NANOVEA®
A Better Measure.

NATURE INSPIRED SURFACE TOPOGRAPHY USING 3D PROFILOMETRY

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INTRO:

Nature has become a vital pool of inspiration for the development of improved surface structure. Understanding the surface structures found in nature has led to adhesion studies based on gecko's feet, resistance studies based on a sea cucumbers textural change and repellency studies based from leaves, among many others. These surfaces have a number of potential applications from biomedical to clothing and automotive. For any of these surface breakthroughs to be successful, fabrication techniques must be developed so surface characteristics can be mimicked and reproduced. It is this process that will require identification and control.

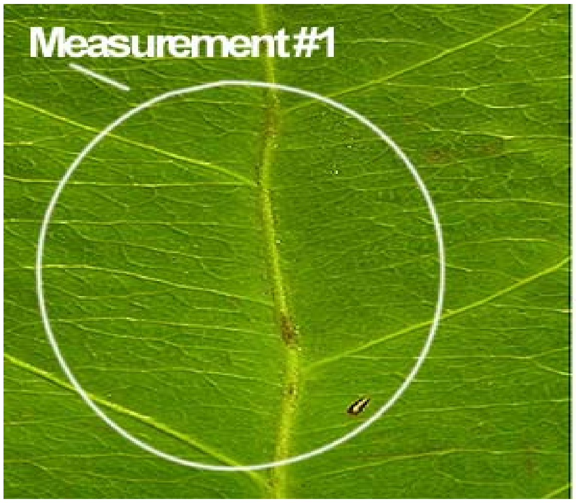
IMPORTANCE OF 3D NON CONTACT PROFILOMETER FOR NATURES SURFACES

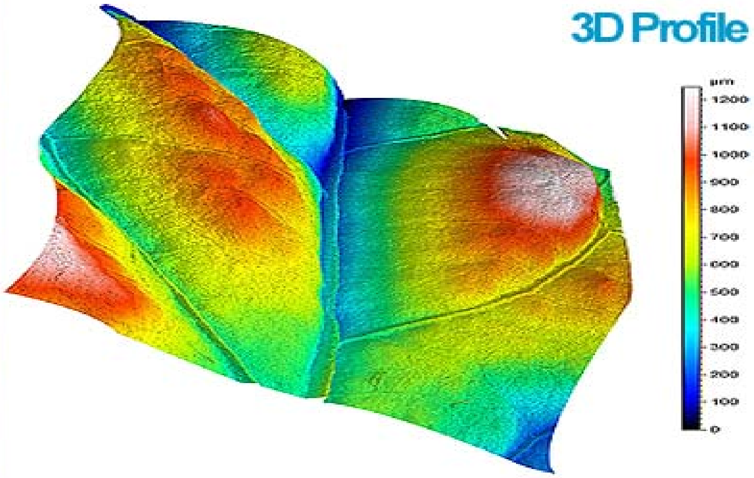
Utilizing chromatic confocal technology, the Nanovea Profilometer has superior capability to measure nearly any material. That includes the unique and steep angles, reflective and absorbing surfaces found within natures broad range of surface characteristics. 3D non contact measurement provides a full 3D image to give a more complete understanding of surface features. Without 3D capabilities, identification of nature's surfaces would be solely relying on 2D information or microscope imaging, which does not provide sufficient information to properly mimic the surface studied. Understanding the full range of the surface characteristics including texture, form, dimension, among many others, will be critical to successful fabrication.

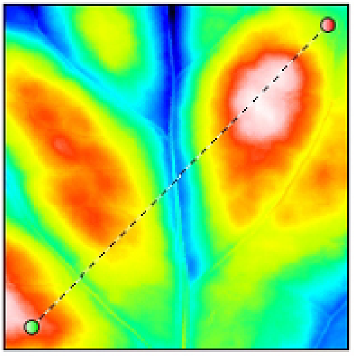
MEASUREMENT OBJECTIVE

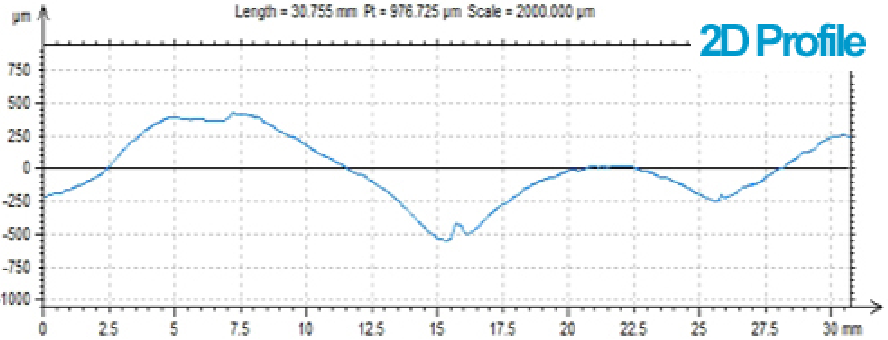
In this application, the Nanovea ST400 is used to measure the surface of a leaf. There is an endless list of surface parameters that can be automatically calculated after the 3D surface scan. Here we will review the 3D surface and select areas of interest to further analyze, including quantifying and investigating the surface roughness, channels and topography.

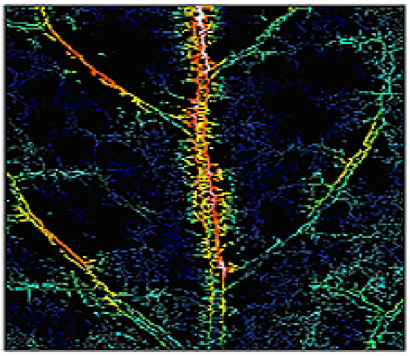
RESULTS:





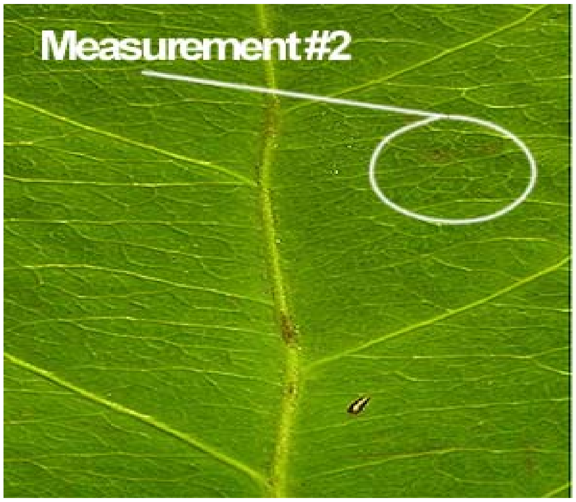


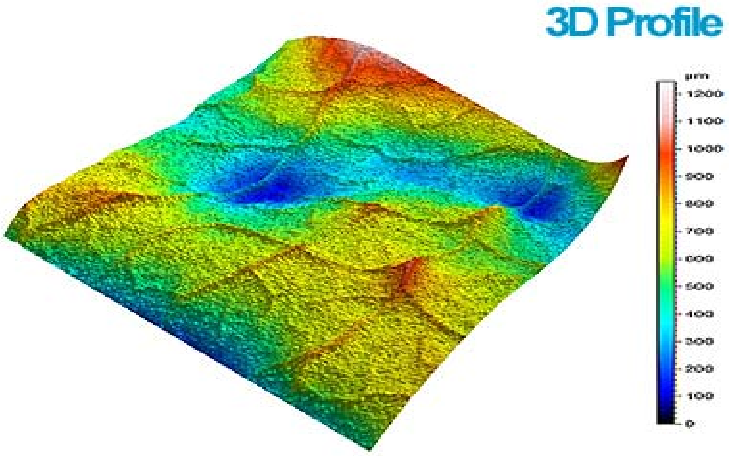


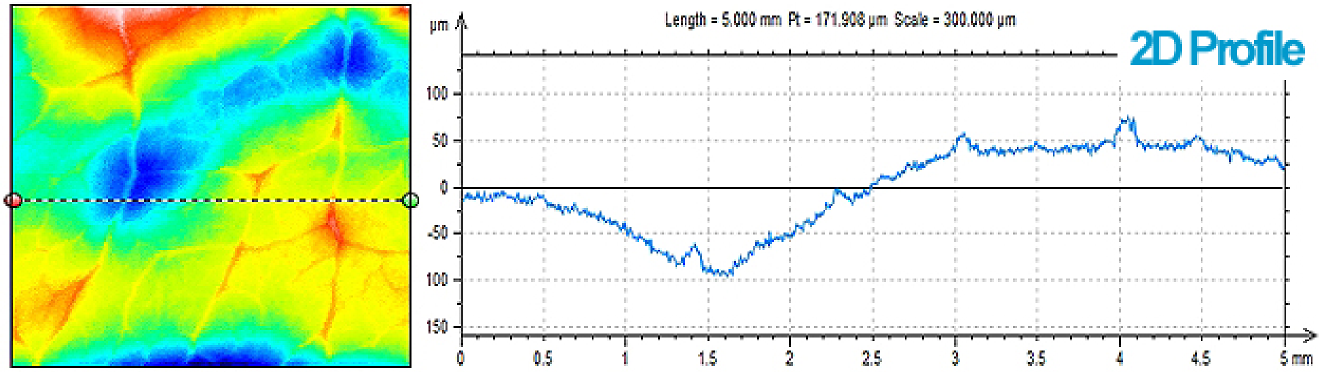


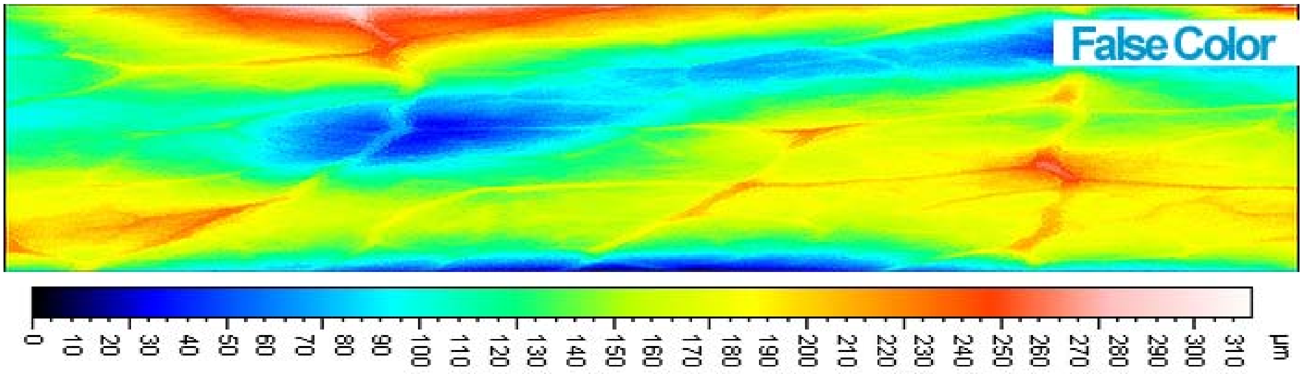
Furrow Depth

Maximum depth of furrows : 359.769 µm
Mean depth of furrows : 97.428 µm
Mean density of furrows : 16.471 cm/cm2


Measurement #2


3D Profile
µm
1200
1100
1000
900
800
700
600
500
400
300
200
100
0


2D Profile
Length = 5.000 mm Pt = 171.908 µm Scale = 300.000 µm
µm
100
50
0
-50
100
150
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5 mm


False Color
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
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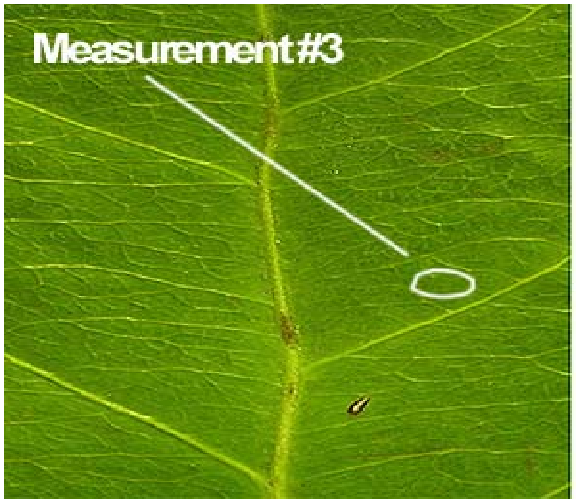
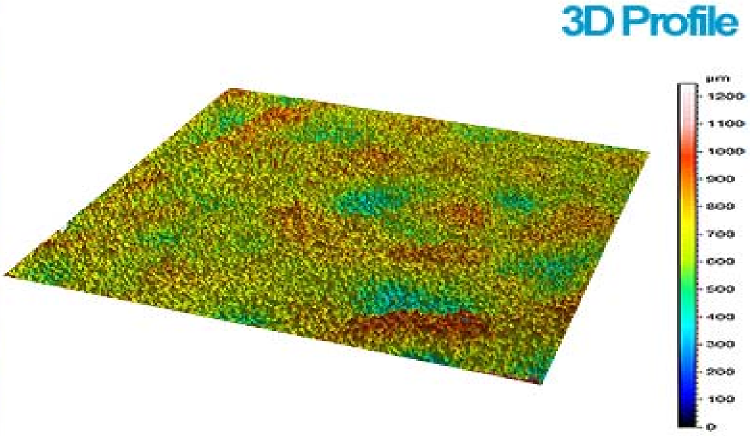
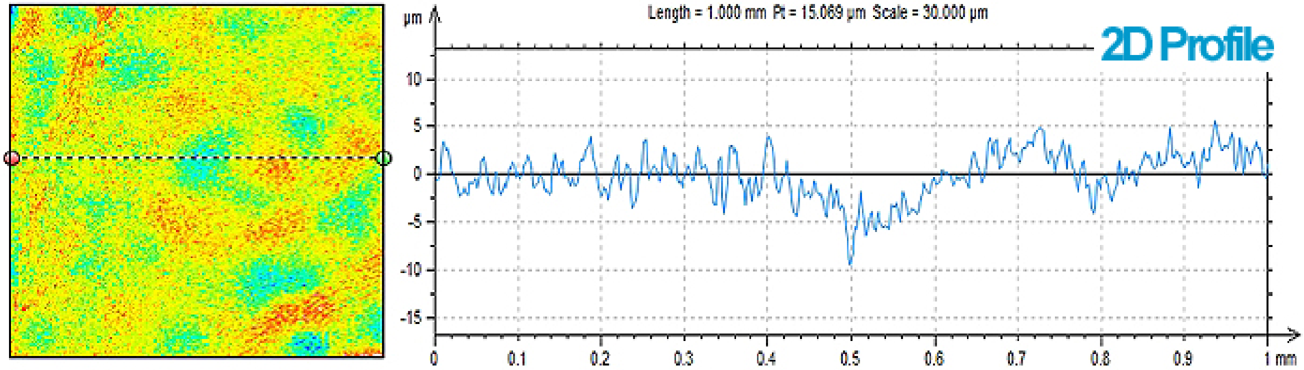
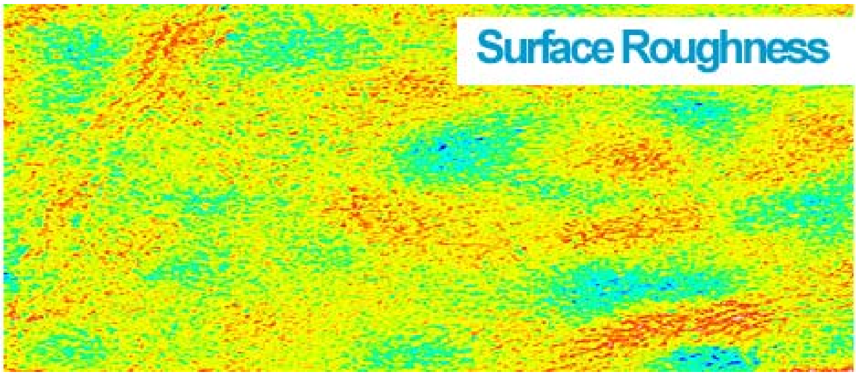
270
280
290
300
310
µm







ISO 25178		
Height Parameters		
Sq	2.161	µm
Ssk	-0.163	
Sku	3.371	
Sp	10.729	µm
Sv	12.372	µm
Sz	23.100	µm
Sa	1.700	µm

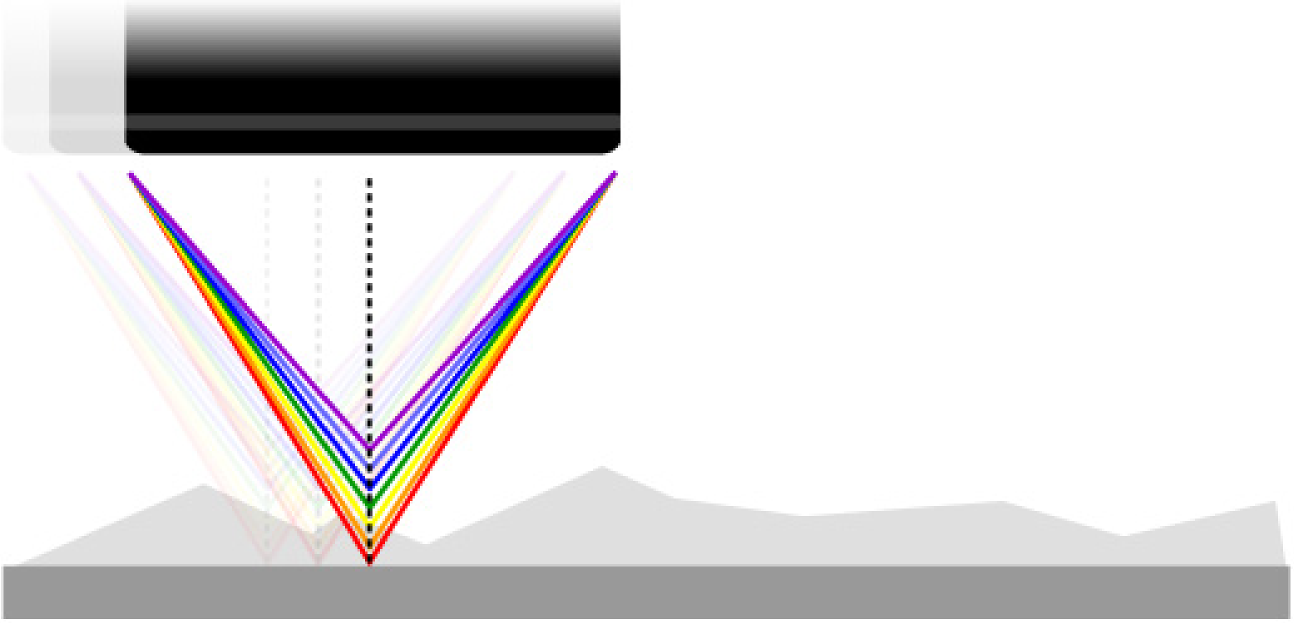


CONCLUSION:

In this application, we have shown how the Nanovea ST400 3D Non Contact Profilometer can precisely characterize both the topography and the nanometer details of a leaf surface. Here we have shown the broad capability to study nature's surfaces. From these 3D surface measurements, areas of interest can quickly be identified and then analyzed with a list of endless measurements (Dimension, Roughness Finish Texture, Shape Form Topography, Flatness Warpage Planarity, Volume Area, Step-Height and others). A 2D cross section can quickly be chosen to analyze further details. With this information nature's surfaces can be broadly investigated with a complete set of surface measurement resources. Special areas of interest could have been further analyzed with integrated AFM module on table top models.
Nanovea also provides a fully portable model for field research.

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.