TOOTH WEAR MEASUREMENT USING 3D PROFILOMETRY

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INTRODUCTION:

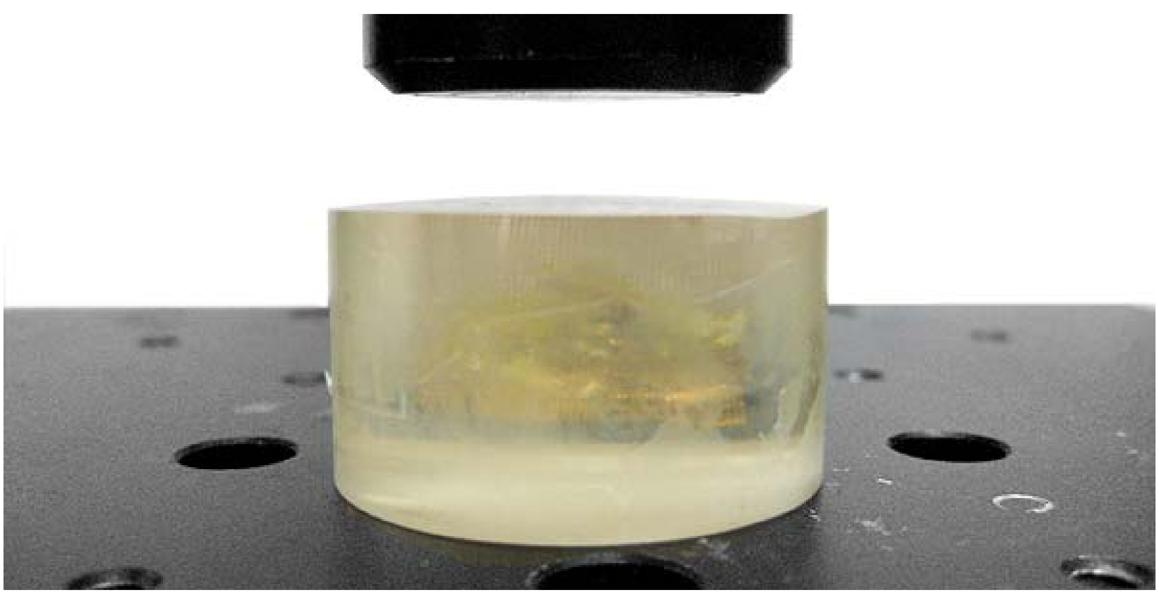
The wear resistance of our teeth is an important area of study in the dental medical field. No matter what kind of wear in particular is being studied or the means by which the wear is produced, there is always a need to characterize the resulting wear track. This could include the maximum depth, width, and surface area of the wear track, as well as the volume of material lost.

IMPORTANCE OF 3D NON CONTACT PROFILOMETER FOR WEAR STUDY

Unlike other techniques such as touch probes or interferometry, the 3D Non Contact Profilometer, using axial chromatism, can measure nearly any surface, sample sizes can vary widely due to open staging and there is no sample preparation needed. Nano through macro range is obtained during surface profile measurement with zero influence from sample reflectivity or absorption, has advanced ability to measure high surface angles and there is no software manipulation of results. Easily measure any material: transparent, opaque, specular, diffusive, polished, rough etc. The technique of the Non Contact Profilometer provides an ideal, broad and user friendly capability to maximize surface studies when volume lost measurements will be needed; along with the benefits of combined 2D & 3D capability.

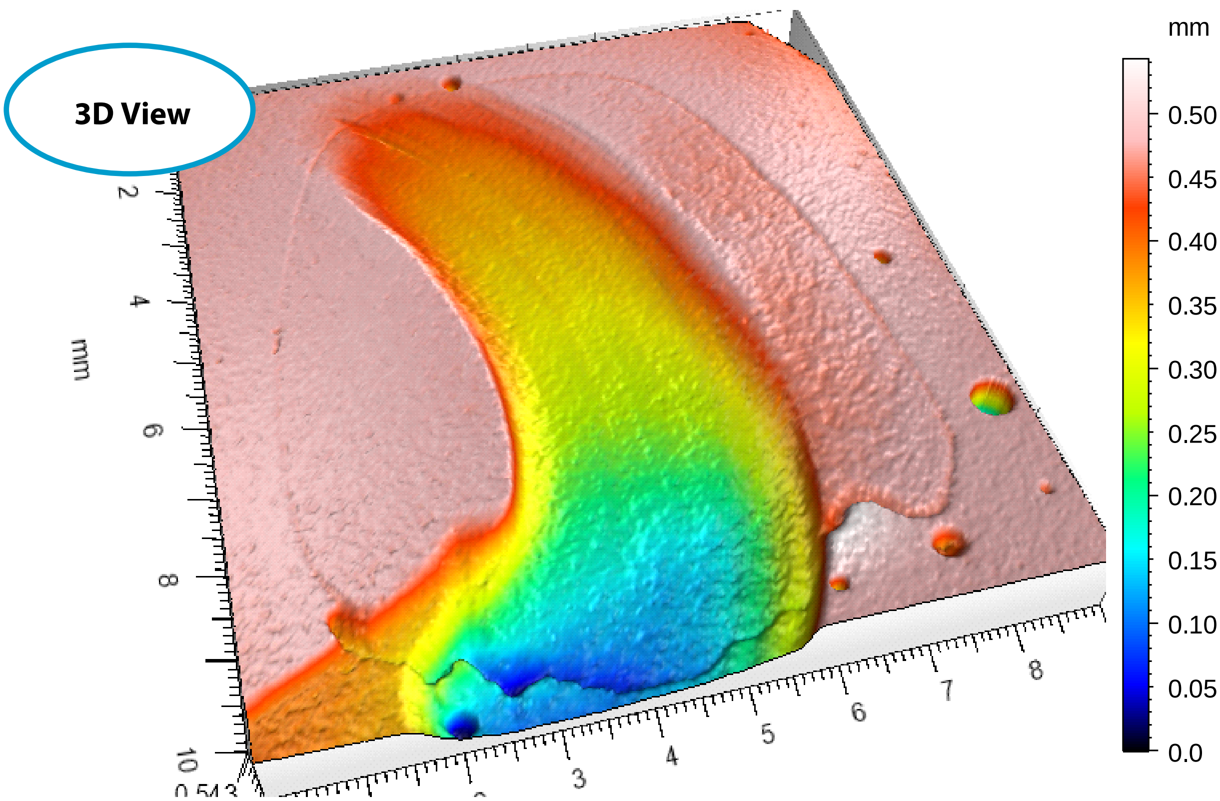
MEASUREMENT OBJECTIVE

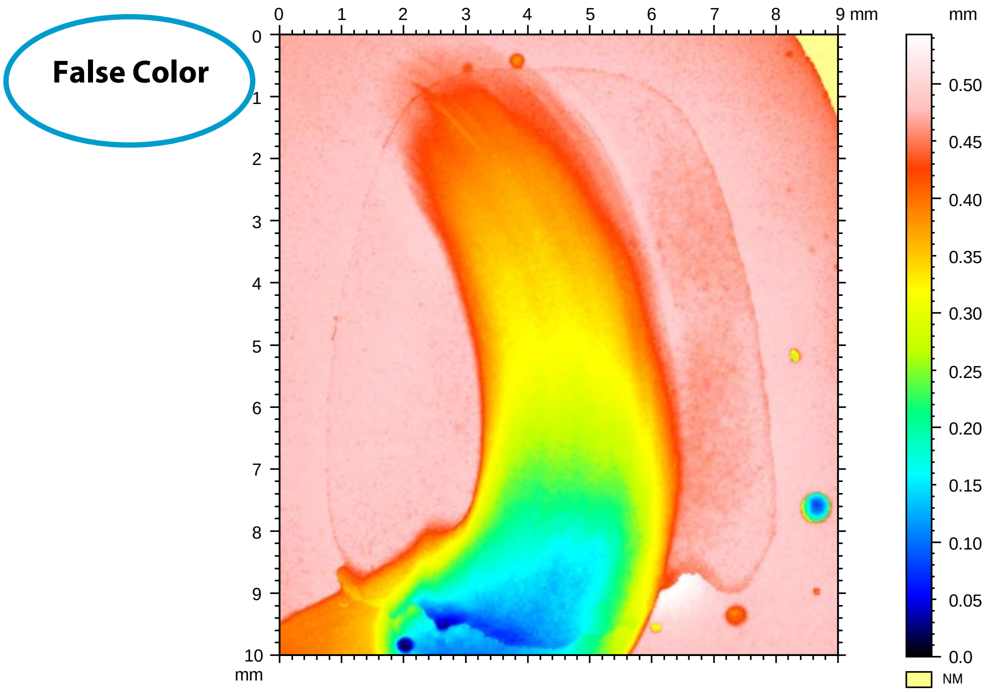
In this application the Nanovea ST400 Profilometer is used to measure the surface of a tooth sample mounted in epoxy that has been put through a chewing simulator. The area measured was the resulting wear and the surrounding surface area. The maximum width, depth, perimeter, surface area, and volume lost will be used to characterize the wear track.

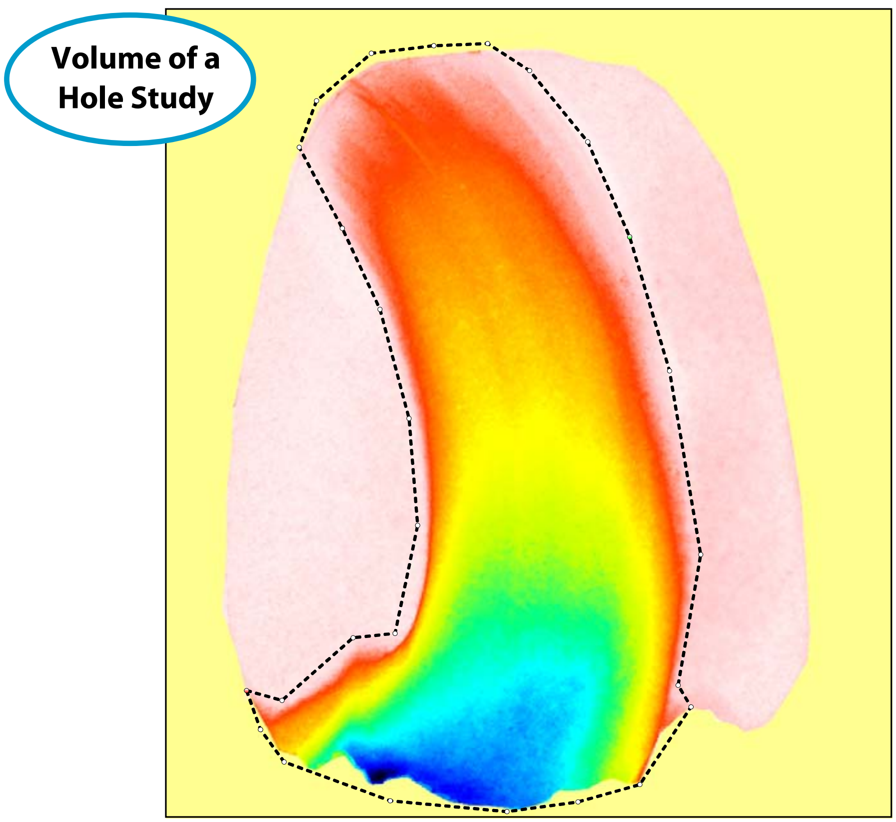


RESULTS: 3D Surface

The 3D View and False Color View of the tooth and surrounding epoxy mount show a significant curved wear track produced by a chewing simulator. It provides users a straightforward tool to directly observe the morphology of the wear track from different angles. A Volume of a Hole study was used to calculate the surface area, volume, maximum depth, and mean depth of the wear track using the surrounding tooth surface as the reference plane.



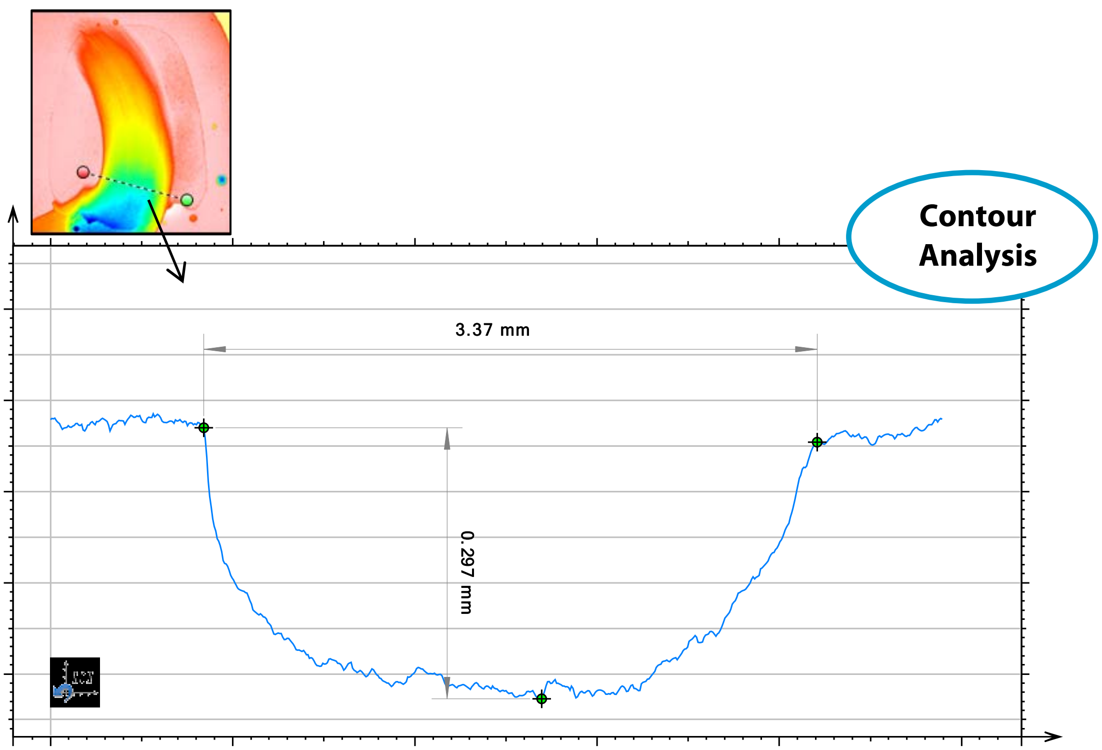


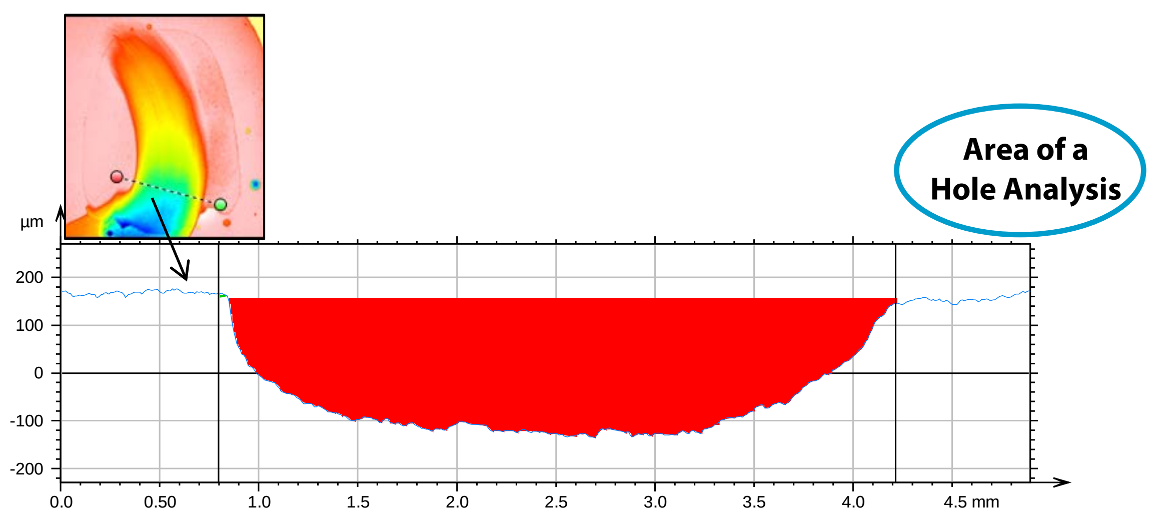


Parameters	Unit	Hole
Surface	mm²	32.06
Volume	mm³	4.871
Max. depth/height	mm	0.4560
Mean depth/height	mm	0.1519

2D Surface Analysis

Line profiles can also be extracted from the surface to show a crossectional view of the wear track. The Countour Analysis and Area of a Hole studies were used to measure precise dimensions at a certain location on the wear track.





Parameters	Value	Unit
Maximum depth	297.2	µm
Area of the hole	0.7934	mm²

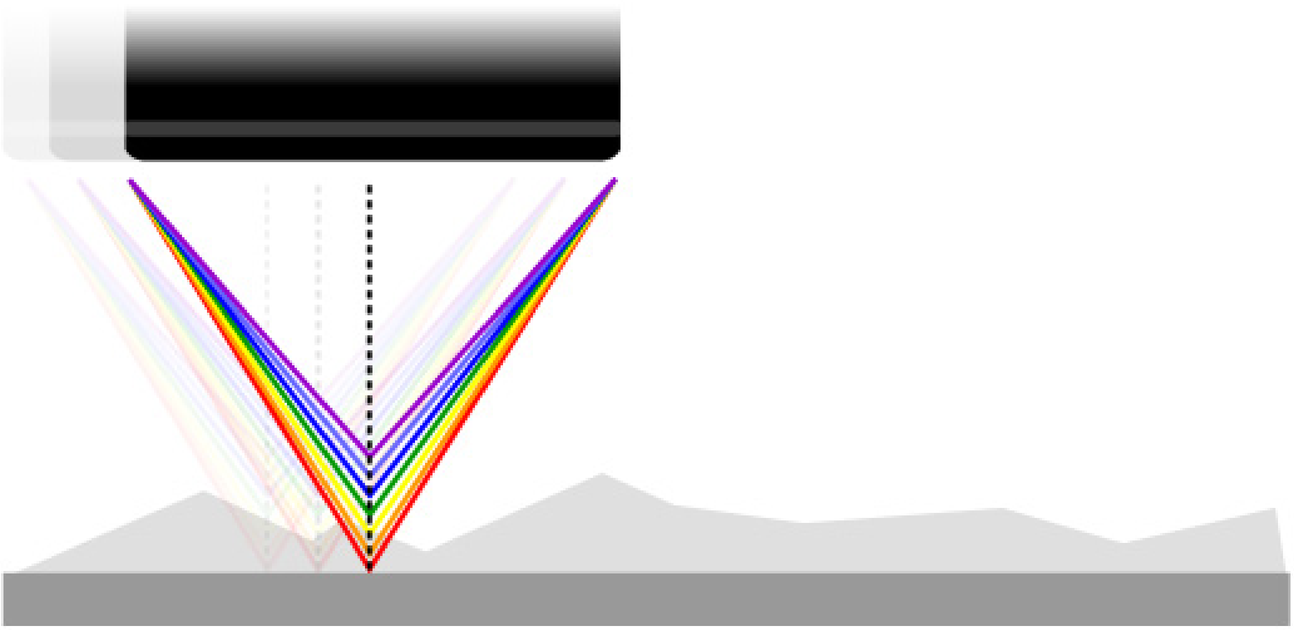
CONCLUSION:

In this application, we have shown how the Nanovea 3D Non Contact Profilometer can precisely characterize a wear track created on a tooth sample, or any other material. The data shows a total volume loss of 4.871 mm^3. The developed surface area of the wear track was found to be 32.06 mm^2 and the maximum depth was 0.456mm. These values, along with the parameters used to produce the wear track, can be used to calculate the wear rate of the tooth and compare the wear resistance of different samples. The data shown here represents only a portion of the calculations available in the analysis software.

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