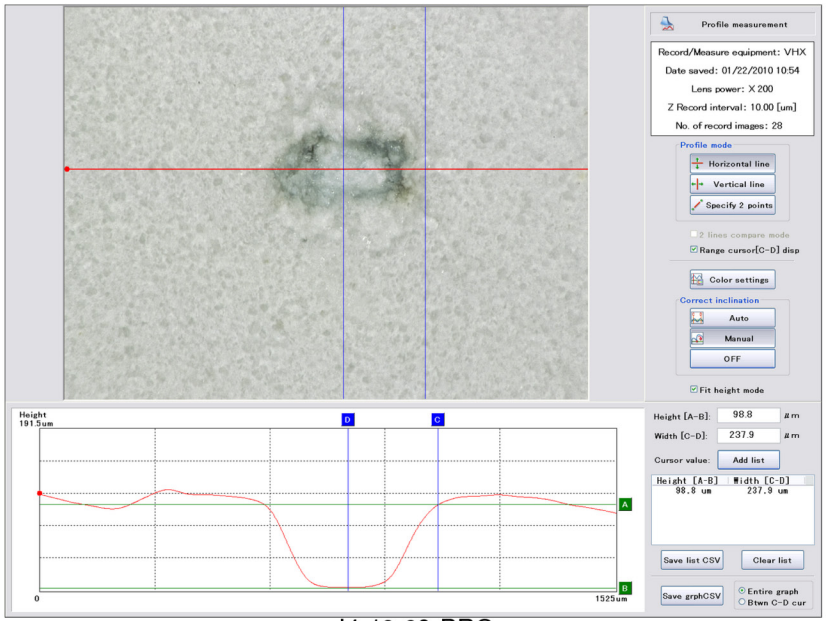
J4-11-23-PRO



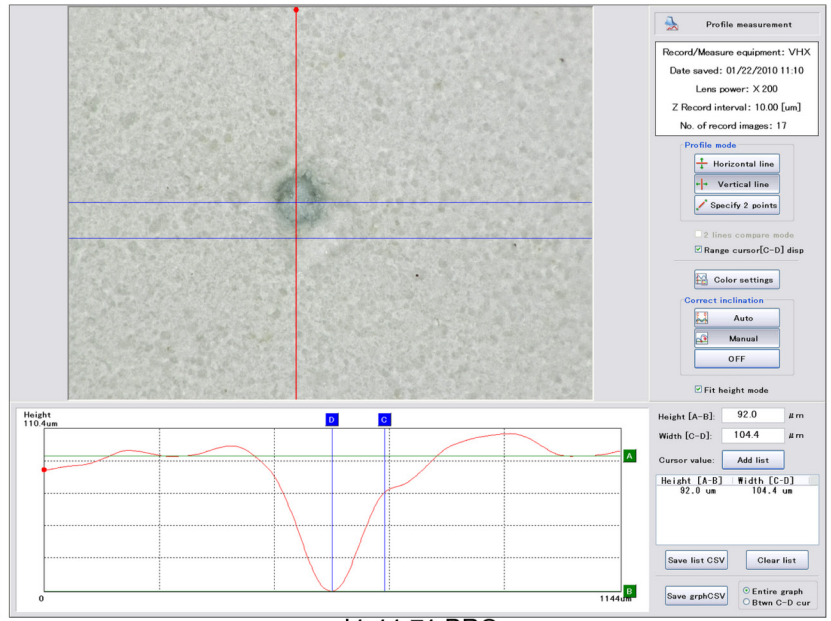
J4-13-57-PRO



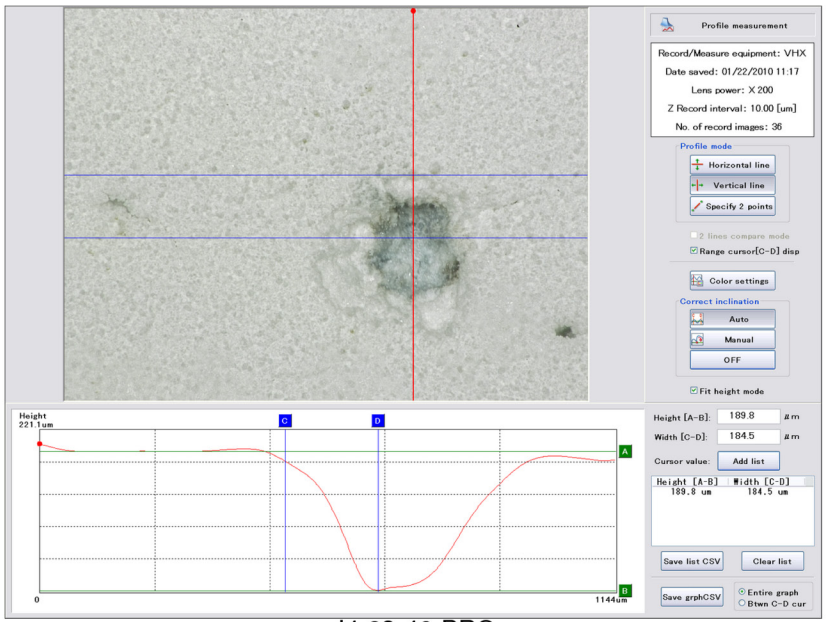
J4-15-08-PRO



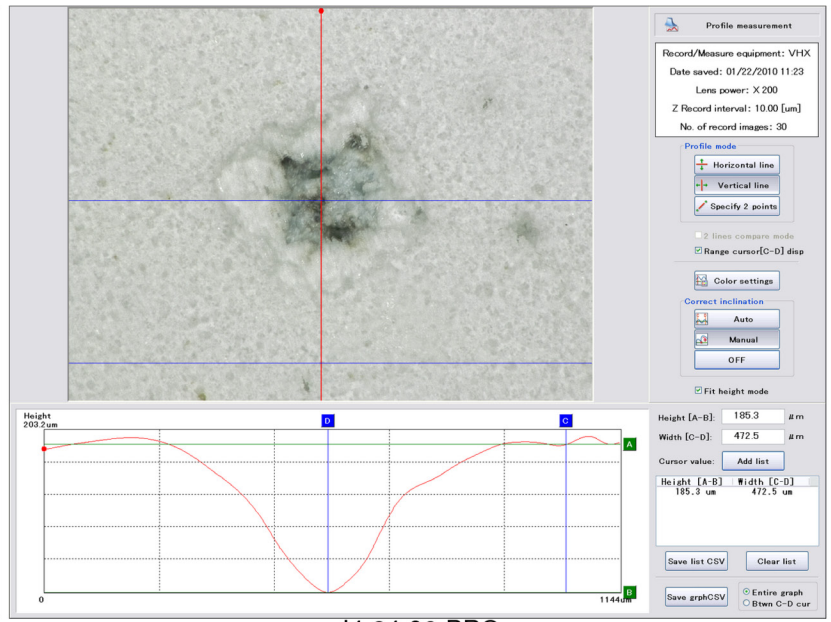
J4-16-69-PRO



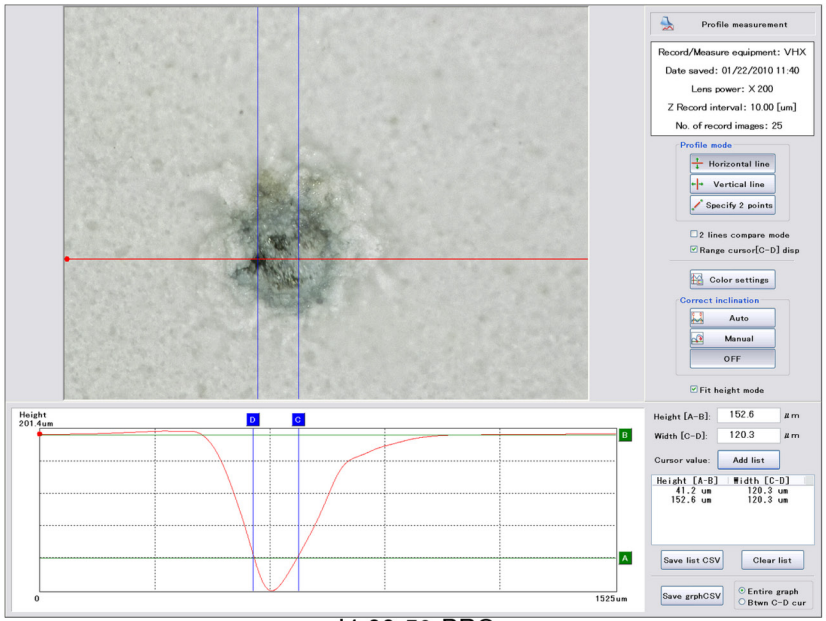
J4-44-74-PRO



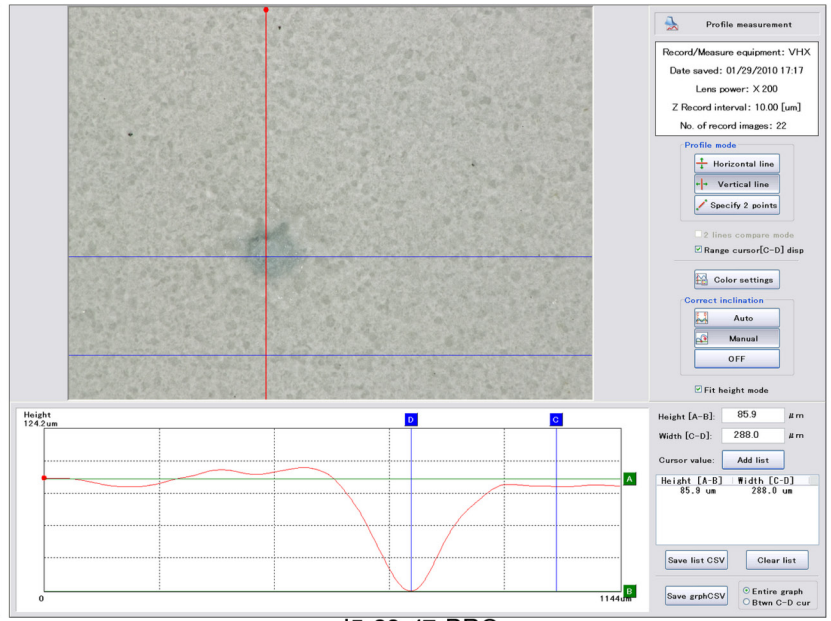
J4-83-46-PRO



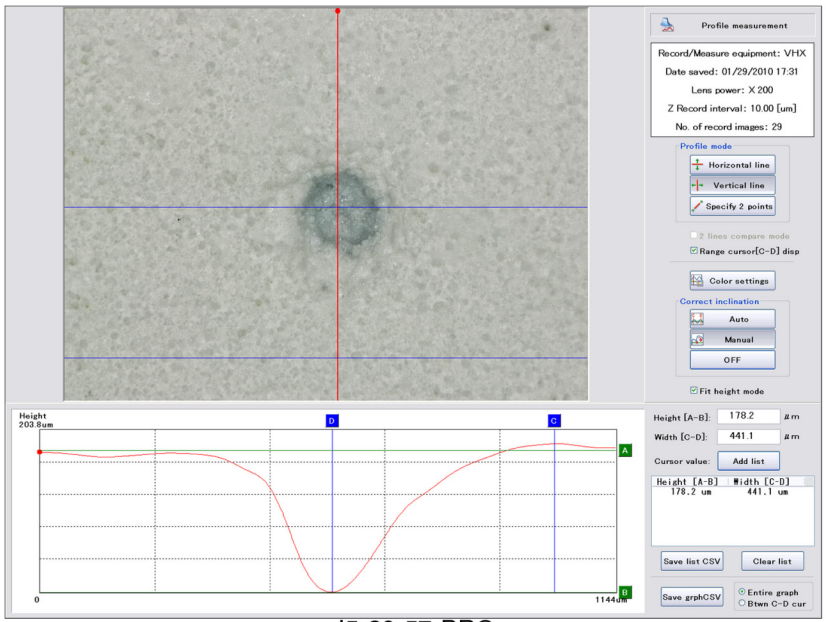
J4-84-96-PRO



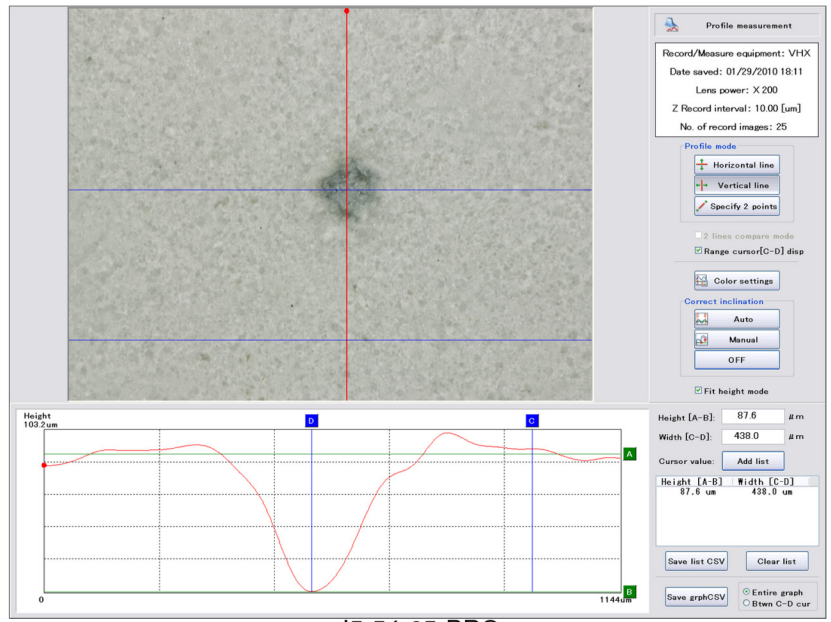
J4-99-50-PRO



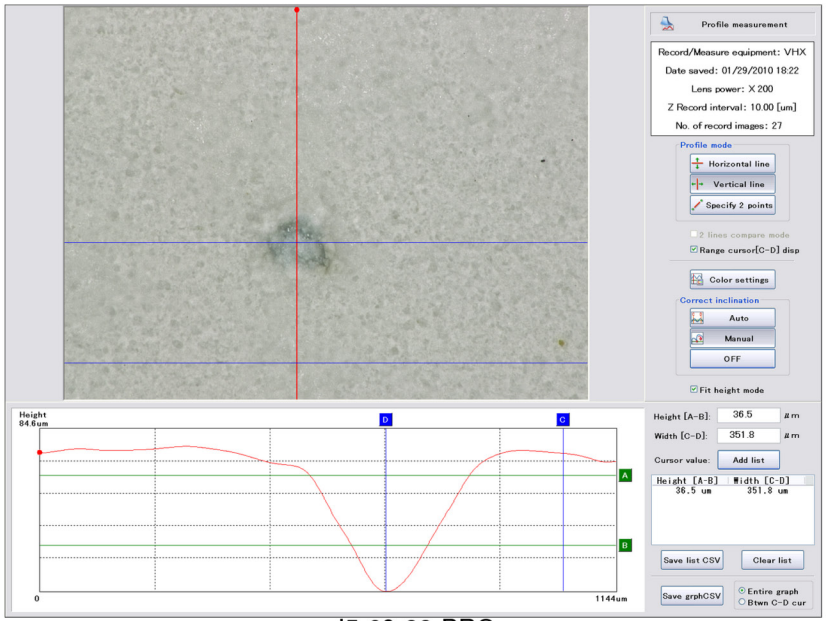
J5-23-47-PRO



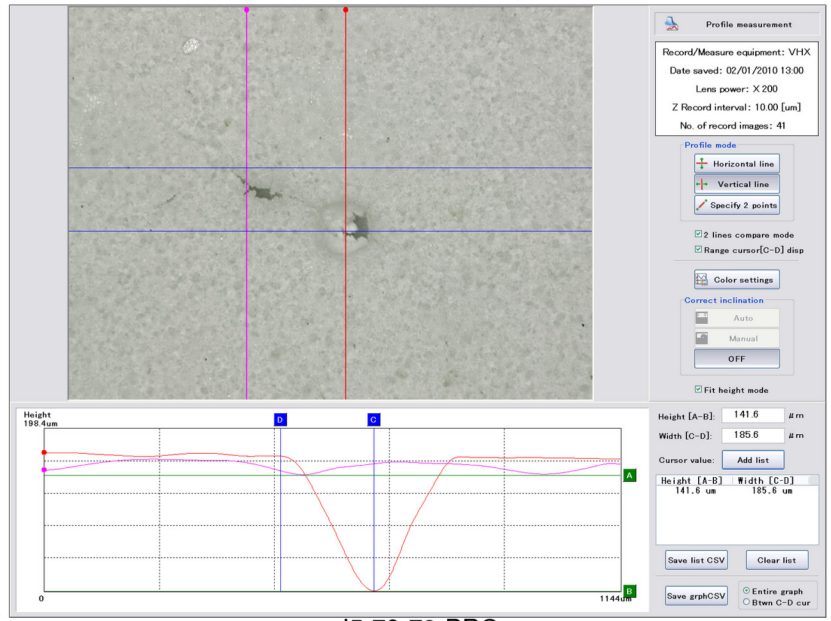
J5-29-57-PRO



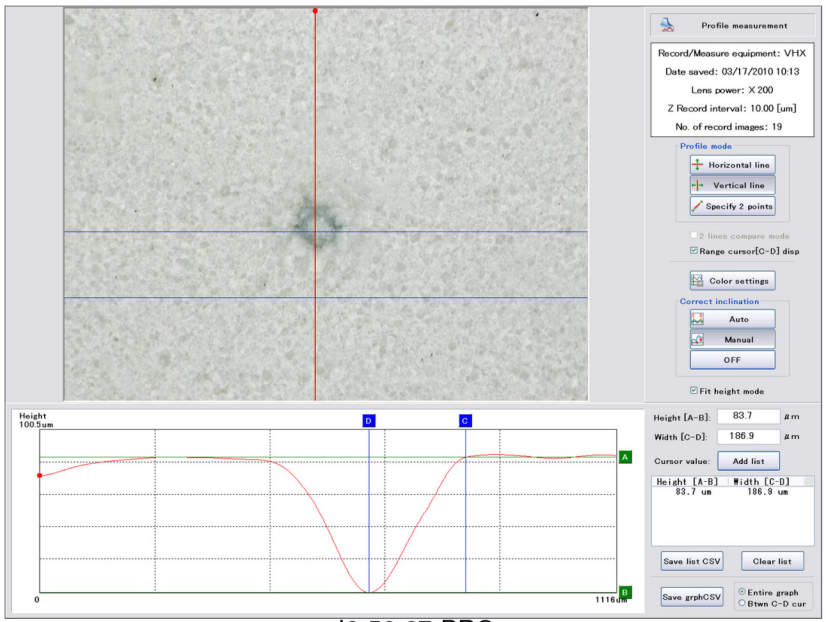
J5-54-65-PRO



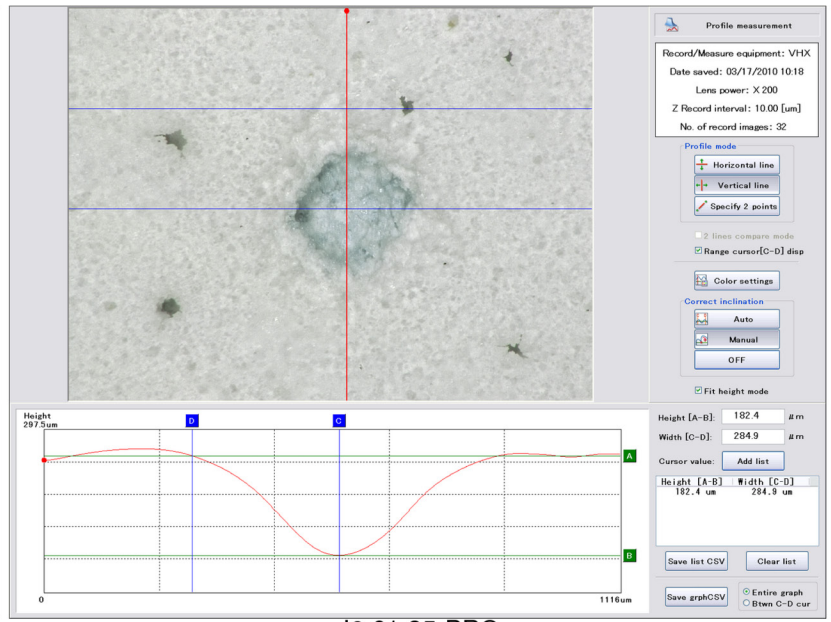
J5-69-88-PRO



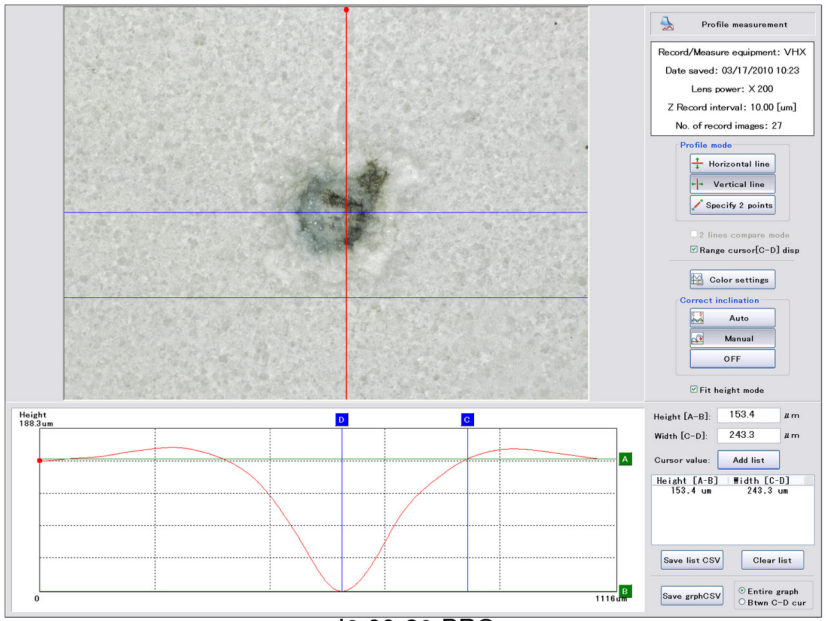
J5-79-78-PRO



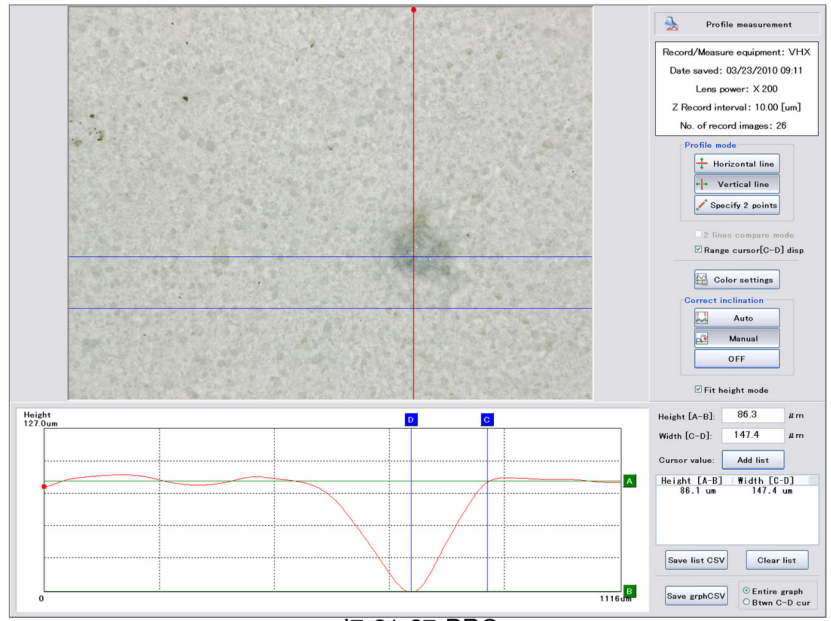
J6-56-87-PRO



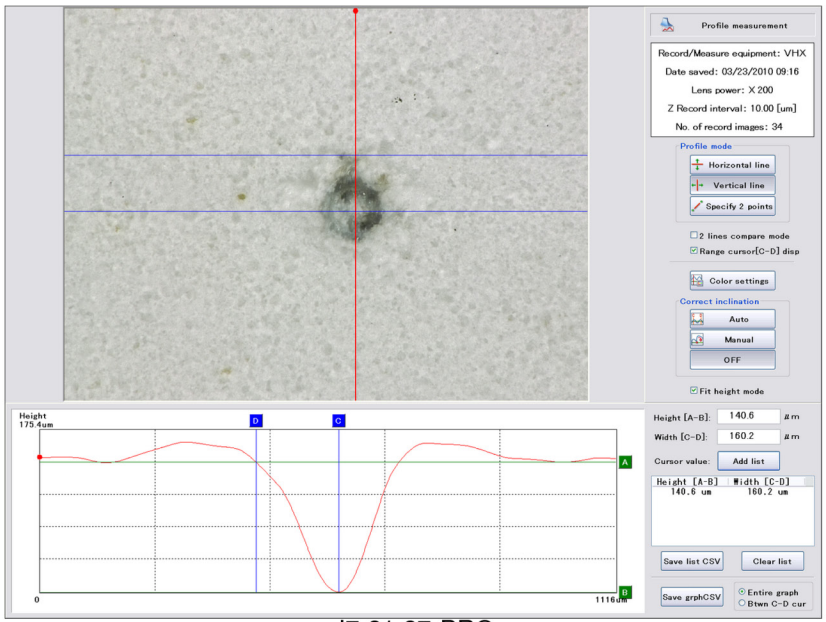
J6-91-35-PRO



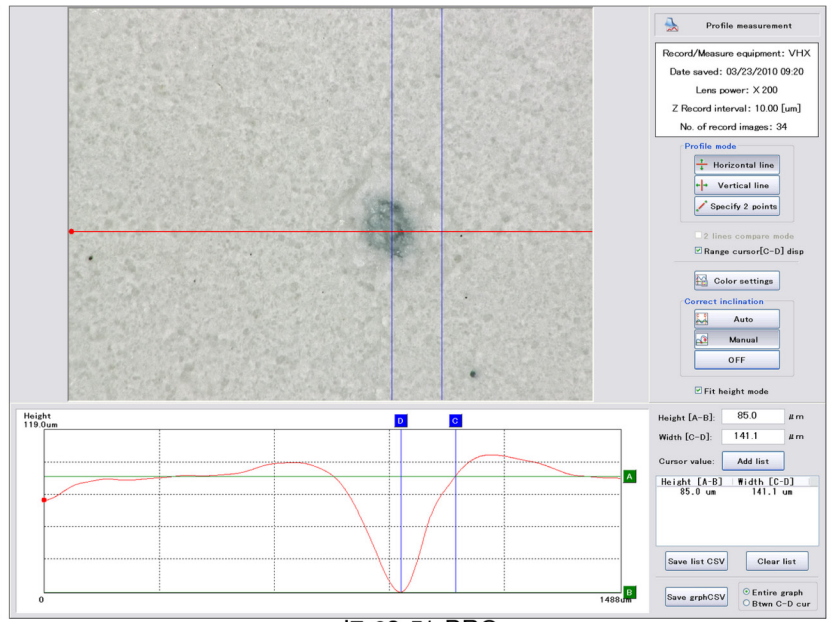
J6-99-26-PRO



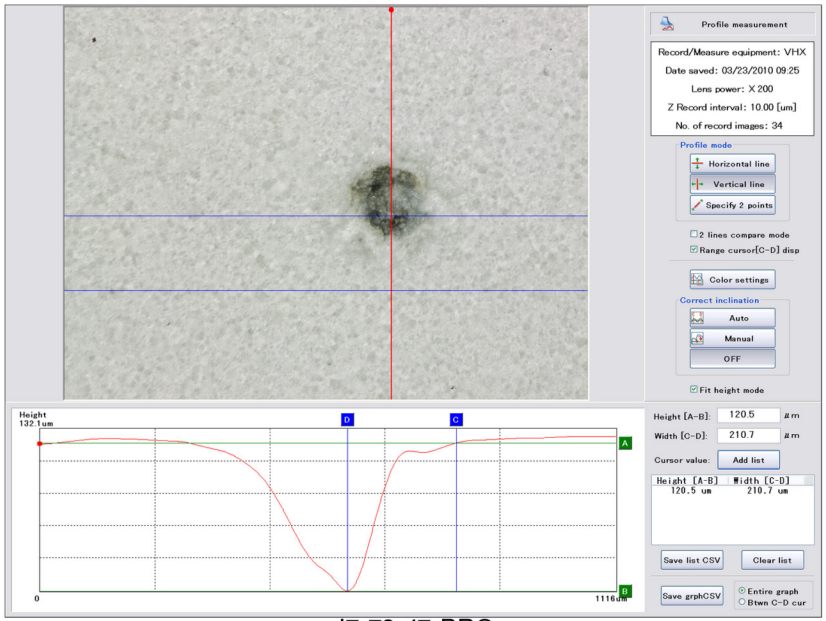
J7-21-27-PRO



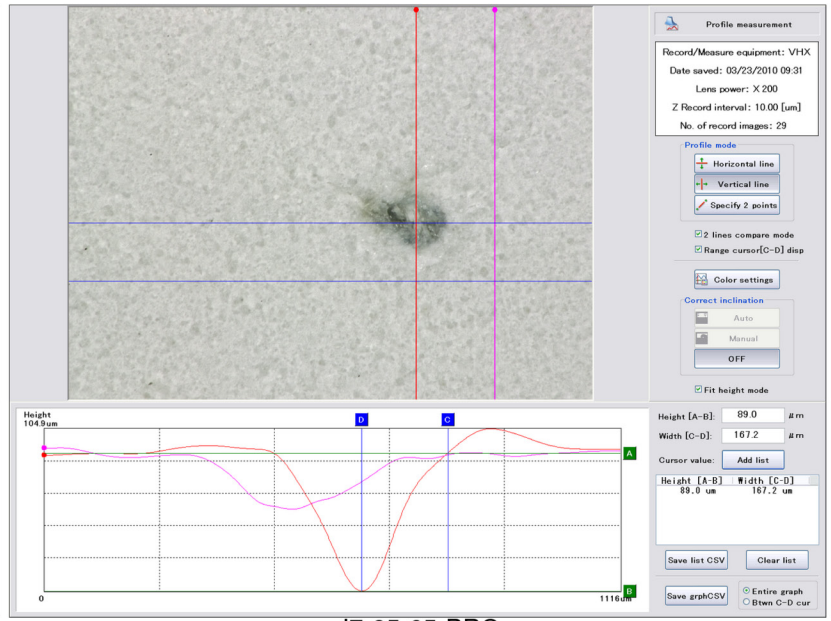
J7-31-37-PRO



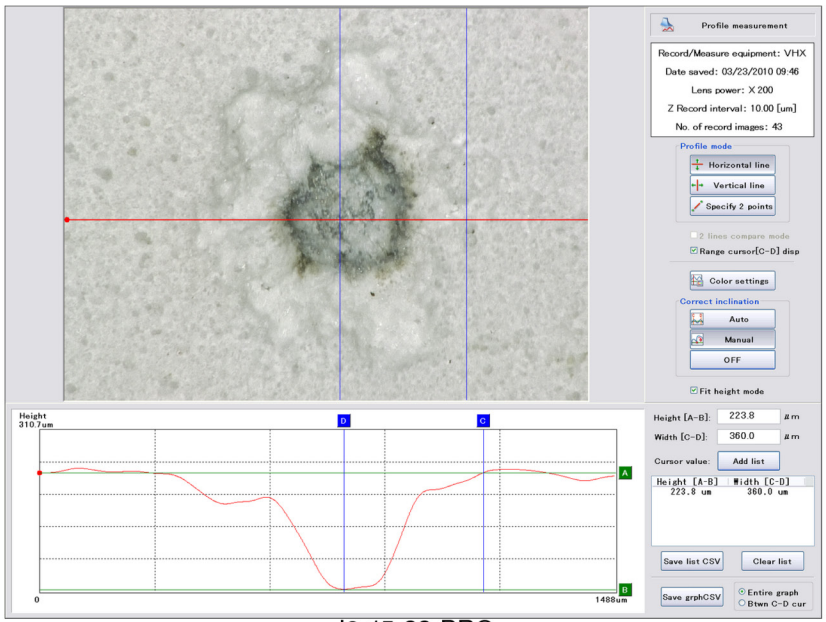
J7-63-51-PRO



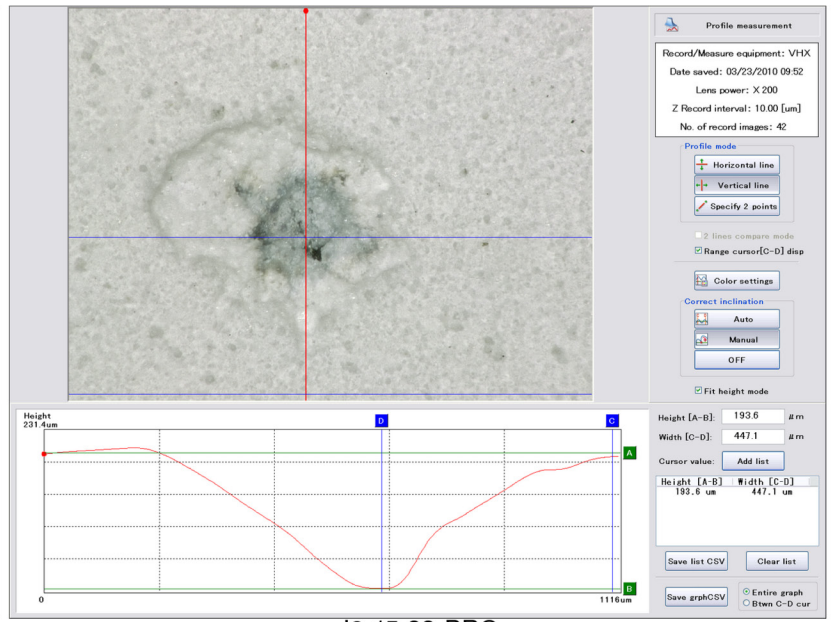
J7-73-47-PRO



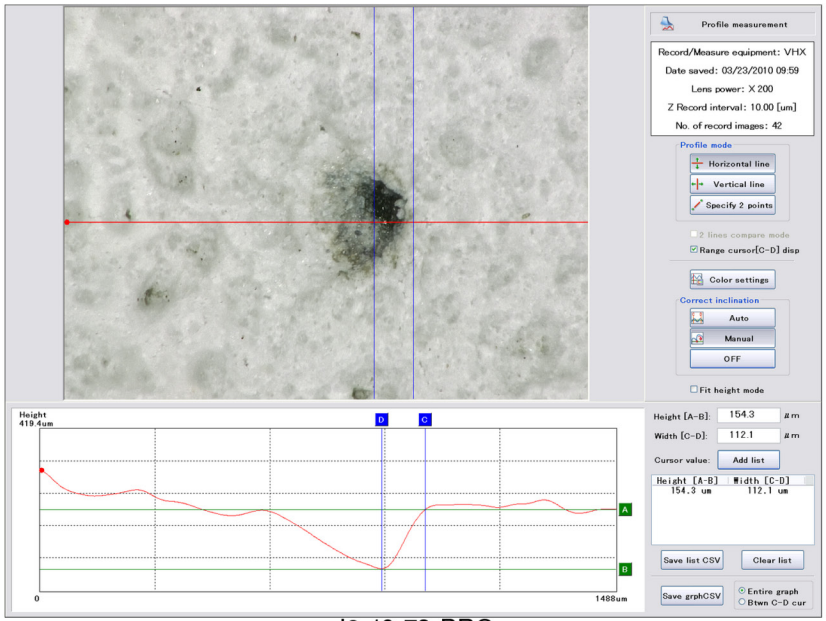
J7-85-65-PRO



J8-15-22-PRO



J8-15-33-PRO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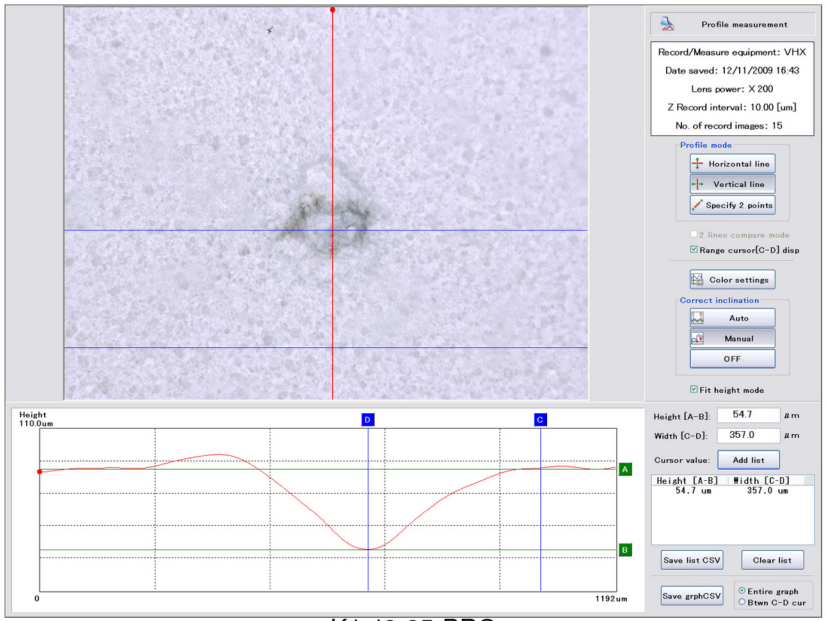
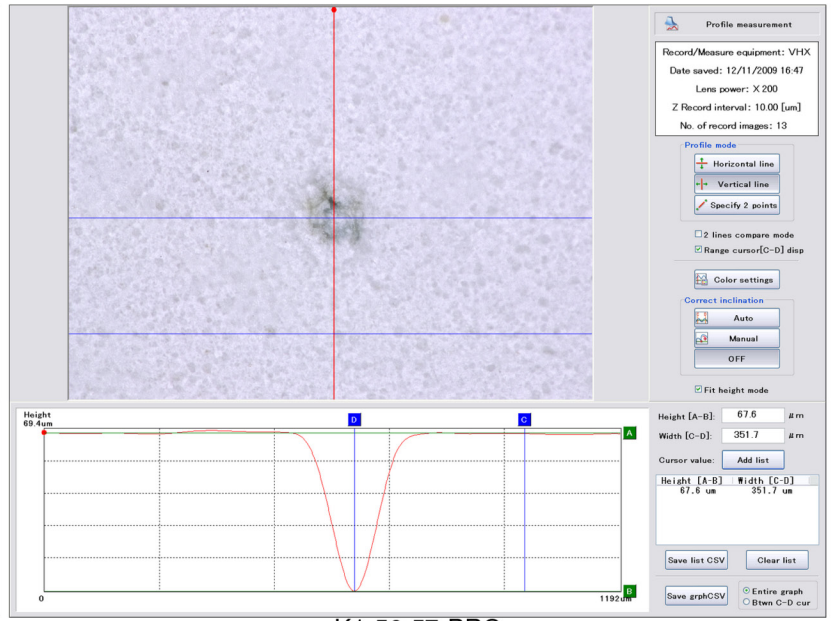
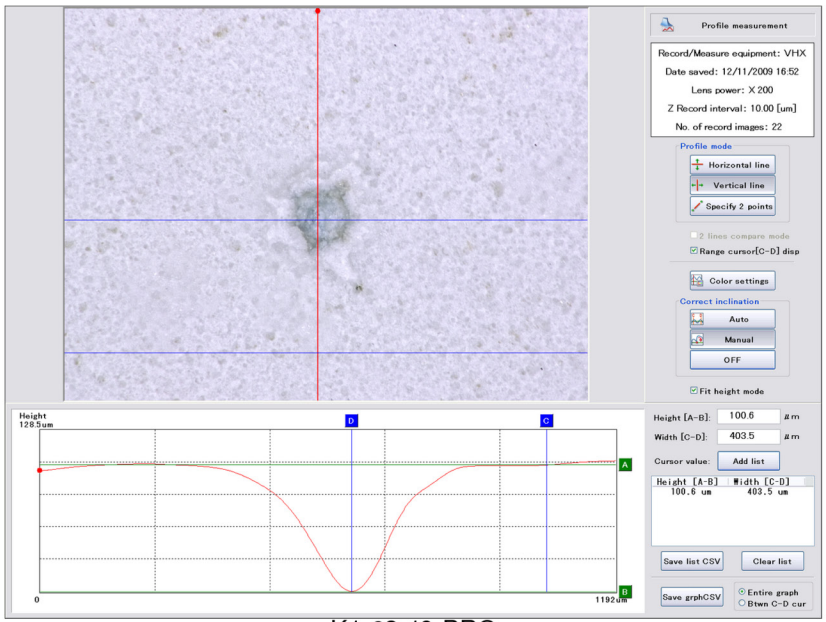
J8-19-73-PRO



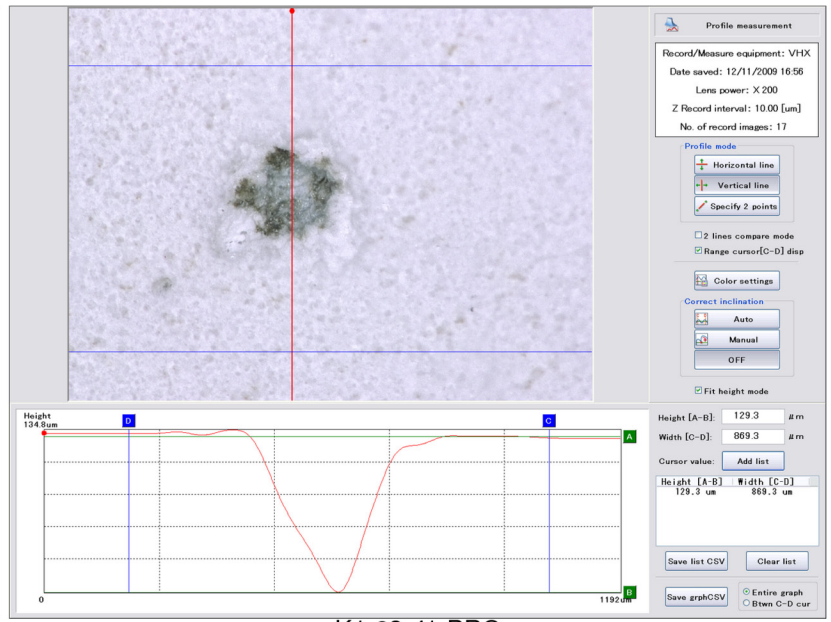
K1-18-85-PRO



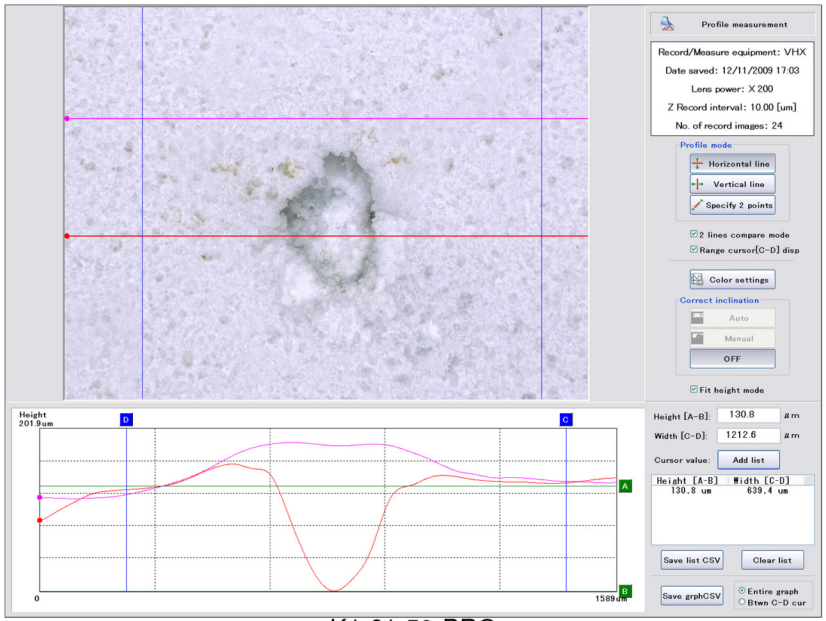
K1-56-57-PRO



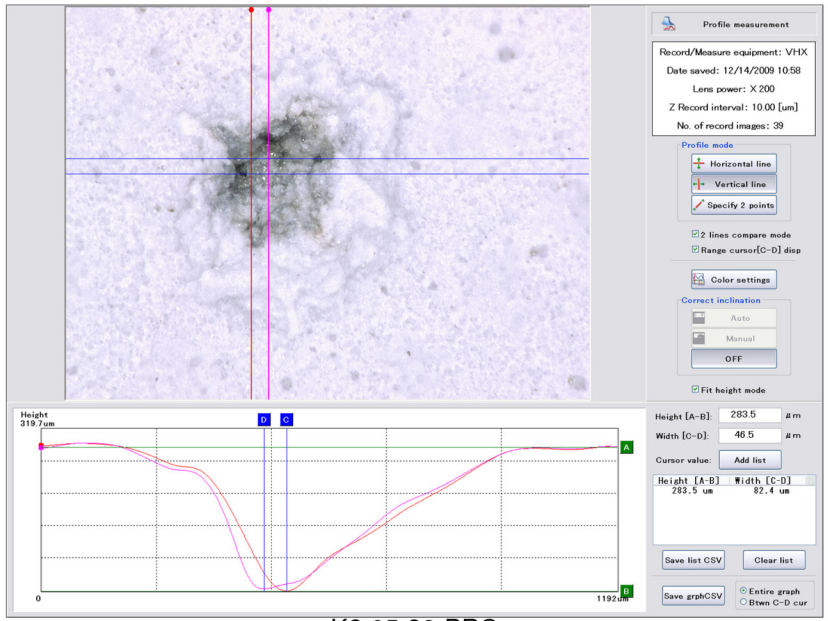
K1-63-19-PRO



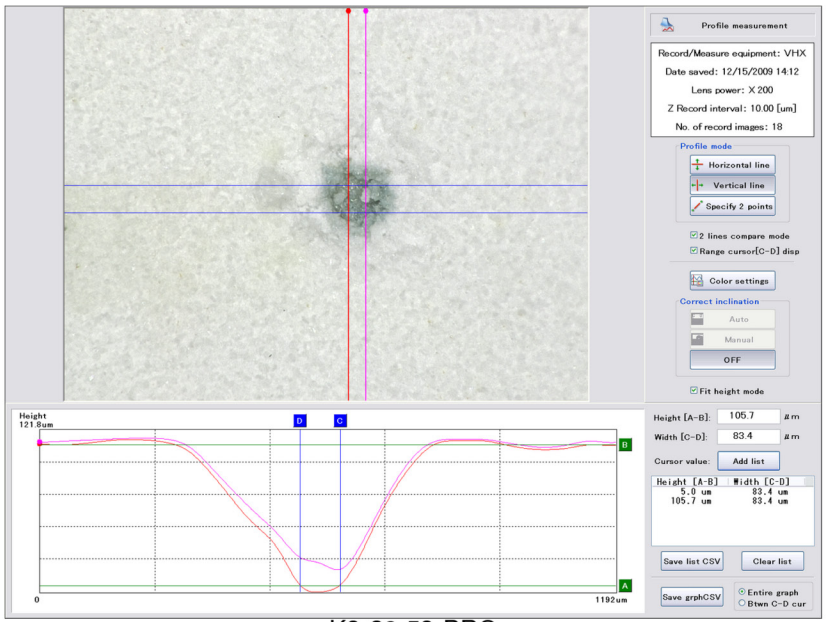
K1-83-41-PRO



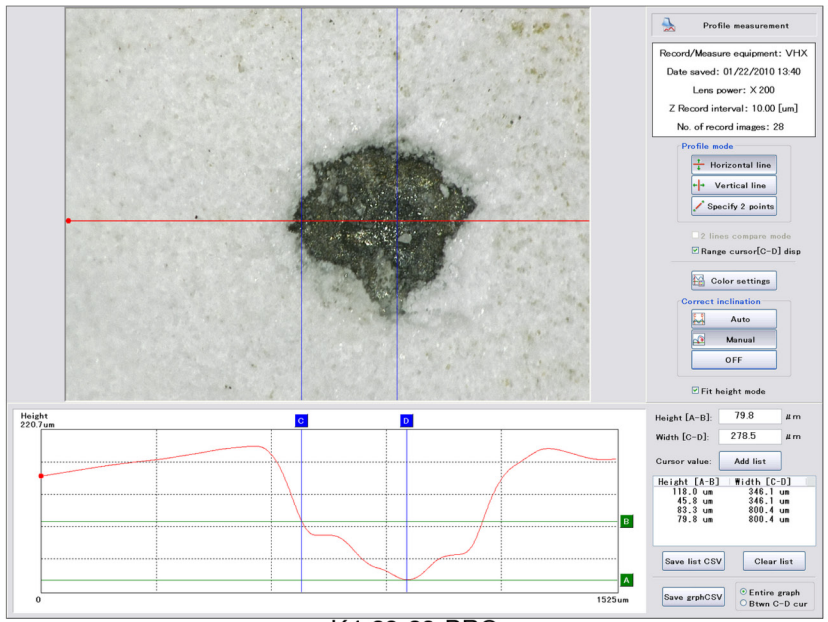
K1-91-50-PRO



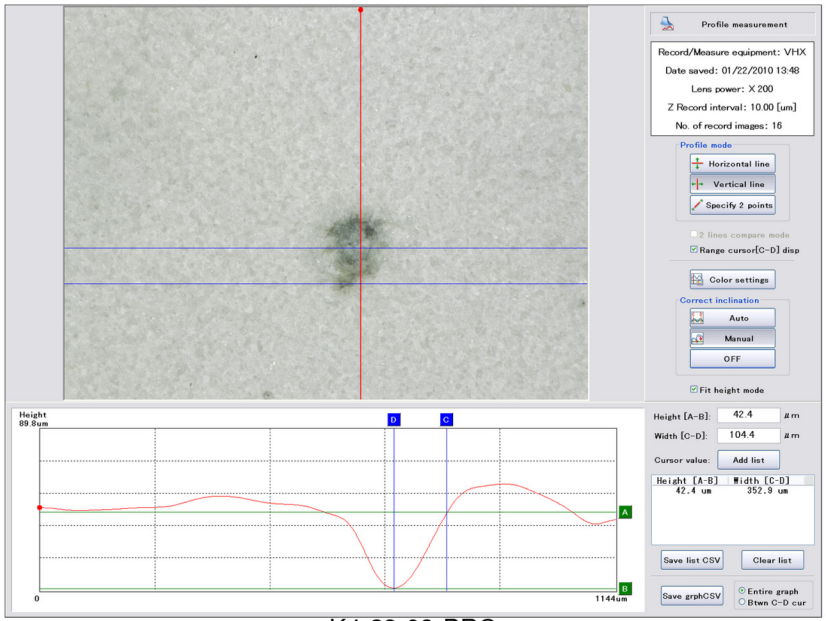
K2-05-38-PRO



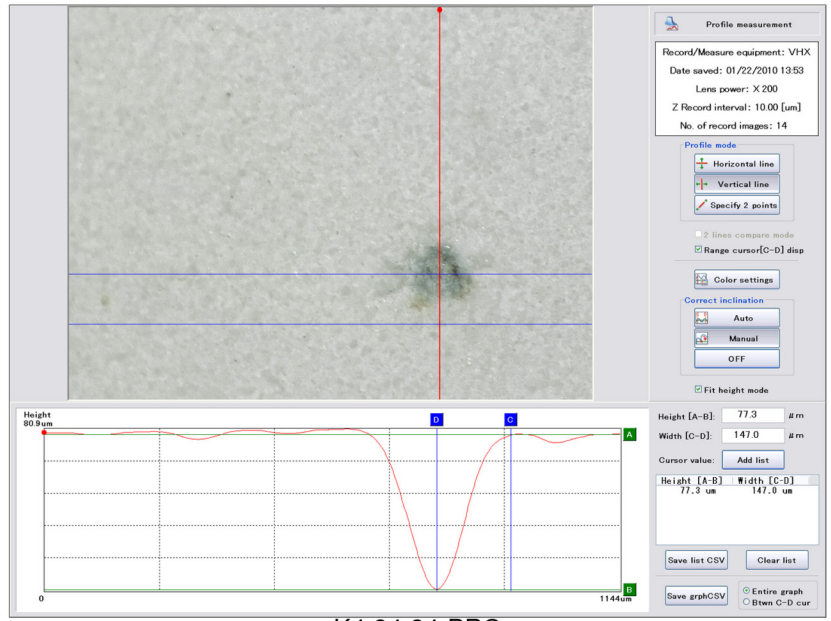
K3-28-53-PRO



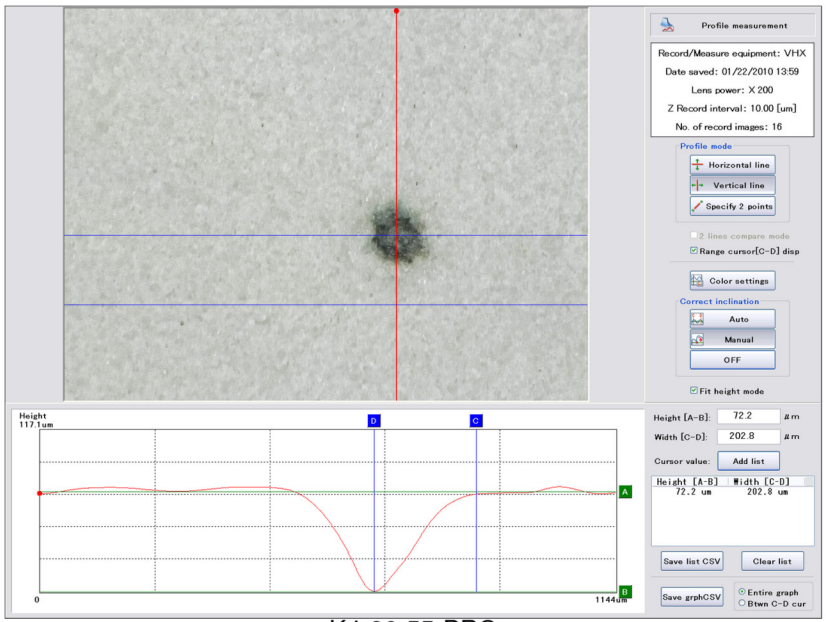
K4-23-23-PRO



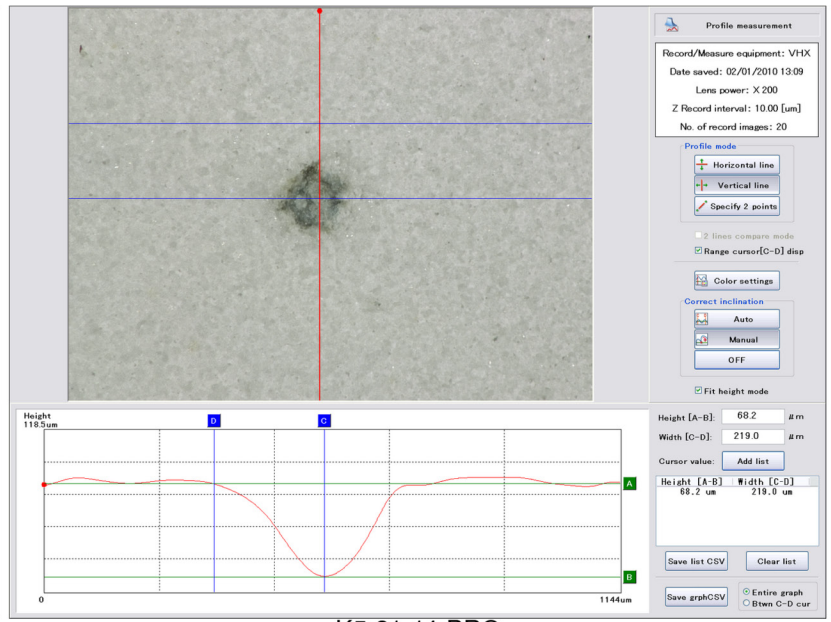
K4-23-93-PRO



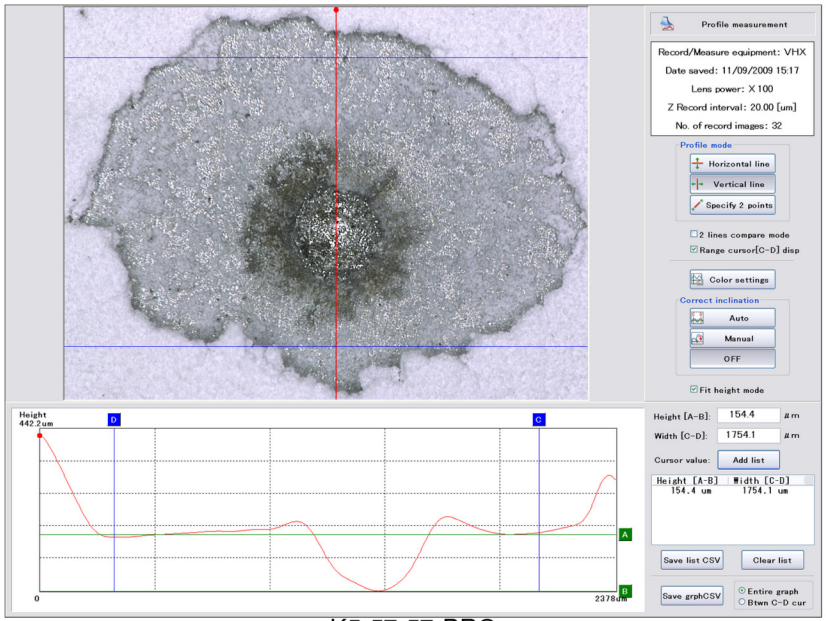
K4-34-34-PRO



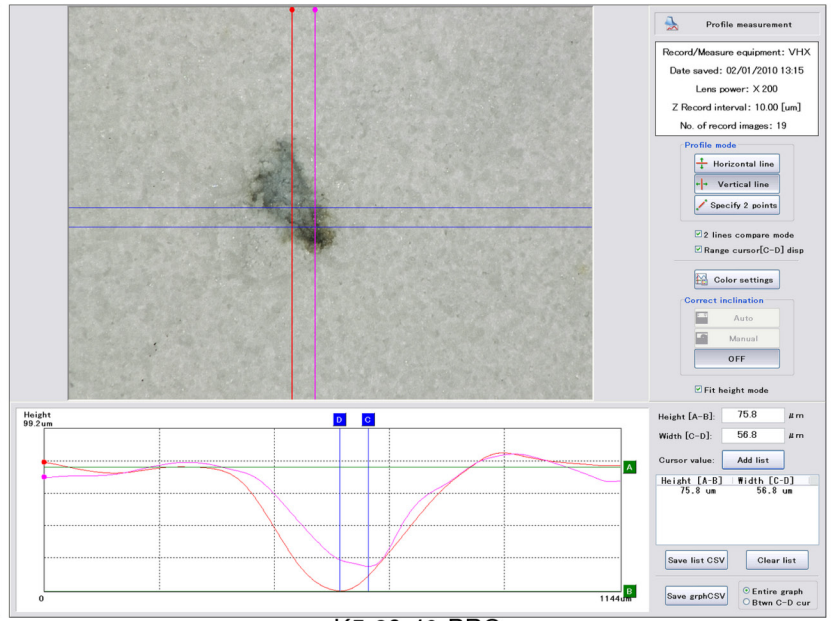
K4-86-55-PRO



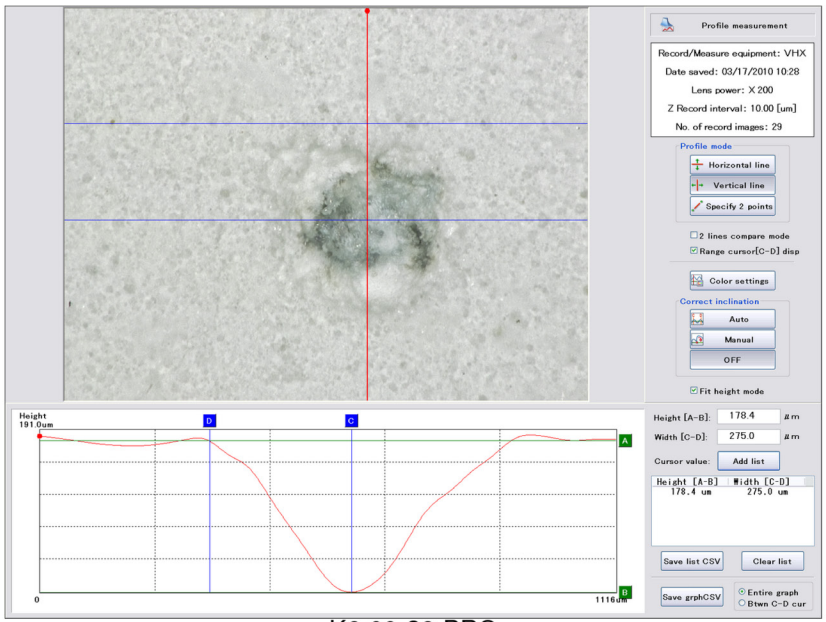
K5-31-14-PRO



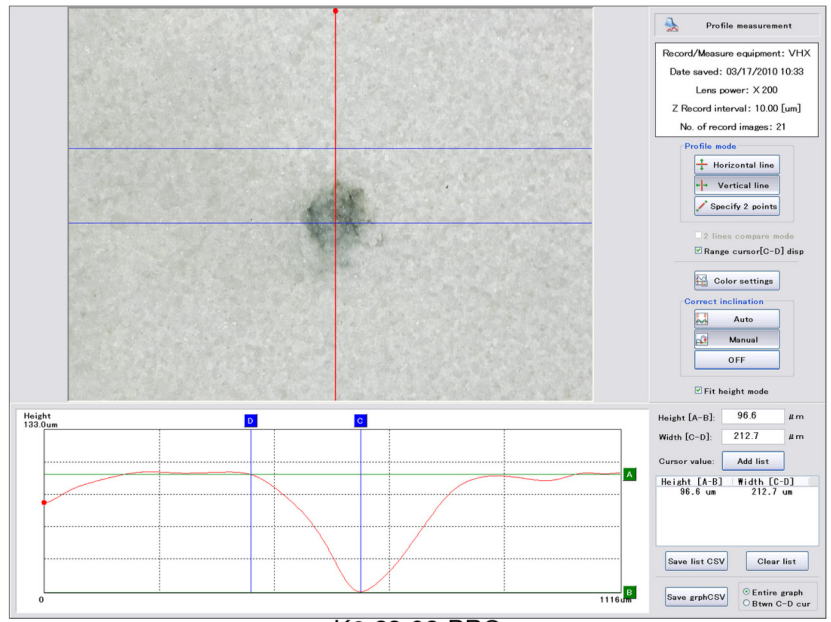
K5-57-57-PRO



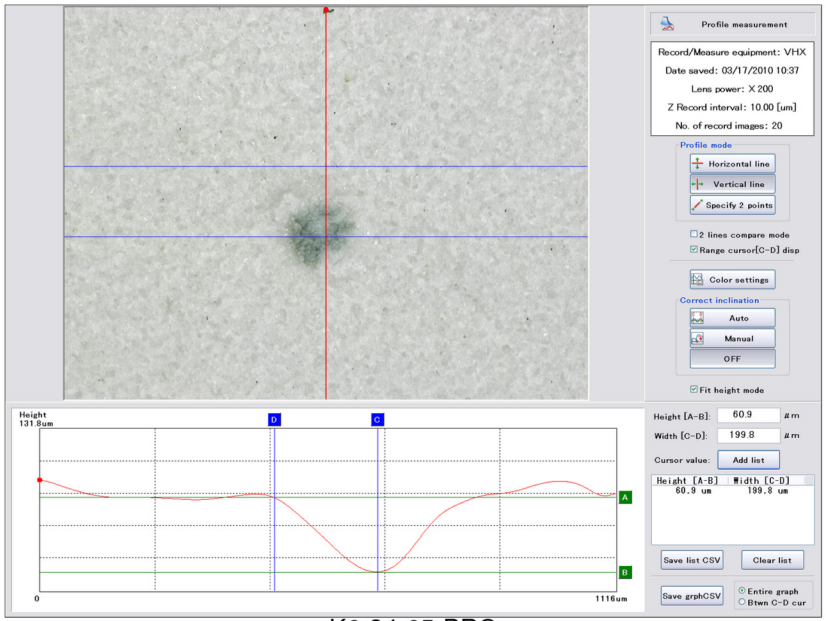
K5-89-40-PRO



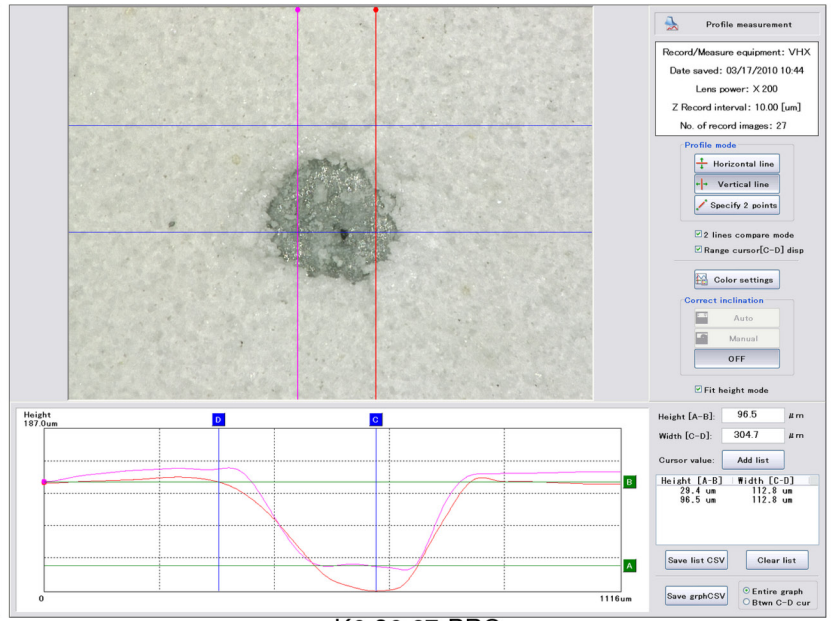
K6-00-26-PRO



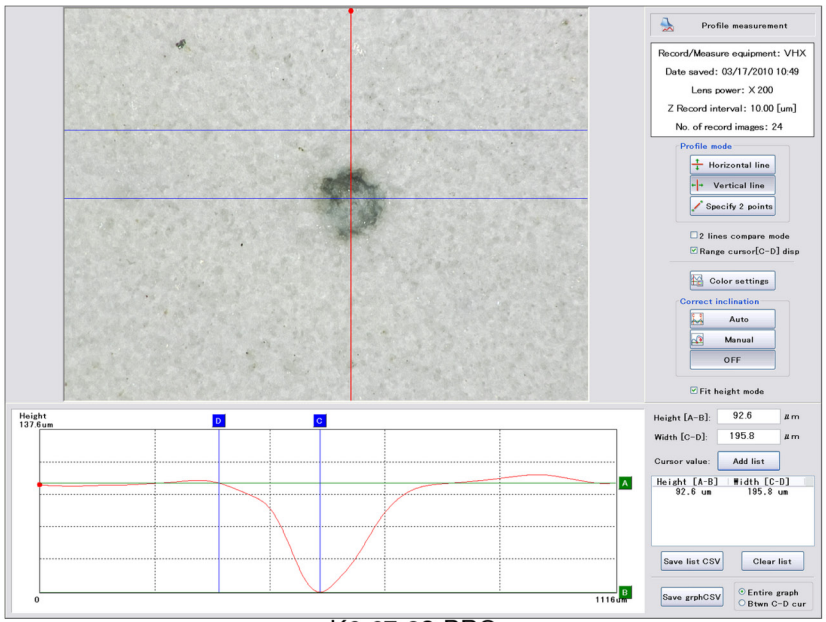
K6-23-92-PRO



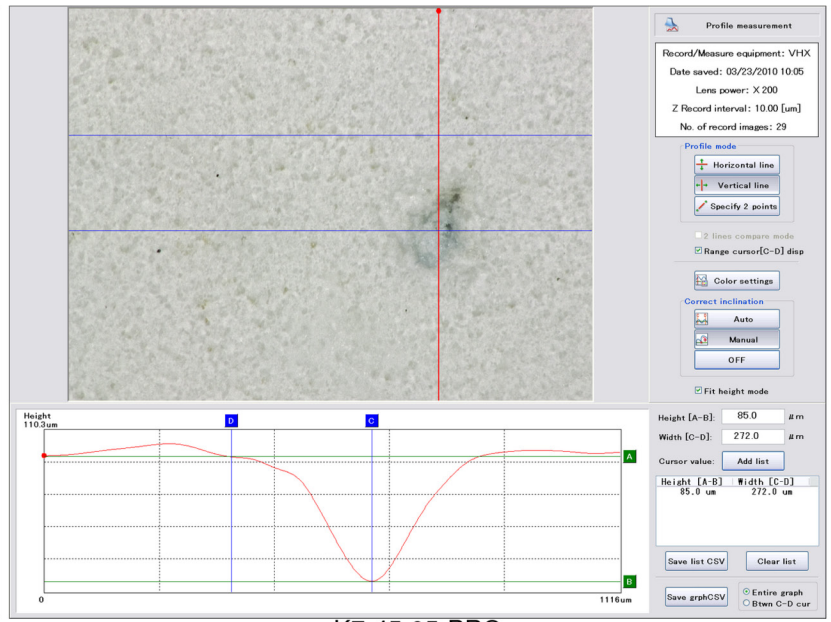
K6-34-65-PRO



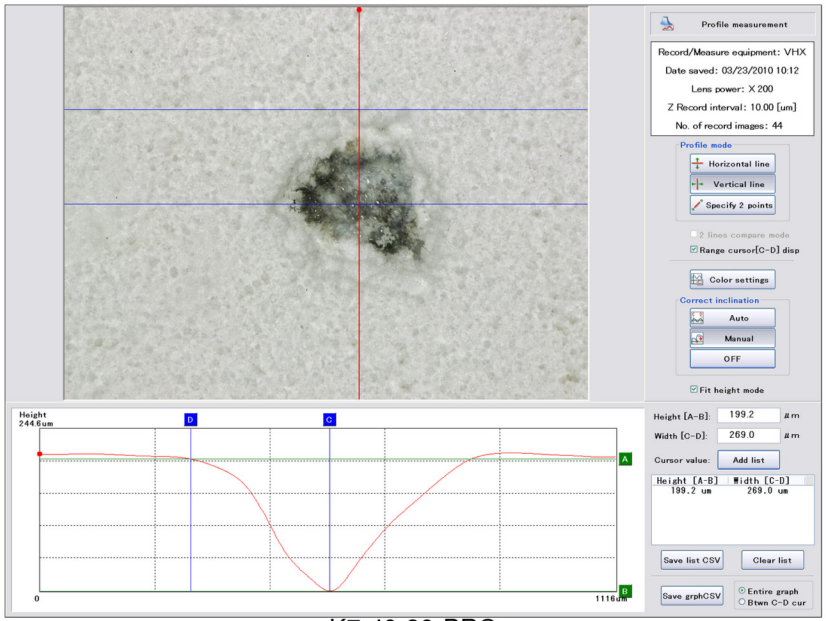
K6-36-87-PRO



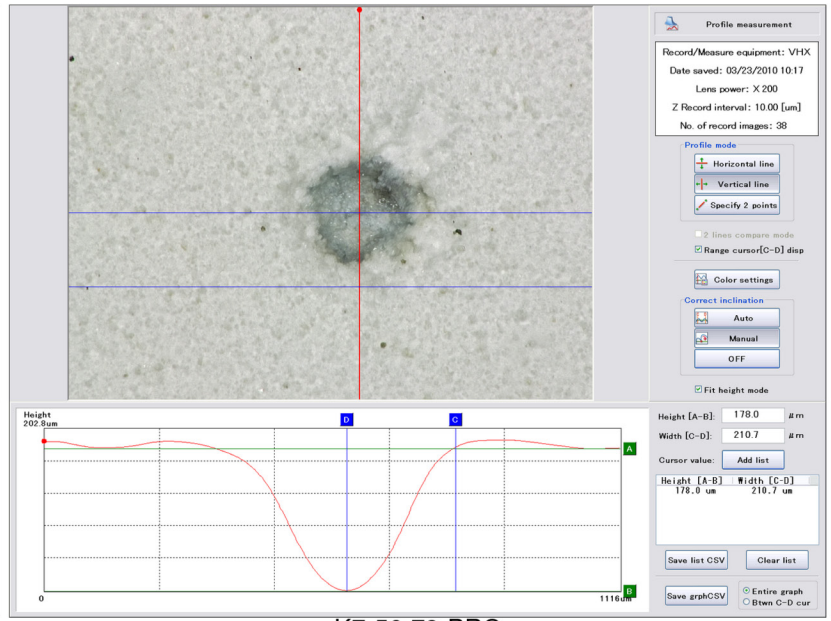
K6-67-82-PRO



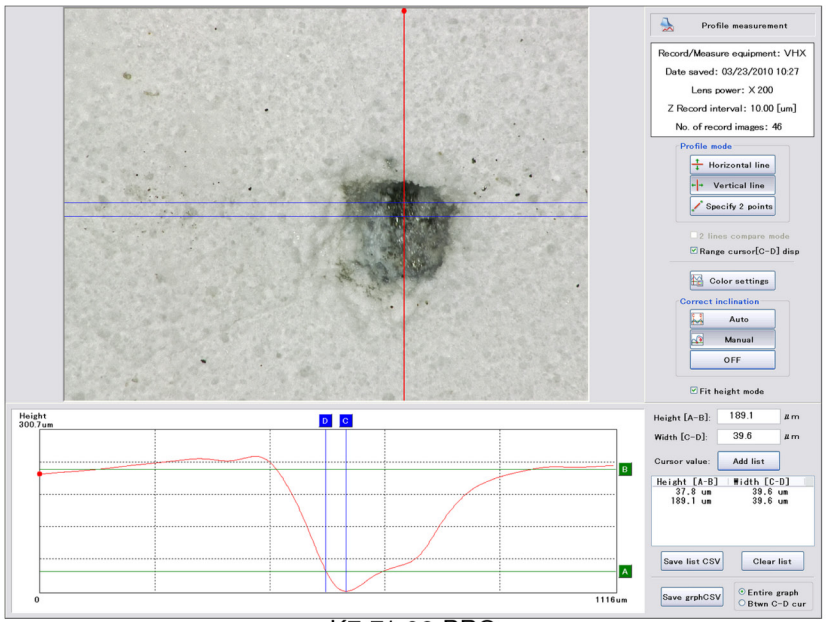
K7-45-05-PRO



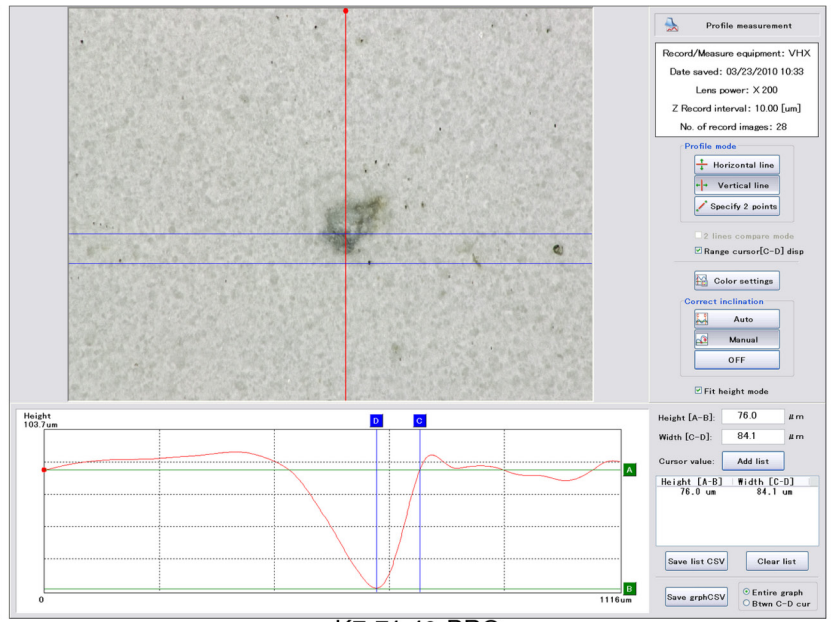
K7-49-39-PRO



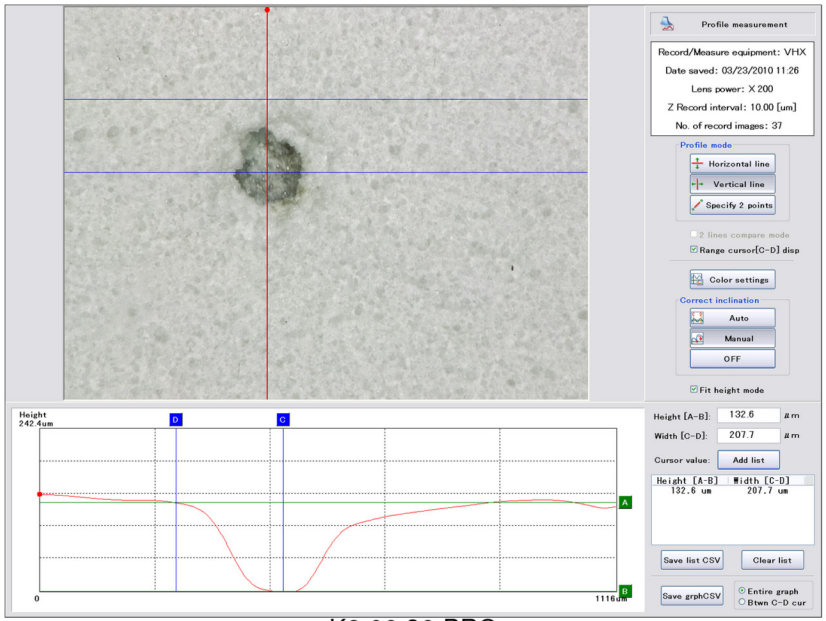
K7-56-78-PRO



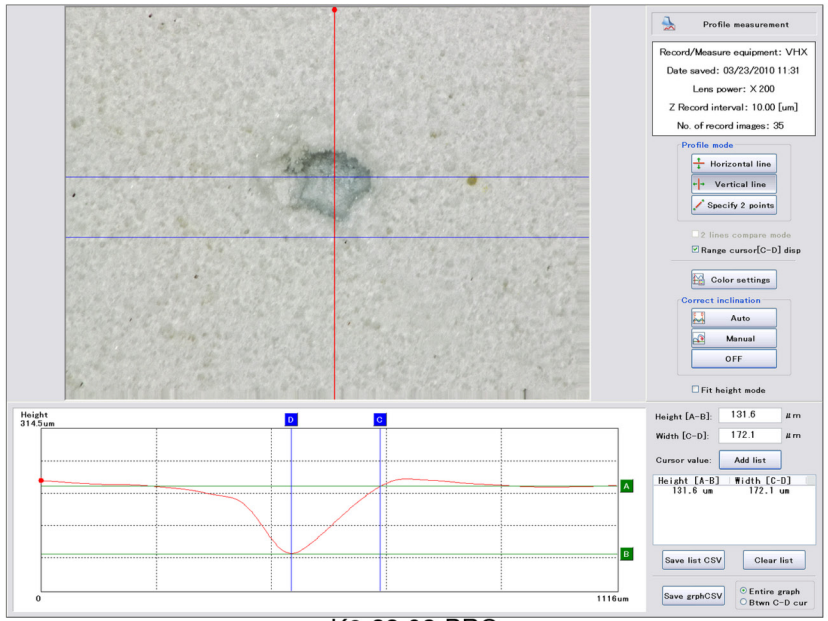
K7-71-06-PRO



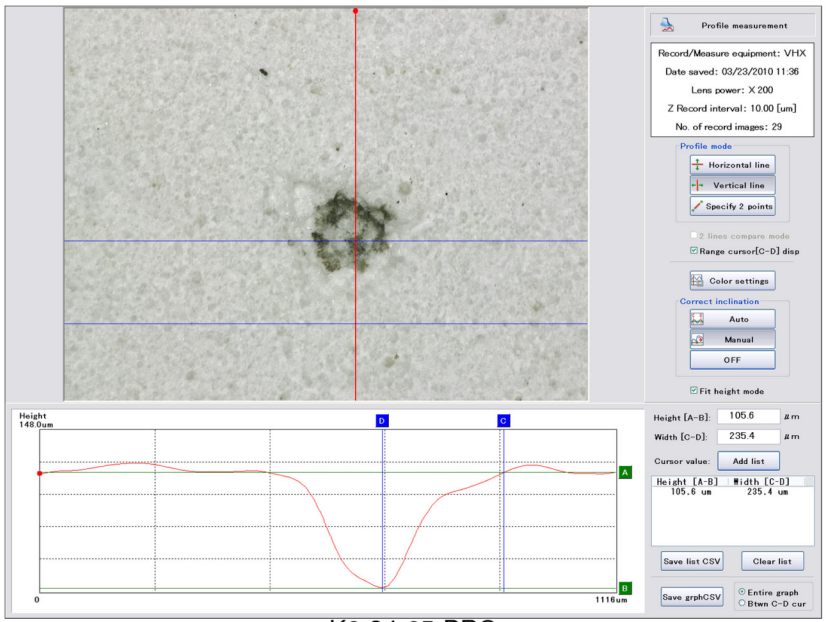
K7-74-40-PRO



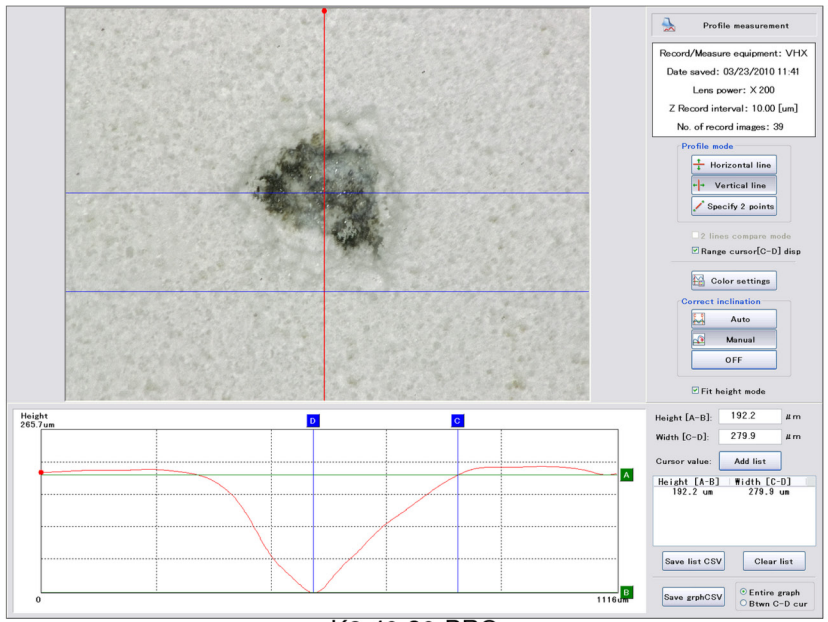
K8-06-36-PRO



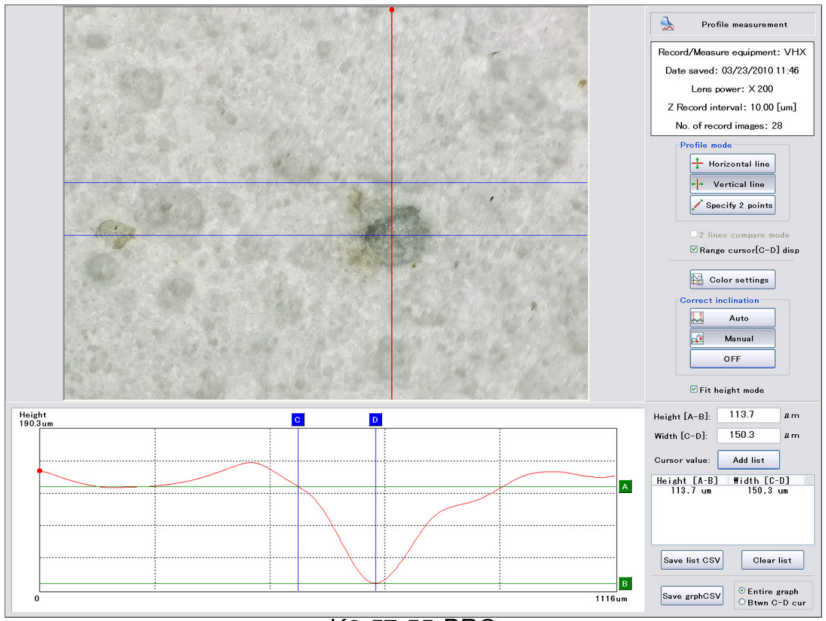
K8-22-92-PRO



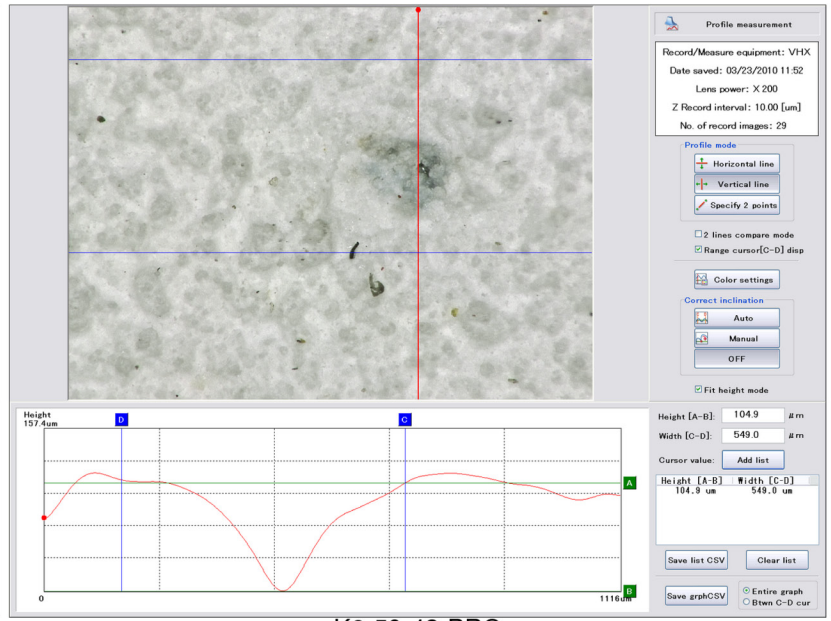
K8-34-65-PRO



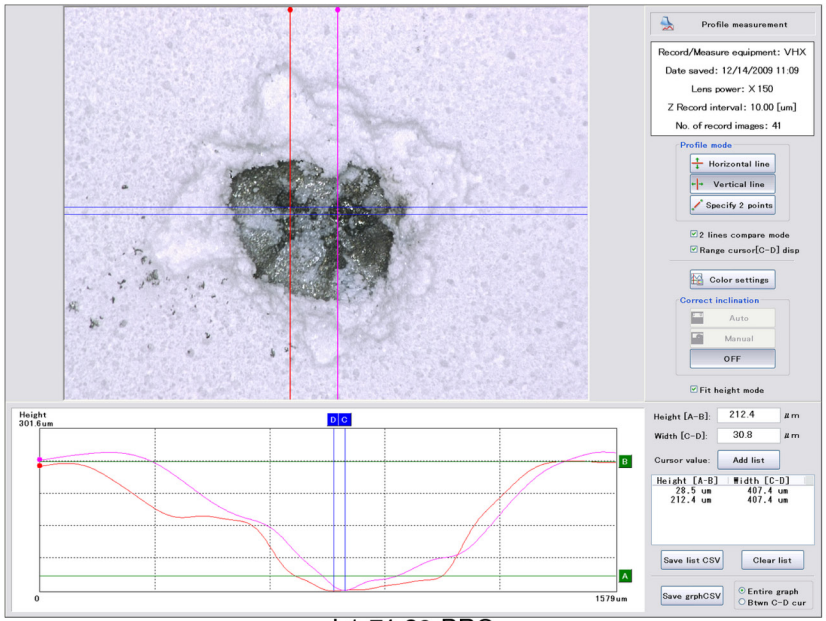
K8-40-30-PRO



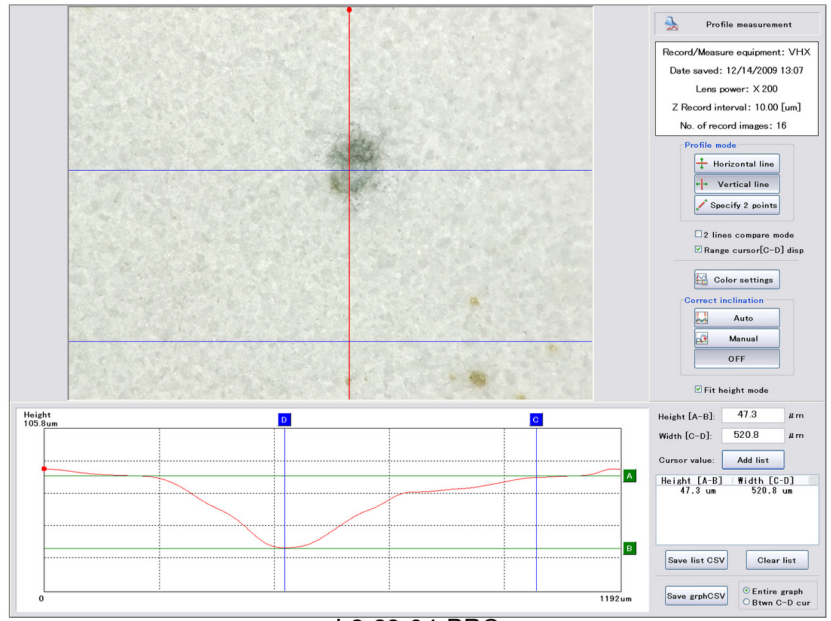
K8-57-55-PRO



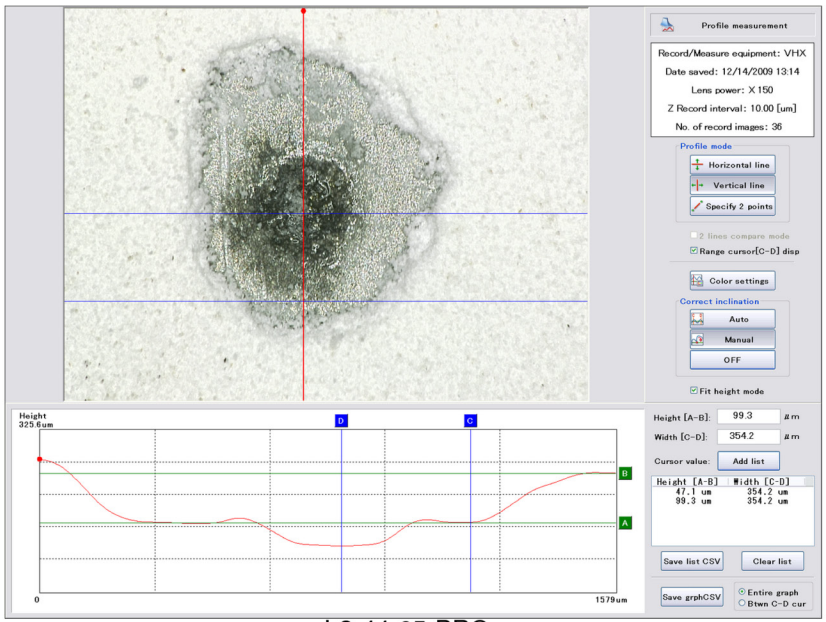
K8-59-42-PRO



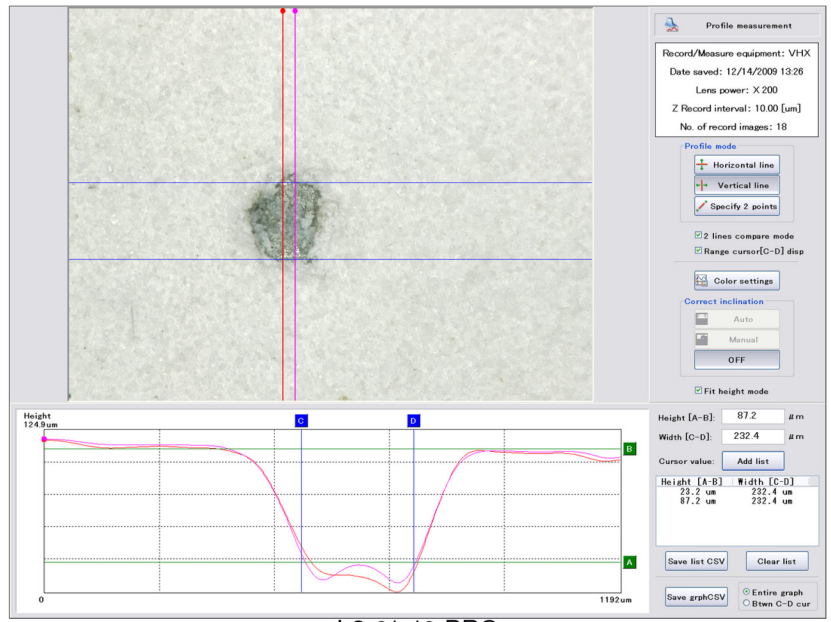
L1-74-28-PRO



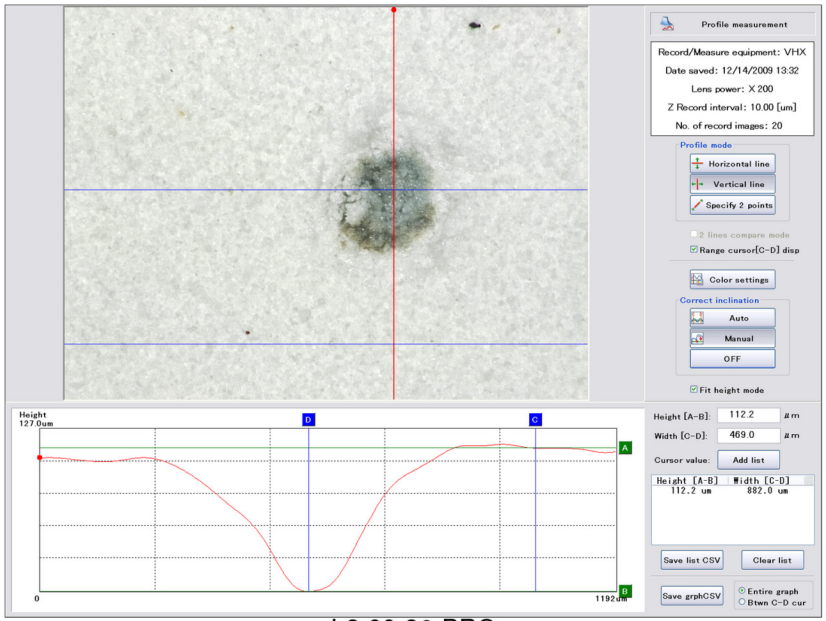
L2-23-94-PRO



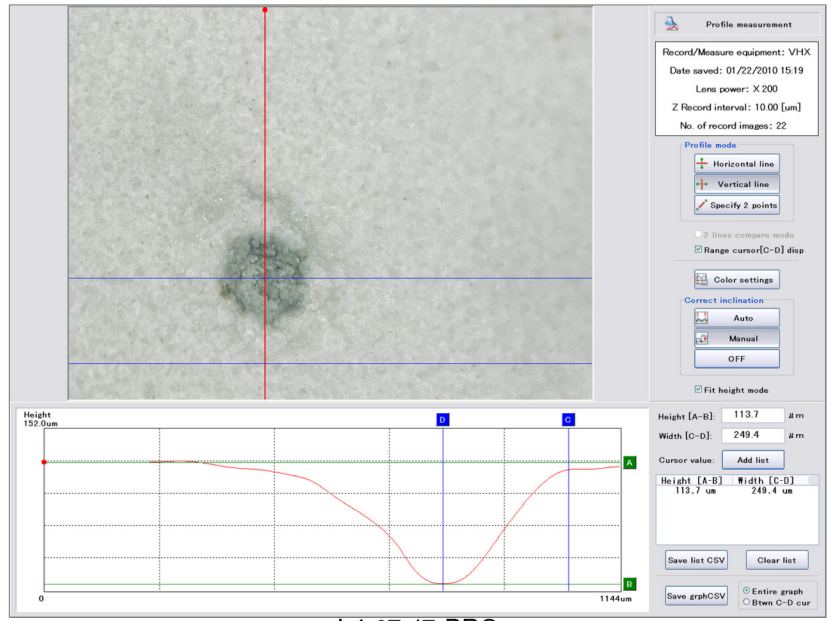
L2-44-65-PROv



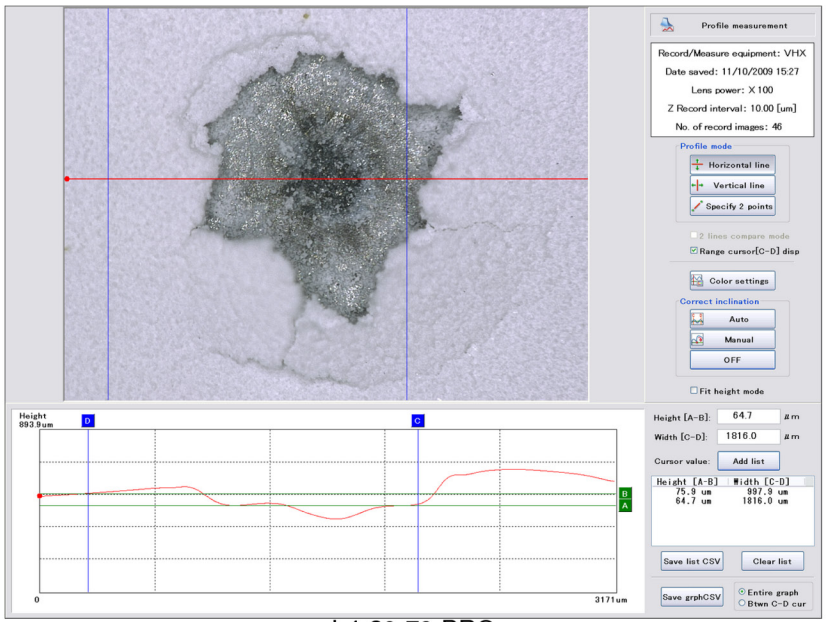
L2-61-16-PRO



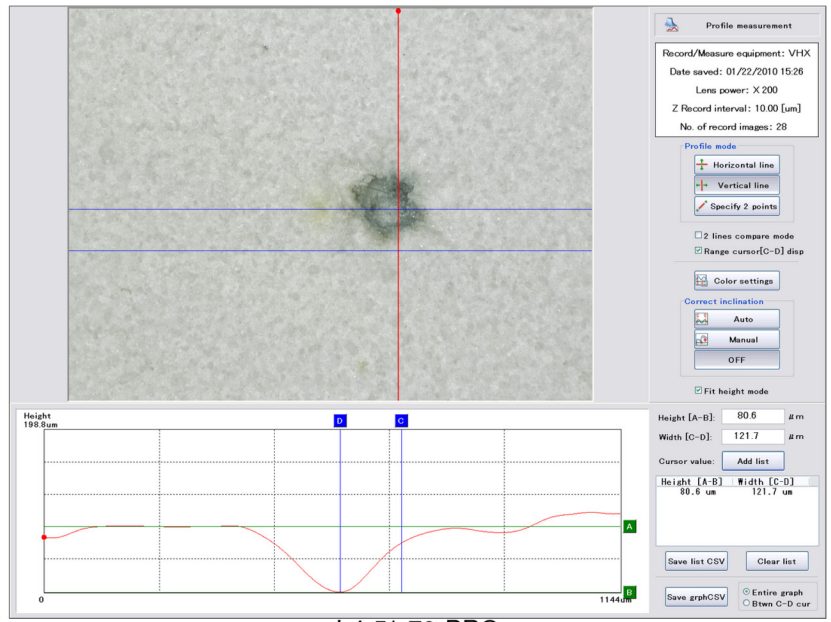
L2-99-36-PRO



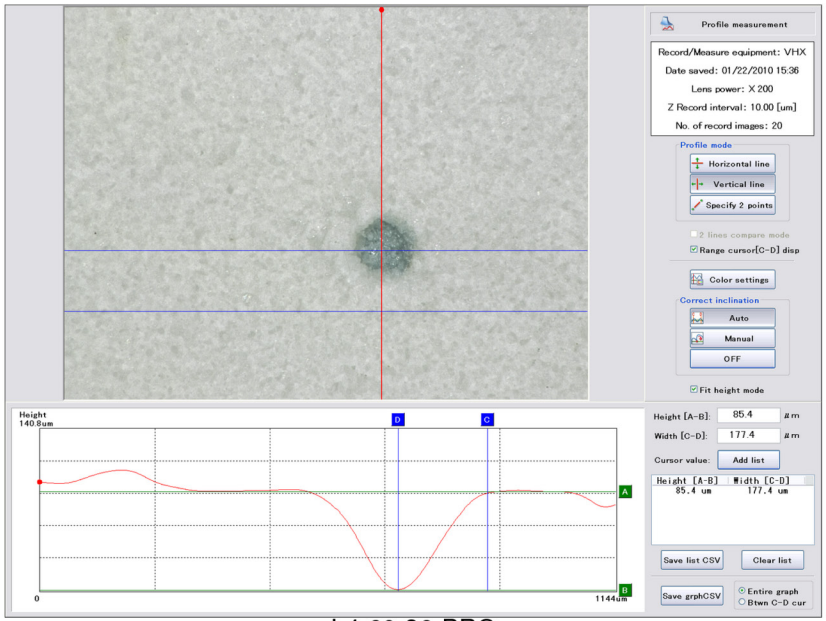
L4-07-17-PRO



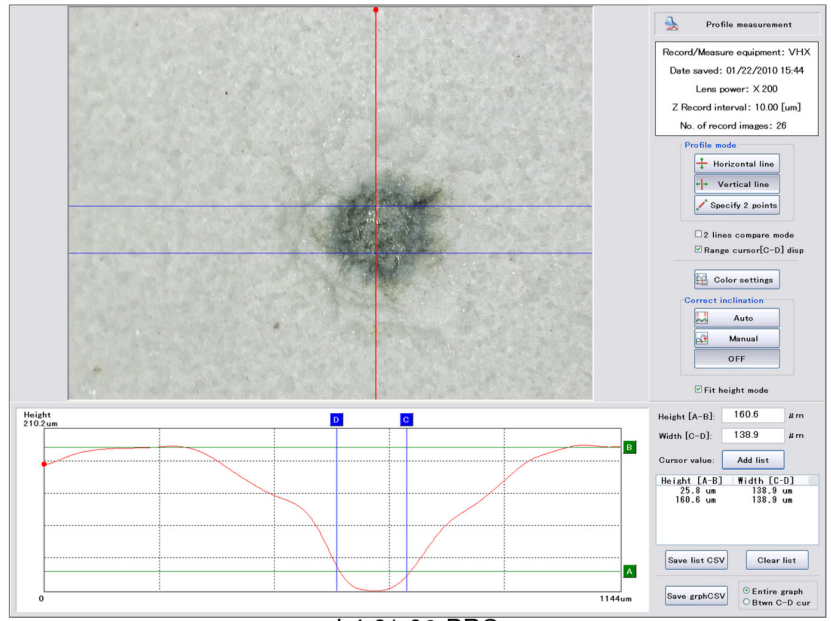
L4-20-76-PRO



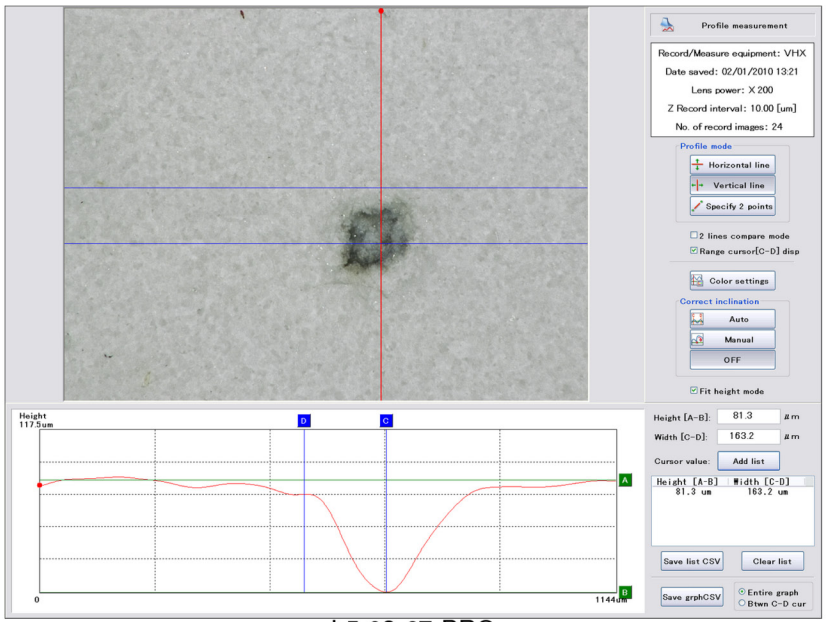
L4-51-70-PRO



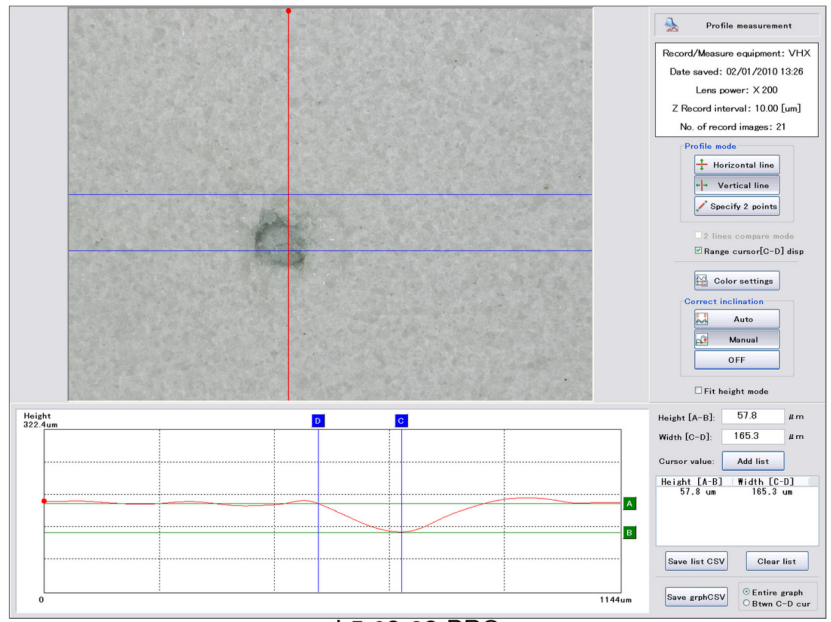
L4-60-36-PRO



L4-91-96-PRO



L5-03-67-PRO



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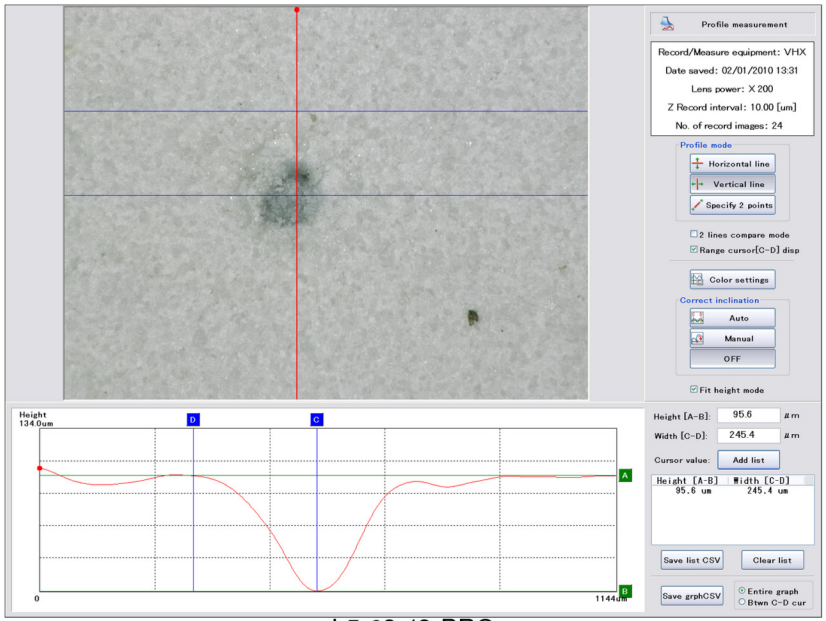
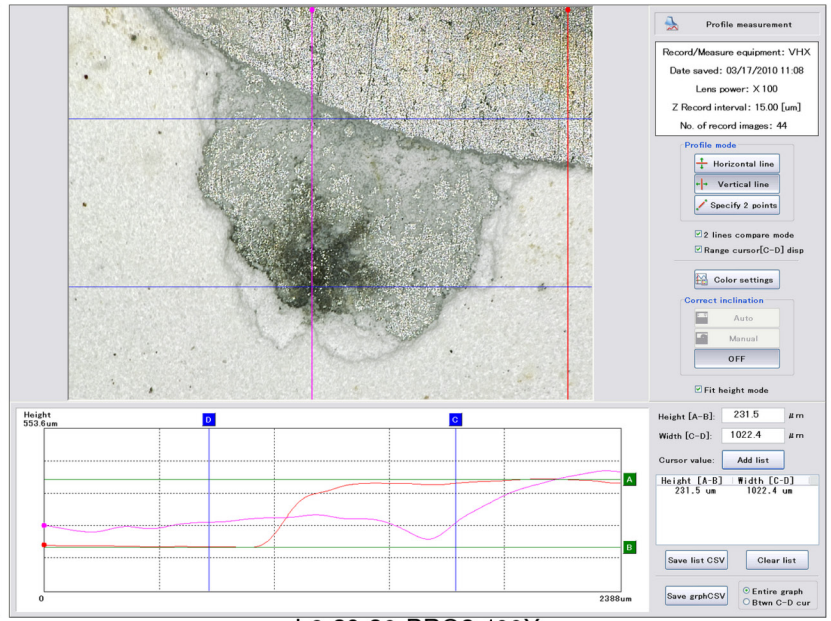
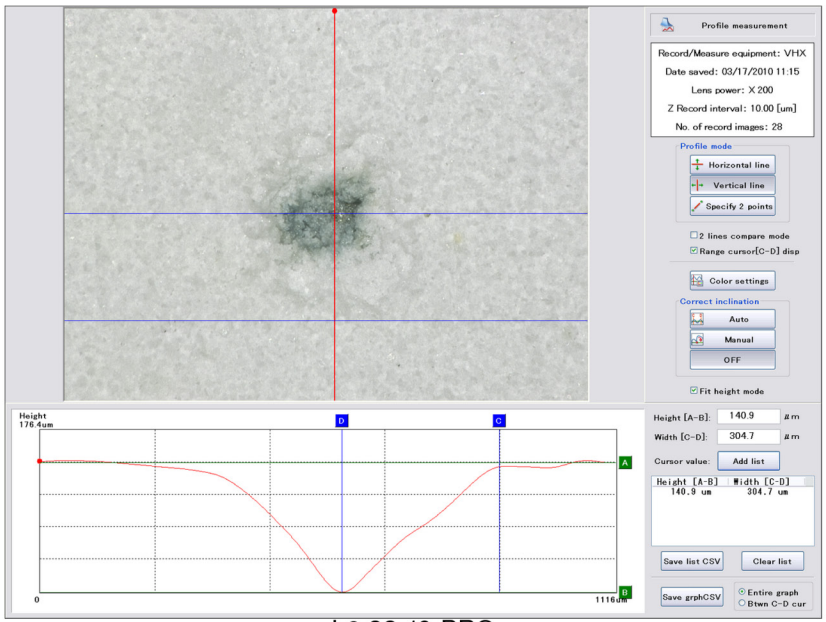


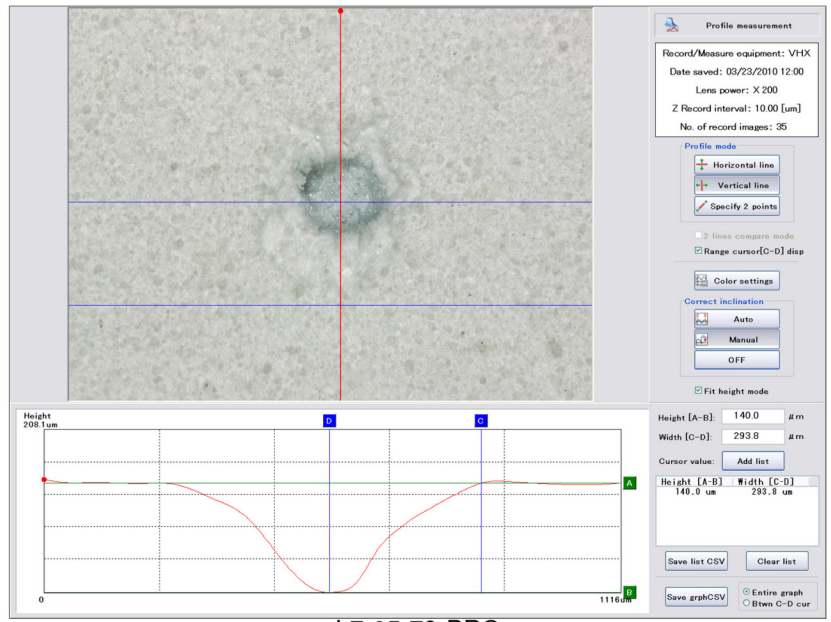
L5-63-13-PRO



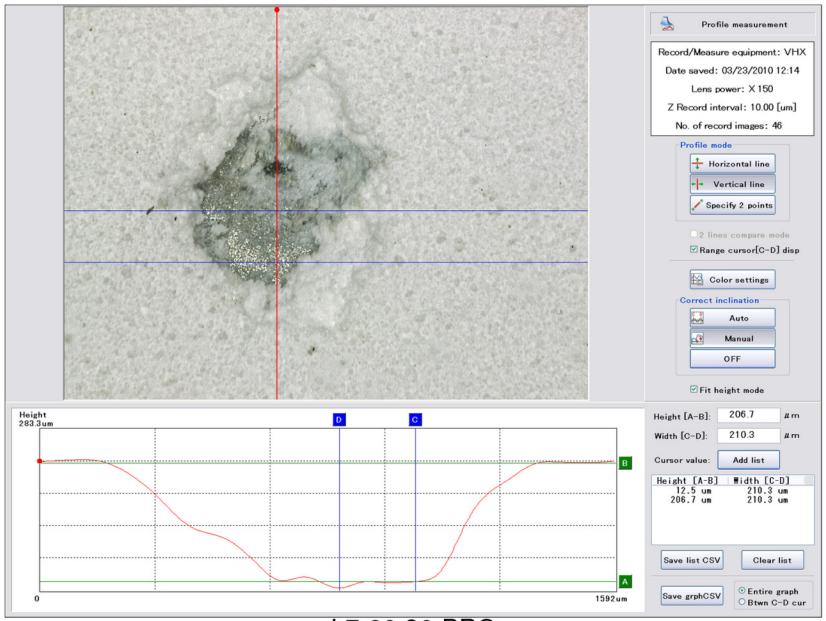
L6-29-30-PRO2-100X



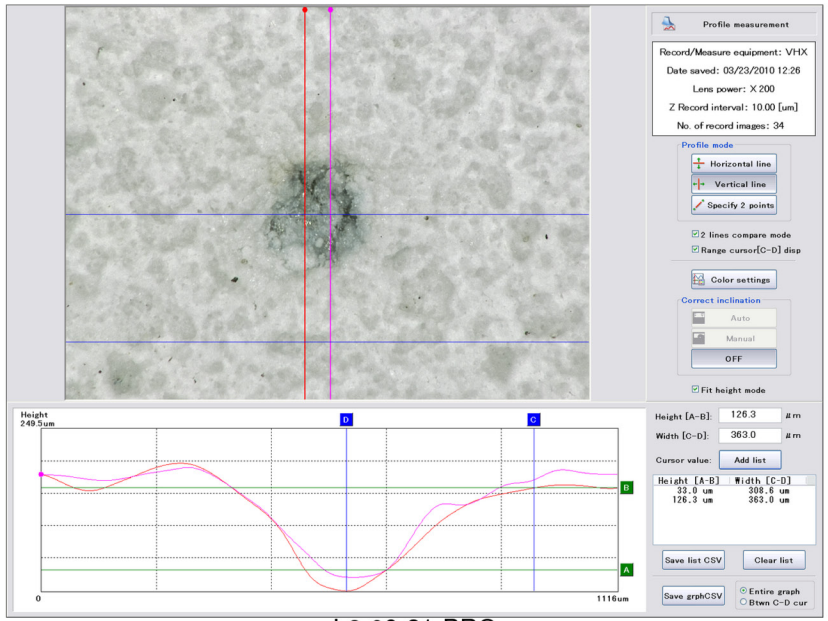
L6-32-19-PRO



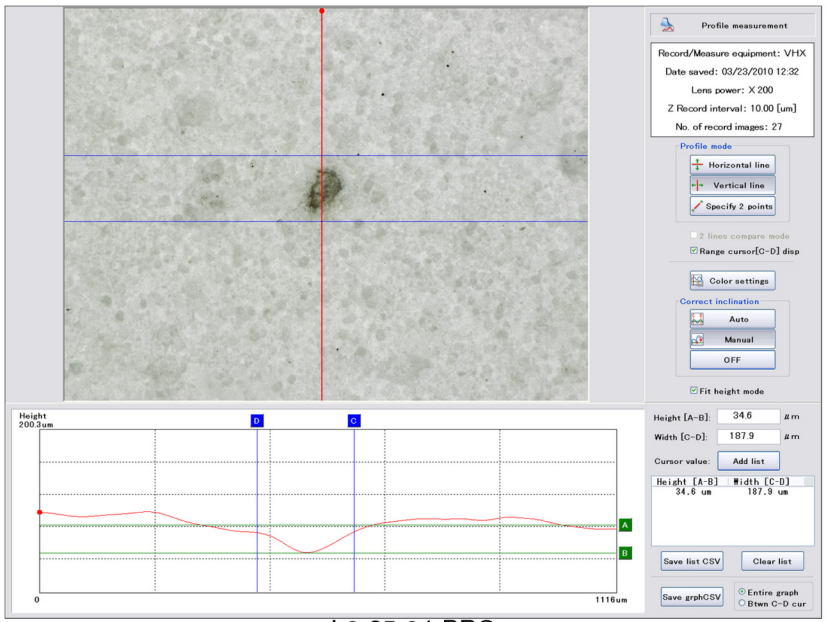
L7-05-79-PRO



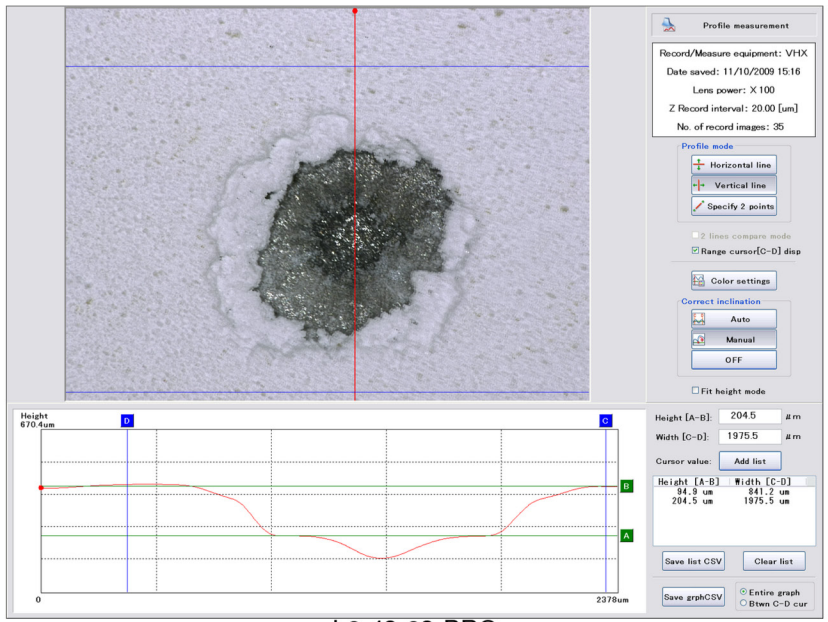
L7-86-36-PRO



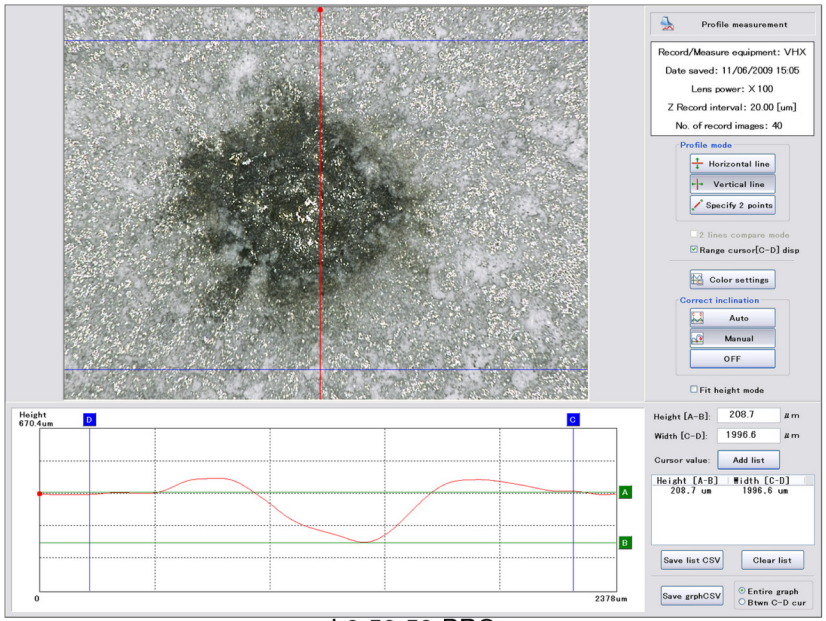
L8-09-31-PRO



L8-25-84-PRO



L8-43-83-PRO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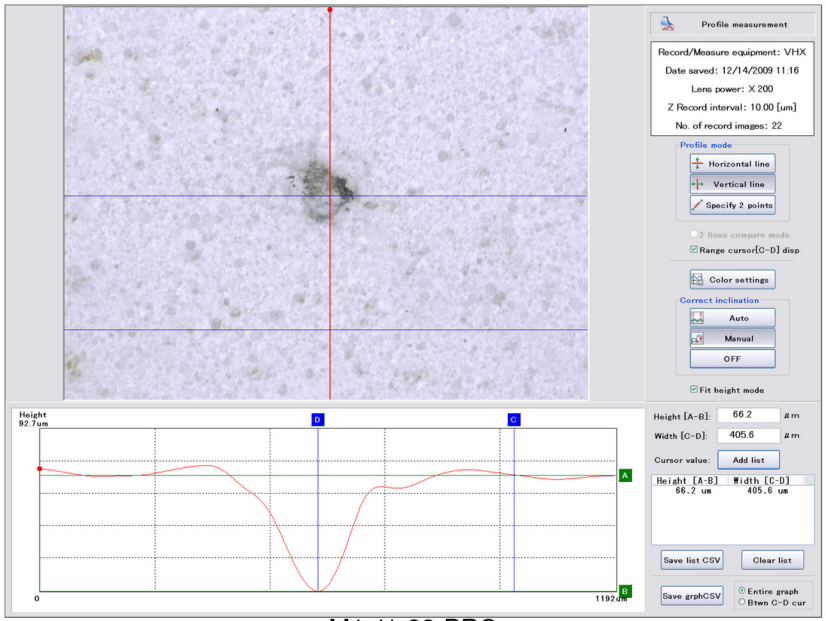
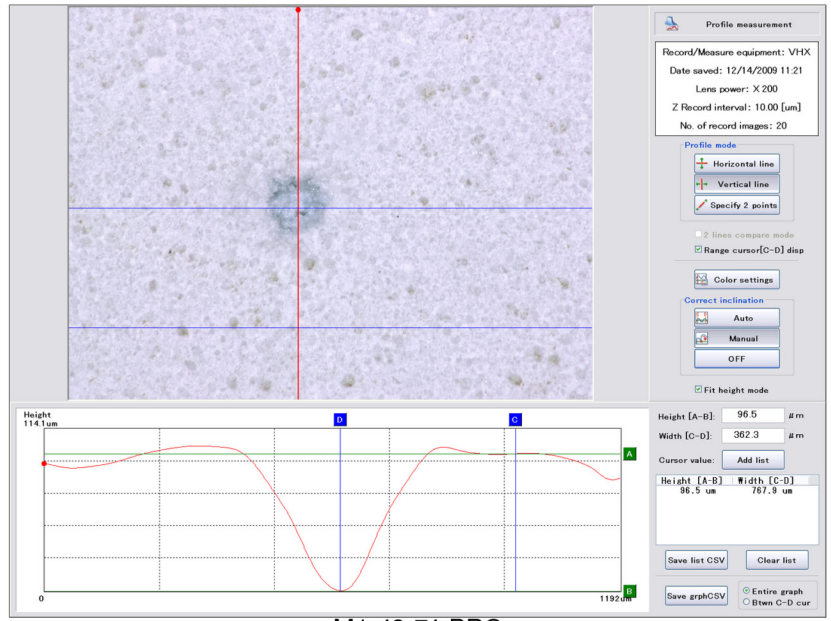
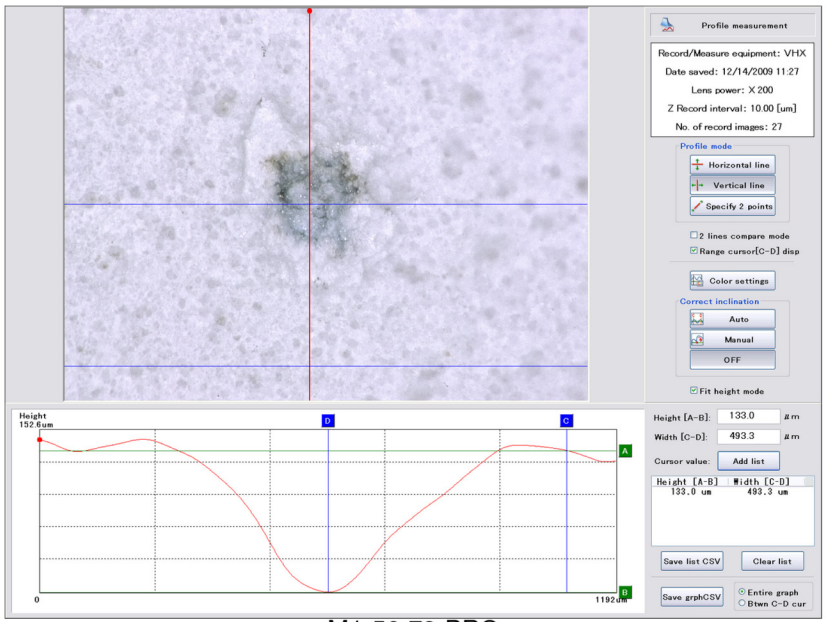
L8-58-58-PRO



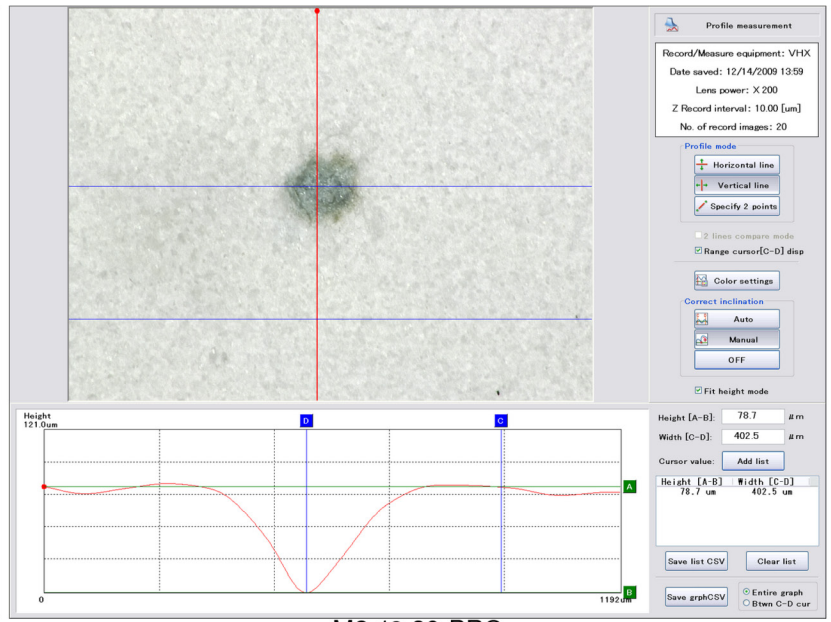
M1-11-22-PRO



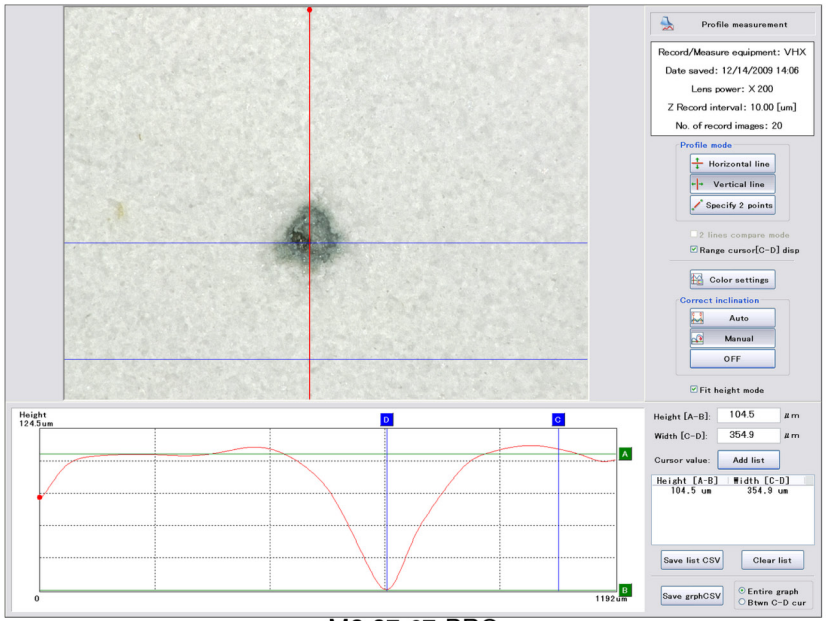
M1-43-74-PRO



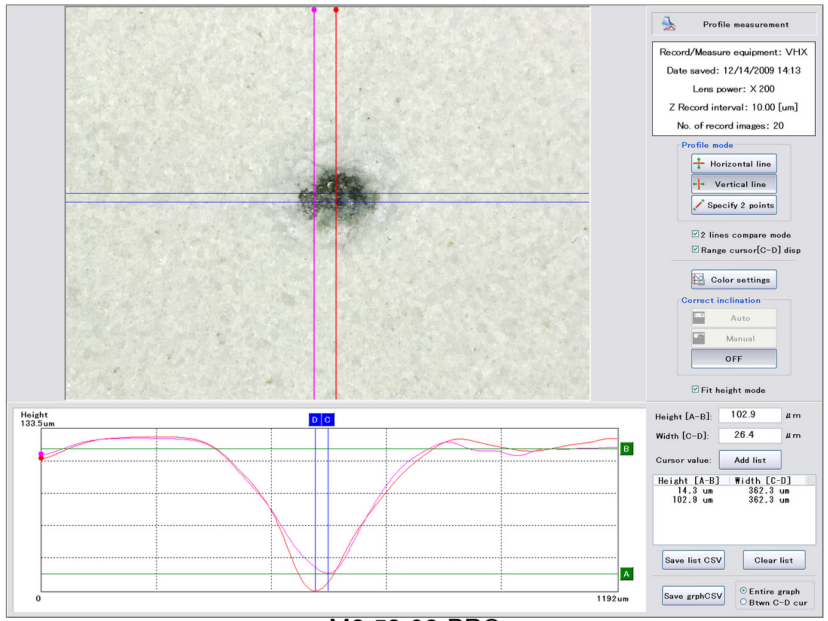
M1-56-78-PRO



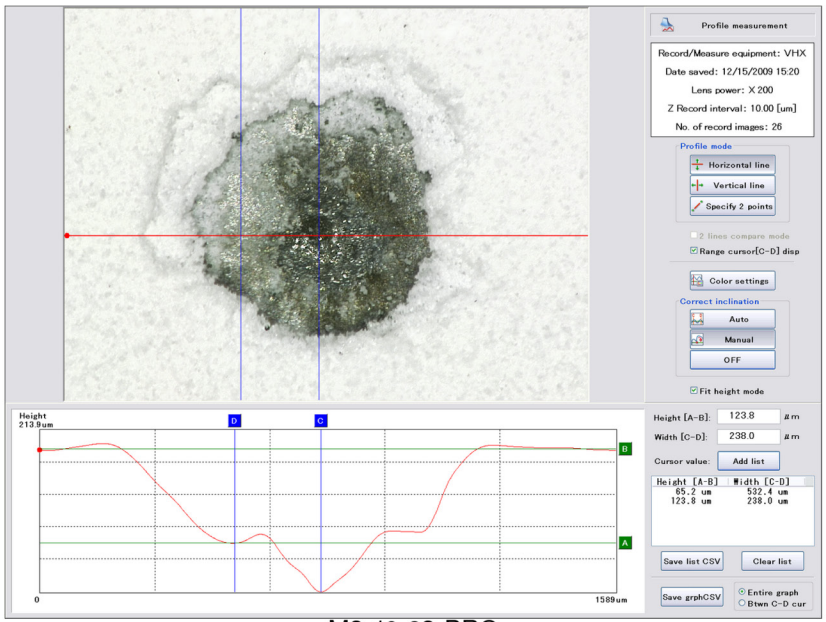
M2-18-39-PRO



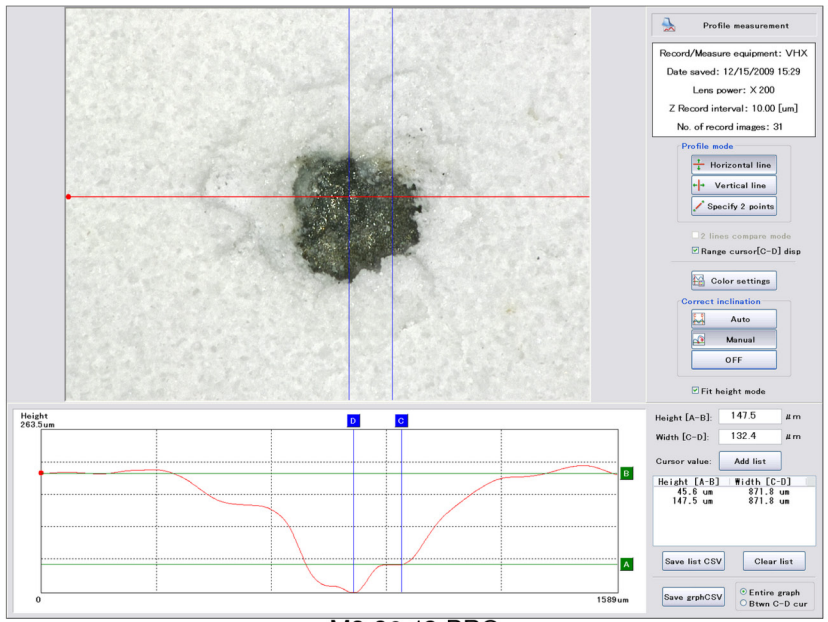
M2-37-67-PRO



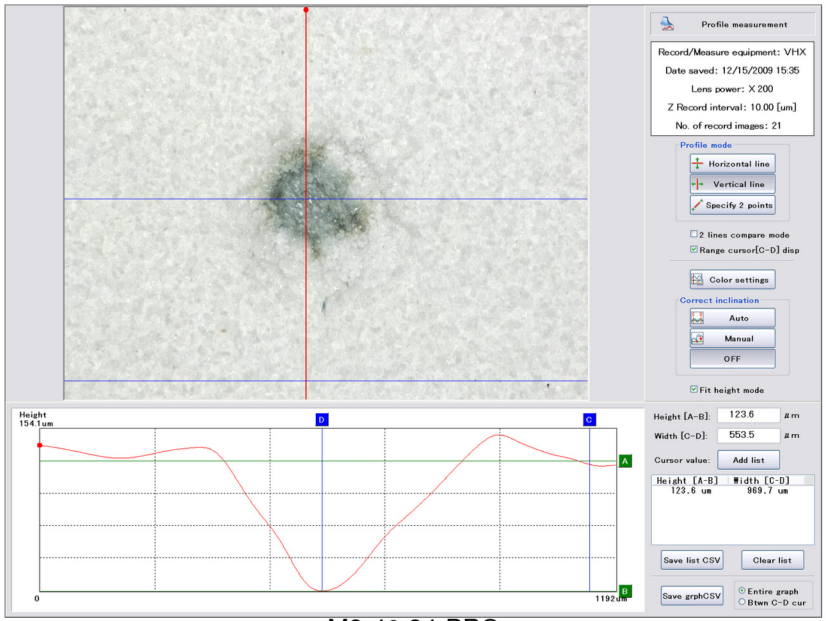
M2-53-92-PRO



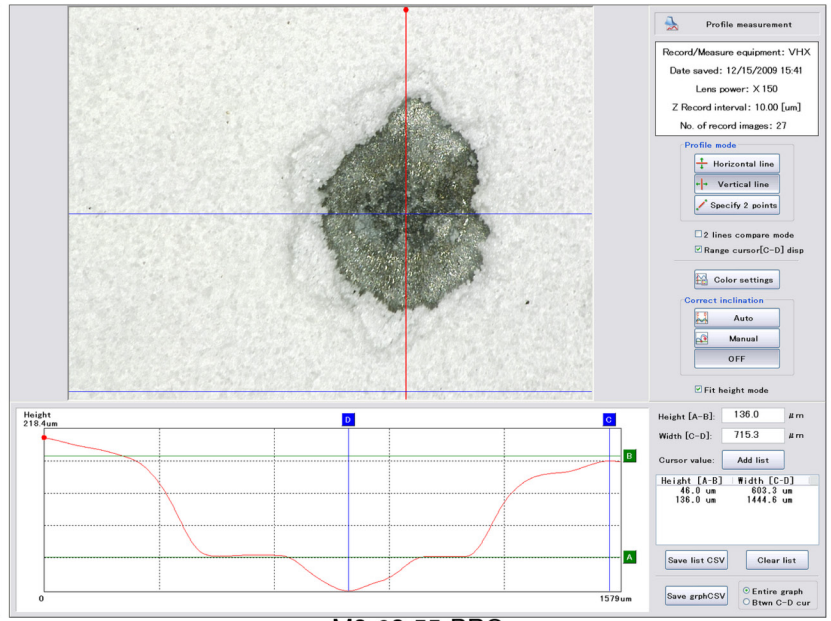
M3-10-83-PRO



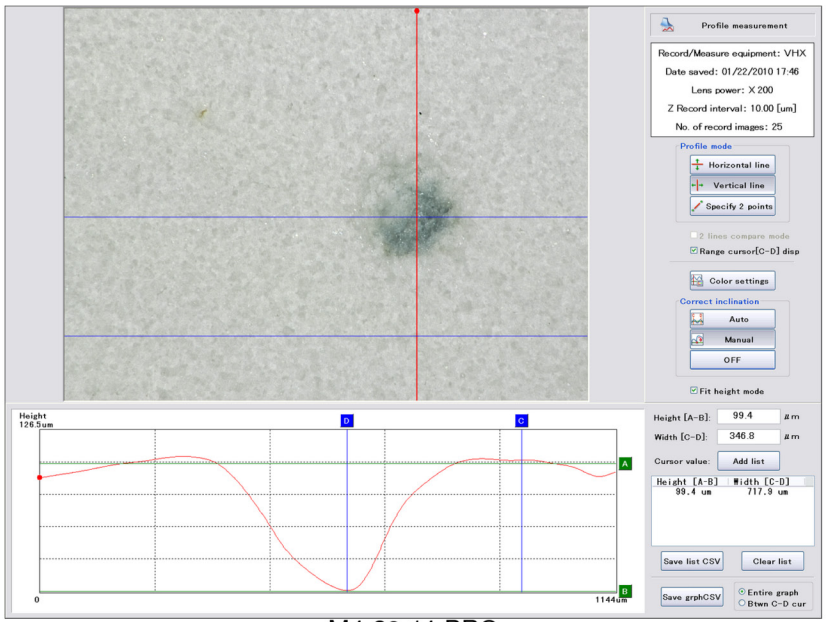
M3-36-12-PRO



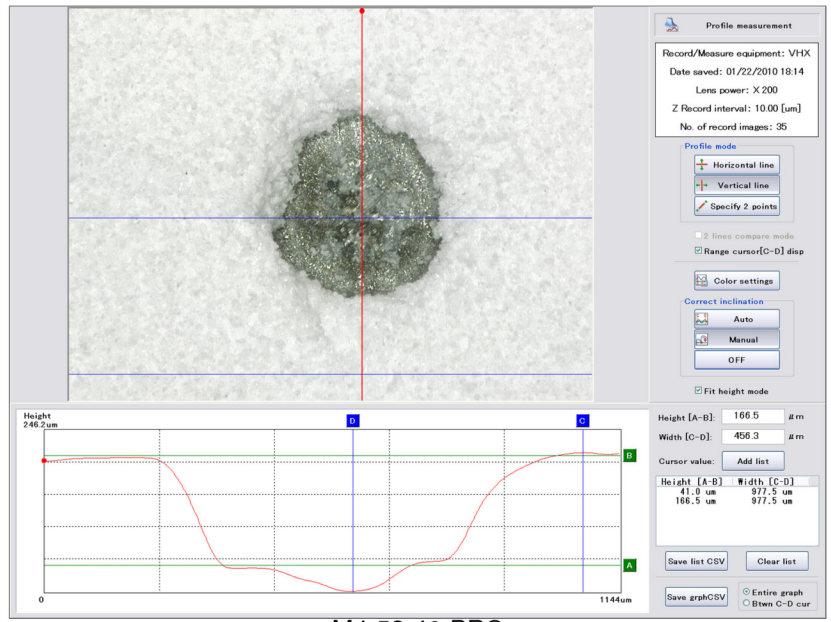
M3-46-34-PRO



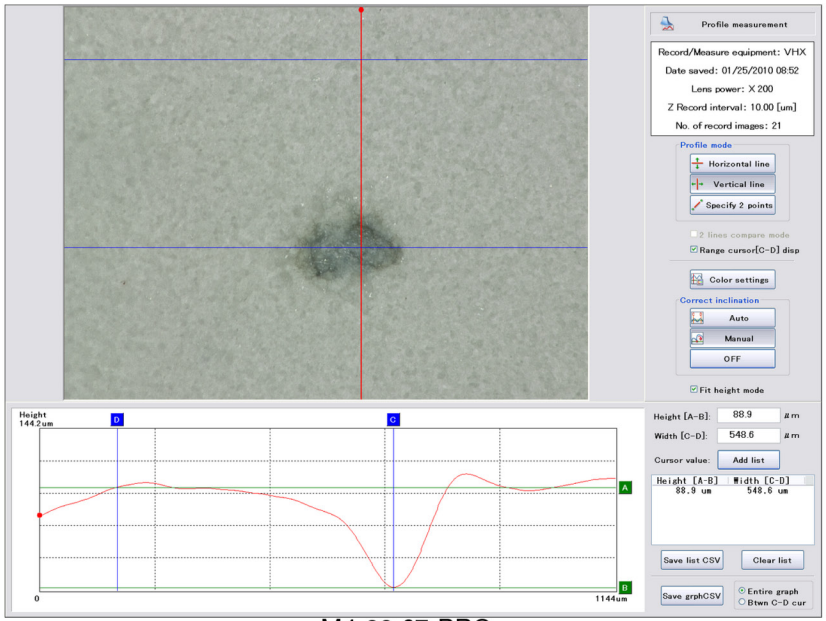
M3-62-55-PRO



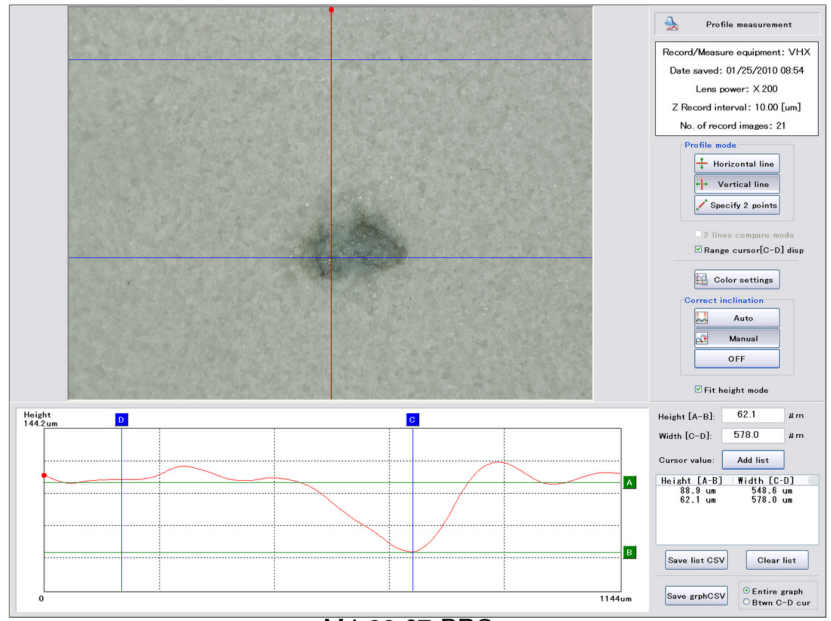
M4-28-14-PRO



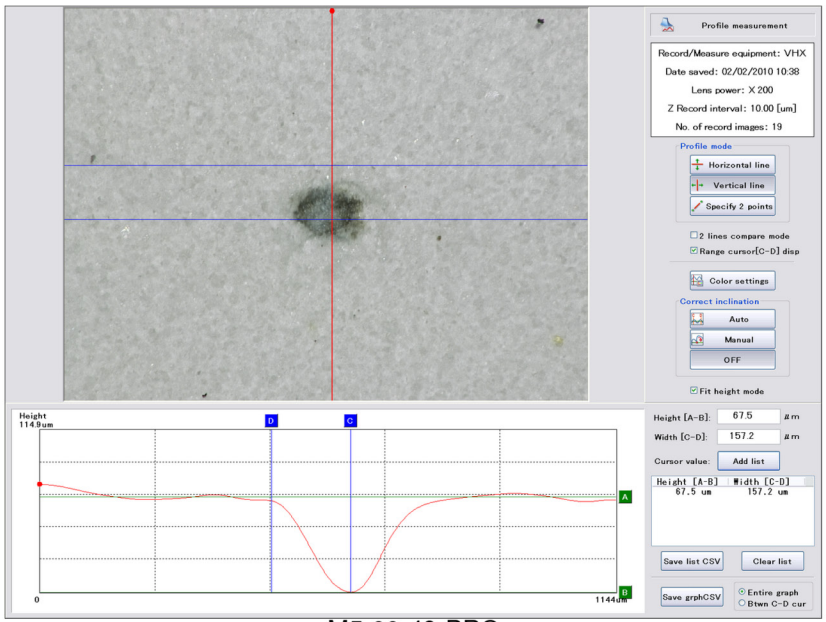
M4-52-46-PRO



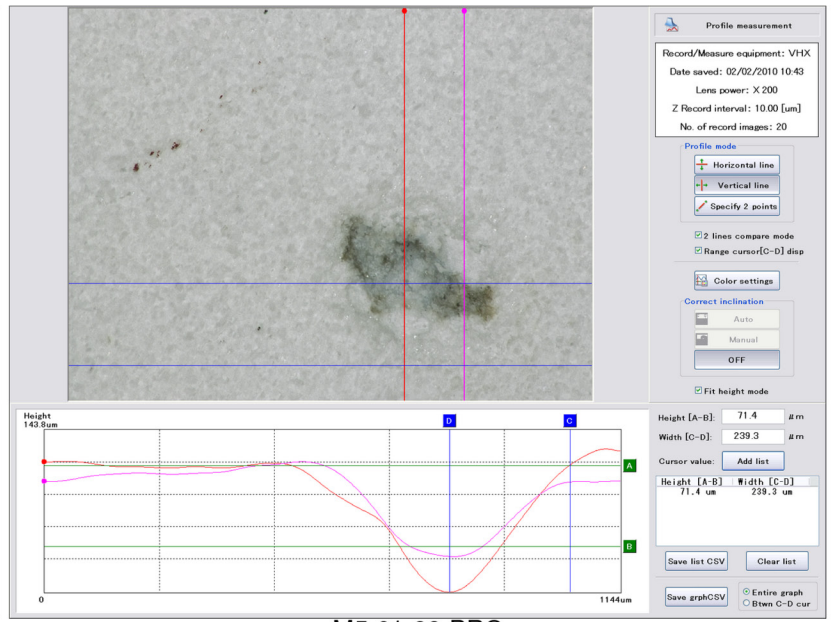
M4-88-97-PROe



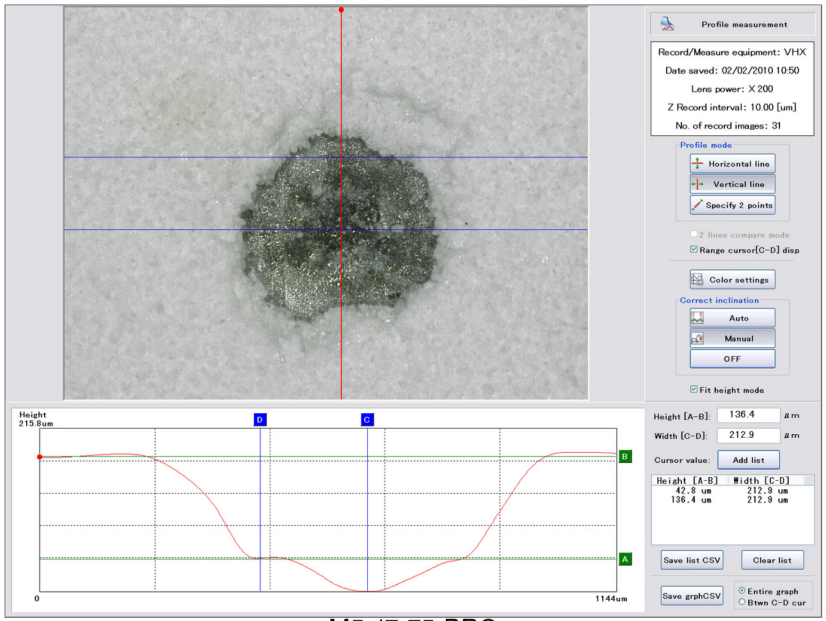
M4-88-97-PROw



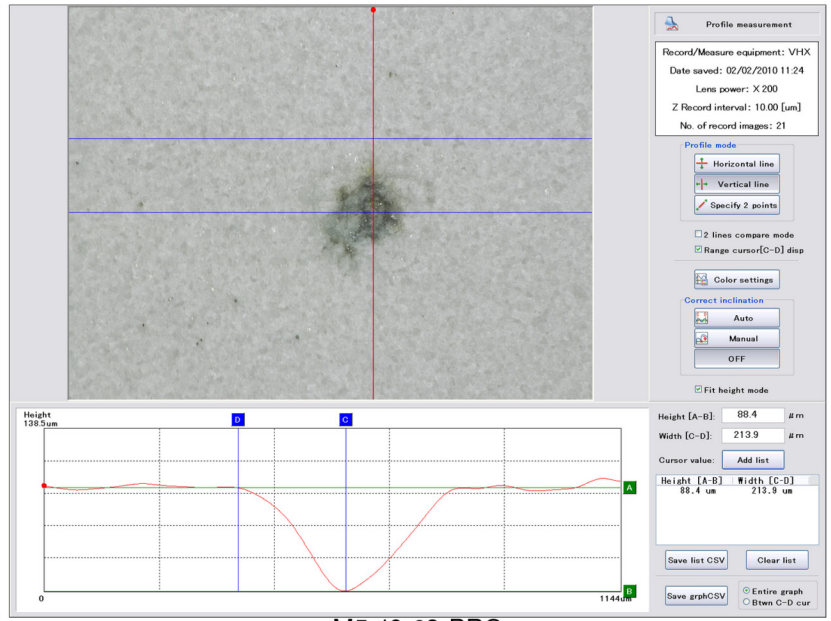
M5-00-49-PRO



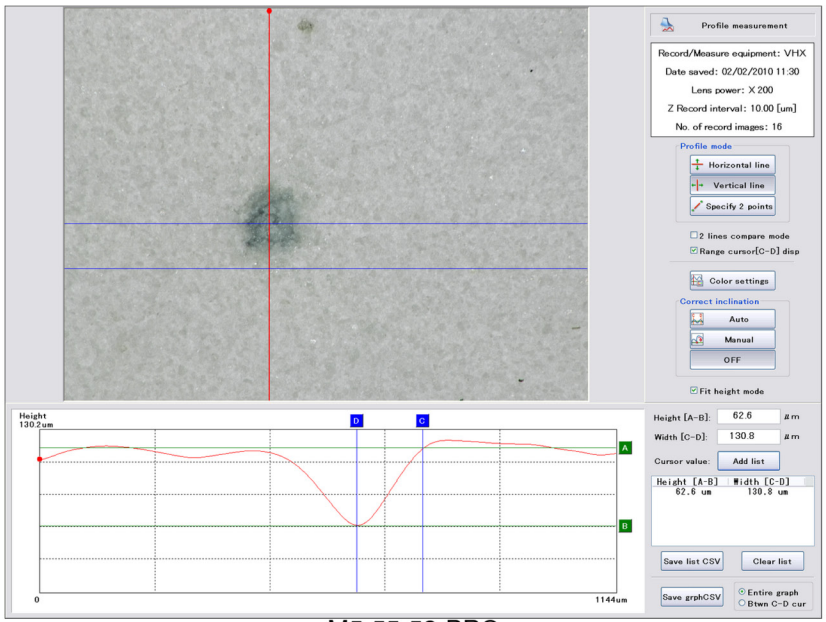
M5-01-66-PRO



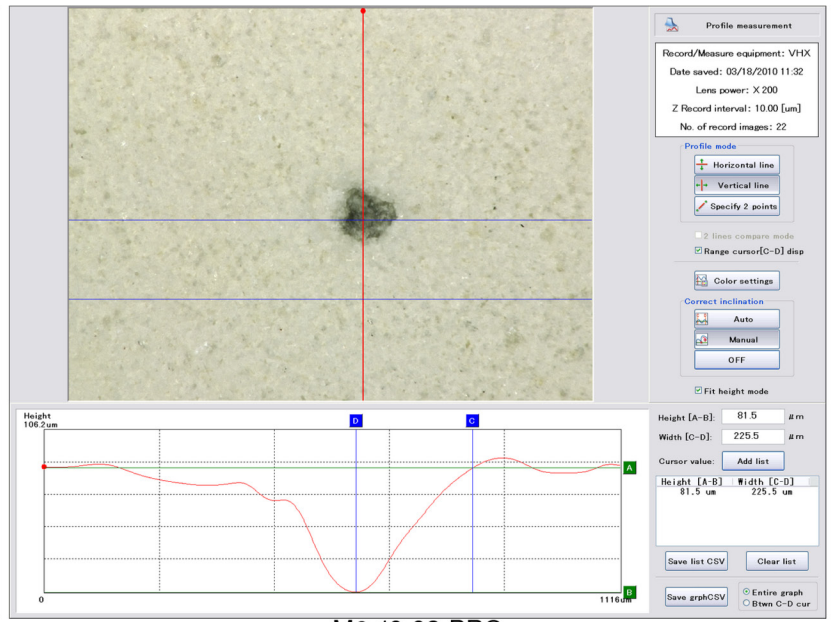
M5-17-75-PRO



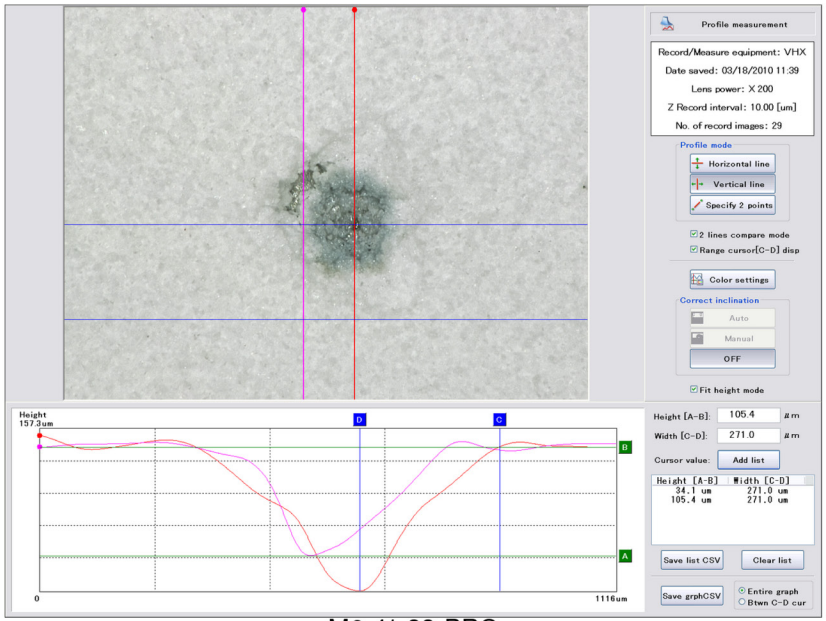
M5-19-63-PRO



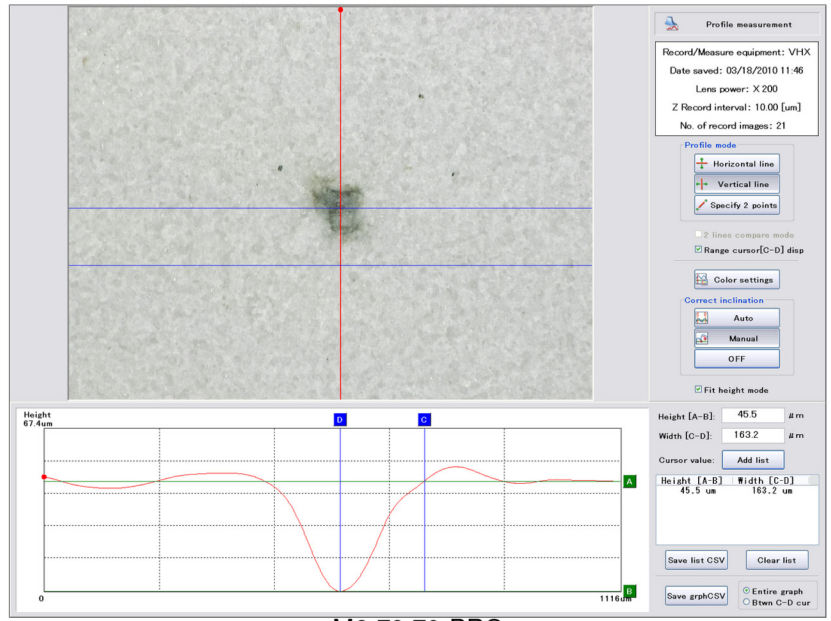
M5-55-52-PRO



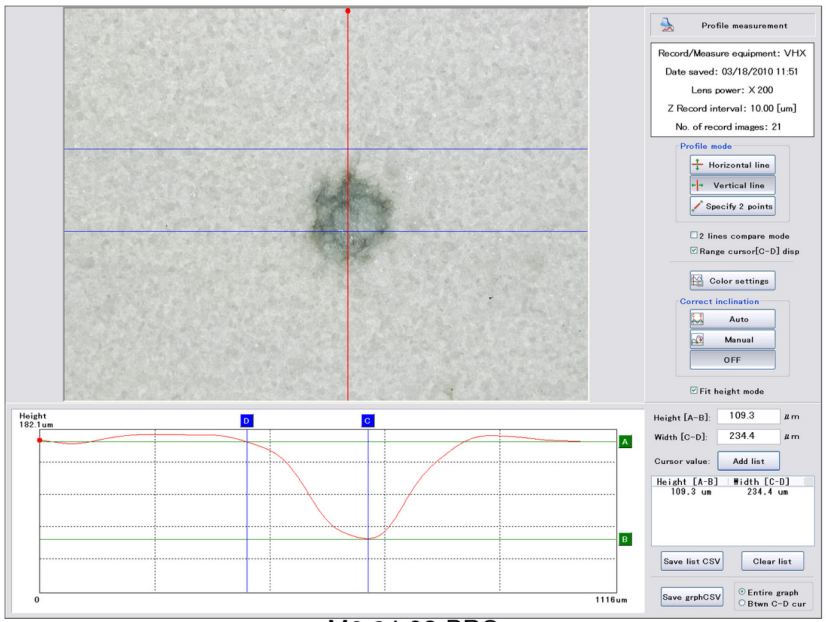
M6-19-92-PRO



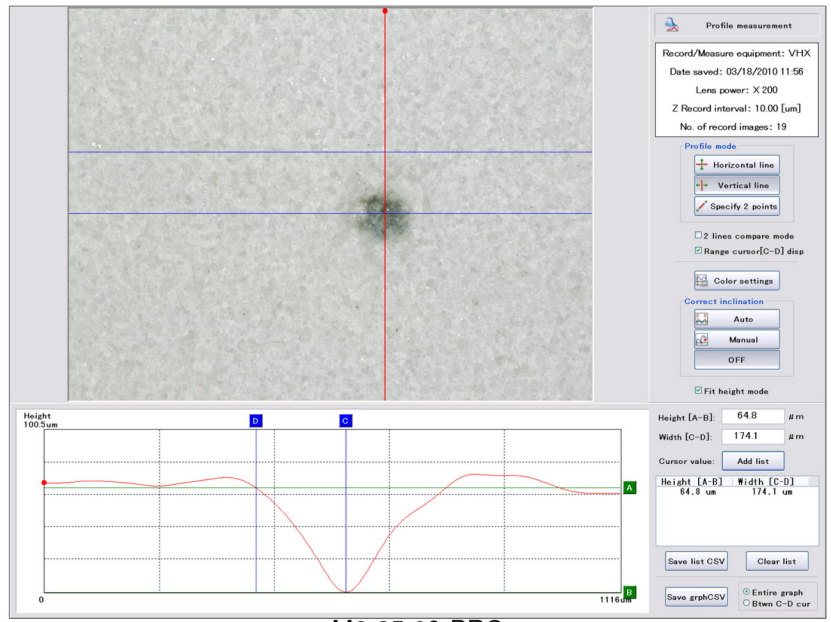
M6-41-33-PRO



M6-76-70-PRO



M6-84-92-PRO



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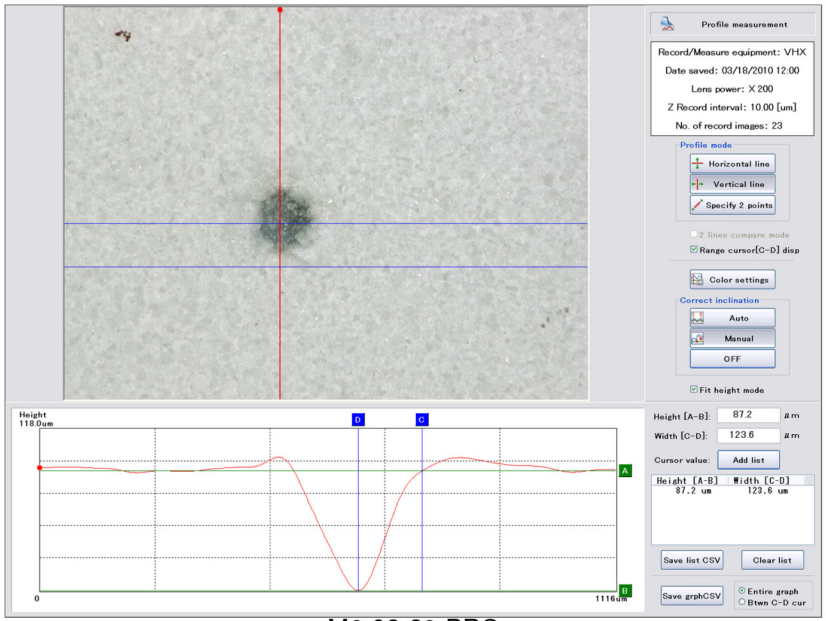
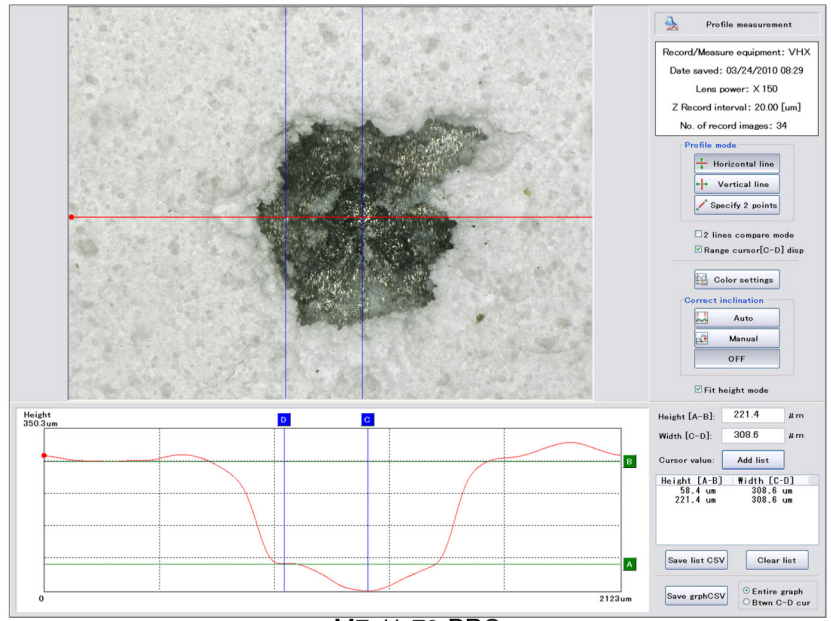
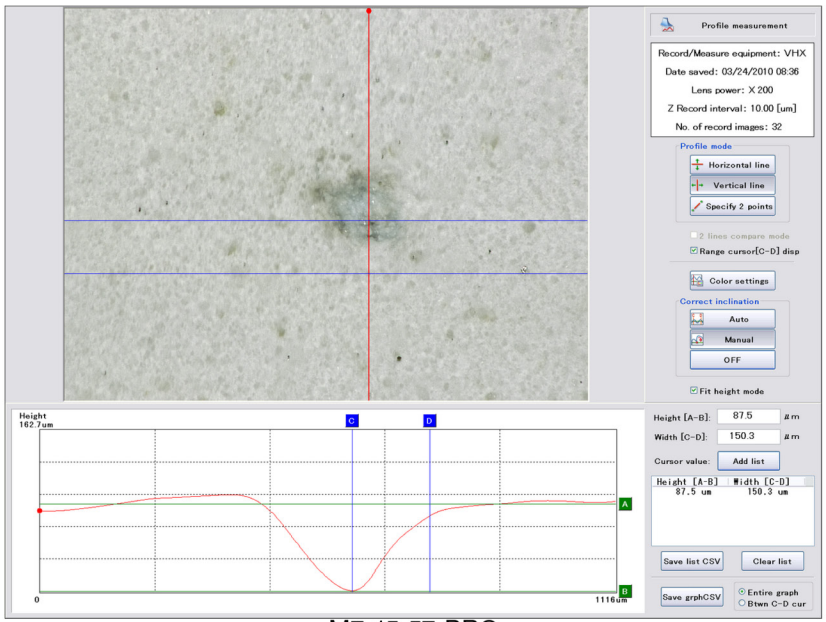


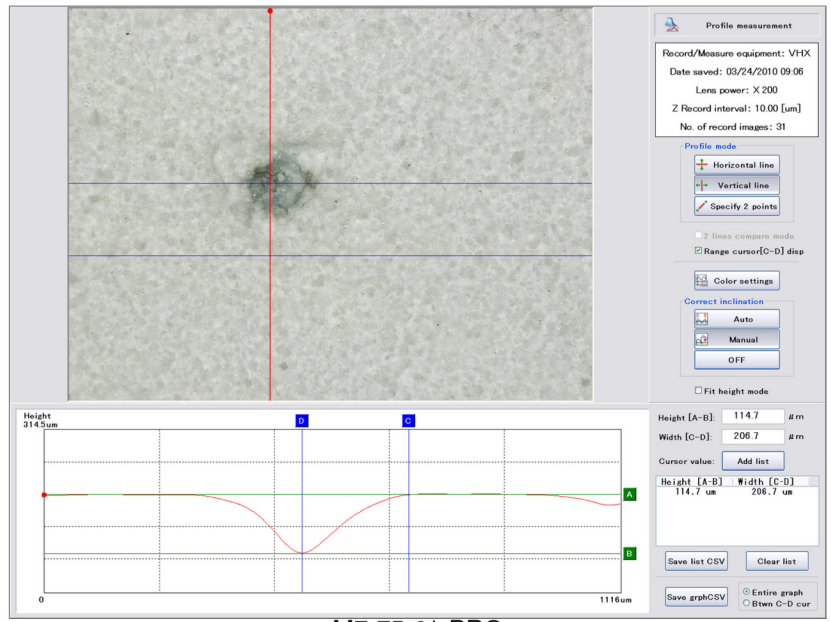
M6-92-20-PRO



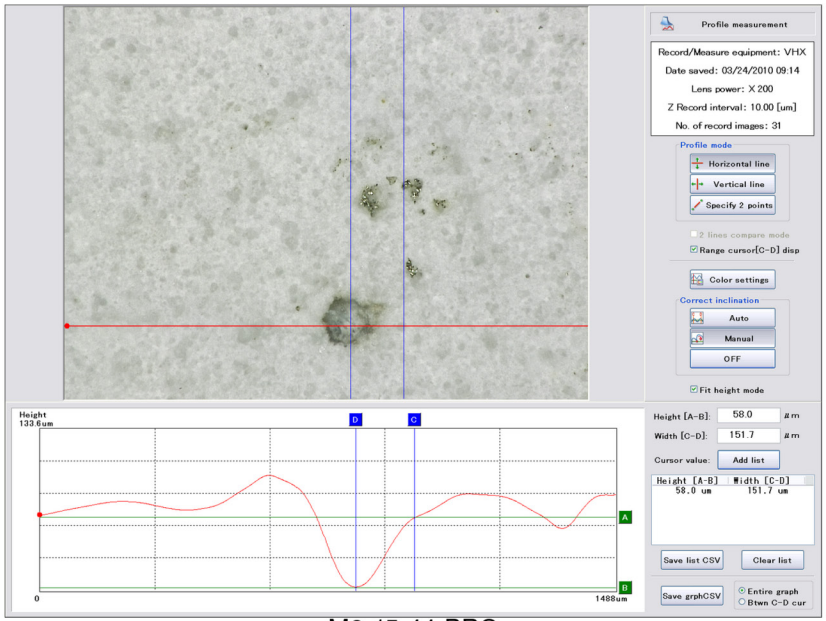
M7-11-76-PRO



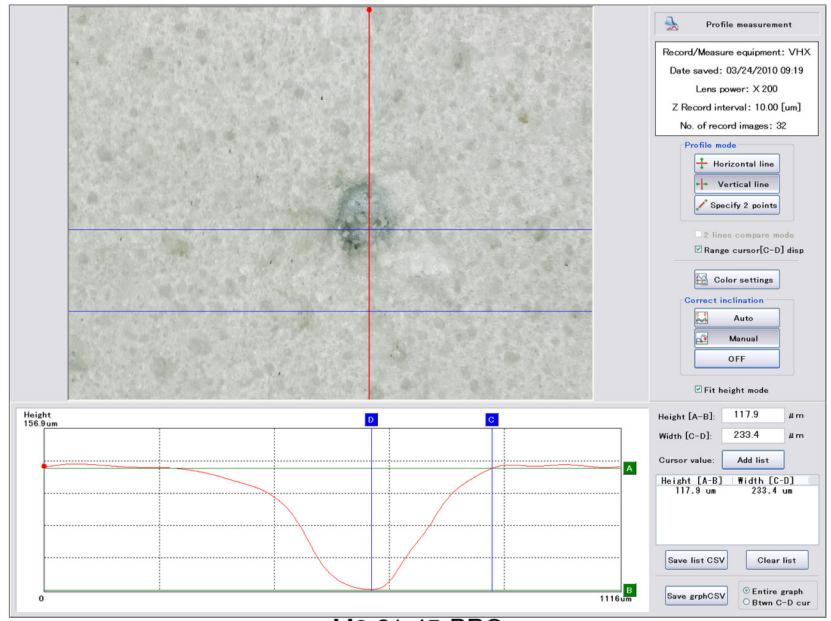
M7-15-57-PRO



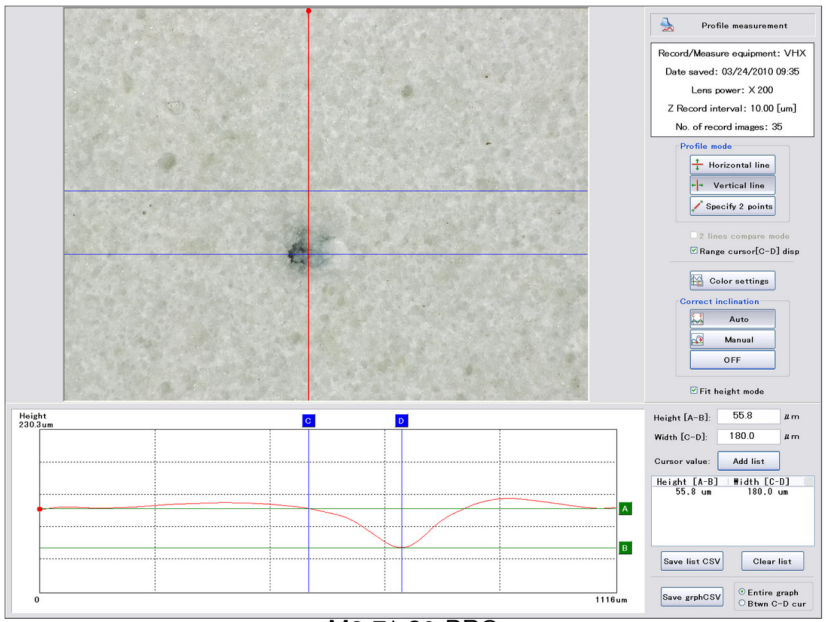
M7-75-61-PRO



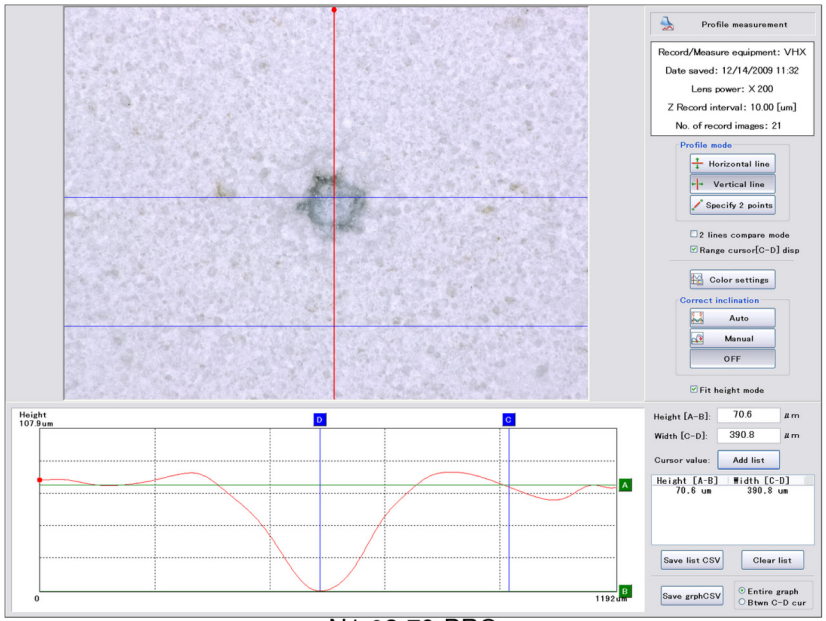
M8-15-44-PRO



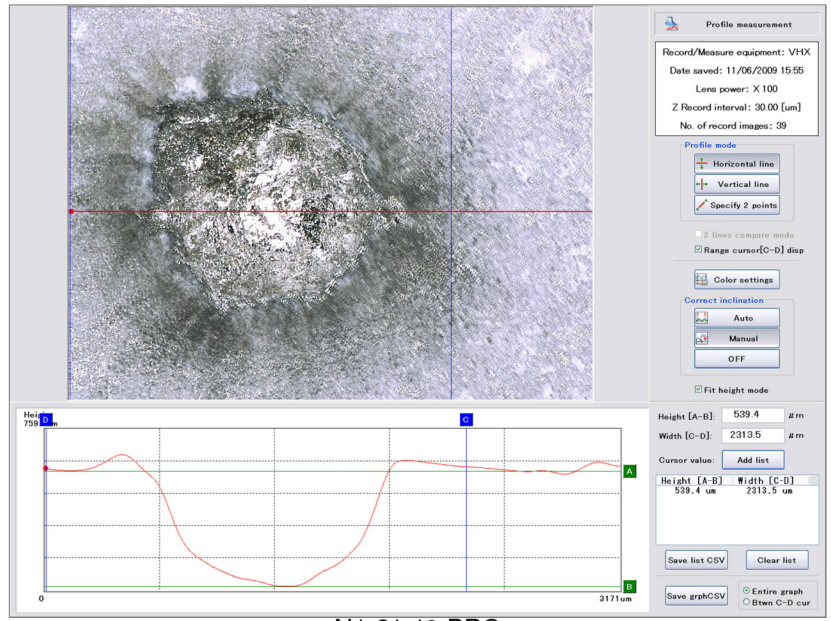
M8-31-45-PRO



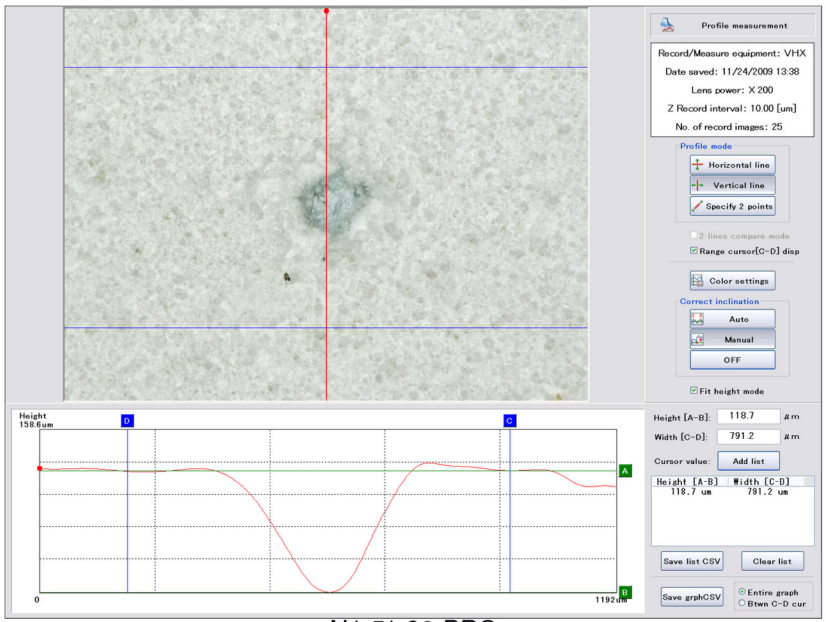
M8-71-30-PRO



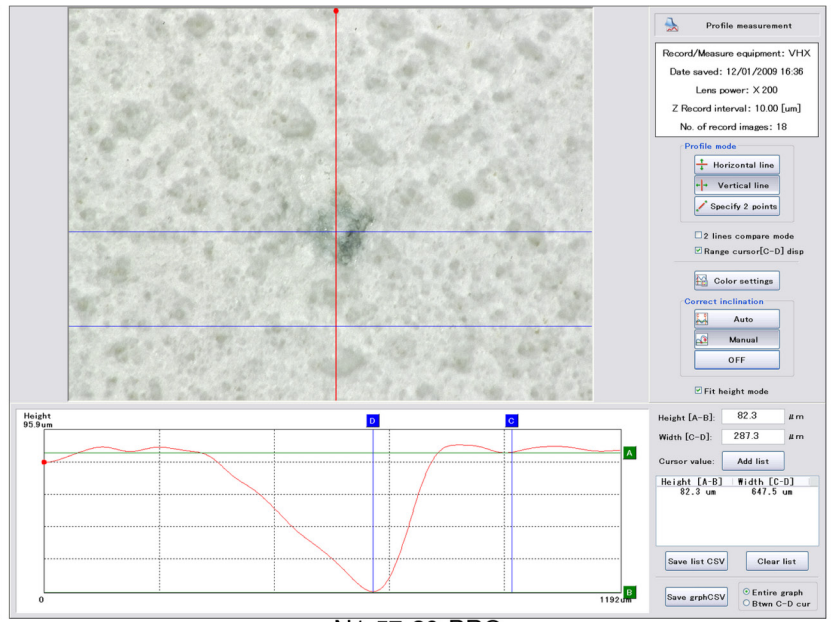
N1-02-79-PRO



N1-21-16-PRO



N1-51-98-PRO



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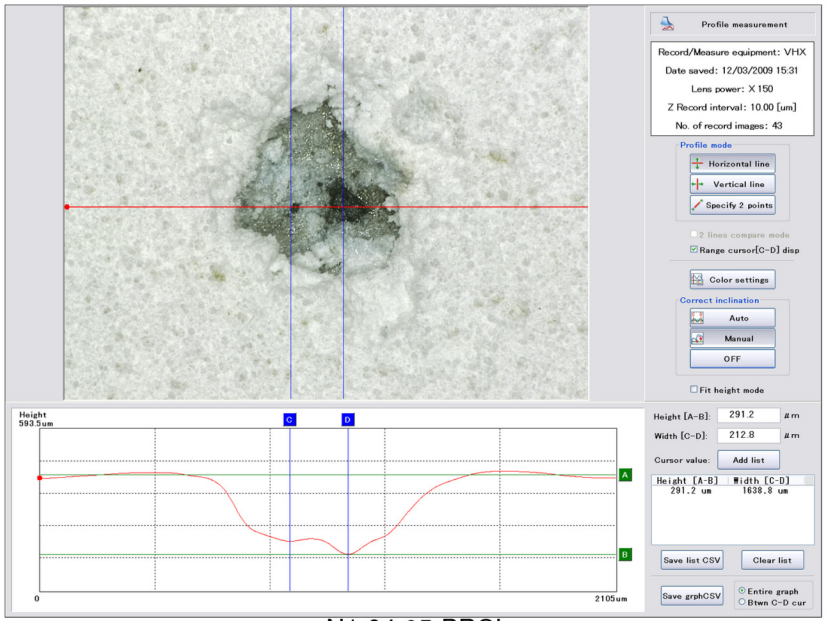
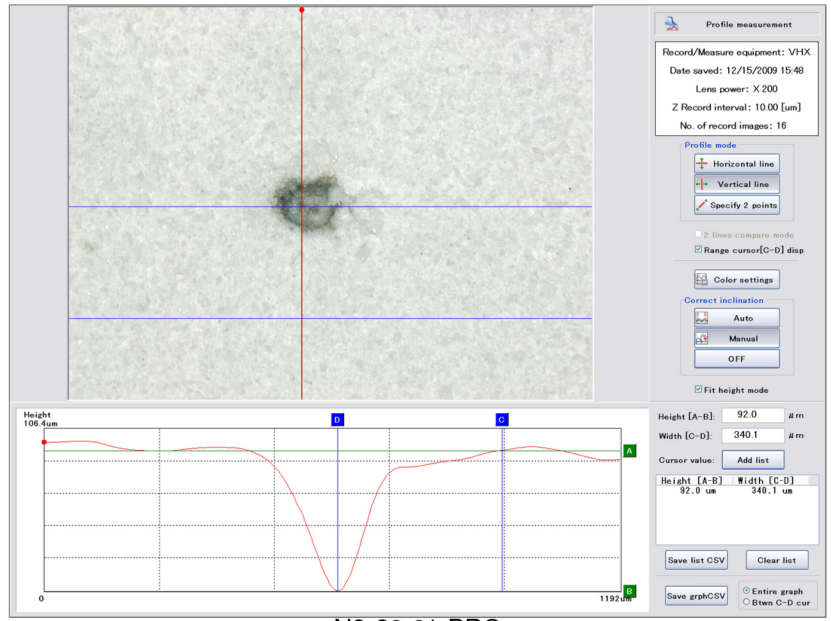
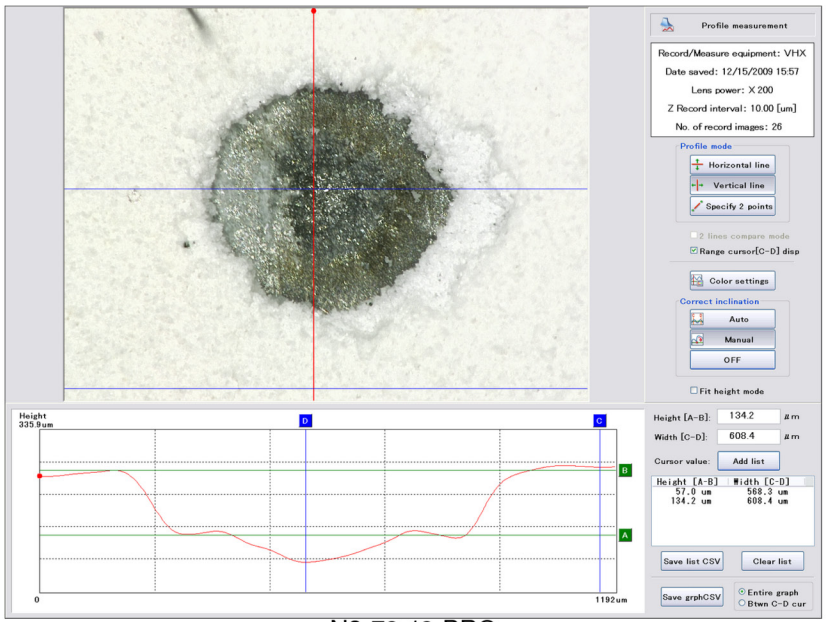


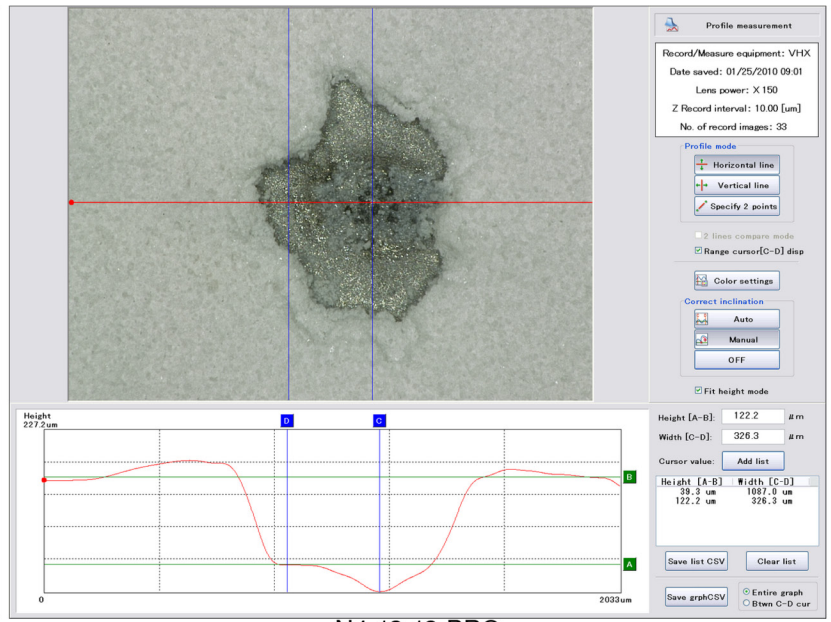
N1-94-05-PROj



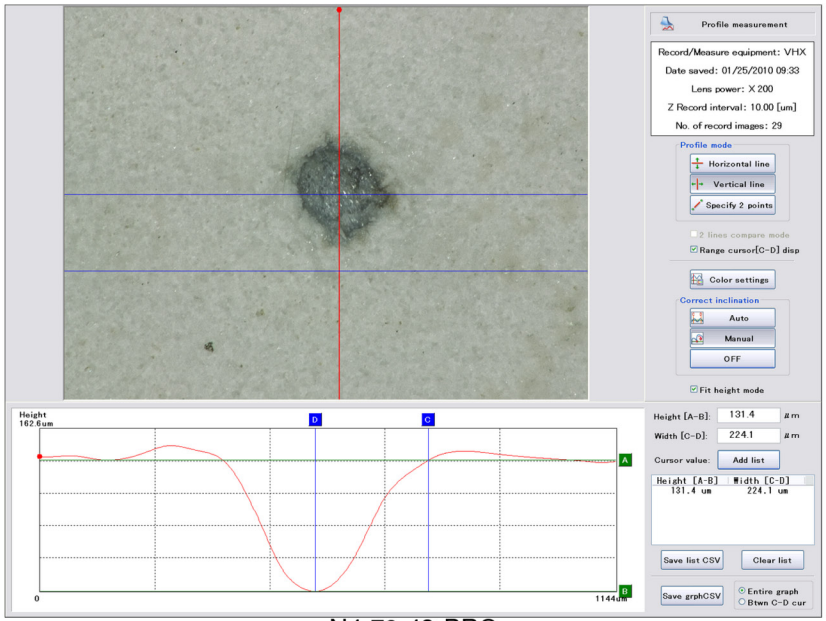
N3-28-81-PRO



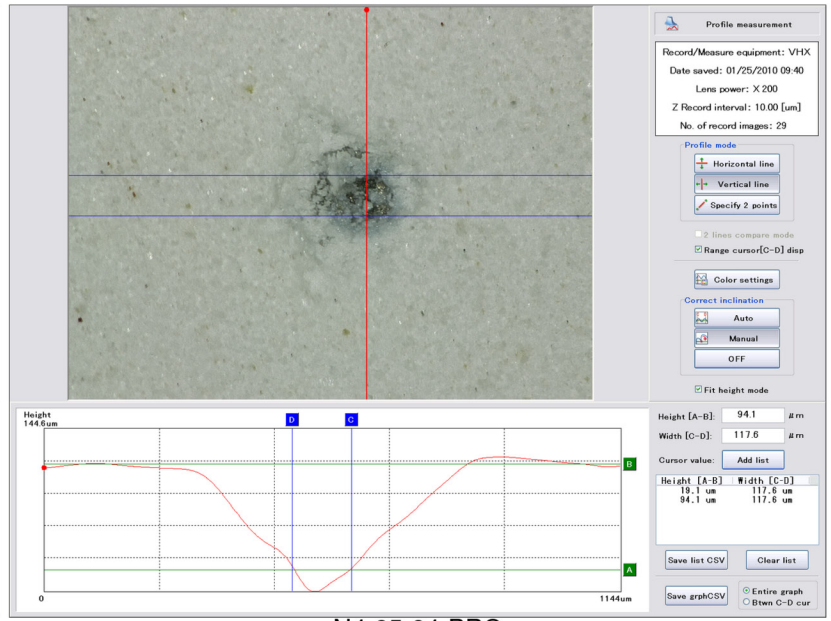
N3-78-18-PRO



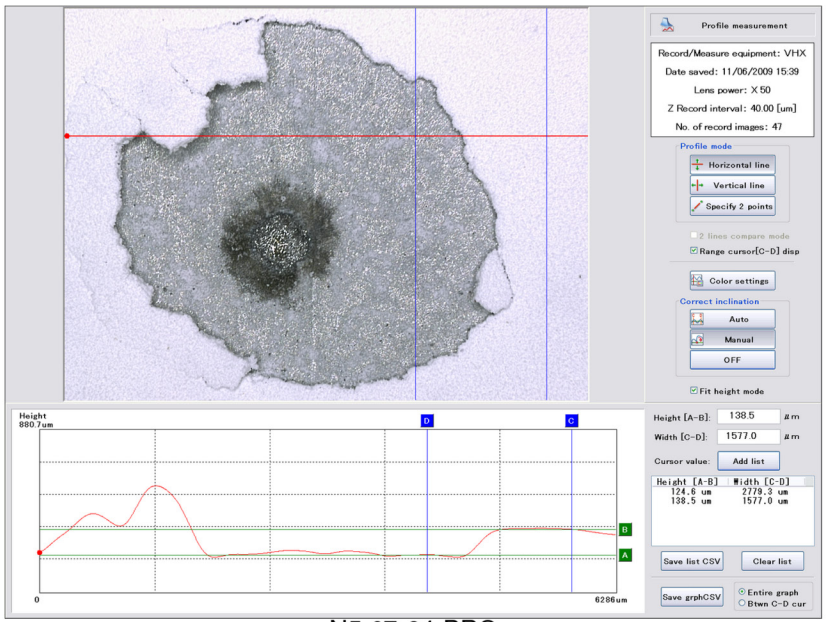
N4-12-12-PRO



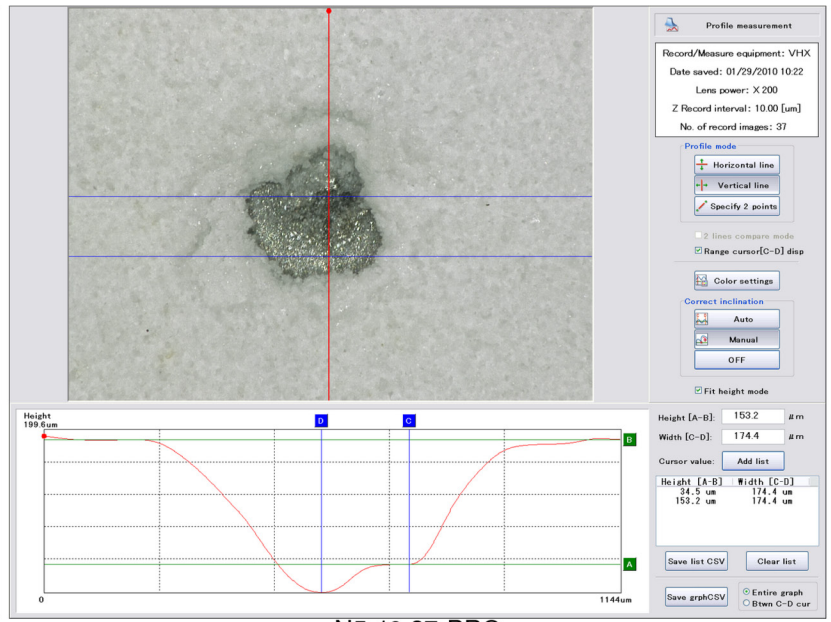
N4-78-43-PRO



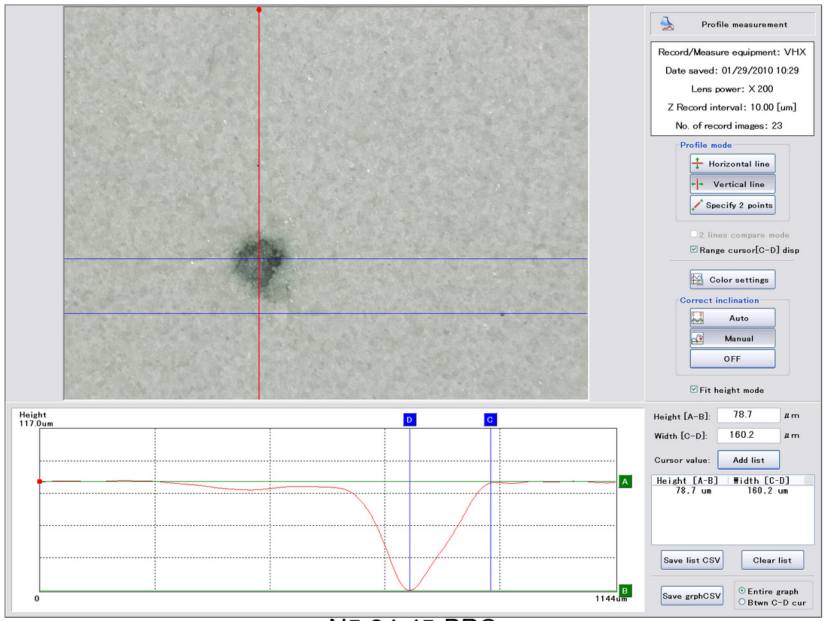
N4-85-84-PRO



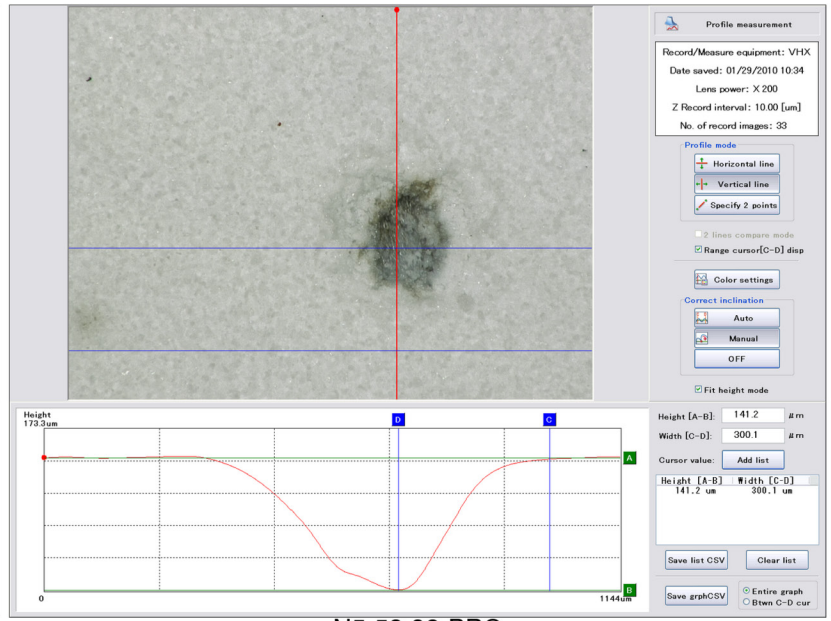
N5-07-64-PRO



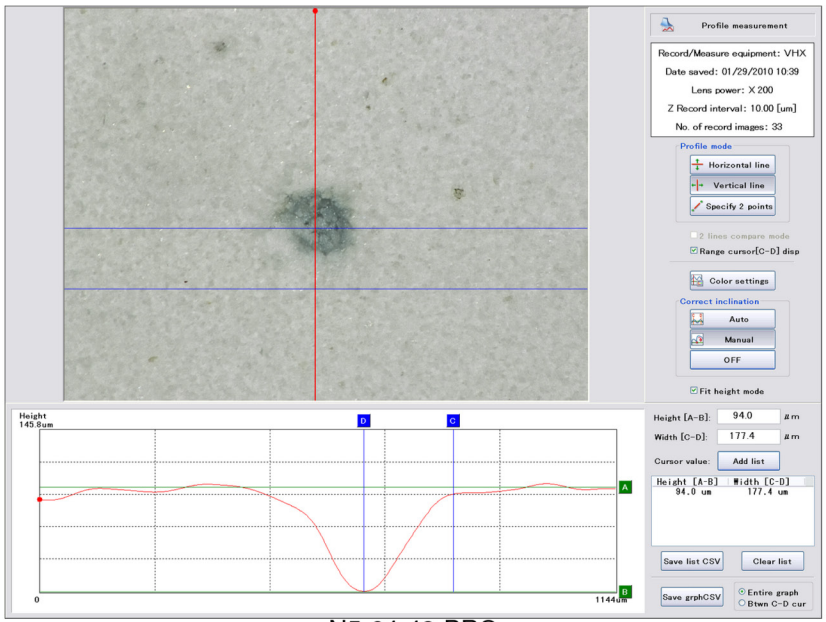
N5-16-37-PRO



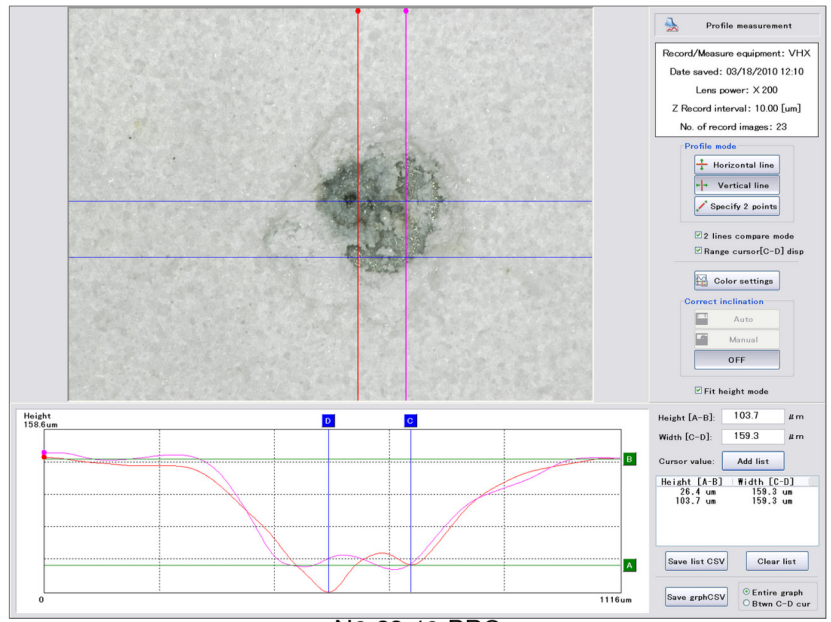
N5-34-45-PRO



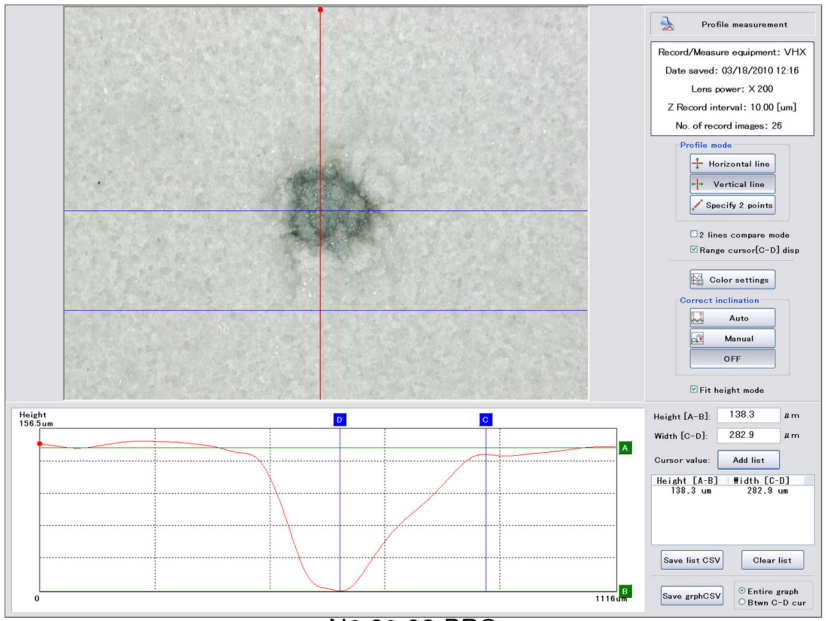
N5-52-32-PRO



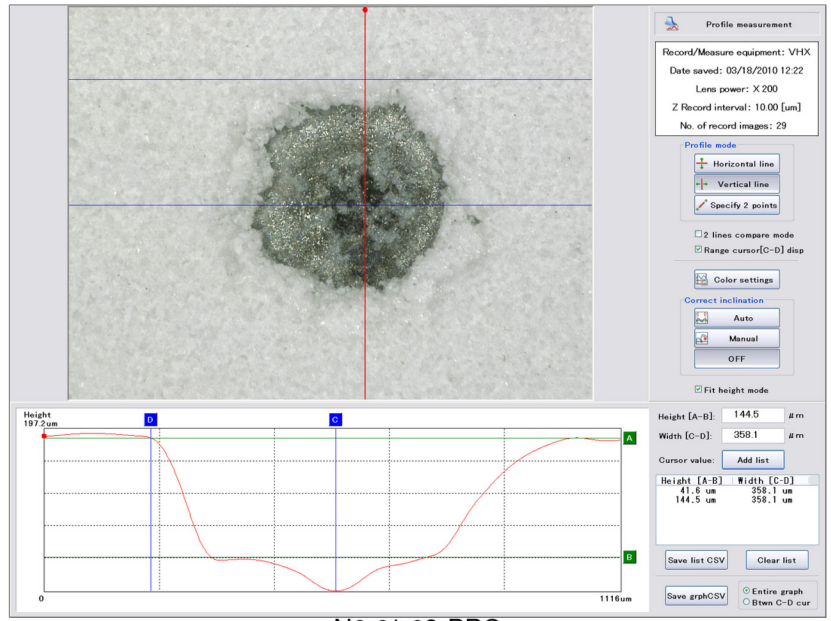
N5-64-48-PRO



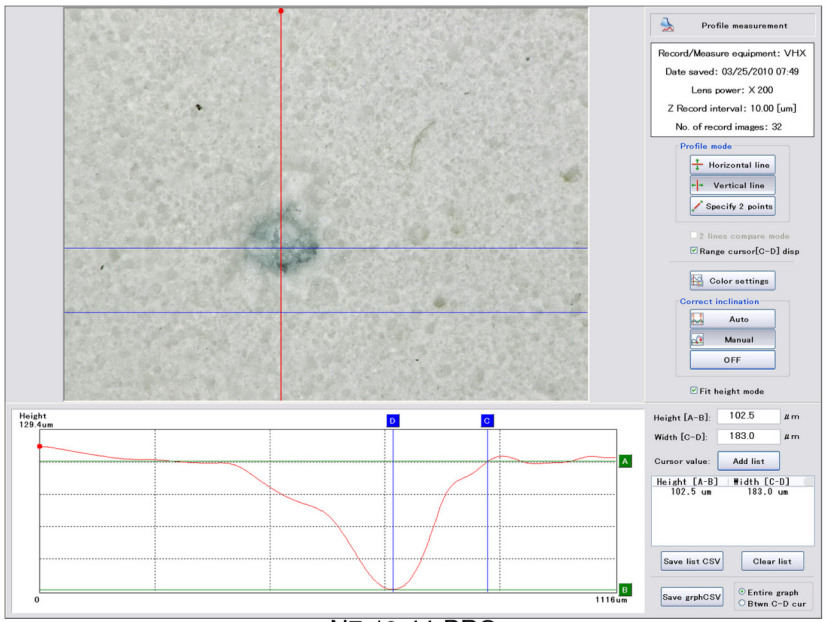
N6-23-16-PRO



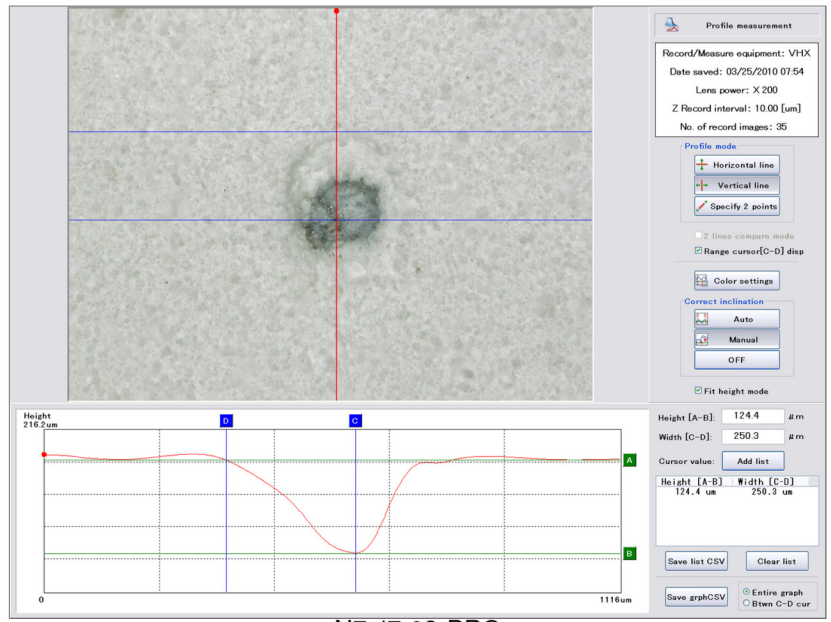
N6-30-92-PRO



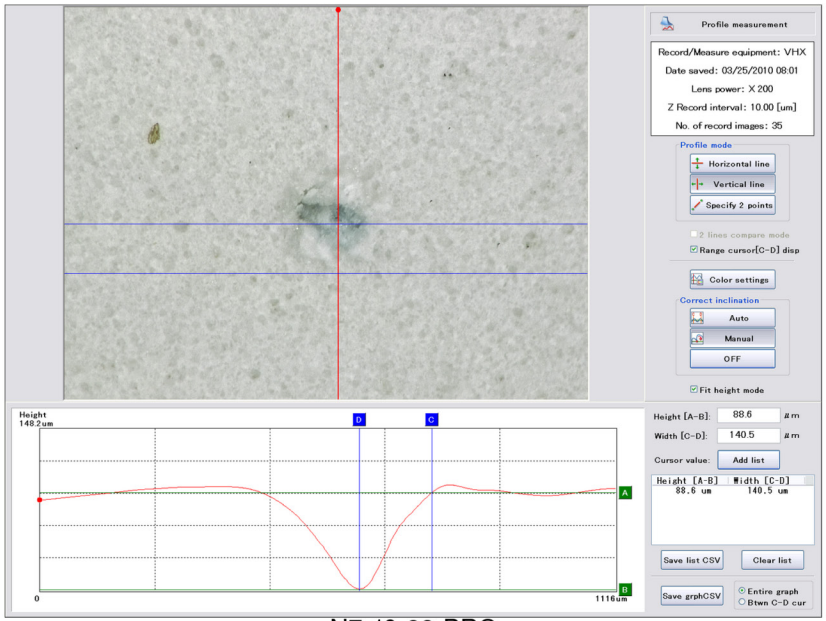
N6-61-03-PRO



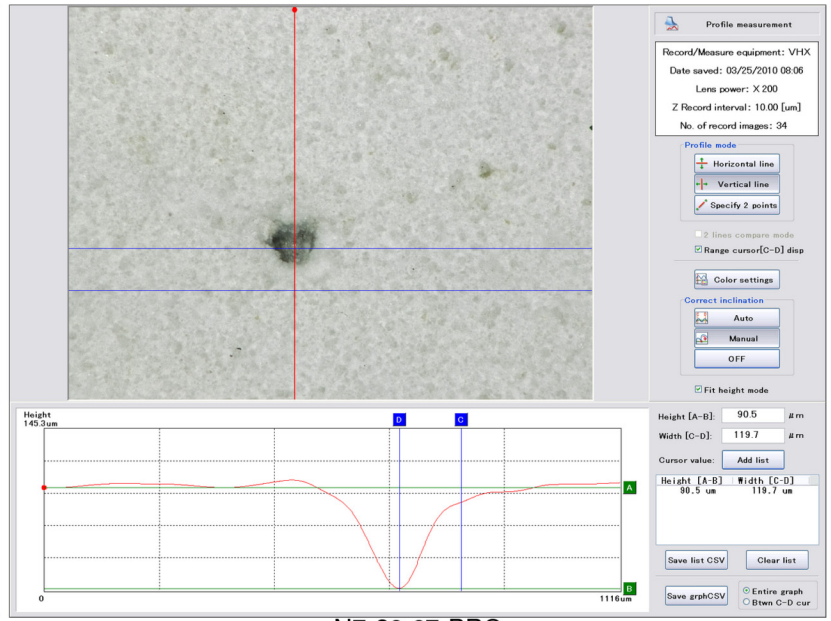
N7-16-44-PRO



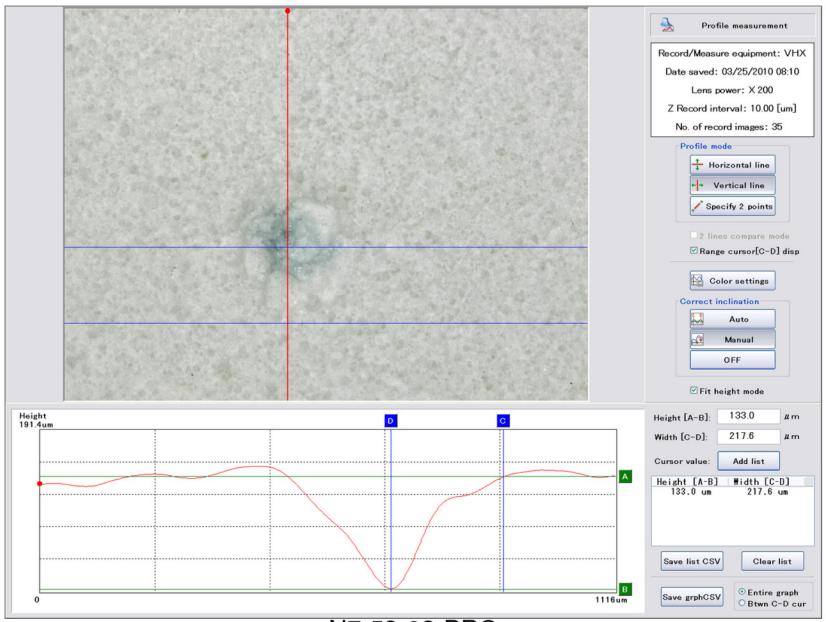
N7-17-03-PRO



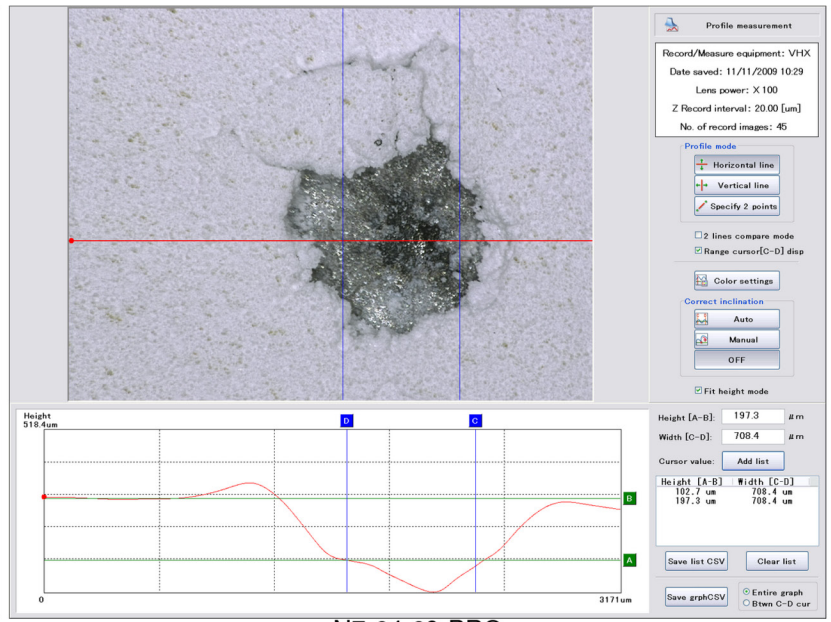
N7-19-88-PRO



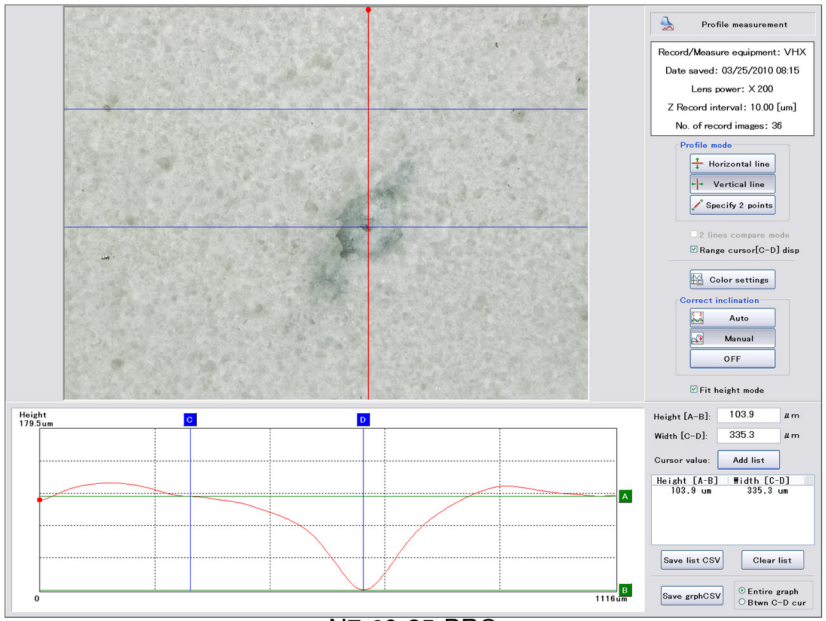
N7-28-87-PRO



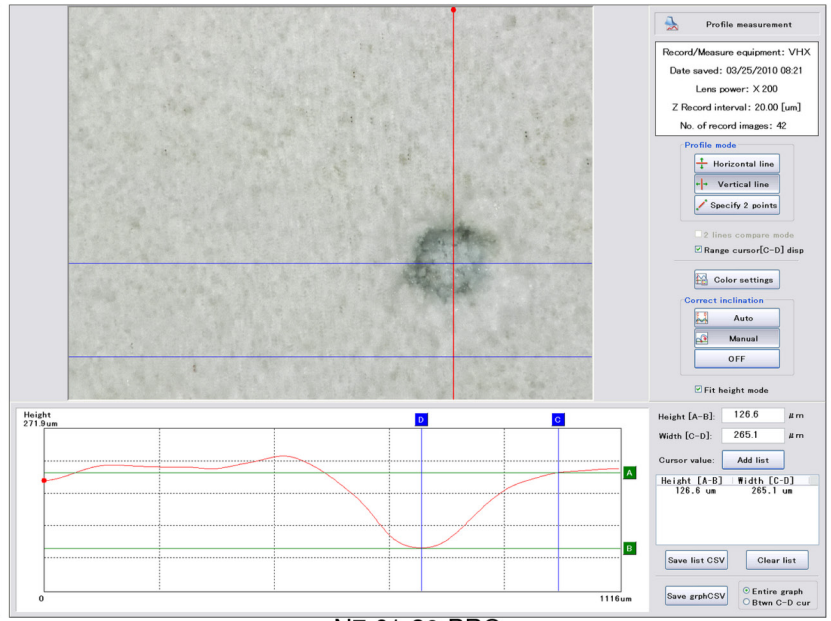
N7-53-82-PRO



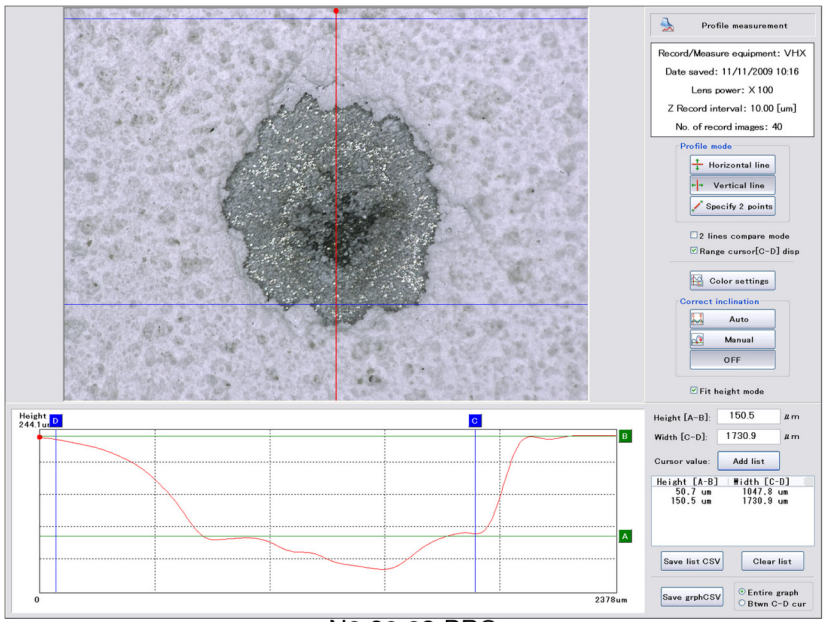
N7-64-69-PRO



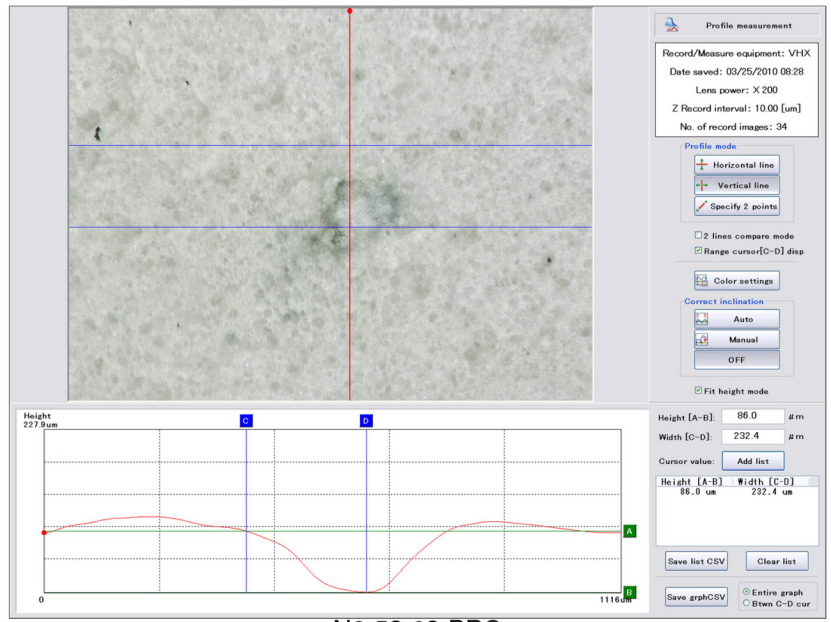
N7-69-25-PRO



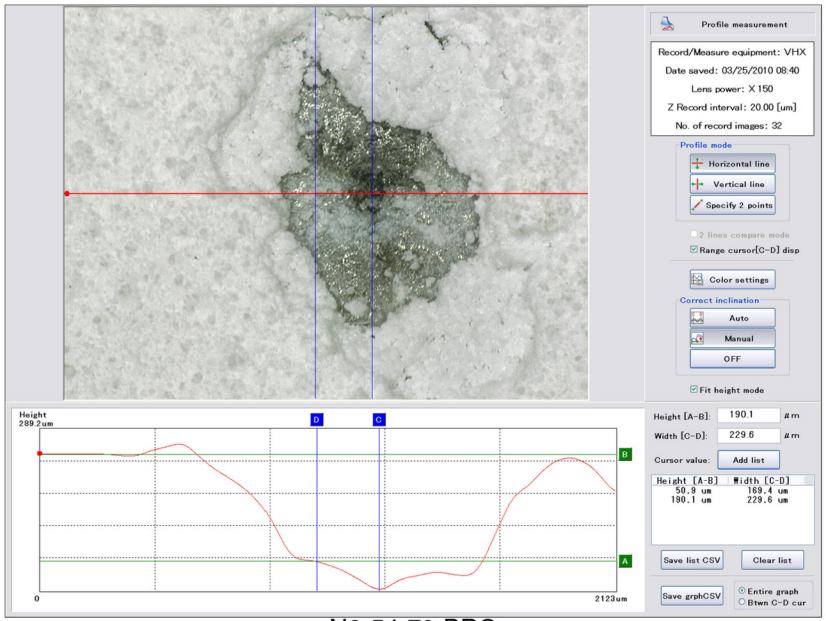
N7-91-26-PRO



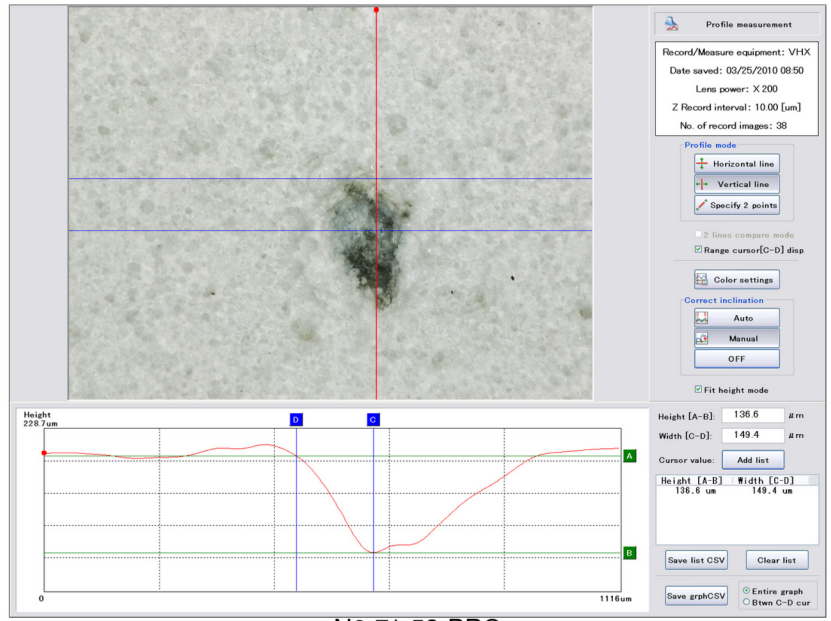
N8-38-82-PRO



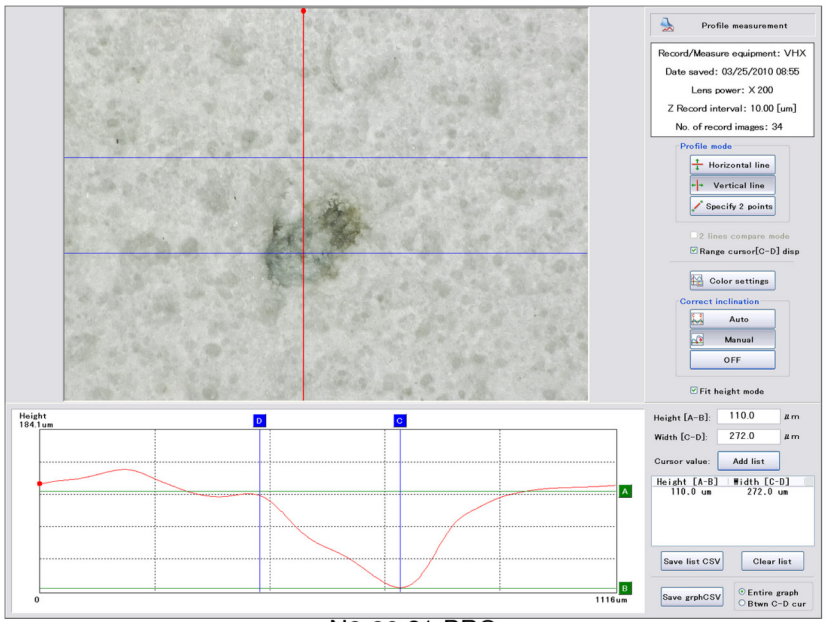
N8-52-62-PRO



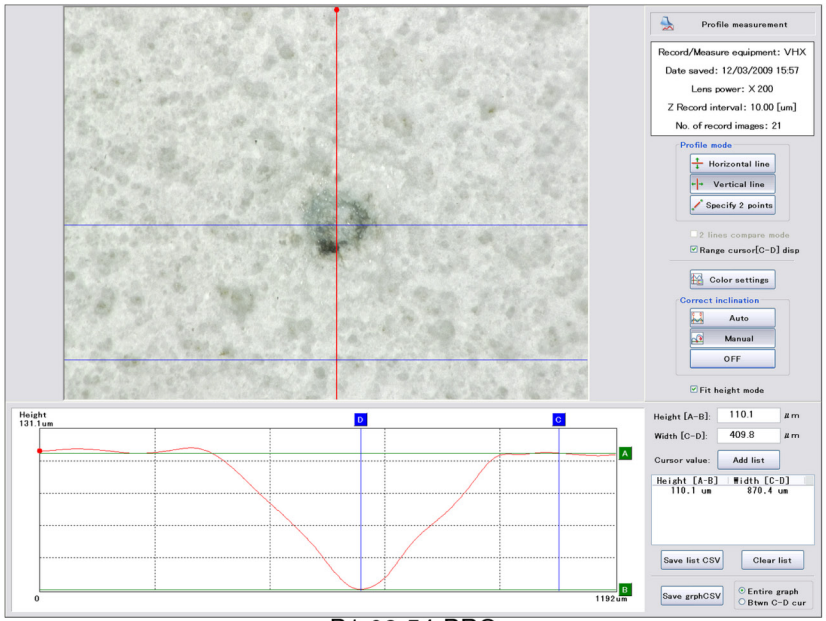
N8-54-76-PRO



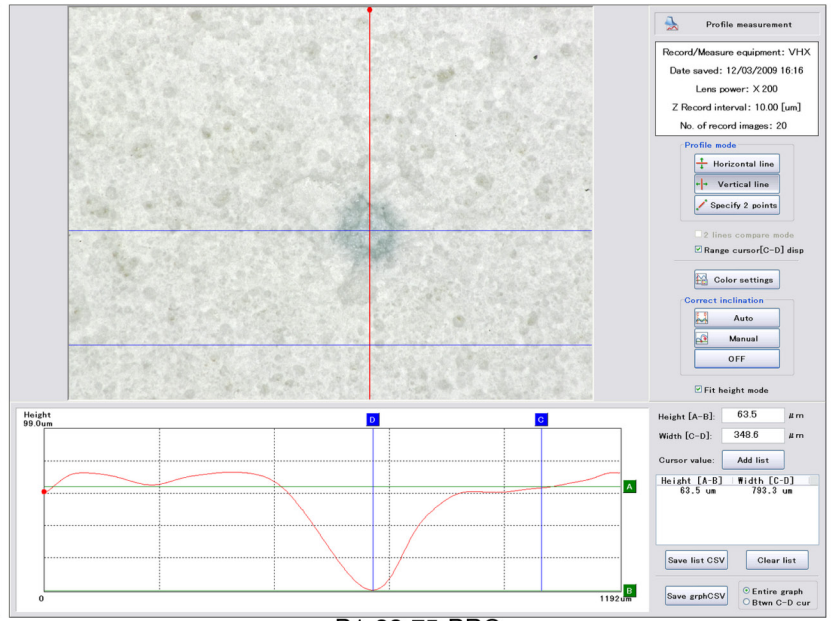
N8-71-52-PRO



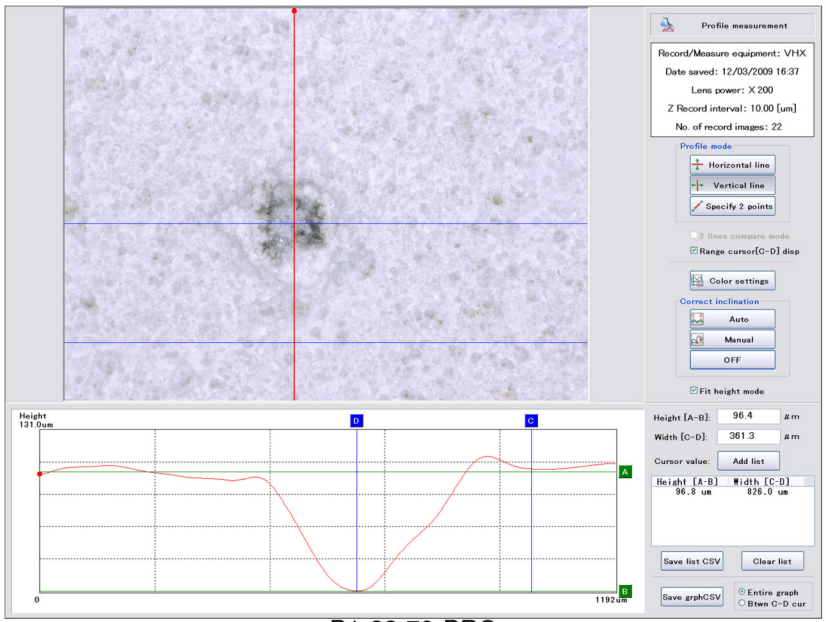
N8-86-31-PRO



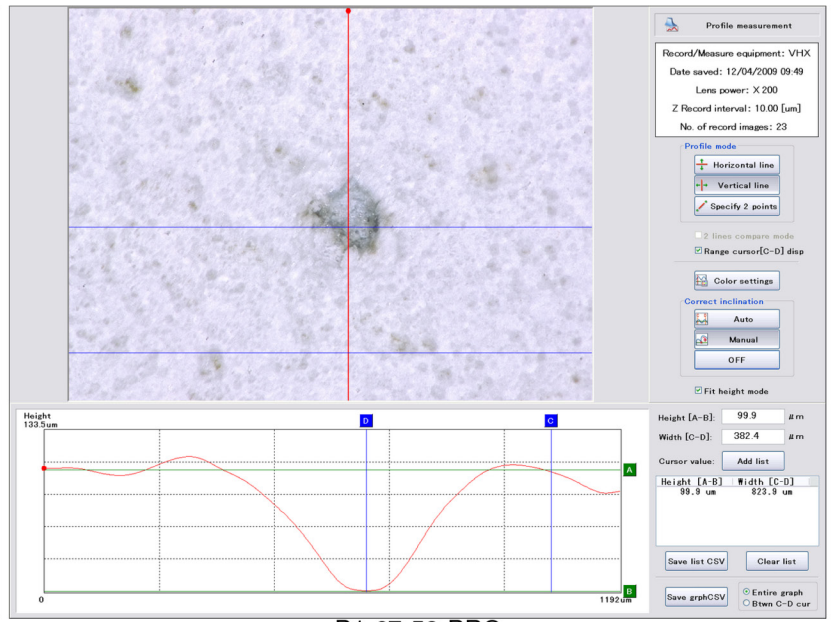
P1-08-54-PRO



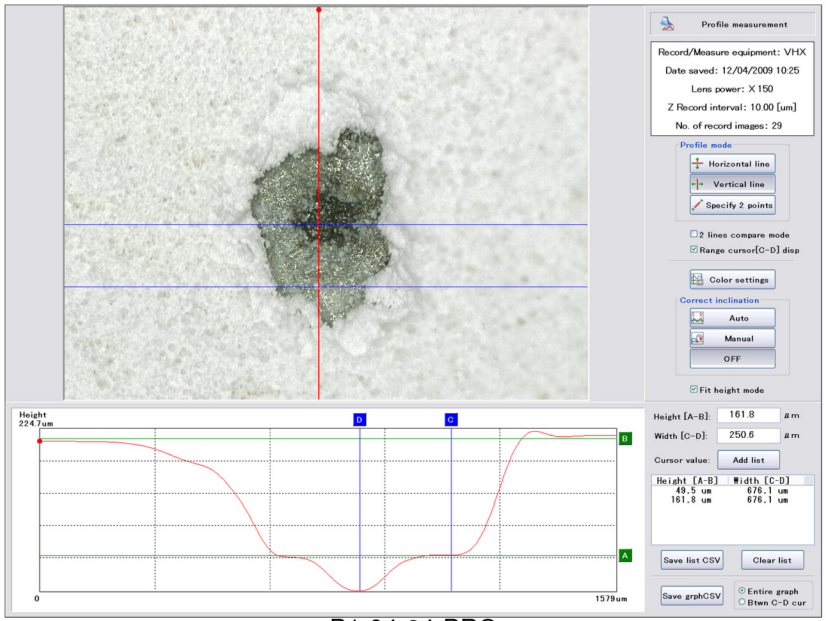
P1-22-75-PRO



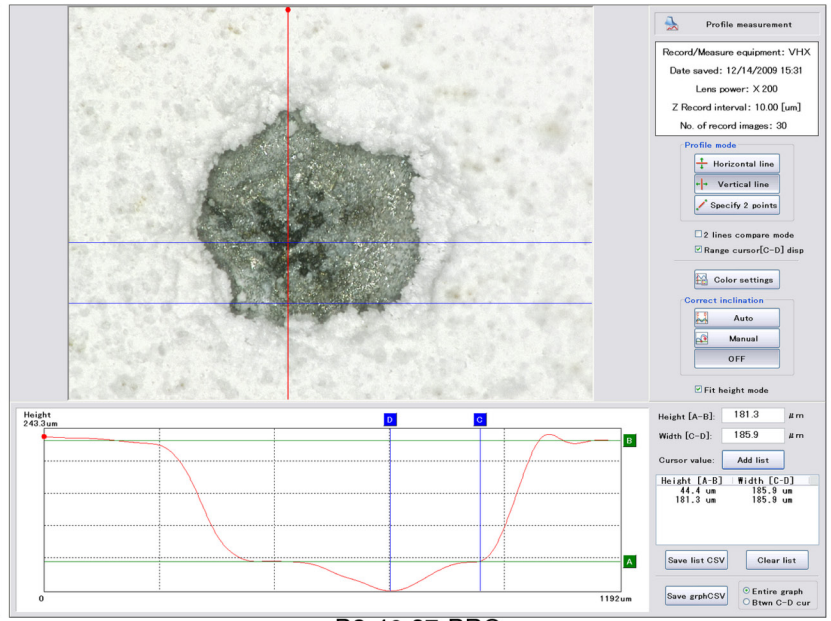
P1-22-79-PRO



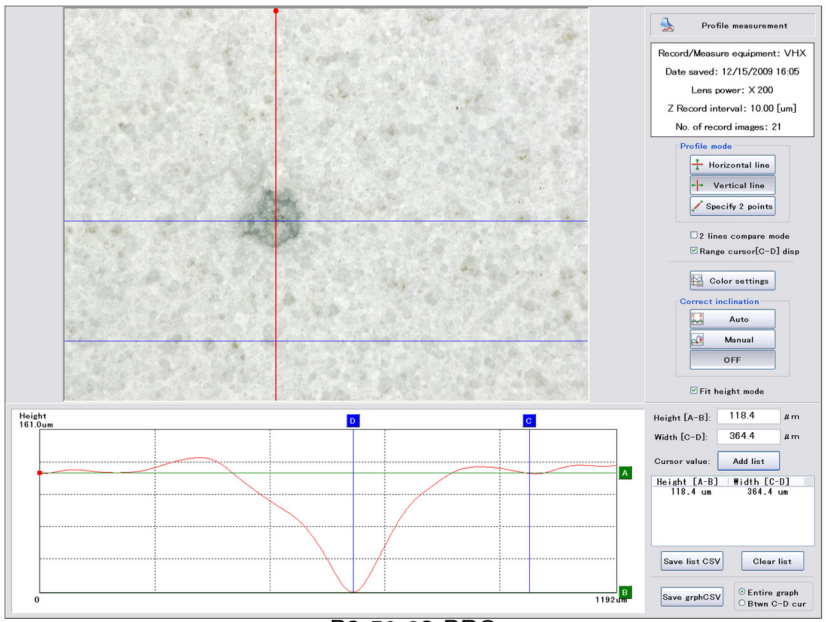
P1-67-58-PRO



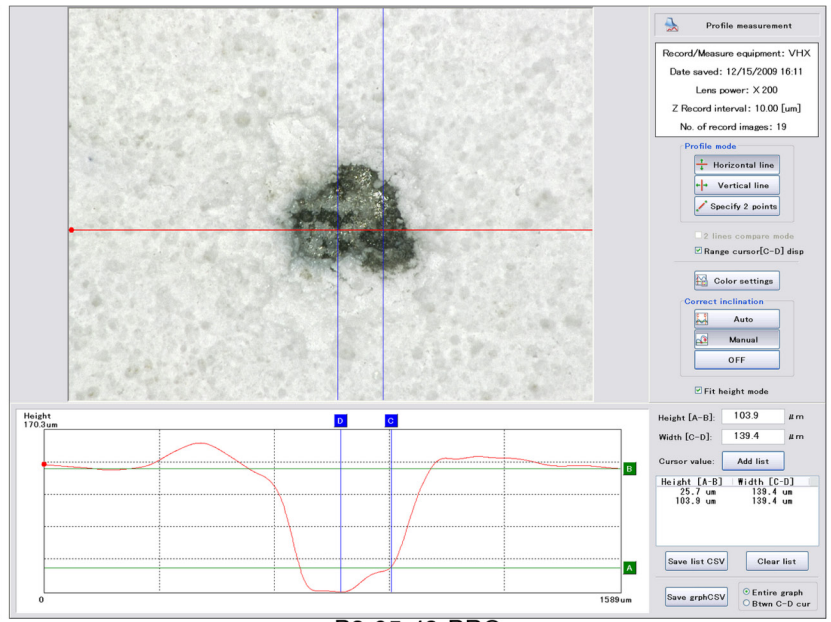
P1-94-84-PRO



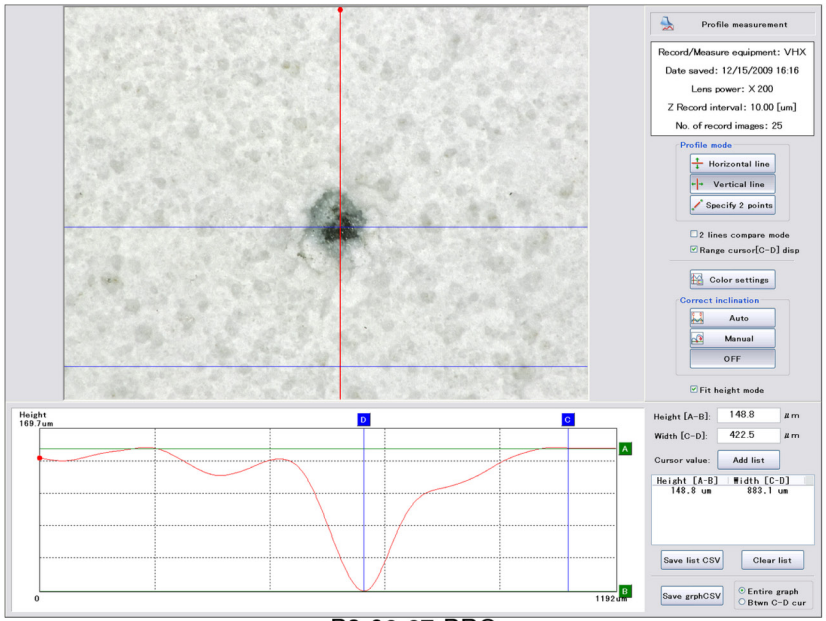
P2-46-37-PRO



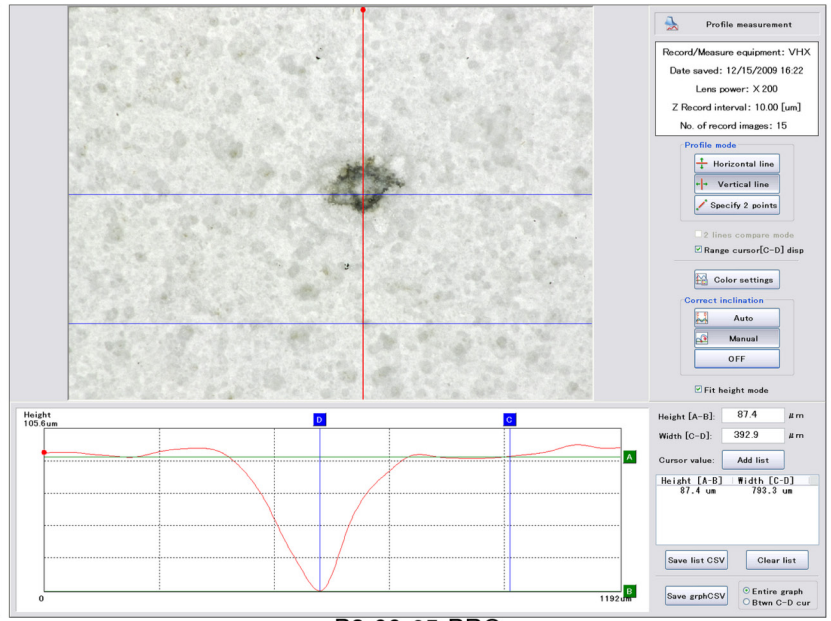
P3-50-83-PRO



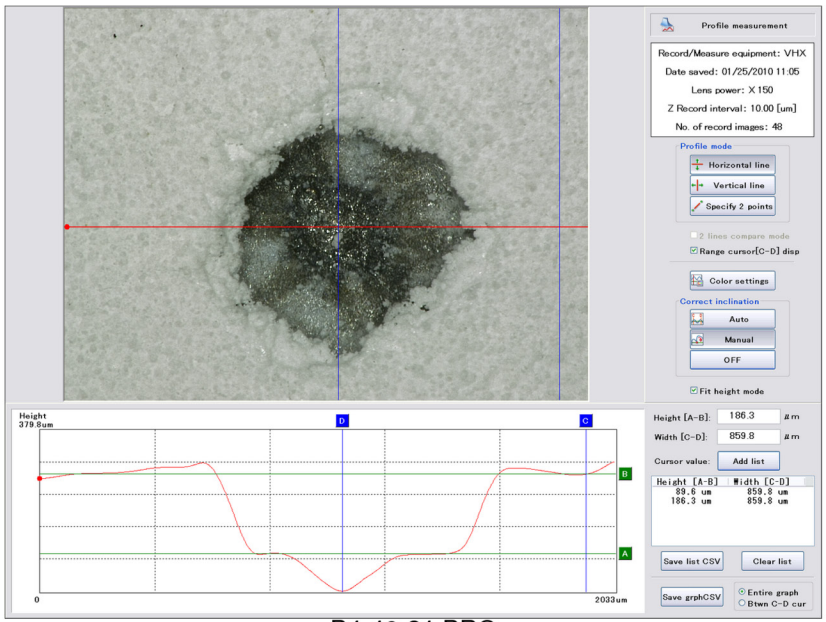
P3-95-43-PRO



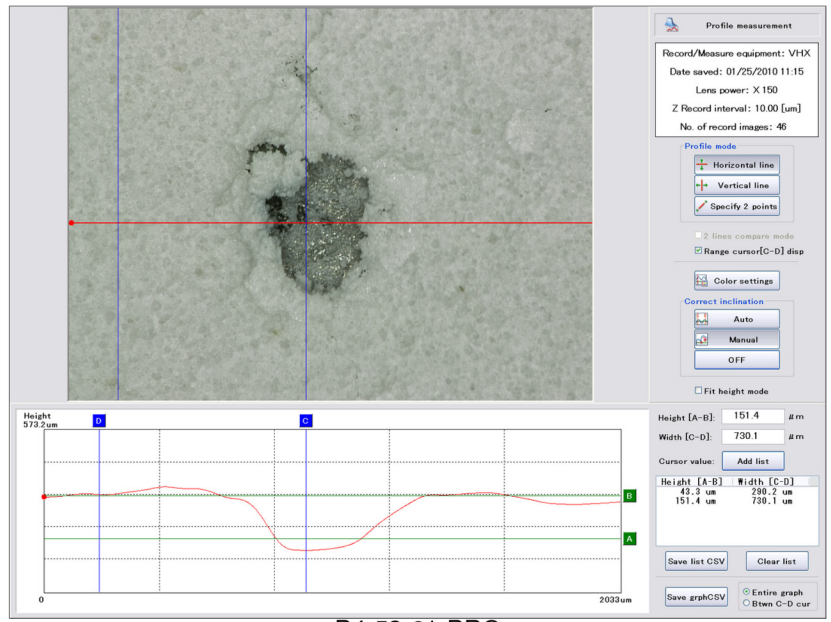
P3-98-87-PRO



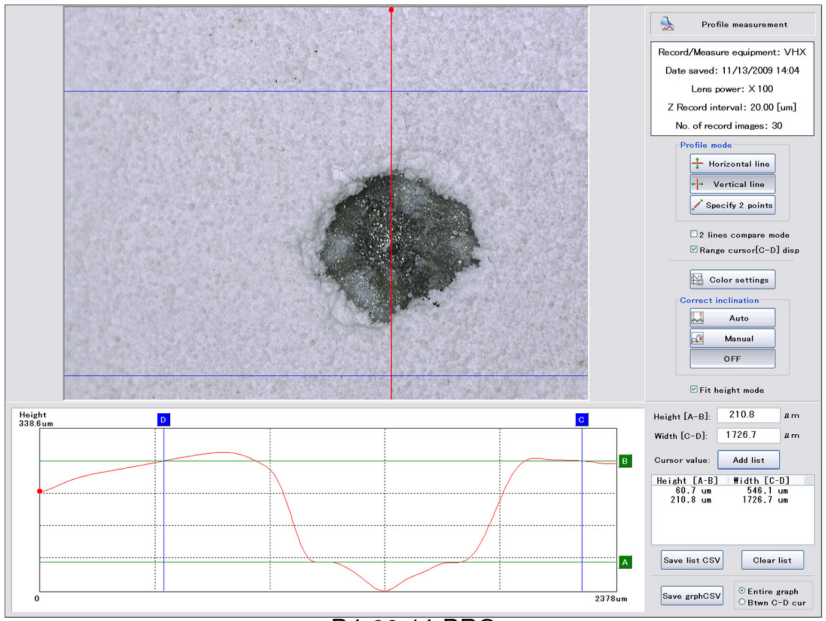
P3-99-65-PRO



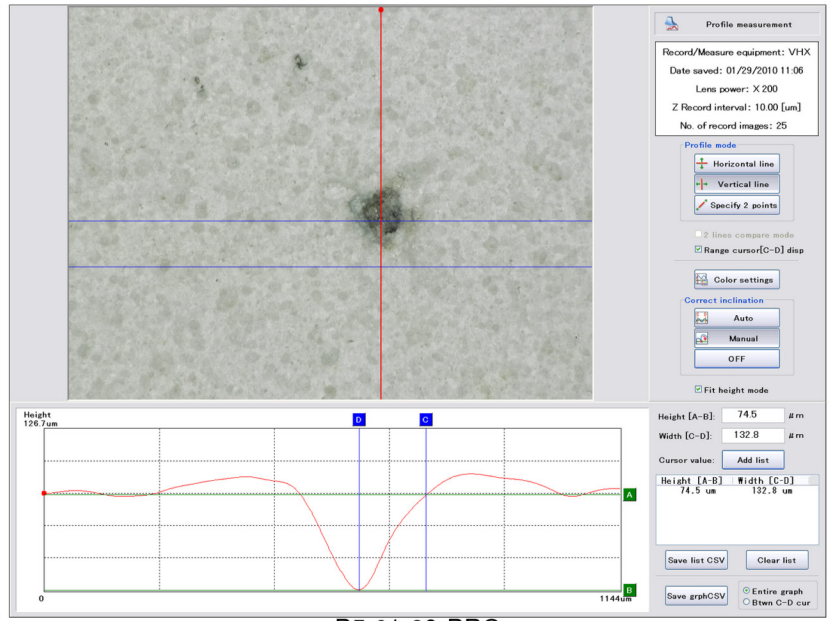
P4-46-24-PRO



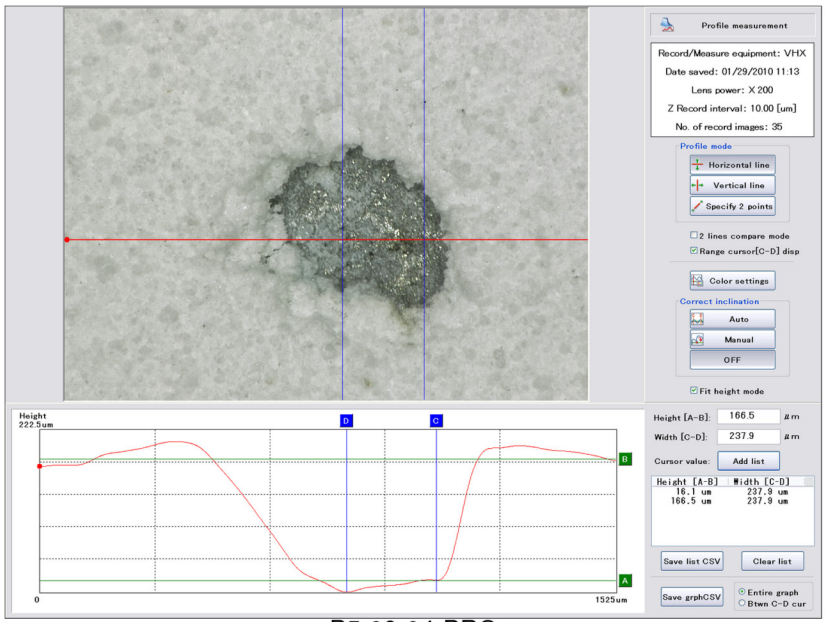
P4-53-81-PRO



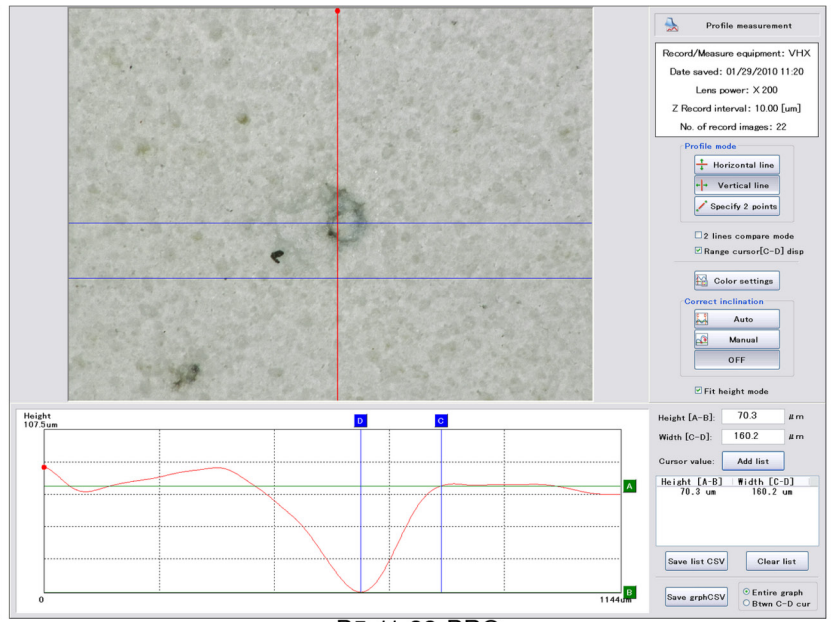
P4-66-14-PRO



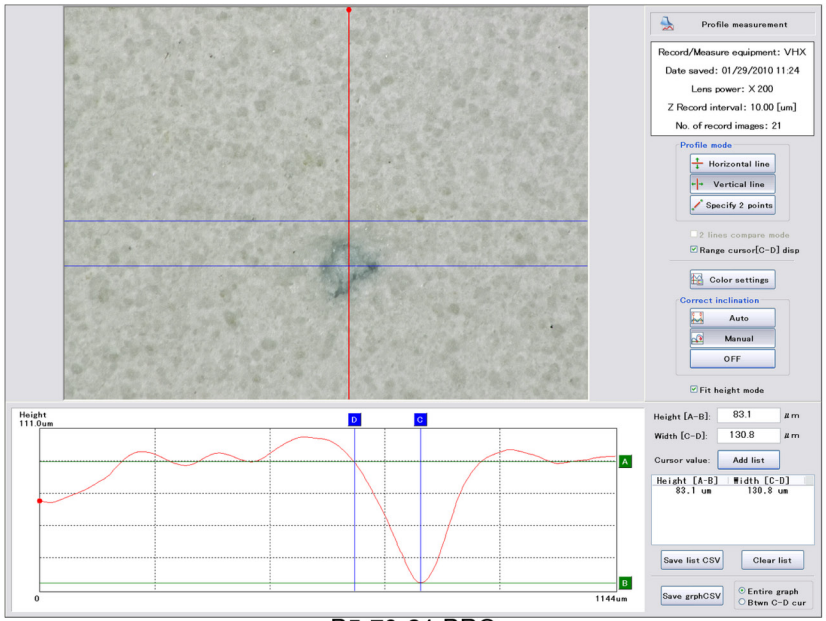
P5-01-89-PRO



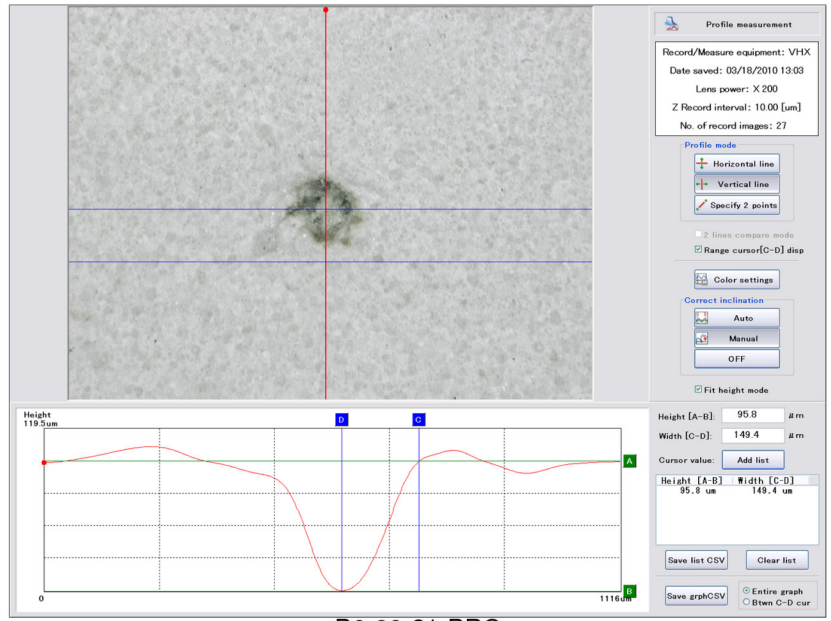
P5-09-04-PRO



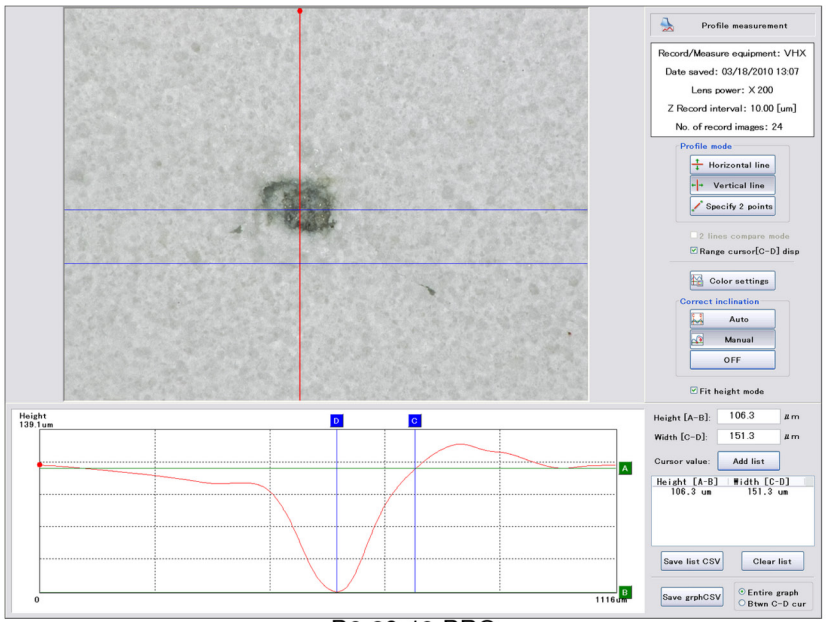
P5-11-33-PRO



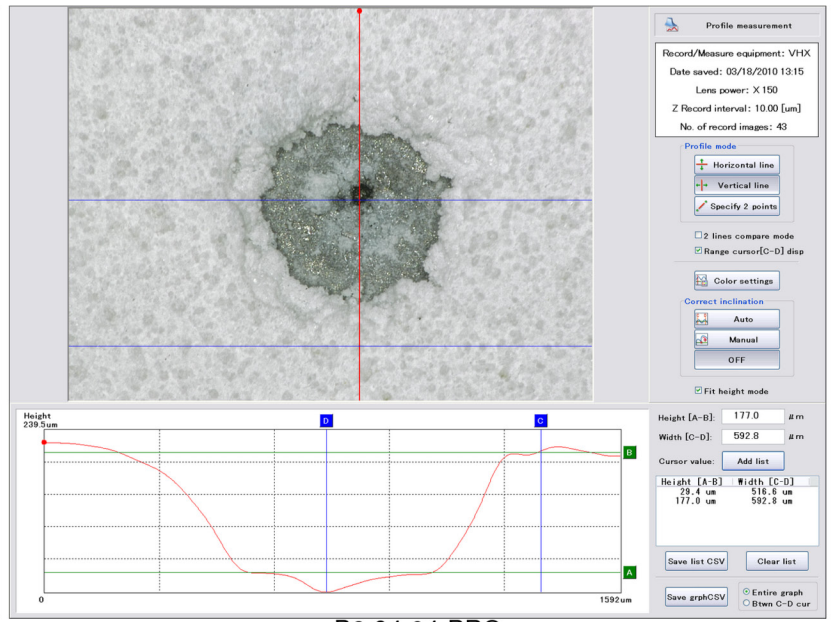
P5-79-24-PRO



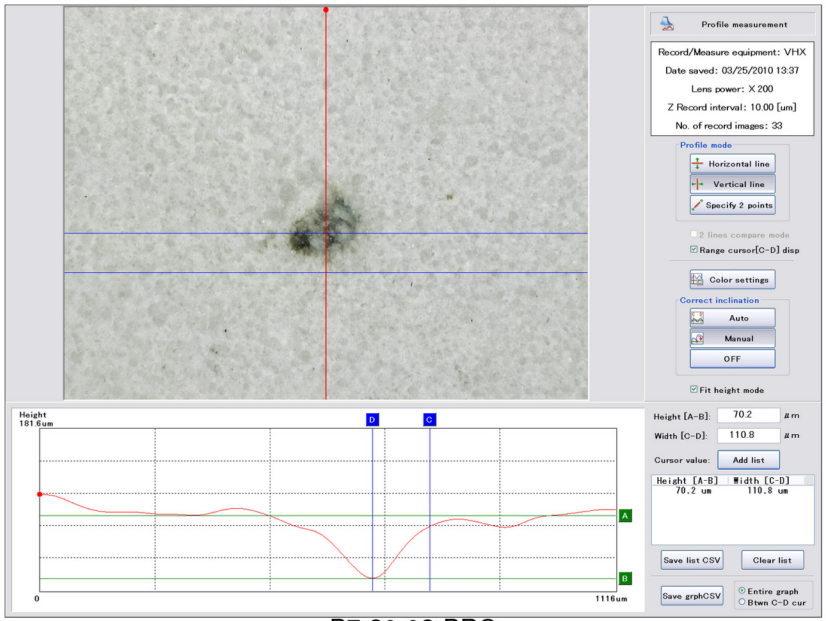
P6-88-21-PRO



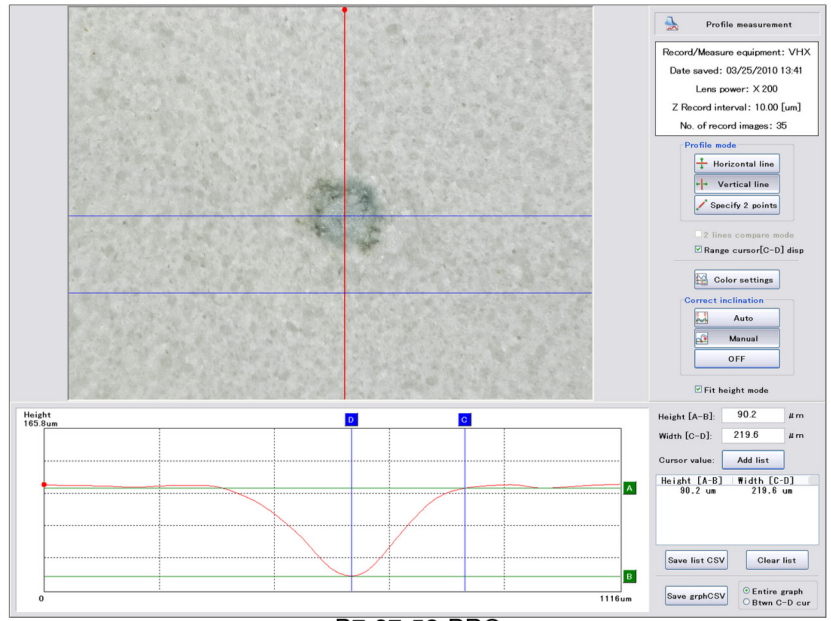
P6-89-16-PRO



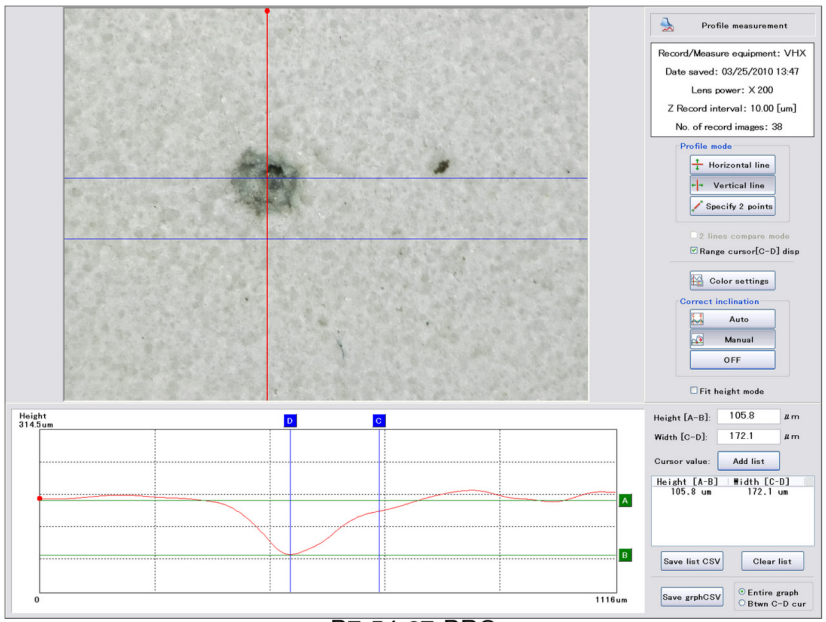
P6-94-04-PRO



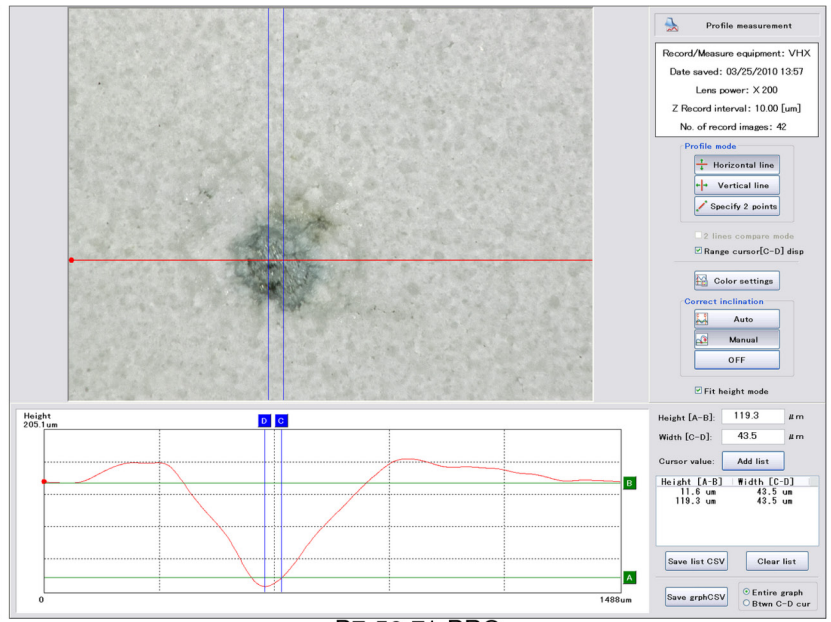
P7-30-02-PRO



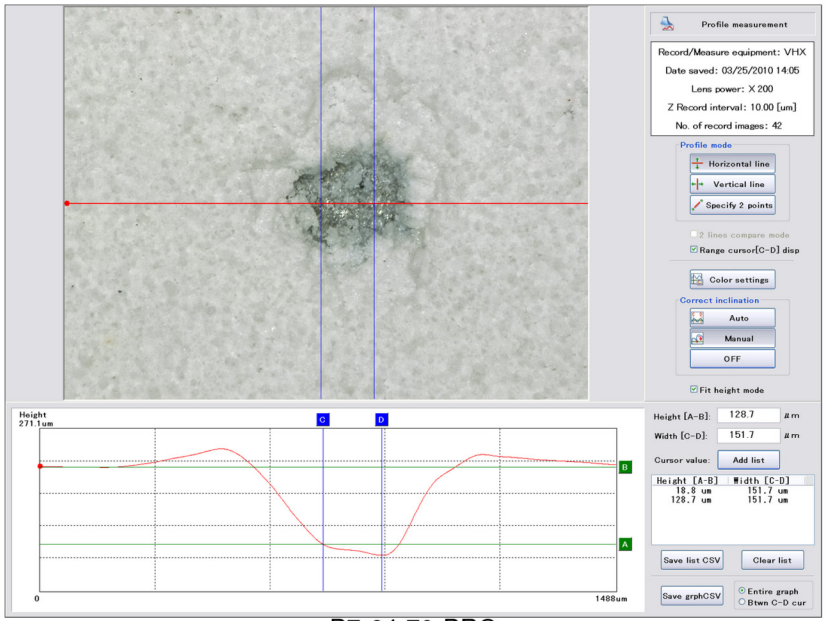
P7-37-52-PRO



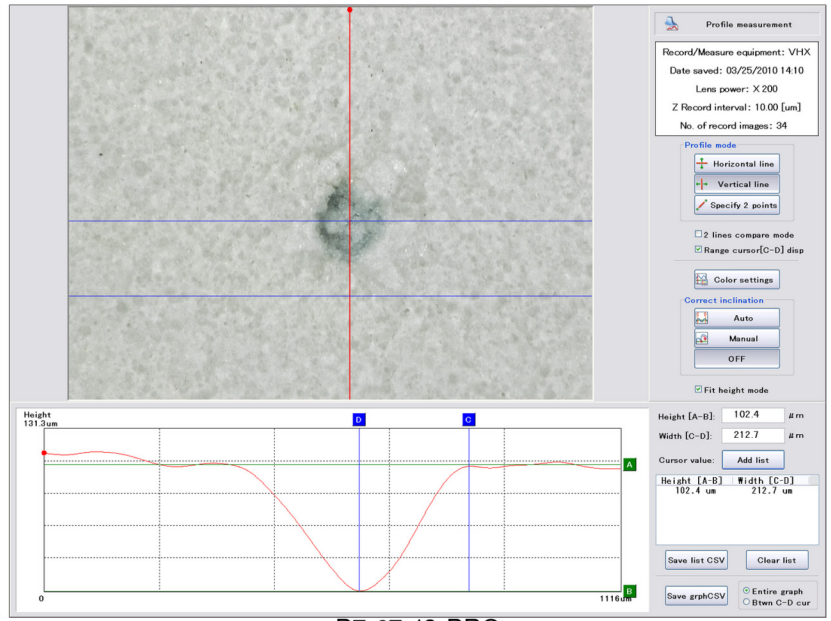
P7-54-87-PRO



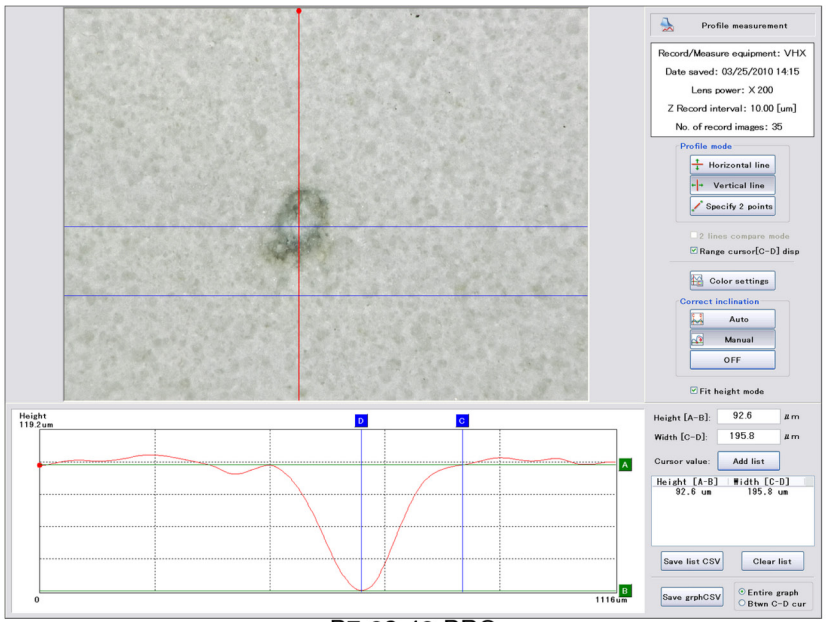
P7-56-71-PRO



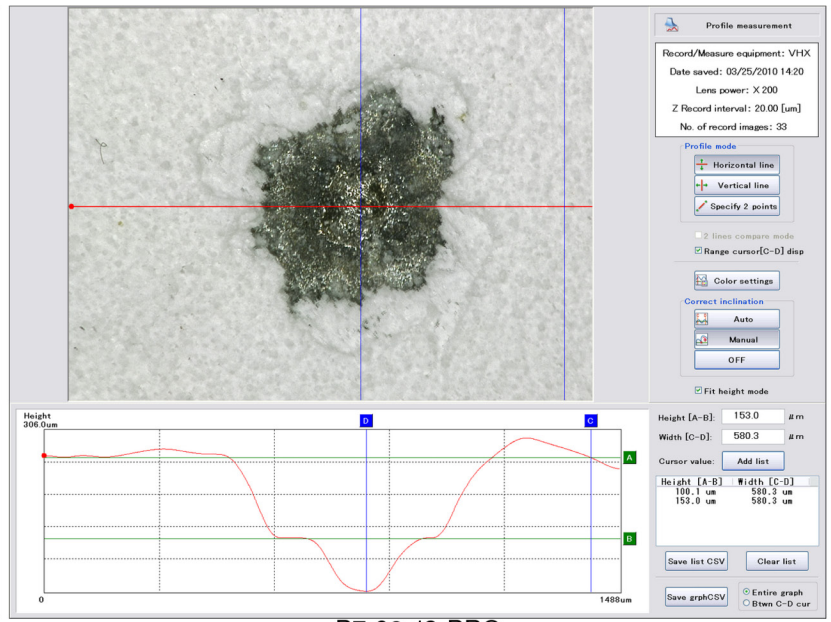
P7-64-70-PRO



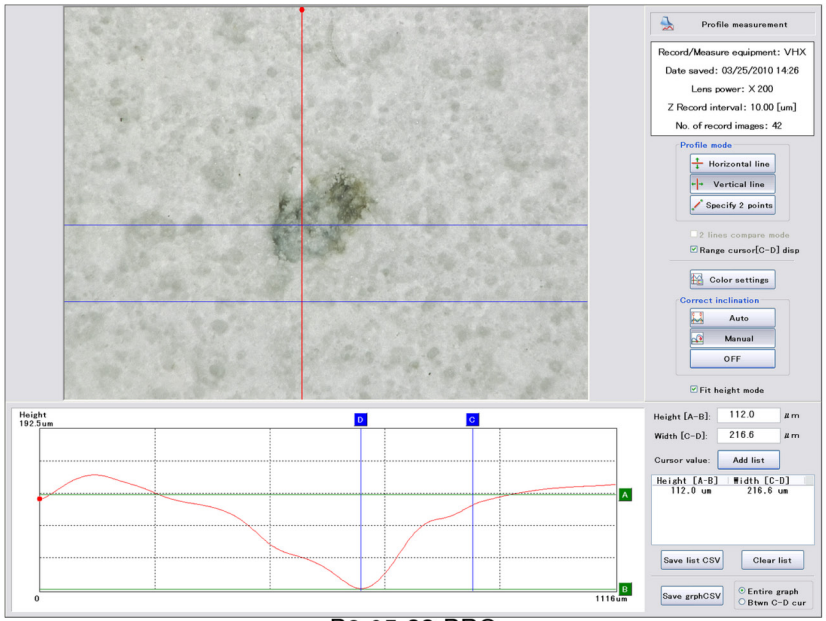
P7-67-13-PRO



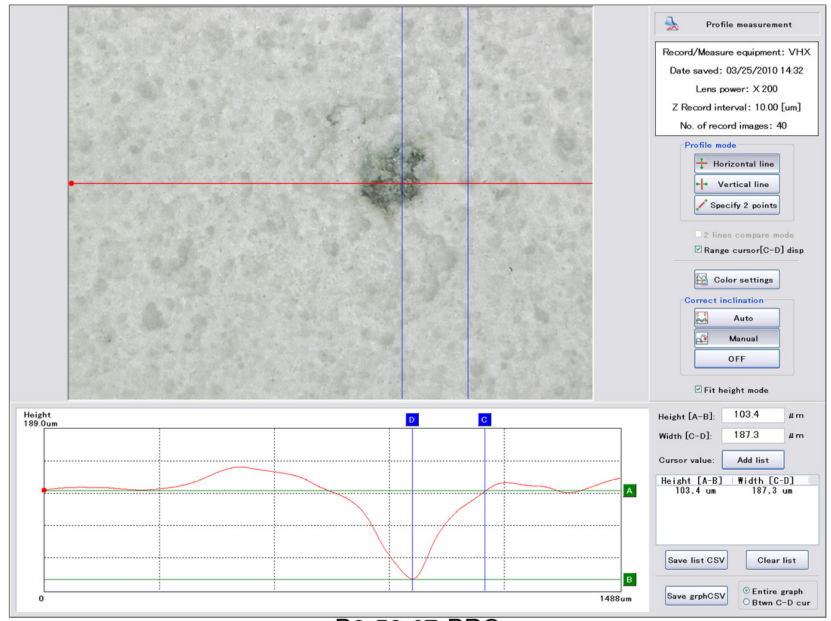
P7-82-48-PRO



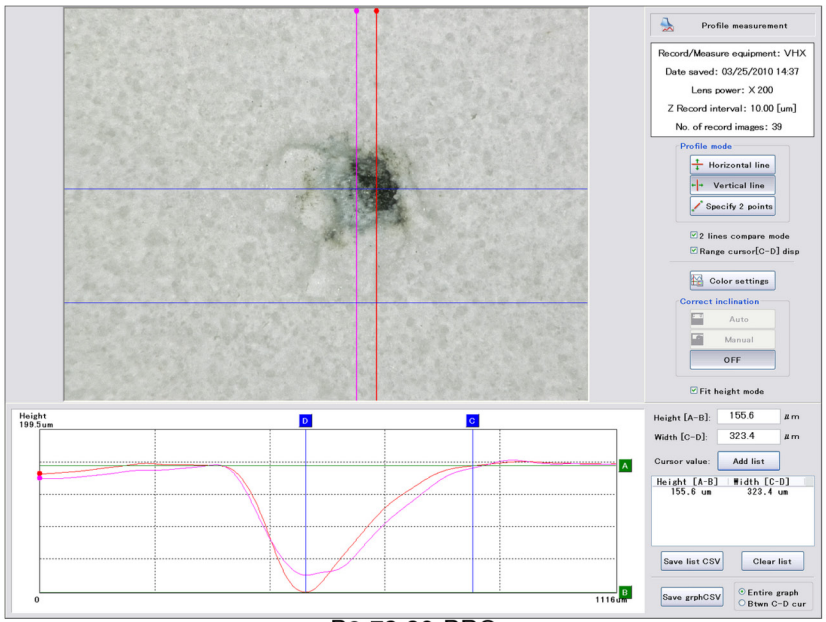
P7-98-13-PRO



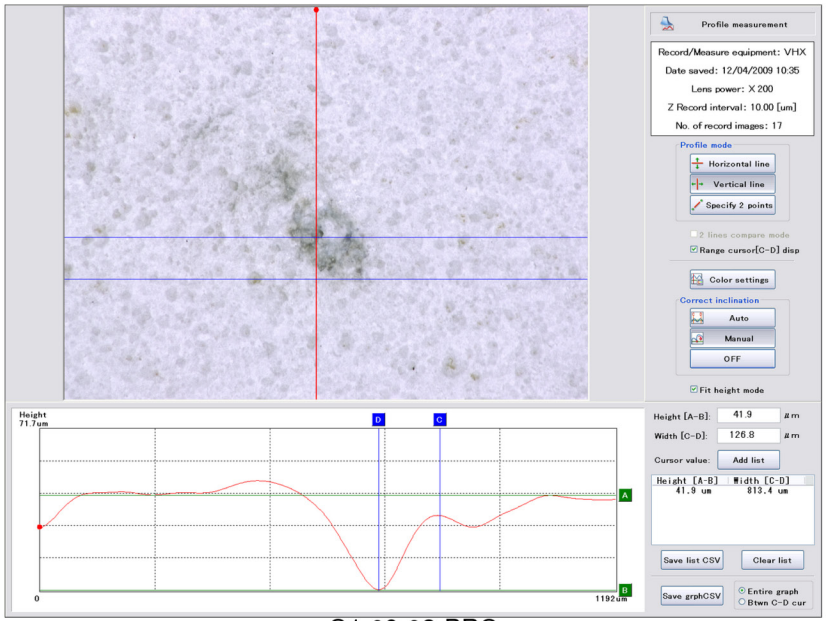
P8-05-22-PRO



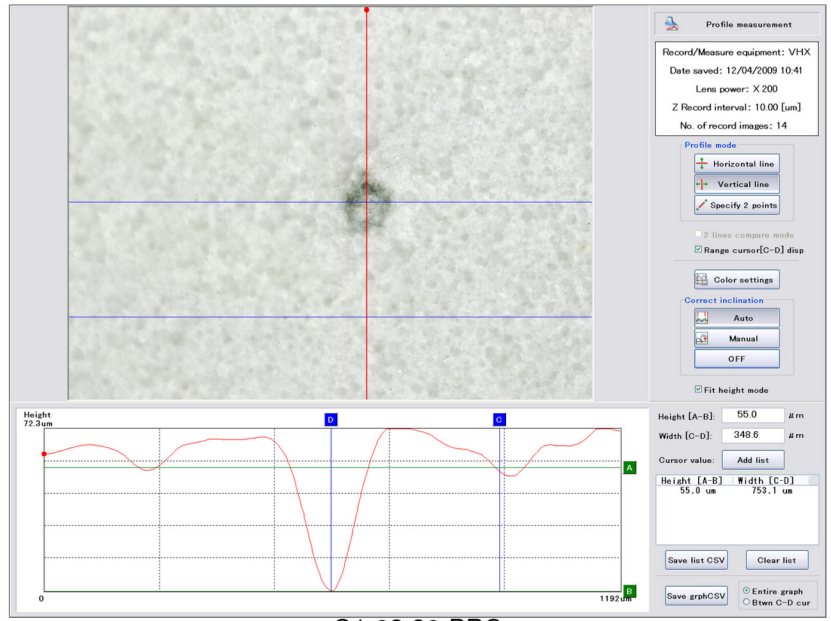
P8-58-07-PRO



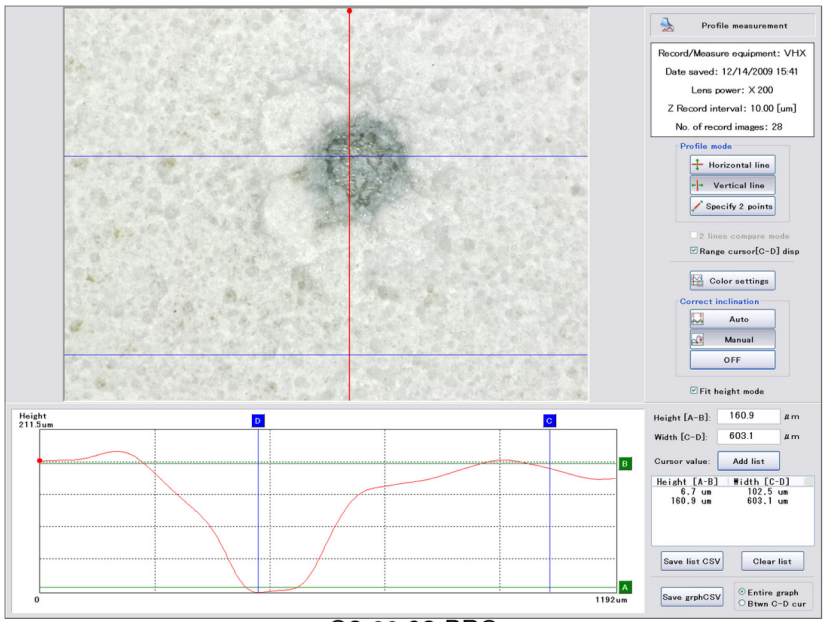
P8-72-39-PRO



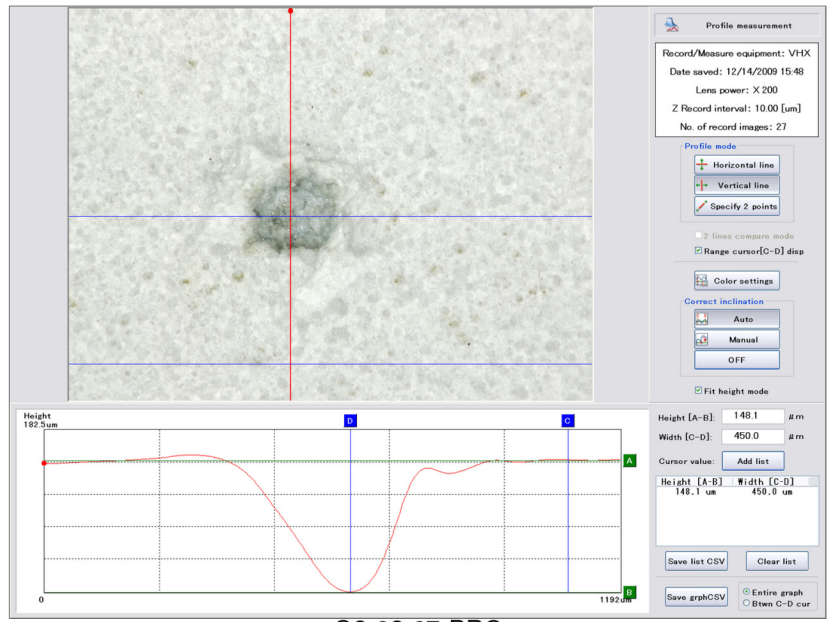
Q1-09-02-PRO



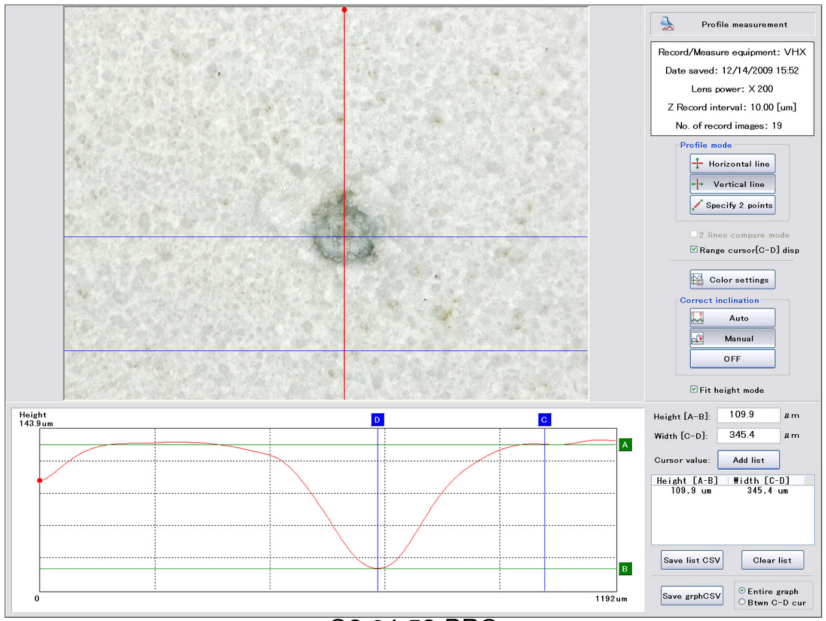
Q1-82-38-PRO



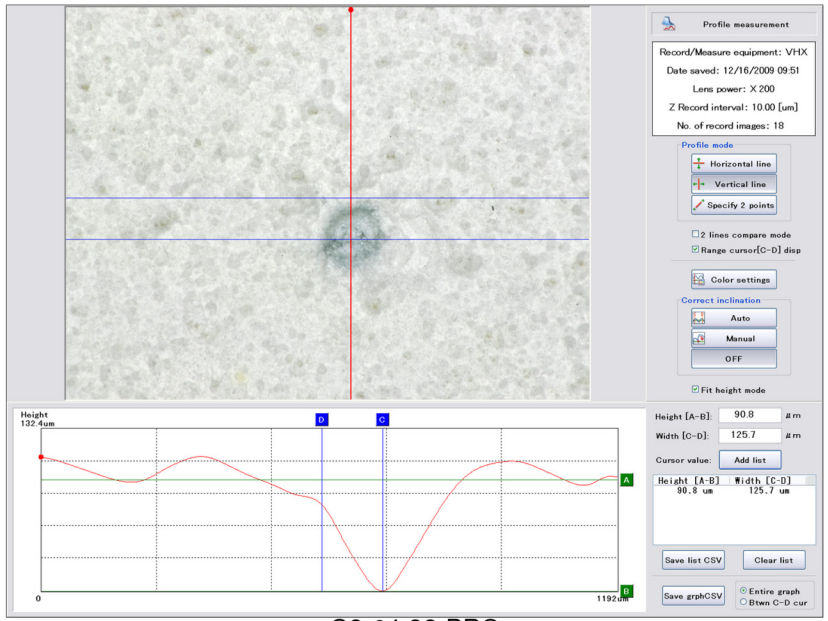
Q2-66-92-PRO



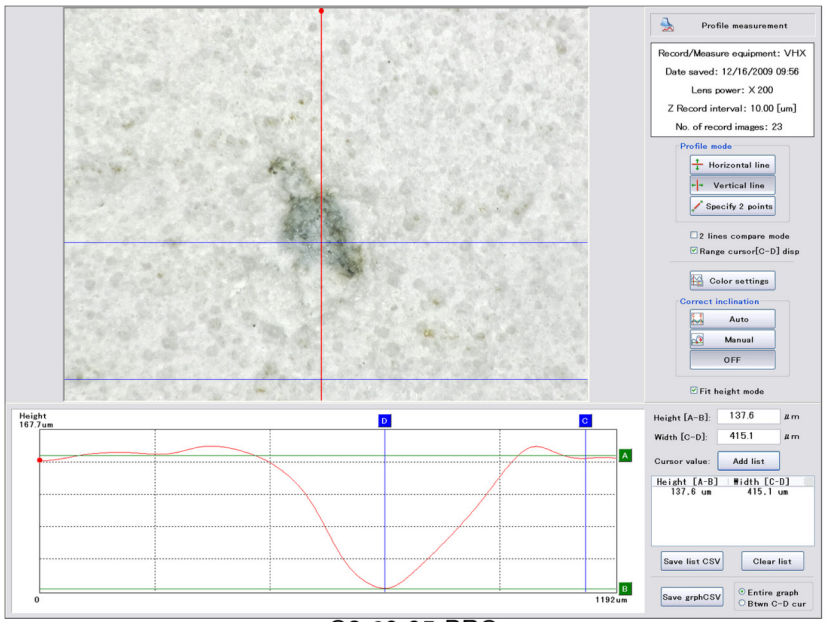
Q2-82-87-PRO



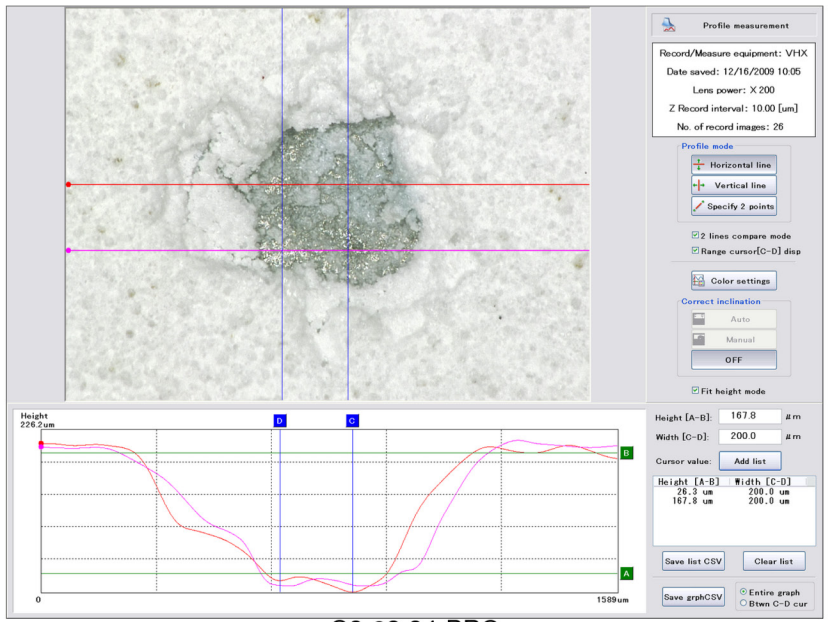
Q2-84-52-PRO



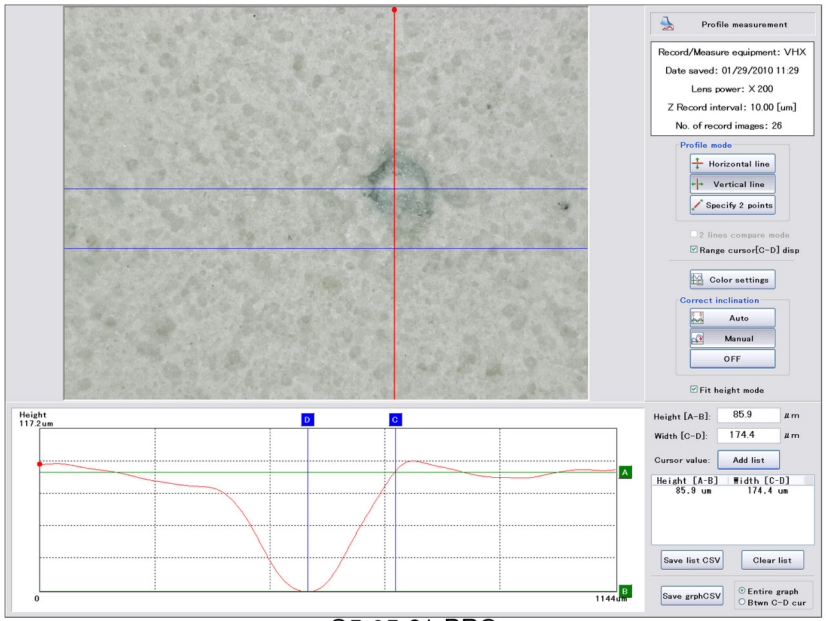
Q3-64-32-PRO



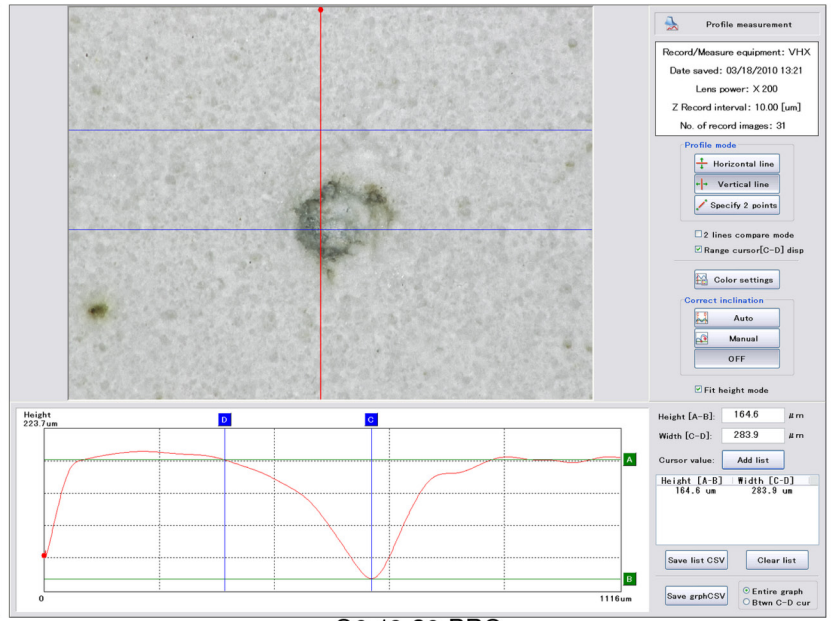
Q3-69-95-PRO



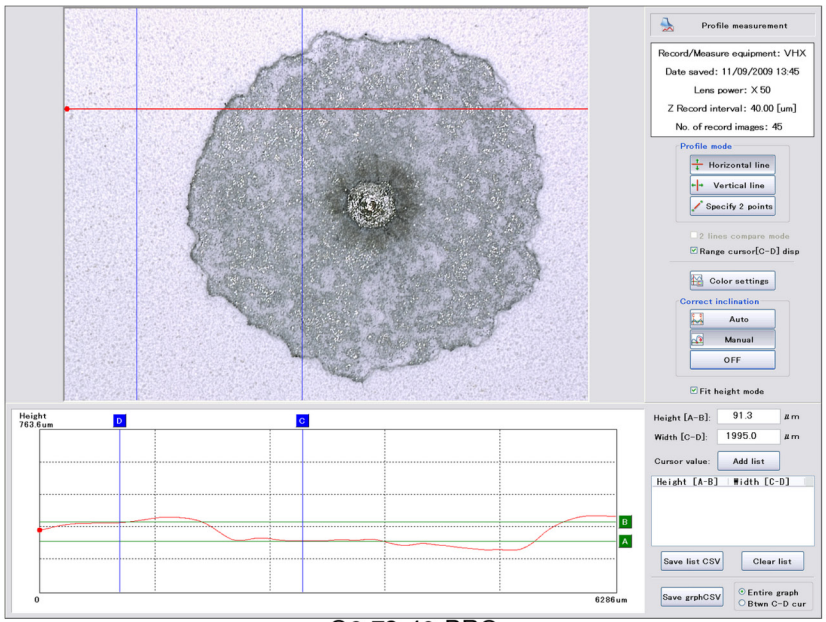
Q3-82-34-PRO



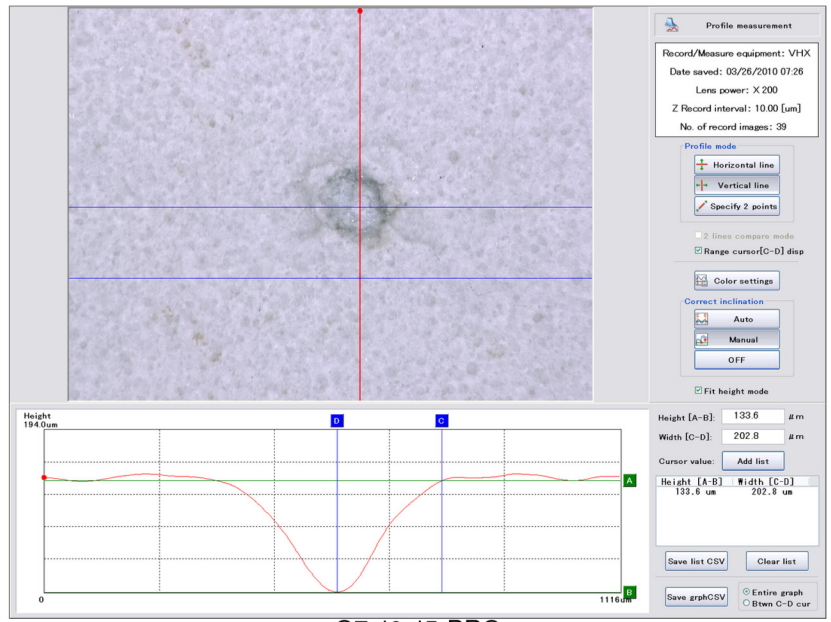
Q5-05-91-PRO



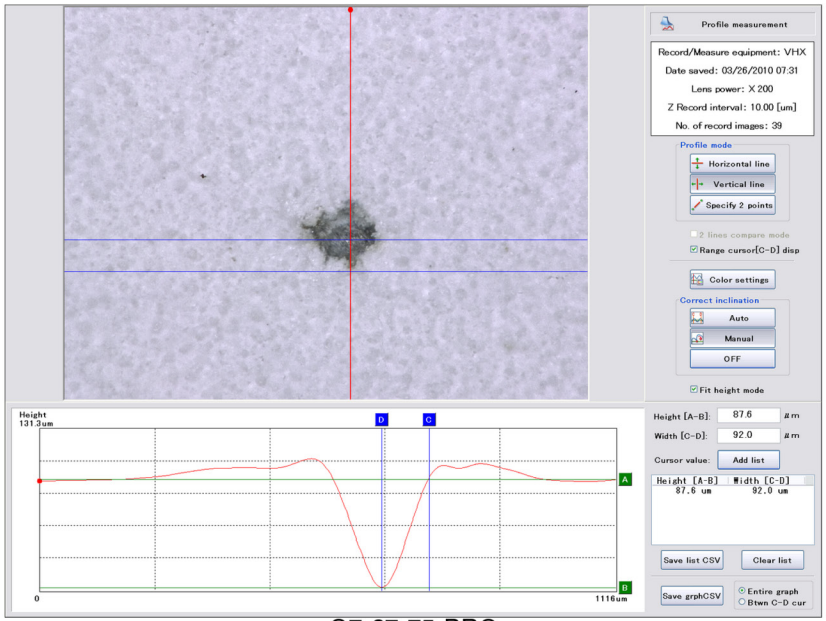
Q6-18-26-PRO



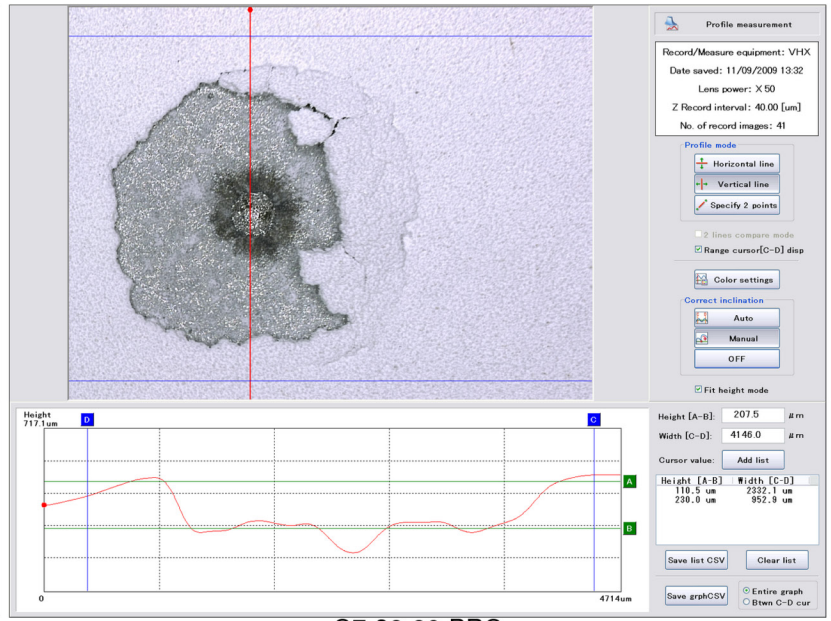
Q6-73-40-PRO



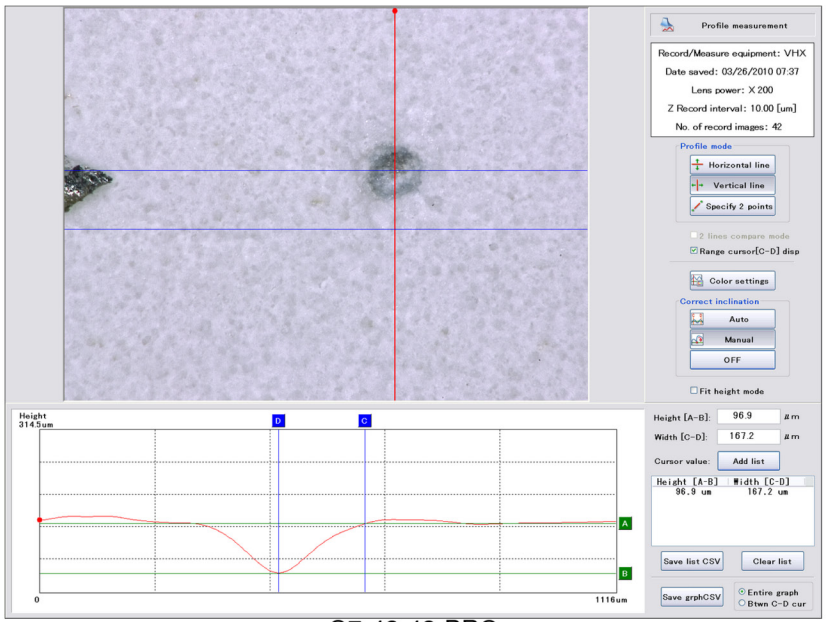
Q7-10-15-PRO



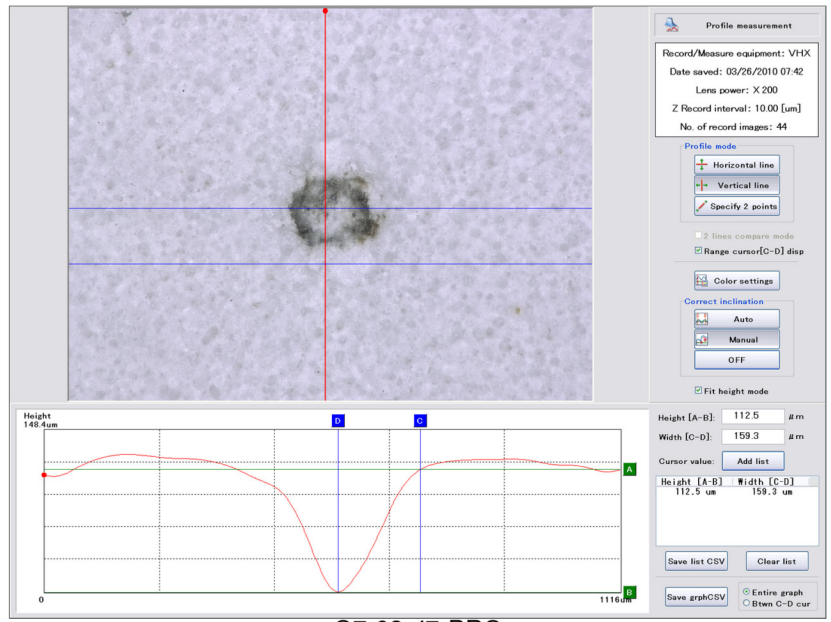
Q7-27-75-PRO



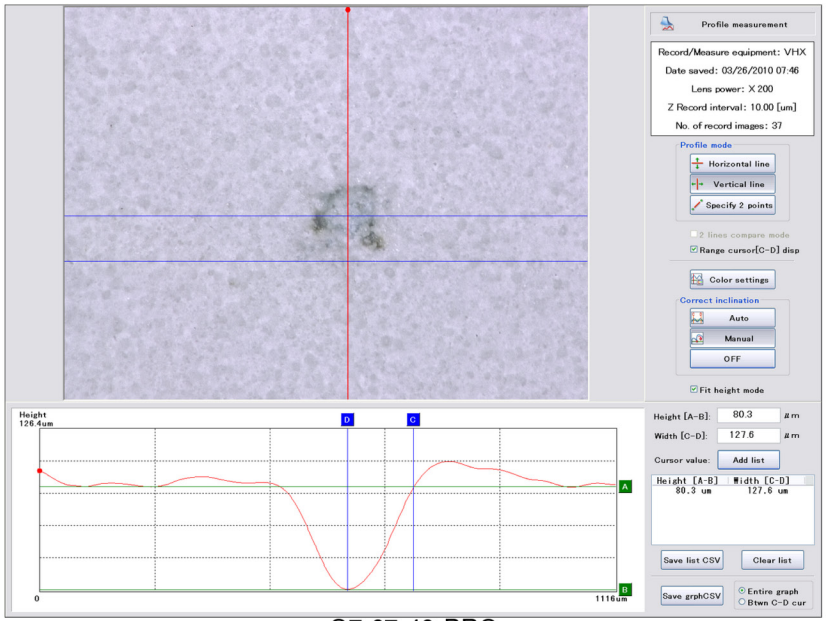
Q7-38-86-PRO



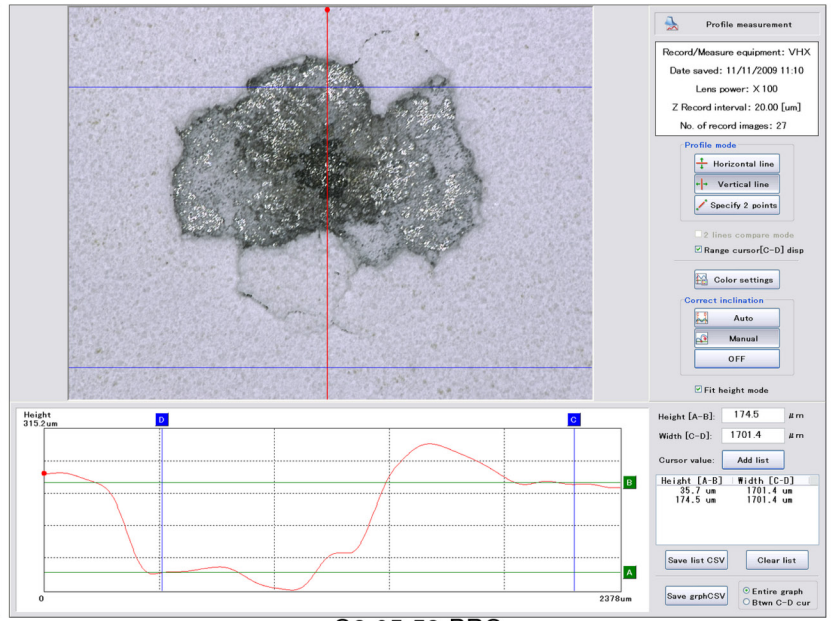
Q7-42-42-PRO



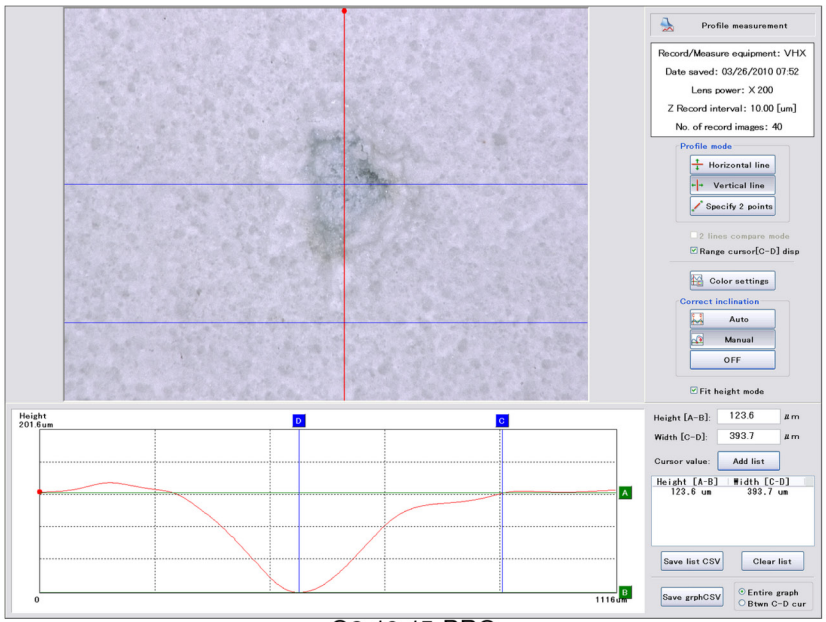
Q7-93-47-PRO



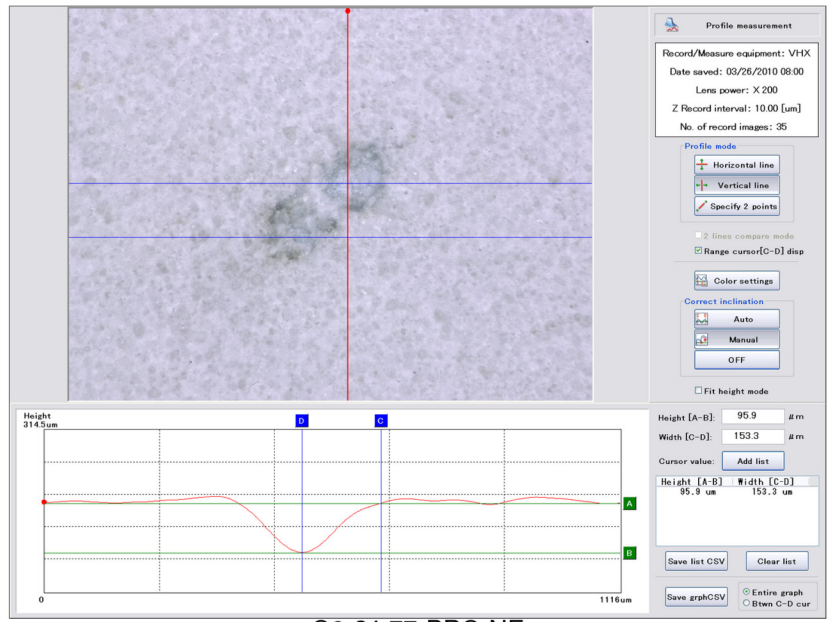
Q7-97-49-PRO



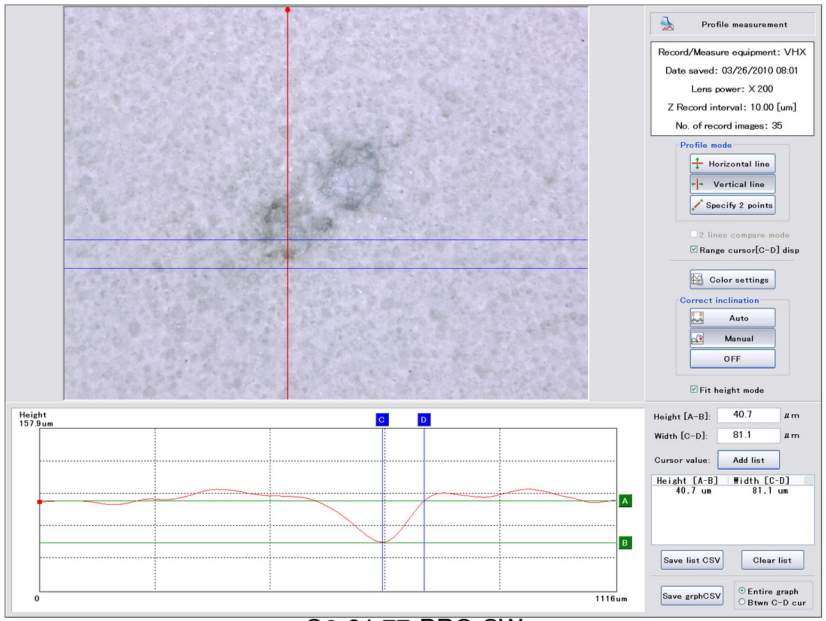
Q8-05-58-PRO



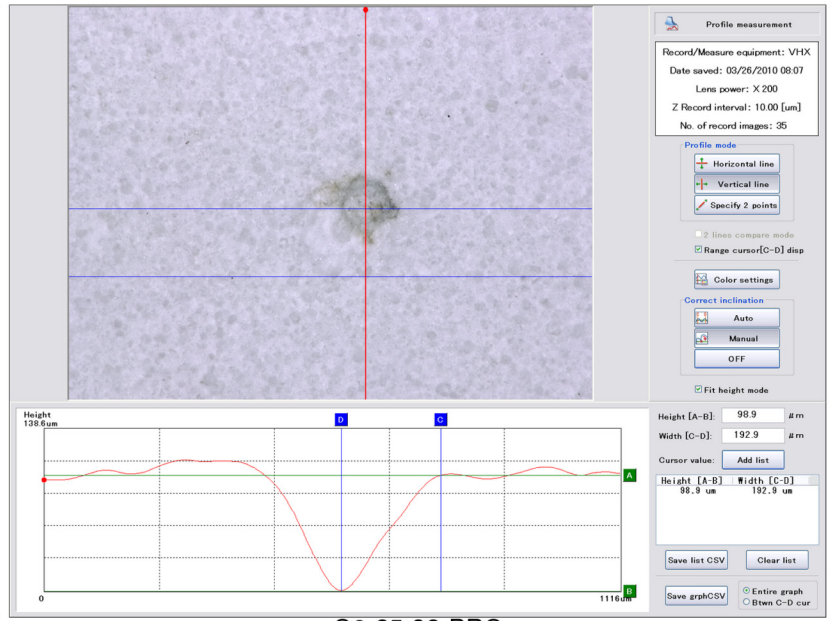
Q8-16-15-PRO



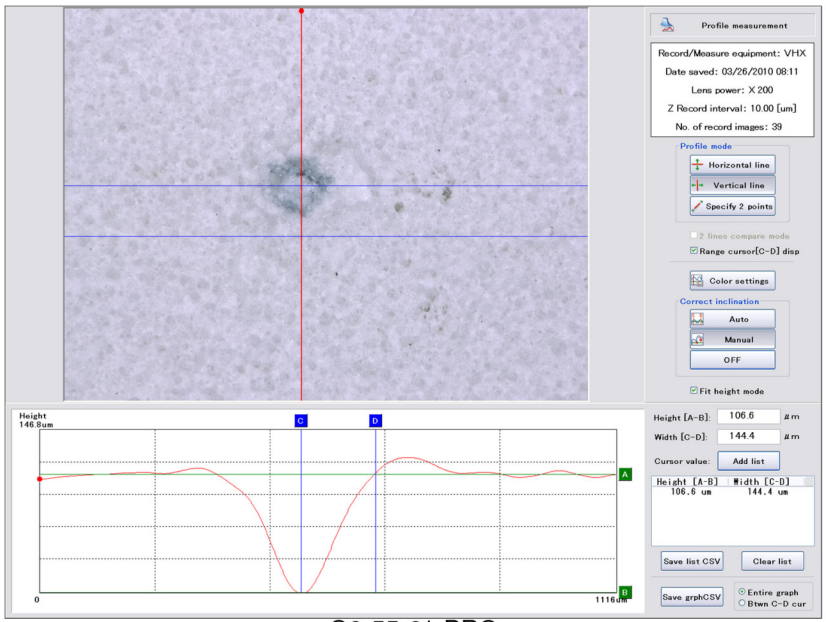
Q8-24-77-PRO-NE



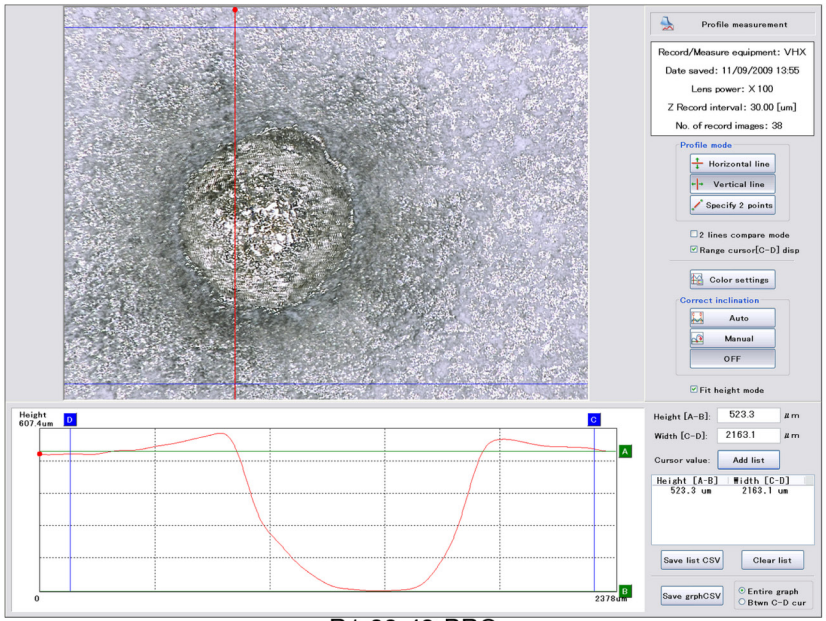
Q8-24-77-PRO-SW



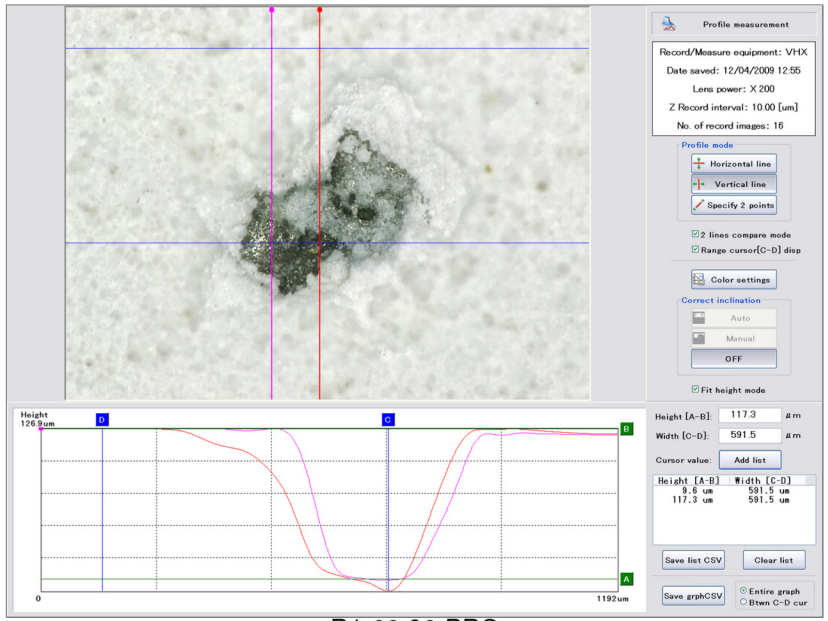
Q8-25-32-PRO



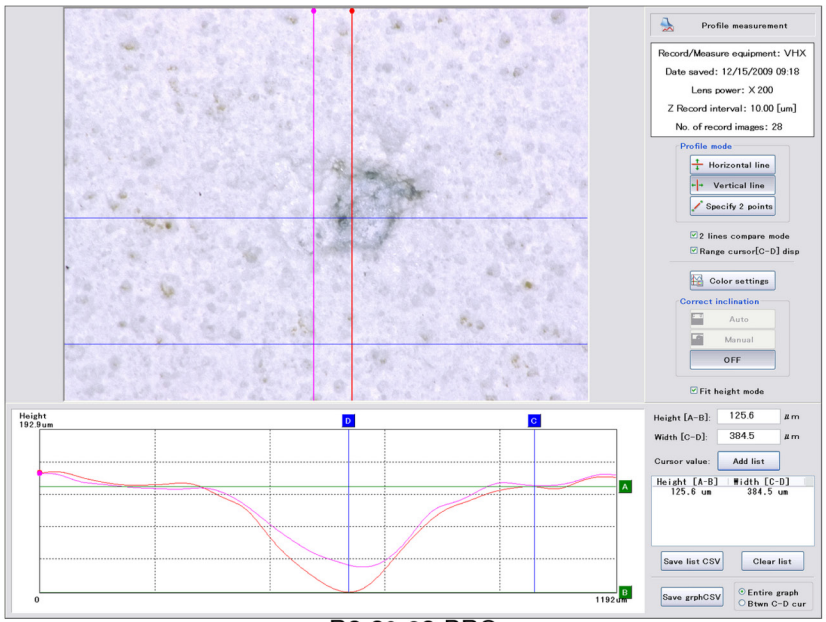
Q8-55-61-PRO



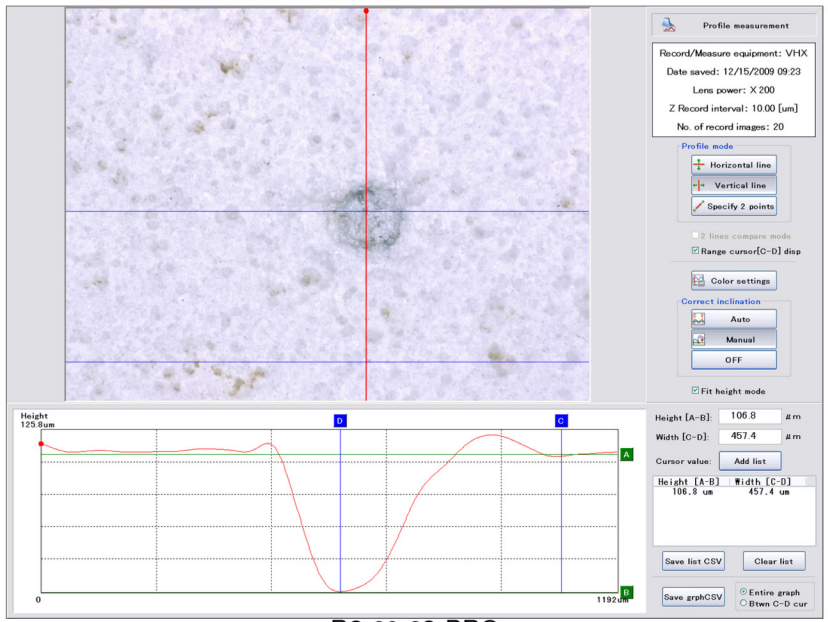
R1-33-43-PRO



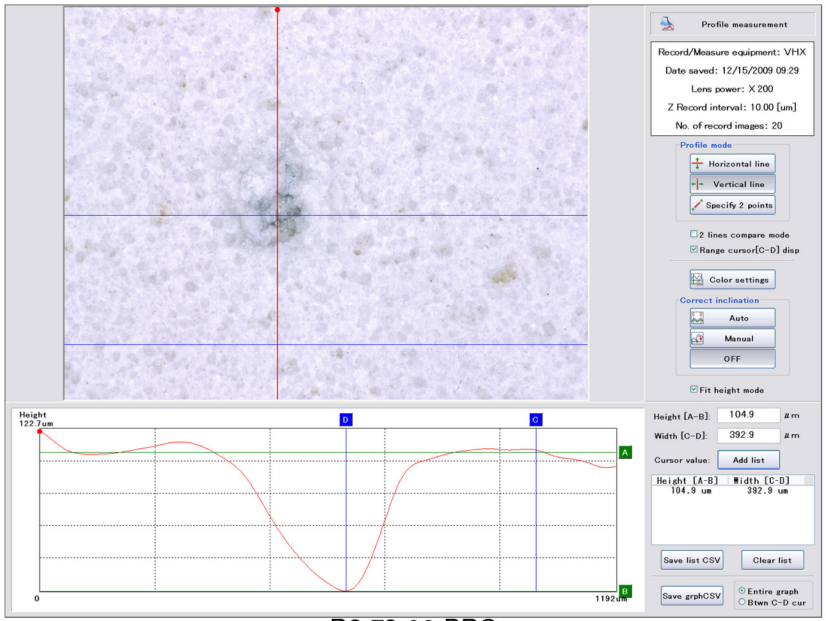
R1-66-96-PRO



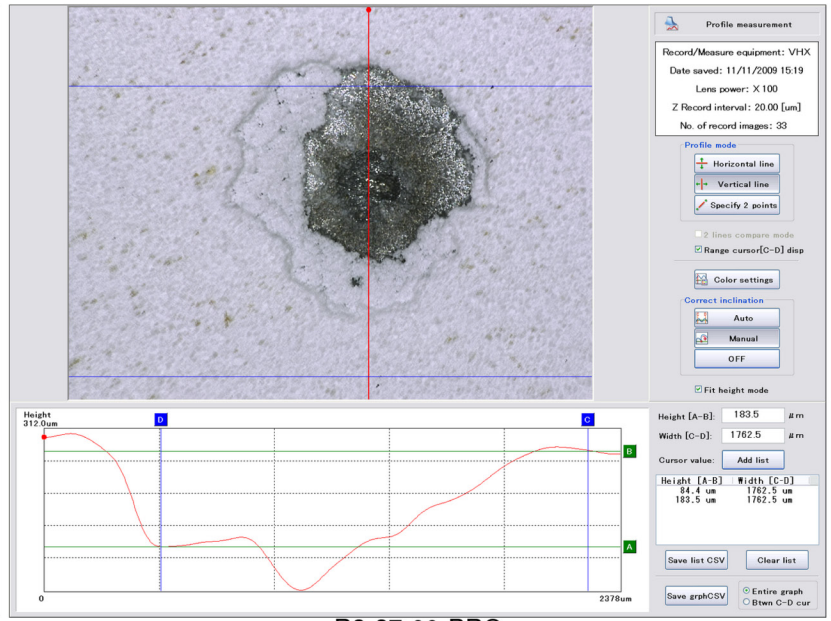
R2-20-82-PRO



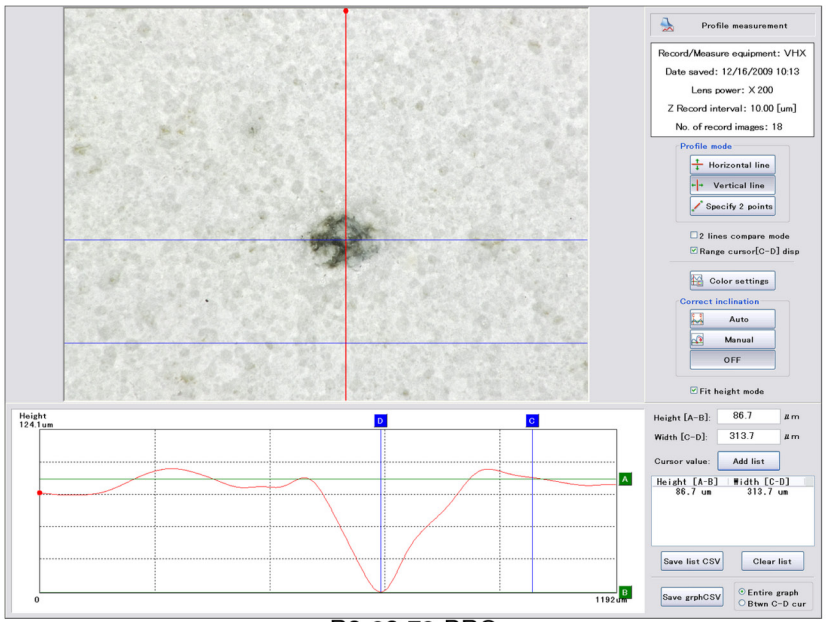
R2-60-83-PRO



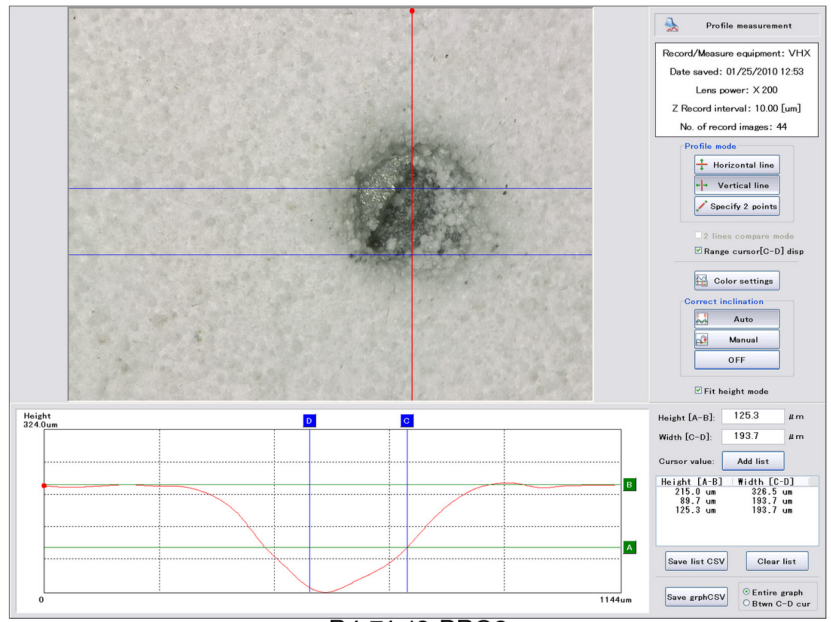
R2-73-06-PRO



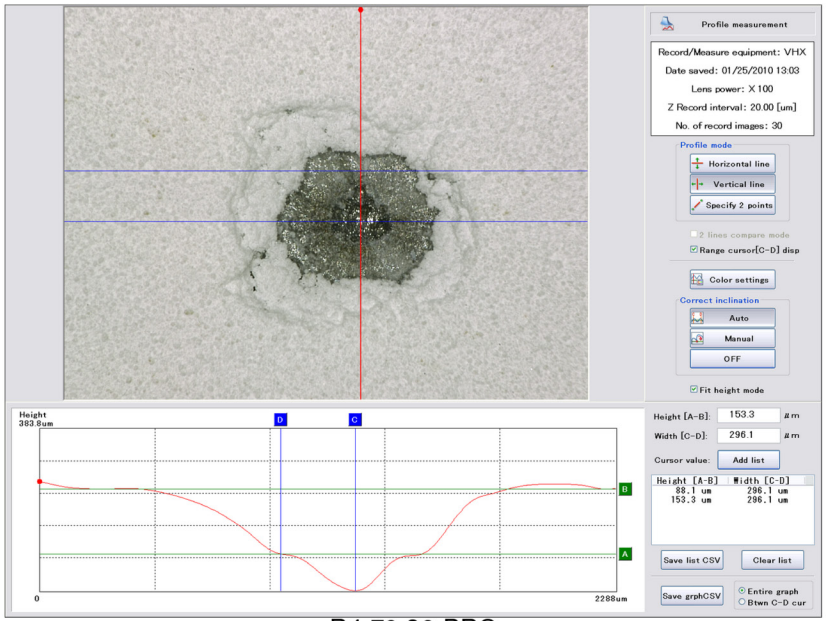
R3-37-00-PRO



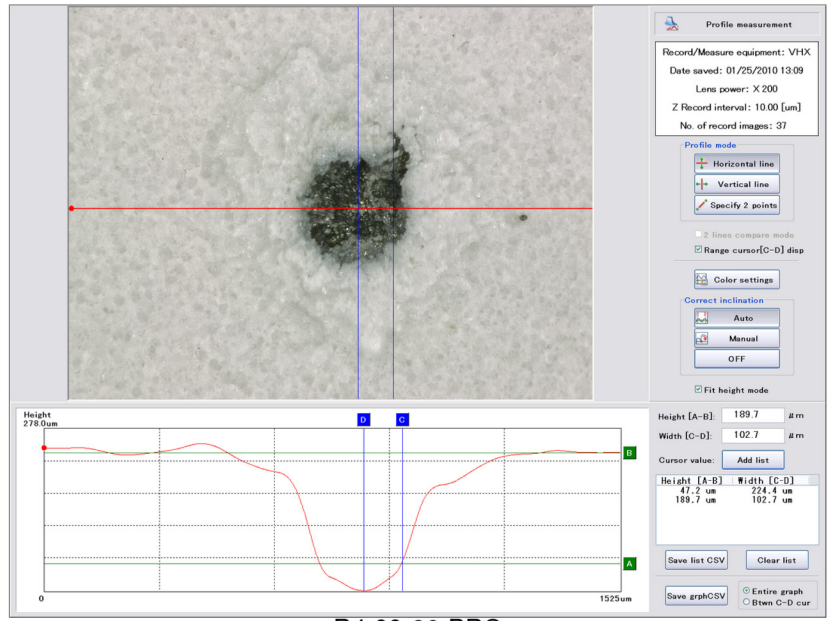
R3-82-78-PRO



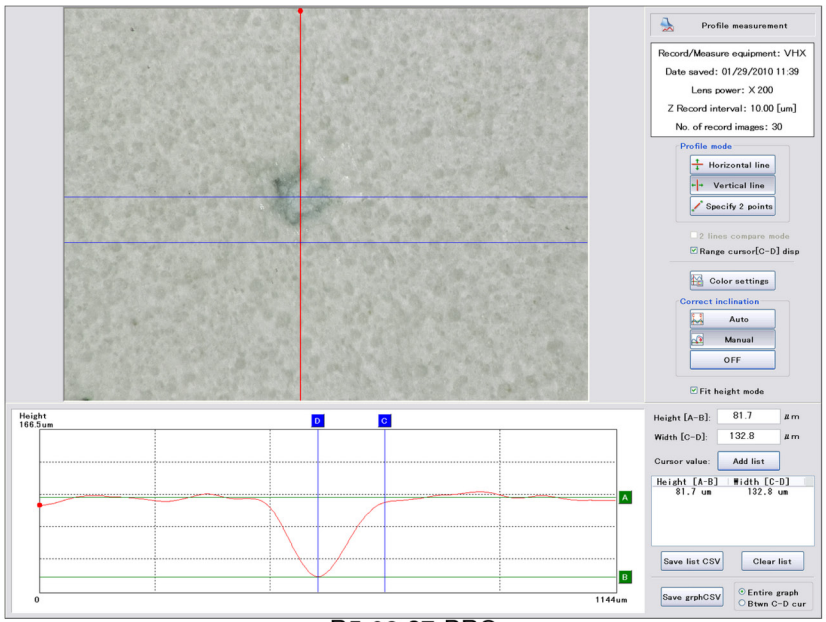
R4-74-13-PRO2



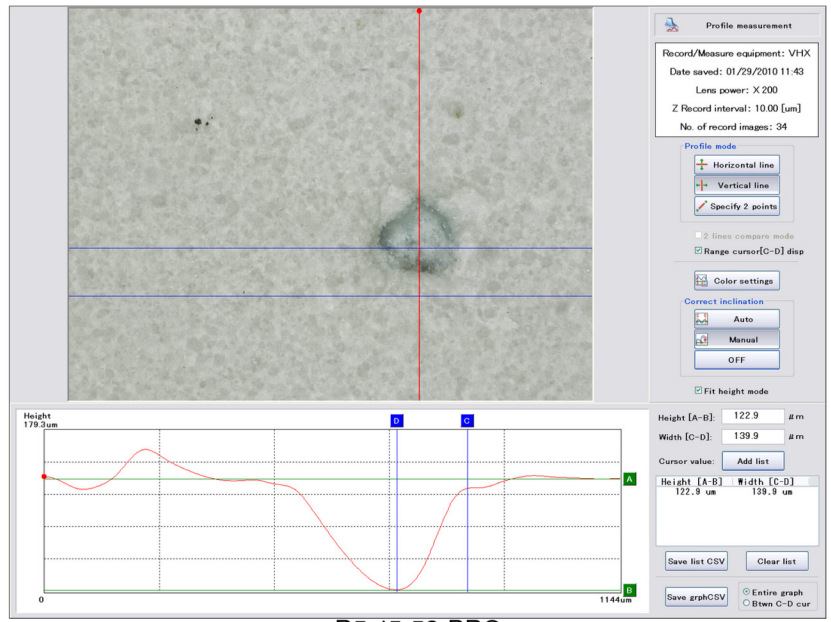
R4-76-36-PRO



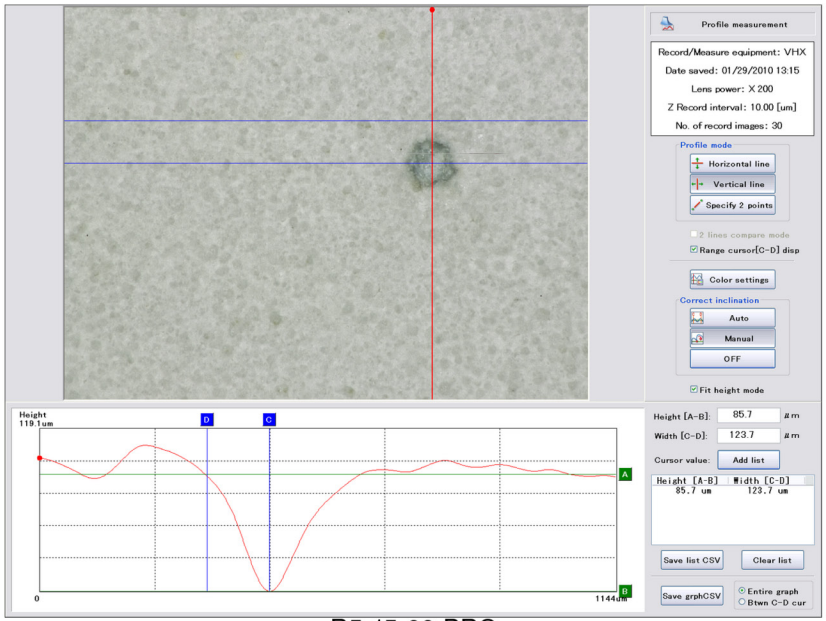
R4-99-86-PRO



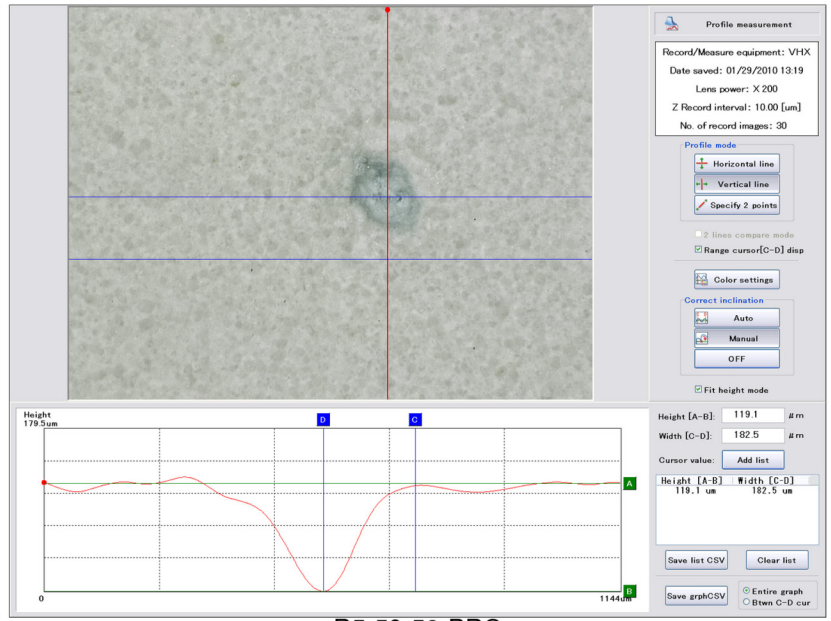
R5-08-37-PRO



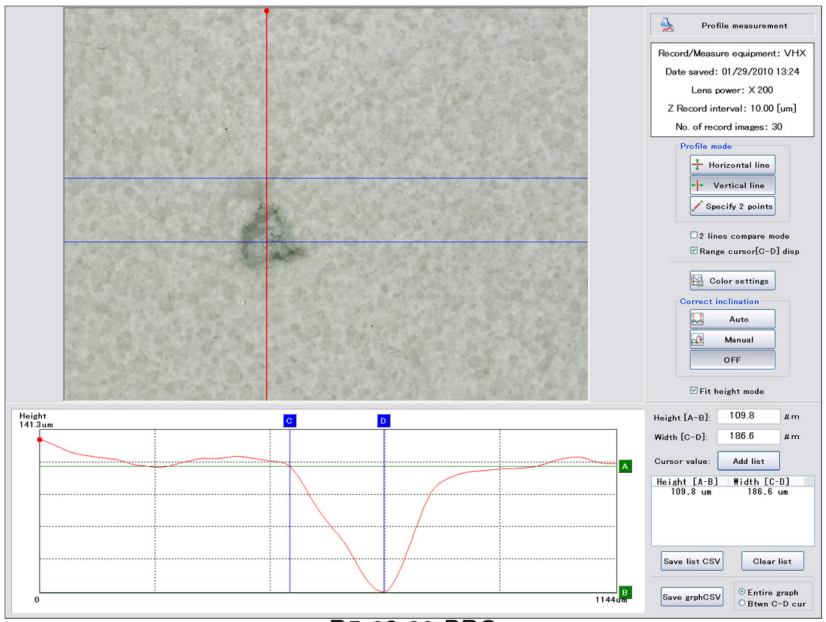
R5-15-52-PRO



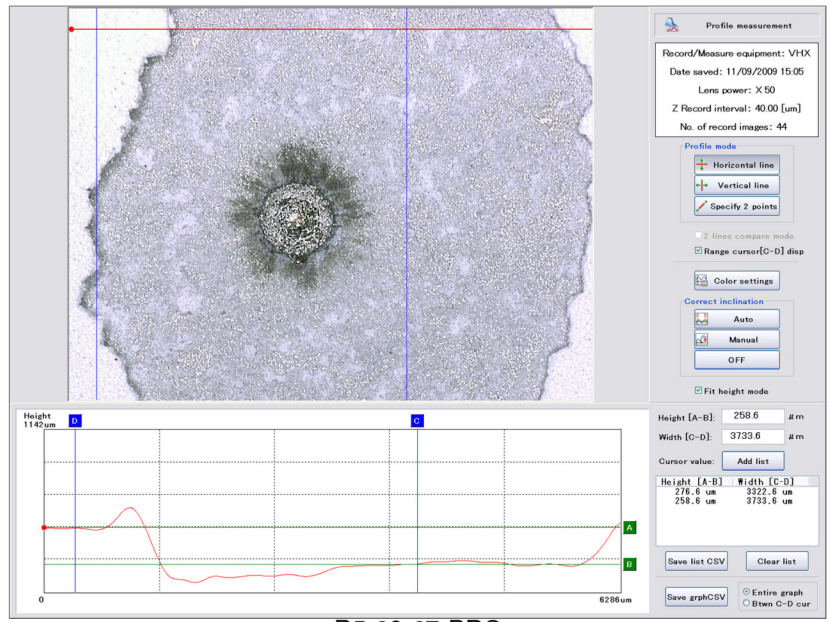
R5-15-66-PRO



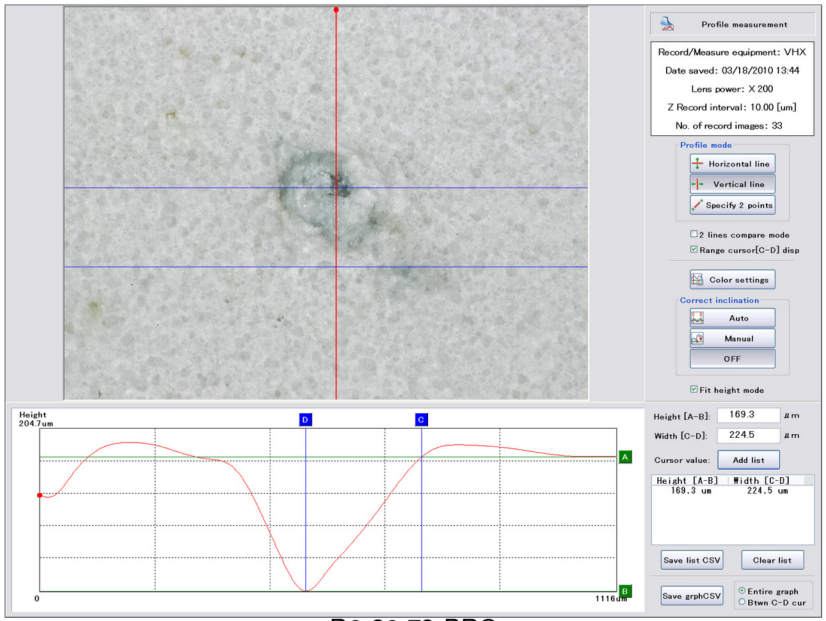
R5-59-58-PRO



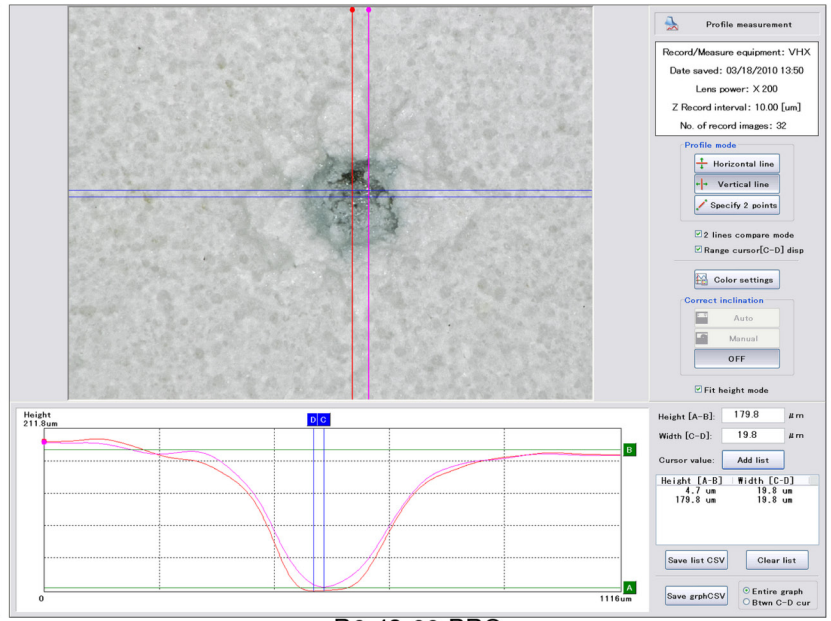
R5-62-80-PRO



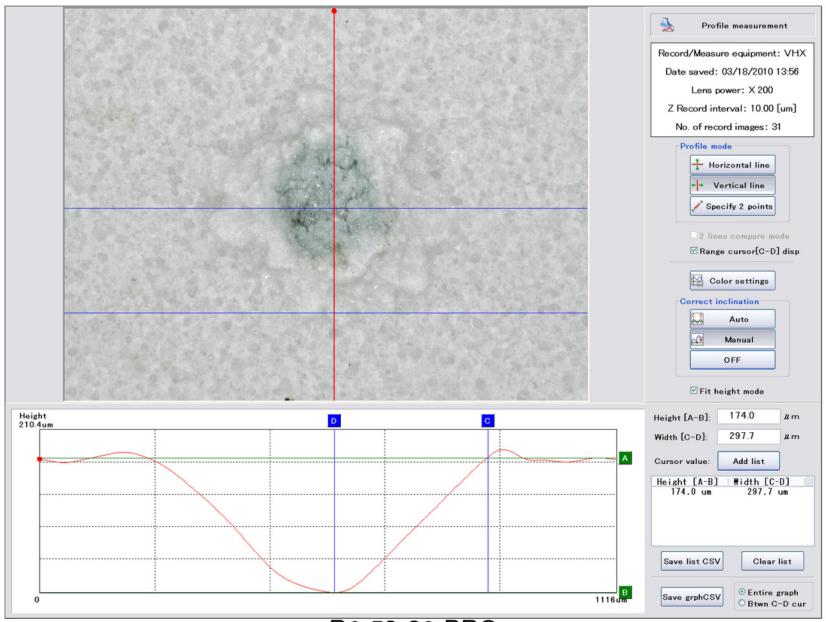
R5-89-67-PRO



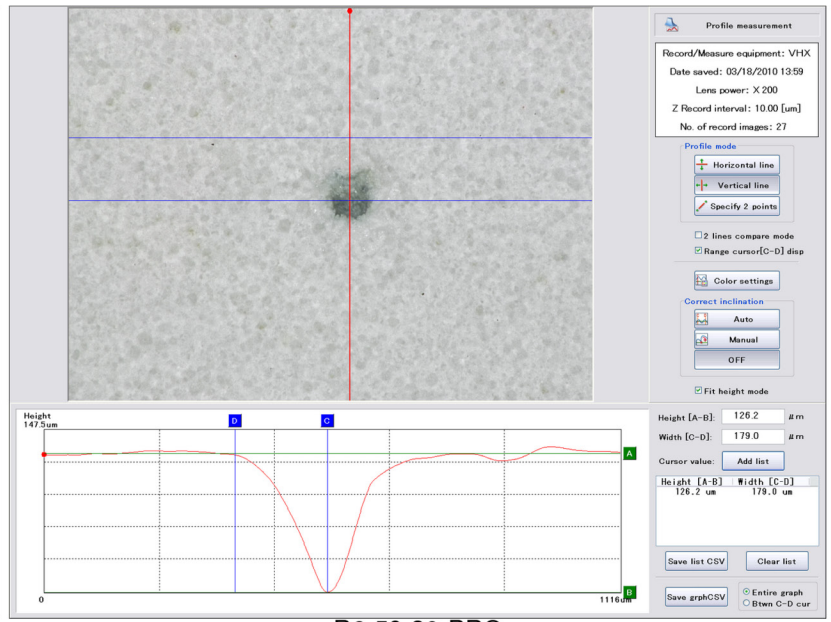
R6-26-73-PRO



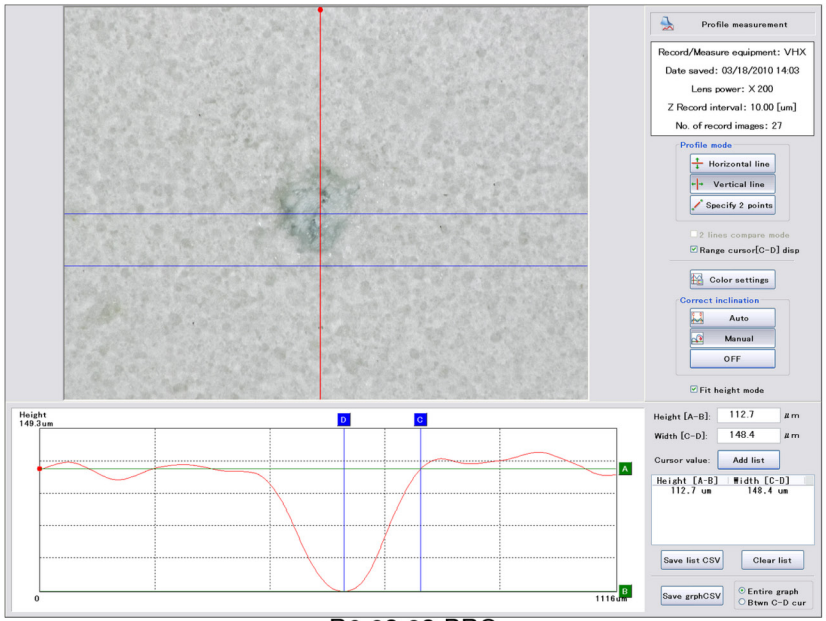
R6-43-66-PRO



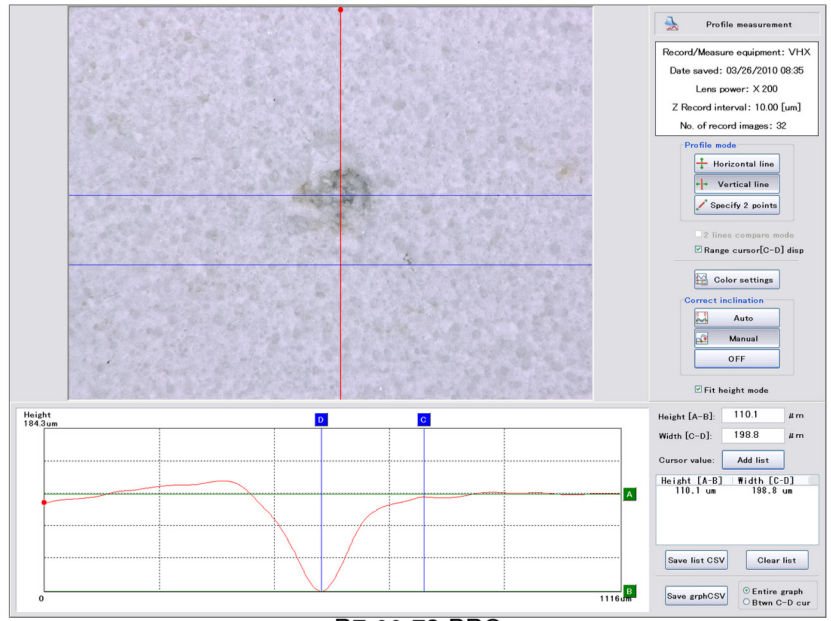
R6-53-26-PRO



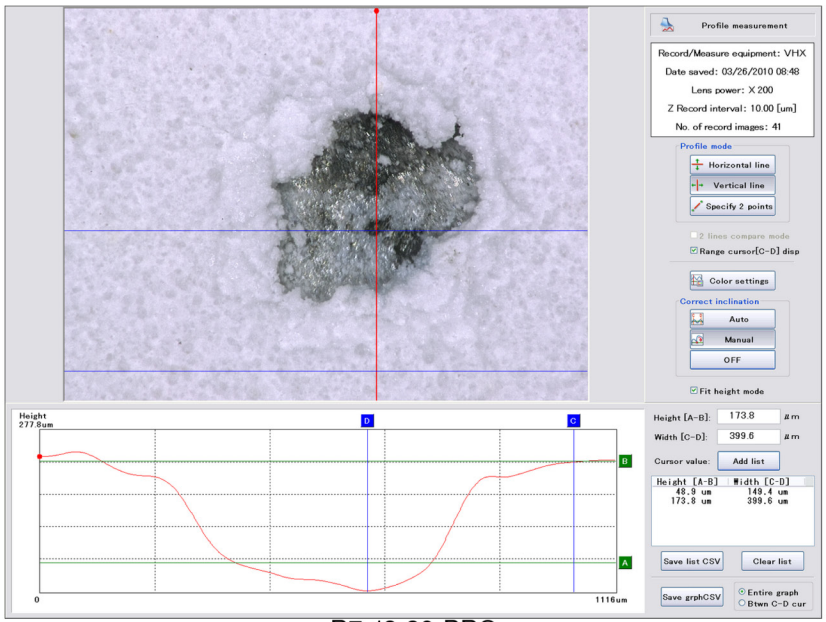
R6-59-30-PRO



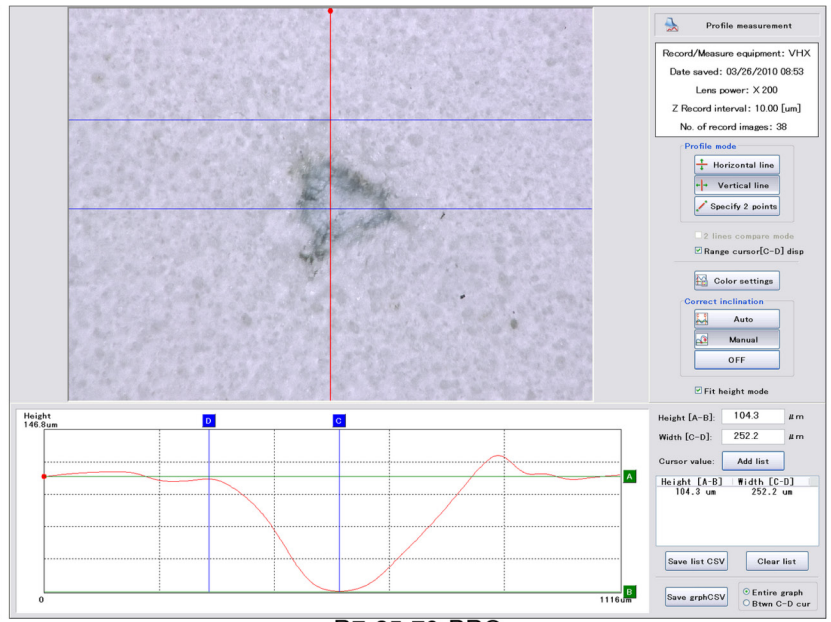
R6-82-82-PRO



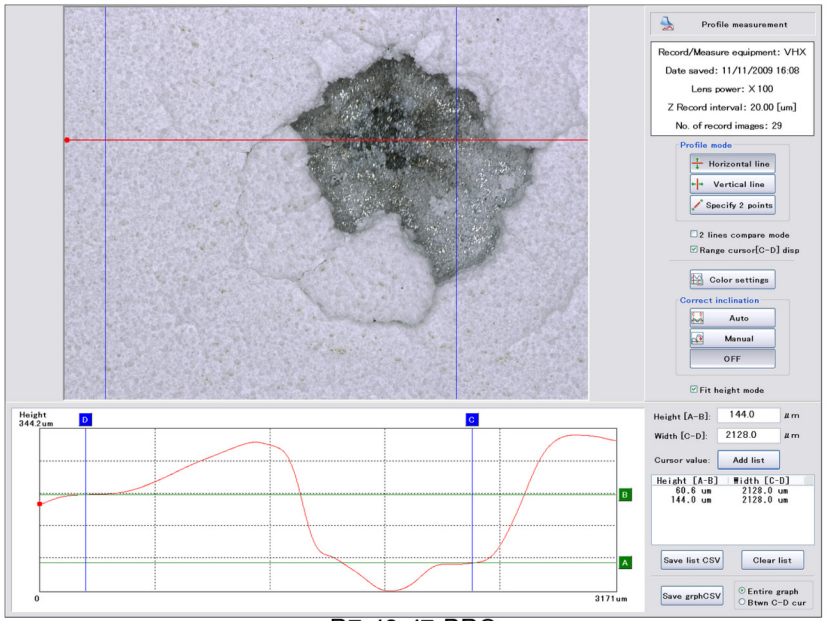
R7-00-72-PRO



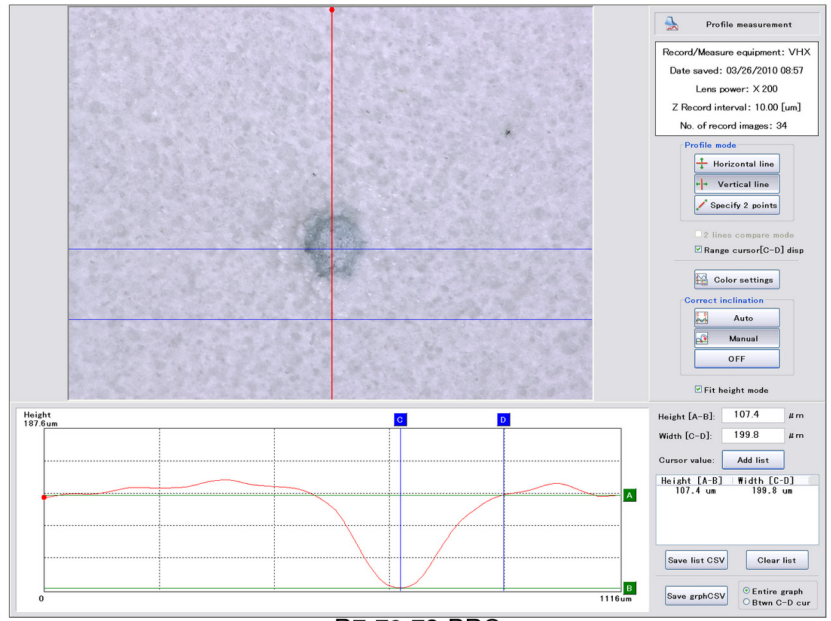
R7-13-39-PRO



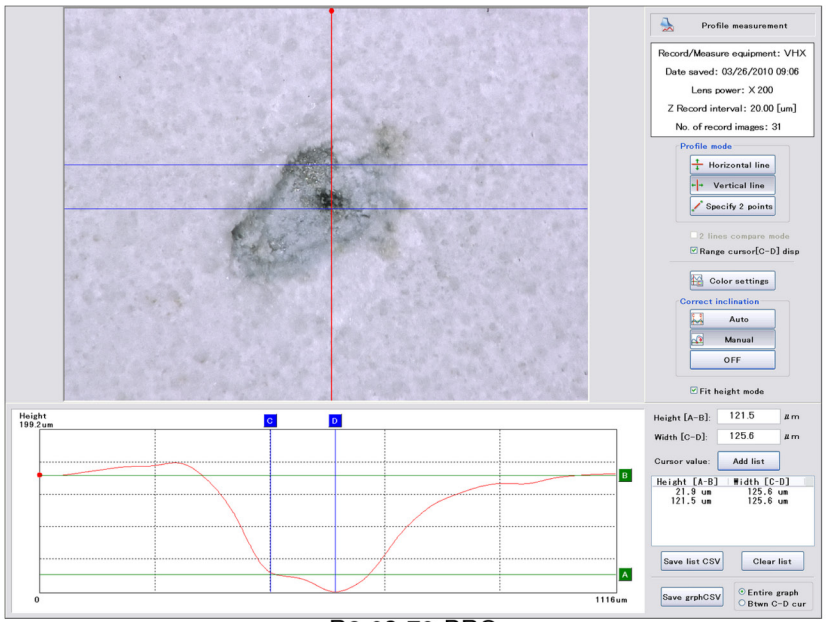
R7-25-79-PRO



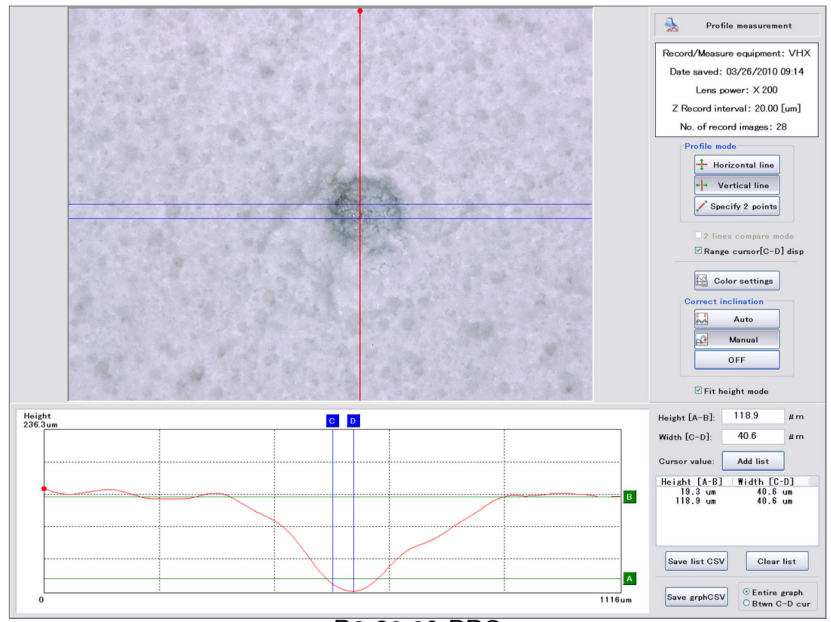
R7-43-47-PRO



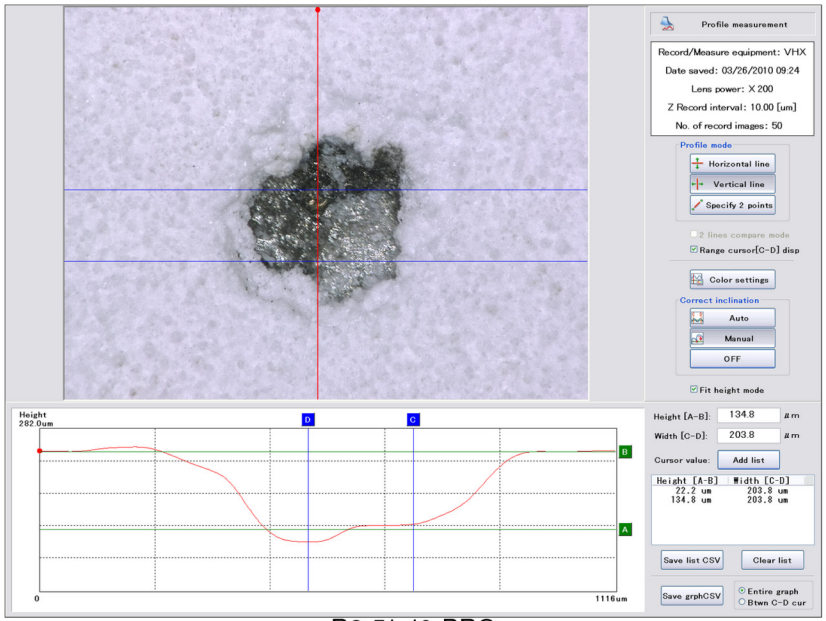
R7-78-72-PRO



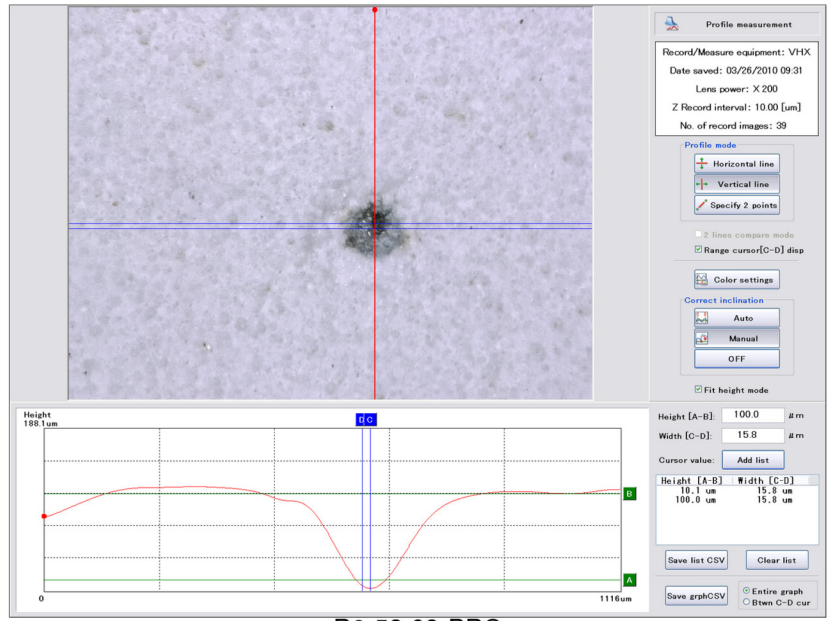
R8-03-70-PRO



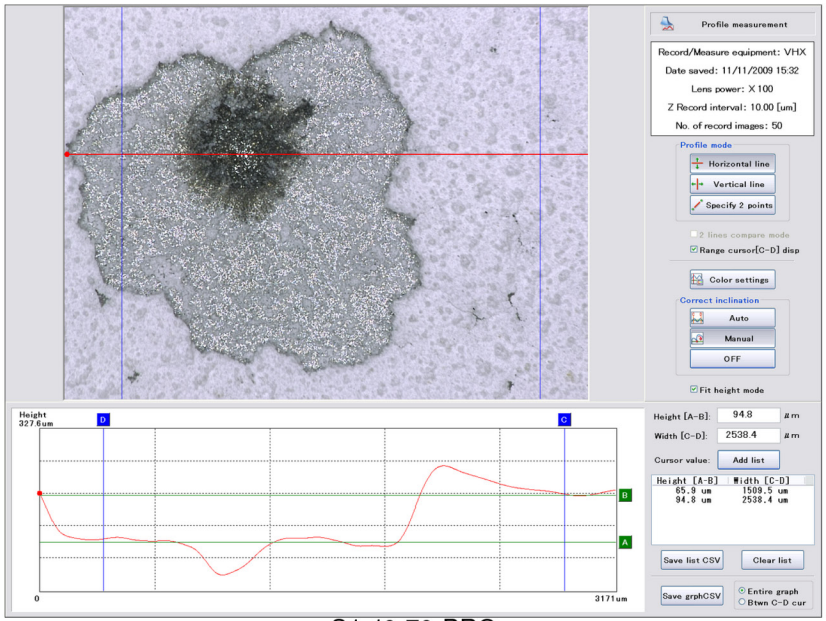
R8-26-89-PRO



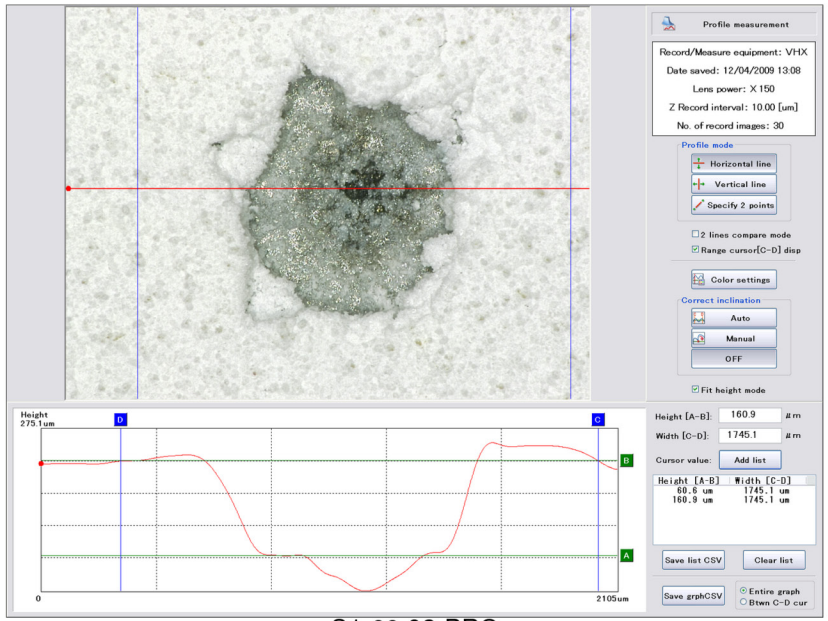
R8-51-10-PRO



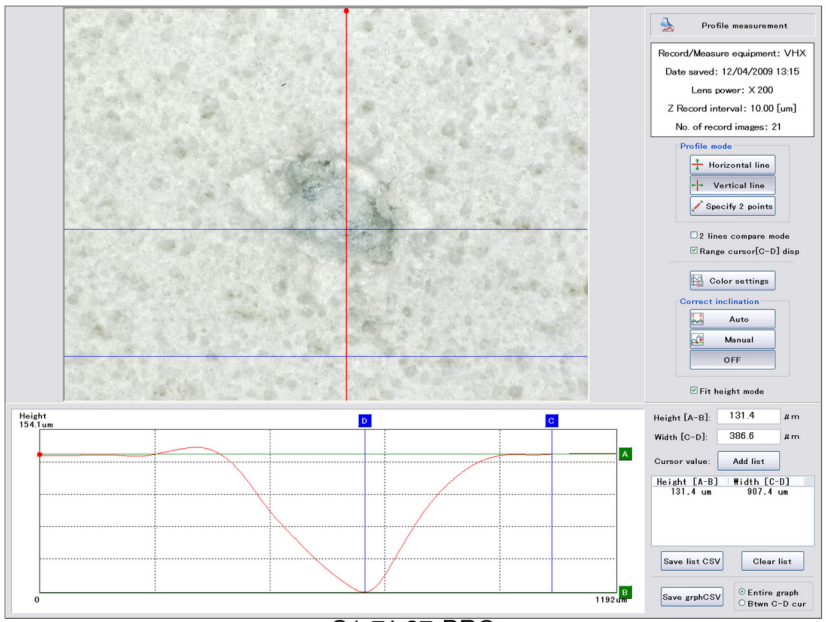
R8-52-93-PRO



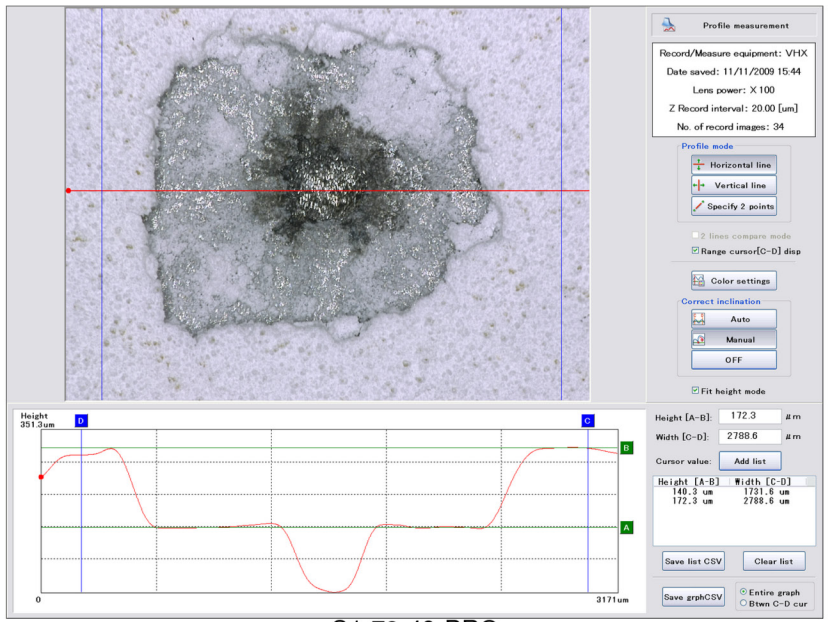
S1-10-70-PRO



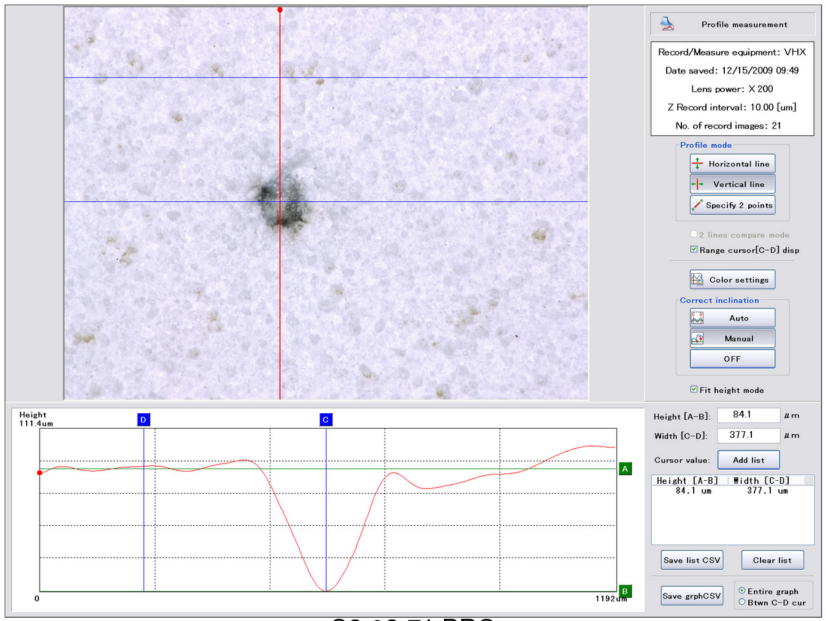
S1-66-92-PRO



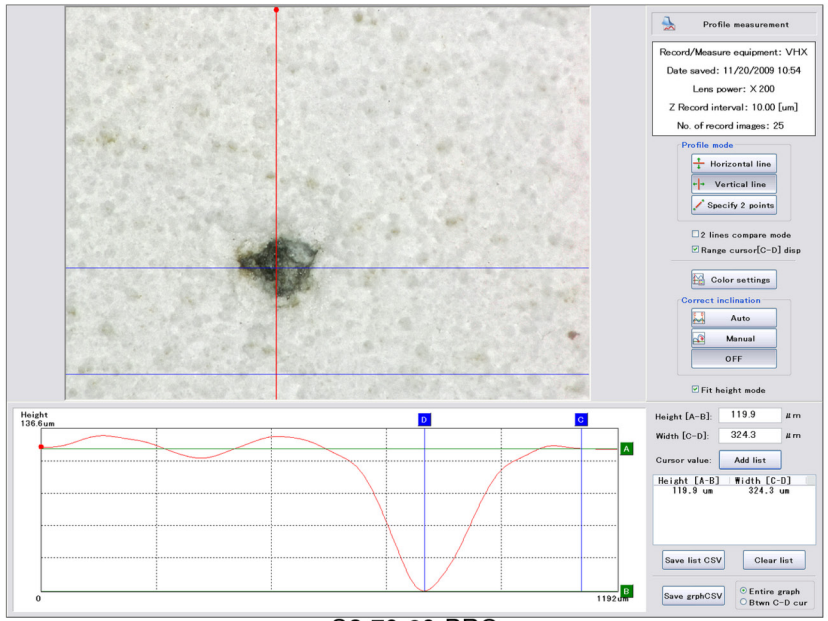
S1-74-37-PRO



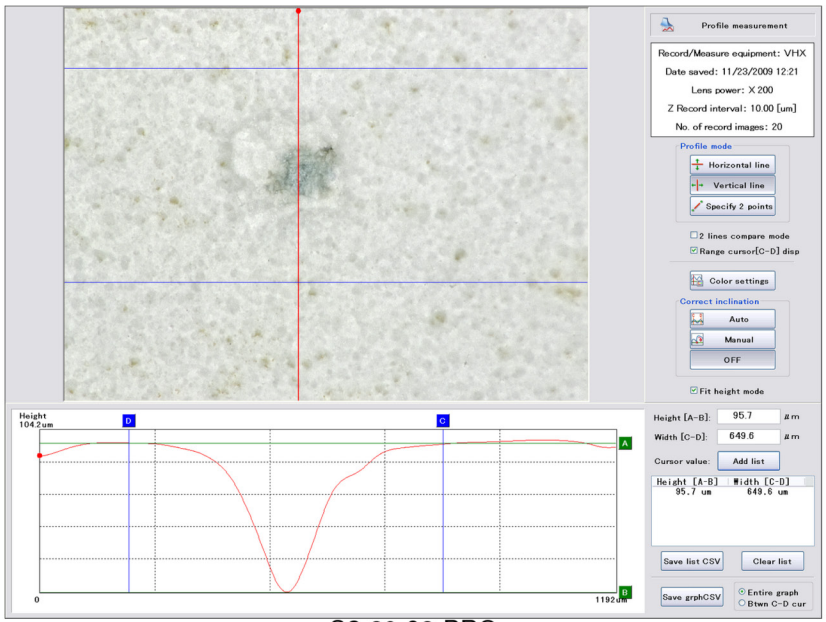
S1-78-49-PRO



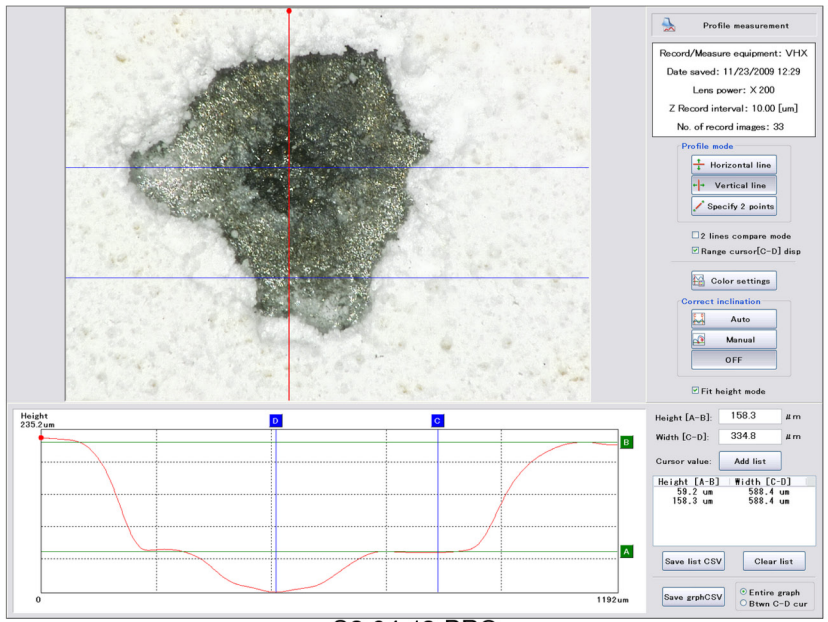
S2-02-74-PRO



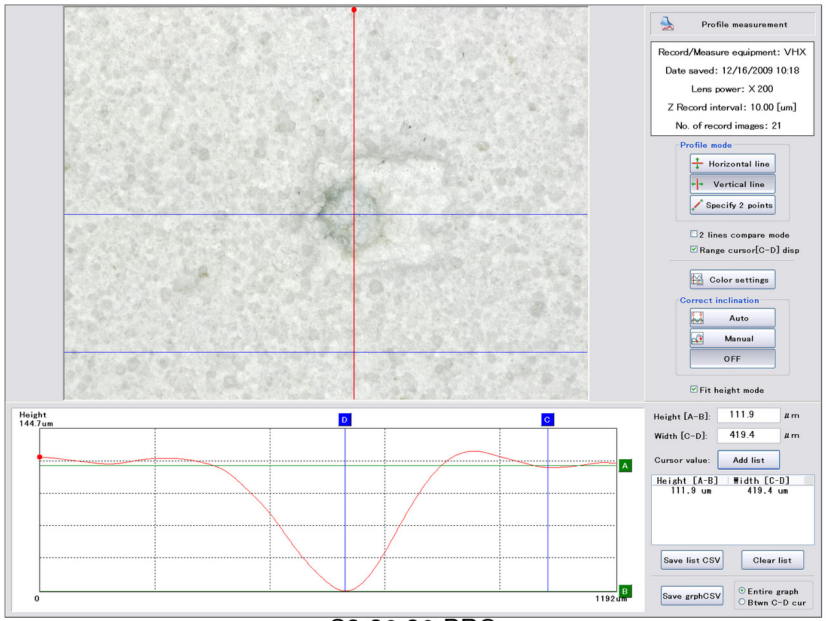
S2-79-89-PRO



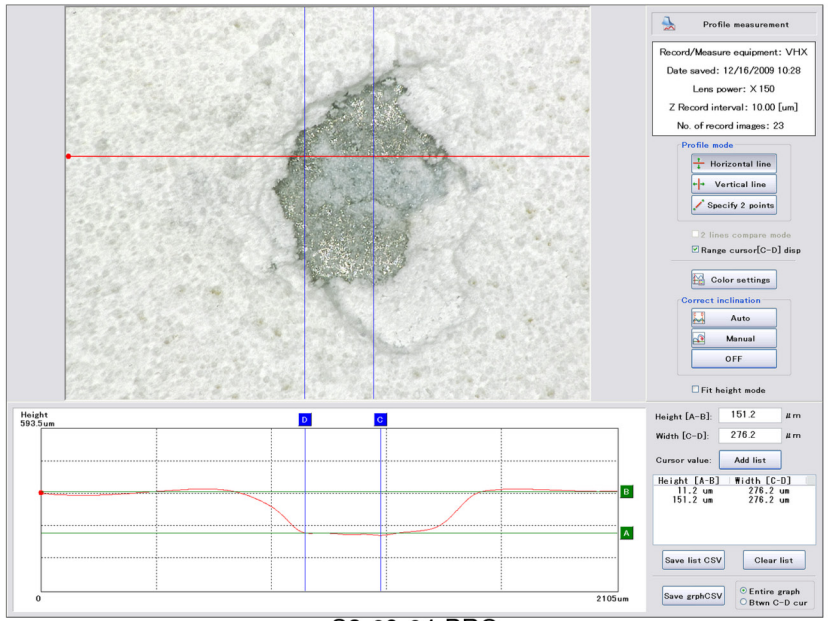
S2-80-98-PRO



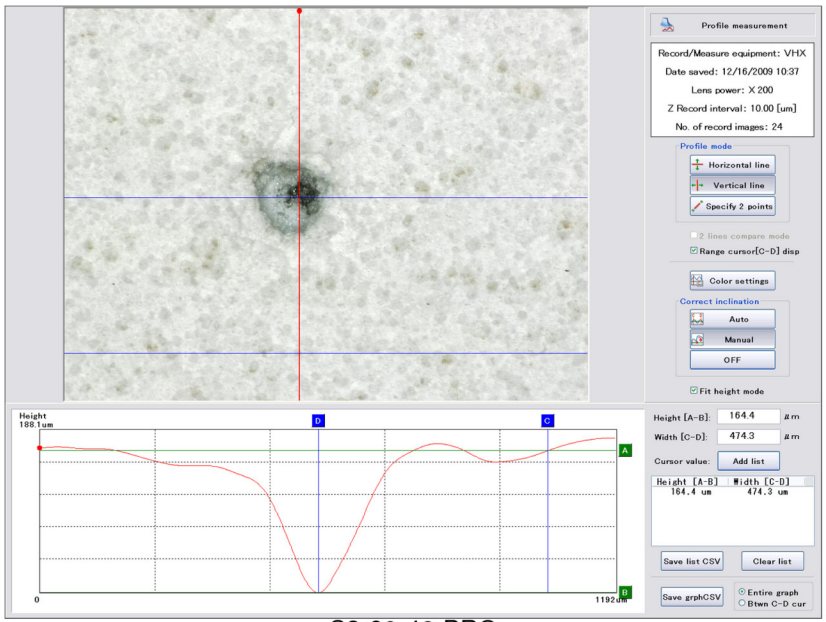
S2-94-12-PRO



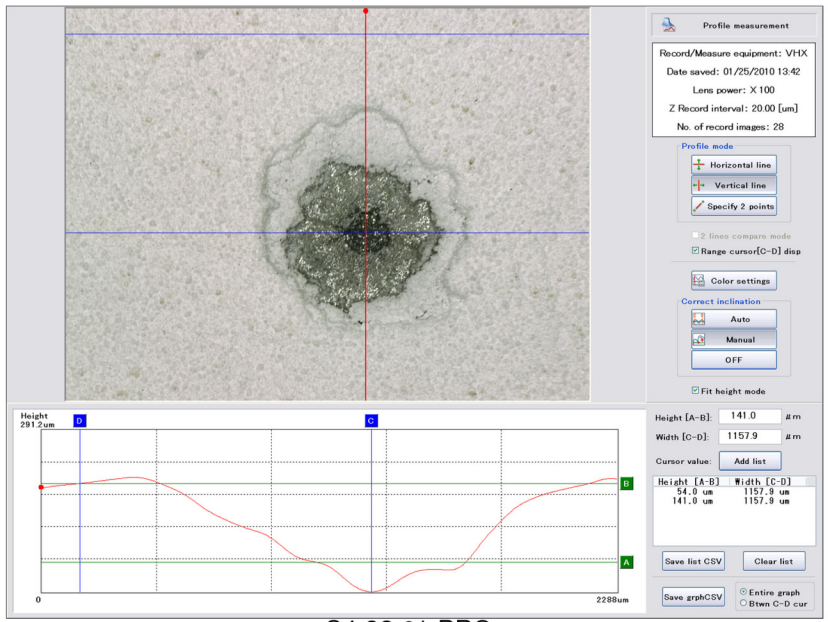
S3-36-36-PRO



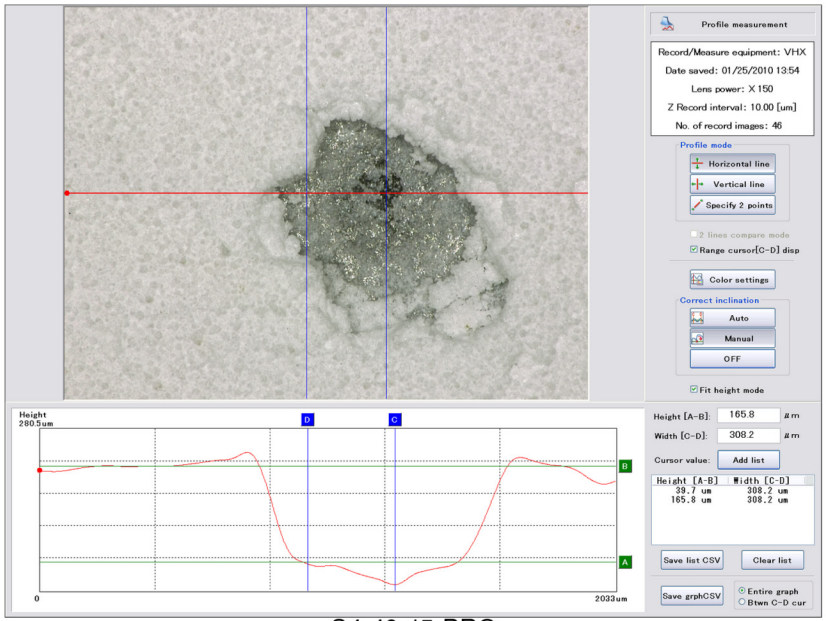
S3-69-64-PRO



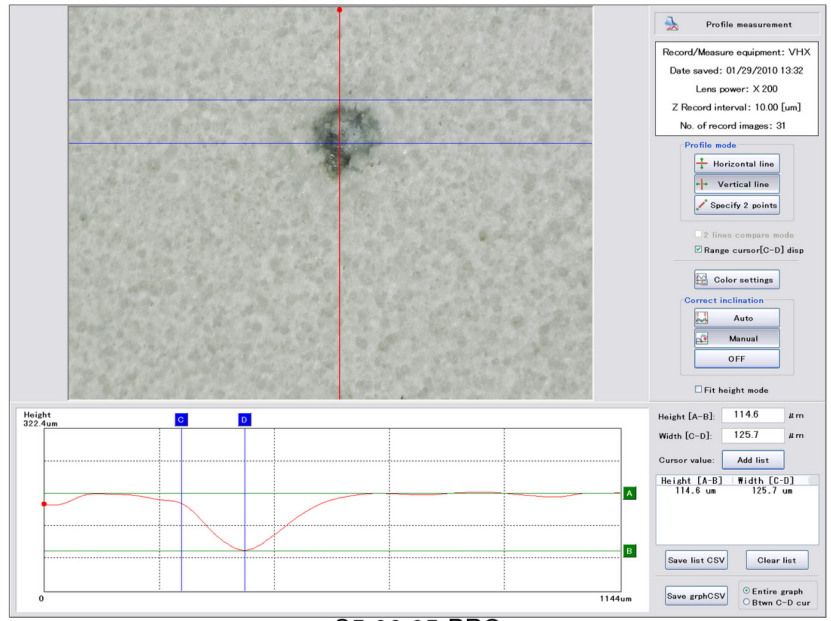
S3-90-46-PRO



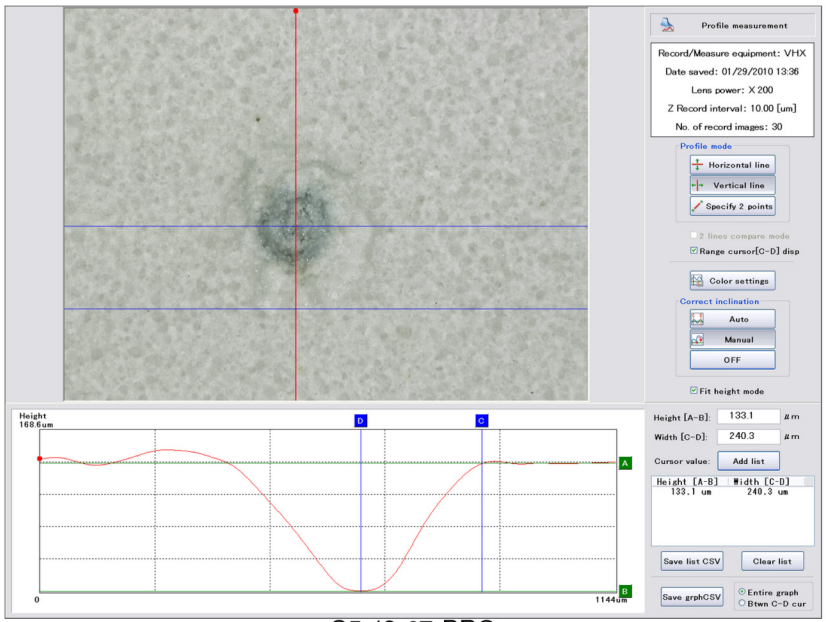
S4-32-01-PROv



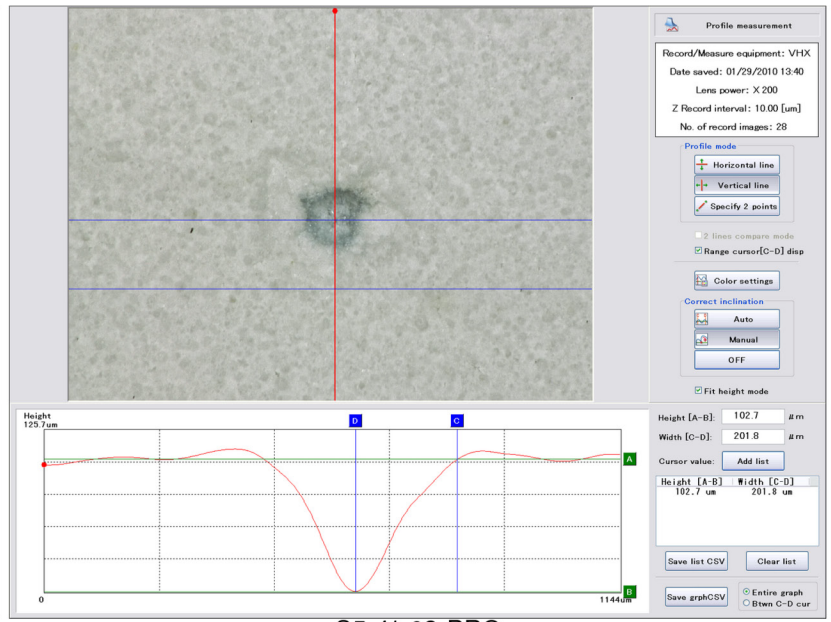
S4-49-15-PRO



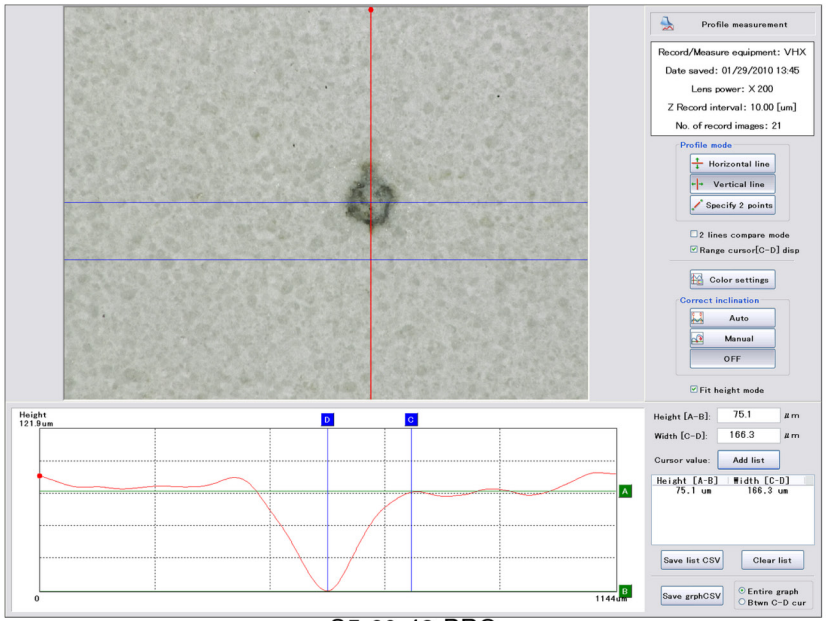
S5-06-05-PRO



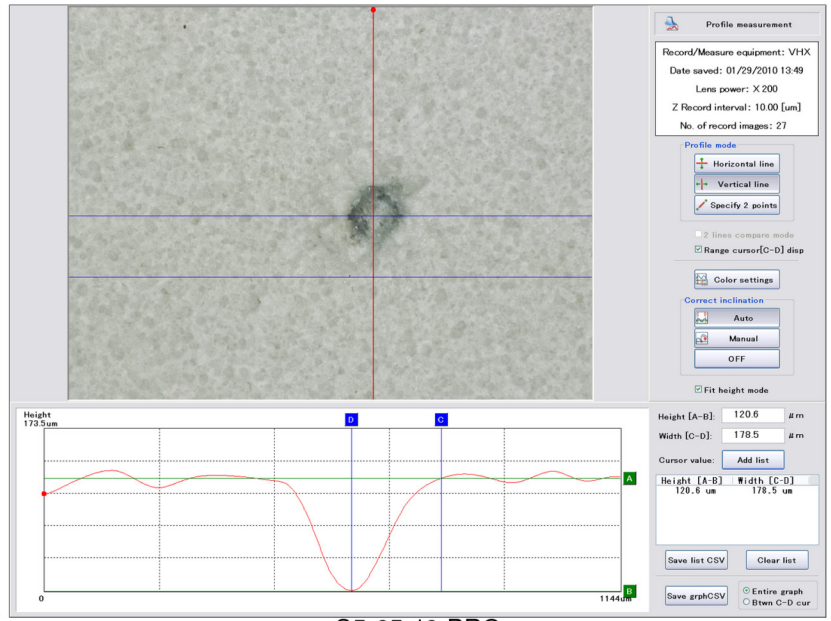
S5-13-67-PRO



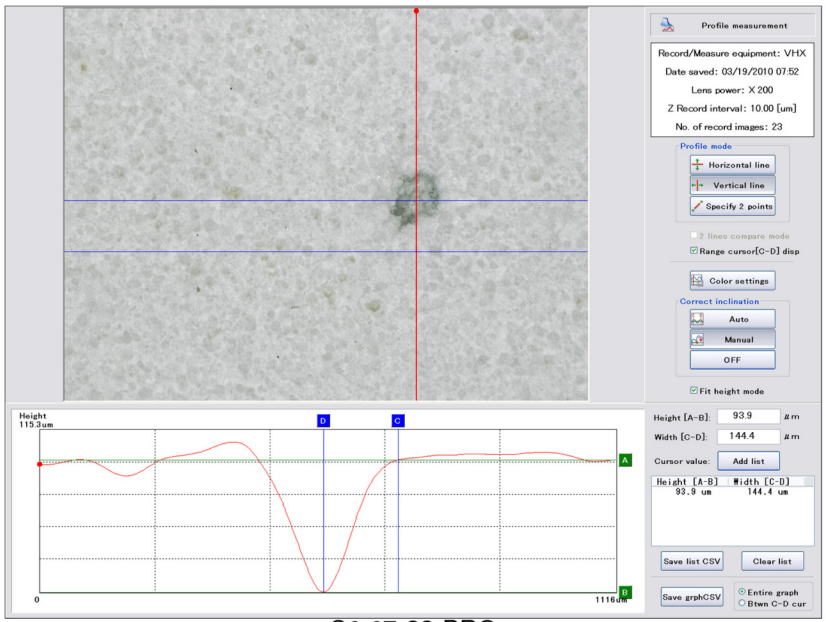
S5-41-03-PRO



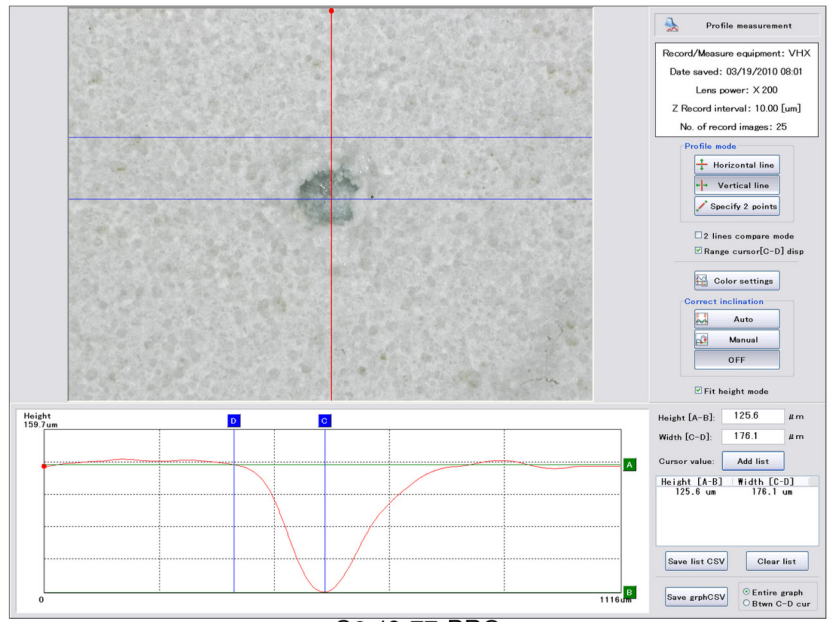
S5-60-48-PRO



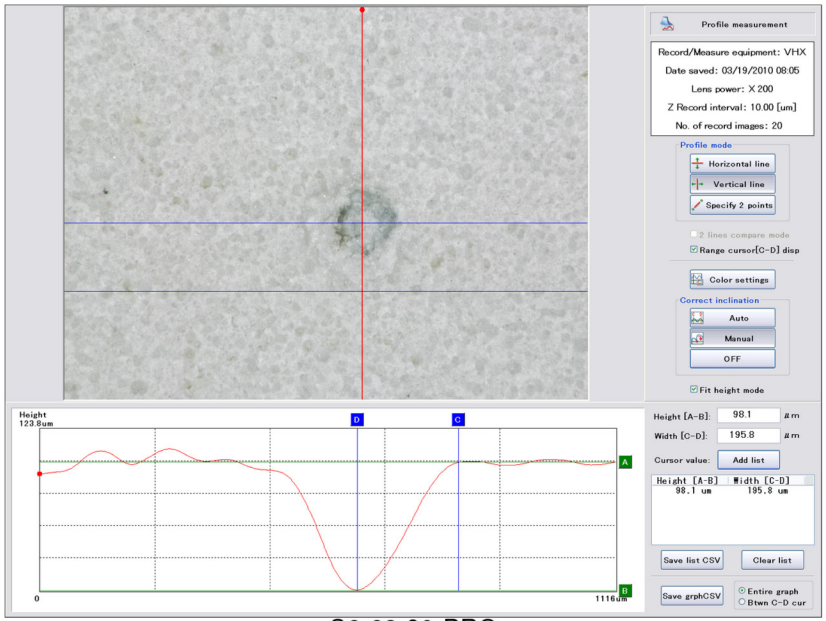
S5-65-16-PRO



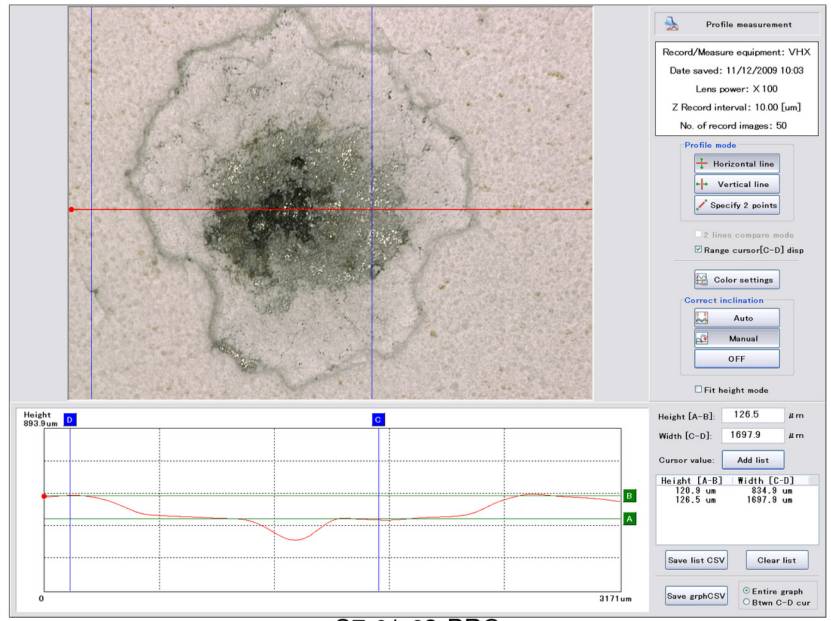
S6-07-22-PRO



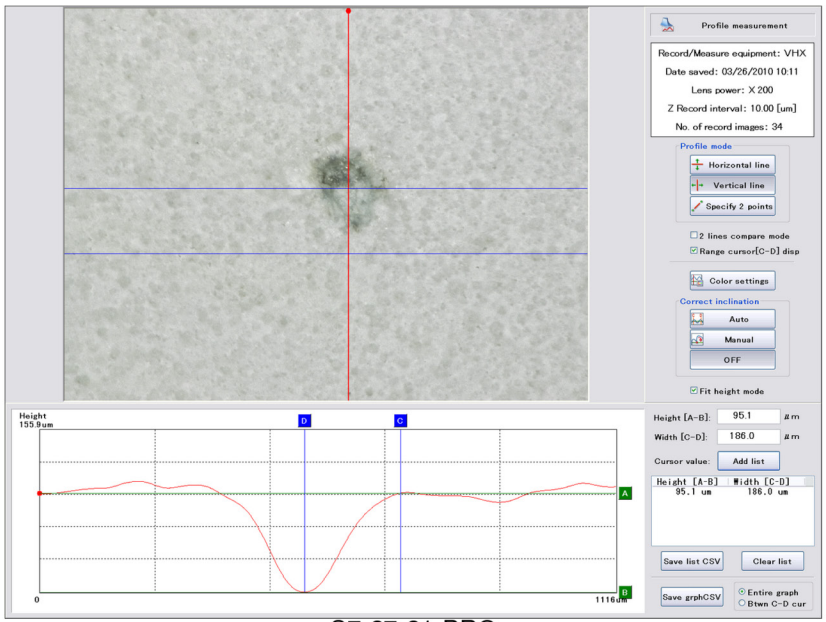
S6-19-77-PRO



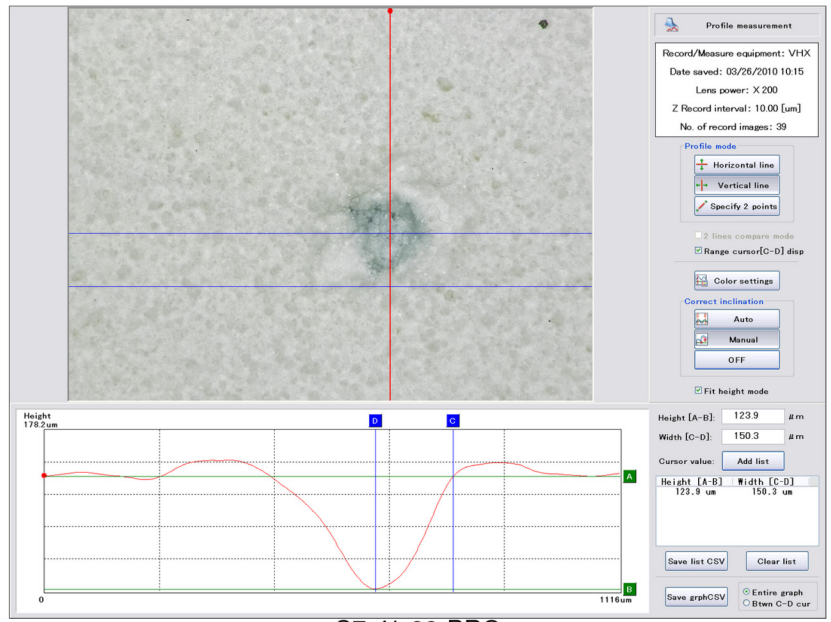
S6-68-90-PRO



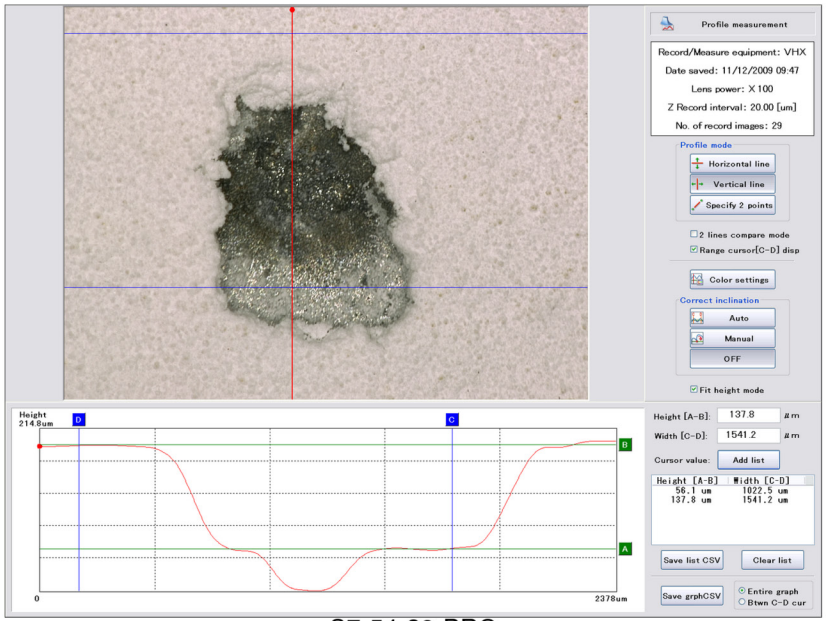
S7-01-63-PRO



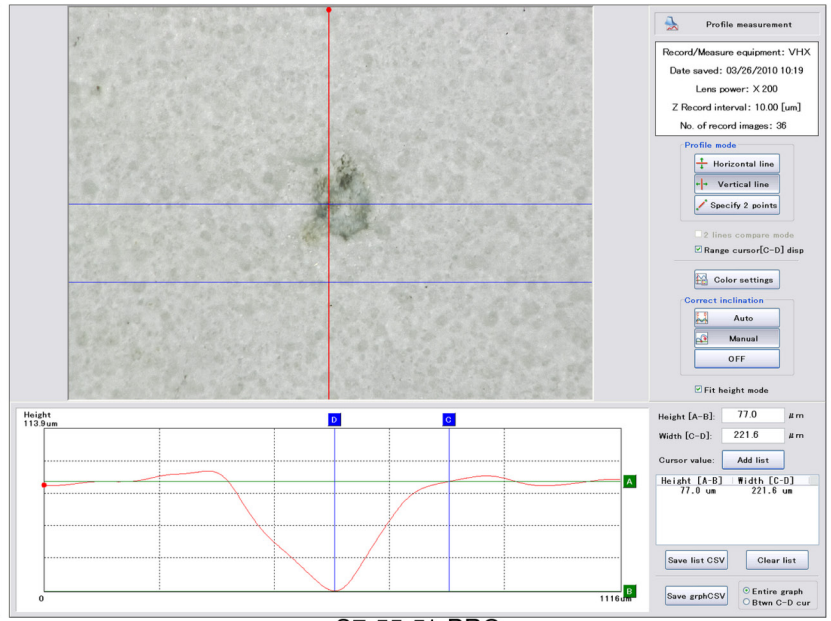
S7-27-21-PRO



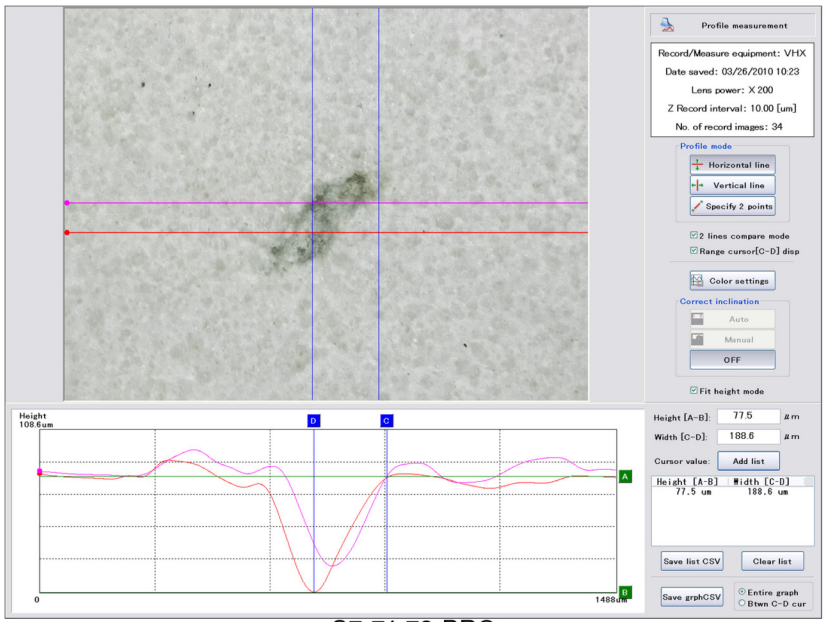
S7-41-88-PRO



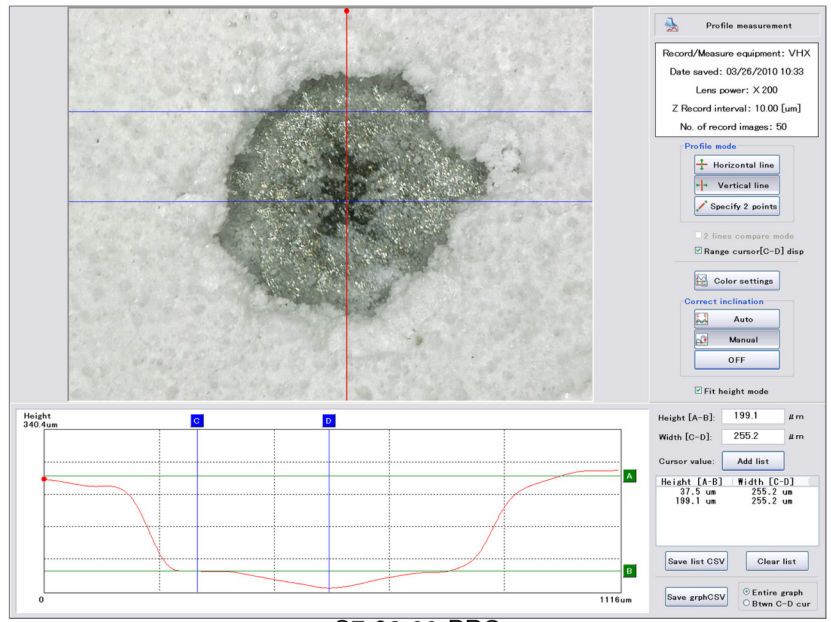
S7-54-28-PRO



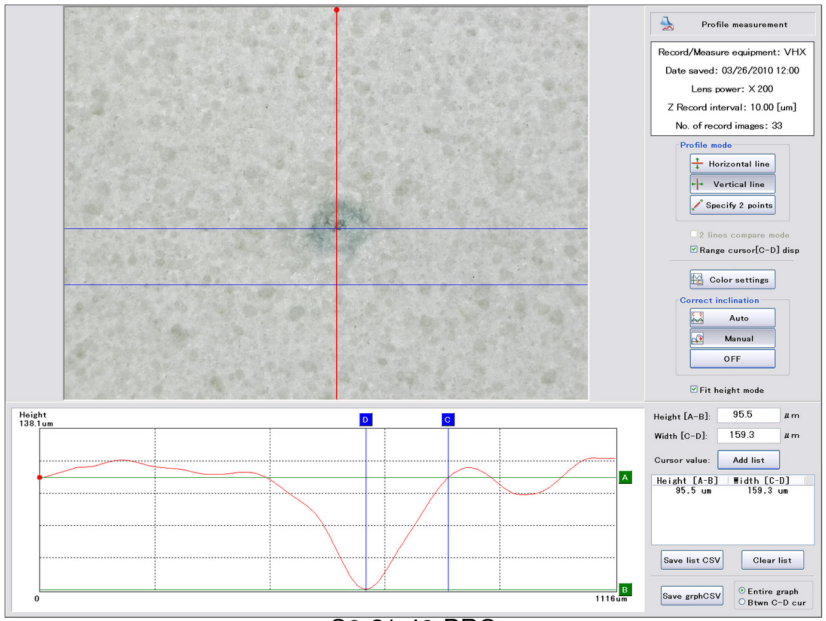
S7-55-51-PRO



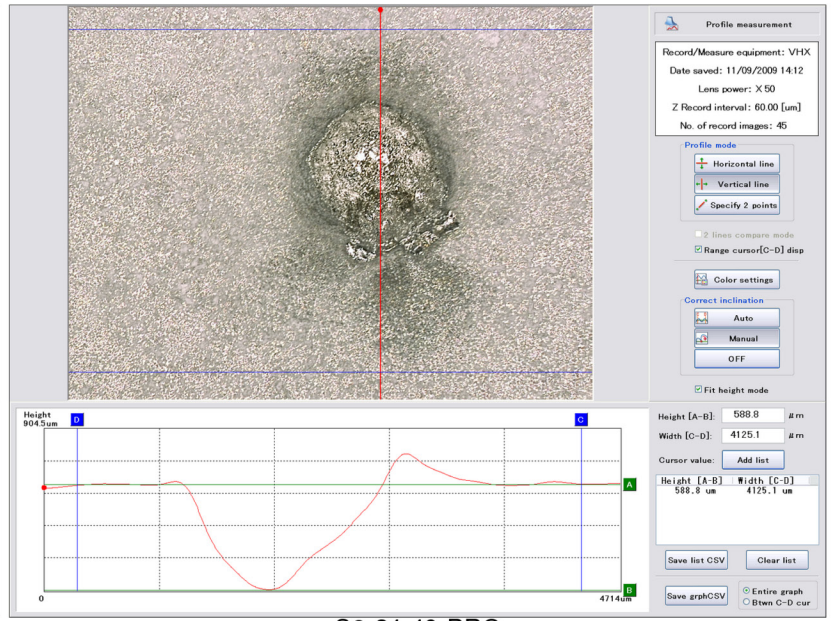
S7-74-72-PRO



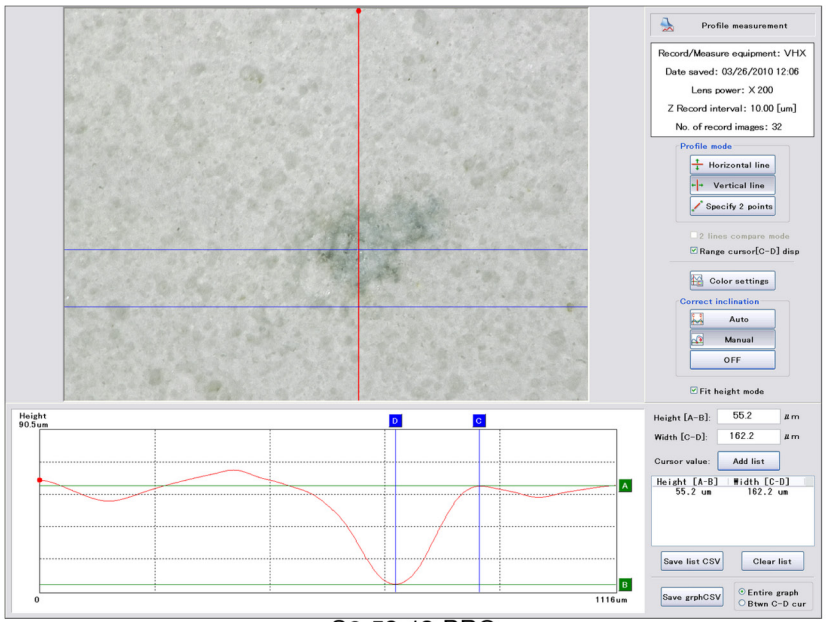
S7-98-00-PRO



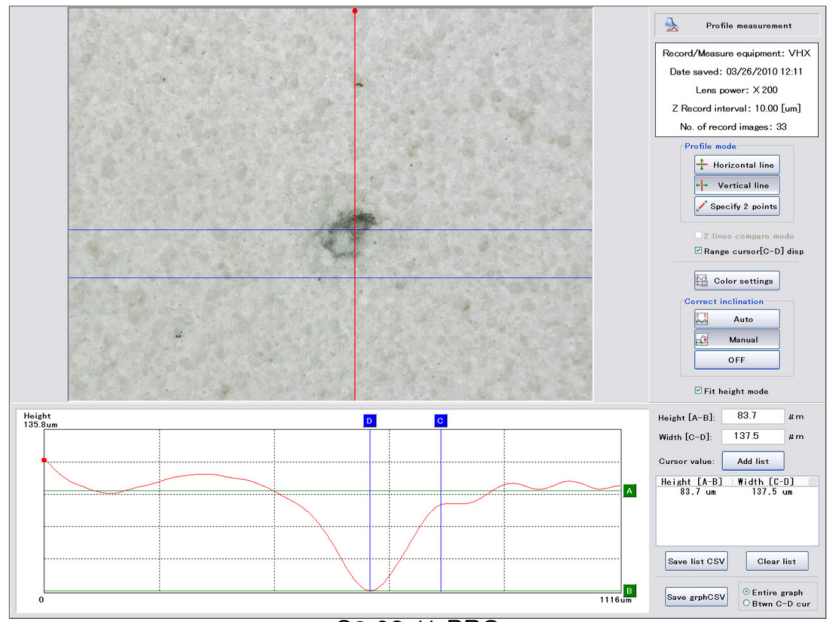
S8-21-48-PRO



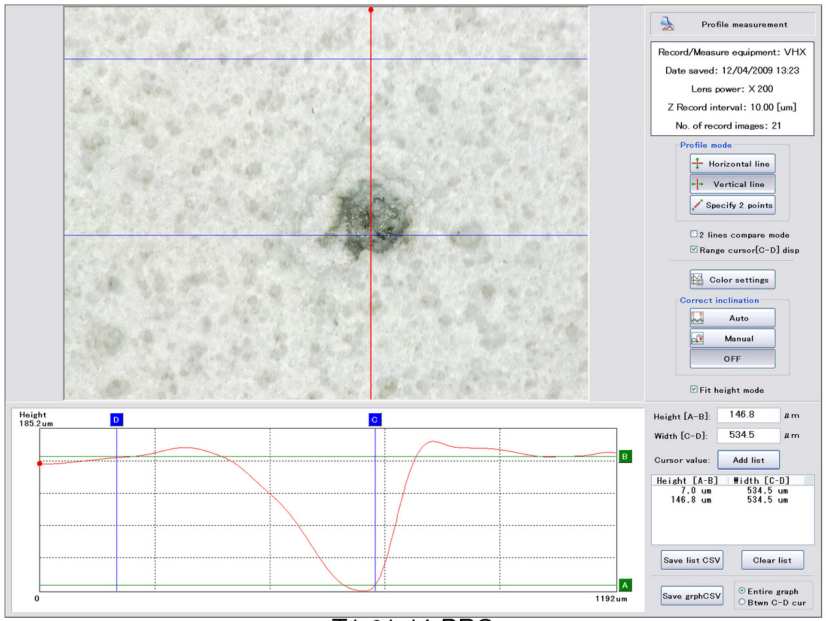
S8-24-49-PRO



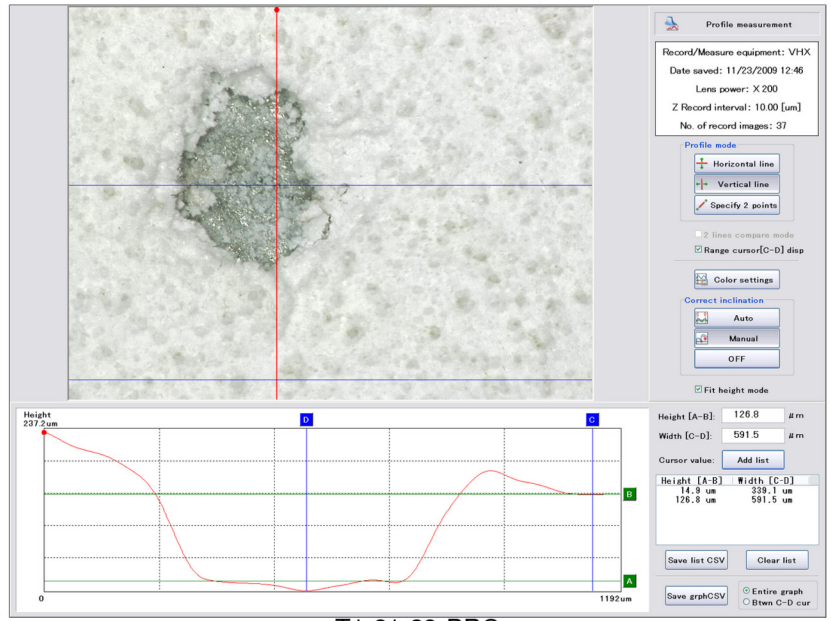
S8-53-12-PRO



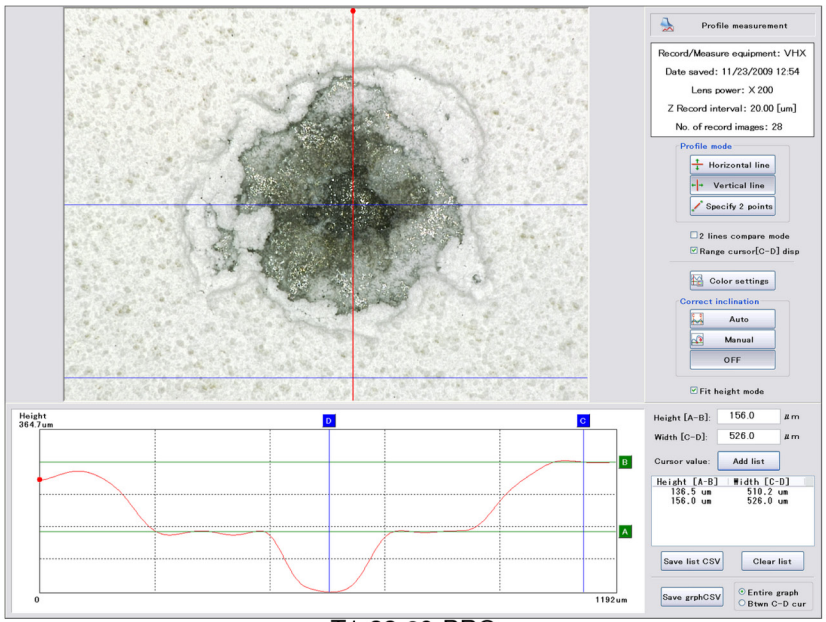
S8-92-11-PRO



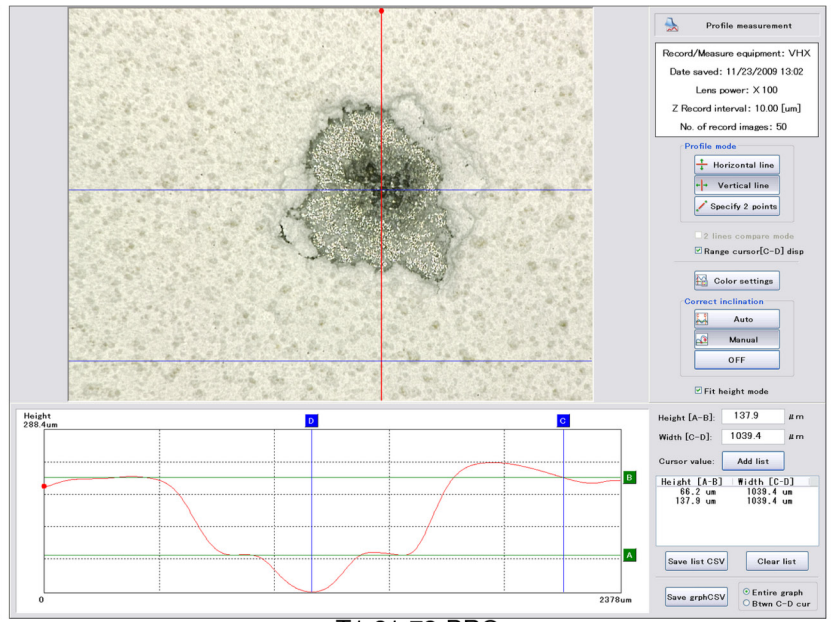
T1-01-14-PRO



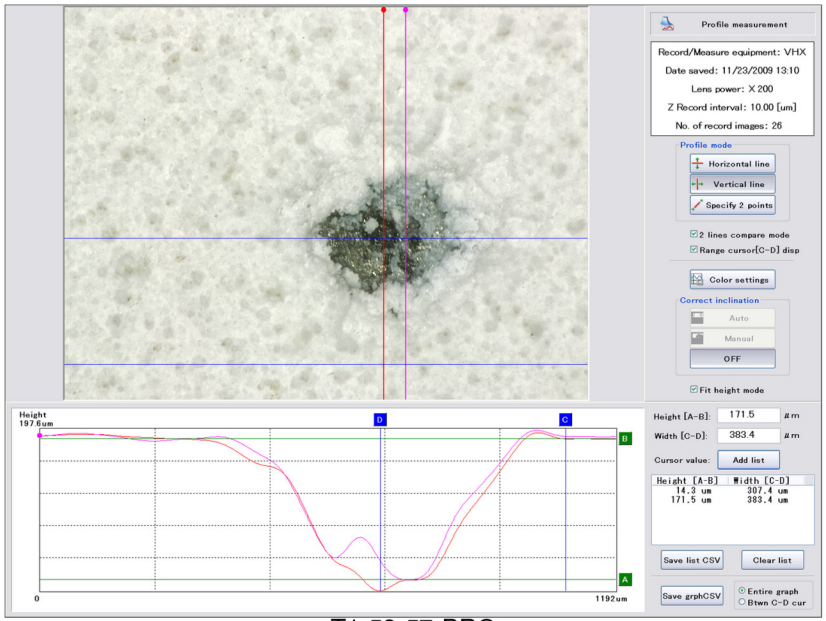
T1-21-23-PRO



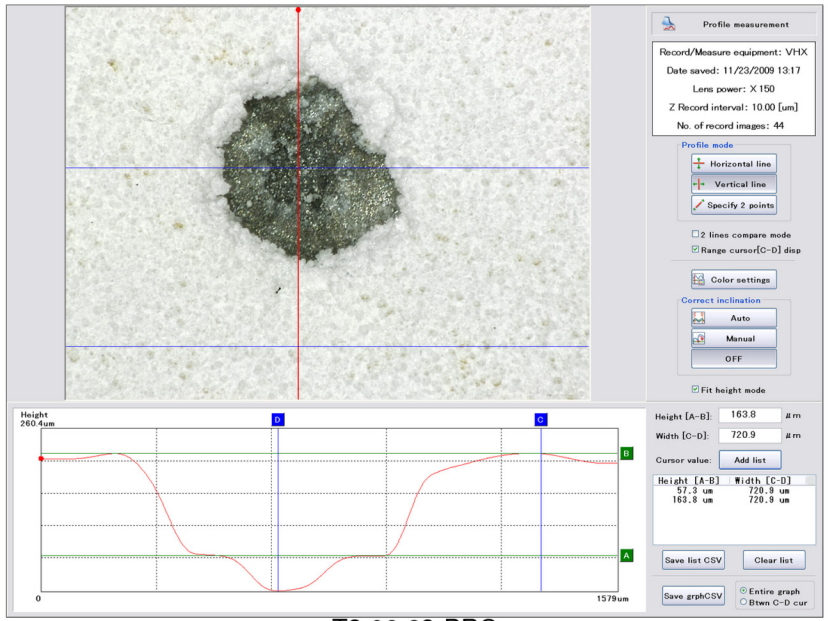
T1-22-89-PRO



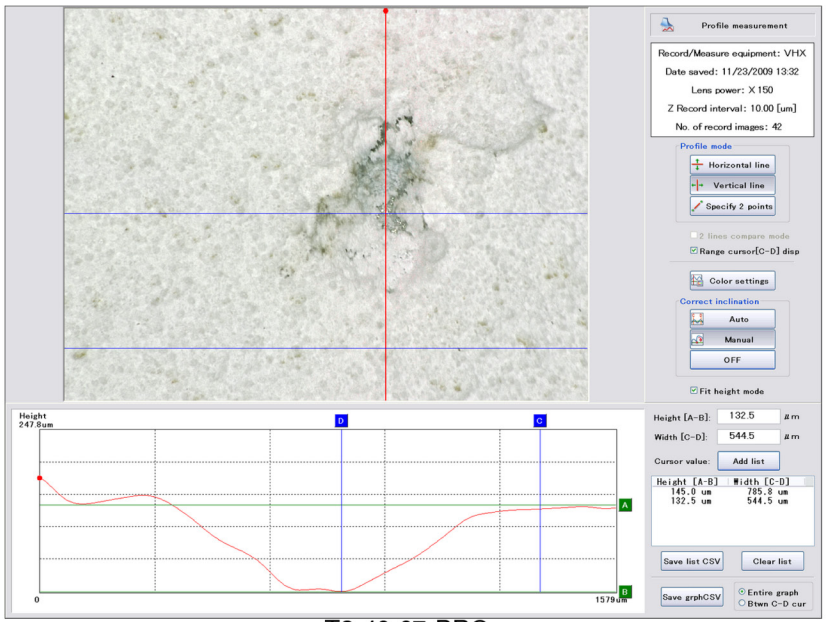
T1-31-72-PRO



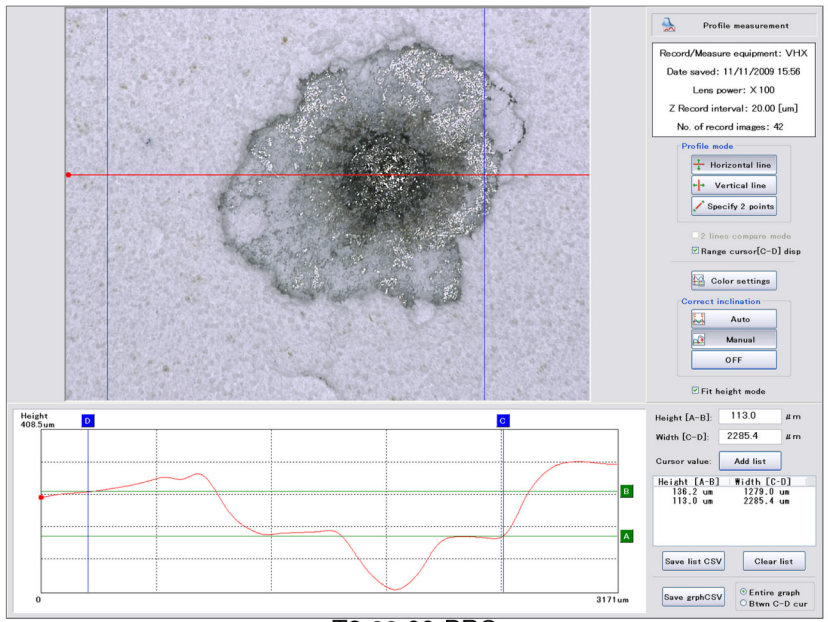
T1-53-57-PRO



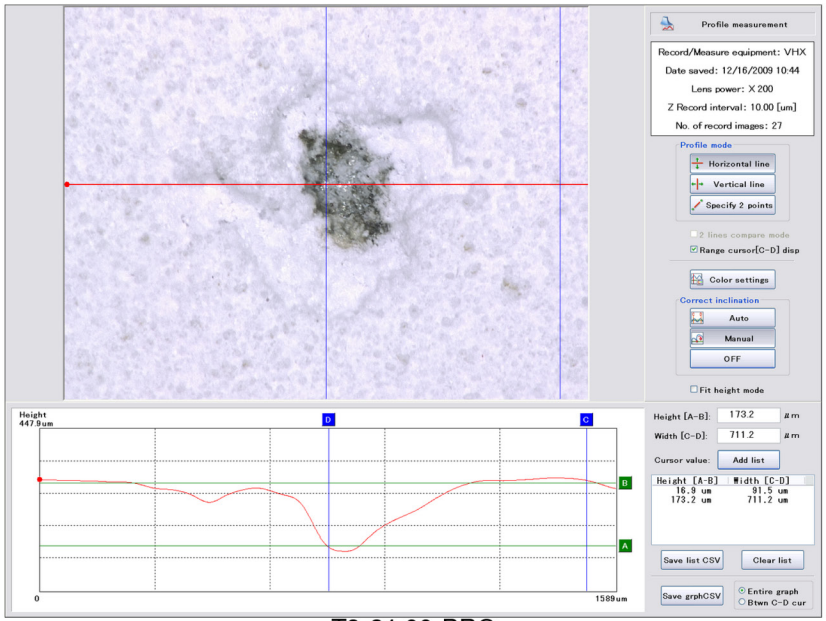
T2-06-83-PRO



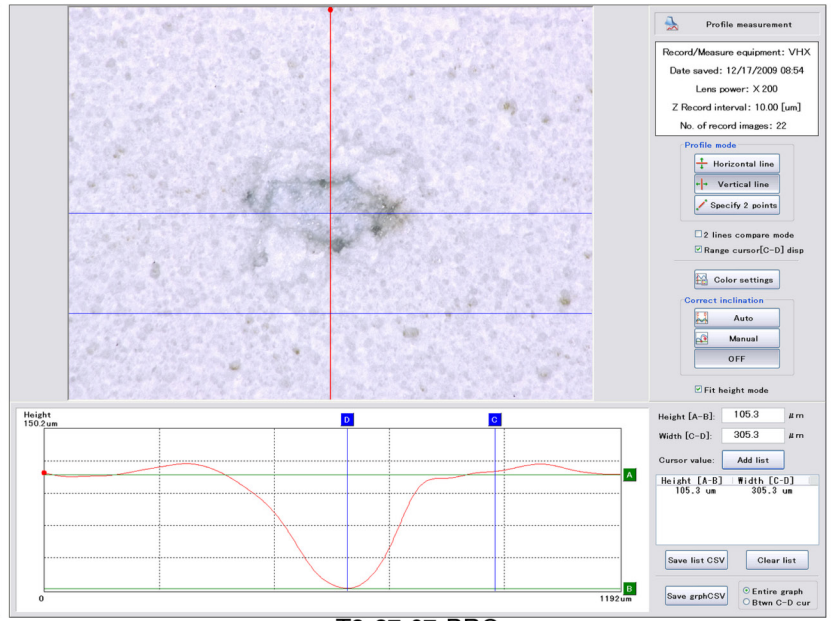
T2-49-97-PROv



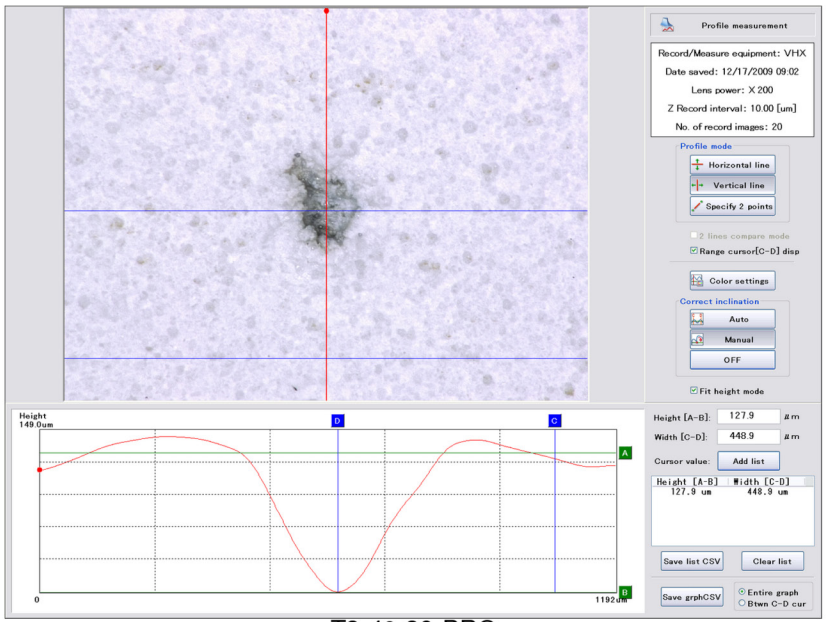
T2-88-99-PRO



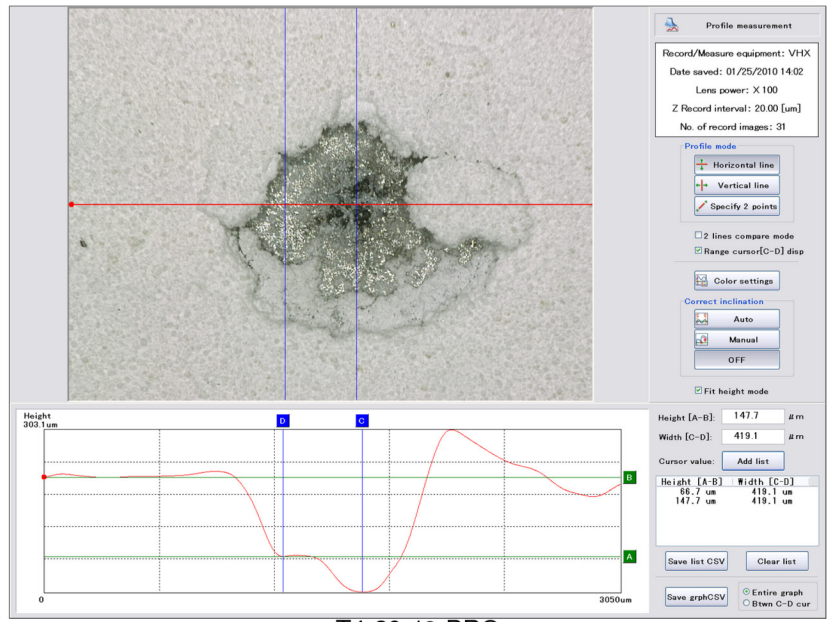
T3-24-99-PRO



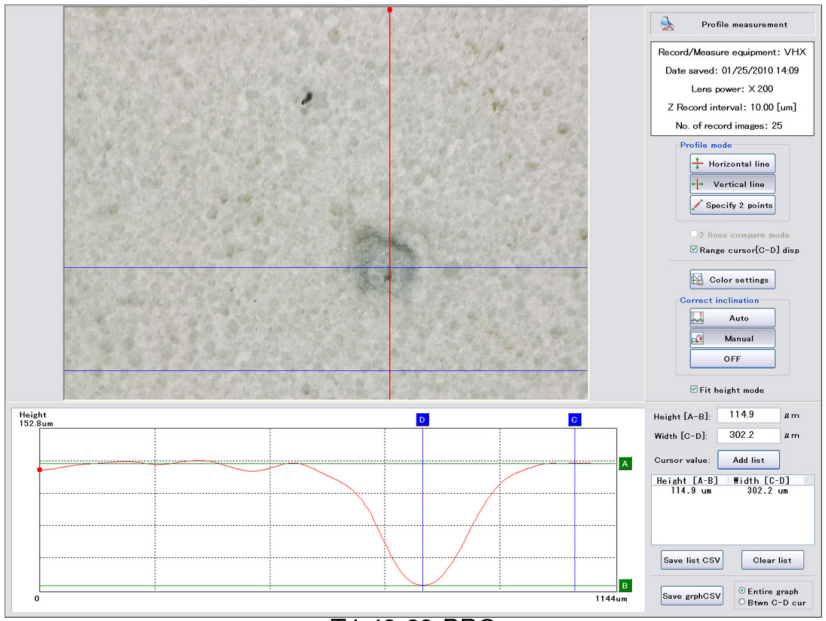
T3-27-97-PRO



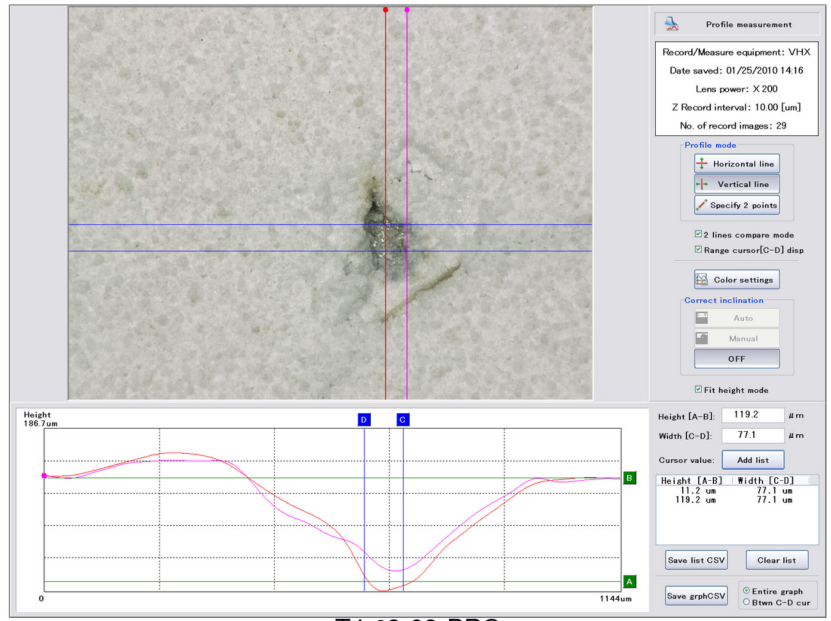
T3-40-39-PRO



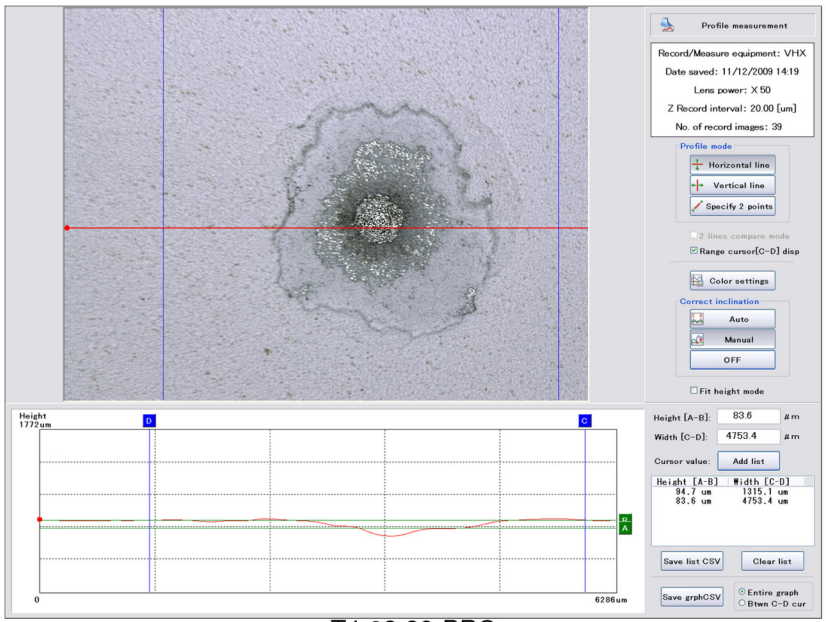
T4-29-18-PRO



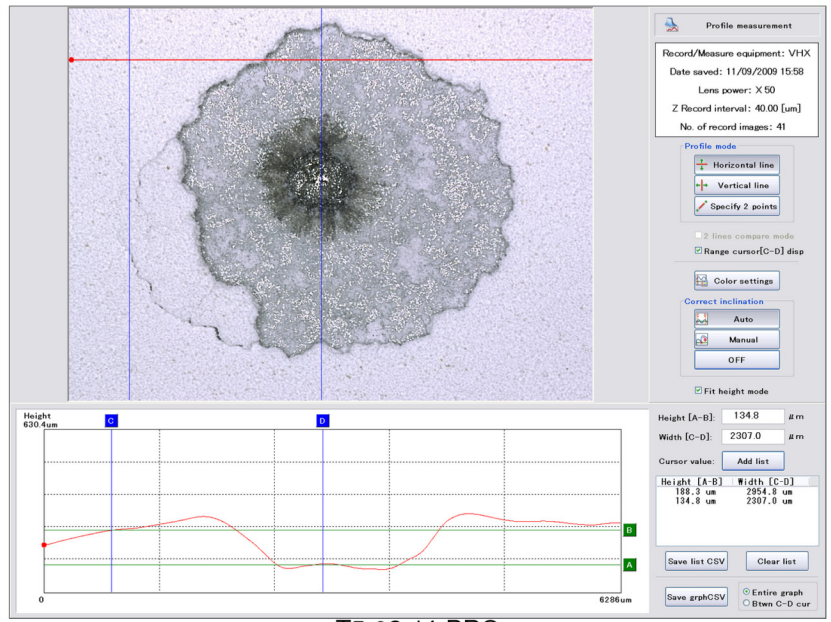
T4-43-23-PRO



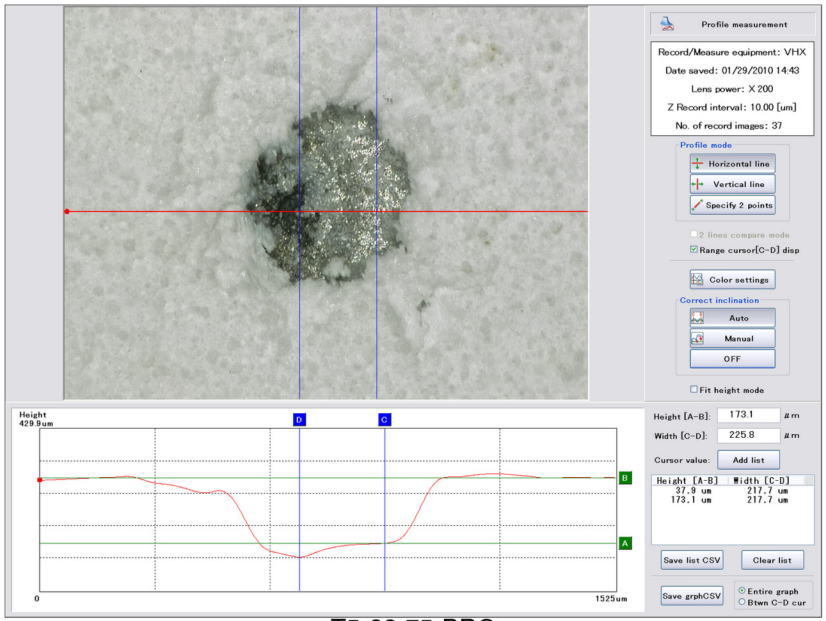
T4-63-93-PRO



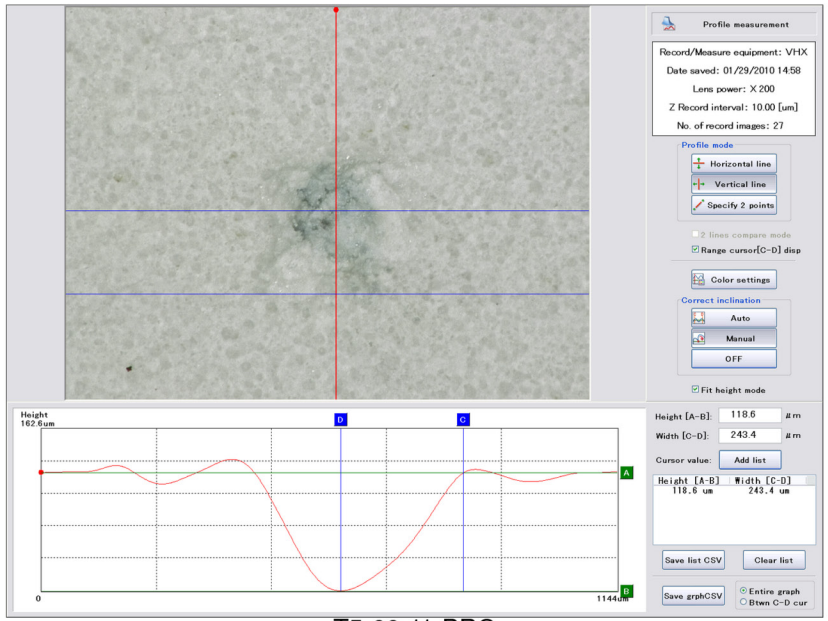
T4-82-39-PRO



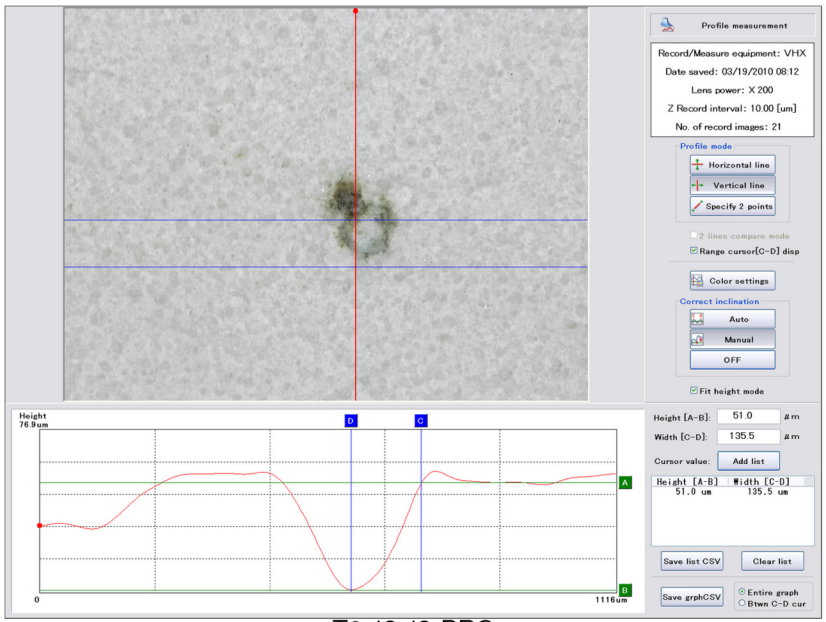
T5-02-14-PRO



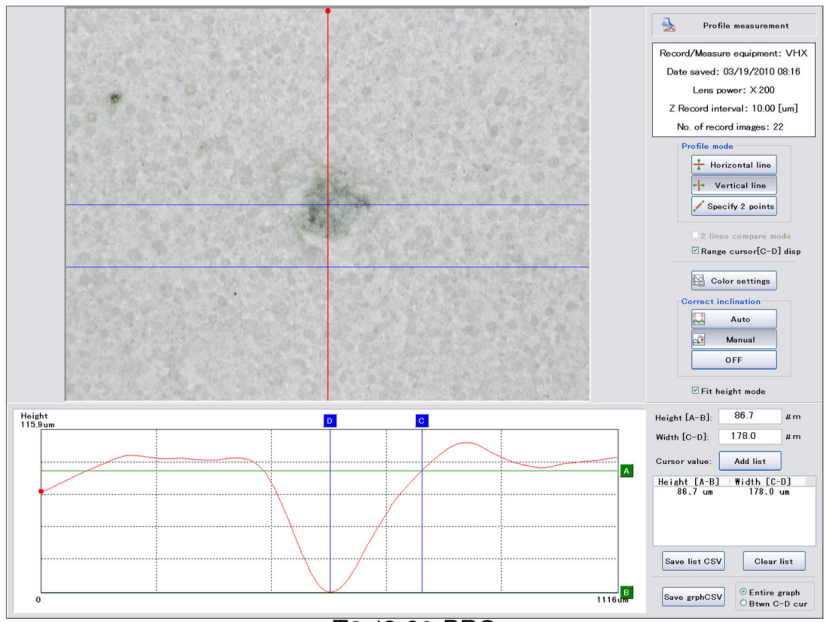
T5-22-75-PRO



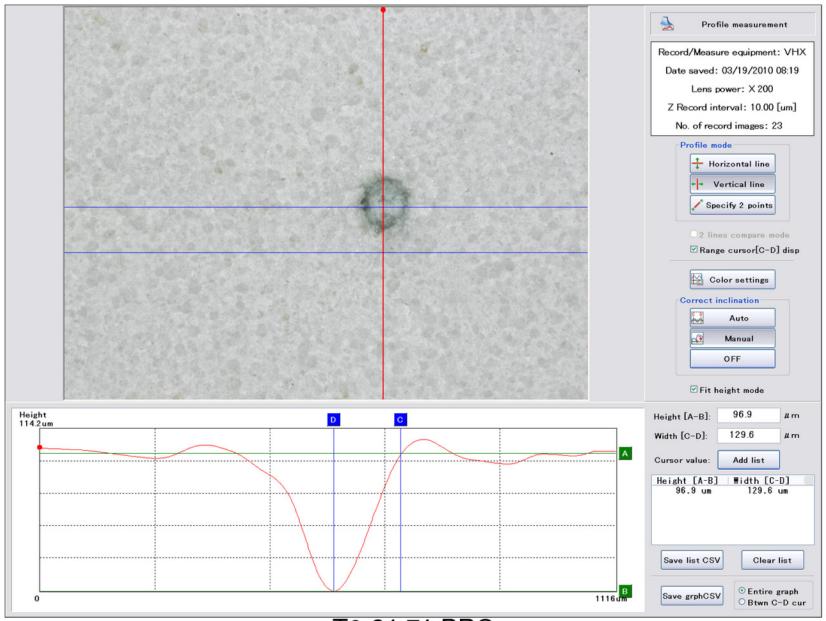
T5-66-11-PRO



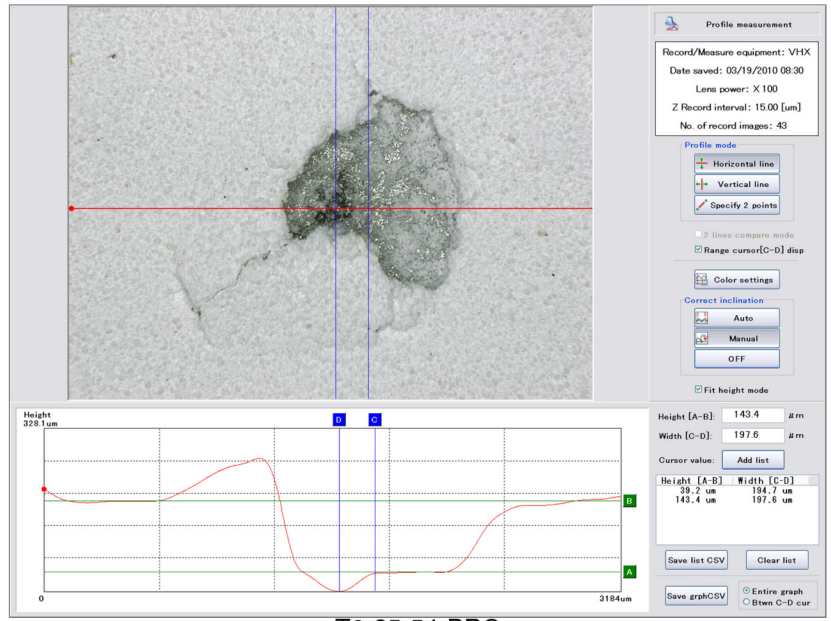
T6-12-13-PRO



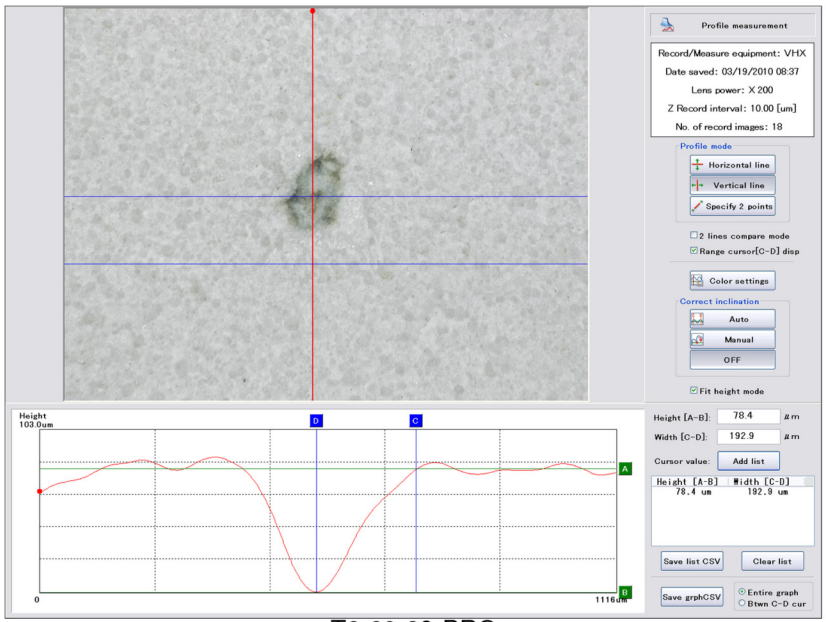
T6-13-90-PRO



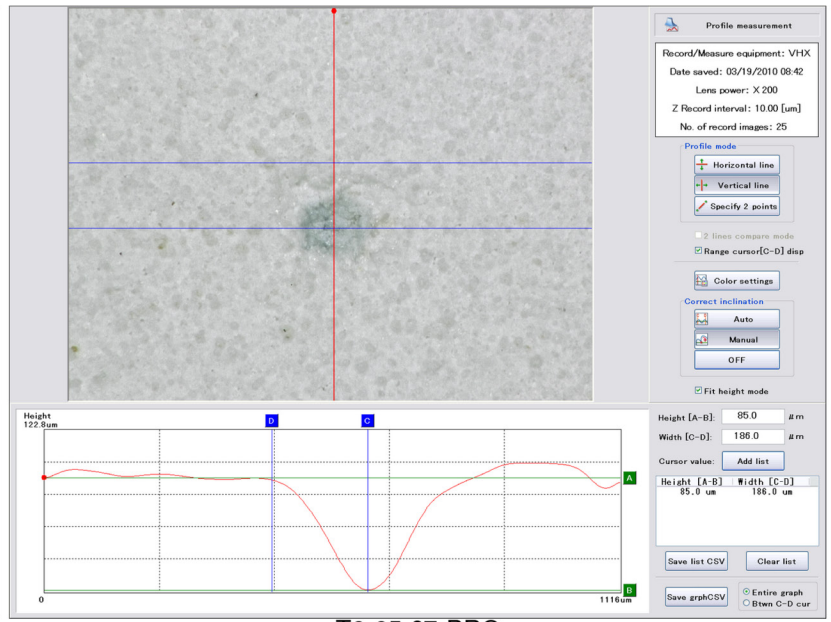
T6-24-74-PRO



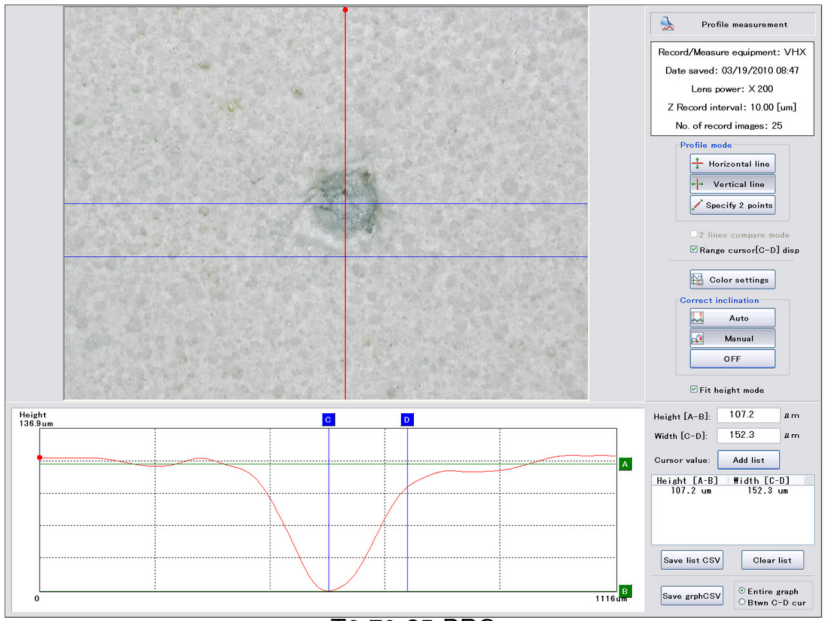
T6-25-54-PRO



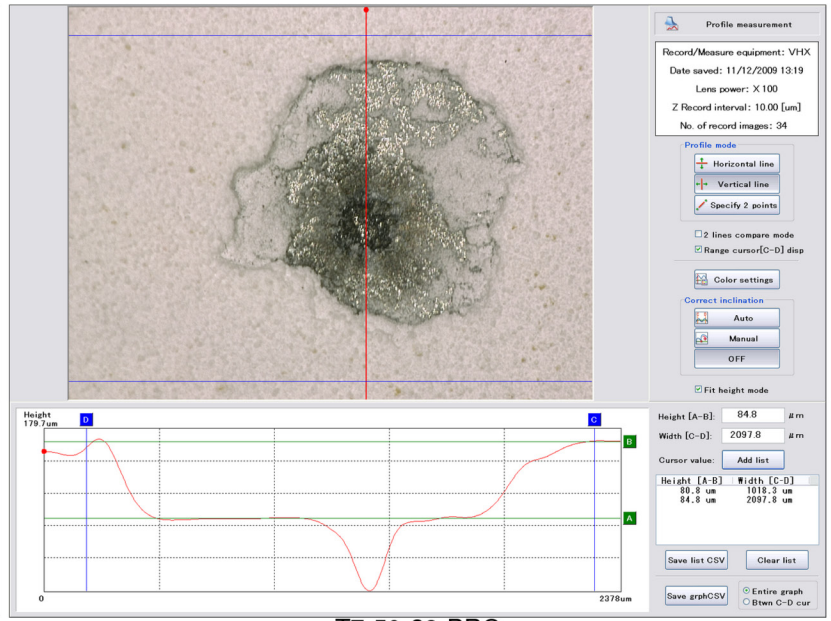
T6-60-89-PRO



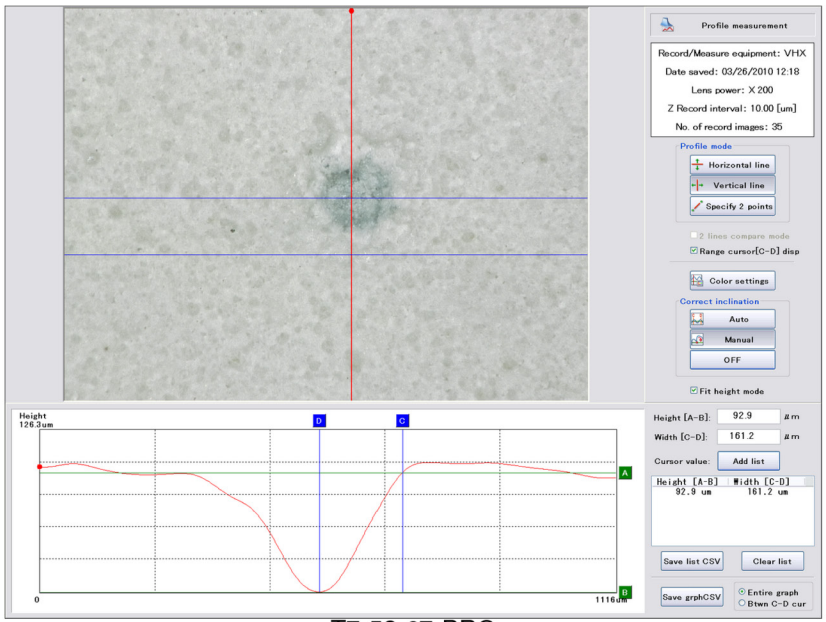
T6-65-97-PRO



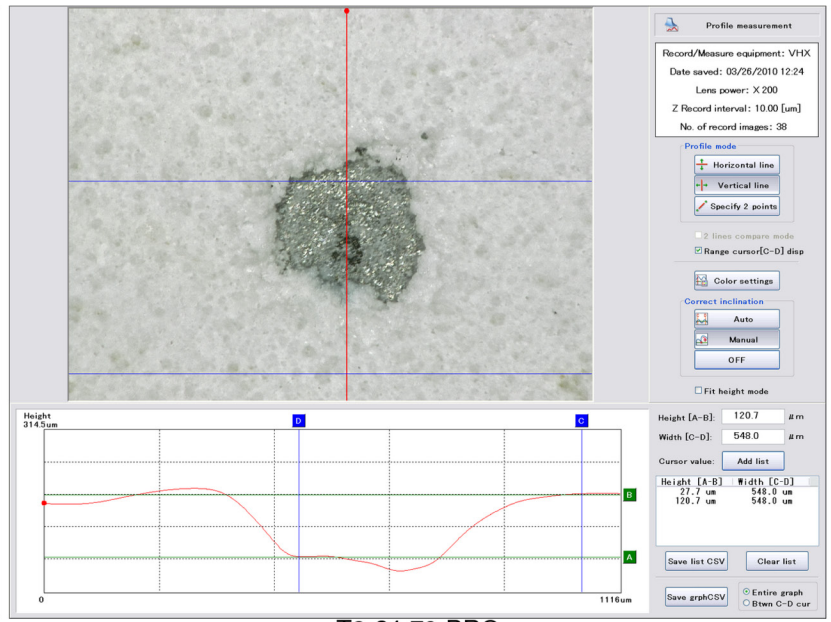
T6-70-25-PRO



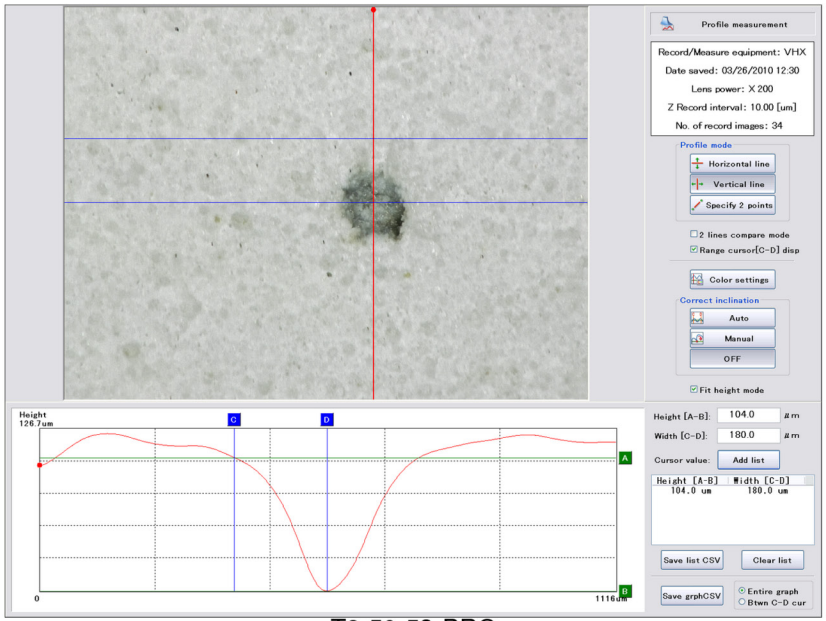
T7-50-28-PRO



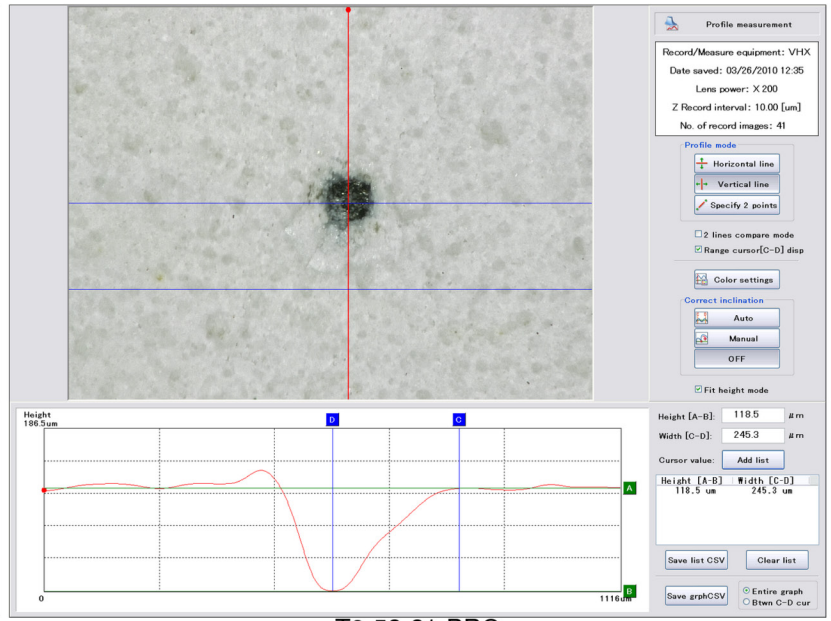
T7-52-67-PRO



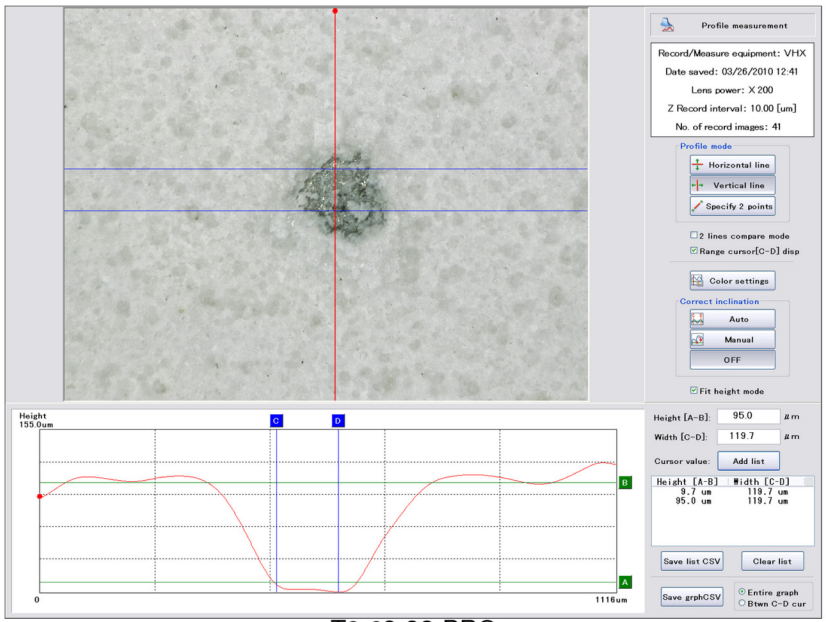
T8-24-76-PRO



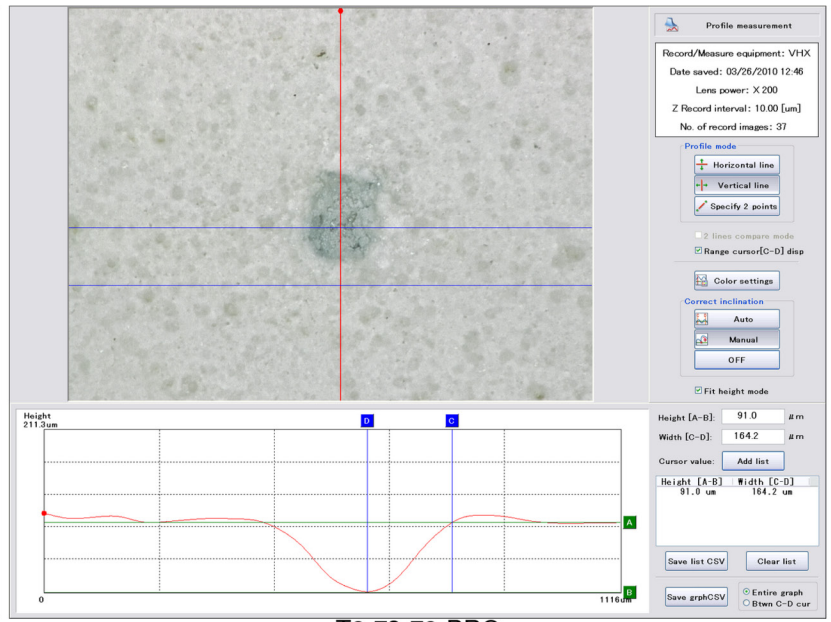
T8-50-53-PRO



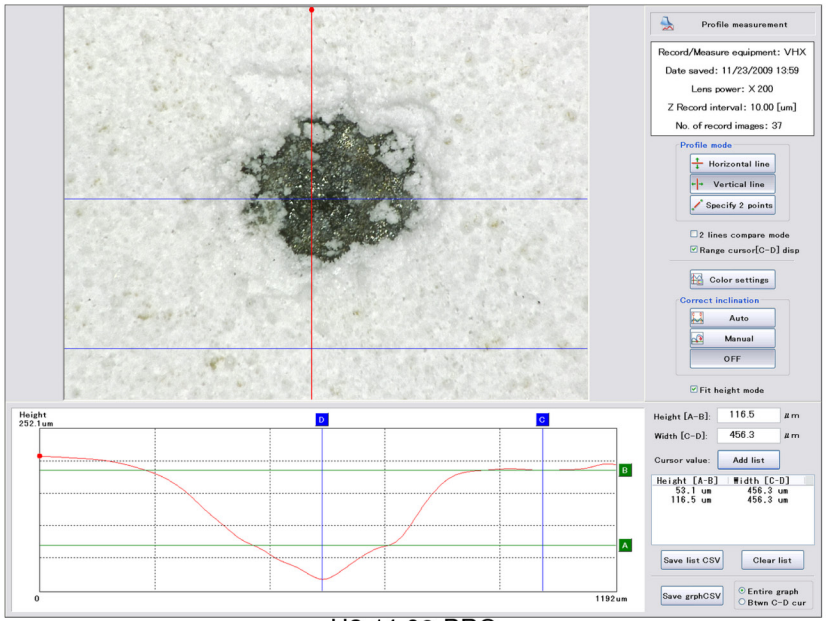
T8-52-21-PRO



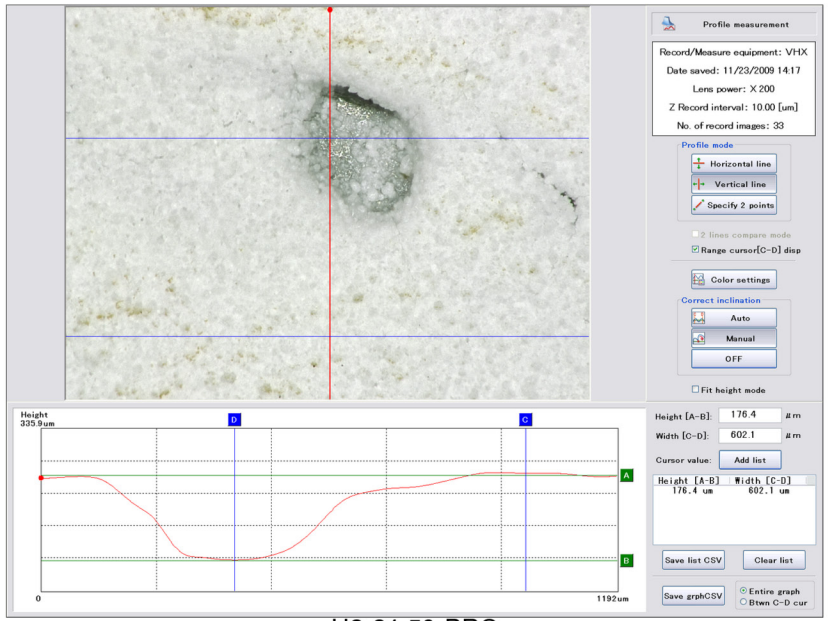
T8-63-32-PRO



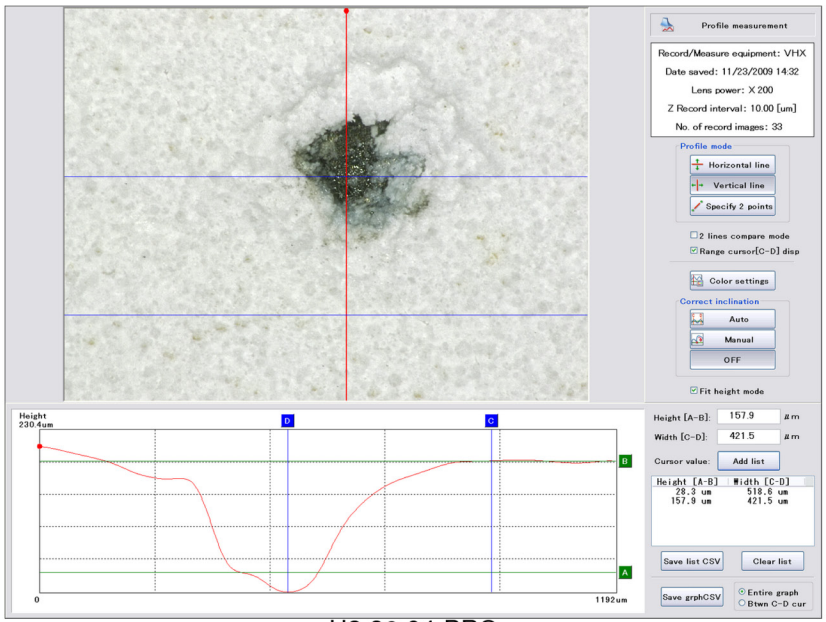
T8-73-78-PRO



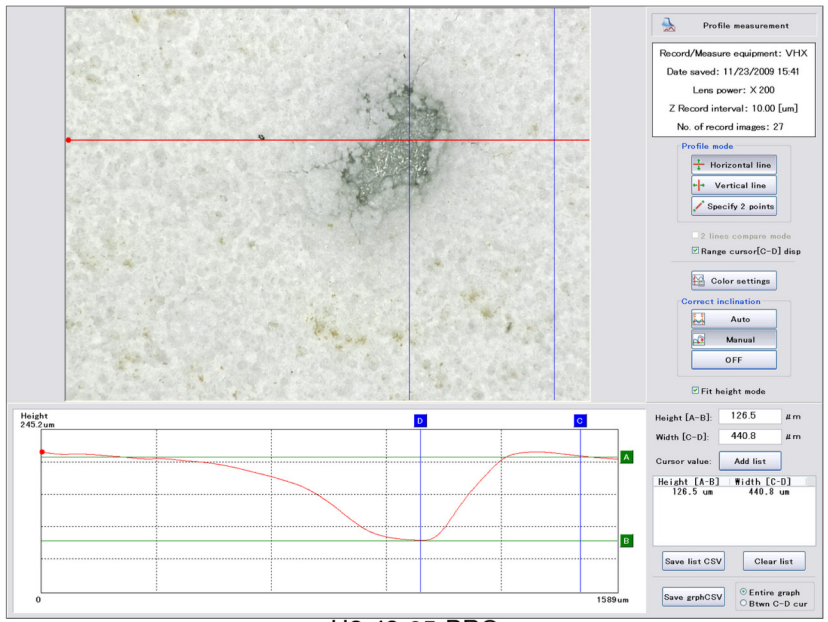
U2-14-98-PRO



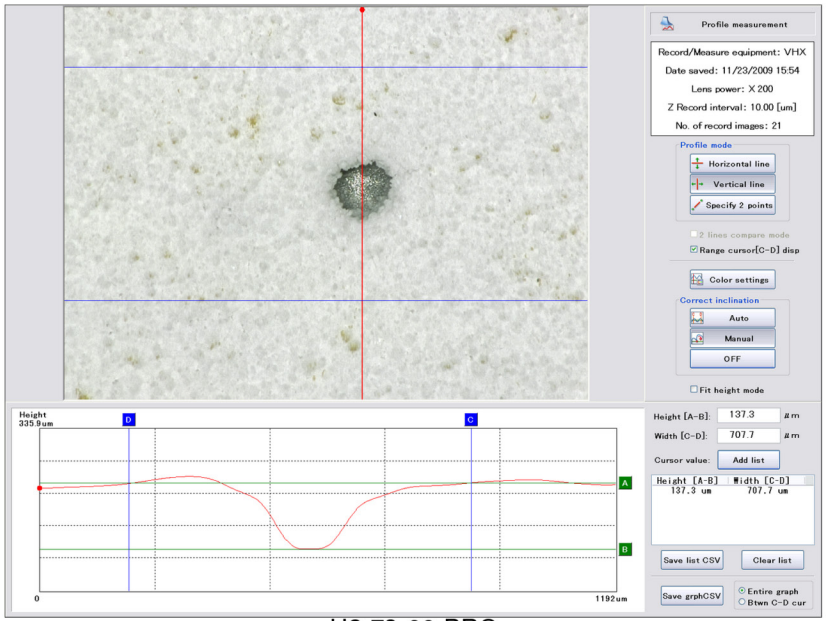
U2-24-59-PRO



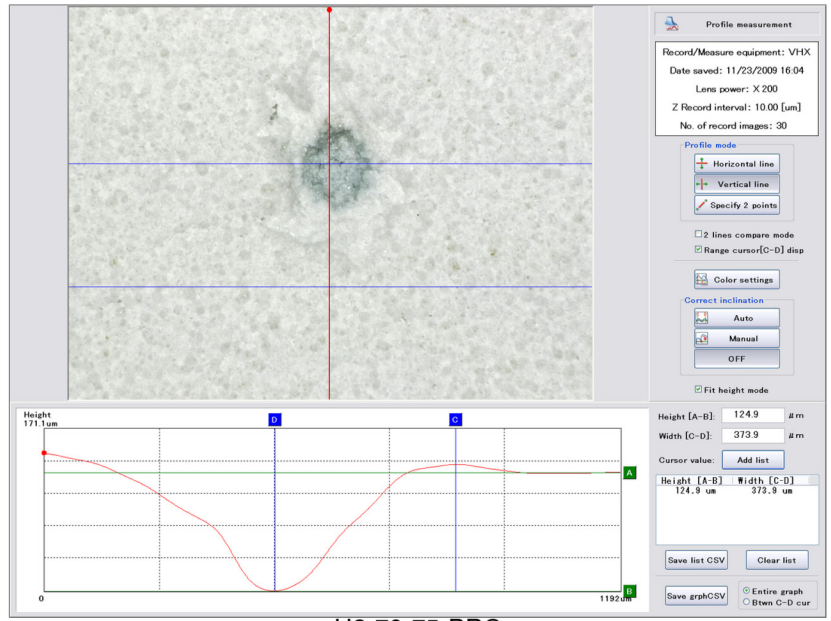
U2-36-94-PRO



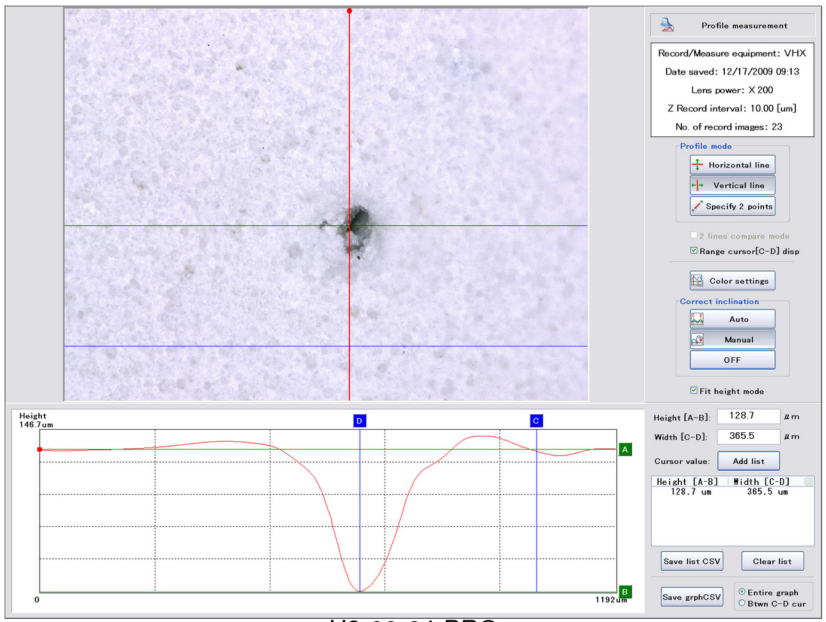
U2-43-85-PRO



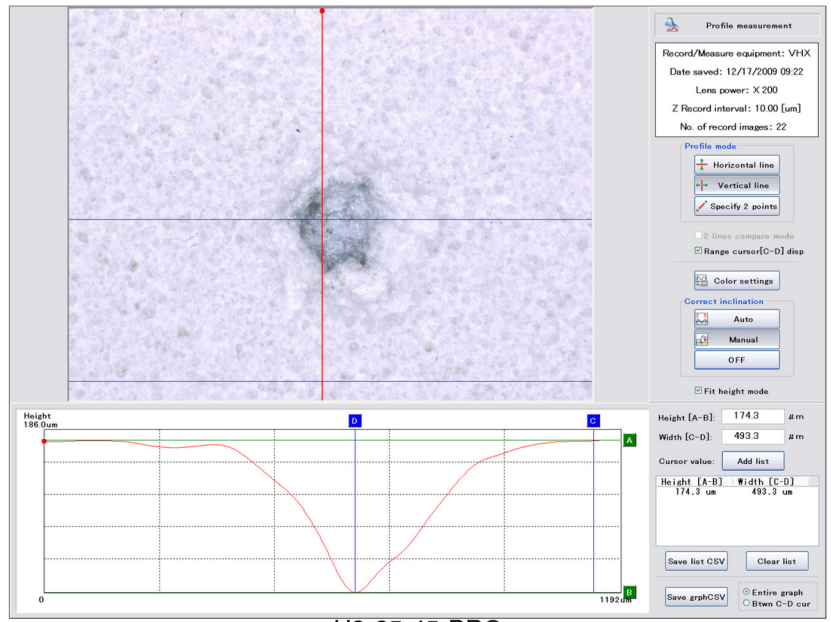
U2-73-66-PRO



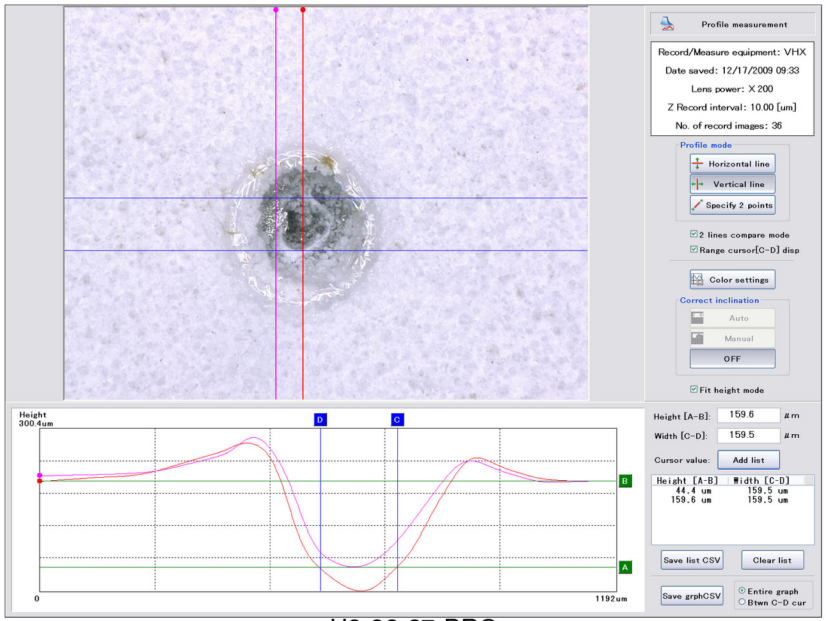
U2-79-75-PRO



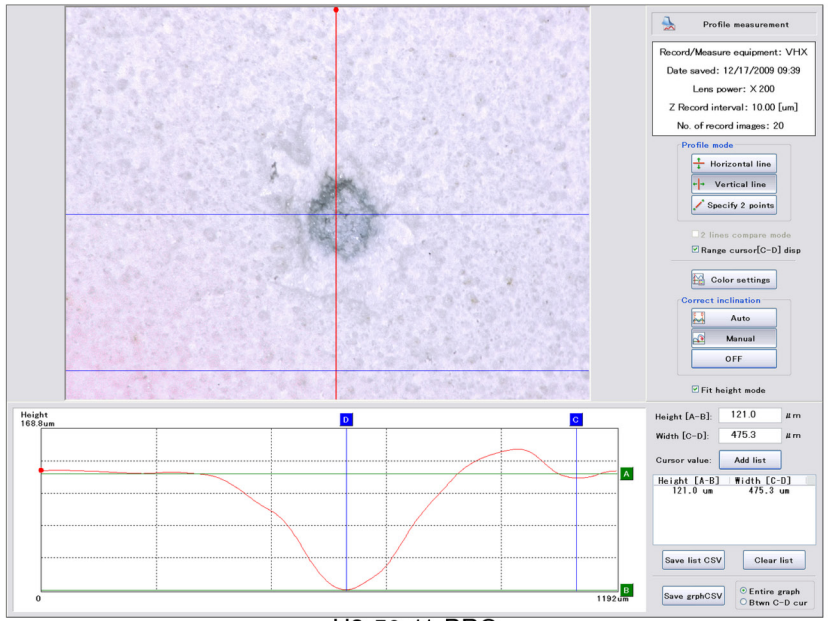
U3-00-64-PRO



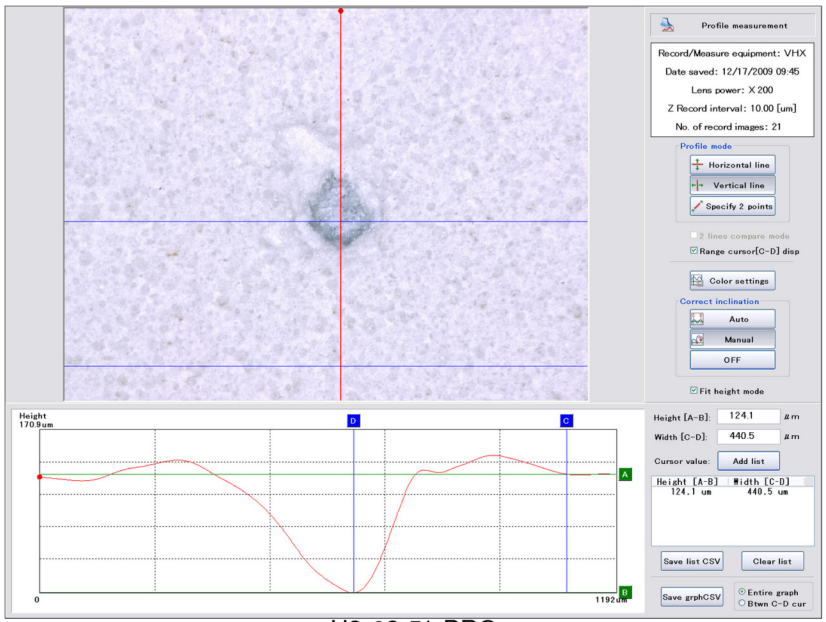
U3-25-45-PRO



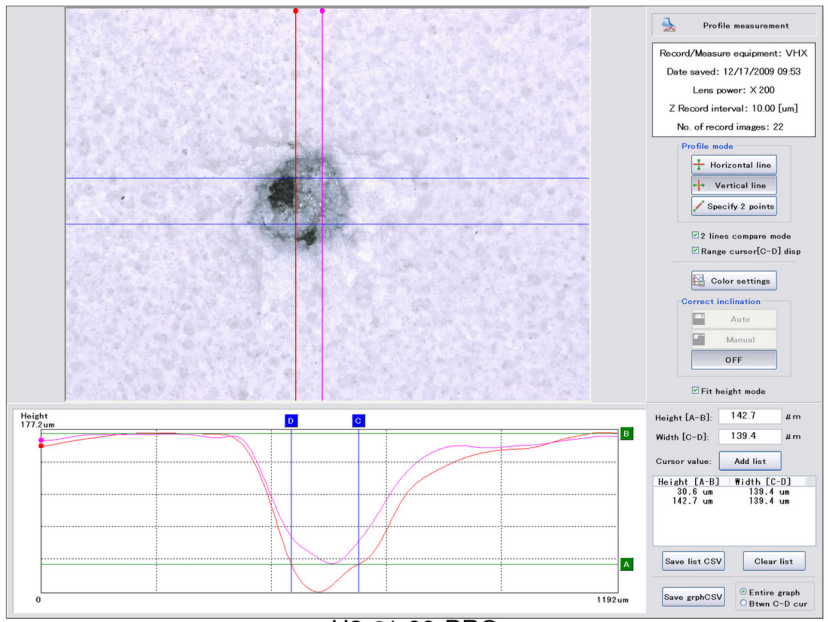
U3-32-27-PRO



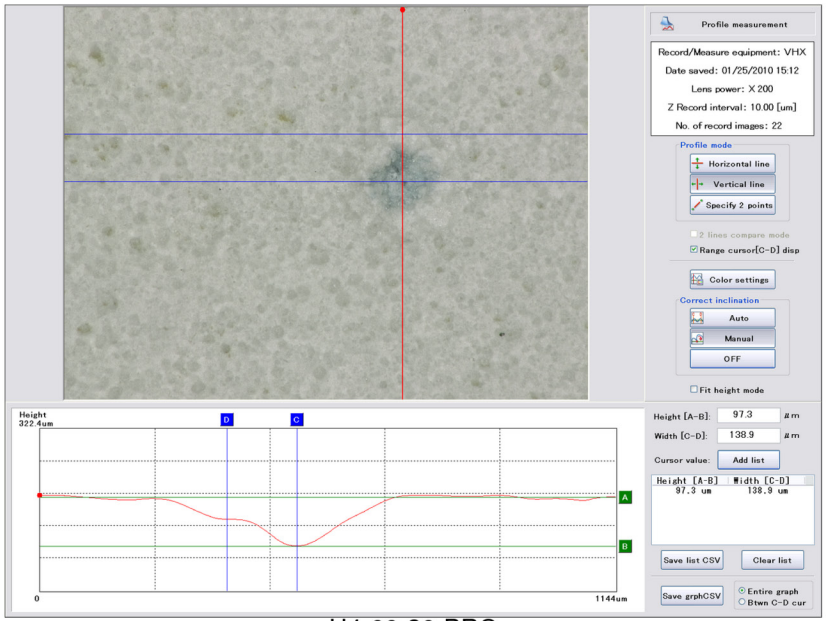
U3-50-11-PRO



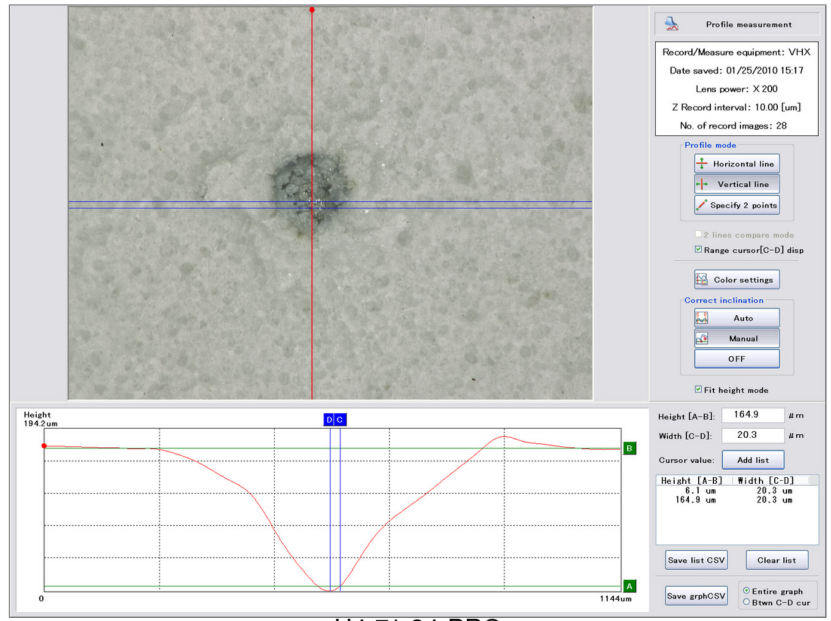
U3-62-51-PRO



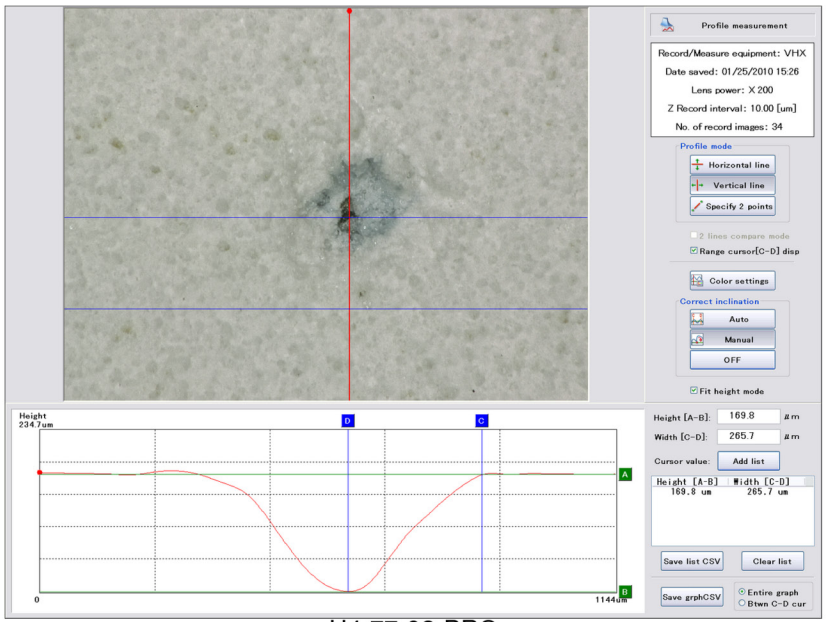
U3-81-99-PRO



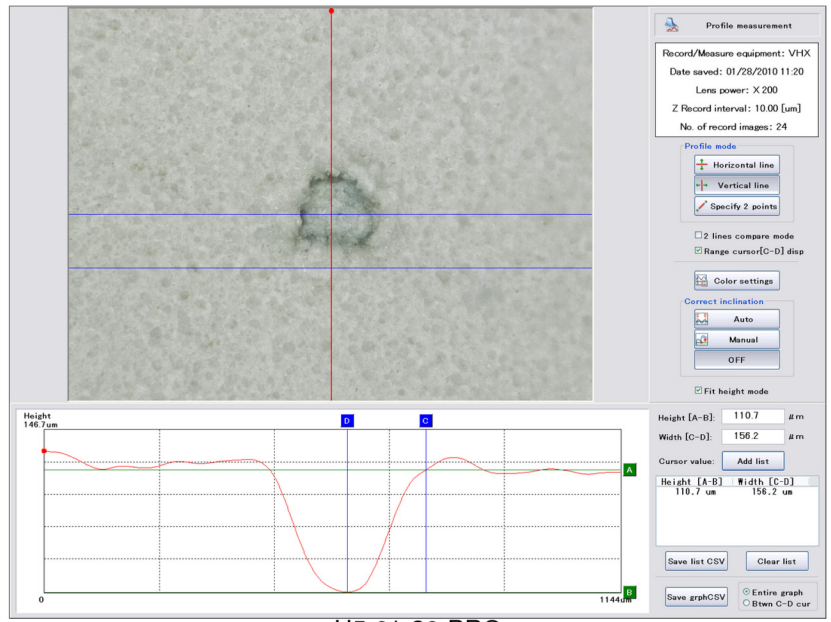
U4-66-26-PRO



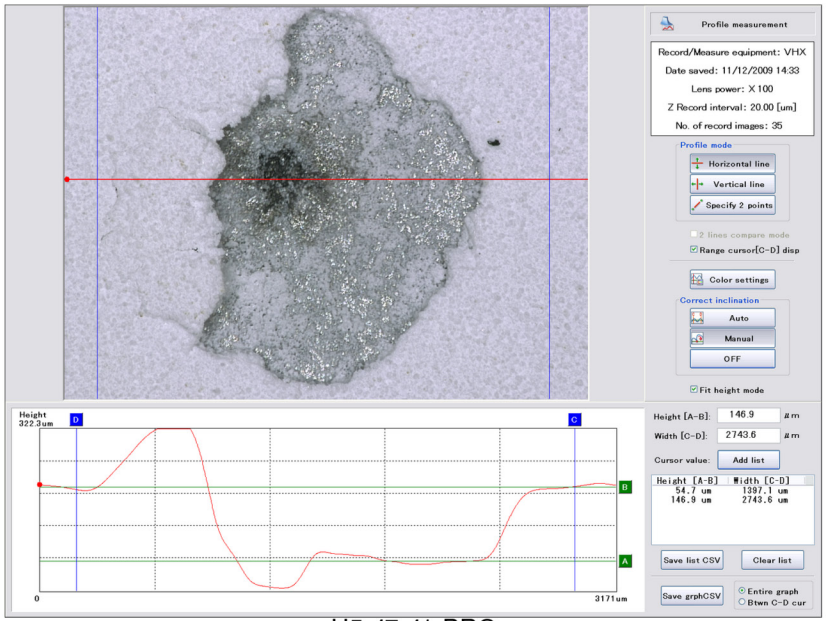
U4-71-34-PRO



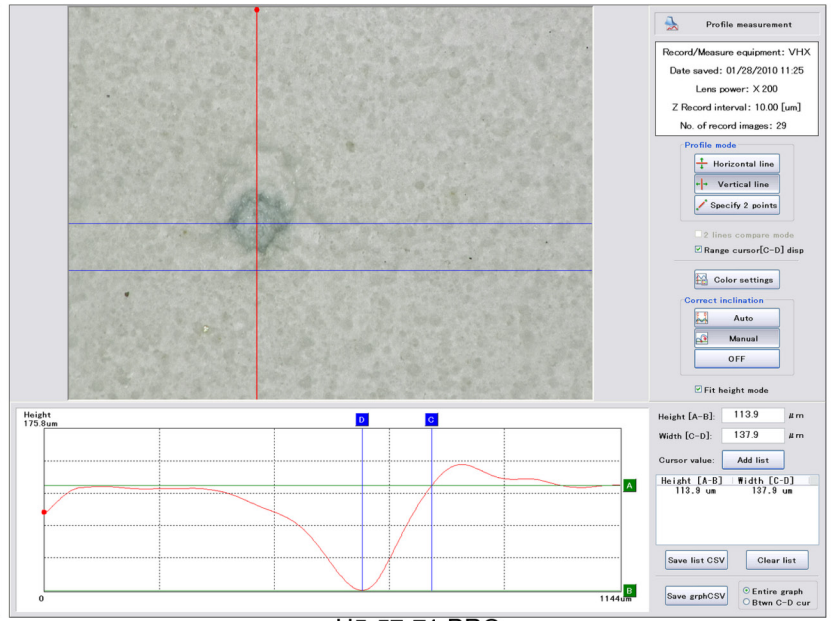
U4-77-92-PRO



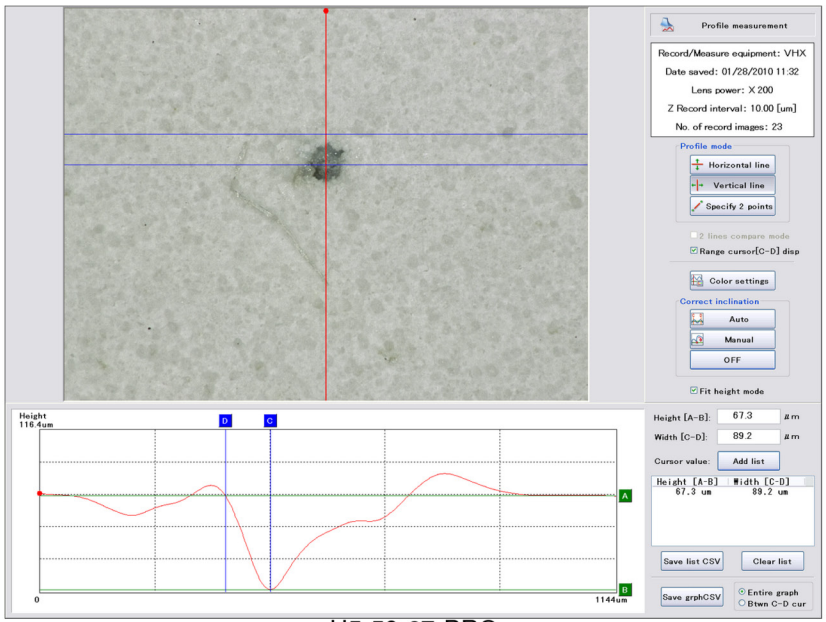
U5-01-26-PRO



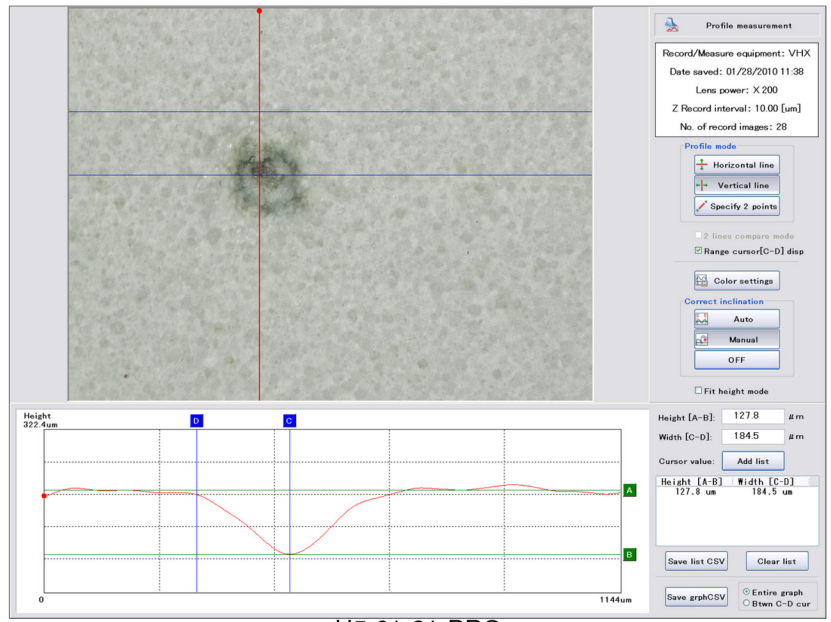
U5-47-41-PRO



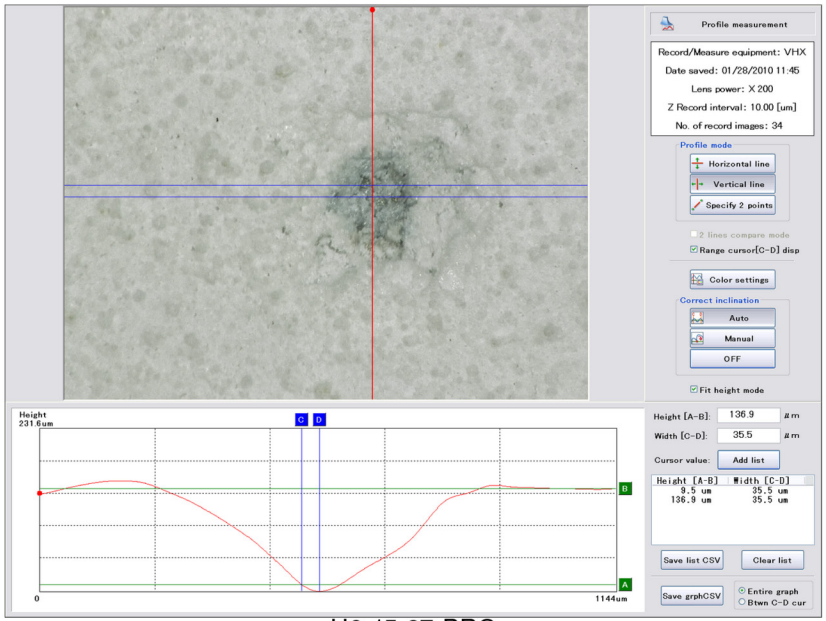
U5-57-74-PRO



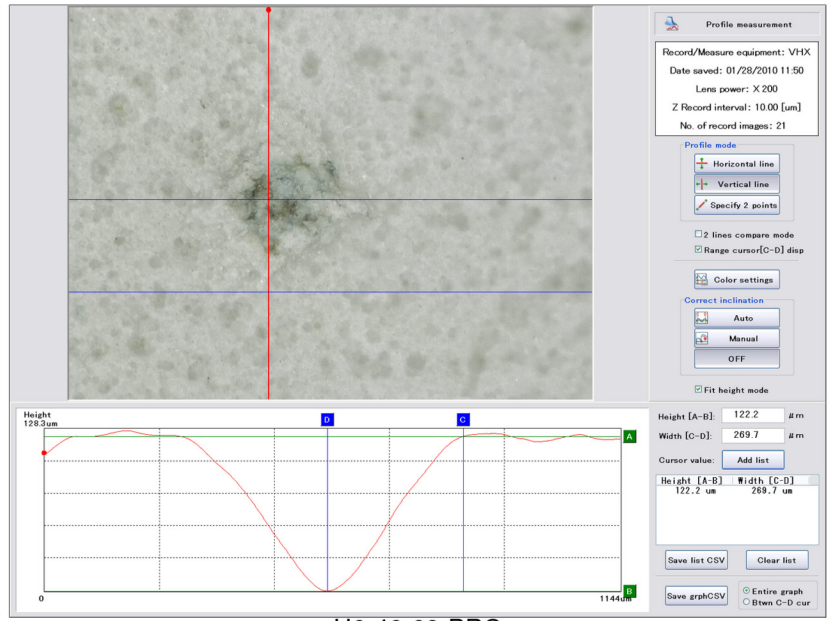
U5-59-87-PRO



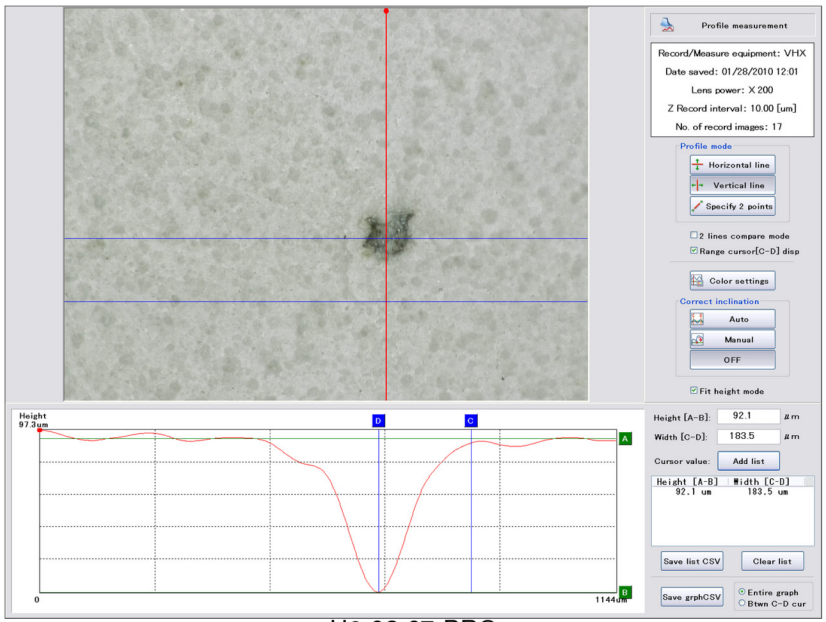
U5-91-21-PRO



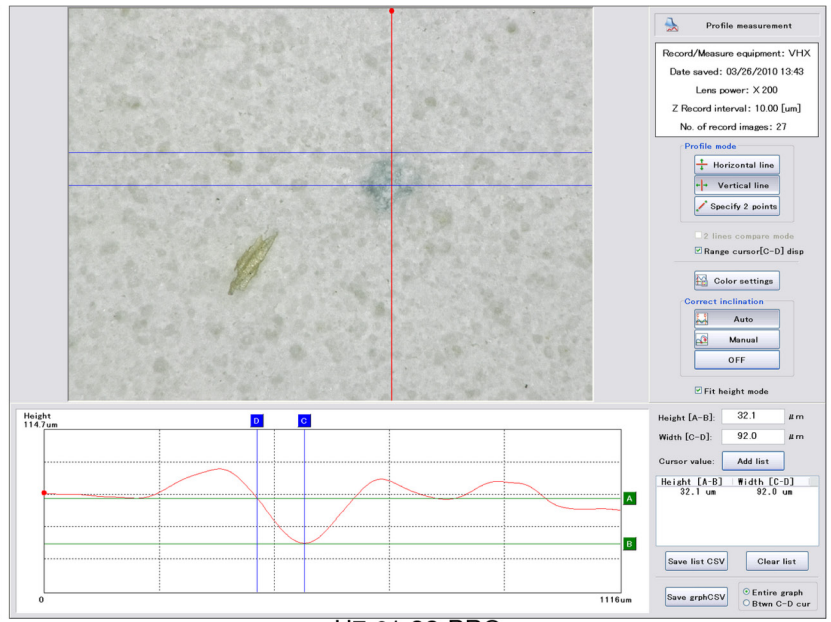
U6-15-87-PRO



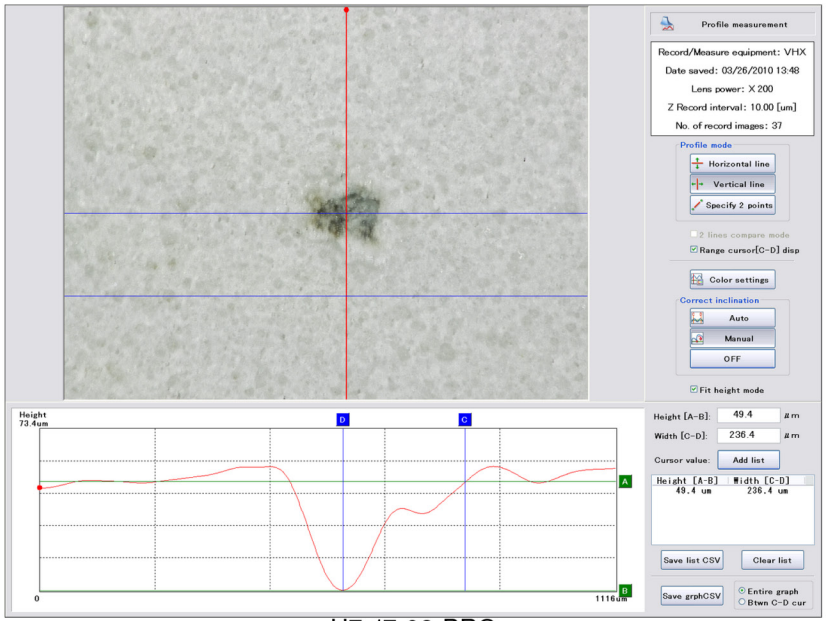
U6-46-68-PRO



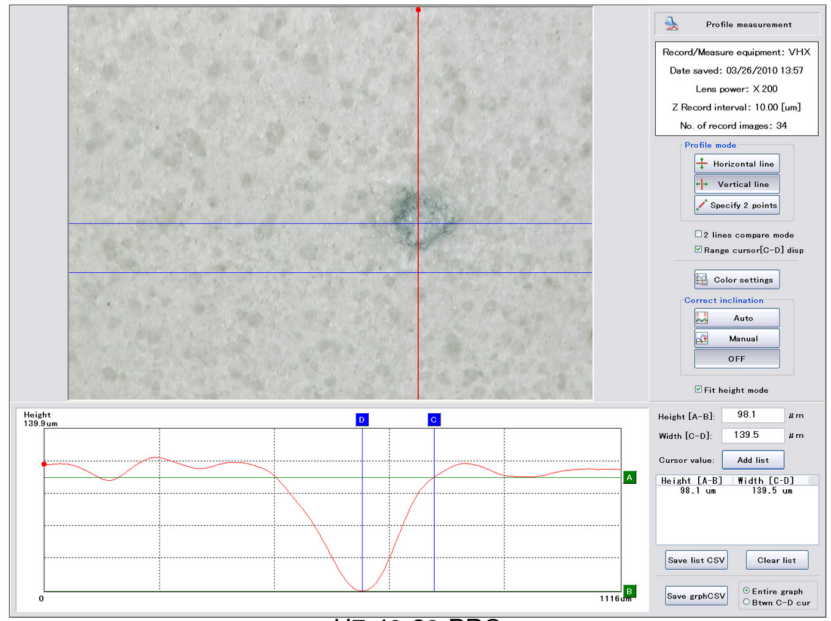
U6-92-97-PRO



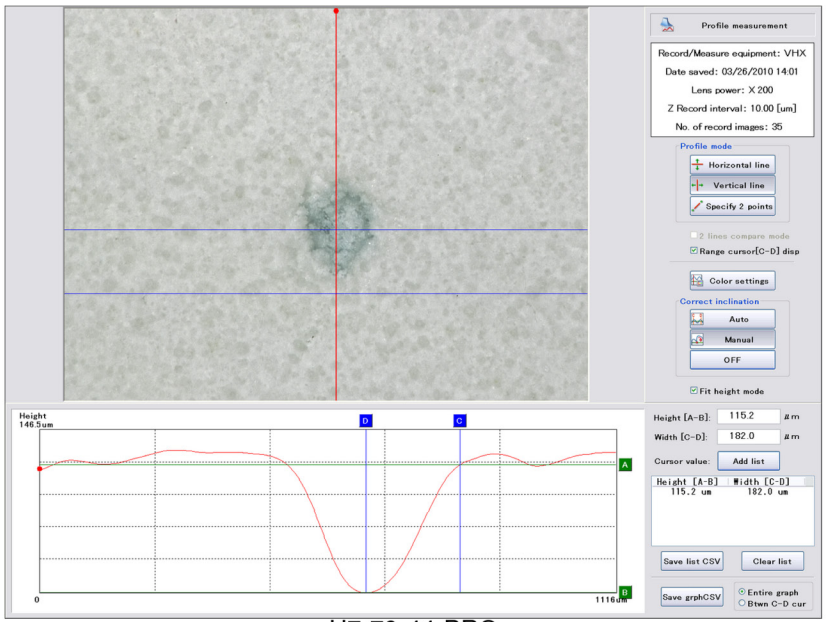
U7-01-32-PRO



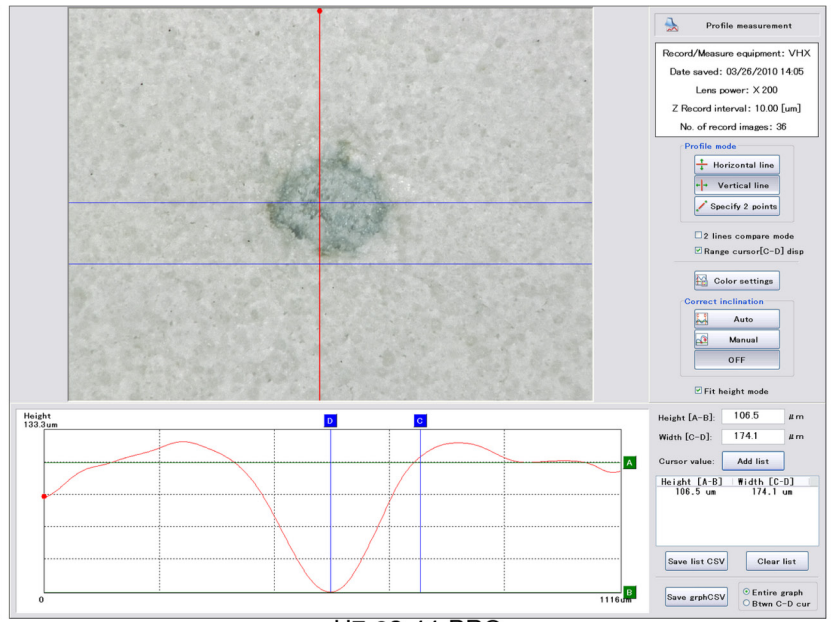
U7-17-08-PRO



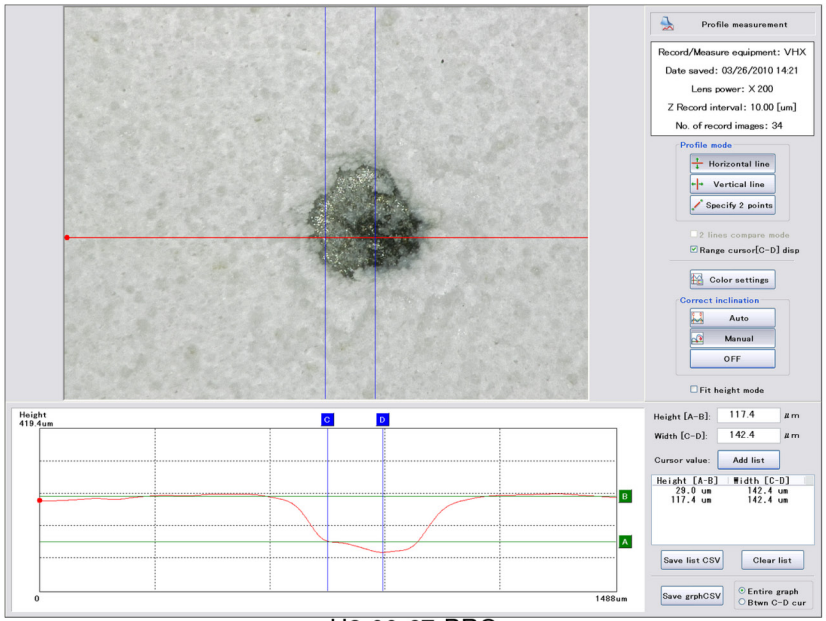
U7-40-28-PRO



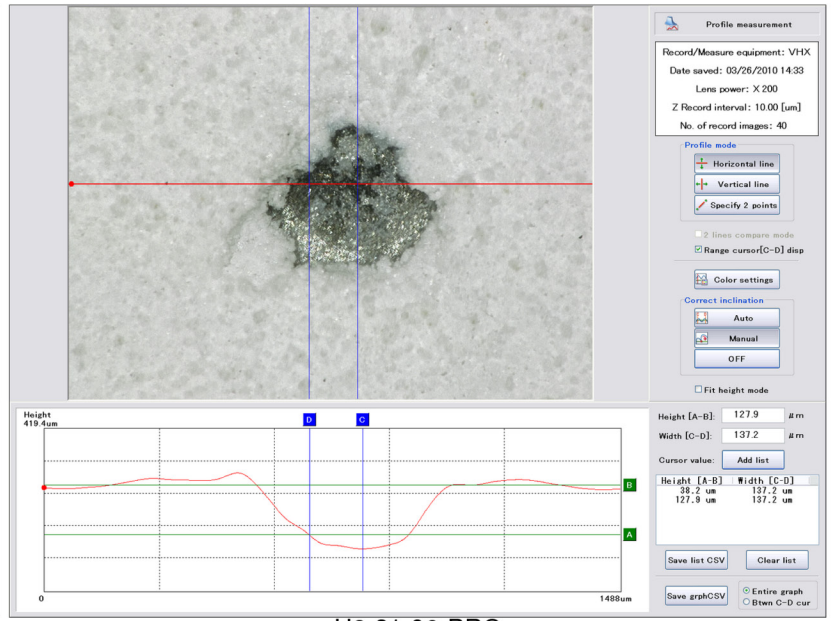
U7-79-44-PRO



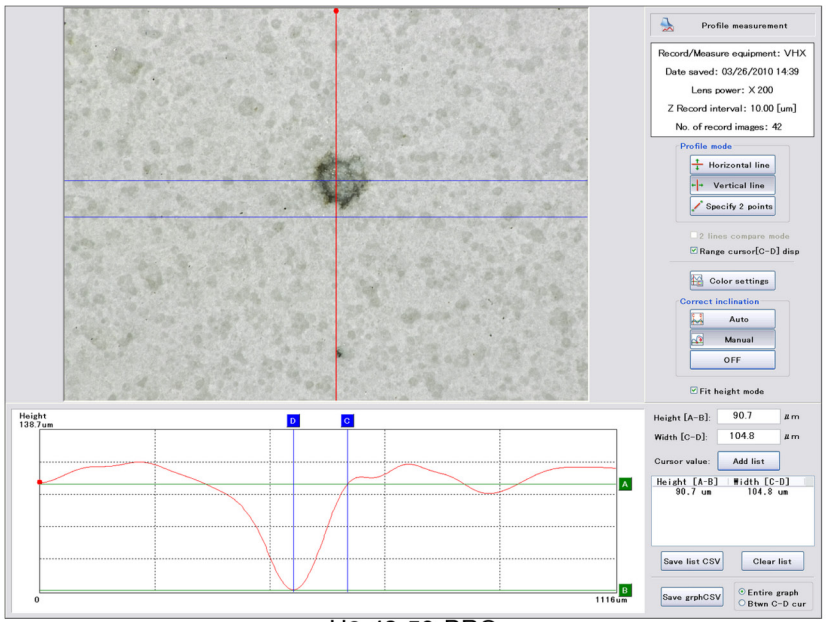
U7-82-44-PRO



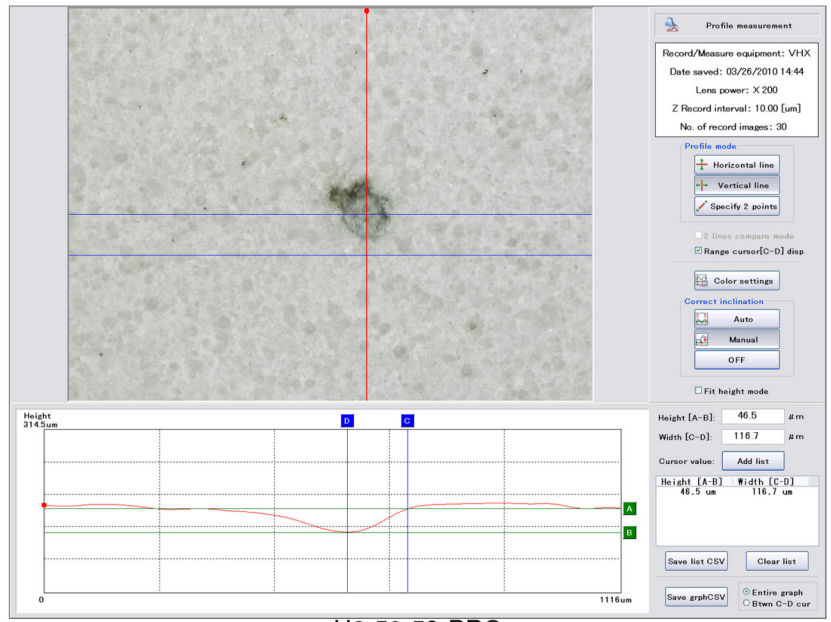
U8-00-67-PRO



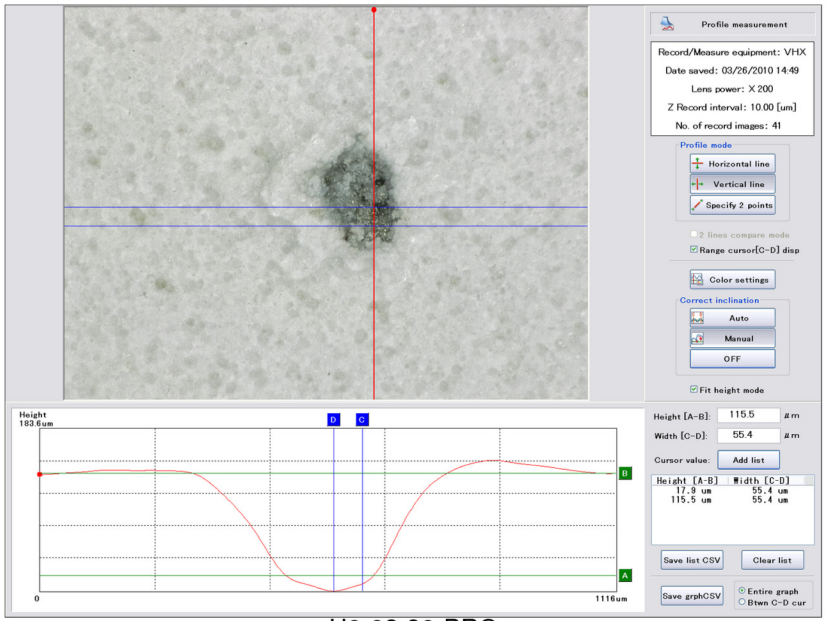
U8-31-96-PRO



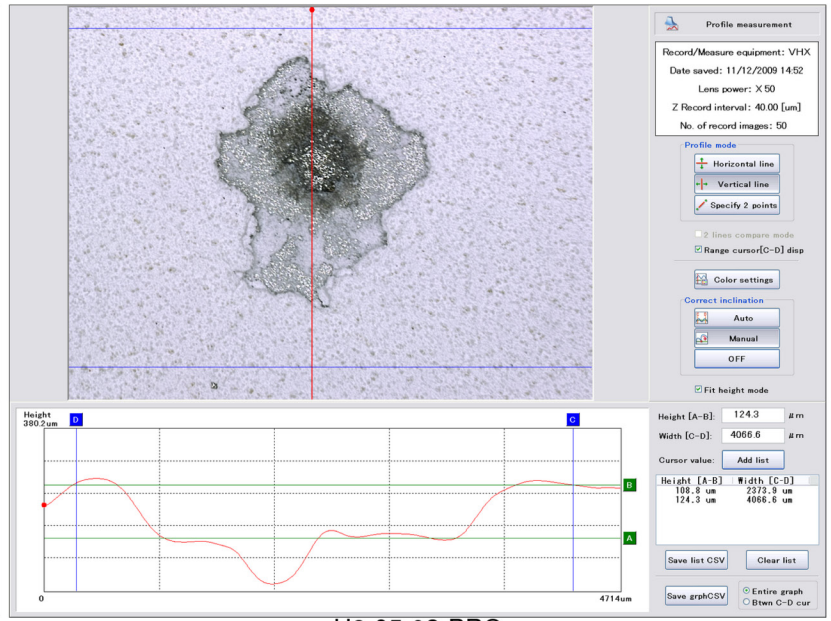
U8-43-59-PRO



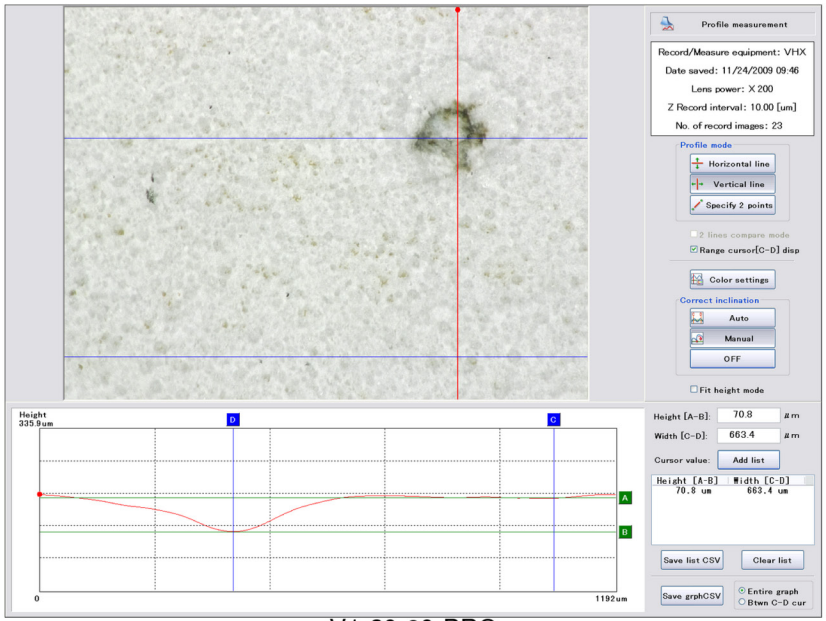
U8-50-59-PRO



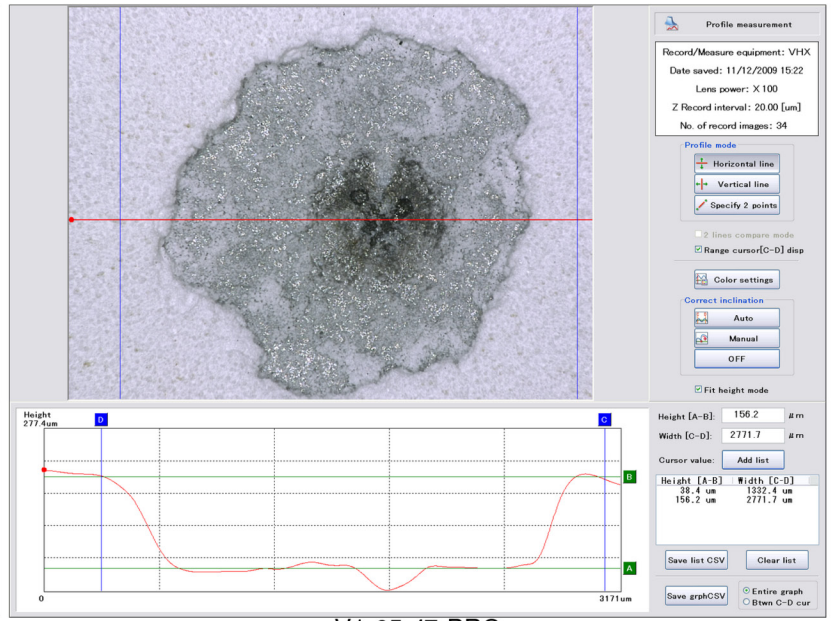
U8-82-38-PRO



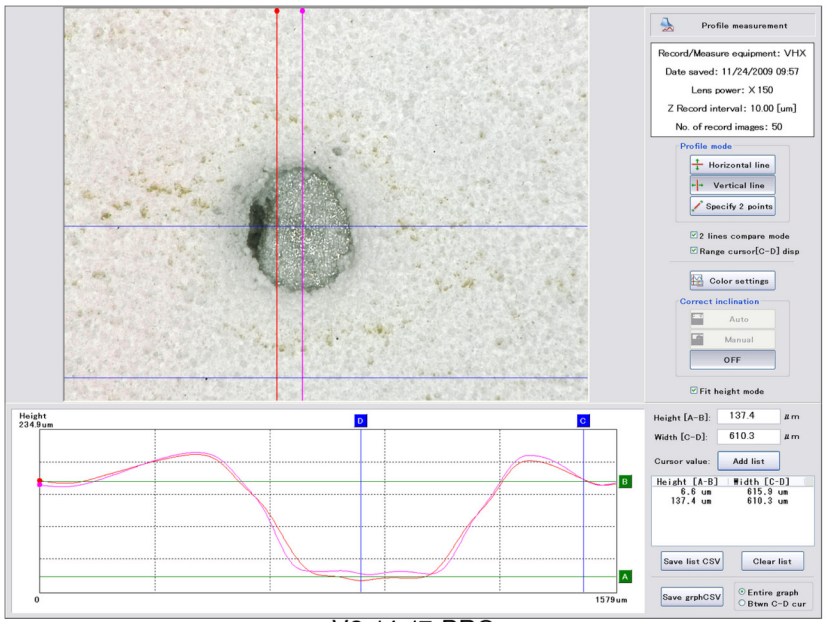
U8-95-02-PRO



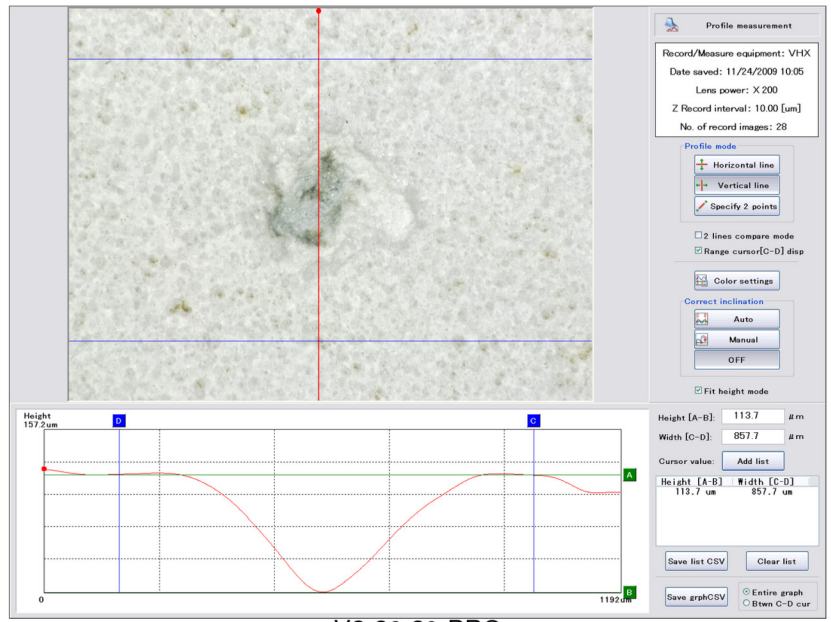
V1-29-89-PRO



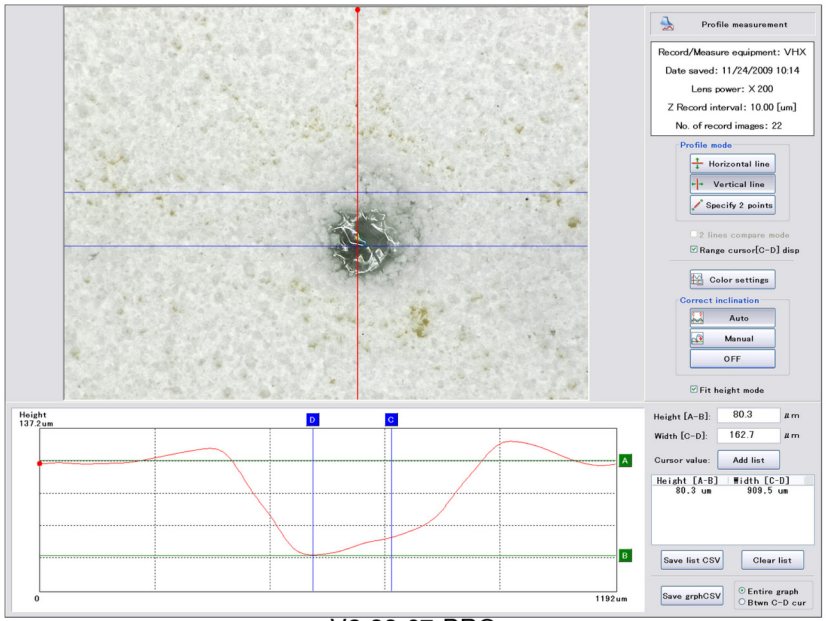
V1-65-47-PRO



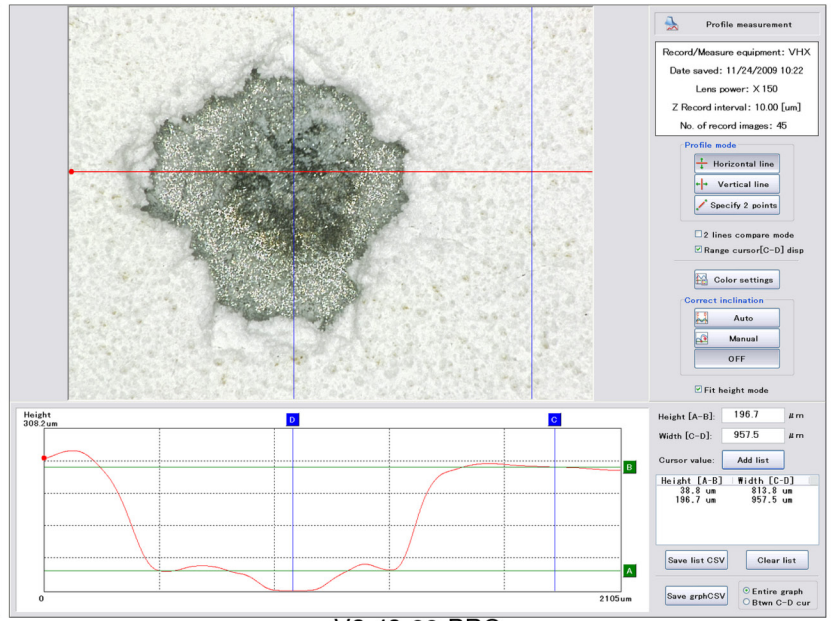
V2-14-17-PRO



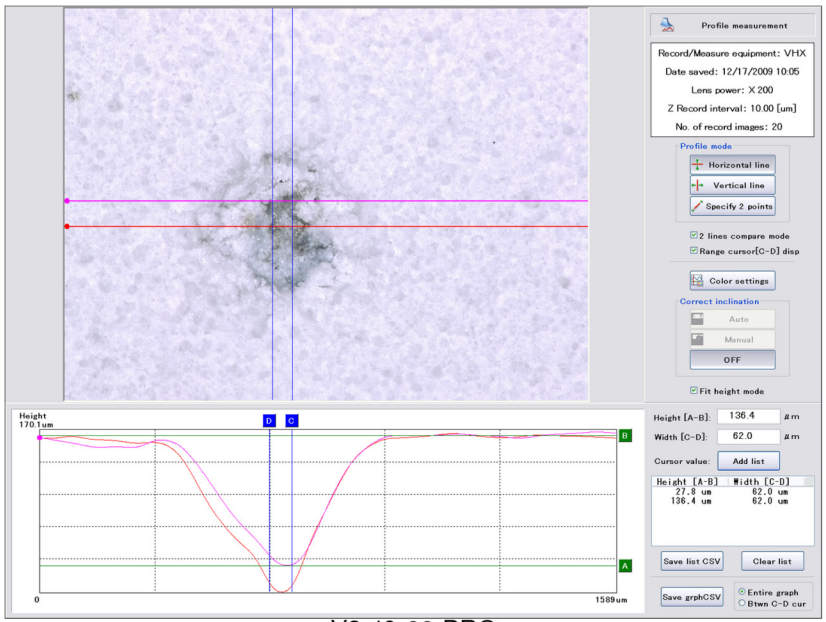
V2-26-20-PRO



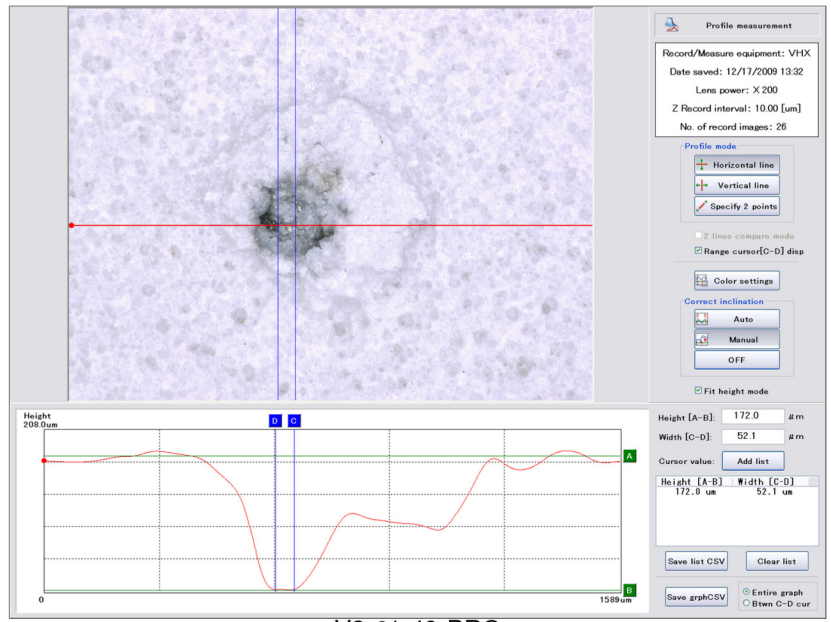
V2-33-97-PRO



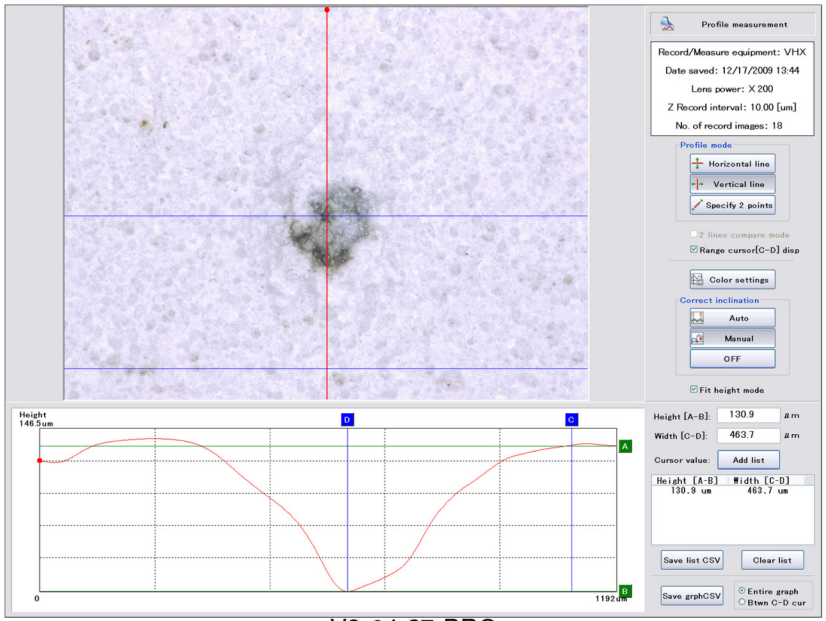
V2-43-88-PRO



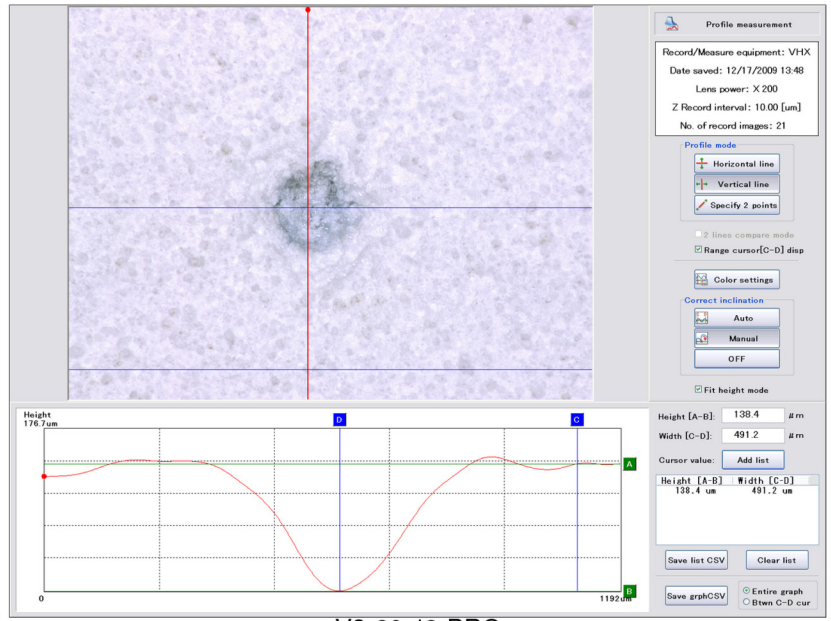
V3-19-66-PRO



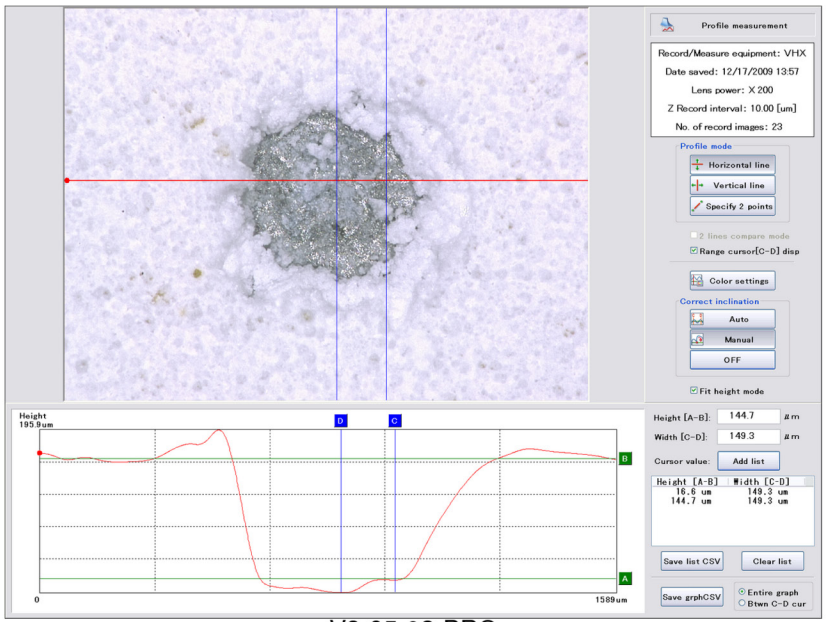
V3-61-49-PRO



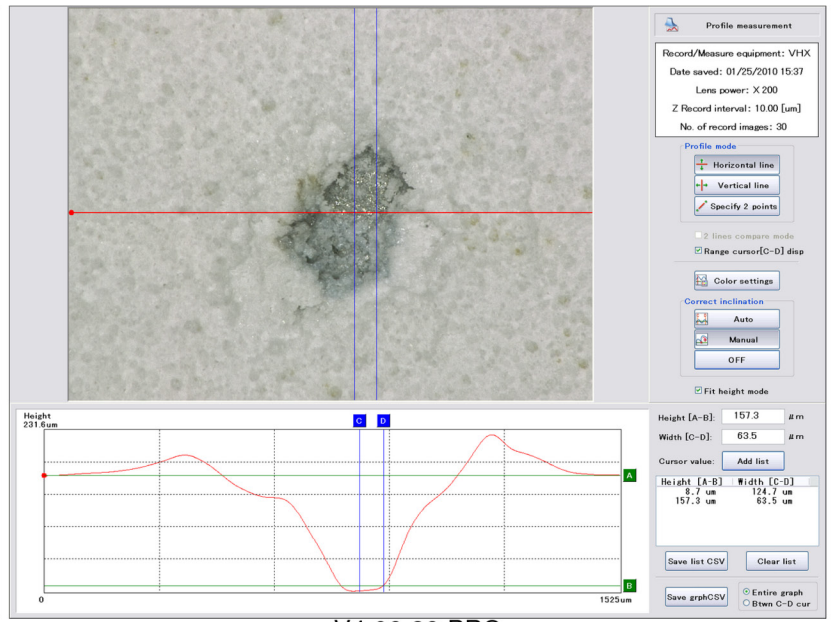
V3-64-27-PRO



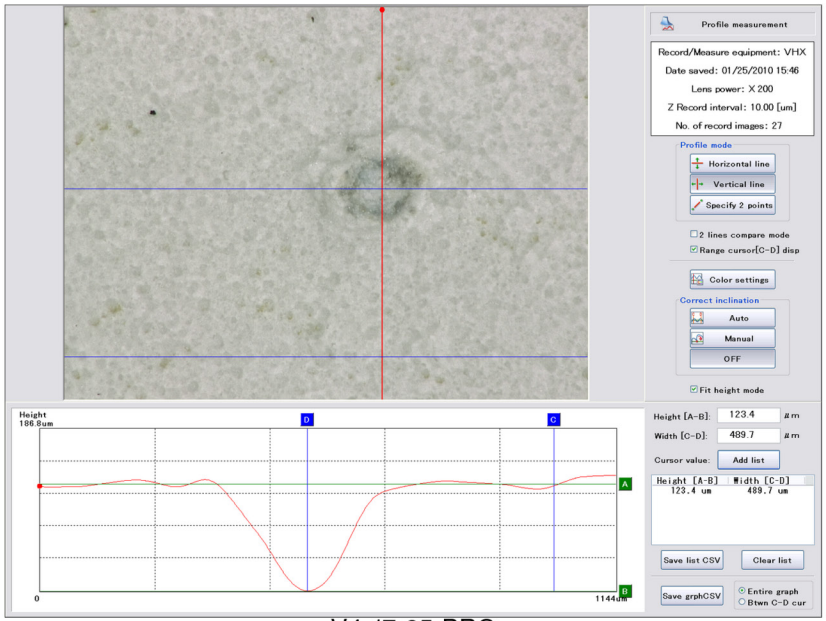
V3-80-18-PRO



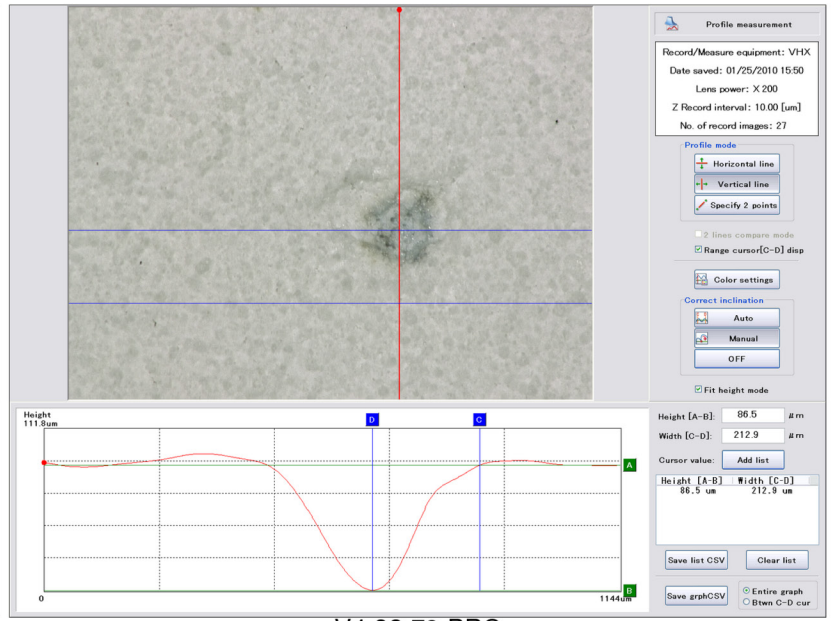
V3-95-02-PRO



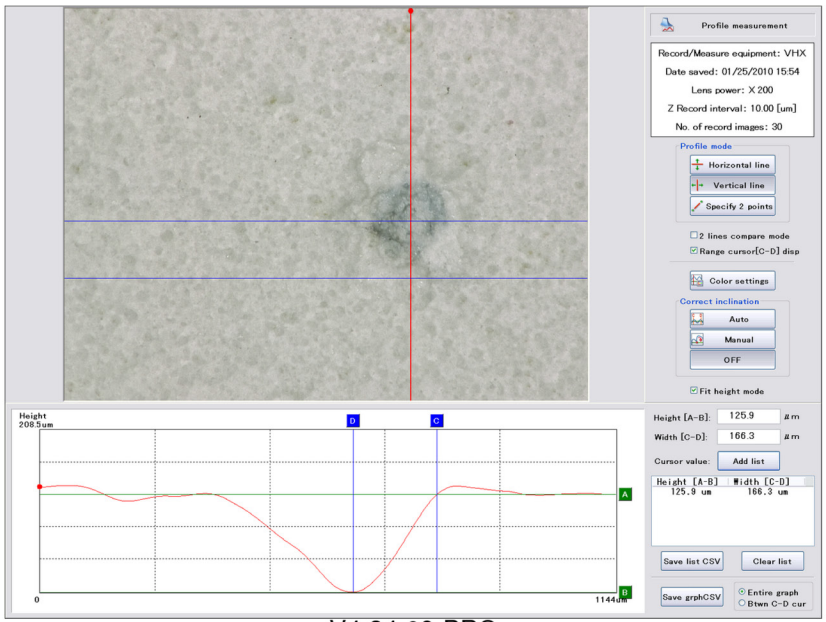
V4-06-86-PRO



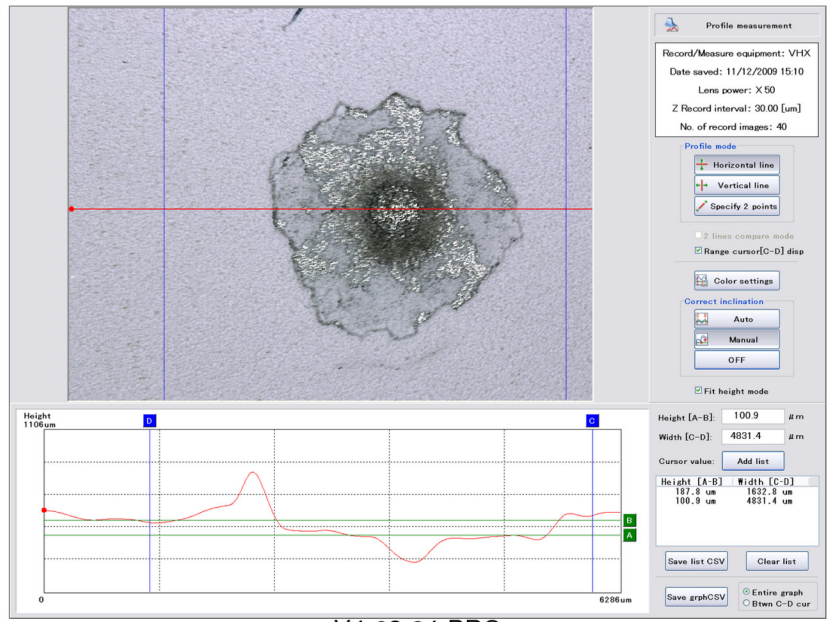
V4-17-85-PRO



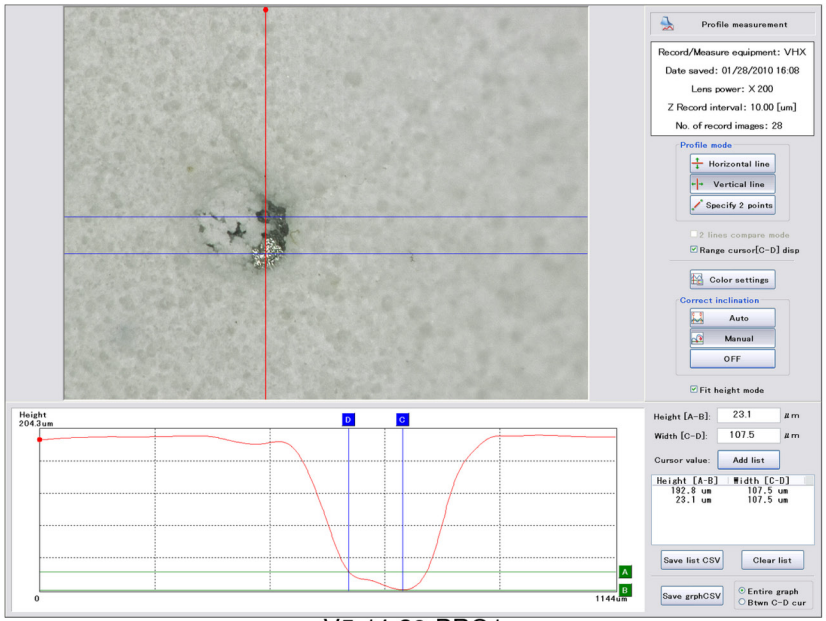
V4-32-78-PRO



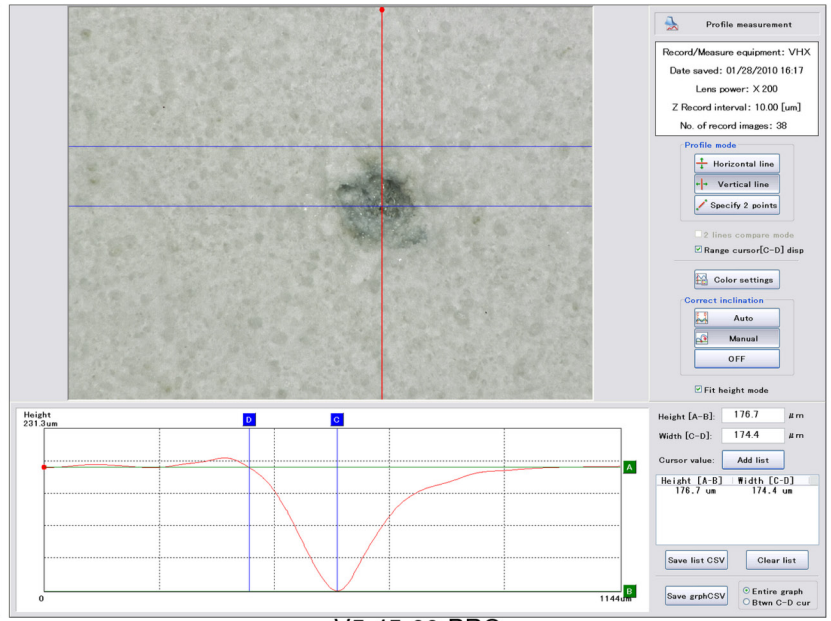
V4-34-09-PRO



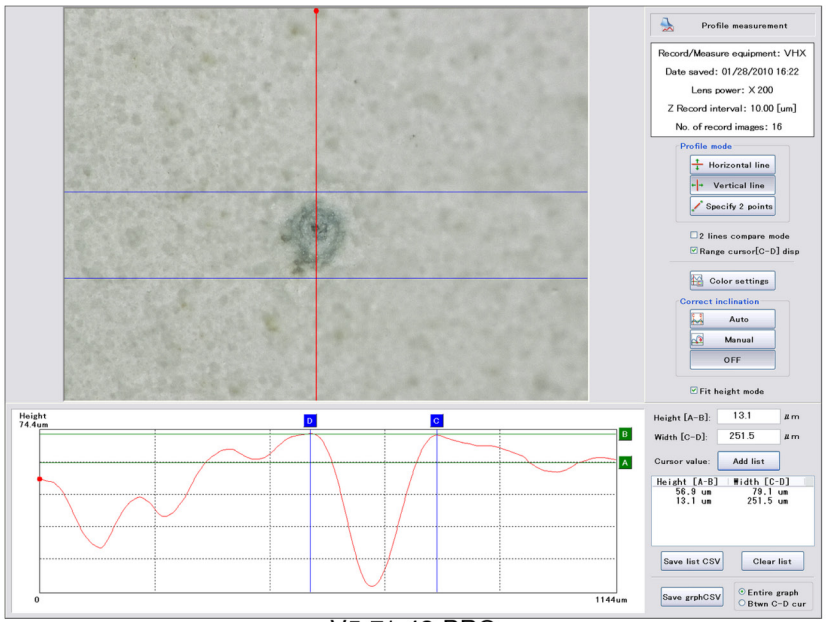
V4-62-84-PRO



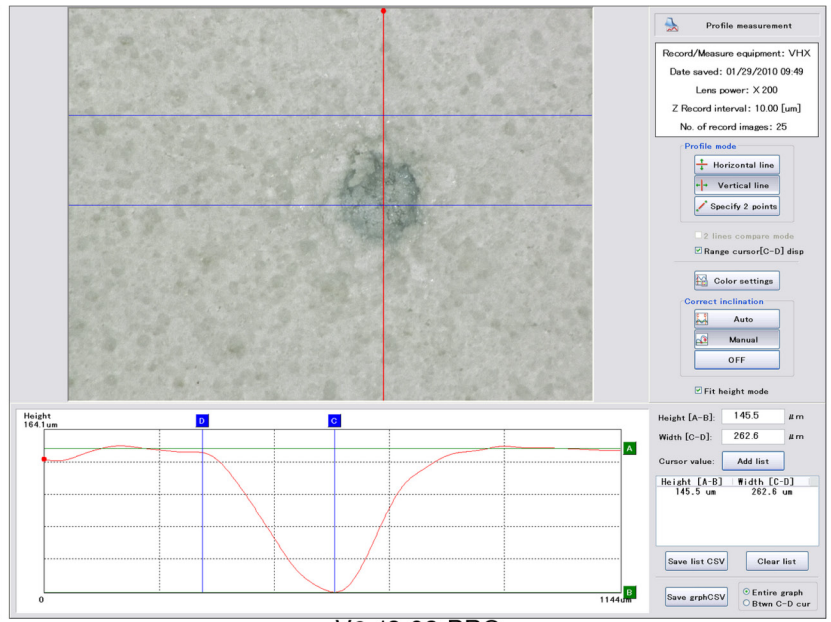
V5-14-28-PRO1



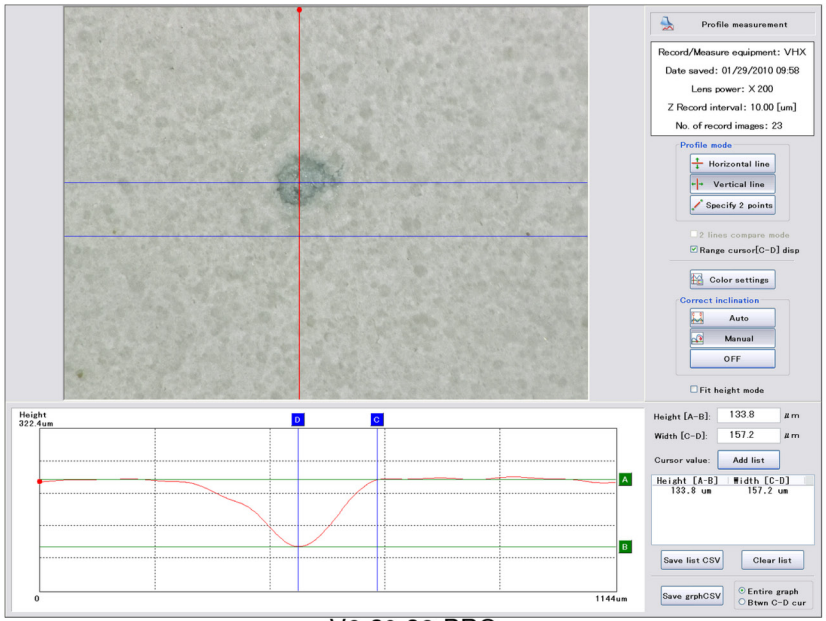
V5-45-66-PRO



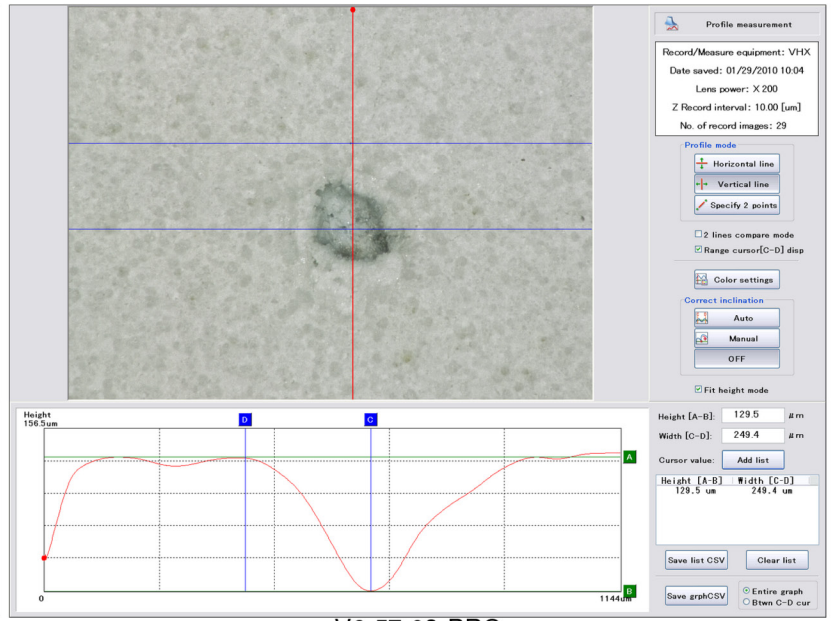
V5-71-42-PRO



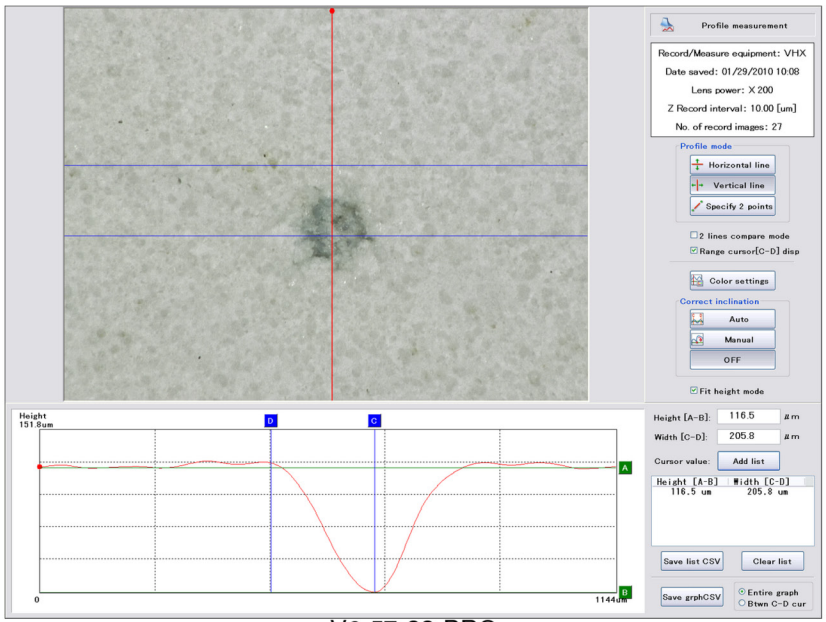
V6-13-92-PRO



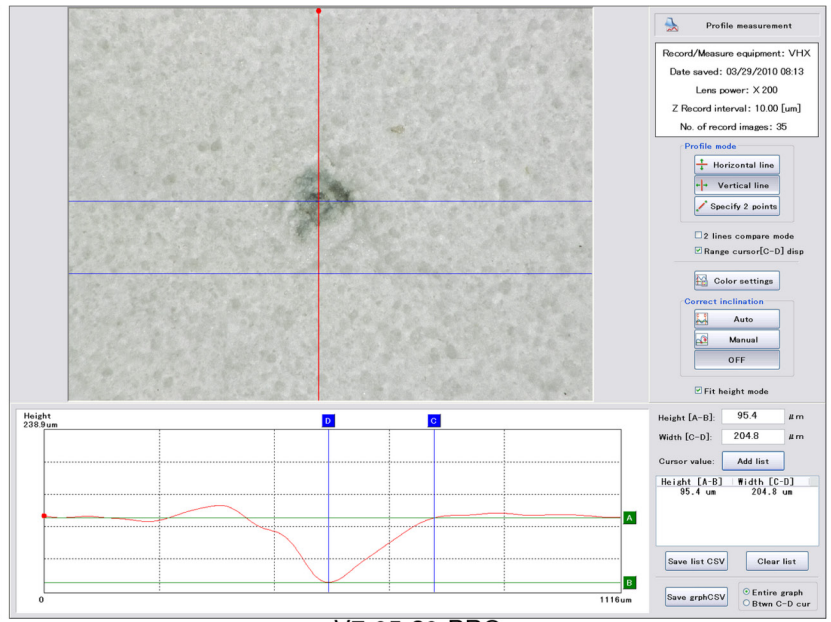
V6-20-38-PRO



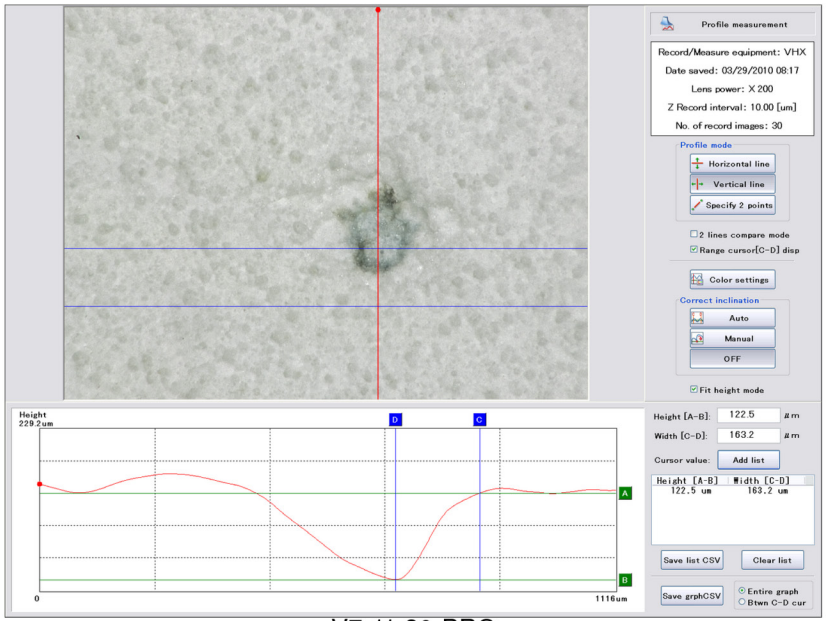
V6-57-03-PRO



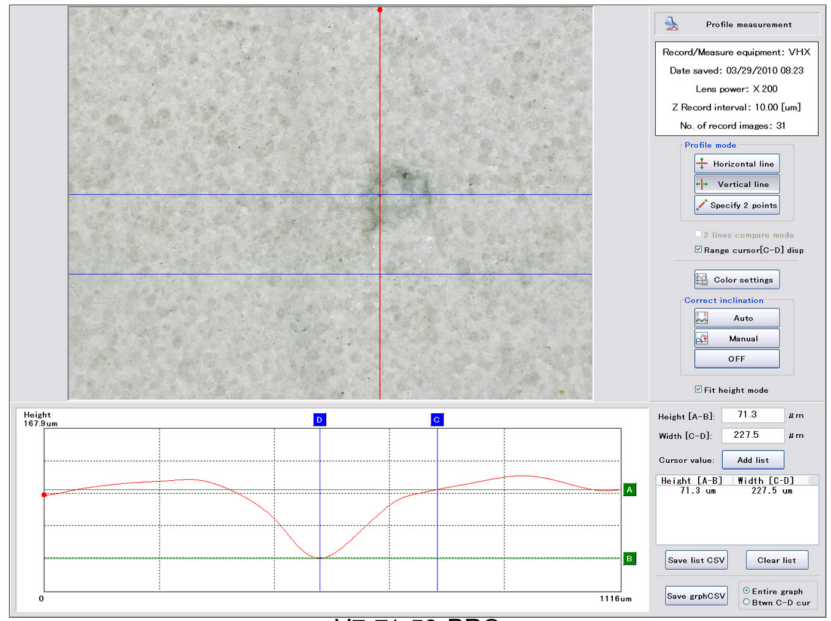
V6-57-22-PRO



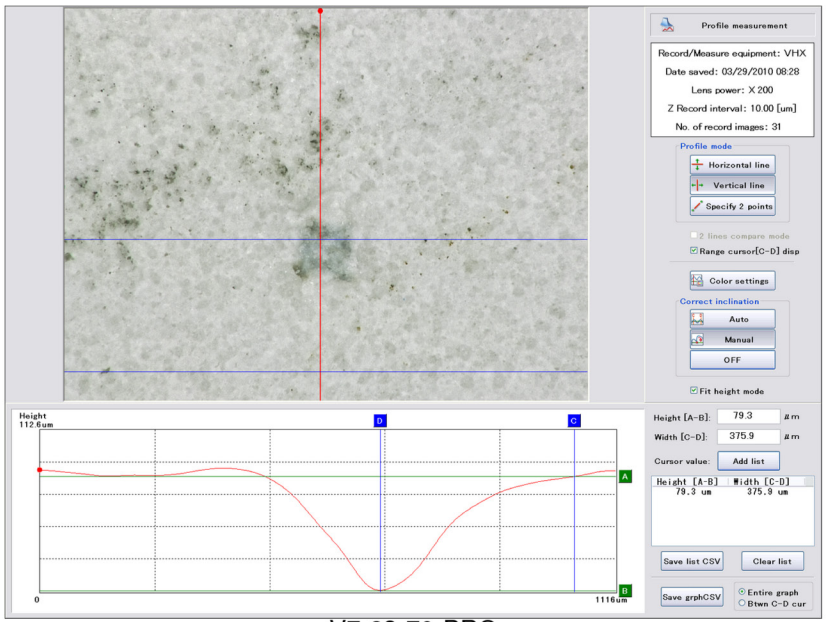
V7-05-20-PRO



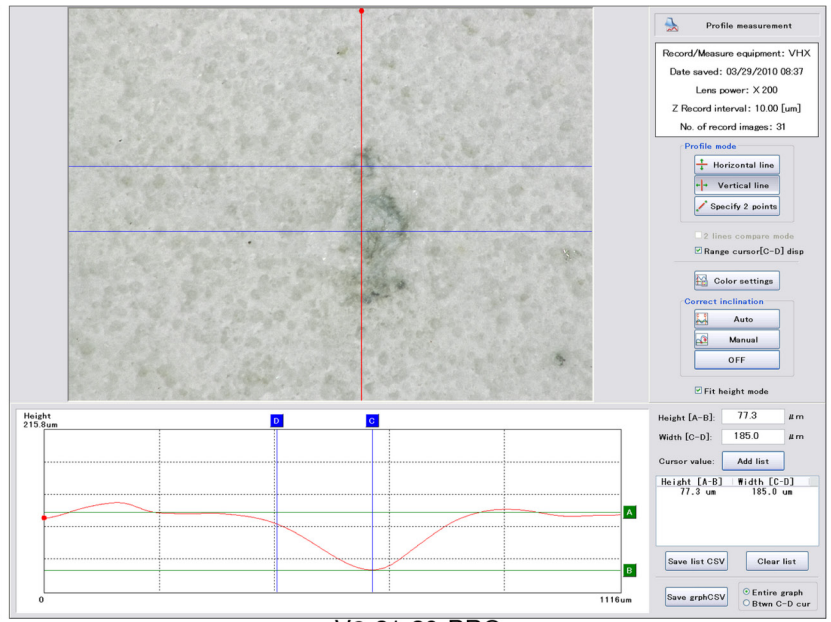
V7-11-30-PRO



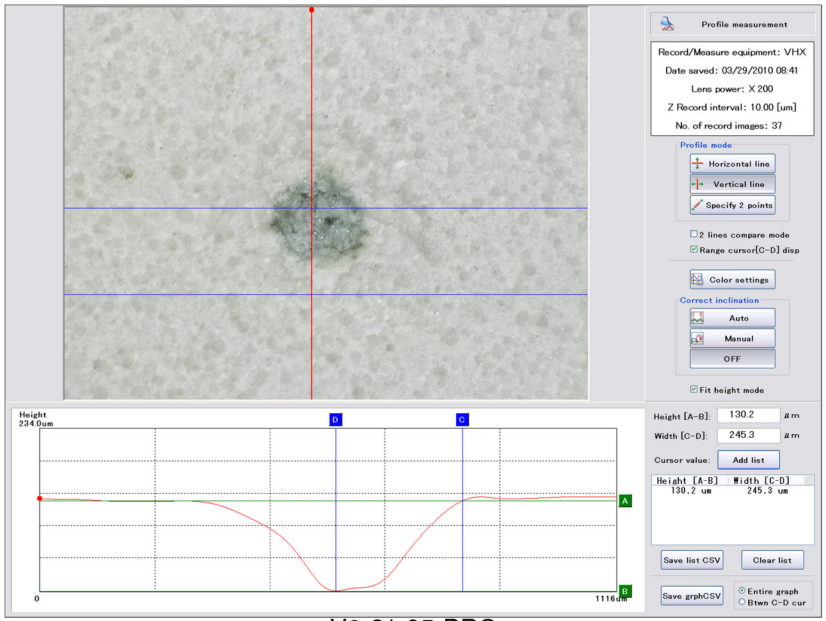
V7-71-59-PRO



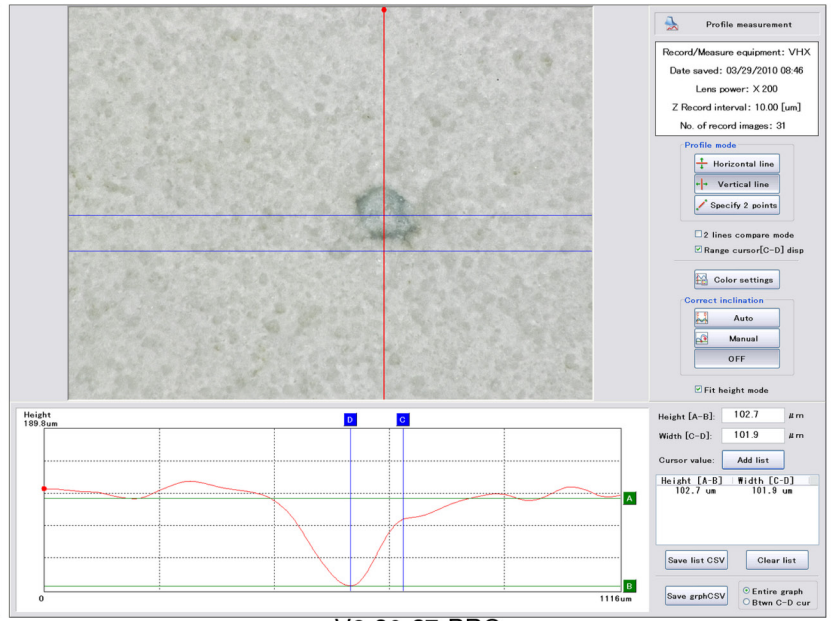
V7-83-70-PRO



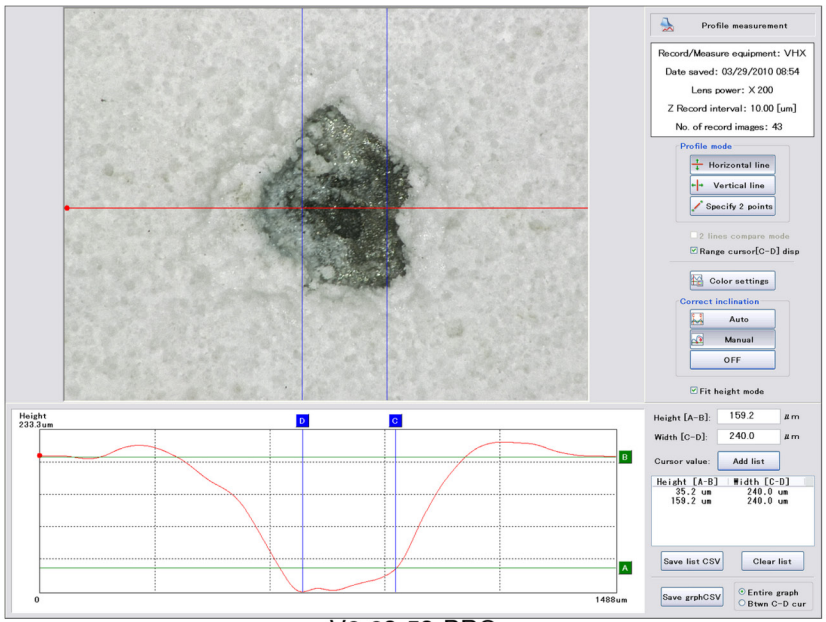
V8-21-29-PRO



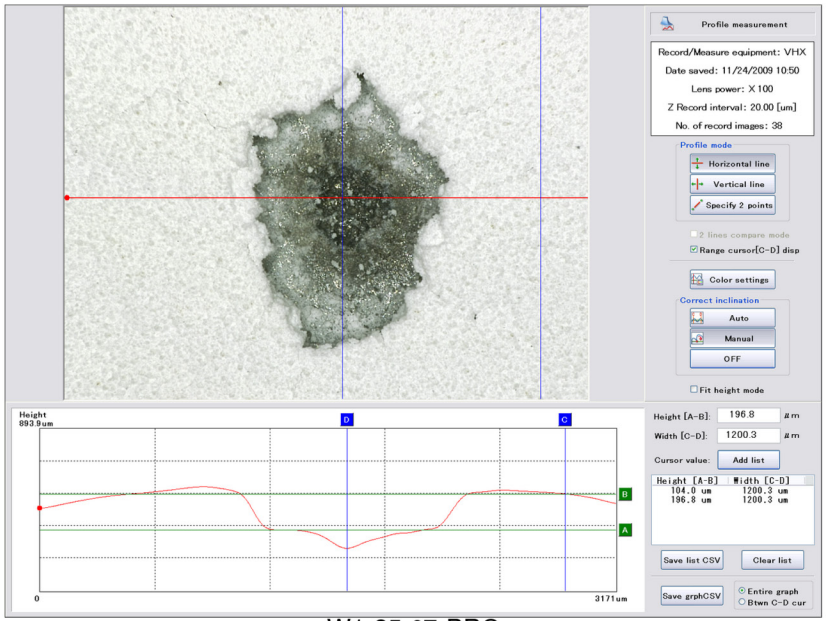
V8-21-95-PRO



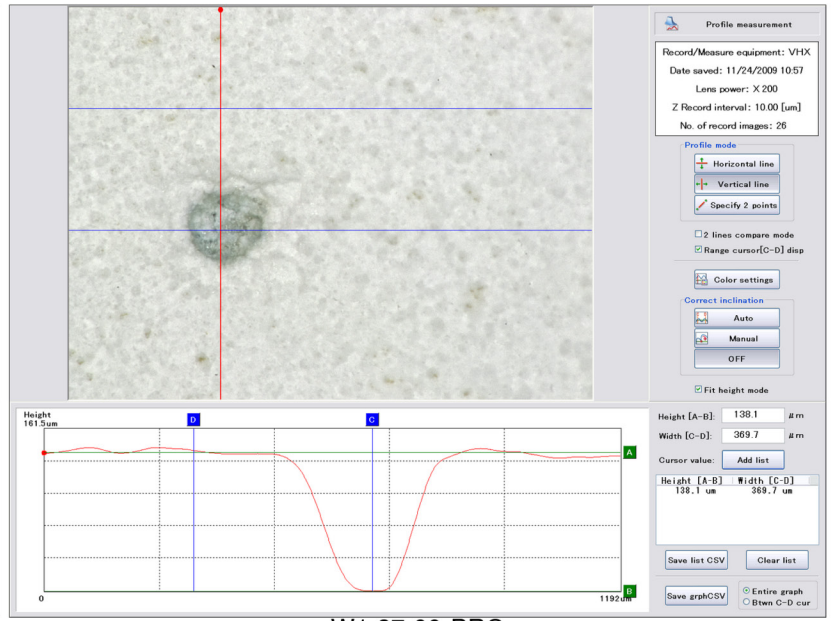
V8-30-27-PRO



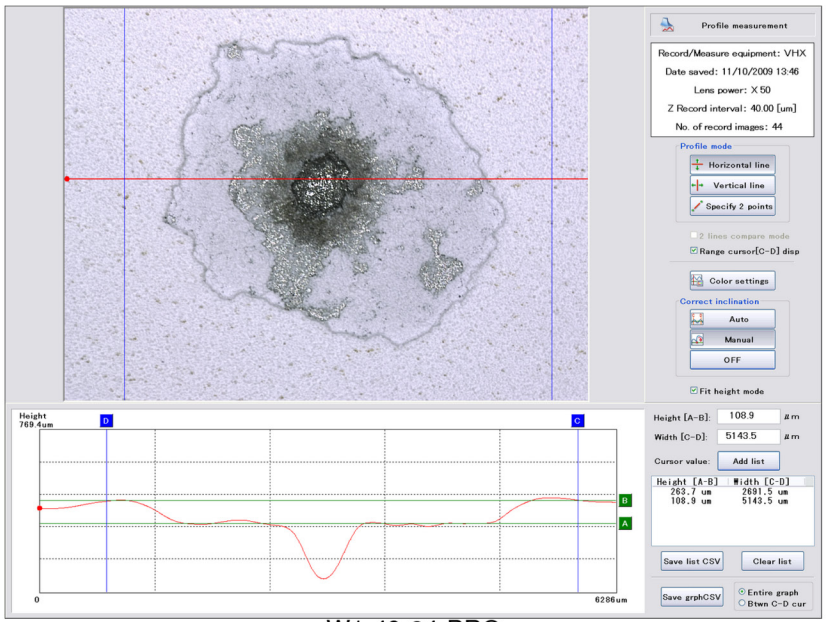
V8-83-53-PRO



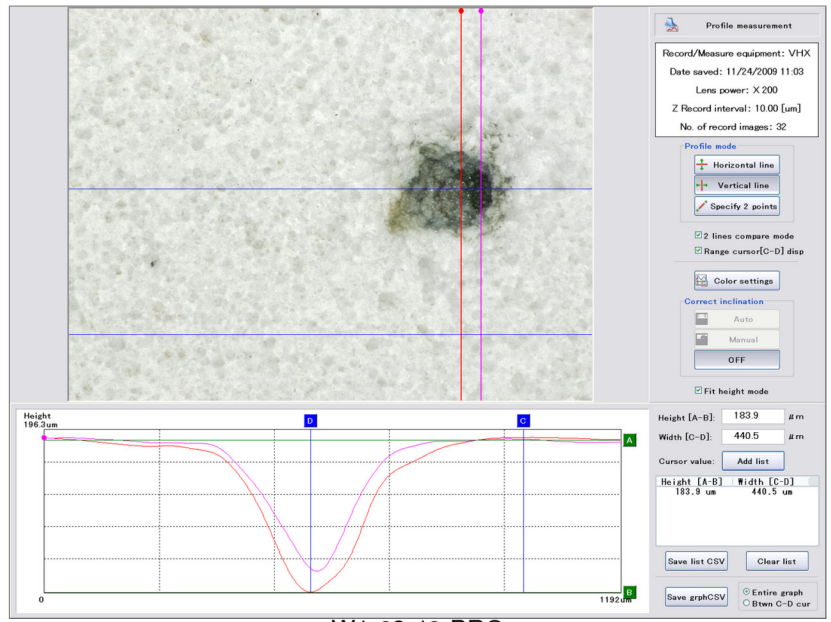
W1-25-07-PRO



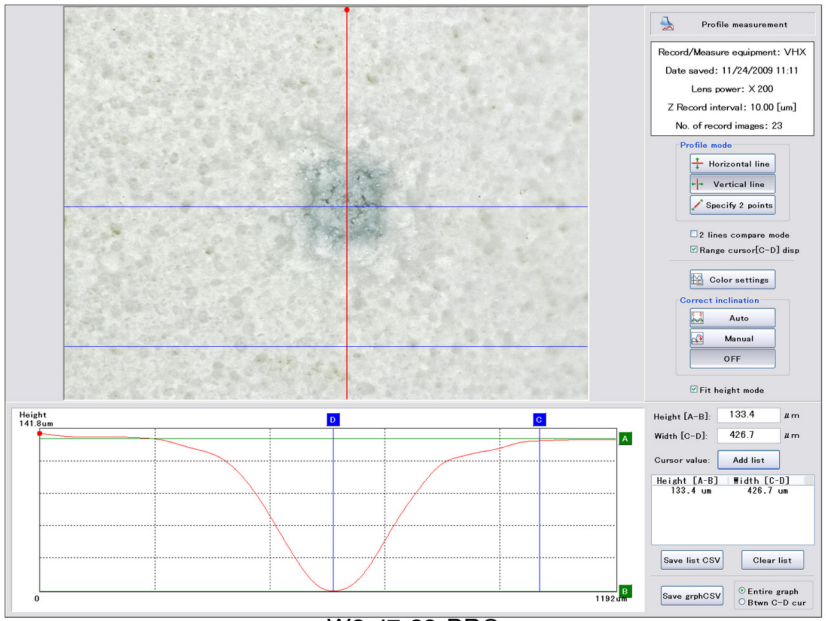
W1-37-99-PRO



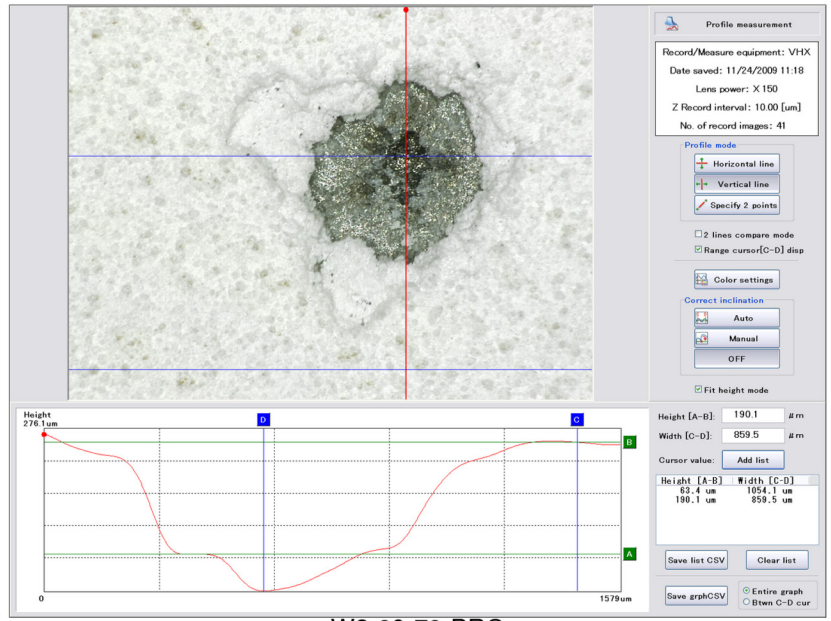
W1-49-84-PRO



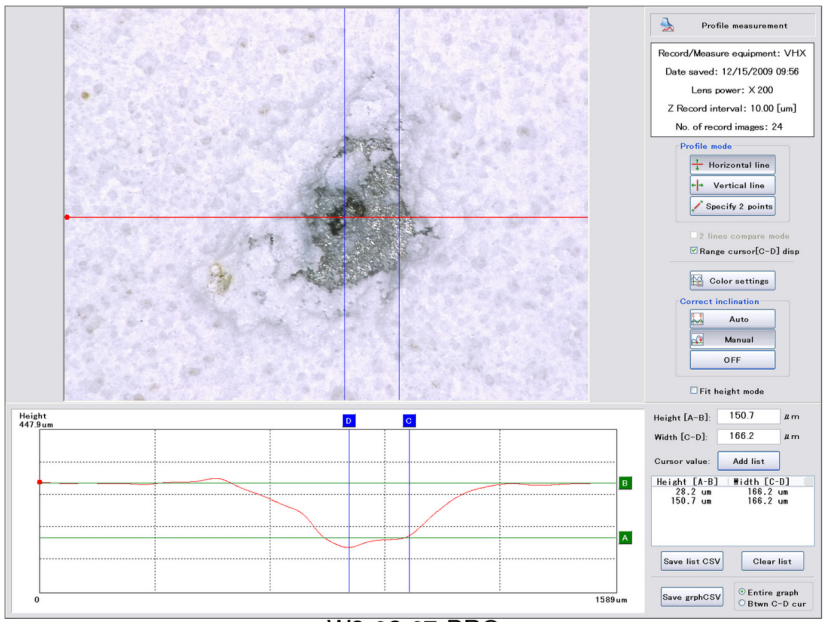
W1-63-18-PRO



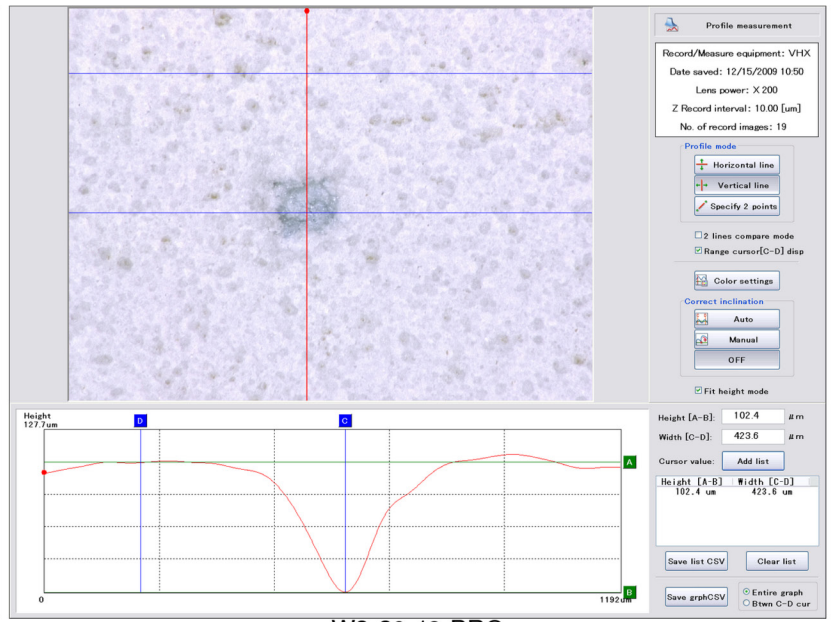
W2-47-23-PRO



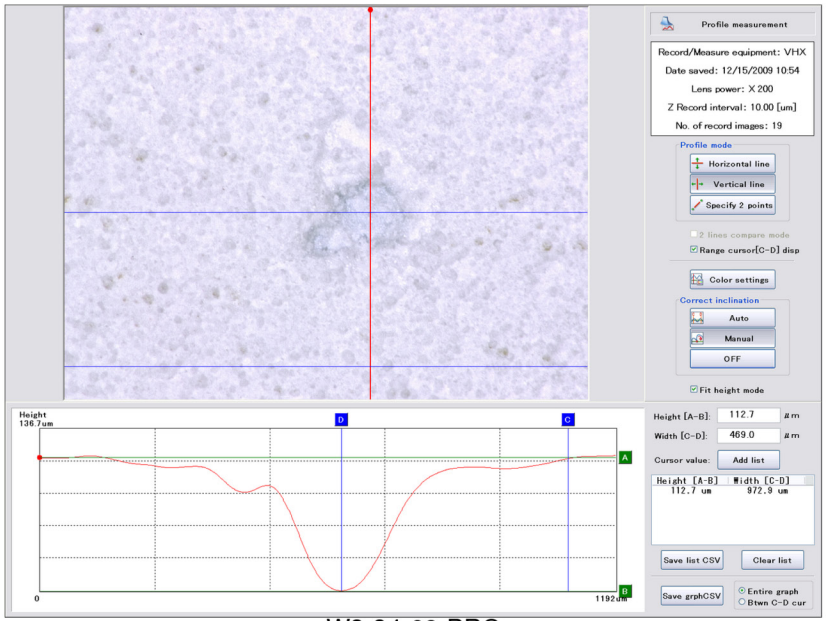
W2-89-78-PRO



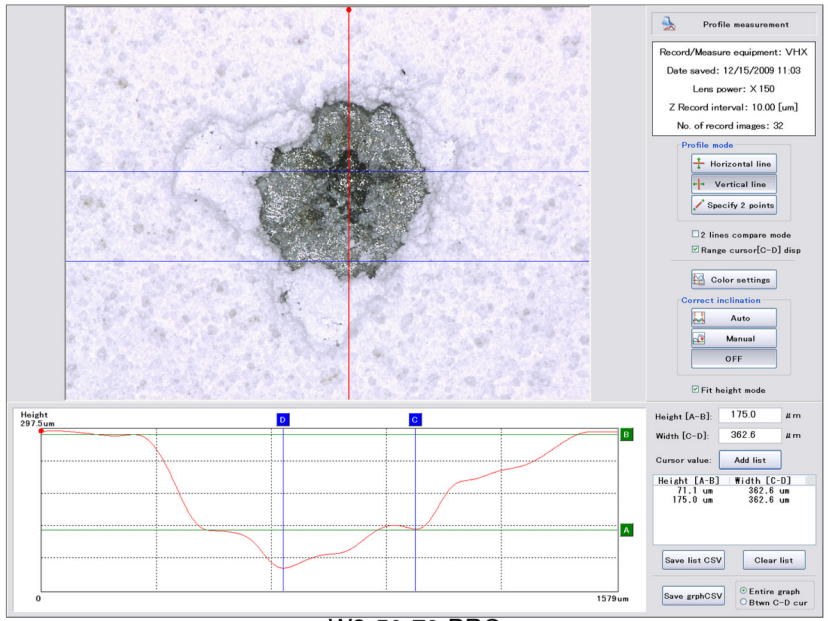
W3-02-07-PRO



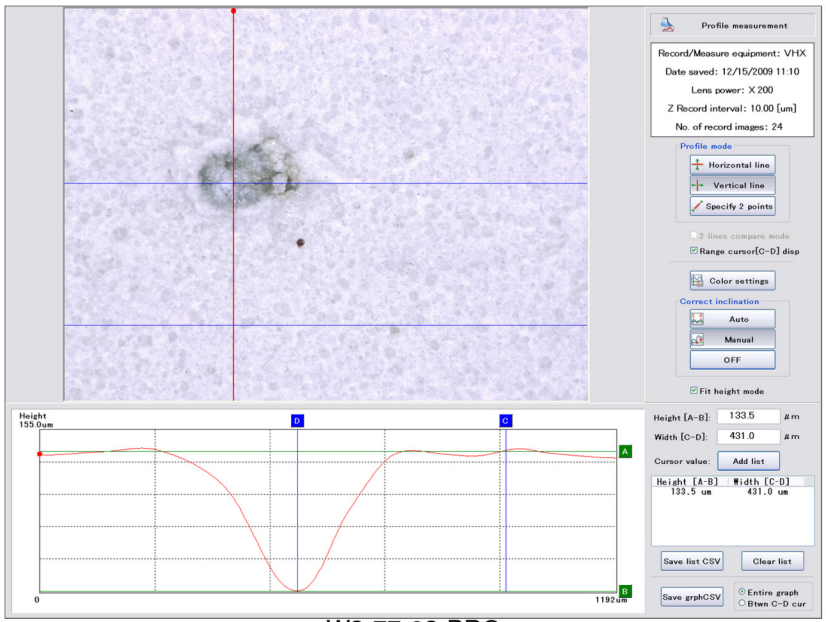
W3-20-18-PRO



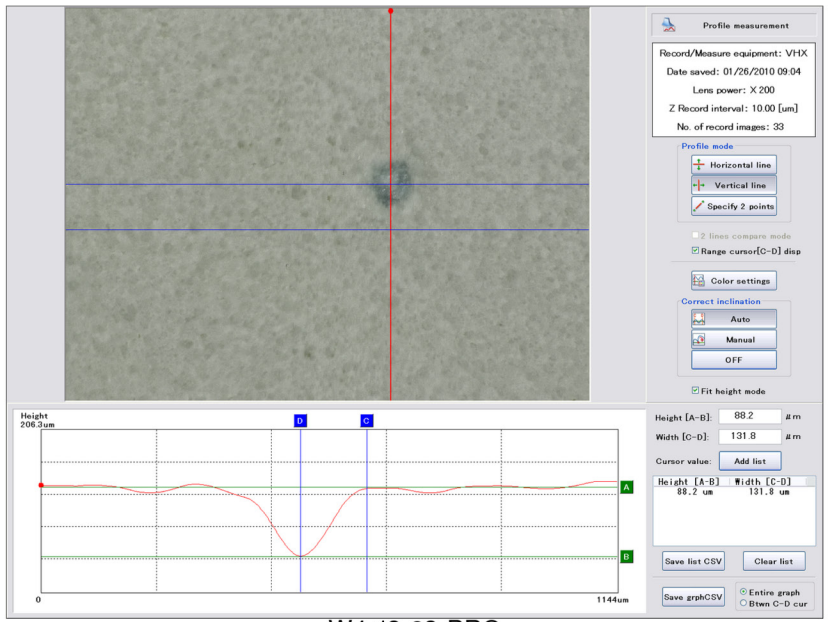
W3-34-68-PRO



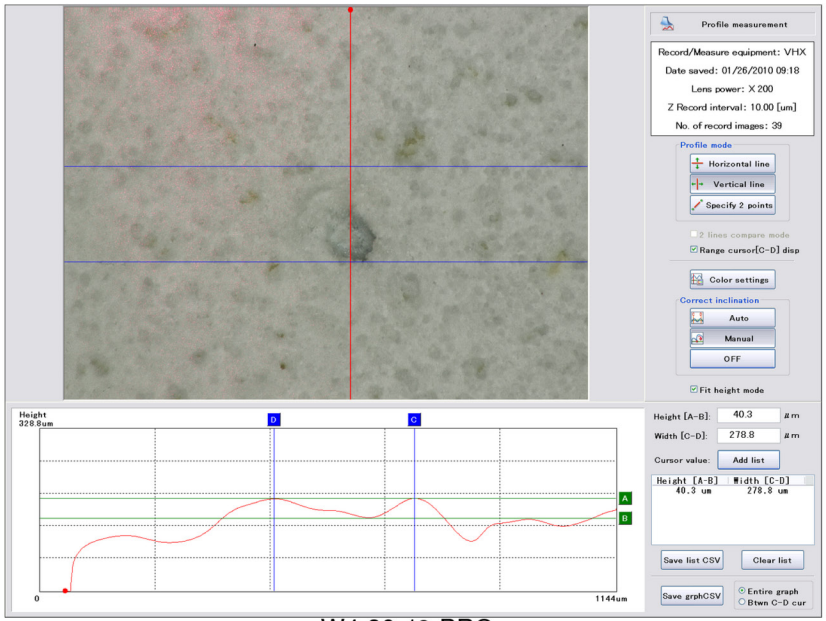
W3-50-76-PRO



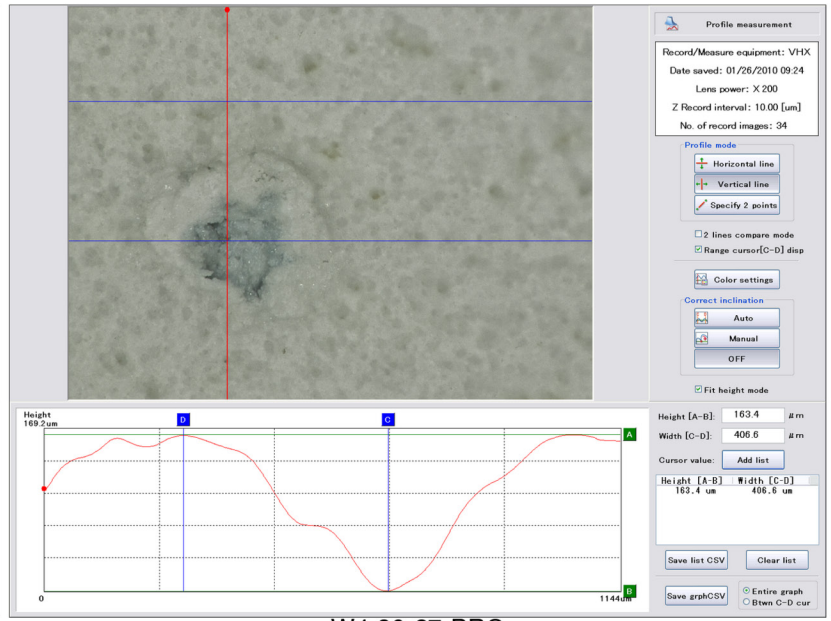
W3-77-82-PRO



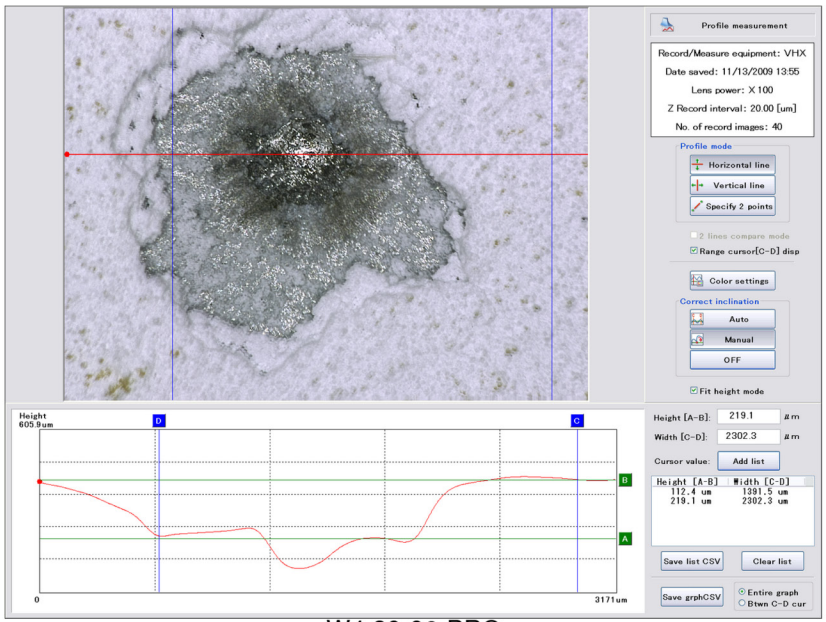
W4-13-83-PRO



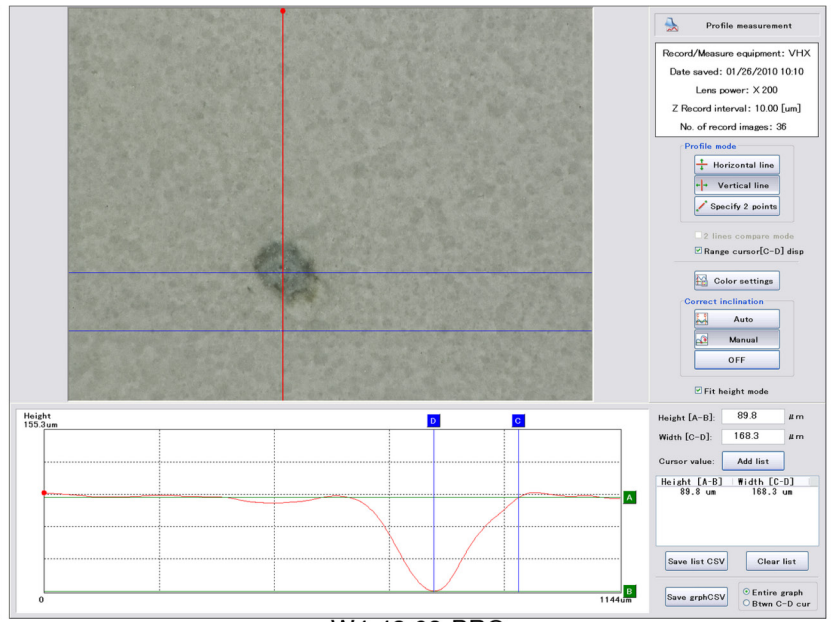
W4-39-18-PROv



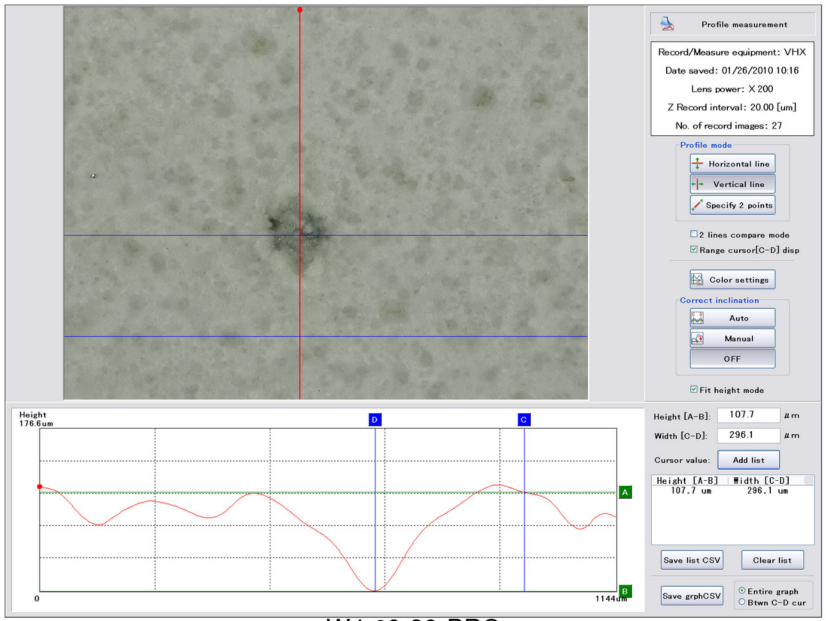
W4-39-27-PRO



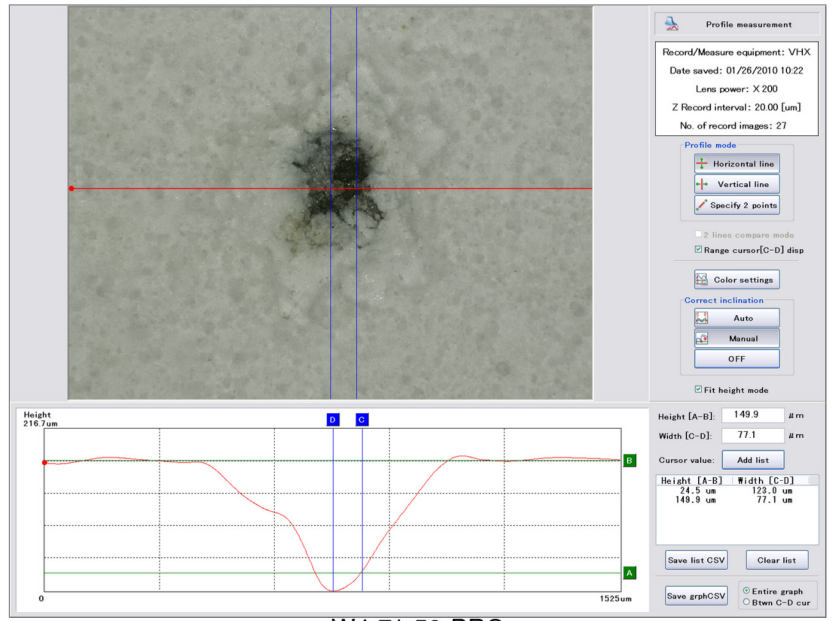
W4-39-96-PRO



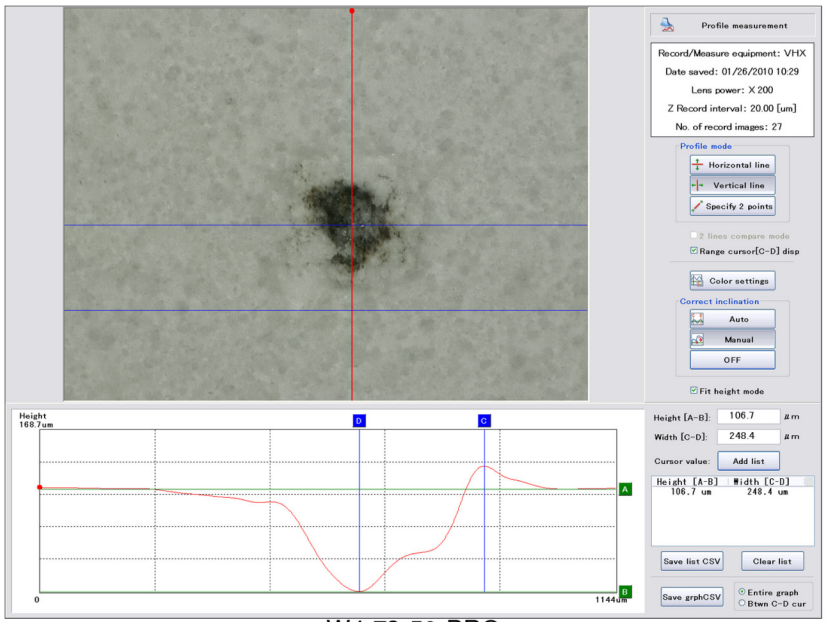
W4-42-93-PRO



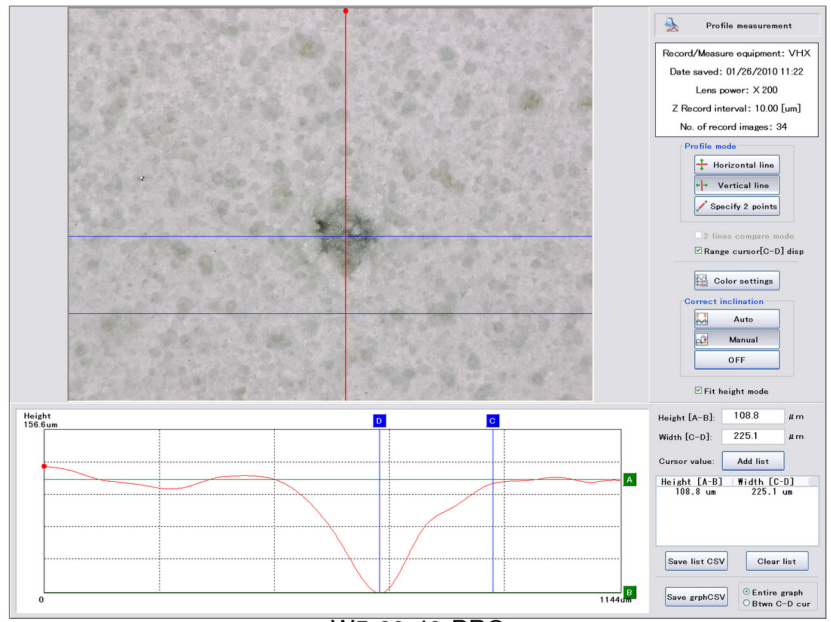
W4-69-39-PRO



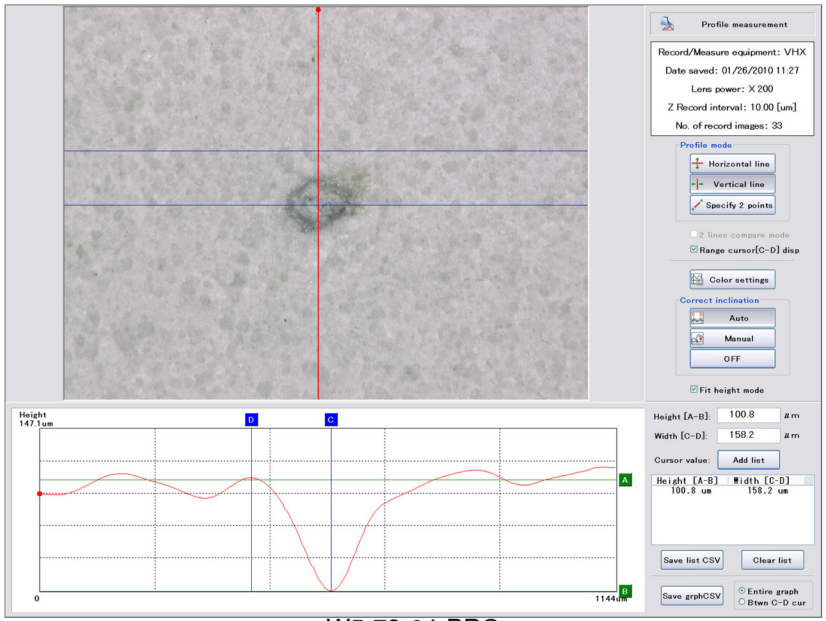
W4-71-58-PRO



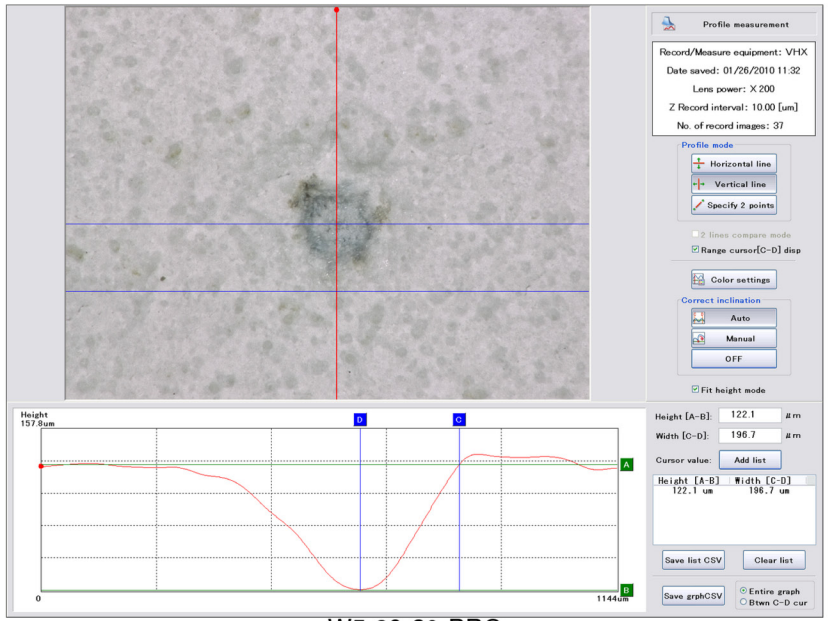
W4-73-50-PRO



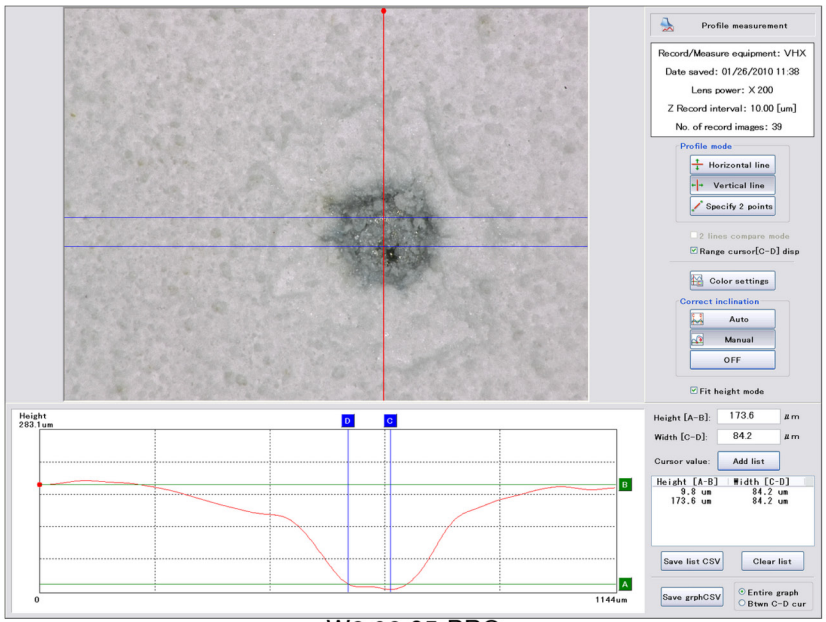
W5-60-40-PRO



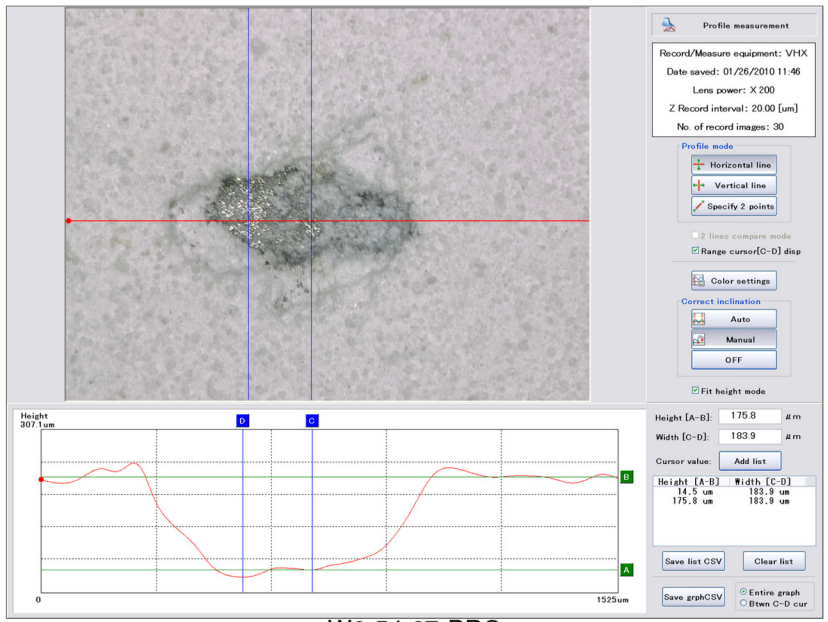
W5-72-64-PRO



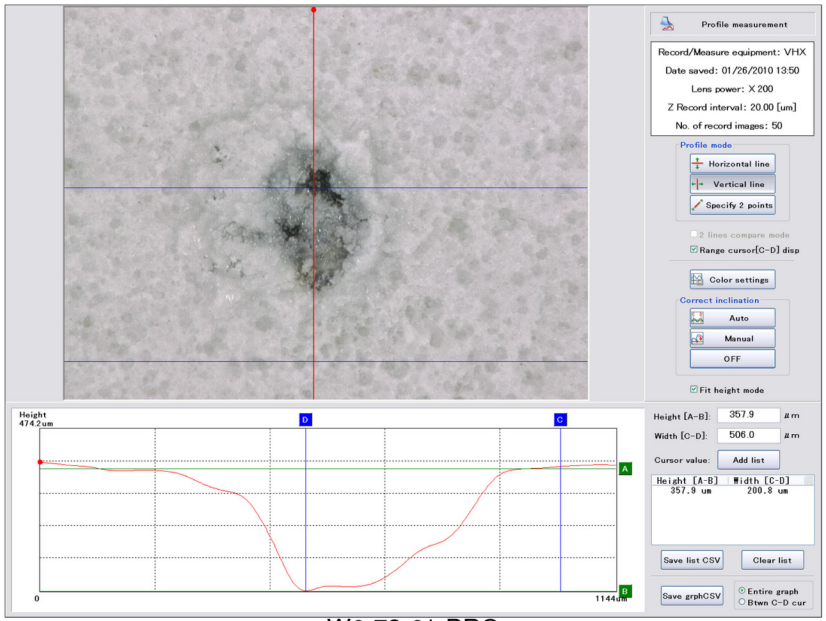
W5-89-20-PRO



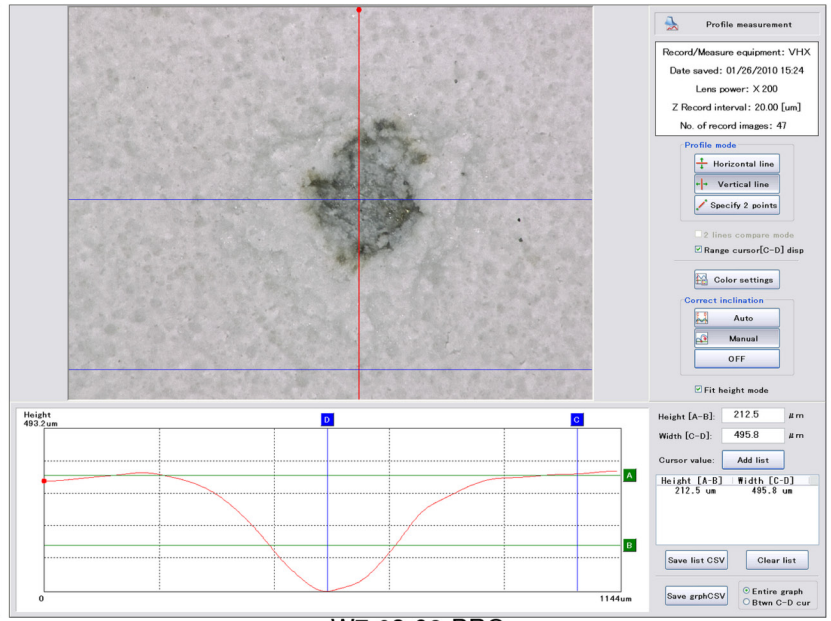
W6-06-95-PRO



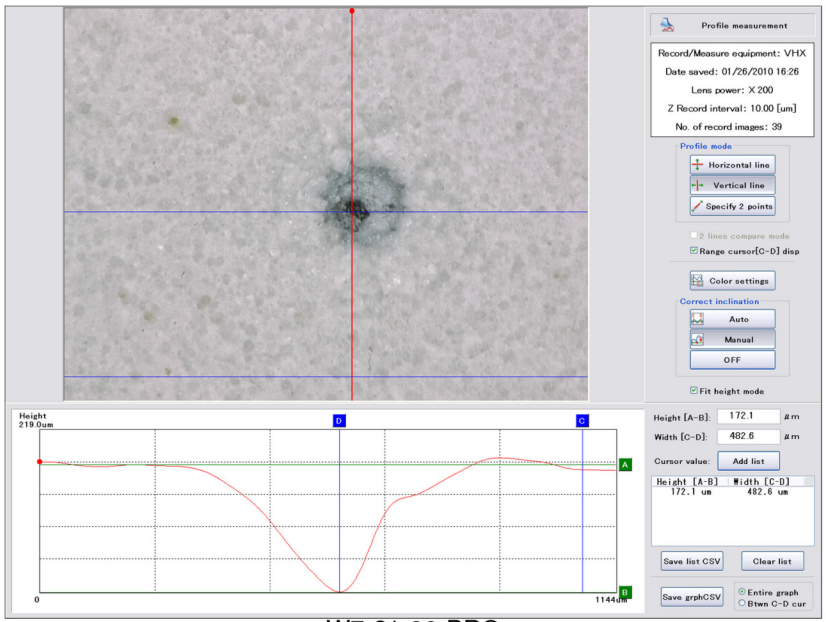
W6-54-87-PRO



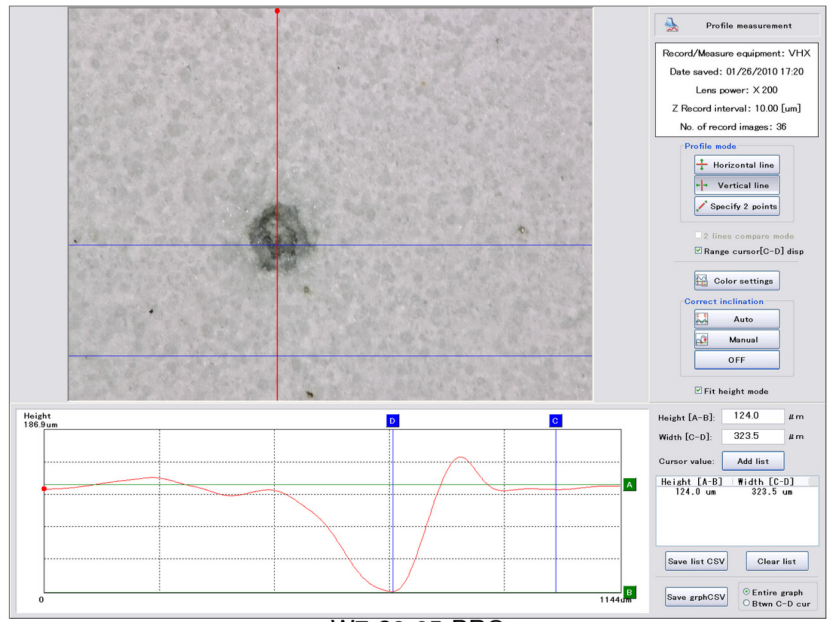
W6-72-61-PRO



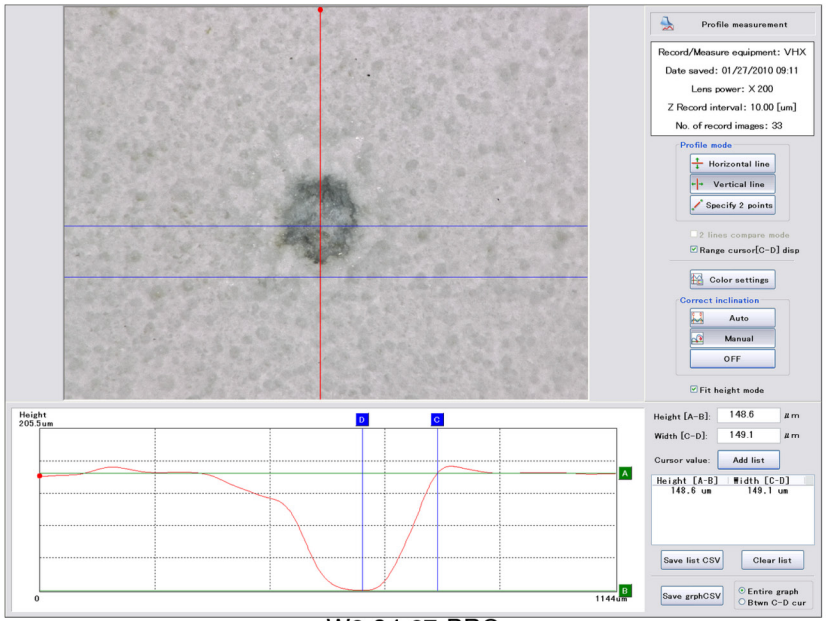
W7-03-98-PRO



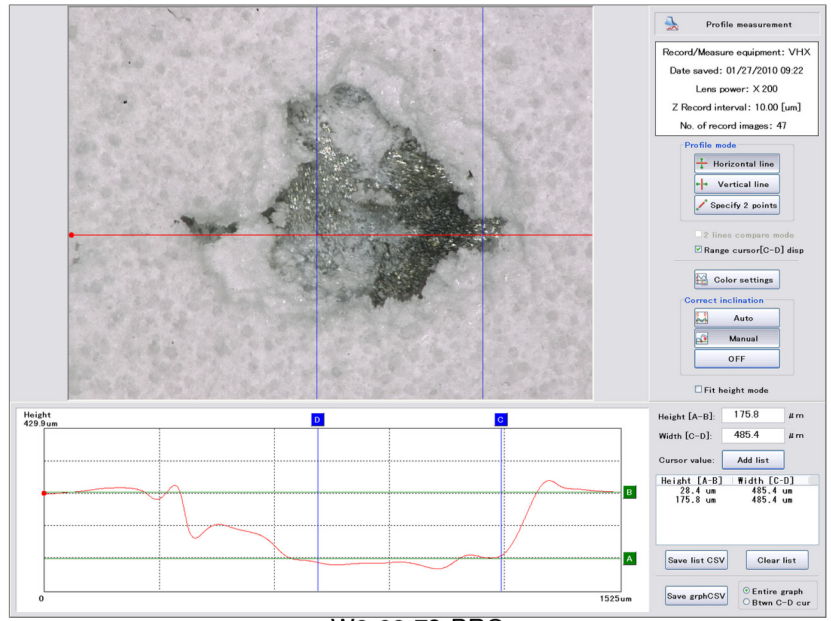
W7-21-86-PRO



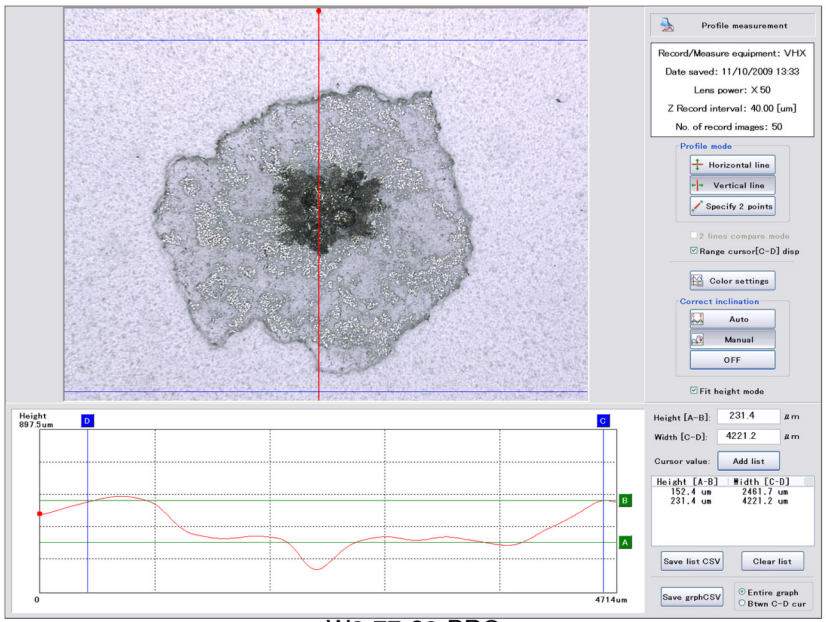
W7-28-65-PRO



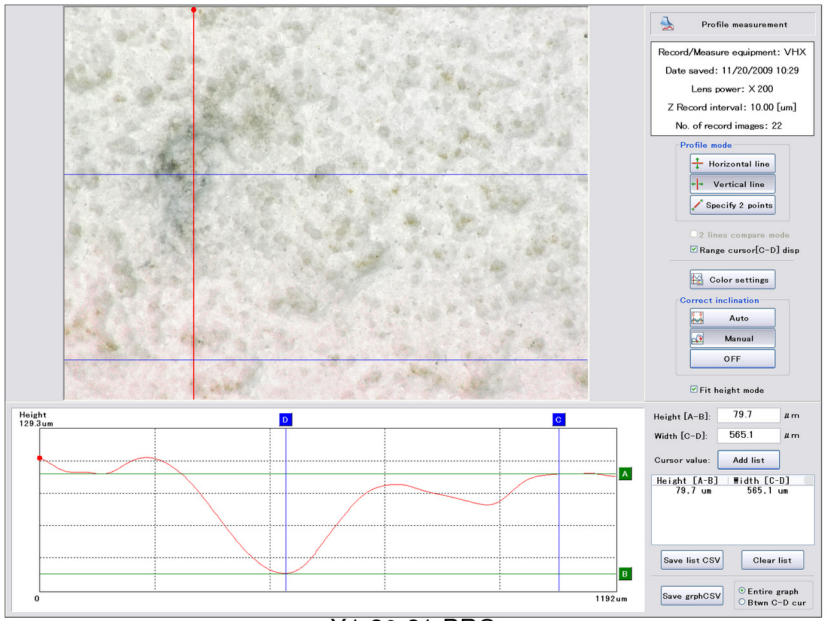
W8-34-87-PRO



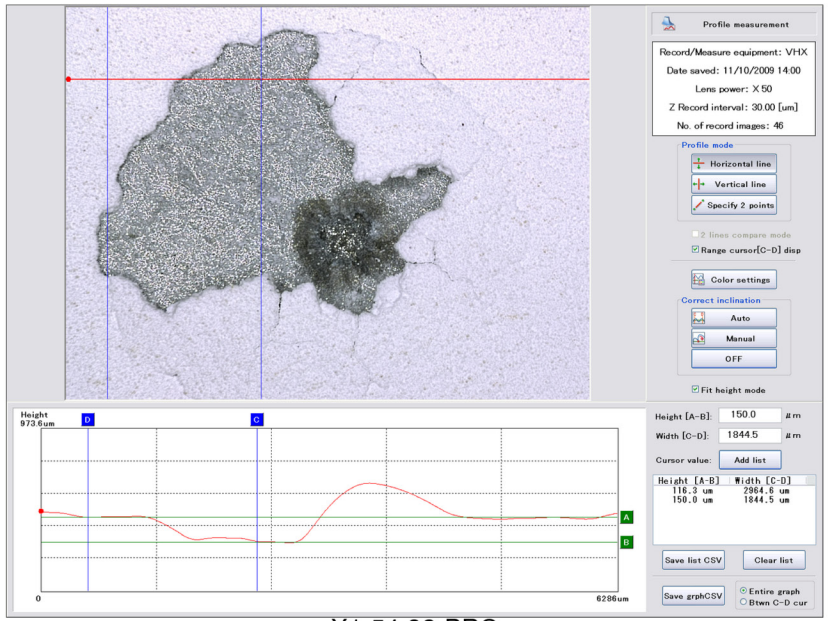
W8-68-73-PRO



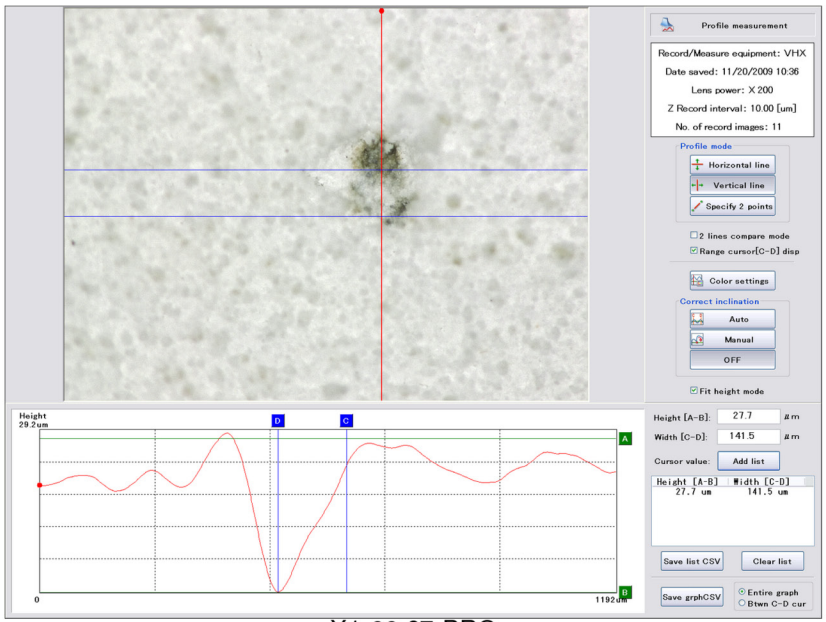
W8-77-28-PRO



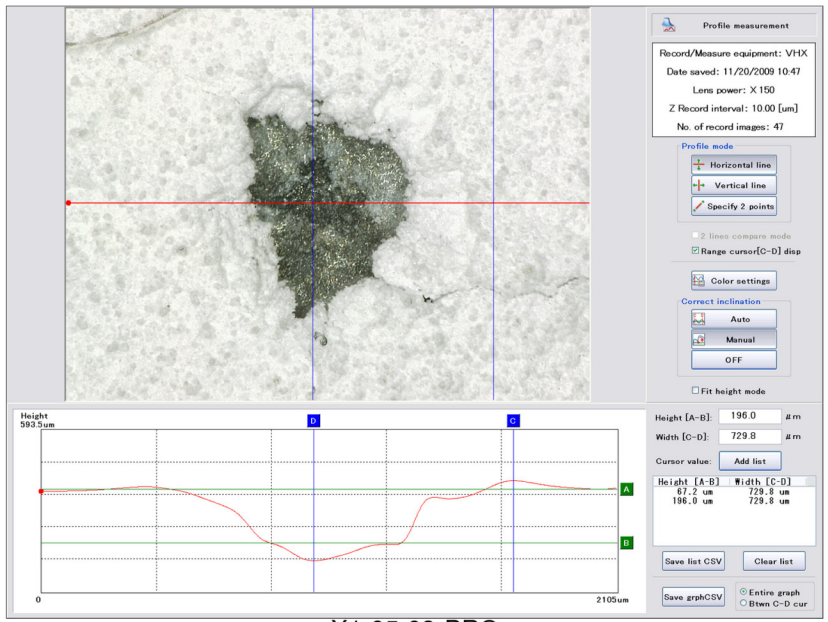
X1-30-31-PRO



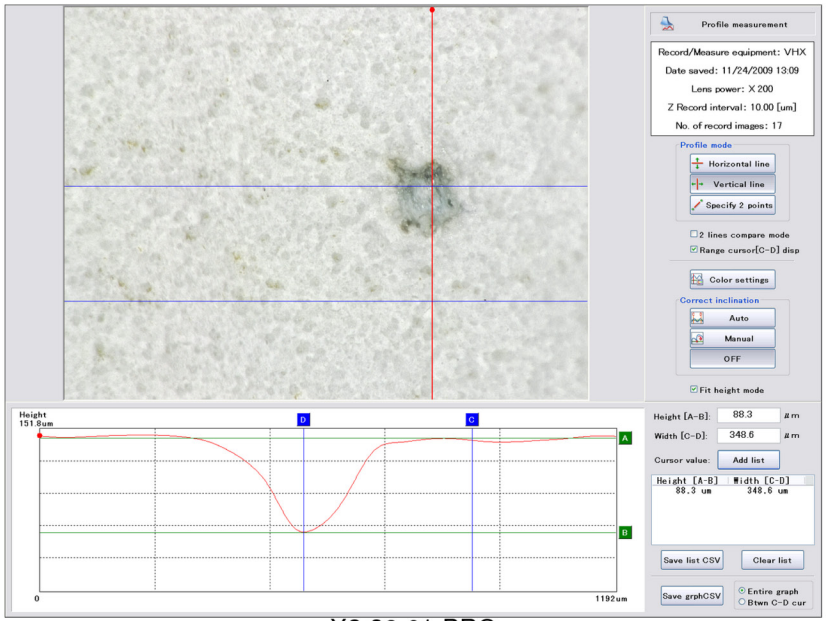
X1-54-32-PRO



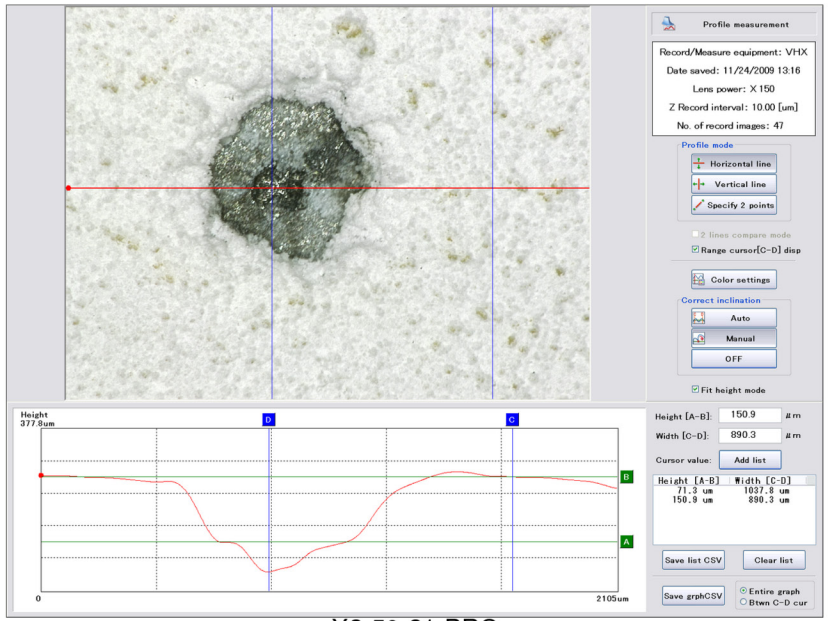
X1-66-97-PRO



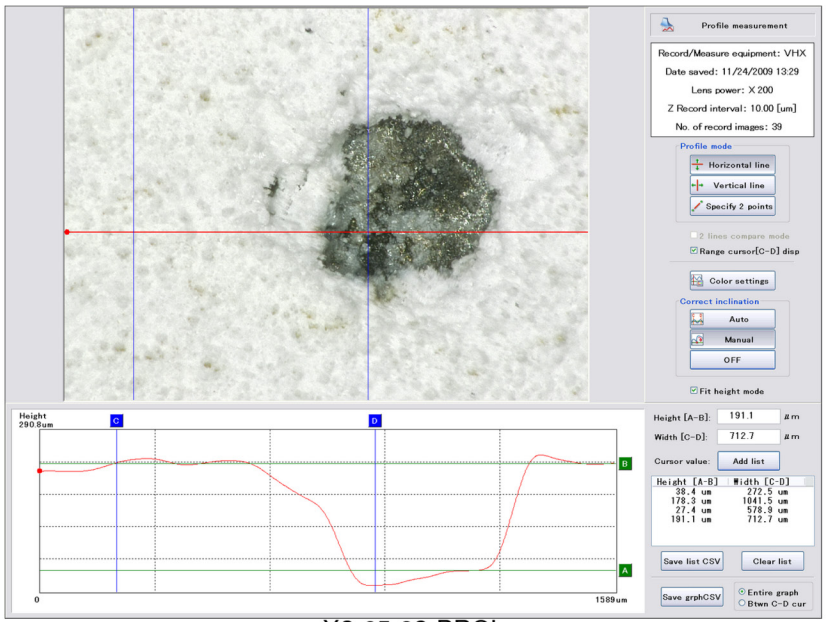
X1-95-93-PRO



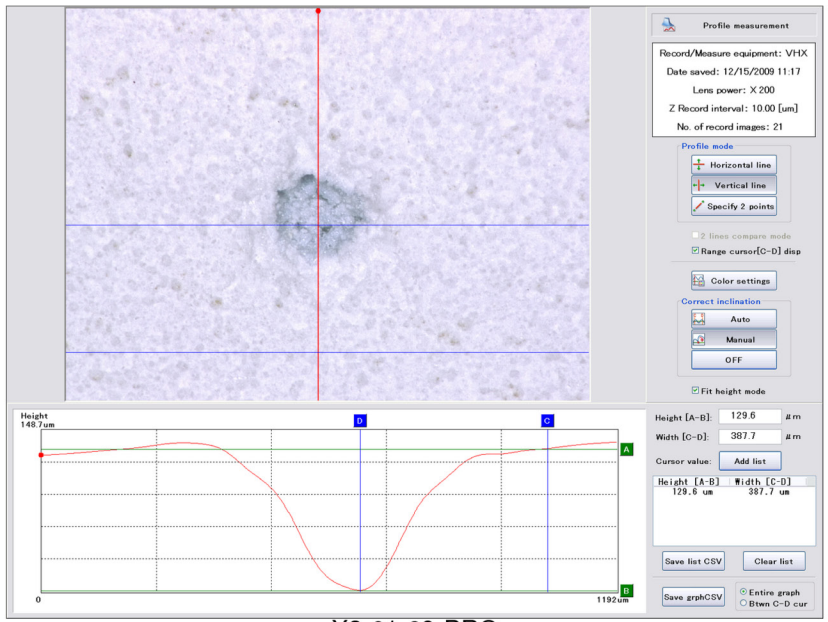
X2-38-01-PRO



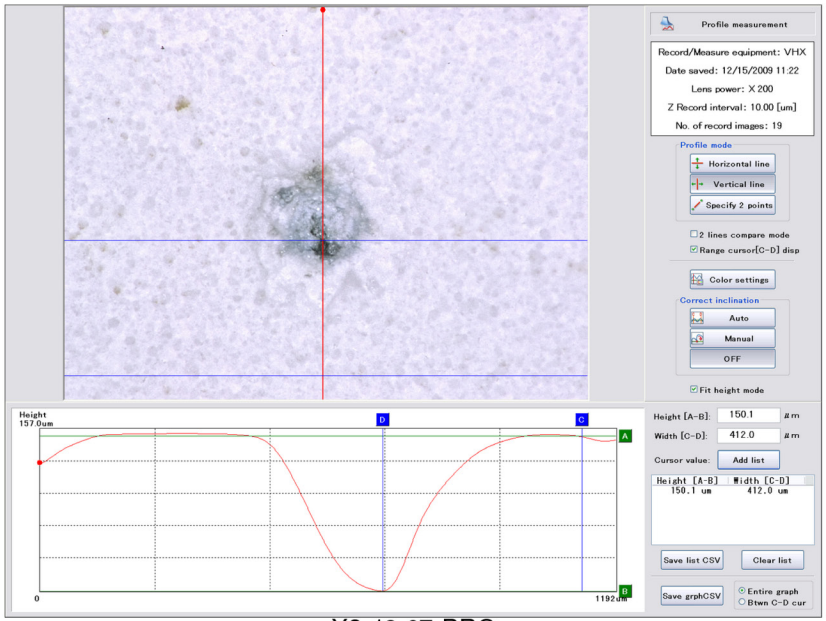
X2-50-21-PRO



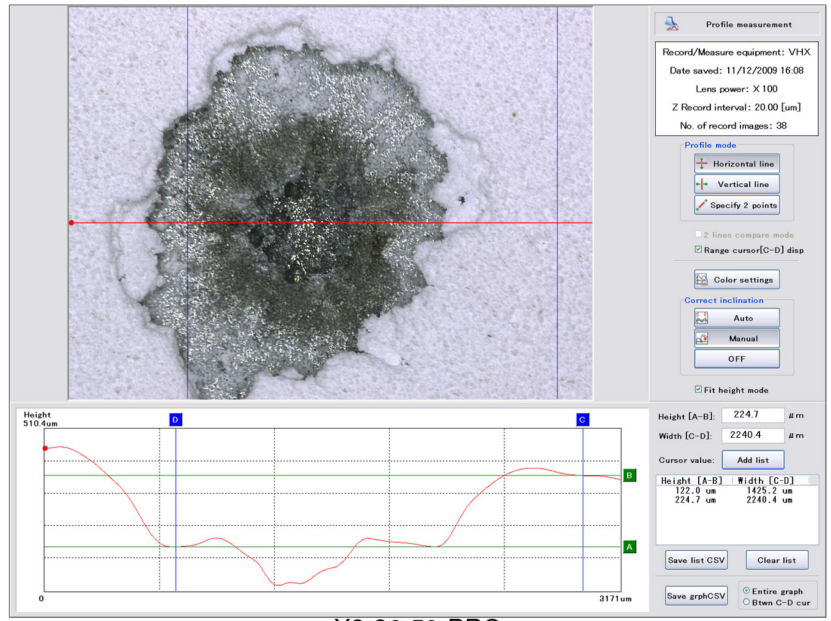
X2-65-82-PROh



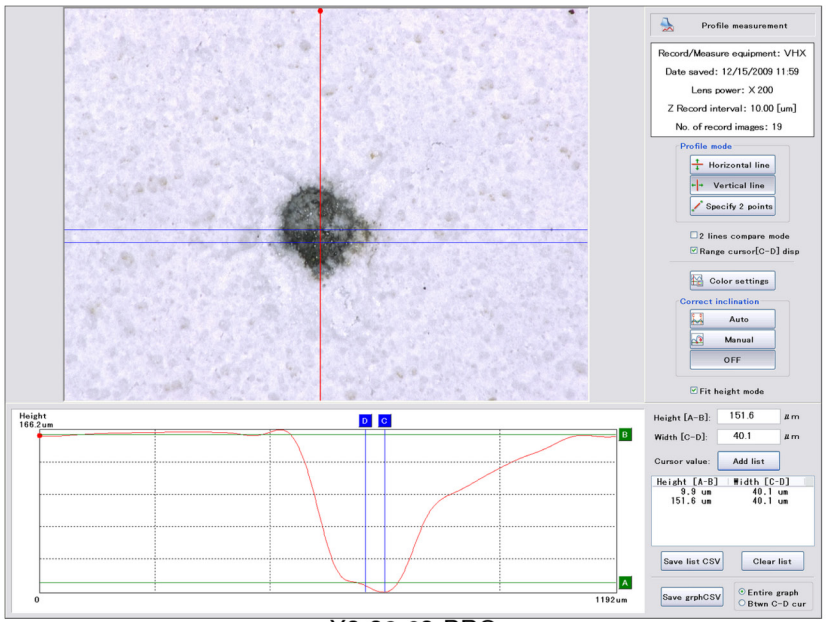
X3-01-69-PRO



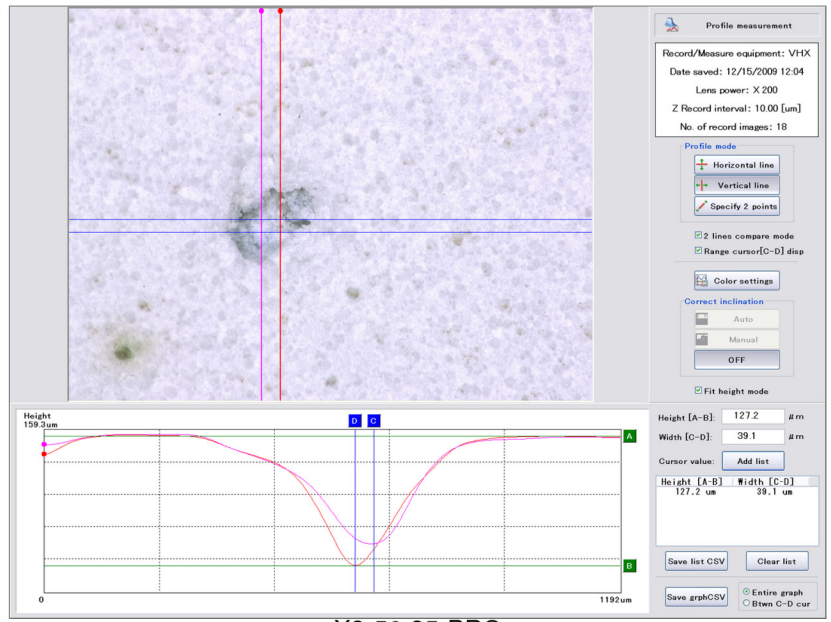
X3-18-07-PRO



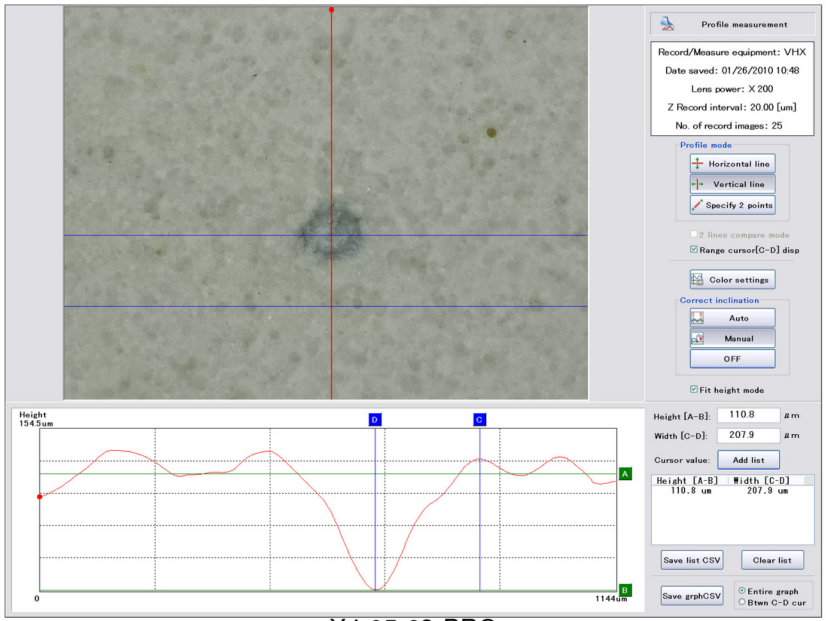
X3-36-50-PRO



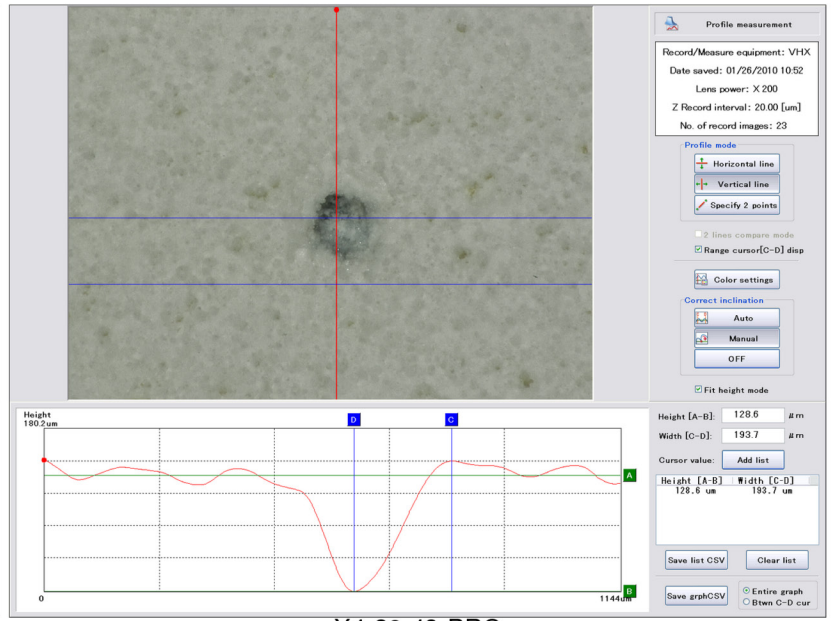
X3-38-63-PRO



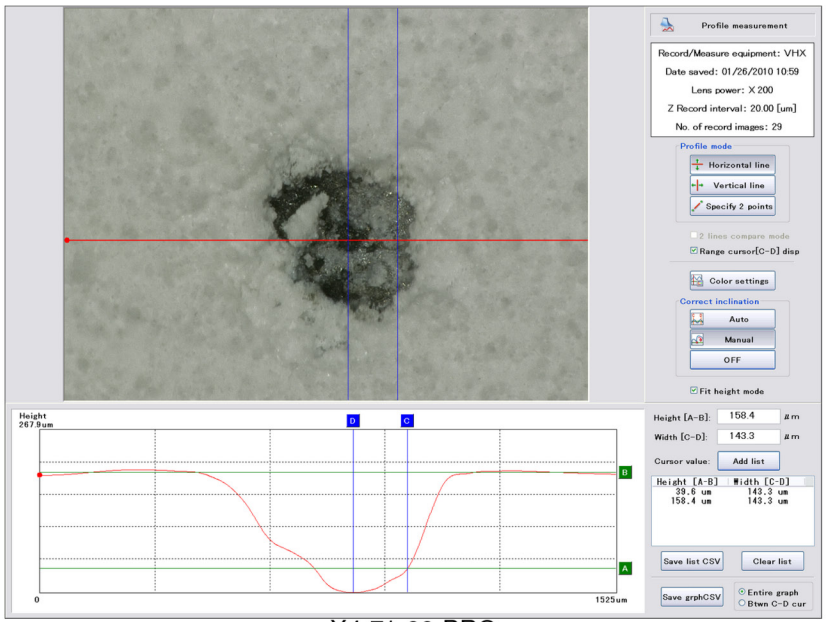
X3-56-35-PRO



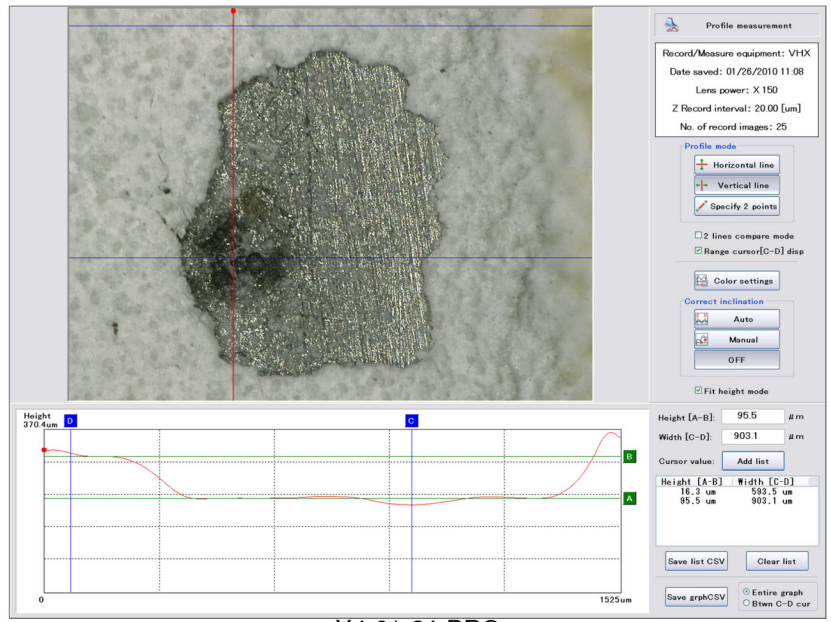
X4-05-63-PRO



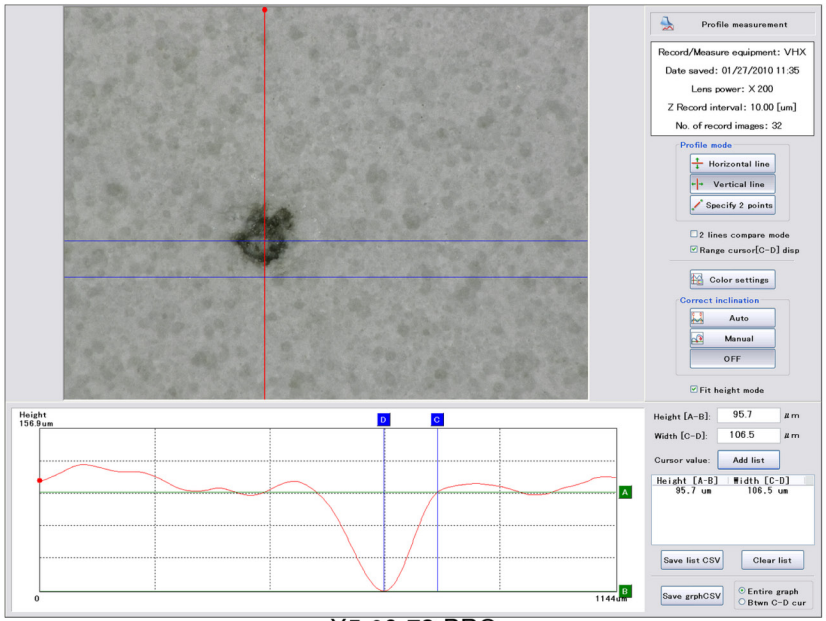
X4-28-43-PRO



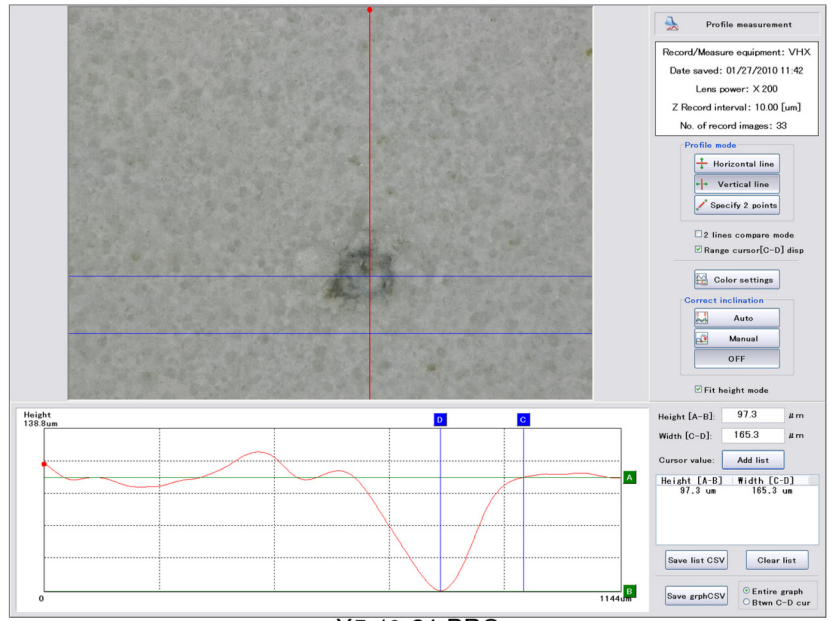
X4-71-66-PRO



X4-91-24-PRO



X5-09-72-PRO



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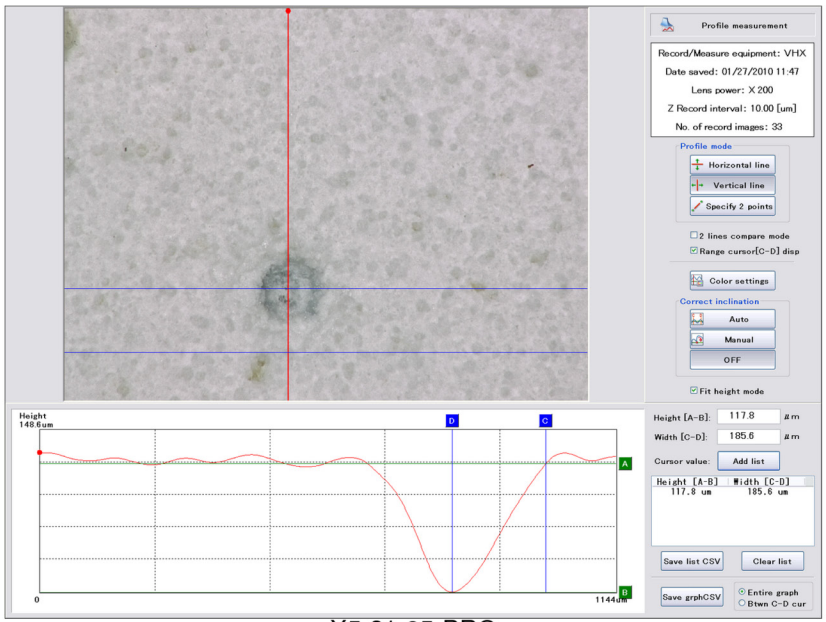

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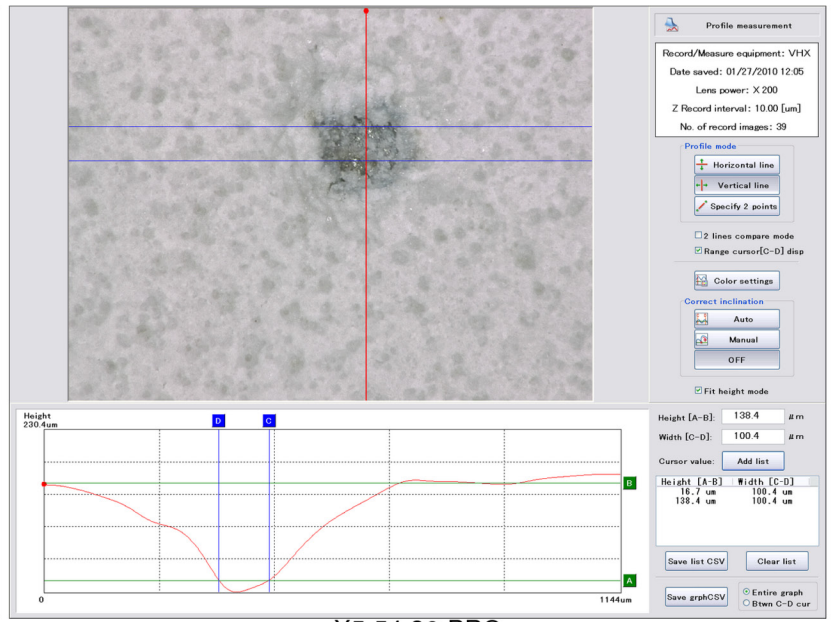

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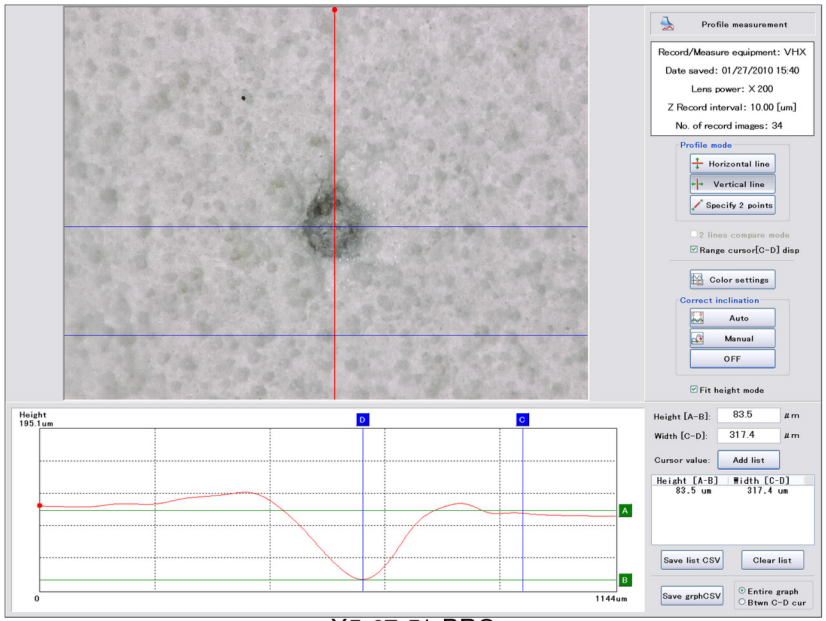

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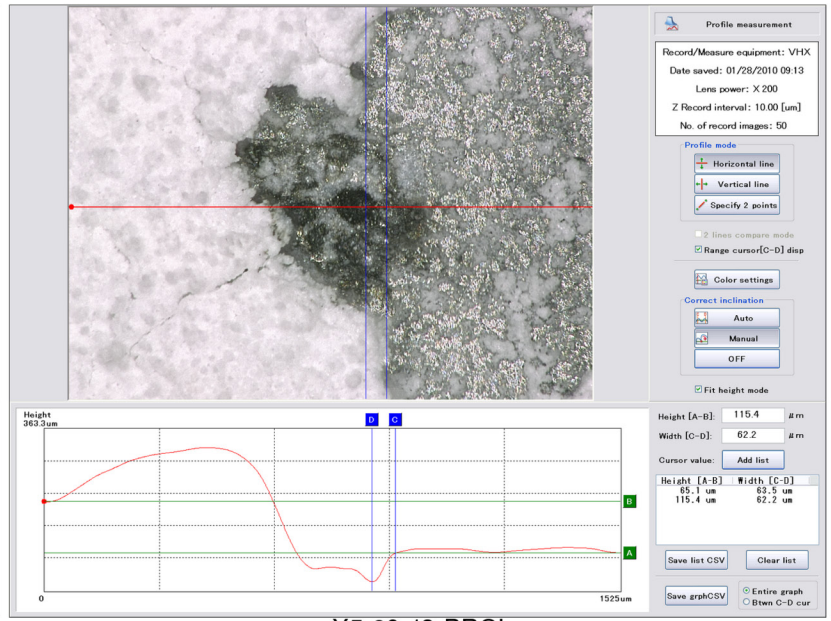

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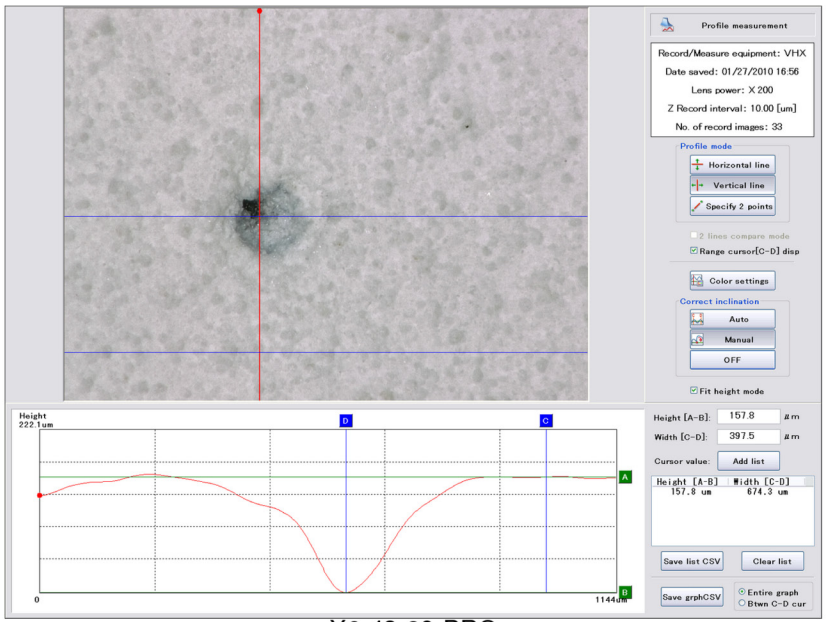

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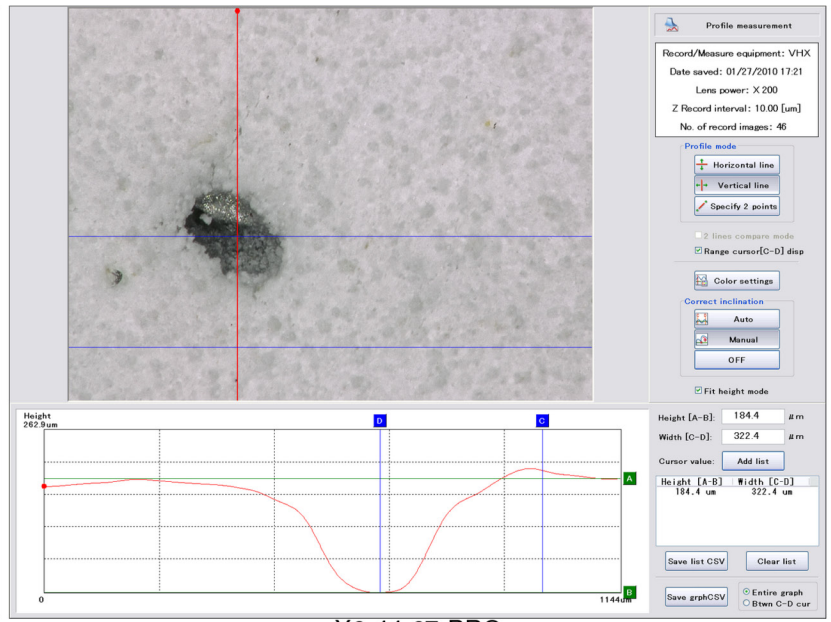

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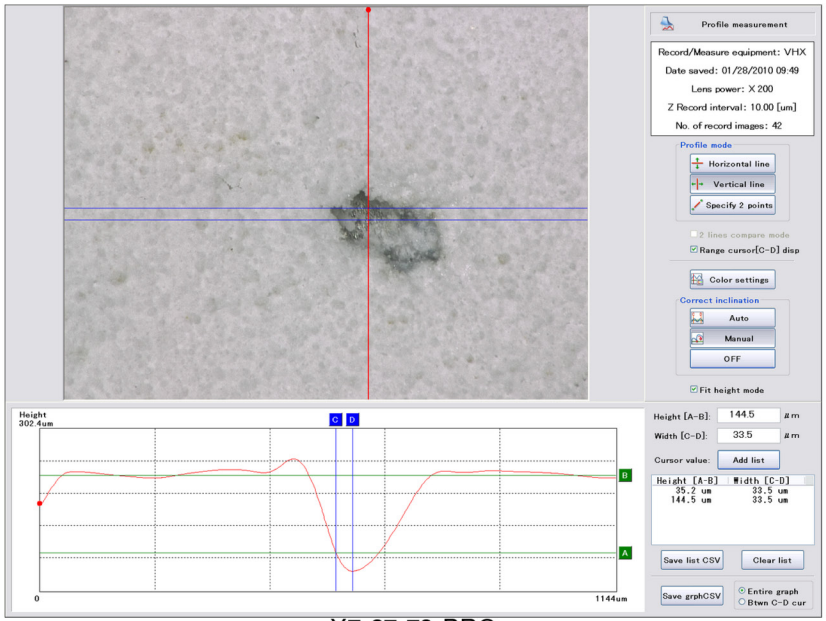

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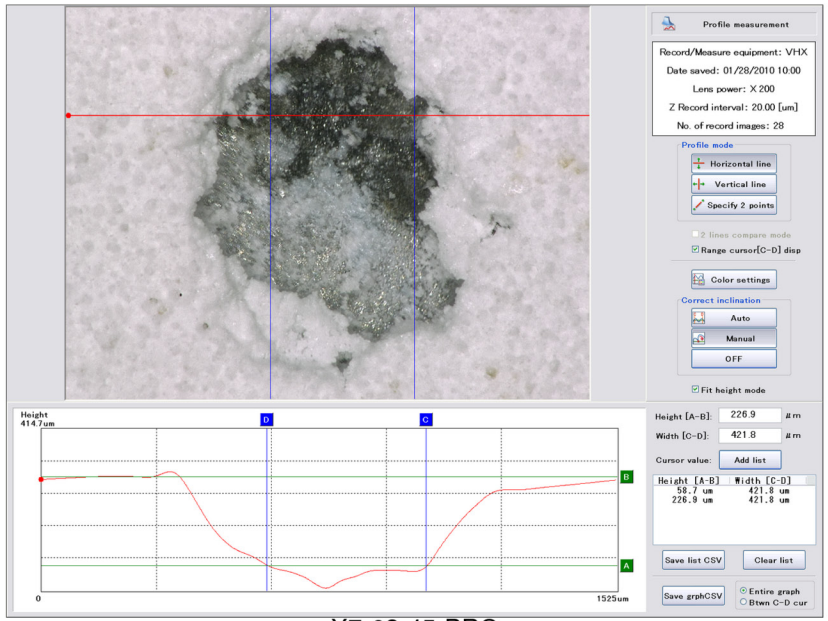

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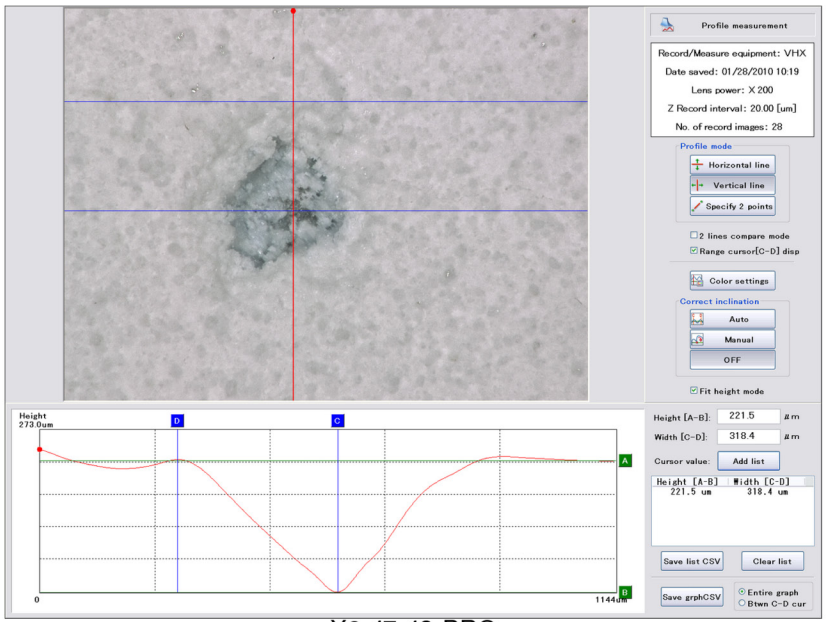

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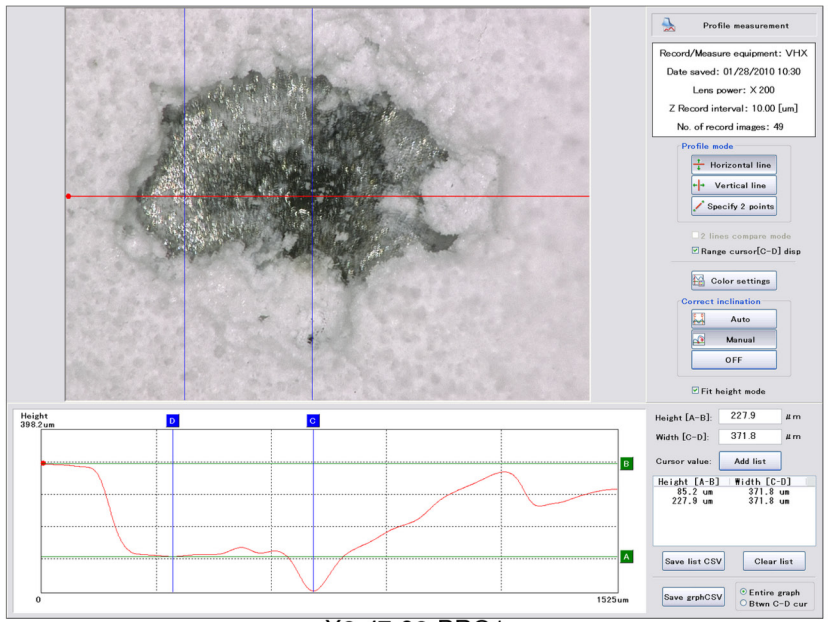

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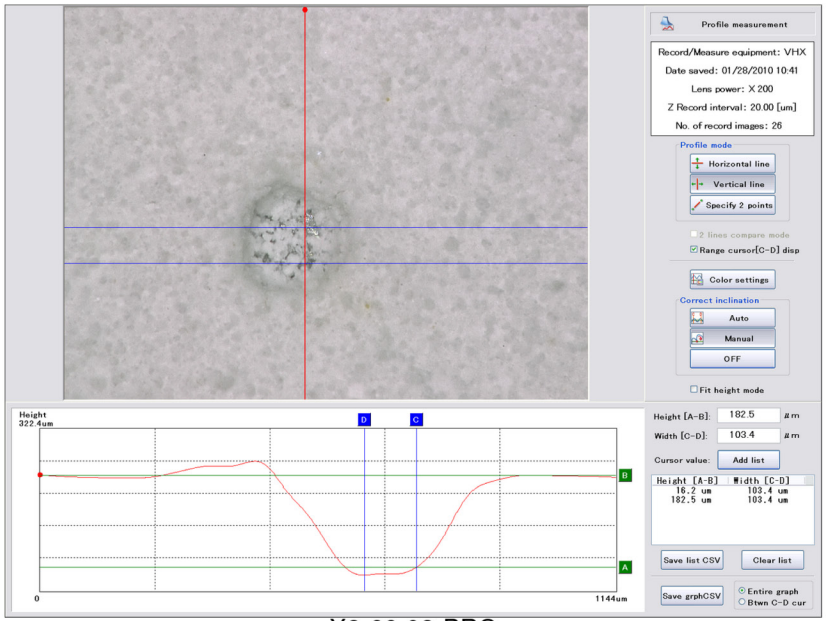

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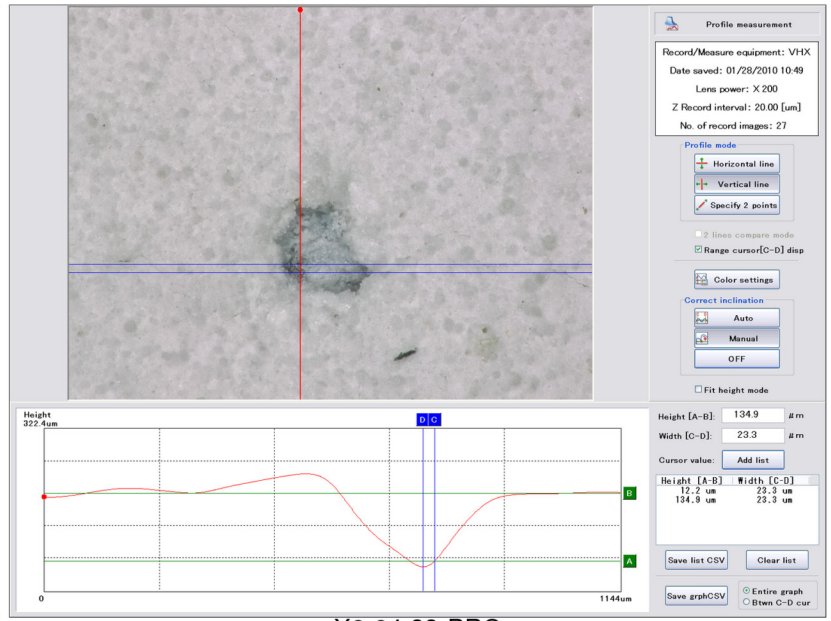

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John N. Opiela, J.-C. Liou, Phillip D. Anz-Meador

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13. ABSTRACT *(Maximum 200 words)*
Over 6 weeks during the summer of 2009, personnel from two NASA Centers performed a post-flight examination of the Hubble Space Telescope Wide Field Planetary Camera 2 (WFPC2) radiator. The objective was to record details about all micrometeoroid and orbital debris impact features with diameters of 300 μm and larger. By using a digital microscope, the team examined and recorded position, diameter, and depth information for each of the 675 craters. The actual measurements were extracted later from recorded images. Measurements include depth and diameter. Depth was measured from the undisturbed paint surface to the deepest point within the crater. Where features penetrate to the metal, both the depth in the metal and the paint thickness were measured. To compare these survey results with ground-based hypervelocity tests and simulations, several diameter measurements were taken: spall area, area of bare metal, area of discolored ("burned") metal, and the lips of the central crater. In the largest craters, the diameter at the surface of the metal was also measured. Location of each crater was recorded at the time of inspection. This document presents the methods and results of the crater measurement effort including the size and spatial distributions of the impact features.

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