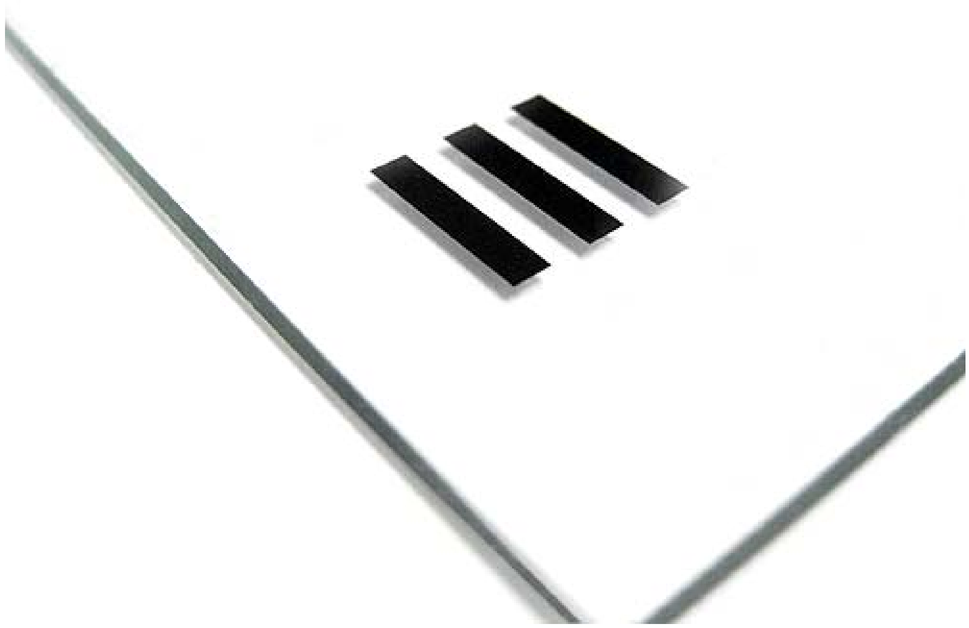
THIN FILM THICKNESS MEASUREMENT USING 3D PROFILOMETER



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INTRO:

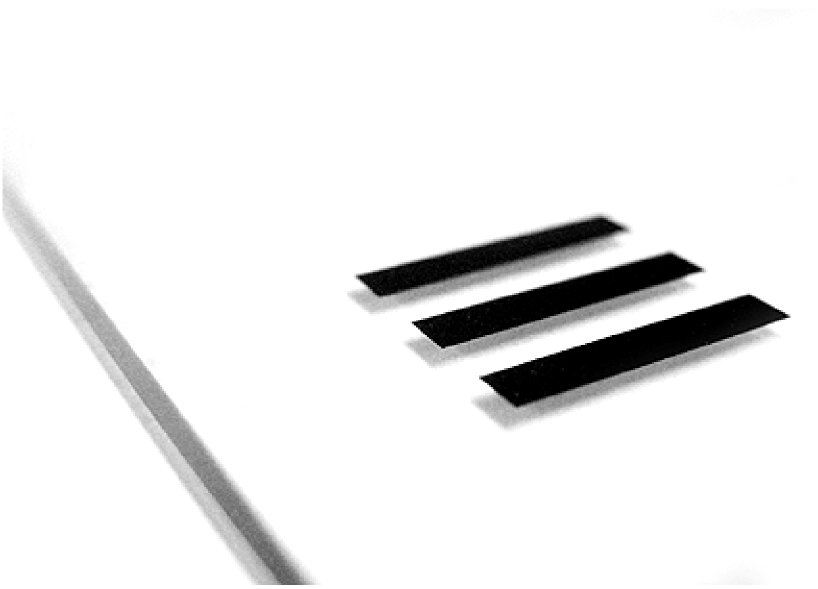
Thin-film deposition is the act of applying a thin film to a surface, any technique for depositing a thin film of material onto a substrate or onto previously deposited layers. "Thin" is a relative term, but most deposition techniques primary concern is the control of layer thickness within a few tens of nanometers. This is crucial for manufacturing the coatings on optics, electronics, packaging and most recently the rise of solar cells.

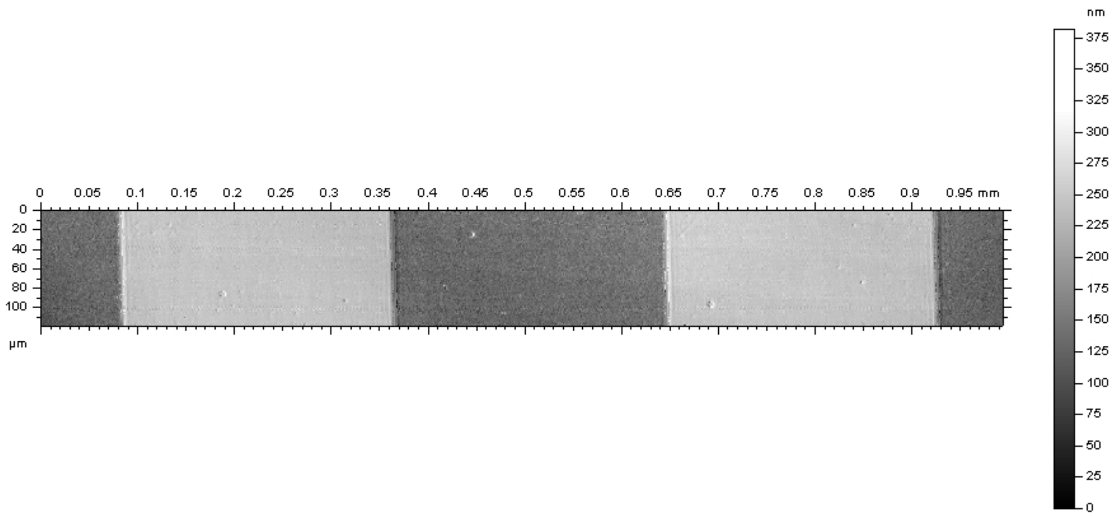
IMPORTANCE OF SURFACE METROLOGY INSPECTION FOR QUALITY CONTROL

From the description above, it can safely be said that thin film thickness control is highly important to the manufacturing process of various highly demanded applications. The ideal technique for assuring this control would be a highly accurate, non-contact, high speed measurement with no disturbance from transparent and or reflective surfaces.

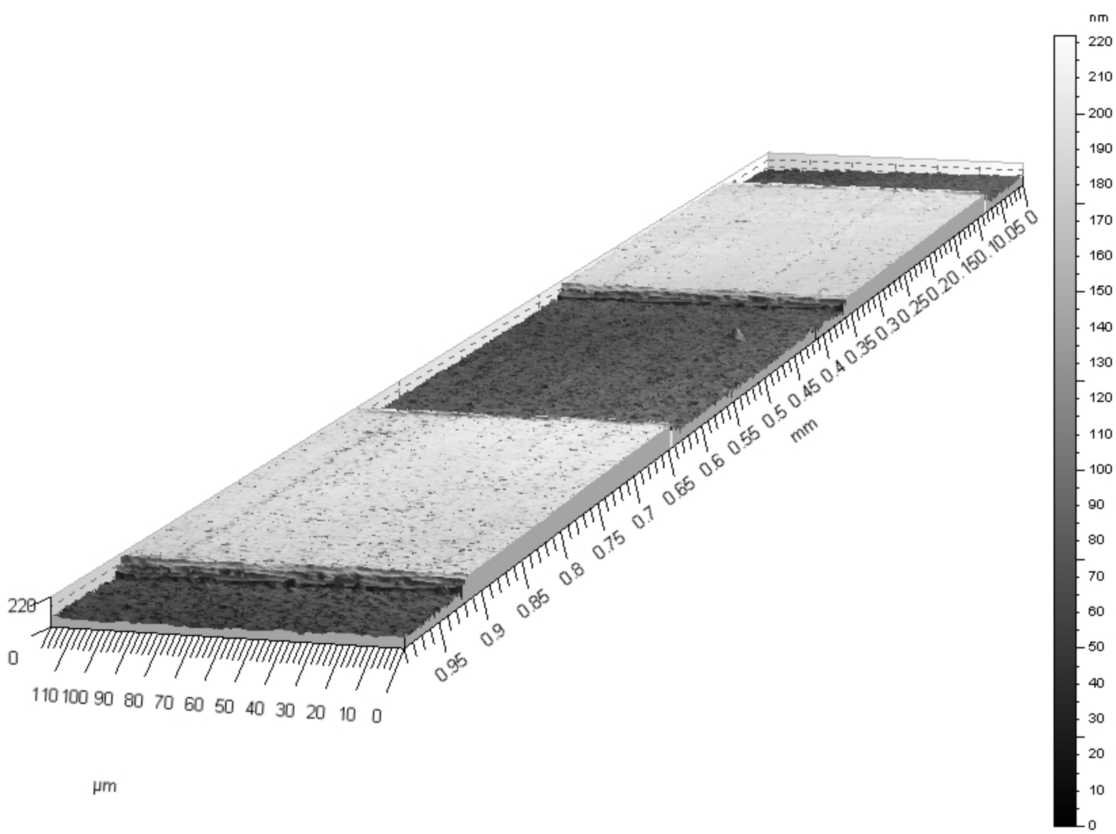
MEASUREMENT OBJECTIVE

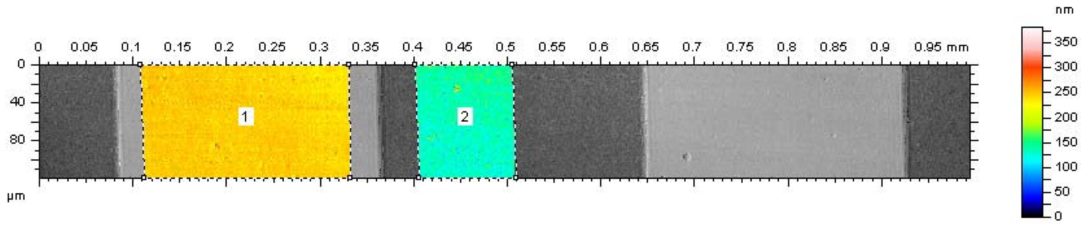
In this application, the Nanovea ST400 is used to measure the thickness of two different areas of highly reflective chrome that has been deposited on transparent glass. By measuring selected areas on the glass and on the chrome, we can derive the mean, maximum and minimum height differences.



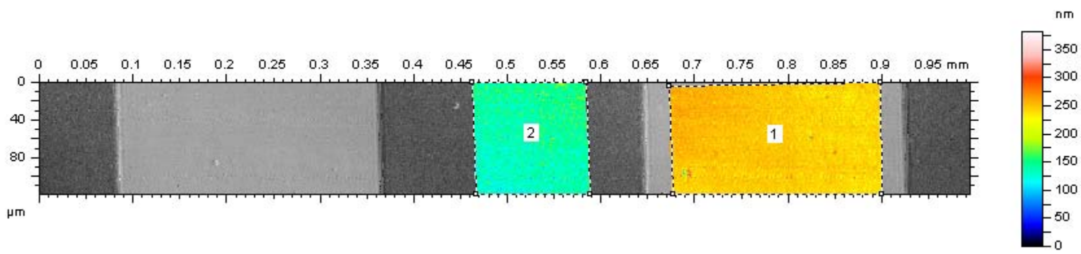


False color representations of same surface





$Z\ (\text{mean})^1 - Z\ (\text{mean})^2 =$ **107.7nm**
$Z\ (\text{min})^1 - Z\ (\text{mean})^2 =$ **-63.3nm**
$Z\ (\text{max})^1 - Z\ (\text{min})^2 =$ **306.8nm**



$Z\ (\text{mean})^1 - Z\ (\text{mean})^2 =$ **104.5nm**
$Z\ (\text{min})^1 - Z\ (\text{mean})^2 =$ -**72.8nm**
$Z\ (\text{max})^1 - Z\ (\text{min})^2 =$ **300.3nm**

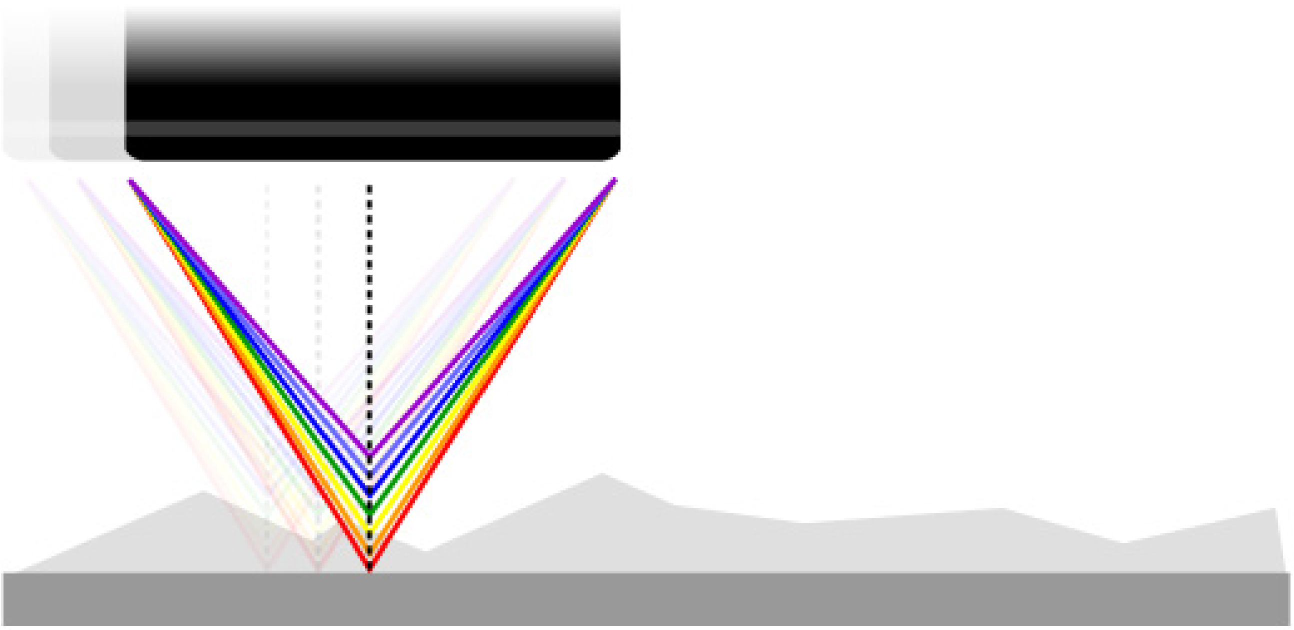
CONCLUSION:

By selecting areas both on the glass and on the chrome, we are able to accurately calculate its thickness. This is represented most obviously by subtracting the mean of the two respective areas. The minimum and maximum values also show that the chrome has inconsistencies in its thickness. The fact that the minimum differences are negative suggests that there were scratches that actually penetrated the glass surface below the chrome. While the maximum differences show nearly triple that of the average, suggesting that either the chrome is very inconsistent or there was something on the glass and/or chrome that skewed these values.

The results above clearly illustrate the Nanovea ST400's ability to precisely measure thin films in the 100nm range, and in other such applications it has been shown on even thinner films. With the ST400 it is also possible to make these types of measurements on transparent films on transparent or opaque substrates.

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.