O-RING SURFACE INSPECTION USING 3D PROFILOMETRY

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INTRO:

The O-ring is a very simple, yet precisely used elastomeric seal between two or more parts. This critical ring of elastomer is one of the most widely used mechanical components and continues to evolve with advances in elastomer research. Like virtually all materials industries, Nanotechnology research is opening new doors to further understanding elastomer at the nano level.

IMPORTANCE OF SURFACE METROLOGY INSPECTION FOR R&D AND QUALITY CONTROL

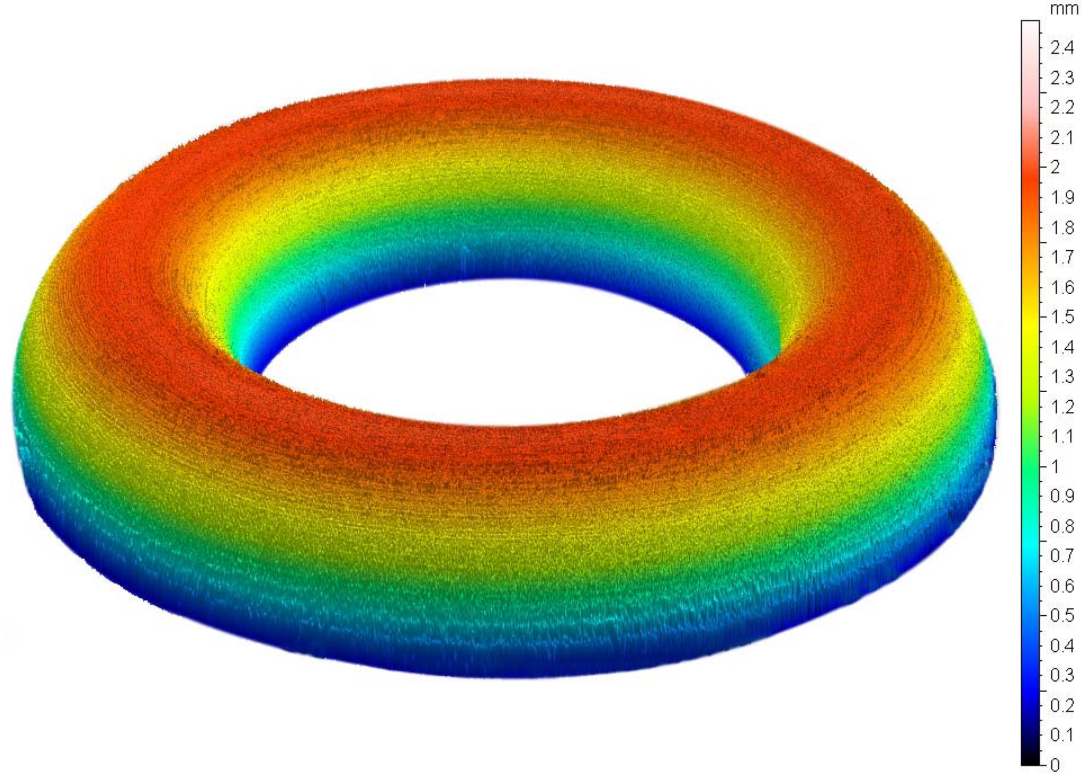
Because an O-ring is designed to seal between two or more parts it is vital to understand how the O-ring surface interacts with these parts. For example, if the O-ring surface is too rough it could cause abrasive wear, on the other hand if the surface is too smooth it can create problems with the seal. Understanding surface roughness/finish is just one of many surface parameters that are vital to quality control and the ultimate success of an O-ring. Other such parameters include: surface shape, form and topography defect among others. To insure the quality control of such parameters will heavily rely upon quantifiable, reproducible and reliable inspection of the O-ring surface. Precise measurement and evaluation of an O-ring surface can lead to the best selection surface roughness/finish and control measures. The Nanovea 3D Non-Contact Profilometers utilize chromatic confocal technology with unmatched capability to measure O-ring surfaces. Where other techniques fail to provide reliable data, due to probe contact, surface variation, angle, absorption or reflectivity, Nanovea Profilometers succeed.

MEASUREMENT OBJECTIVE

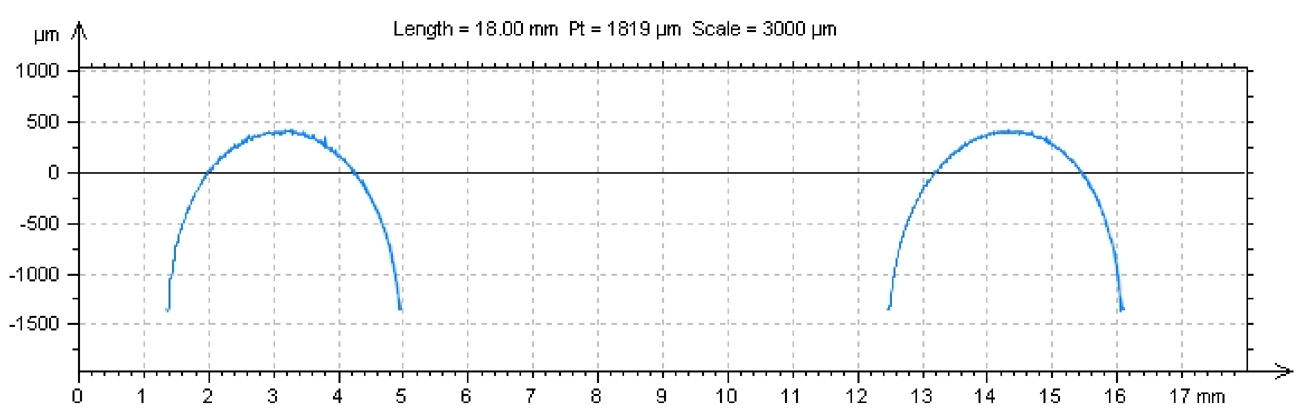
In this application, the Nanovea ST400 is used to measure the surface profile of an O-ring. Several surface parameters will be automatically calculated from the O-ring profile including the most common, Sa (average surface roughness), shape and form. Additionally, the cross section of the O-ring will also be further analyzed.

RESULTS:

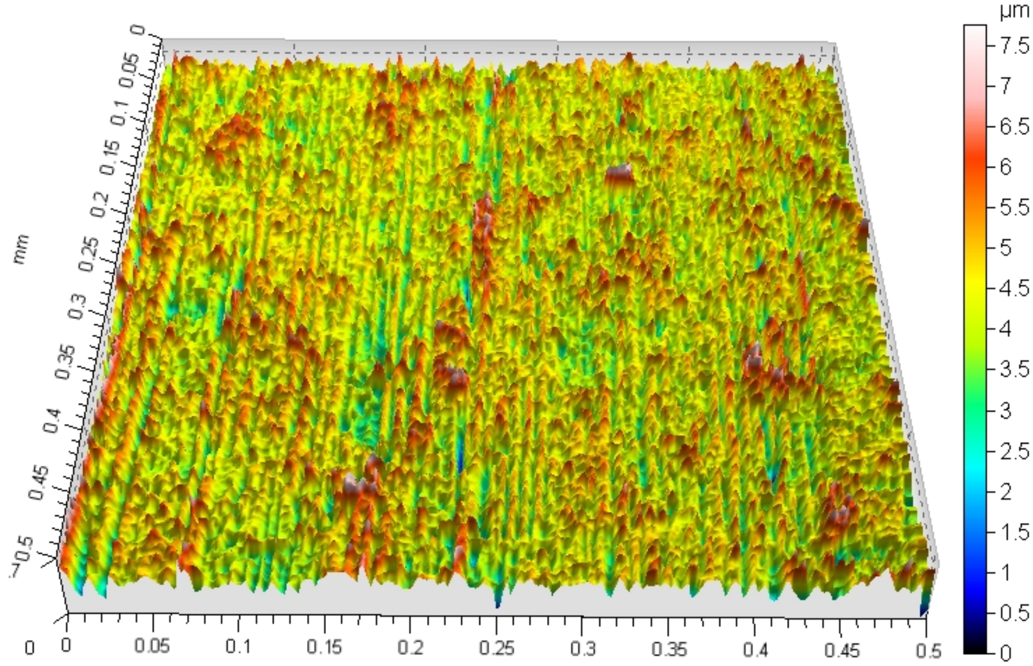
O-ring



3D Profile of O-ring

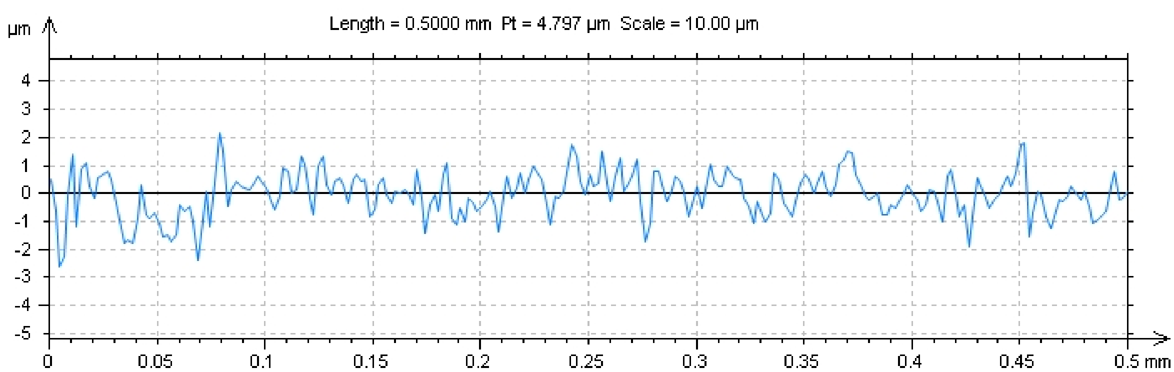


2D Profile Extraction of O-ring

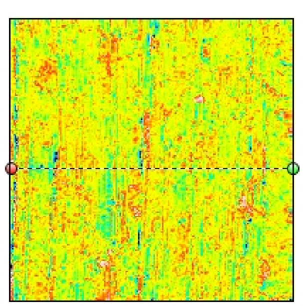


3D Profile of O-ring Surface

2D Roughness Profile Extraction

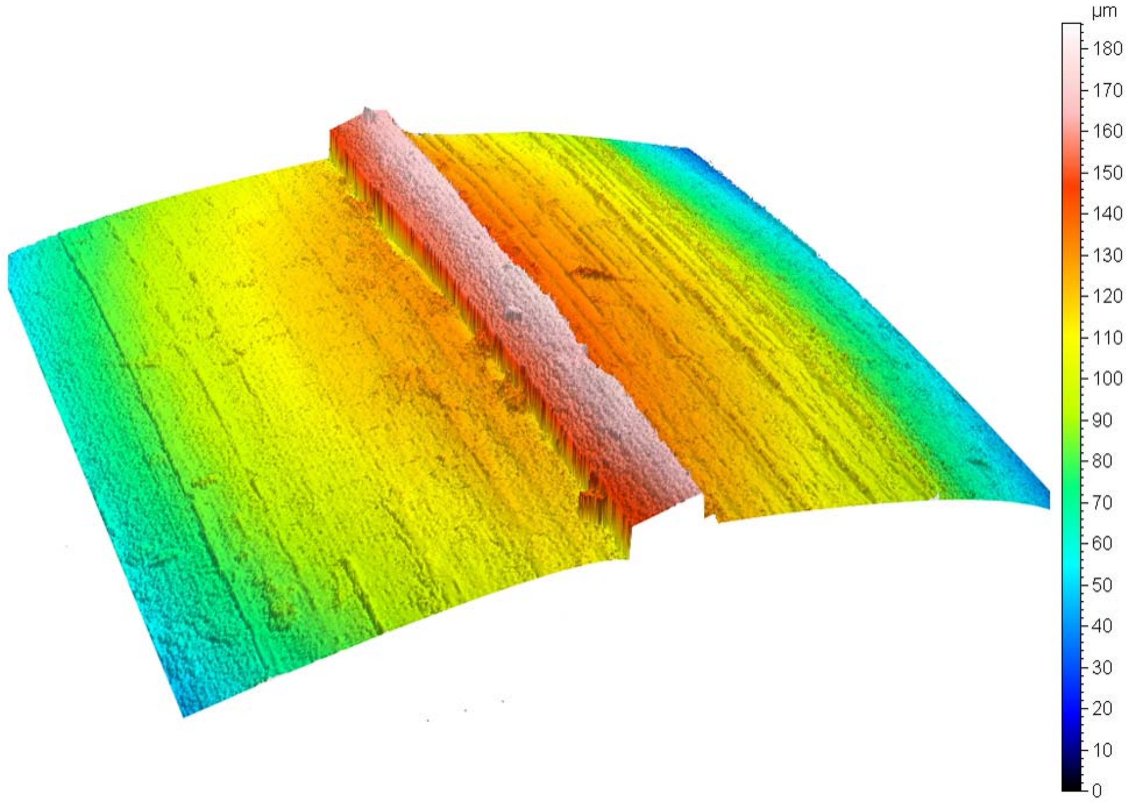


Roughness Profile Extracted

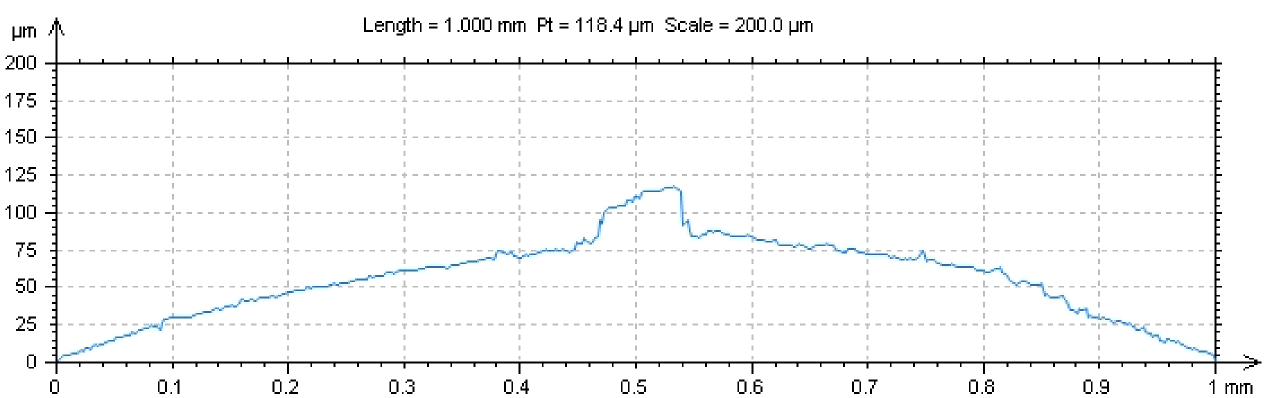


(ISO 25178) Height Parameters

Sq	0.480	µm
Ssk	-1.231	
Sku	8.681	
Sp	3.499	µm
Sv	5.562	µm
Sz	9.062	µm
Sa	0.344	µm



3D Profile of O-ring Cross Section



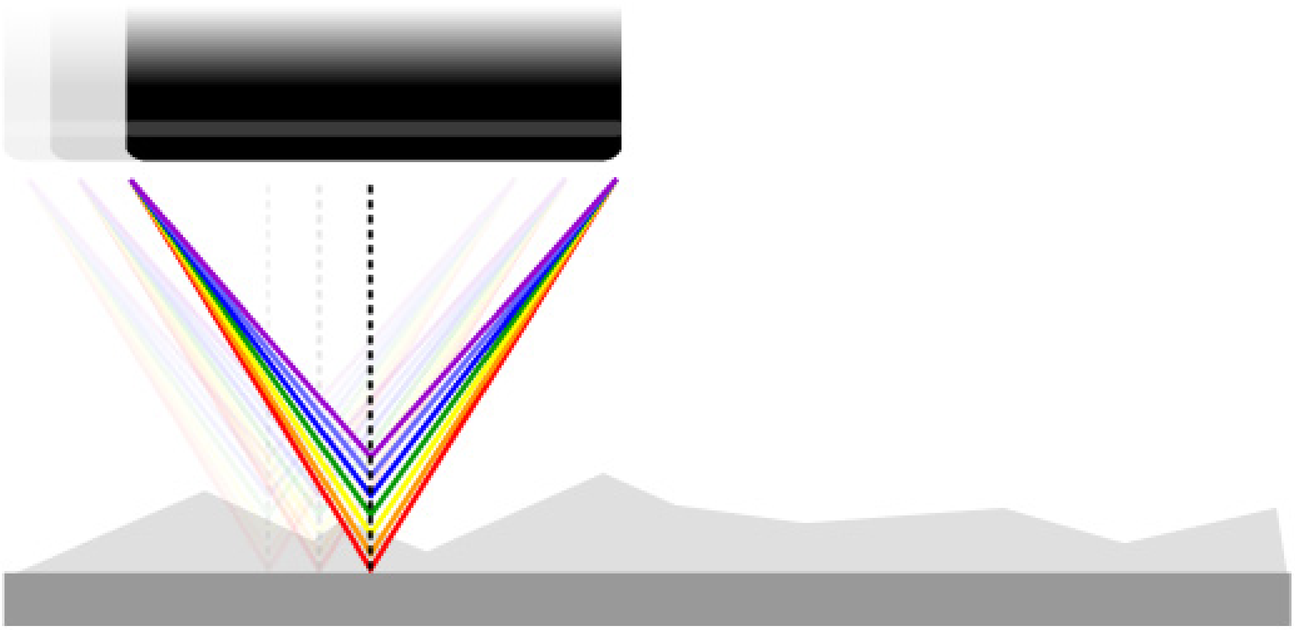
2D Profile Extraction of O-ring Cross Section

CONCLUSION:

In this application, we have shown how the Nanovea ST400 3D Profilometer can precisely characterize both the topography and the nanometer details of the O-ring surface. (*Note, many other measurements could have also been made besides those shown here) With this information an O-ring surface can be investigated for R&D or quality control procedures. To further view in detail a 2D cross section can quickly be chosen to analyze, at nanometer range, special areas of interest. Special areas of interest could have been further analyzed with integrated AFM or Microscope module. 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.