

**QUARTZ CRYSTAL MICROBALANCE
SURFACE FLATNESS & FINISH**



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INTRO

The Quartz Crystal Microbalance (QCM) is a key component used in a variety of research and industrial instruments to detect and monitor the small variation of mass, adsorption, density and corrosion, etc. As an extremely sensitive mass sensor capable of measuring mass change in the nanogram range, the manufacturing of QCM requires stringent quality control to ensure its precision. Any surface defect on the QCM plate may cause significant measurement inaccuracy and errors.

IMPORTANCE OF 3D NON-CONTACT PROFILOMETER FOR QUALITY CONTROL OF QCM

Reliable quality control heavily relies upon accurate, quantifiable and reproducible surface inspection. Flatness & finish of the QCM surface are vital to its accuracy and both measurements in 3D guarantees proper manufacture processing and control measures. Unlike a touch probe technique, the Nanovea Profilometer performs a 3D non-contact surface measurement of the sample. This eliminates the risk of creating micro scratches on the QCM surface that may cause inaccuracy or errors in the mass measurement.

MEASUREMENT OBJECTIVE

In this application, the Nanovea ST400 is used to measure the surface flatness & finish of a QCM sample. We showcase the capacity of Nanovea non-contact profilometer in providing 3D profile measurement on the delicate samples with high precision.

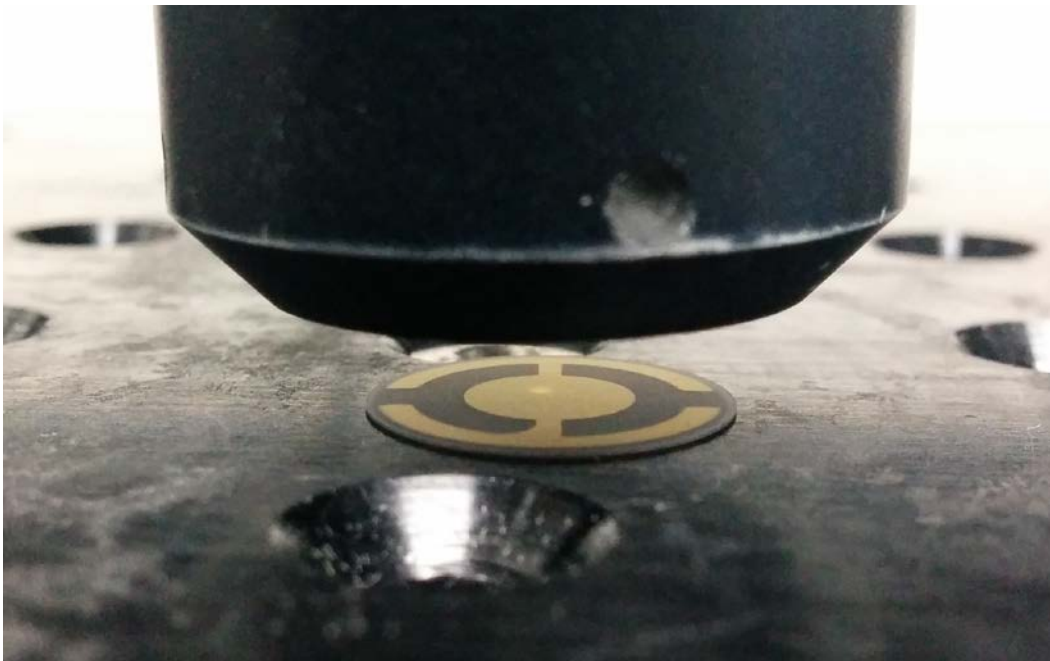


Fig. 1: Optical sensor scanning on the surface of a QCM sample.

RESULTS AND DISCUSSION

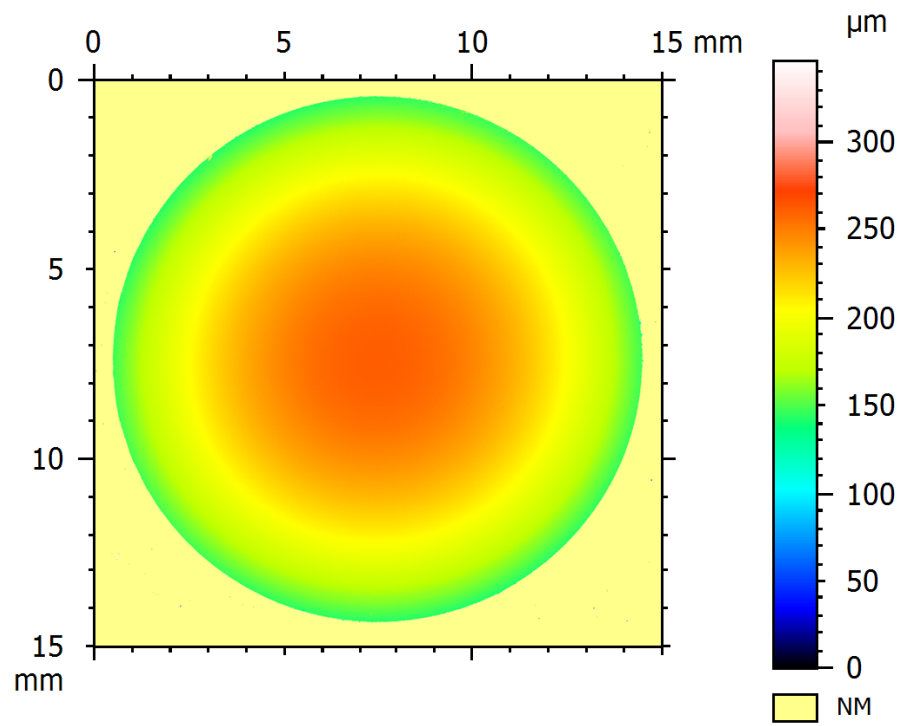
An array of 3×3 images is automatically taken and stitched by Nanovea ST400, as shown in Fig. 2, for a larger microscopic observation of the QCM sample. The area of interest is then chosen for 3D scan.



Fig. 1: 3×3 mico image array of the QCM sample under the microscope.

The false color view and the 3D view of the QCM sample surface is shown in Fig. 3, allowing users to observe the QCM sample from different angles and magnifications. Flatness variation can be seen clearly by color and height changes at the top of the QCM sample. The center of the QCM sample is slightly elevated compared to the edge. The flatness is $246 \mu\text{m}$ according to ISO 12781 standard, as calculated by Nanovea analysis software. The QCM is an extremely sensitive and accurate device capable of detecting the mass change down to 0.1 nanogram. The flatness and uniformity of the QCM play an important role in ensuring its quality and accuracy.

(a)



(b)

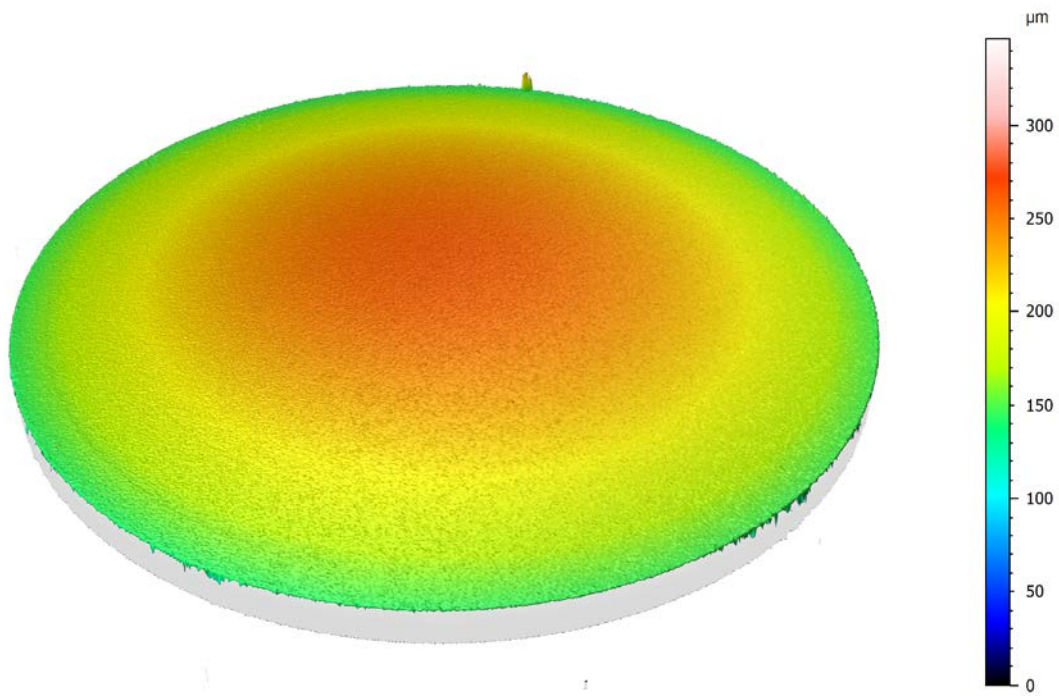


Fig. 3: (a) False color view and (b) 3D view of the QCM sample.

The 3D non-contact surface scan provides a useful tool to determine the surface finish quality with high precision. Fig. 4 shows the QCM sample surface after form removal. The finish values are calculated and summarized in Table 1. Fig. 5 presents the surface morphology of the QCM sample at a high magnification. Depending on the applications of the QCM, such as monitoring thin film deposition and cell growth, the QCM requires different surface finishes. The capacity of high resolution scan enables users to measure the detailed morphology and tiny surface features. Moreover, it can pick up any undesired defects including scratches or cracks on the sample surface.

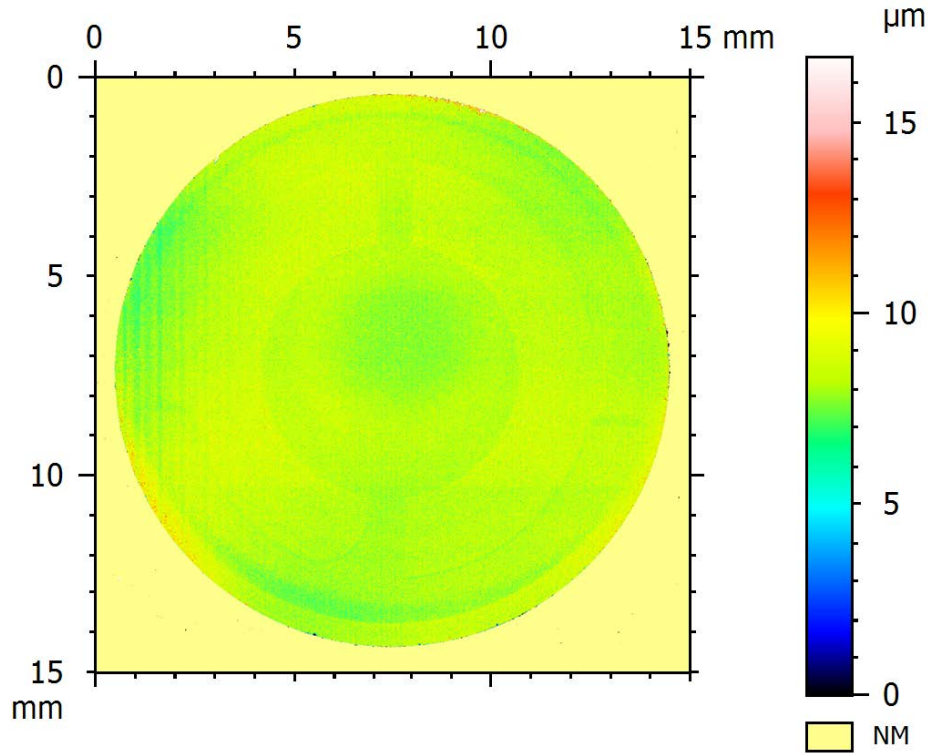


Fig. 4: QCM sample after form removal.

ISO 25178			
Height Parameters			
Sq	0.868	μm	<i>Root-mean-square height</i>
Ssk	-0.169		<i>Skewness</i>
Sku	9.50		<i>Kurtosis</i>
Sp	8.29	μm	<i>Maximum peak height</i>
Sv	8.40	μm	<i>Maximum pit height</i>
Sz	16.7	μm	<i>Maximum height</i>
Sa	0.654	μm	<i>Arithmetic mean height</i>

Table 1: Summary of finish values.

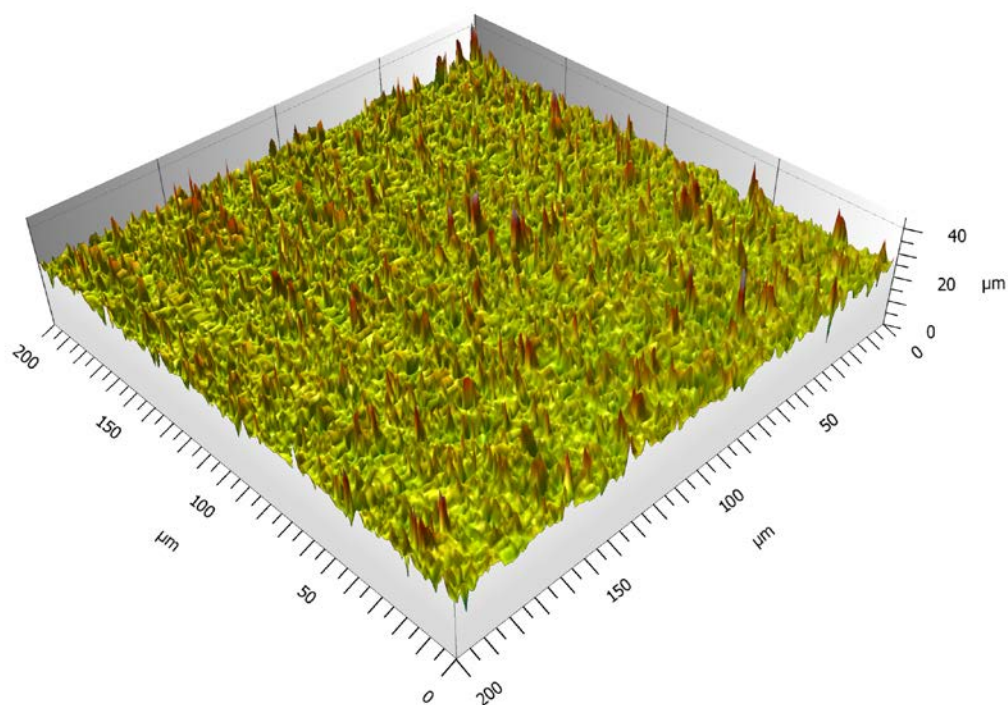


Fig. 5: Surface finish of the QCM sample at a high magnification.

Fig. 6 displays the light intensity map of the QCM sample surface. The metal electrode shows a much higher intensity compared to the quartz substrate. This function provides users additional information that may be used to determine the different materials or phases on the sample surface.

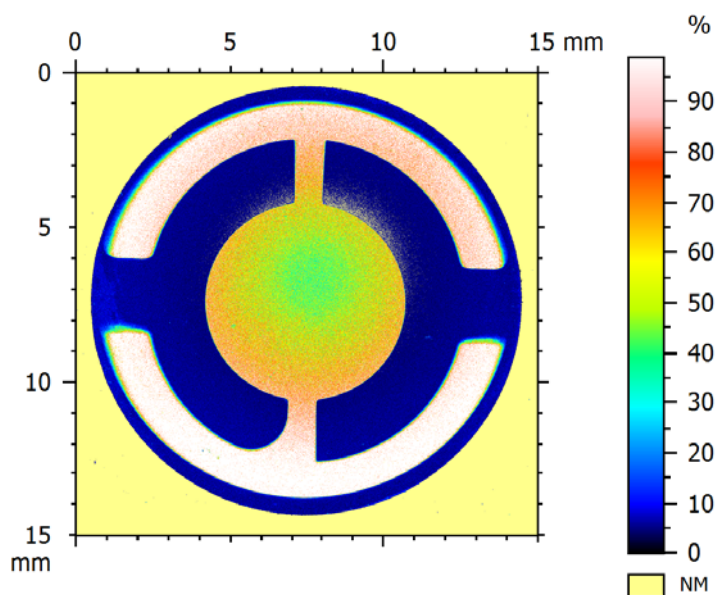


Fig. 2: Intensity map image of the QCM sample.

CONCLUSION

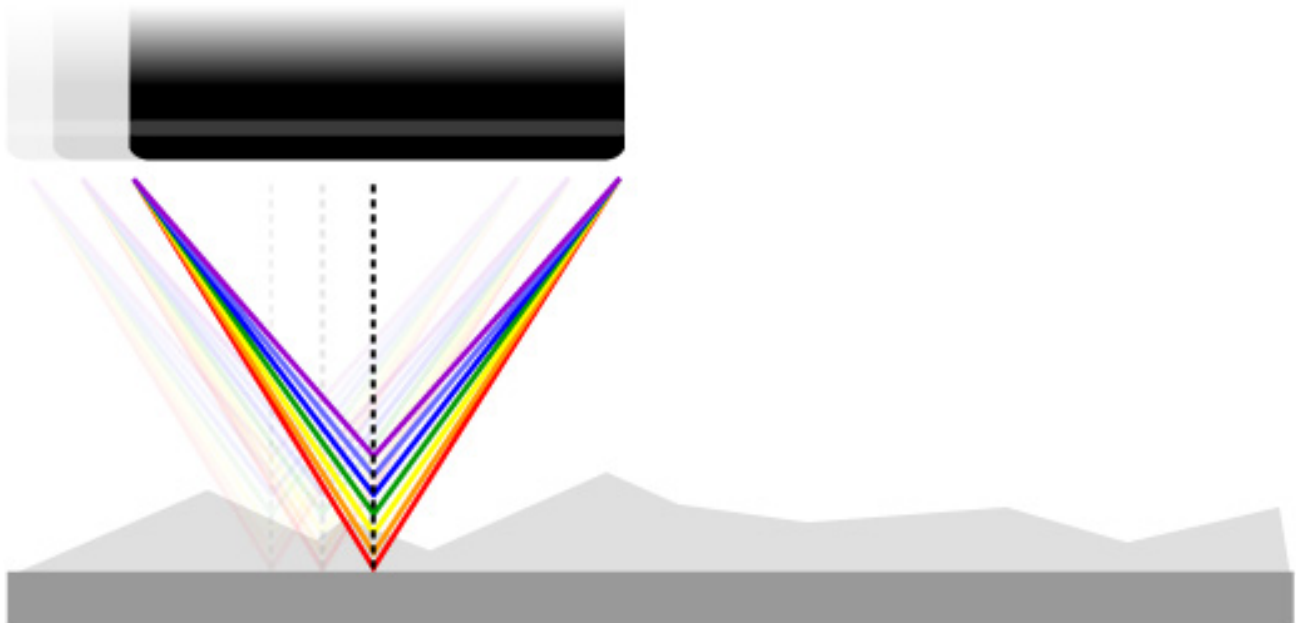
In this application, we have showcased that the Nanovea ST400 3D Non-Contact Profilometer performs surface inspection on a QCM sample with high accuracy. The automatic microscope image array enables observation of a larger surface under the microscope. The 3D non-contact surface scan is a very useful quality control tool to determine whether the manufactured QCMs fall in line with specifications including finish and flatness.

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](#)

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. $Sa = \frac{1}{A} \iint_A z(x, y) dx dy$
Sq	Root Mean Square Height	Standard deviation of the height distribution, or RMS surface roughness. $Sq = \sqrt{\frac{1}{A} \iint_A z^2(x, y) dx dy}$ 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. $Ssk = \frac{1}{Sq^3} \left[\frac{1}{A} \iint_A z^3(x, y) dx dy \right]$ 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. $Sku = \frac{1}{Sq^4} \left[\frac{1}{A} \iint_A z^4(x, y) dx dy \right]$ 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.