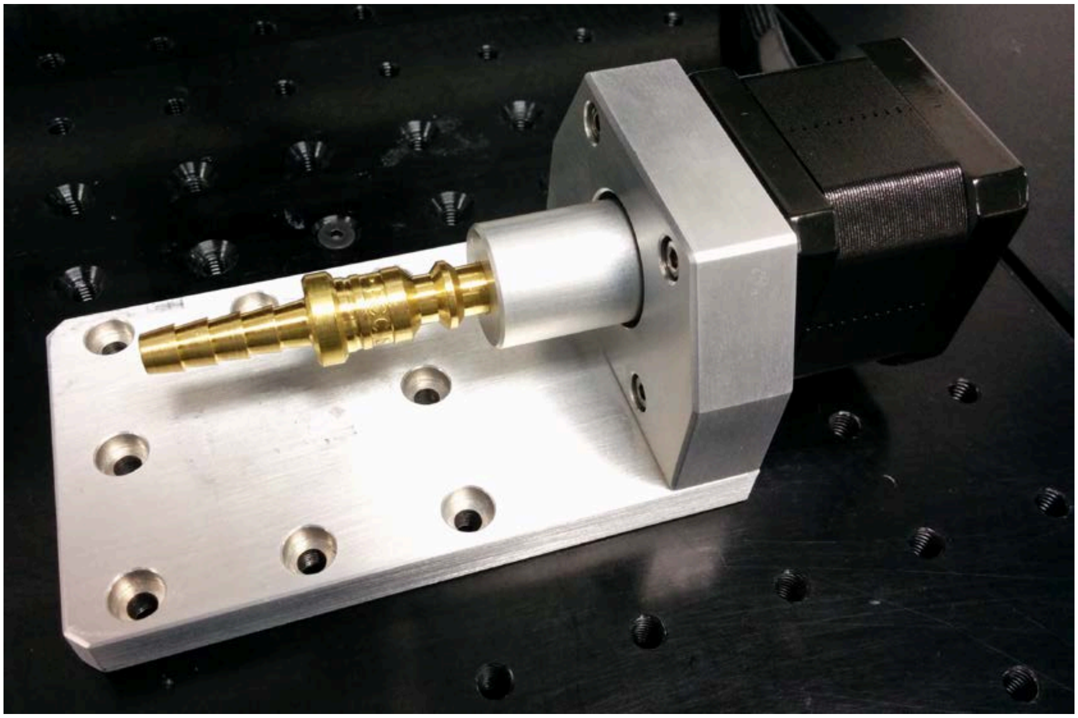
NANOVEA
A Better Measure.

ROTATIONAL MEASUREMENT USING 3D PROFILOMETRY



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INTRODUCTION

High resolution profilometry provides accurate surface topography, roughness, and step height measurement. It detects tiny surface features which may not be discernable by the naked eye. Unlike other techniques such as touch probes, the Nanovea 3D Non-Contact Profilometer measures the surface features without touching the sample. The profilometer analysis software offers a wide range of studies applicable to the unique surfaces.

IMPORTANCE OF ROTATION STAGE FOR PART INSPECTION

Surface roughness and texture of the mechanical parts is vital to its end use. Conventional surface profilometry usually scan the sample surface from just one direction. A precise 360° surface inspection of parts with a cylindrical shape is in need to measure detailed surface feature from different angles. Such 360° 3D inspection ensures the narrowest tolerances in quality control of manufacturing processes. Moreover, during the service time, wear creates dents, cracks, and surface roughening all over the cylindrical part surface. Surface inspection on one face of the sample may miss important information hidden on the backside.

MEASUREMENT OBJECTIVE

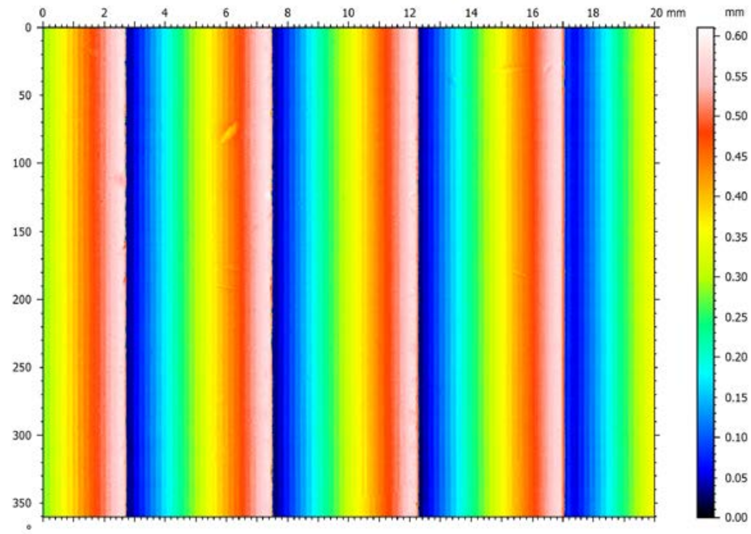
In this study, the Nanovea ST400 Profilometer equipped with a rotation stage is used to measure the 360° surface profile of a brass hose fitting as a representative sample. We would like to showcase that the Nanovea profilometer equipped with a rotation stage is an ideal tool for characterizing the surface features of a cylindrical-shape sample.

Fig. 1: Non-contact optical pen scanning on the sample.

RESULTS AND DISCUSSION

The false color view and 3D view of the surface profile of the hose fitting sample are shown in Fig. 2, providing users a tool to easily observe the surface features of the cylindrical sample at different angles.

(a)



(b)

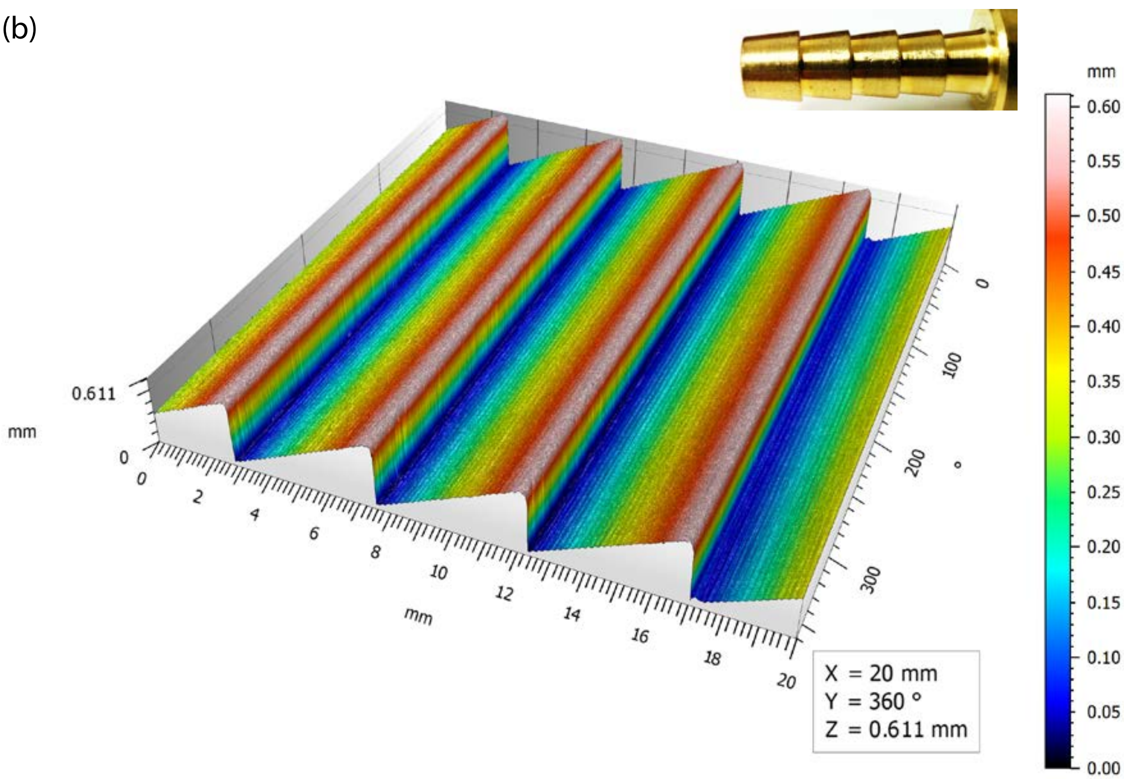


Fig. 2: (a) False color view and (b) 3D View of the scanned surface.

Line profile is extracted along the longitudinal direction to show a crossectional view of the hose fitting contour in Fig. 3. The size of the peaks of the surface shape is fairly uniform. By setting up a tolerance limit value, the analysis software can automatically determine the quality of the hose fitting, allowing users to make a quick and accurate fail/pass decision on the part.

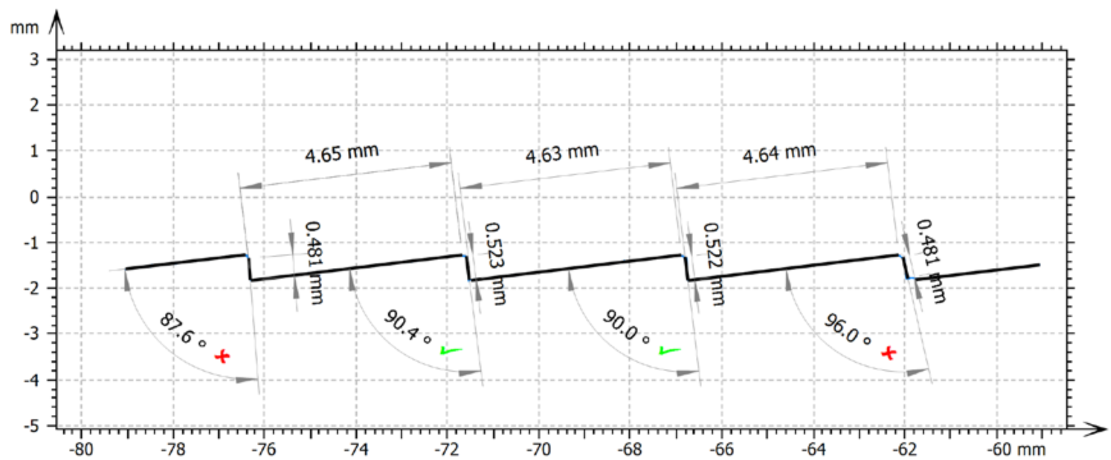


Fig. 3: 2D profile contour analysis of the hose fitting sample.

The roughness and uniformity of the part surface play an important role in ensuring its quality and functionality. Fig. 4 presents the local surface morphology of the sample at a high magnification. The surface roughness values and texture direction are calculated and summarized in Table 1. Directional machine marks were created during the sample manufacture. A dent is detected on the sample surface as a local defect.

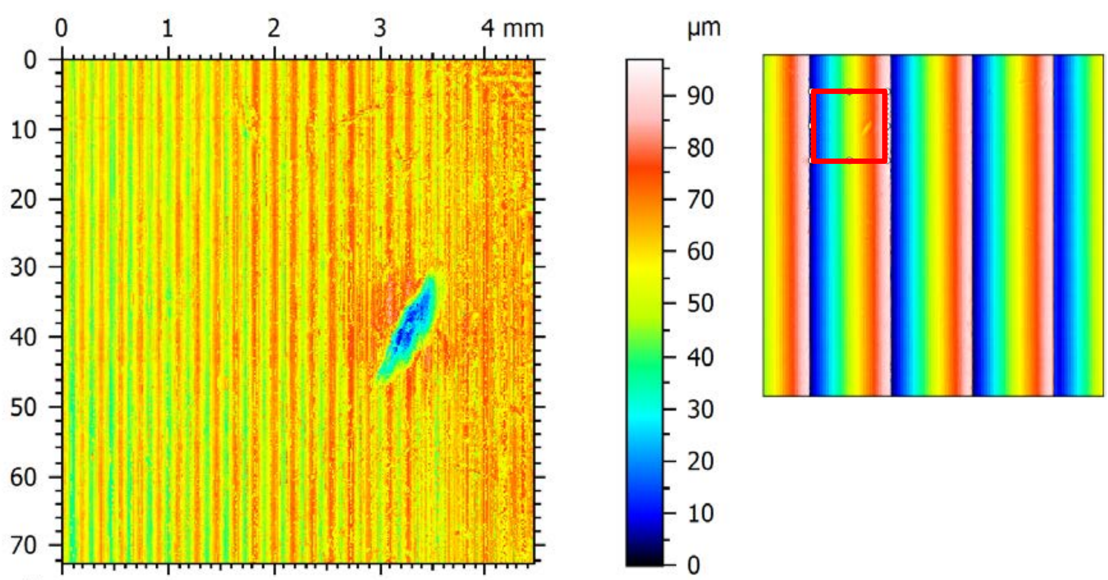


Fig. 4: Local surface finish of the hose fitting sample at a higher magnification.

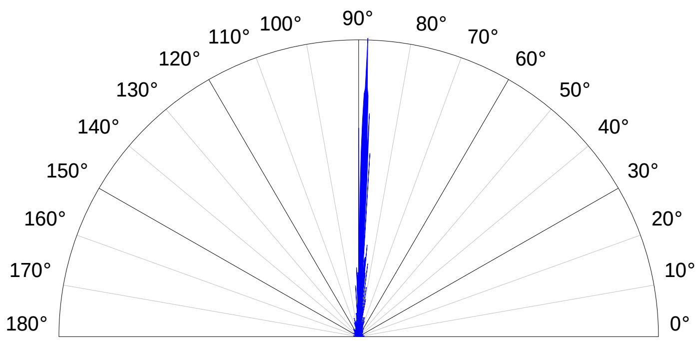
(a) Roughness:

ISO 25178

Height Parameters

Sq	9.05	µm	*Root-mean-square height*
Ssk	-0.514		*Skewness*
Sku	3.69		*Kurtosis*
Sp	38.2	µm	*Maximum peak height*
Sv	58.5	µm	*Maximum pit height*
Sz	96.7	µm	*Maximum height*
Sa	7.34	µm	*Arithmetic mean height*

(b) Texture direction:



Parameters	Value	Unit
Isotropy	100	%
First Direction	88.3	°
Second Direction	83.1	°
Third Direction	93.5	°

Fig. 5: surface roughness and texture direction.

CONCLUSION

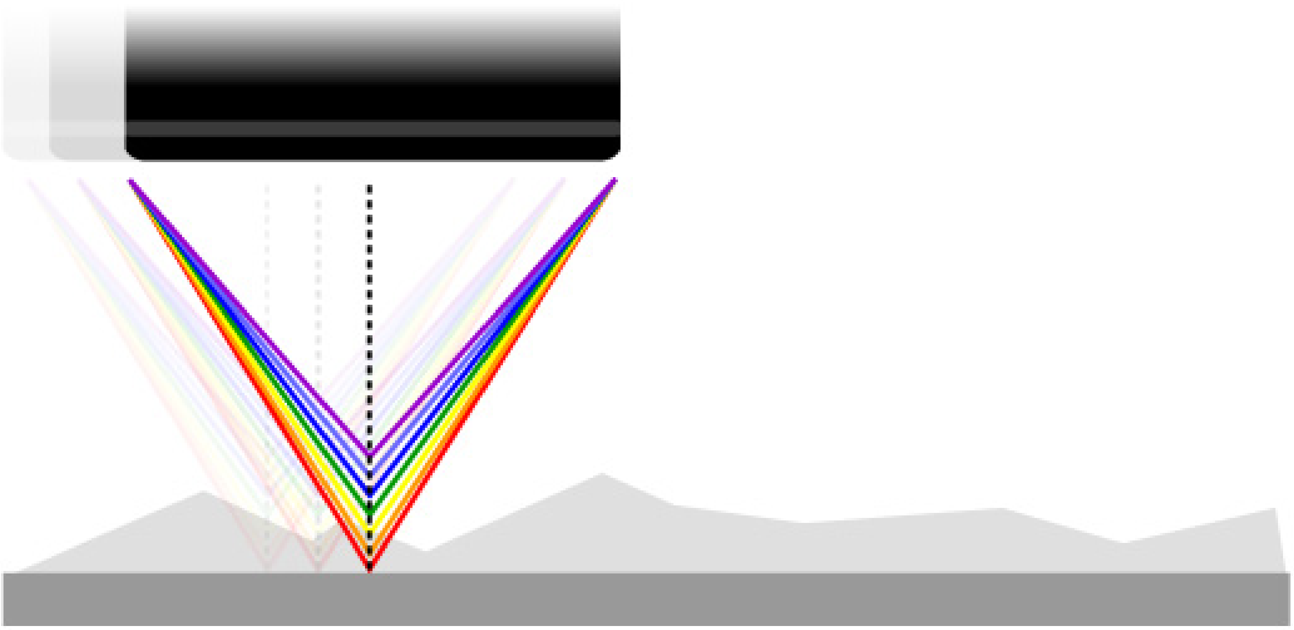
In this application, we comprehensively studied the 3D surface features of a hose fitting sample using a ST400 Nanovea 3D Non-Contact Profilometer. We showcase that Nanovea 3D Non-Contact Profilometer equipped with a rotation sample stage can accurately characterize the 360° 3D surface morphology of samples with a cylindrical shape. The detailed and precise 360° surface scan provides an ideal tool for quality control and part inspection.

The data shown here represents only a portion of the calculations available in the analysis software. Nanovea Profilometers measure virtually any surface in fields including Semiconductor, Automotive, Aerospace, Metallurgy, Machining, Biomedical, and Others.

Learn more about the Nanovea Profilometer or Lab Services

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. $$Sa = \frac{1}{A}\iint_A |z(x,y)|dxdy$$
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.