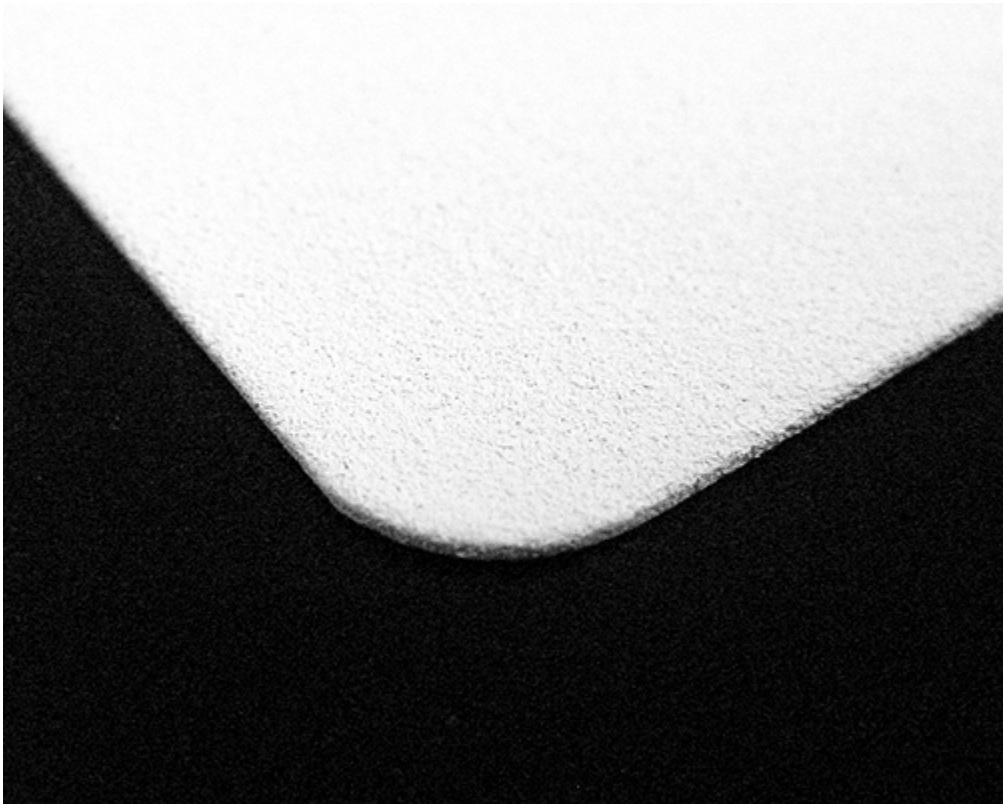
NANOVEA®
A Better Measure.

SURFACE ROUGHNESS STATISTICAL ANALYSIS USING 3D PROFILOMETRY



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INTRODUCTION:

With constant development of new materials and processes, it is often a challenge to find credible ways to properly assess material surfaces for quality control. Manufacturers have had to find or develop new ways to make sure that materials are in compliance to specific internal or external manufacturing standards. The Nanovea Profilometer can do much more than that. It can meet and exceed expectations by developing new standards, DOE's, survey sampling, predictions and forecasting's.

IMPORTANCE OF 3D NON CONTACT PROFILOMETER FOR STATISTICAL ANALYSIS

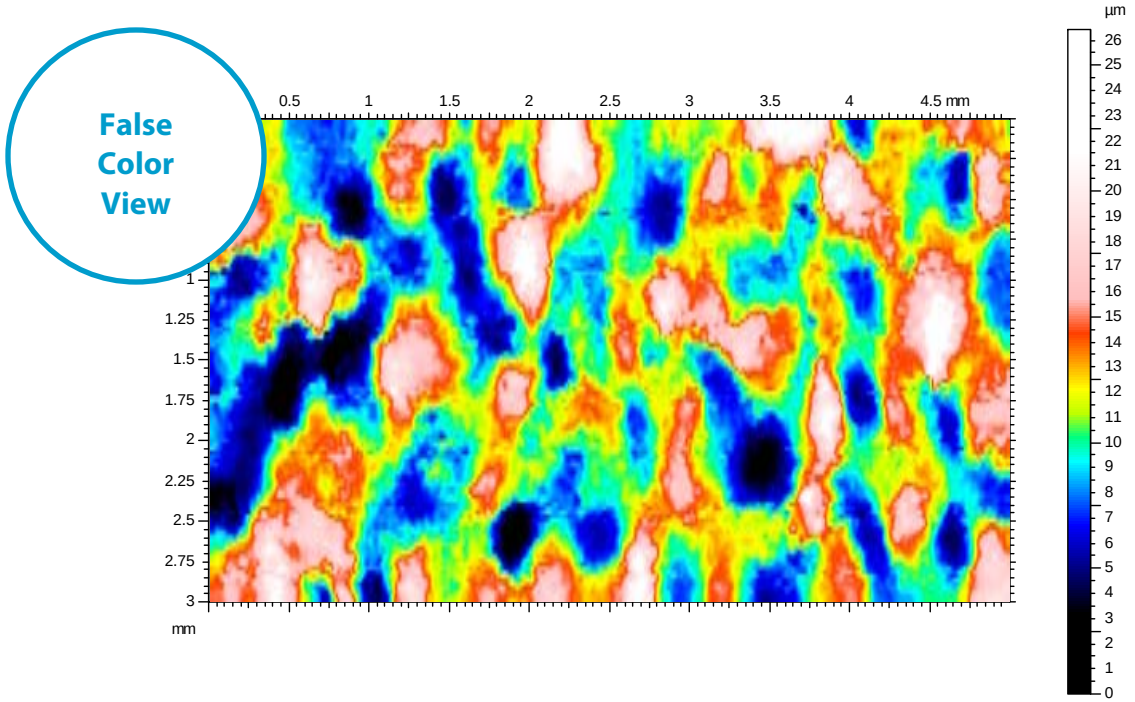
Nanovea's 3D non-contact profilometer is capable of measuring the widest range of surfaces to assess roughness, planarity and many others. Surface roughness at the micron level can often be challenging to assess for manufactures and is vital when asked to develop new standards or DOE's. Nanovea's 3D non-contact profilometer can provide a real value to measurements produced and test the probability of observations unlike theoretical statistics where the data is portrayed.

MEASUREMENT OBJECTIVE

In this application the Nanovea ST400 Profilometer is used to measure over 30 coupons with similar surface features with only slight differences. The surfaces were analyzed for parameters such as surface roughness, maximum height, maximum peak height and root mean square. A statistical analysis was then performed using histograms, tables, control charts, box plots and scatter plots.

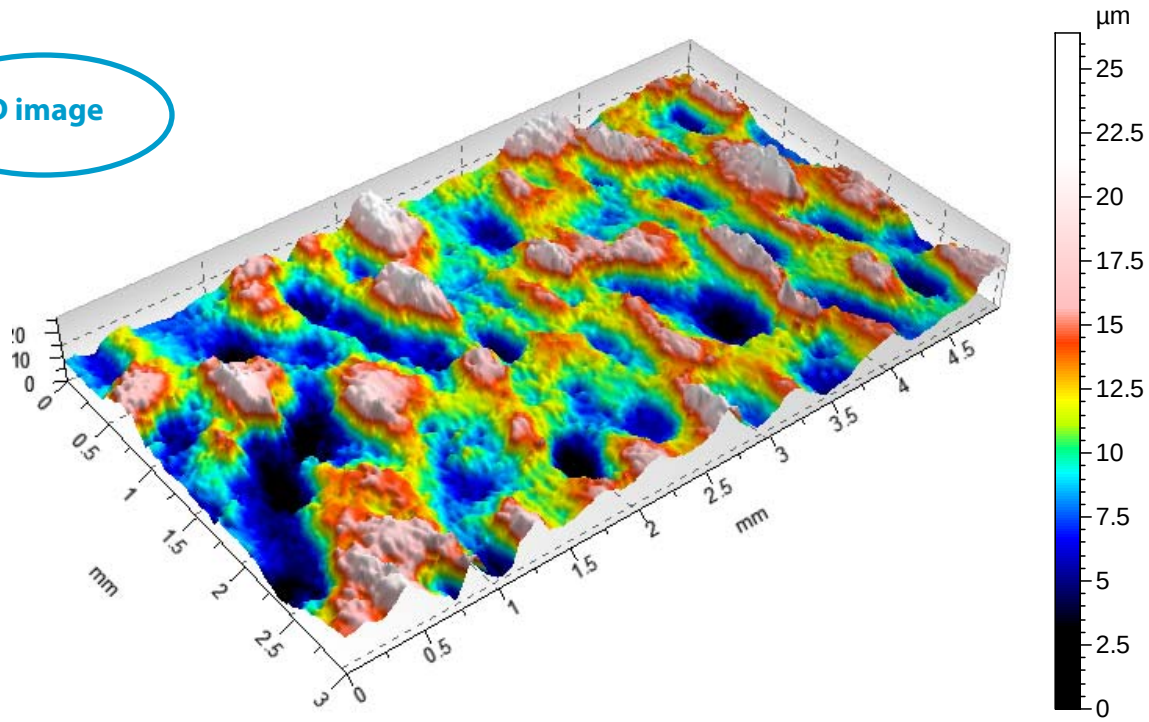
RESULTS: Statistical Analysis for 30 samples

False Color View

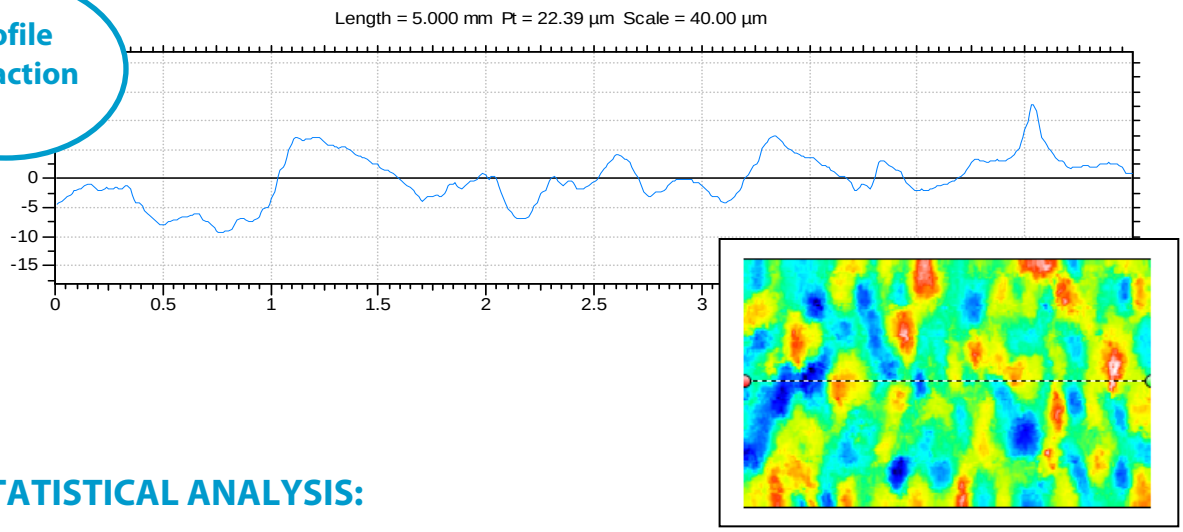


*Images are a representation of the 30 samples measured for analysis

3D image



Profile Extraction



STATISTICAL ANALYSIS:

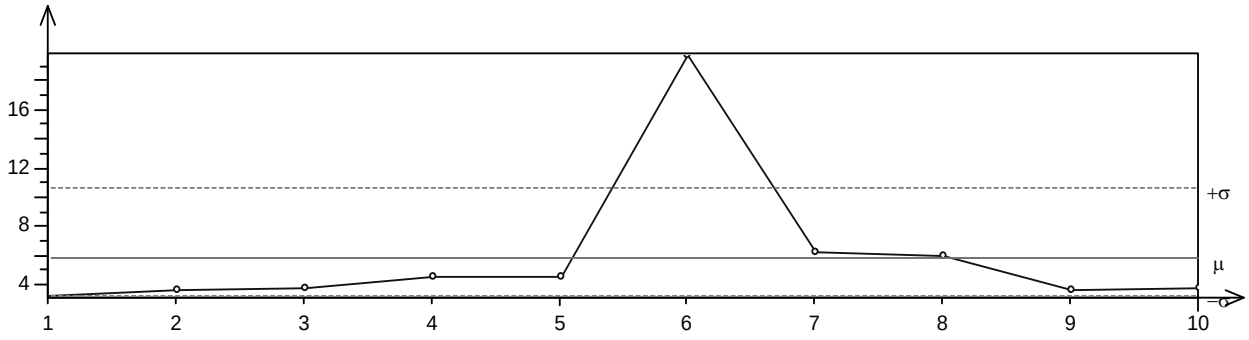
Summary for all samples measured

Statistical summary of all populations

Parameter	Unit	Mean	Std dev	Min	Max	Range
Sa	µm	3.781	0.7091	3.024	5.368	2.343
Sq	µm	4.905	1.037	3.8	7.468	3.668
Sz	µm	31.01	7.98	22.47	50.01	27.54
Ssk		0.3805	0.8227	-2.537	1.91	4.447
Sku		8.142	13.16	3.044	67.9	64.85
Sp	µm	24.22	10.6	13.73	62.25	48.52
Sv	µm	28.51	32.88	9.687	145.6	135.9
St	µm	52.73	33.57	25.97	161.4	135.5
Tolerance(Sa - 7)		0.449	0.4974	0	1	1

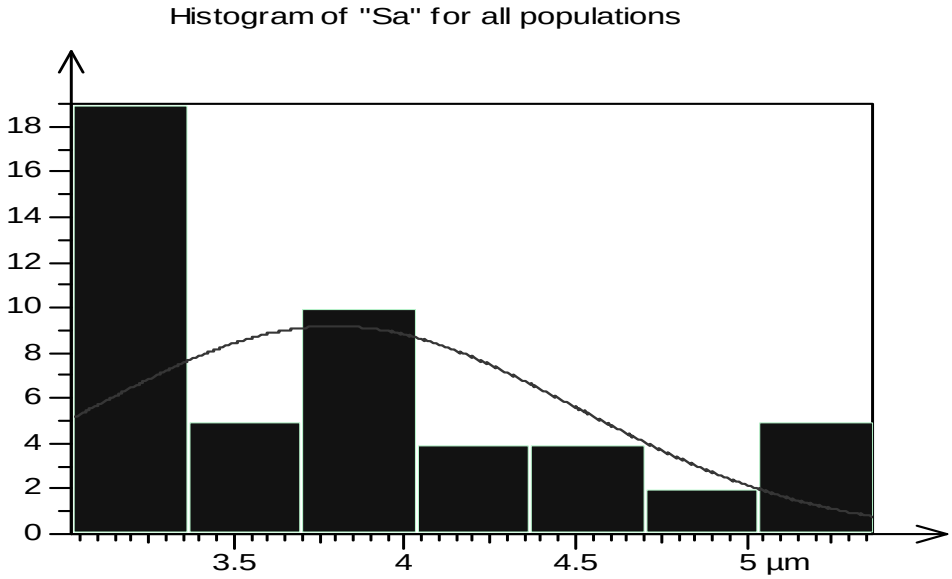
A summary table is a visualization of statistical information about the data. The table above shows a statistical summary for the parameters measured with Nanovea's 3D non-contact profiler.

Control Chart - Skewness (measure of asymmetry)



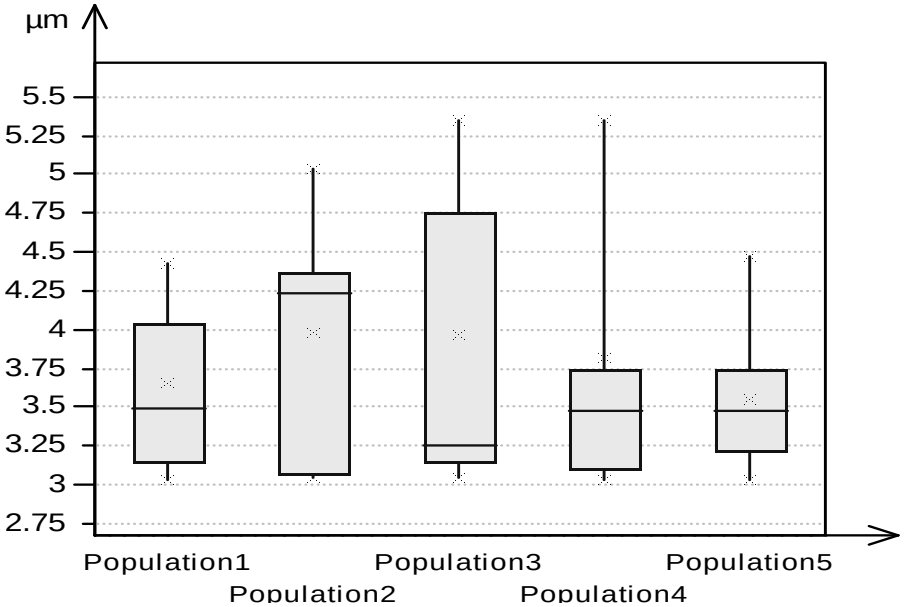
A control chart is a good statistical tool to monitor the quality of products and also good for detection of out of control processes. In the image above we can see that when assessing the skewness of the samples measured, sample 6 deviates from the average range.

Histograms



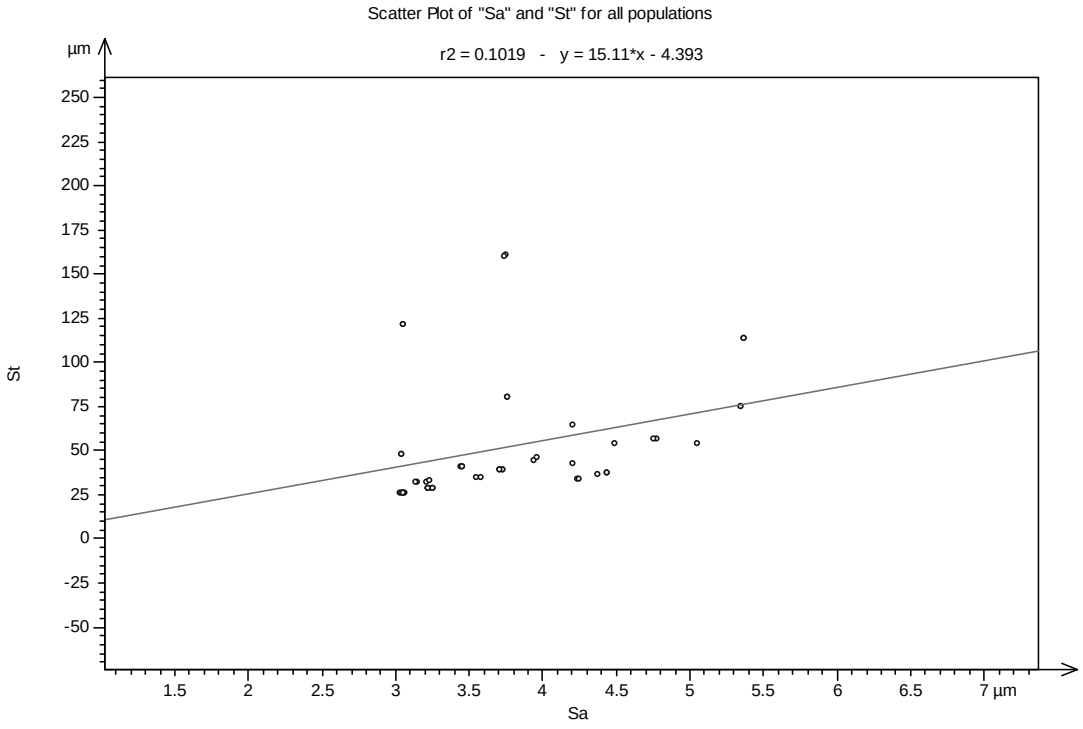
Histograms are bar graphs the rerpresent the ranges of values for a selected parameter along the horizontal axis and the number of obsevations in these ranges along the vertical axis. In this case the Sa (surface roughness) shows the number of samples falling under specific levels of roughness.

Box Plot-Sa (surface roughness)



Box plots are used to summarize large amounts of data and display the range of distribution of data a long a number line. The box plot is used to put in order the data by arranging the values from leat to greatest and then finding the median to split the data into equal groups and then adiditonal slitting sub groups. The box plot above is arranging Sa (surface roughness) by plotting data from all 30 samples measured and arranging them as necessary.

Scatter plot- Sa (surface roughness) **& St** (total height)



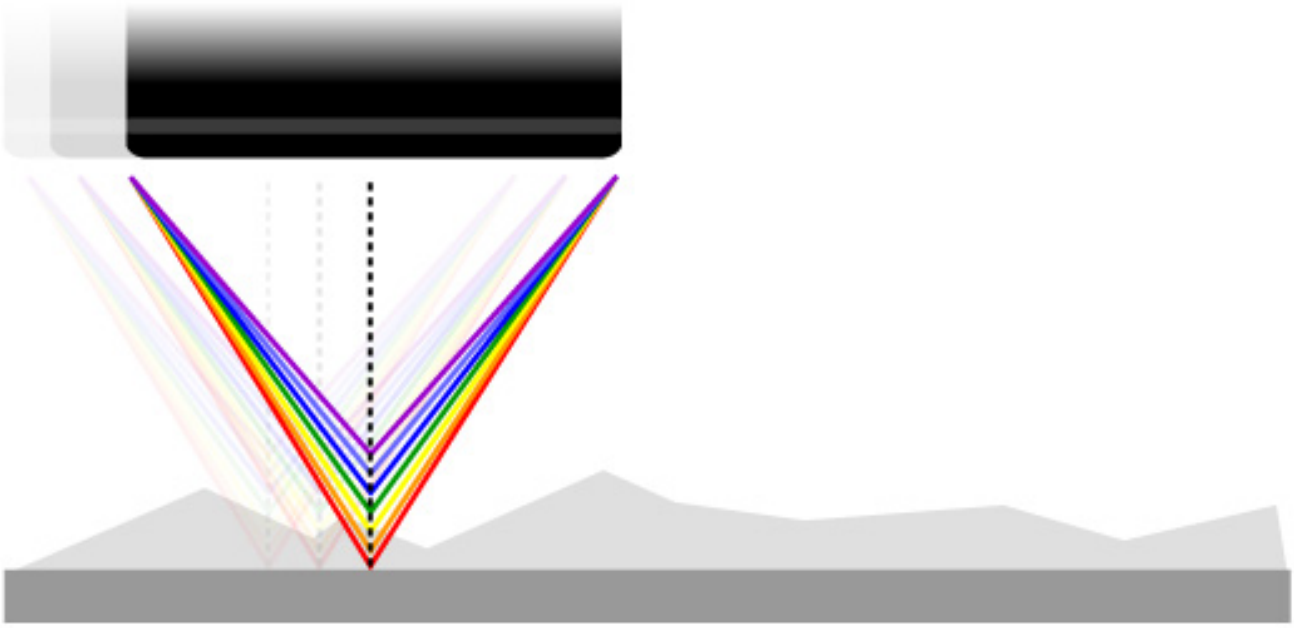
Scatter plots are plottd points the show the relationship between to sets of data. This information can be used to determine correlation between the two sets or it can be determined of the two sets of data have a negative correlation. In the case above, The two parameters plotted are Sa (surface roughness and St (total height), this plot indicates a high positive correlation between the two parameters.

CONCLUSION:

In this application, we have shown how the Nanovea 3D Non Contact Profilometer can precisely characterize the surfaces of similar types and create multiple study modules to assess materials. By summarizing, and developing control charts, box plots and histograms. These features can be a valuable tool to improve and streamline products and processes.
Learn more: 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. $Sa = \frac{1}{A}\iint_A \lvert z(x,y)\rvert dxdy$
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.