INTRODUCTION

Surface deformation of materials induced by environmental elements such as temperature, humidity and corrosion is vital to its service quality and functionality. Accurate 3D surface morphology measurement allows quantifying the physical deformations of the surface form, roughness, volume/area, etc. Surfaces prone to deformation due to contact wear, high heat and others need regular inspection to ensure performance reliability.

IMPORTANCE OF 3D NON-CONTACT PROFILOMETER FOR MORPHOLOGY ANALYSIS

Unlike other techniques such as touch probes or interferometry, Nanovea 3D Non Contact Profilometer, using axial chromatism, can measure nearly any surface with nano through macro range. No sample surface preparation is needed for surface profile measurement of any material, including transparent, opaque, specular, diffusive, polished and rough, etc. The non-contact technique makes it possible to precisely scan samples with complex shape and soft texture. Nanovea Non-Contact Profilometer provides an ideal, broad and user friendly tool to maximize surface studies.

MEASUREMENT OBJECTIVE

In this application, the Nanovea ST400 Profilometer is used to measure the surface morphology of a polymer sample before and after heat deformation. The deformation will be characterized by the change in relative volume change and flatness as defined by ISO 12781.


Fig. 1: Optical sensor scanning on the polymer sample.

RESULTS AND DISCUSSION

Fig. 2 displays the 3D view of the polymer sample surface before and after the heat deformation, providing users a straightforward tool to directly observe the sample from different angles. Table 1 compares the Roughness and Flatness values of the polymer surface before and after heat deformation. The surface morphology has been substantially changed by the heating process, forming a hole in the center of the sample. It leads to increased Roughness, Sa, from 1.17 to 74 µm, as well as increased Flatness, FLTt, from 3.8 to 502 µm.

(a) Polymer surface before heat deformation:
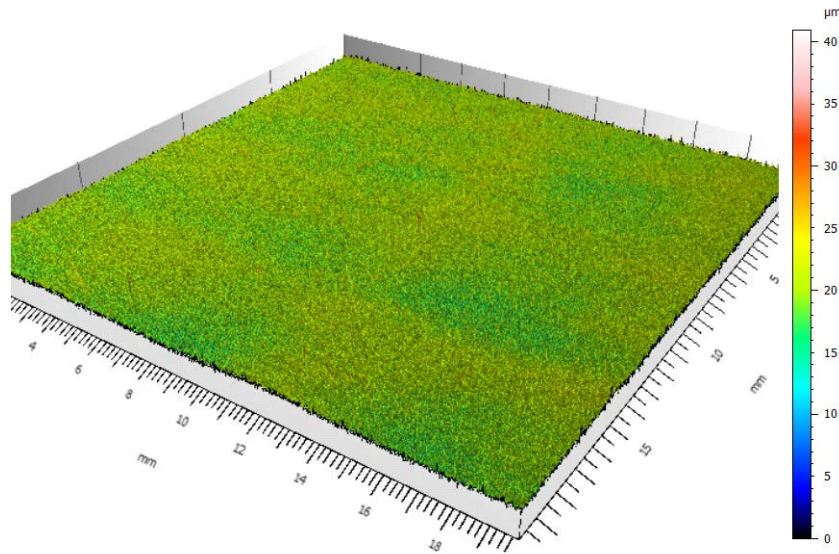
(b) Polymer surface after heat deformation:
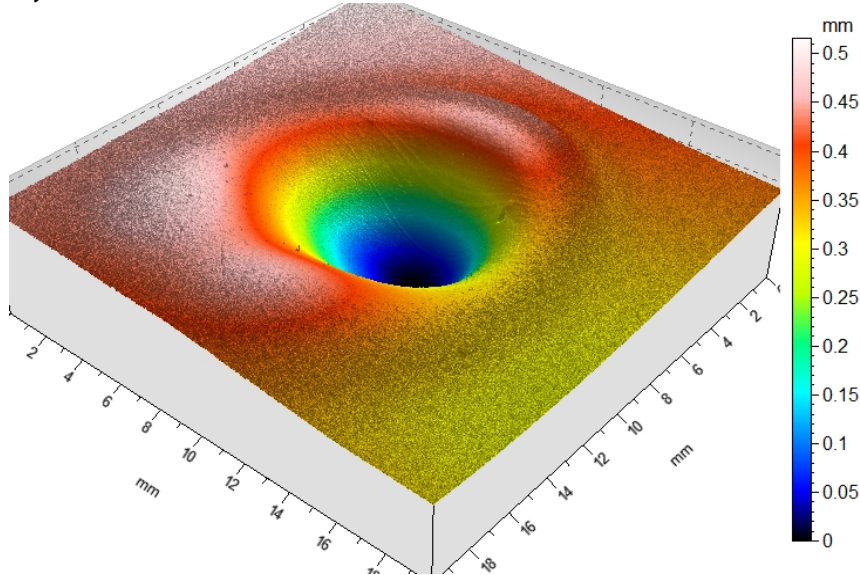

Fig. 2: The 3D morphology of the polymer surface before and after heat deformation.

Parameter	Unit	Before	After	Note
Sq	µm	1.52	97.8	Root-mean-square height
Ssk		0.248	-1.49	Skewness
Sku		4.6	5.49	Kurtosis
Sp	µm	22.3	149	Maximum peak height
Sv	µm	18.7	364	Maximum pit height
Sz	µm	41	513	Maximum height
Sa	µm	1.17	74	Arithmetic mean height
FLTt	µm	3.8	502	Peak-to-valley surface flatness deviation

Table 1: The Roughness and Flatness values of the polymer surface before and after heat deformation.

Fig. 3 shows the deformed surface subtracted from the original surface with the mean plane of the original surface at zero, illustrating the local height difference between the surface before and after deformation. As the hole forms and grows during heat deformation in the center of the sample, the surface surrounding the hole slightly rises at the same time. This leads to drastic change in the height, both positive and negative, from the original surface. The relative volume calculations by the analysis software show that the volume of the center hole is 12.68 mm^3, and the peak volume at the edge of the hole is 3.582 mm^3.
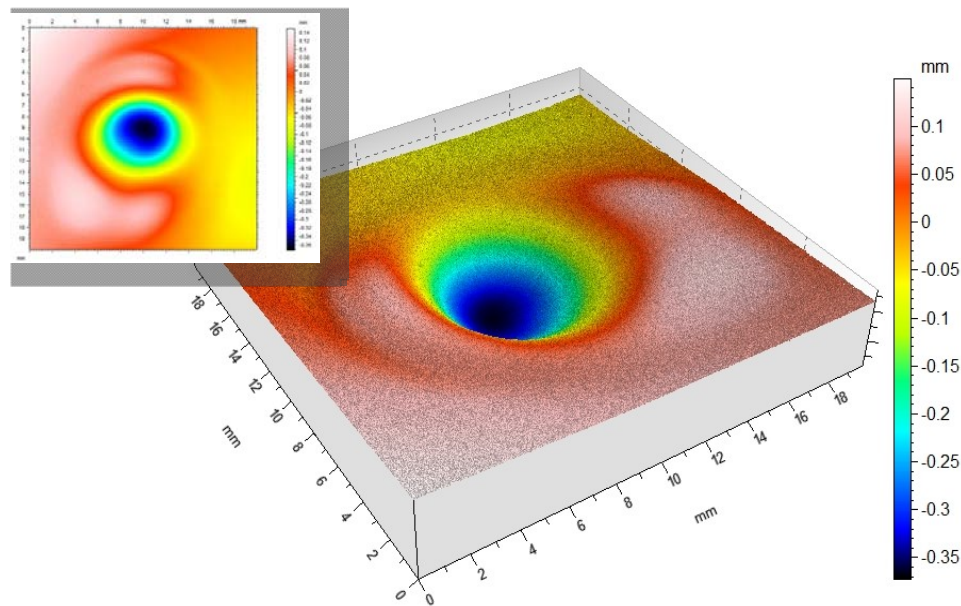

Fig. 3: The 3D view of the deformed surface subtracted from the original surface.

CONCLUSION

In this application, we have shown that the Nanovea 3D Non-Contact Profilometer characterizes the surface morphology of heat deformed polymer. The subtraction of the deformed surface from the original one provides a useful tool to precisely pinpoint the area

where shape change occurs, as well as to quantify the volume of such change. Surface deformation of materials may have critical effect on its service quality and functionality. Nanovea Non-Contact Profilometer provides an ideal tool for surface deformation 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, Microelectronics, Solar, Fiber Optics, Automotive, Aerospace, Metallurgy, Machining, Coatings, Pharmaceutical, Biomedical, Environmental and many others.

Learn more about the: 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.
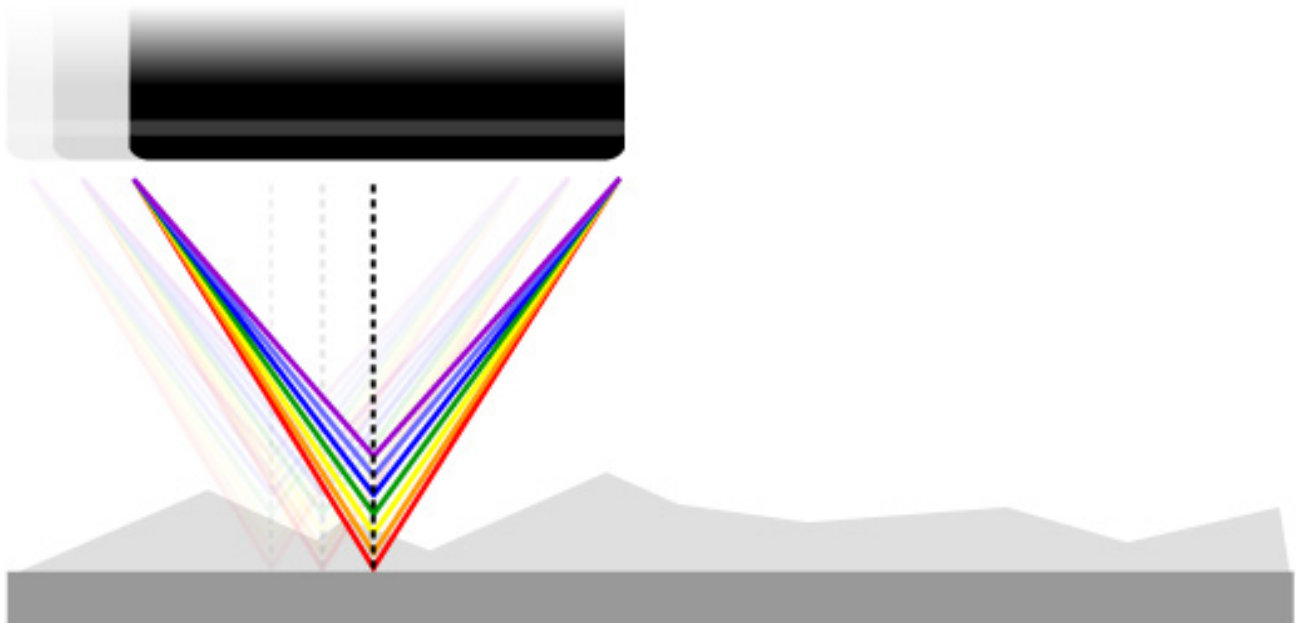
Unlike the errors caused by probe contact or the manipulative Interferometry technique, Chromatic Confocal technology measures height directly from the detection of the wavelength that hits the surface of the sample in focus. It is a direct measurement with no mathematical software manipulation. This 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. $$Sa = \frac{1}{A} \iint_A |z(x,y)| dxdy$$
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.