SURFACE BOUNDARY MEASUREMENT USING 3D PROFILOMETRY

Prepared by

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INTRO:

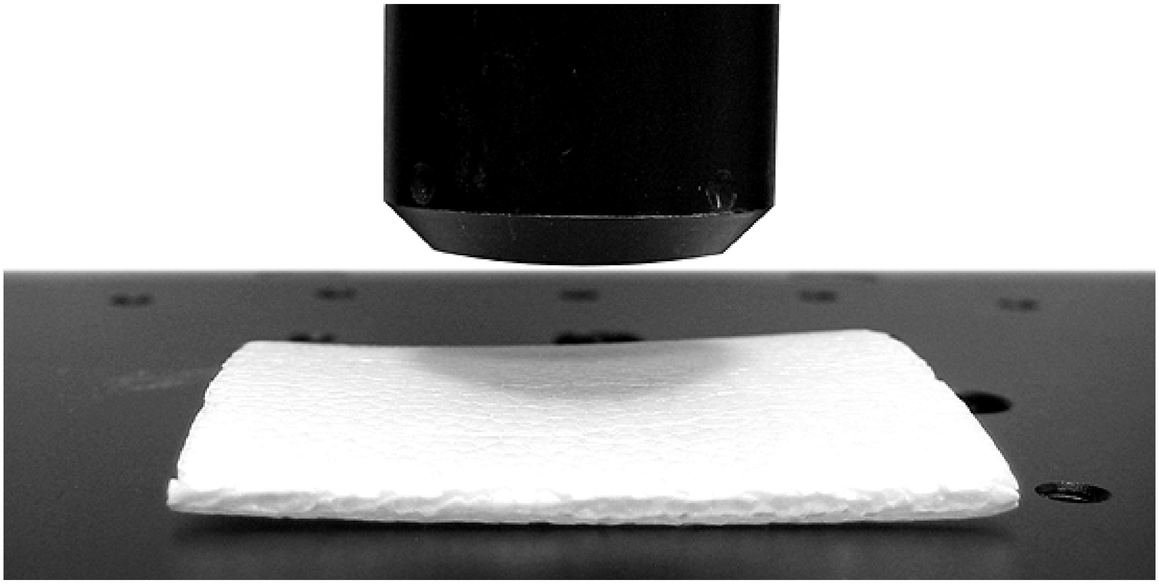
In studies where the interface of surface features, patterns, shapes etc., are being evaluated for orientation, it will be useful to quickly identify areas of interest over the entire profile of measurement. By segmenting a surface into significant areas the user can quickly evaluate boundaries, peaks, pits, areas, volumes and many others to understand their functional role in the entire surface profile under study. For example, like that of a grain boundary imaging of metals, the importance of analysis is the interface of many structures and their overall orientation. By understanding each area of interest defects and or abnormalities within the overall area can be identified. Although grain boundary imaging is typically studied at a range surpassing Profilometer capability, and is only 2D image analysis, it is a helpful reference to illustrate the concept of what will be shown here on a larger scale along with 3D surface measurement advantages.

IMPORTANCE OF 3D NON CONTACT PROFILOMETER FOR SURFACE SEPARATION STUDY

Unlike other techniques such as touch probes or interferometry, the 3D Non Contact Profilometer, using axial chromatism, can measure nearly any surface, sample sizes can vary widely due to open staging and there is no sample preparation needed. Nano through macro range is obtained during surface profile measurement with zero influence from sample reflectivity or absorption, has advanced ability to measure high surface angles and there is no software manipulation of results. Easily measure any material: transparent, opaque, specular, diffusive, polished, rough etc. The technique of the Non Contact Profilometer provides an ideal, broad and user friendly capability to maximize surface studies when surface boundary analysis will be needed; along with the benefits of combined 2D & 3D capability.

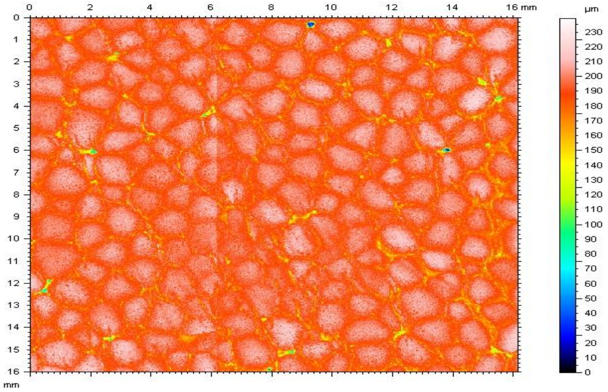
MEASUREMENT OBJECTIVE

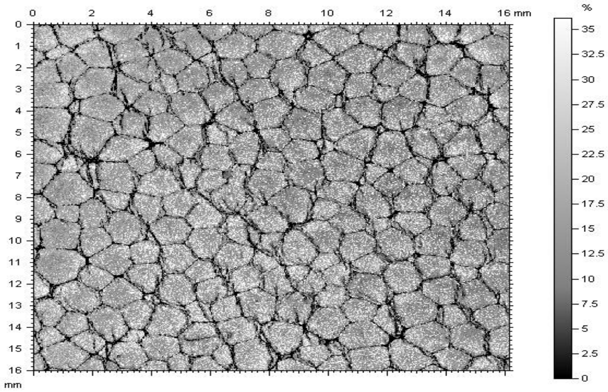
In this application the Nanovea ST400 Profilometer is used to measure the surface area of Styrofoam. Boundaries were established by combining a reflected intensity file along with the topography, which are simultaneously acquired using the Nanovea ST400. This data was then used to calculate different shape and size information of each Styrofoam “grain”.



RESULTS: 2D Surface Boundary Measurement

Topography image(below left) masked by refelcted intensity image(below right) to clearly define grain boundaries. All grains below 565µm diameter have been ignored by applying filter.





Total number of grains: 167

Total projected area occupied by the grains: 166.917 mm² (64.5962 %)

Total projected area occupied by boundaries: (35.4038 %)

Density of grains: 0.646285 grains / mm2

Area = 0.999500 mm² +/- 0.491846 mm²

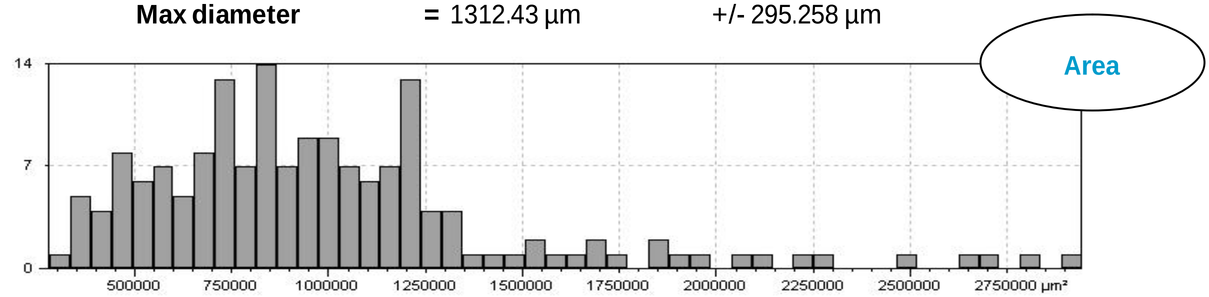
Perimeter = 9114.15 µm +/- 4570.38 µm

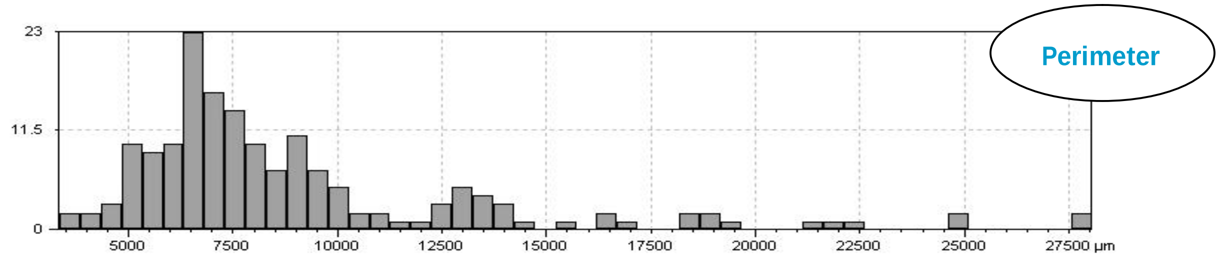
Equivalent diameter = 1098.61 µm +/- 256.235 µm

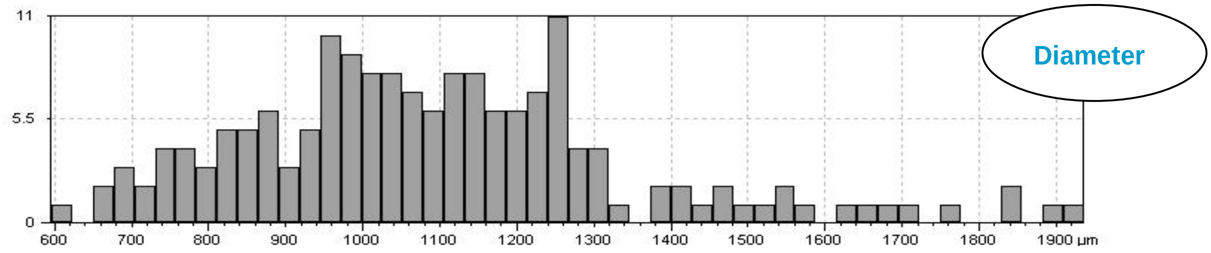
Mean diameter = 945.373 µm +/- 248.344 µm

Min diameter = 675.898 µm +/- 246.850 µm

Max diameter = 1312.43 µm +/- 295.258 µm

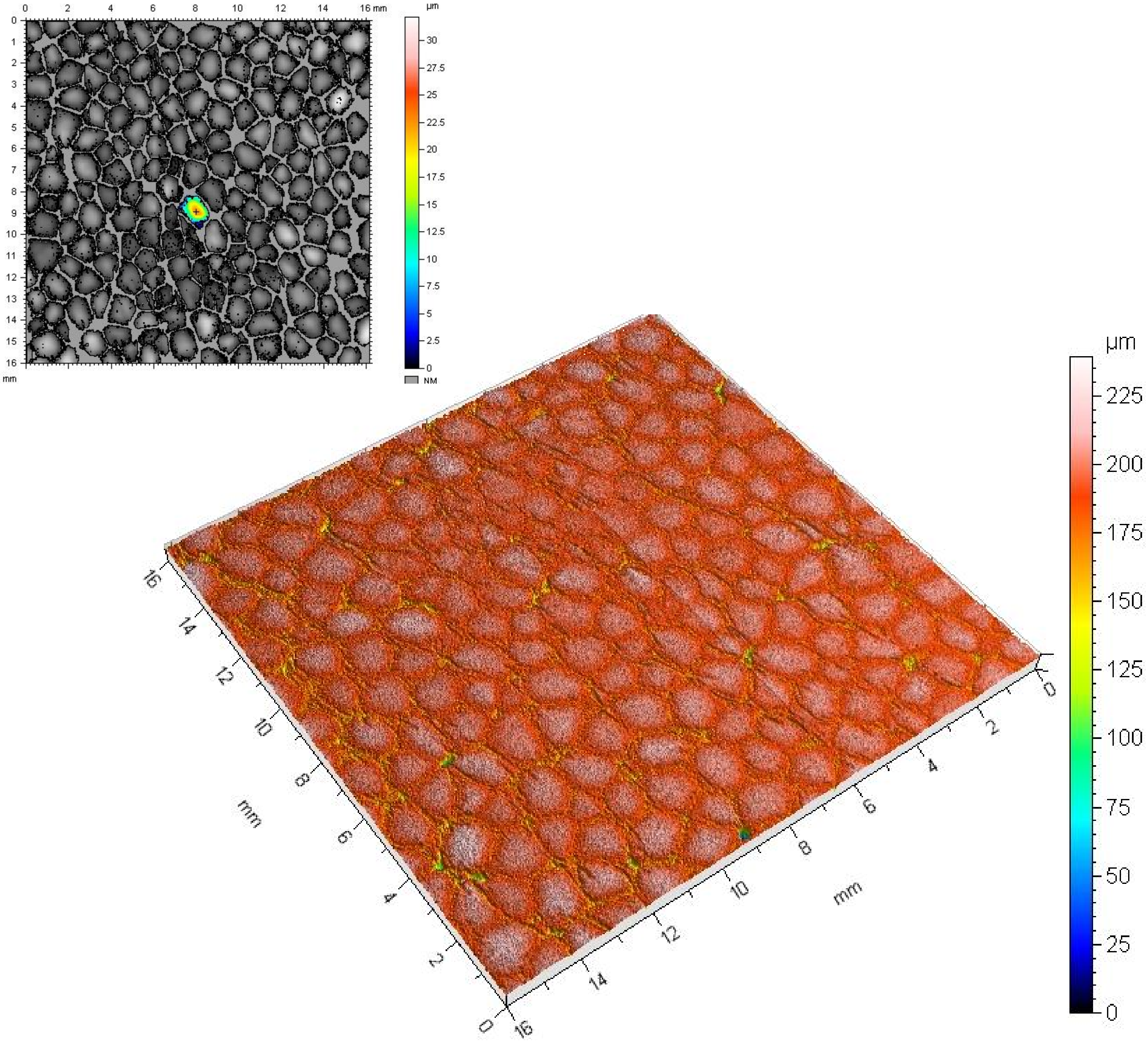






3D Surface Boundary Measurement

By using the 3D topography data obtained, the volume, height, peak, aspect ratio and general shape information can be analyzed on each grain. Total 3D area occupied: 2.525mm3

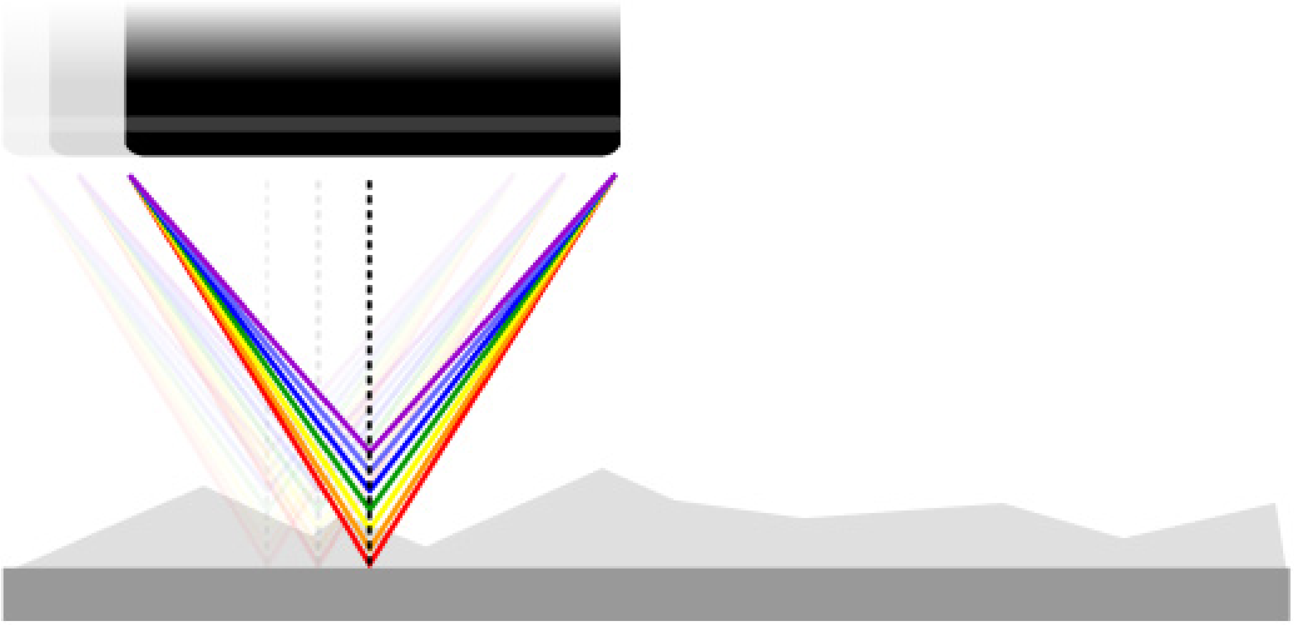


CONCLUSION:

In this application, we have shown how the Nanovea 3D Non Contact Profilometer can precisely characterize the surface of Styrofoam. Statistical information can be gained over the entire surface of interest or on individual grains, whether they are peaks or pits. In this example all grains larger than a user defined size were used to show the area, perimeter, diameter and height. The features shown here can be critical to research and quality control of natural and pre fabricated surfaces ranging from bio medical to micromachining applications along with many others. Learn more: Nanovea Profilometer

MEASUREMENT PRINCIPLE:

The Chromatic Confocal technique uses a white light source, where light passes through an objective lens with a high degree of chromatic aberration. The refractive index of the objective lens will vary in relation to the wavelength of the light. In effect, each separate wavelength of the incident white light will re-focus at a different distance from the lens (different height). When the measured sample is within the range of possible heights, a single monochromatic point will be focalized to form the image. Due to the confocal configuration of the system, only the focused wavelength will pass through the spatial filter with high efficiency, thus causing all other wavelengths to be out of focus. The spectral analysis is done using a diffraction grating. This technique deviates each wavelength at a different position, intercepting a line of CCD, which in turn indicates the position of the maximum intensity and allows direct correspondence to the Z height position.



Unlike the errors caused by probe contact or the manipulative Interferometry technique, Chromatic Confocal technology measures height directly from the detection of the wavelength that hits the surface of the sample in focus. It is a direct measurement with no mathematical software manipulation. This provides unmatched accuracy on the surface measured because a data point is either measured accurately without software interpretation or not at all. The software completes the unmeasured point but the user is fully aware of it and can have confidence that there are no hidden artifacts created by software guessing.

Nanovea optical pens have zero influence from sample reflectivity or absorption. Variations require no sample preparation and have advanced ability to measure high surface angles. Capable of large Z measurement ranges. Measure any material: transparent or opaque, specular or diffusive, polished or rough. Measurement includes: Profile Dimension, Roughness Finish Texture, Shape Form Topography, Flatness Warpage Planarity, Volume Area, Step-Height Depth Thickness and many others.

DEFINITION OF HEIGHT PARAMETERS

	Height Parameter	Definition
Sa	Arithmetical Mean Height	Mean surface roughness. $Sa = \frac{1}{A}\iint_A \lvert z(x,y)\rvert dxdy$
Sq	Root Mean Square Height	Standard deviation of the height distribution, or RMS surface roughness. $Sq = \sqrt{\frac{1}{A}\iint_A z^2(x,y)dxdy}$ Computes the standard deviation for the amplitudes of the surface (RMS).
Sp	Maximum Peak Height	Height between the highest peak and the mean plane.
Sv	Maximum Pit Height	Depth between the mean plane and the deepest valley.
Sz	Maximum Height	Height between the highest peak and the deepest valley.
Ssk	Skewness	Skewness of the height distribution. $Ssk = \frac{1}{Sq^3}\left[\frac{1}{A}\iint_A z^3(x,y)dxdy\right]$ Skewness qualifies the symmetry of the height distribution. A negative Ssk indicates that the surface is composed of mainly one plateau and deep and fine valleys. In this case, the distribution is sloping to the top. A positive Ssk indicates a surface with a lot of peaks on a plane. Therefore, the distribution is sloping to the bottom. Due to the large exponent used, this parameter is very sensitive to the sampling and noise of the measurement.
Sku	Kurtosis	Kurtosis of the height distribution. $Sku = \frac{1}{Sq^4}\left[\frac{1}{A}\iint_A z^4(x,y)dxdy\right]$ Kurtosis qualifies the flatness of the height distribution. Due to the large exponent used, this parameter is very sensitive to the sampling and noise of the measurement.
Spar	Projected Area	Projected surface area.
Sdar	Developed Area	Developed surface area.