TISSUE SURFACE TOPOGRAPHY USING 3D PRFILOMETRY

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INTRO:

Surface area, texture and topography are all crucial measurements required when studying the interaction between tissue and biomaterial surfaces. During the Microfabrication of biomaterials successful development will rely heavily upon precisely controlled surface areas. Changes within surface topography can result in unintended or intended surface interaction. It is for this reason that a reliable method of measurement is critical to assure the intended surface characteristics during development.

IMPORTANCE OF 3D NON CONTACT PROFILOMETER FOR BIOMEDICAL 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 biomedicals 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 biomedical surfaces would be solely relying on 2D information or microscope imaging, which does not provide sufficient information to properly understand the surface studied. Understanding the full range of the surface characteristics surface area, texture and topography, among many others, will be critical to successful fabrication.

MEASUREMENT OBJECTIVE

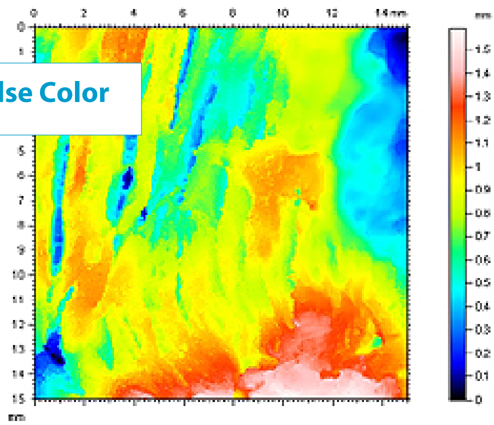
In this application, the Nanovea ST400 is used to measure the surface of raw steak. There is an endless list of surface parameters that can be automatically calculated after the 3D surface scan. Here we will review the 3D surface and select areas of interest to further analyze, including quantifying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

RESULTS:

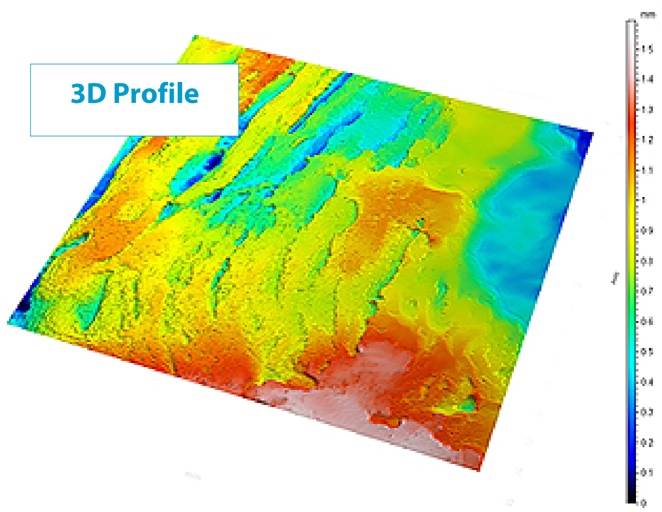
Surface Measurement 1

Scan Length: 15.0mm | Scan Step Size: 50.0µm

False Color

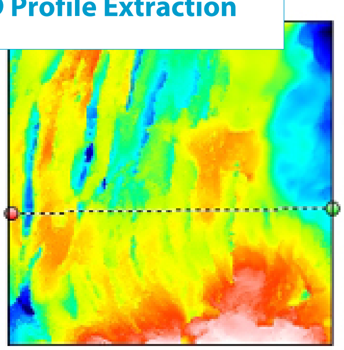


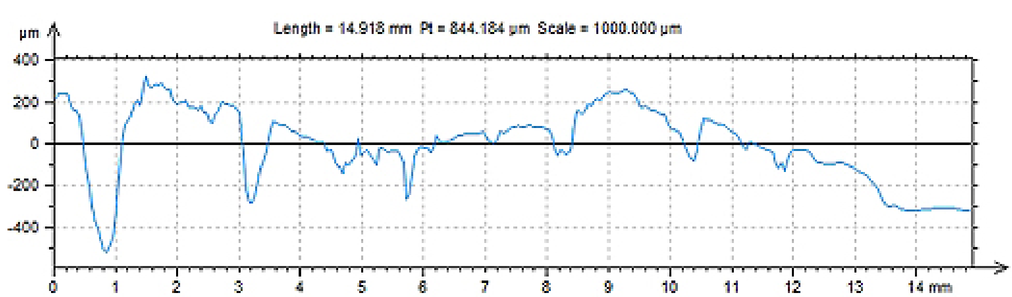
3D Profile



ISO 25178			
Height Parameters			
Sa	0.205933	mm	Arithmetic mean height
Sq	0.265343	mm	Root mean square height
Sz	1.59481	mm	Maximum height
Sp	0.757889	mm	Maximum peak height
Sv	0.836916	mm	Maximum pit height
Sku	3.01740		Kurtosis
Ssk	-0.0660996		Skewness
Other 3D Parameters			
Miscellaneous			
Sdar	331.242	mm²	Developed area
Spar	225.000	mm²	Projected area
EUR 15178N			
Functional Parameters			
Sk	0.0398999	mm	Core roughness depth
Spk	0.0514194	mm	Reduced summit height
Svk	0.079518	mm	Reduced valley depth
Sr1	15.3890	%	Upper bearing area
Sr2	81.7890	%	Lower bearing area
Sr2	81.7890	%	Lower bearing area

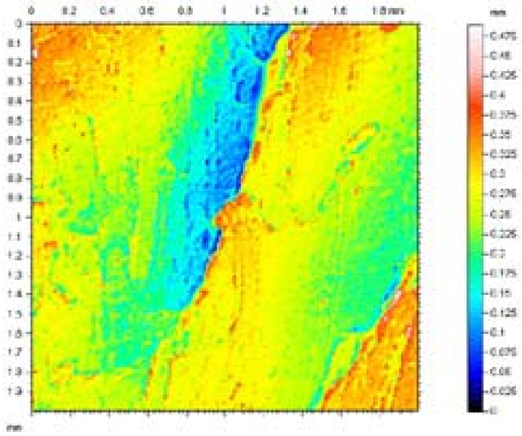
2D Profile Extraction



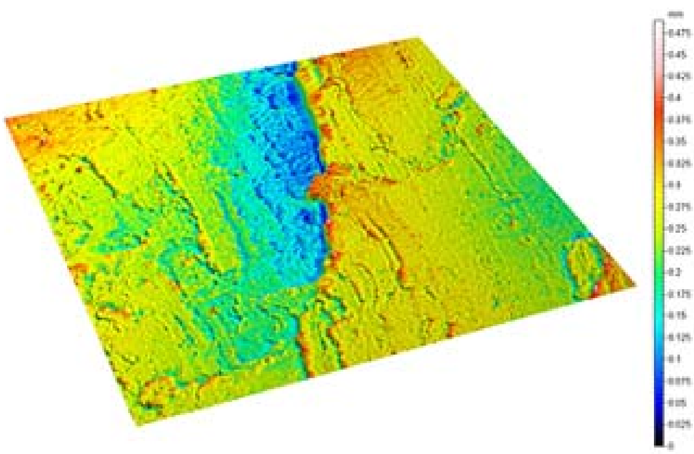


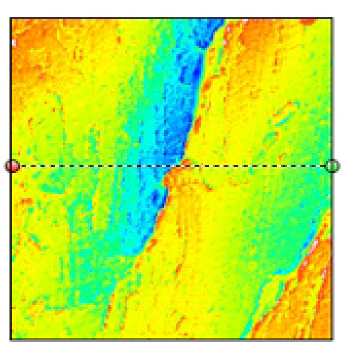
Surface Measurement 2

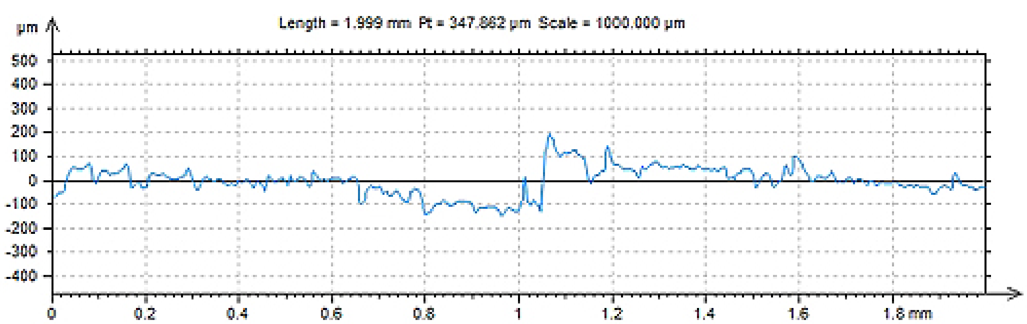
Scan Length: 2.0mm | Scan Step Size: 2.6µm



ISO 25178			
Height Parameters			
Sa	0.0467994	mm	*Arithmetic mean height*
Sq	0.0600867	mm	*Root mean square height*
Sz	0.489343	mm	*Maximum height*
Sp	0.237807	mm	*Maximum peak height*
Sv	0.251536	mm	*Maximum pit height*
Sku	3.39089		*Kurtosis*
Ssk	-0.536478		*Skewness*
Other 3D Parameters			
Miscellaneous			
Sdar	33.5989	mm²	*Developed area*
Spar	3.99760	mm²	*Projected area*
EUR 15178N			
Functional Parameters			
Sk	0.0713327	mm	*Core roughness depth*
Spk	0.0628999	mm	*Reduced summit height*
Svk	0.0648758	mm	*Reduced valley depth*
Sr1	12.0392	%	*Upper bearing area*
Sr2	81.9892	%	*Lower bearing area*
Sr2	81.9892	%	*Lower bearing area*





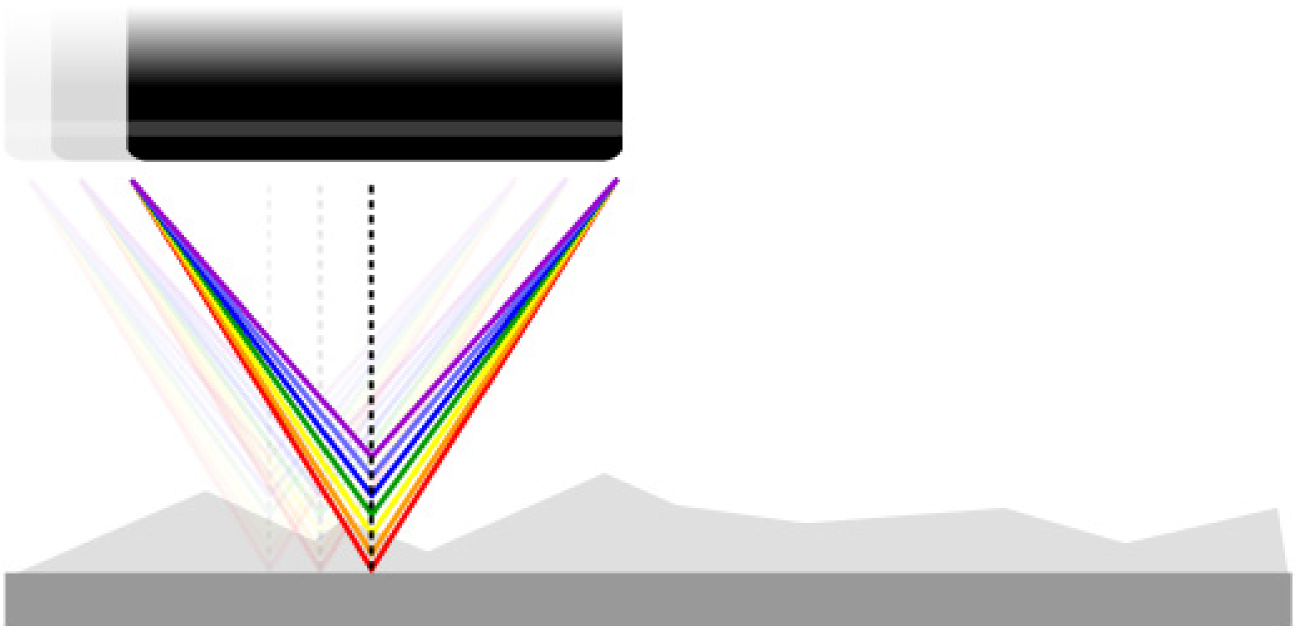


CONCLUSION:

In this application, we have shown how the Nanovea ST400 3D Non Contact Profilometer can precisely characterize both the topography and the nanometer texture/roughness of a tissue surface. Here we have shown the broad capability to study biomedical 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 biomedical 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 3D Profilometers speeds range from 20mm/s to 1m/s for laboratory or research to the needs of hi-speed inspection; can be built with custom size, speeds, scanning capabilities, Class 1 Clean Room compliance, with Indexing Conveyor and for Inline or online Integration.

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.