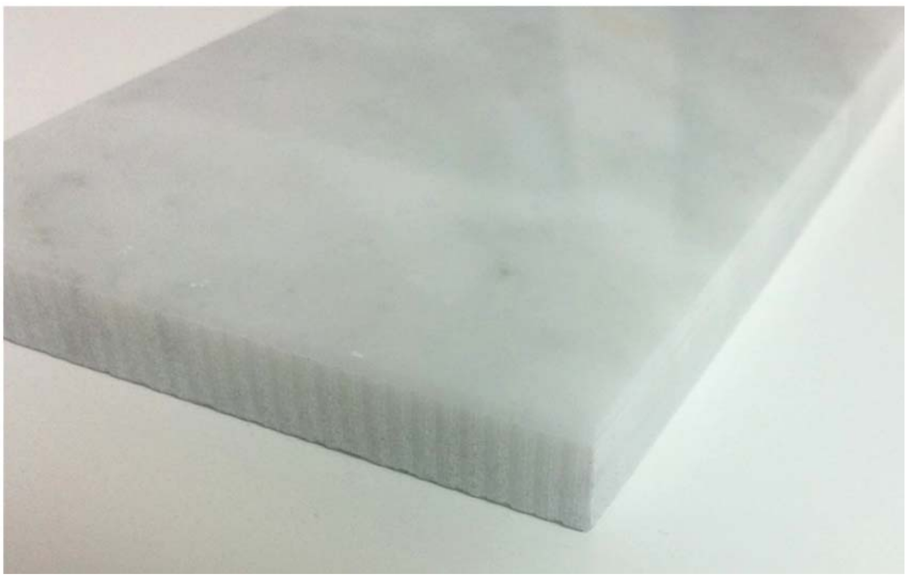
MACHINING SURFACE FINISH QUALITY USING 3D PROFILOMETRY



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INTRODUCTION

Cutting tools remove material from the workpiece through shear deformation. Quality cutting tools possess high hardness, toughness and wear resistance. There are different types of cutting tool techniques, including but not limited to linear cutting tools such as tool bits and broaches, and rotary cutting tools such as drill bits, countersinks and chop saws. Cutting tools are selected depending on the specific requirements of the applications.

IMPORTANCE OF SURFACE ROUGHNESS AND TEXTURE ON CUT SURFACE

Different cutting technique creates cut sections exhibiting different surface features. Flatness, roughness and texture of a cut/machined surface is vital to its end use. Accurate clean cut reduces the further work on grinding and rough edge removal. For example, when marble tiles are manufactured, inaccurate and rough cutting may lead to mismatch during the tile floor installation. Quantitative measurement of the surface texture, consistency, roughness and others is critical in improving the cutting/machining processing and quality control measures.

MEASUREMENT OBJECTIVE

The roughness and texture of three faces of a marble tile with different surface finish were measured and compared using Nanovea ST400 optical profilometer to showcase the capability of Nanovea optical profilometer in providing comprehensive and user friendly surface analysis of cut/machined surface.

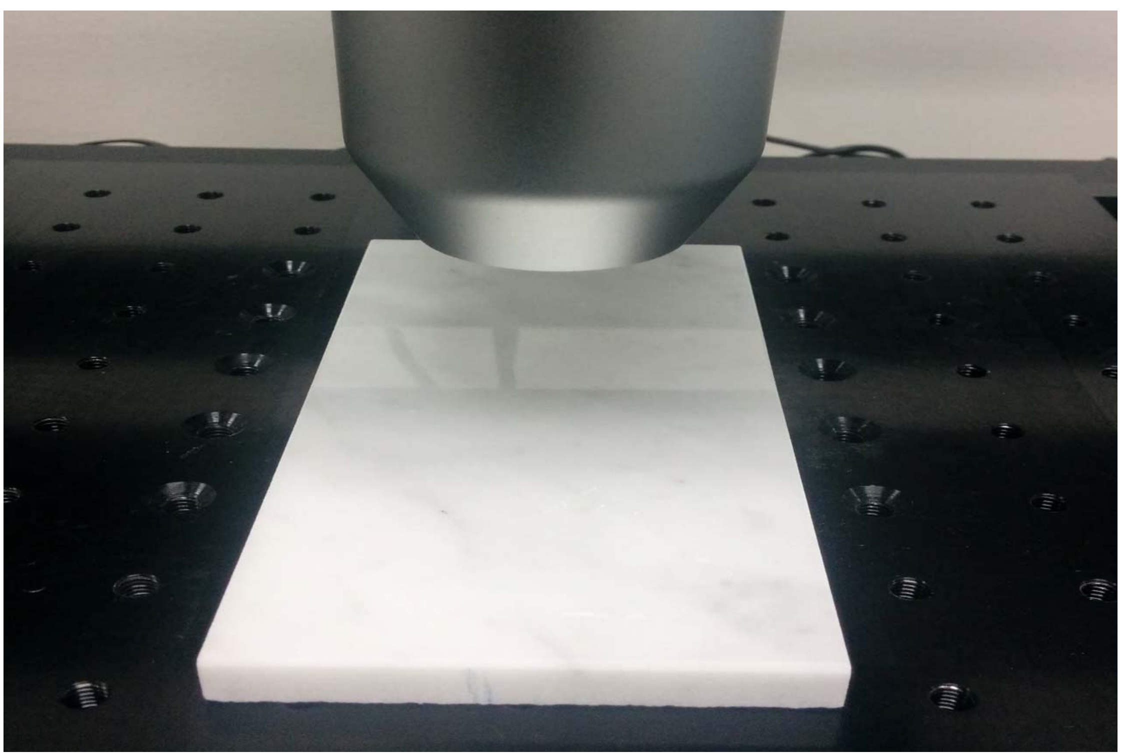
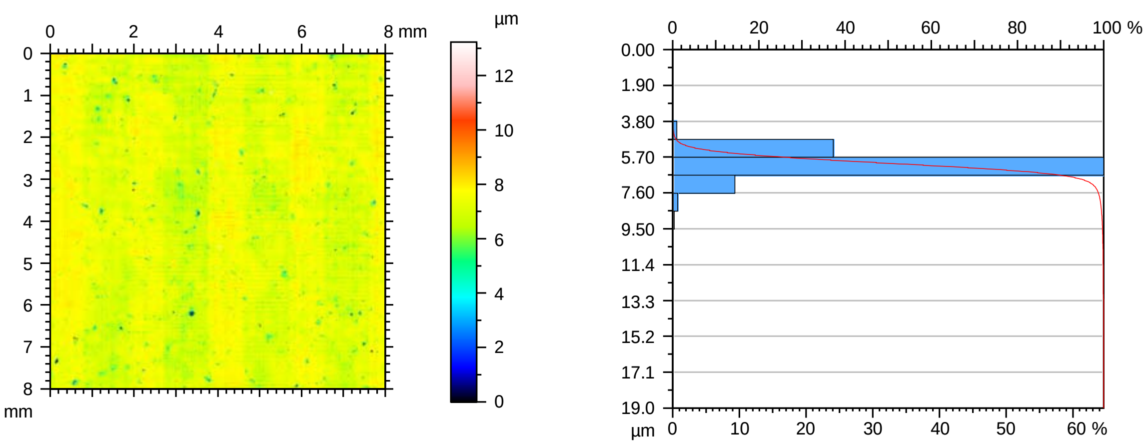


Fig. 1: Non-contact optical pen scanning on the marble tile sample.

RESULTS AND DISCUSSION

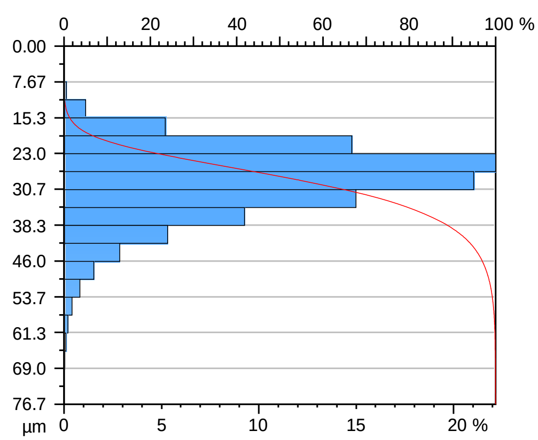
The false color view and Abbott-Firestone curves of the three faces of the marble tile with different surface finish are compared in Fig. 2. Table 1 summarizes the roughness values. The Abbott-Firestone curve is the cumulative probability density function of the surface profile's height, and it describes the surface texture of the sample.

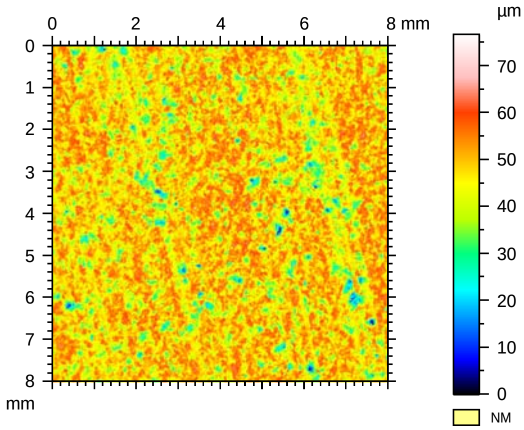
The polished top Face 1 shows a relatively smooth surface with a S_a of 0.41 µm. The surface height has a very small variation as shown in the Abbott-Firestone curve. In comparison, Face 2 at the back of the tile without polishing possesses a rough surface with a large height variation ranging from ~10 to above 60 µm. It therefore possesses a much higher roughness S_a of 5.94 µm. Face 3 at the side of the tile shows a patterned surface with directional grooves which were created during the cutting process. The height difference of the peak and valley of the grooves is reflected in the Abbott-Firestone curve. Two maximums at a height of ~50 and 120 µm appear in the plot, resulting a high roughness S_a of 34 µm.



(a) Face 1:

(b) Face 2:





(c) Face 3:

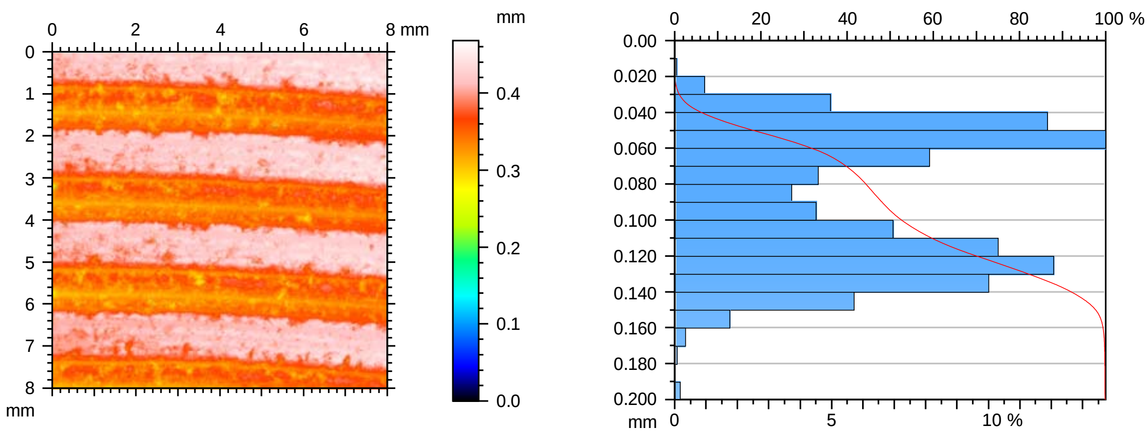


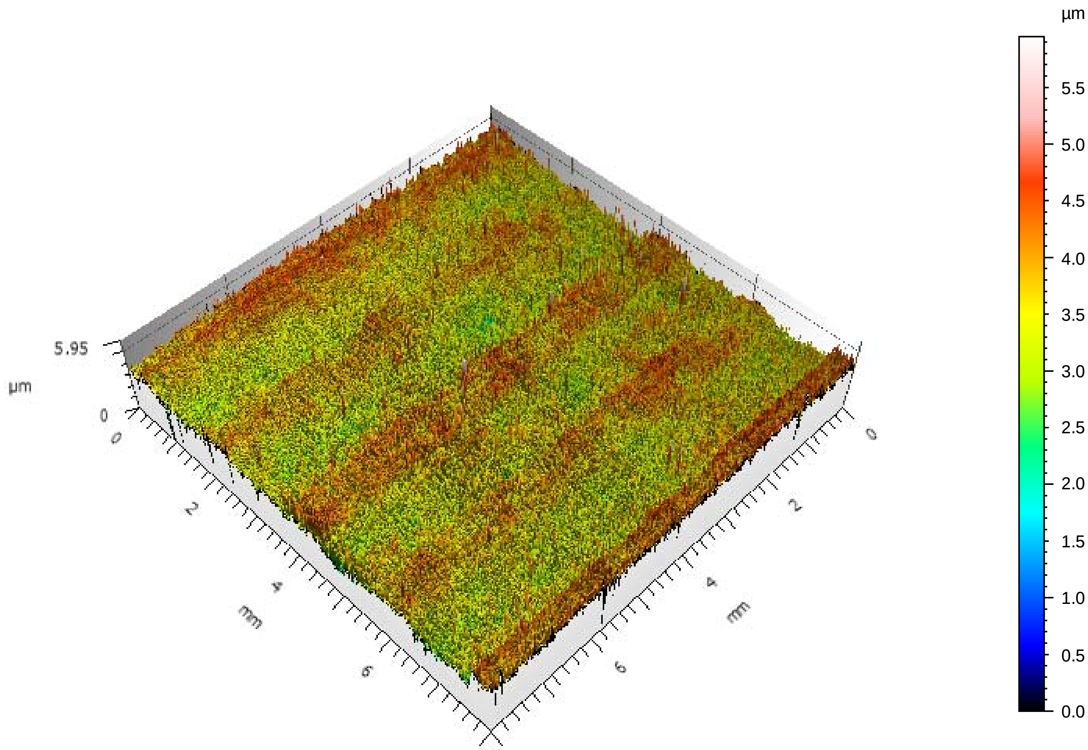
Fig. 2: False color view and Abbott-Firestone curves of three faces of the marble tile.

		Face 1	Face 2	Face 3	Note
Sq	µm	0.61	7.71	38.10	Root-mean-square height
Ssk		-2.38	-0.89	-0.34	Skewness
Sku		29.54	4.56	3.79	Kurtosis
Sp	µm	6.04	29.02	91.10	Maximum peak height
Sv	µm	7.19	47.64	377.24	Maximum pit height
Sa	µm	0.41	5.94	33.99	Arithmetic mean height

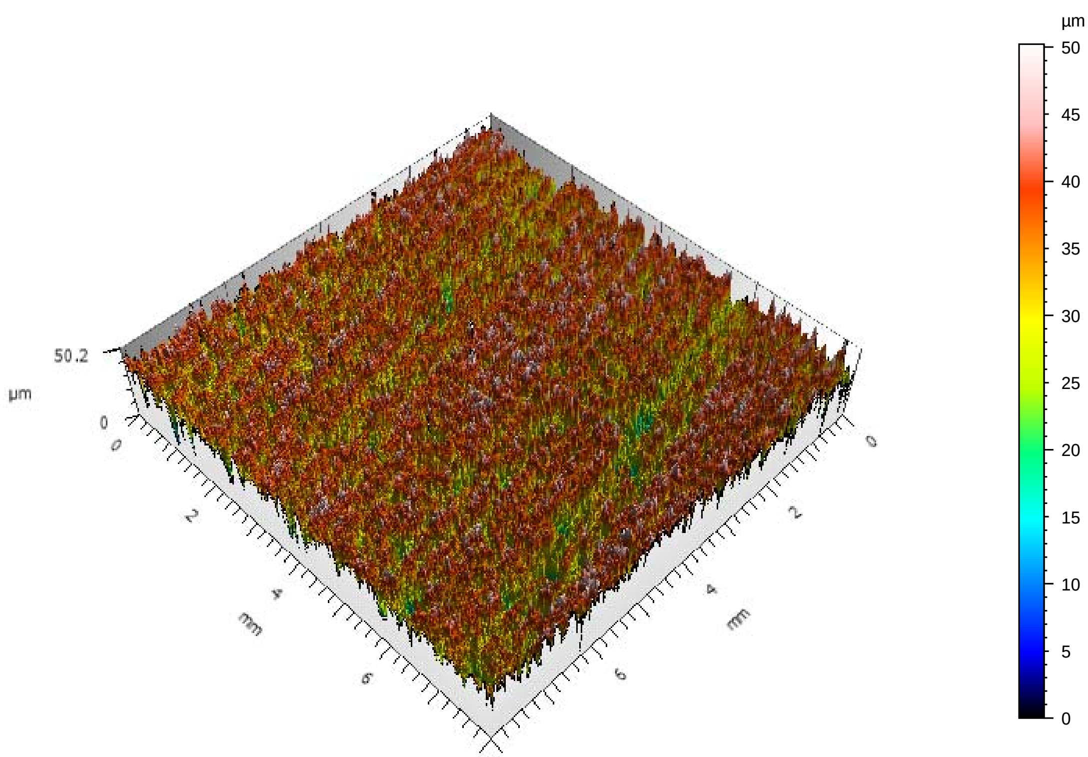
Table 1: Comparison of roughness values of the three faces.

The 3D view of the three surfaces with different finish as displayed in Fig. 3 provide users an ideal tool to directly observe the surface morphology from different angles in detail and to evaluate the shape, flatness and roughness of the marble tile for the purpose of quality control.

(a) Face 1:



(b) Face 2:



(c) Face 3:

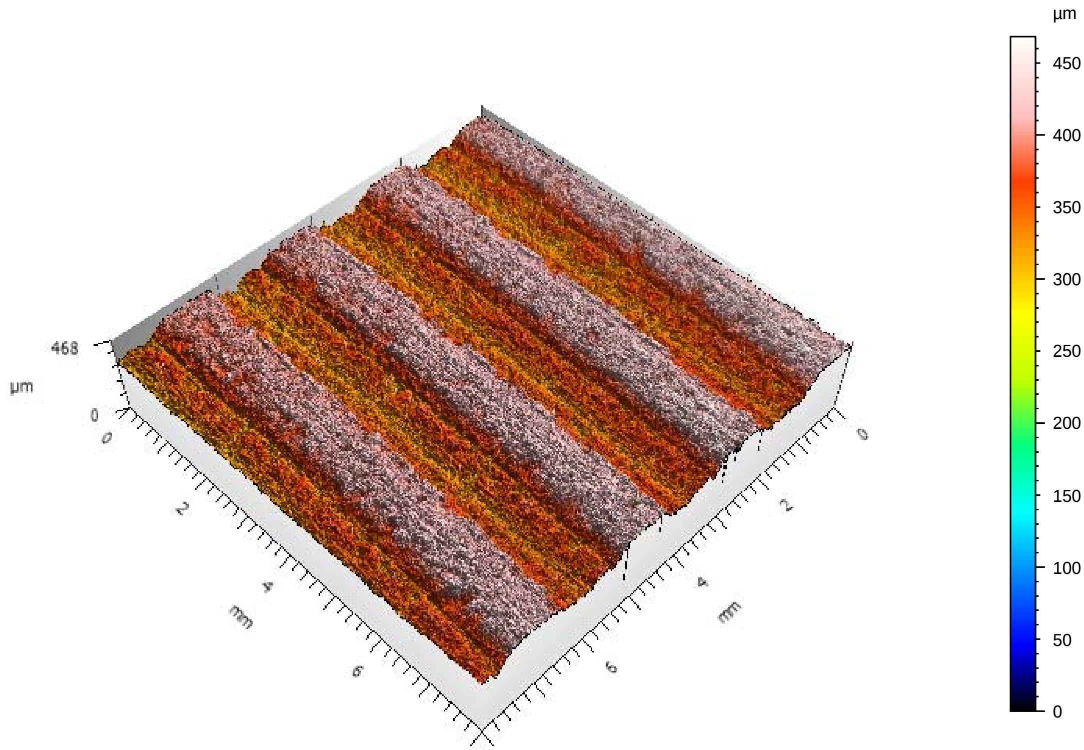
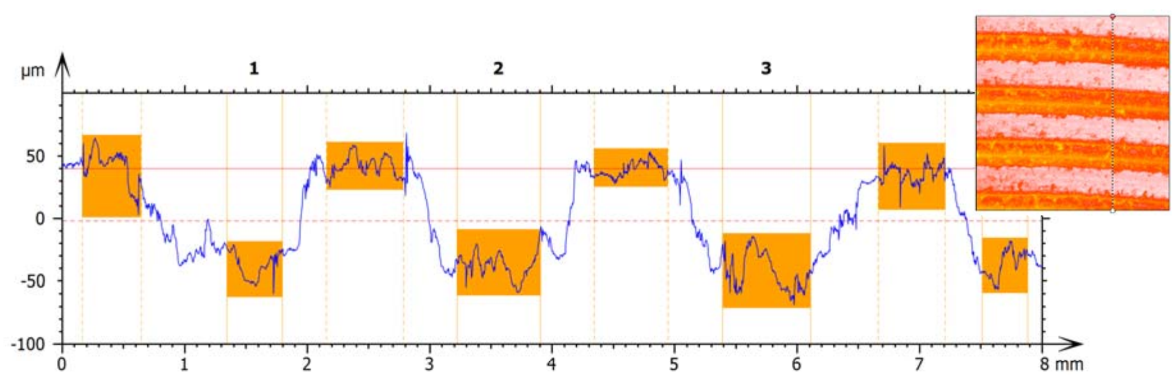


Fig. 3: 3D view of the scanned surfaces.

The 2D profiles across the machine mark direction of Face 3 is shown in Fig. 4 as an example. The depth and distance of the valleys of the surface texture is fairly uniform. The valleys have an average depth of ~77 µm, in agreement with the result shown in the Abbott-Firestone curve.



Parameters	Unit	Step 1	Step 2	Step 3	Step 4
Width	mm	0.453	0.684	0.717	0.369
Maximum depth	µm	99.7	98.6	109	96.6
Mean depth	µm	77.9	77.7	82.3	76.2

Fig. 4: 2D profile analysis of Face 3.

CONCLUSION

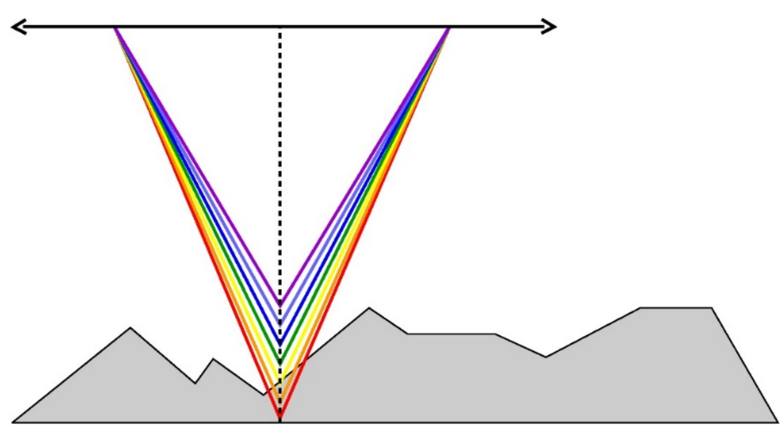
The roughness and texture of three faces of a marble tile with different surface finish are measured using Nanovea ST400 non-contact profilometer. We show that Nanovea 3D profilometer is a useful tool in quality control of the surface finish after cutting and machining. Nanovea Profilometers measure a variety of materials, including but not limited to metals, polymers, ceramics and glass. The analysis software provides measurements such as uniformity and roughness, texture, peak and valley profile, enabling users to obtain comprehensive information of the surface quality.

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 or Lab Services

APPENDIX: MEASUREMENT PRINCIPLE

The axial chromatism 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.



Chromatic Confocal White Light Measurement

Unlike the errors caused by probe contact or the manipulative Interferometry technique, White light Axial Chromatism 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.