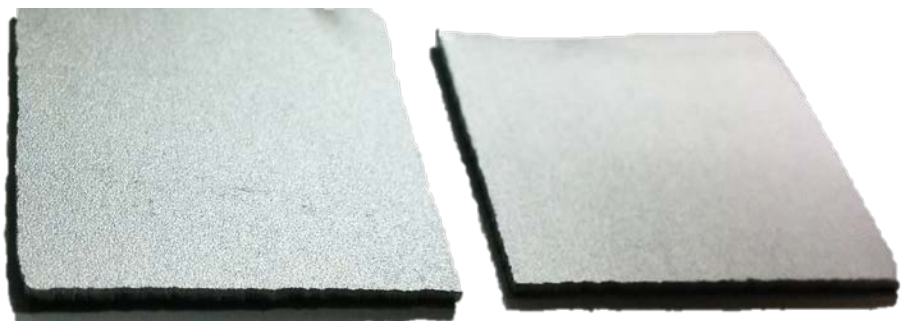
SURFACE TEXTURE EFFECT ON LUSTER OF ANODIZED ALUMINUM USING 3D PROFILOMETRY



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INTRODUCTION

Anodizing is an electrolytic passivation process commonly applied to convert aluminum to aluminum oxide. It can modify the surface texture and changes the microstructure of the metal near the surface. Such an anodized aluminum oxide layer is generally much stronger and more adherent than most types of paint and metal plating. It can significantly enhance corrosion and wear resistance and improve cosmetic effects of the products. Anodized aluminum is widely used on electronic devices and consumer products, such as cell phones, cameras, mp3 players and many others.

IMPORTANCE OF 3D PROFILOMETER FOR ANODIZED ALUMINUM INSPECTION

The appearance of a product plays an important role in influencing consumer product choice. It communicates aesthetic and functional characteristics and makes an impression of the product quality. Roughness and texture of the anodized aluminum surface is critical in the final product appearance. A better understanding of the effect of surface texture, consistency and directional patterns on the product appearance allows optimizing the processing and control measures to obtain the best result. Quantifiable, precise and reliable surface inspection of the anodized aluminum is in need to control surface parameters for endless applications of anodized aluminum. The Nanovea 3D Non-Contact Profilometers utilizes chromatic confocal technology with unique capability to precisely measure the sample surface.

MEASUREMENT OBJECTIVE

In this study, the Nanovea ST400 non-contact profilometer is used to measure and compare two anodized aluminum samples with different surface finish. We showcase the capacity of Nanovea non-contact profilometer in providing precise 3D profile measurement and comprehensive in-depth analysis of surface finish.

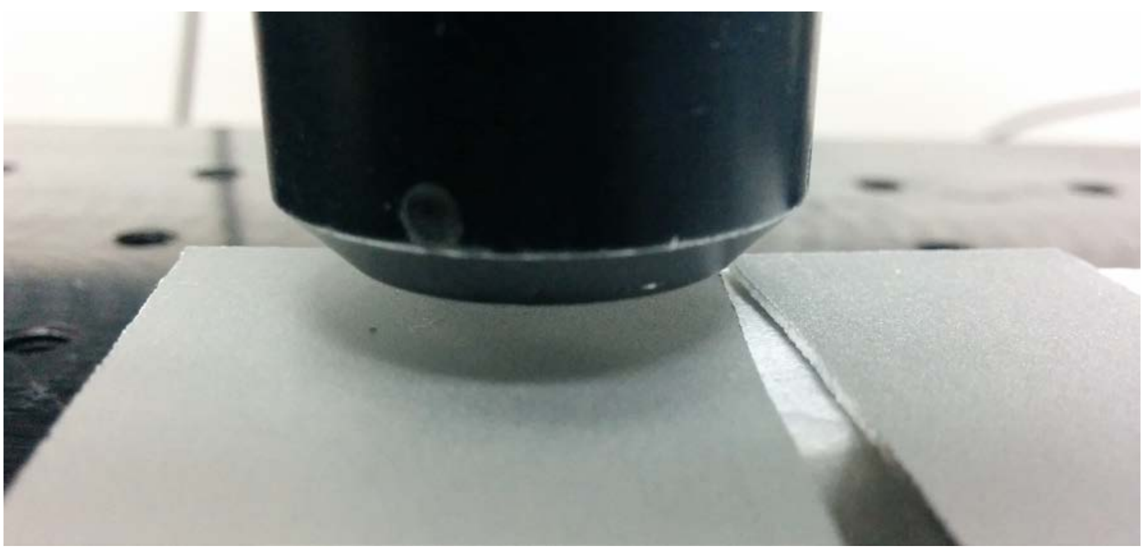


Fig. 1: Optical sensor scanning on the surface of the anodized aluminum sample.

RESULTS AND DISCUSSION

Sample 1 is more lustrous compared to Sample 2, making it more visually appealing and thus seemingly better quality. In order to understand the cause of such effect, the surface of Samples 1 and 2 under the optical microscope are compared in Fig. 2. Sample 1 appears to reflect more light under the same condition.

(a) Sample 1: **(b) Sample 2:**

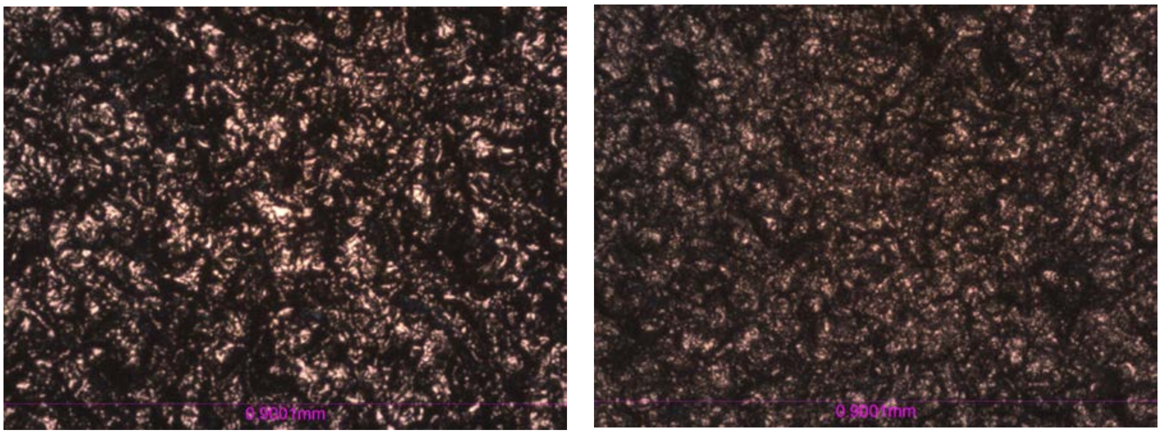
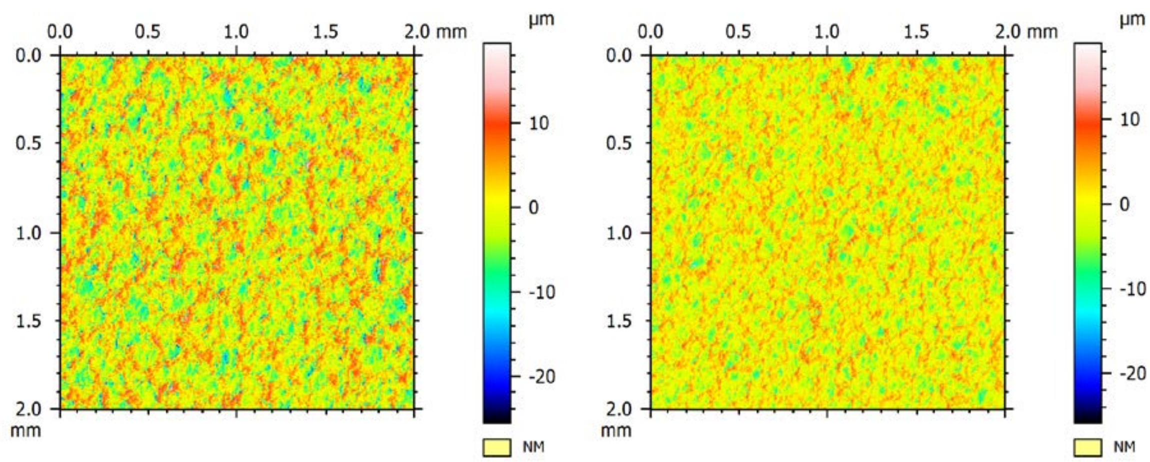


Fig. 2: The surface of Samples 1 and 2 under the optical microscope.

The false color view and roughness of the two anodized aluminum samples are compared in Fig. 3. Sample 1 shows a relatively coarser surface texture with a higher roughness R_a of 3.94 µm, compared to a R_a of 2.65 µm for Sample 2. Such an observation seemingly contradicts to the common sense, where smoother surface (with a lower roughness value) usually possesses higher reflectivity.

Sample 1: **Sample 2:**



ISO 25178		
Height Parameters		
Sq	5.13	µm
Ssk	-0.412	
Sku	4.14	
Sp	17.9	µm
Sv	24.3	µm
Sz	42.3	µm
Sa	3.94	µm

ISO 25178		
Height Parameters		
Sq	3.39	µm
Ssk	-0.305	
Sku	3.62	
Sp	11.9	µm
Sv	16.1	µm
Sz	28.0	µm
Sa	2.65	µm

Fig. 3: False color view and roughness of the two anodized aluminum samples.

In order to further investigate the effect of the surface texture on the luster of the anodized aluminum, more detailed 3D profile evaluation on these two anodized aluminum samples is performed and discussed in the following section. The 3D view and 2D profile of the two samples at a higher magnification are displayed in Fig. 4. It can be observed that both Sample 1 and Sample 2 have a rough surface. However, Sample 1 shows plateaus of larger sizes and flatter surface, which reflect more light compared to the small asperities on Sample 2. 2D profile analysis confirms this conclusion: Although Sample 1 possesses a rougher surface due to the deeper pores between the plateaus, the plateaus show smoother micro texture.

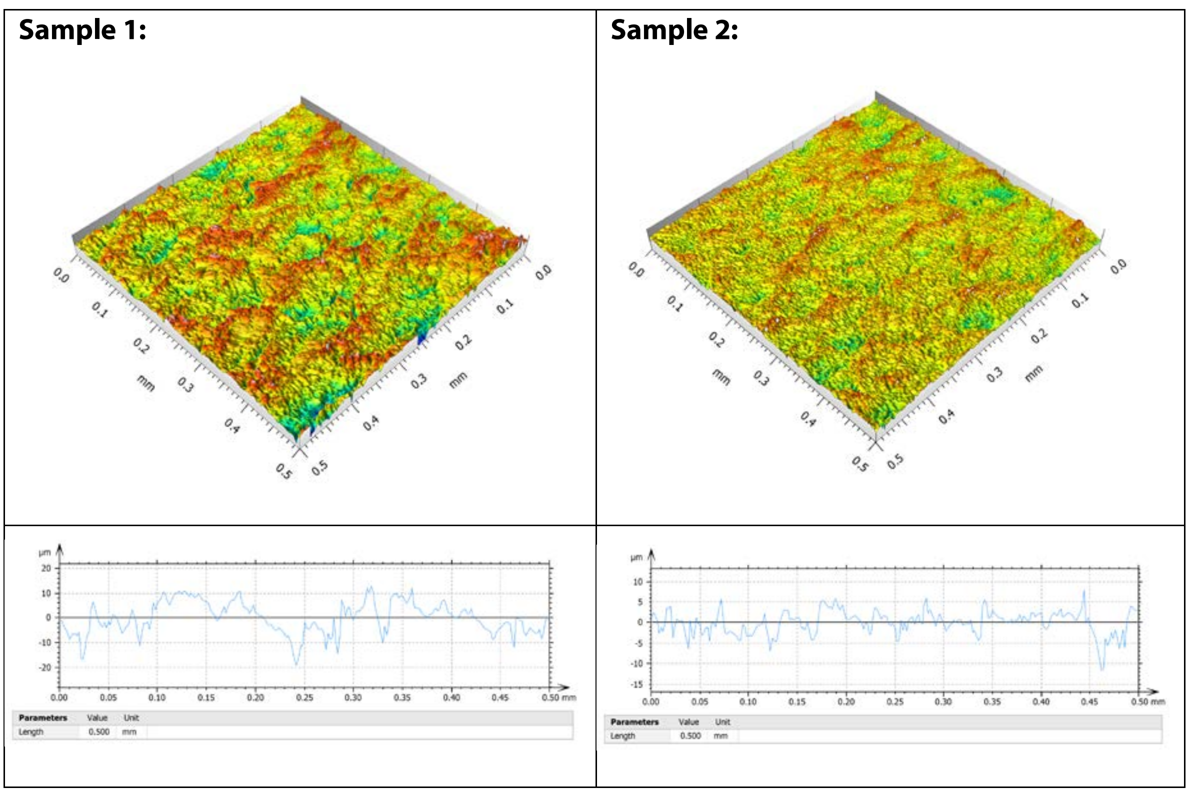


Fig. 4: 3D and 2D profiles of the anodized aluminium samples.

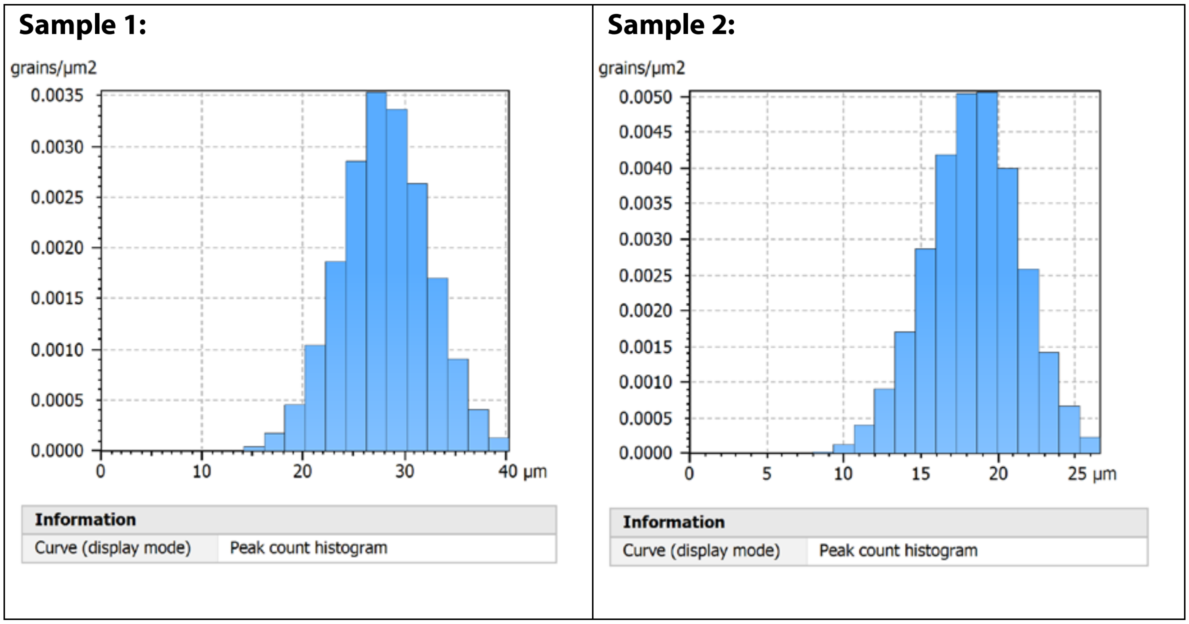


Fig. 5: Grain size analysis of the anodized aluminum samples.

Grain size analysis of the anodized aluminum samples is compared in Fig. 5. Each grain here represents a plateau on the sample surface. It can be observed that the plateaus on Sample 1 have an average size of ~28 µm, compared to ~19 µm for Sample 2. The larger plateau exhibits better reflectivity, in agreement with the above 3D analysis.

CONCLUSION

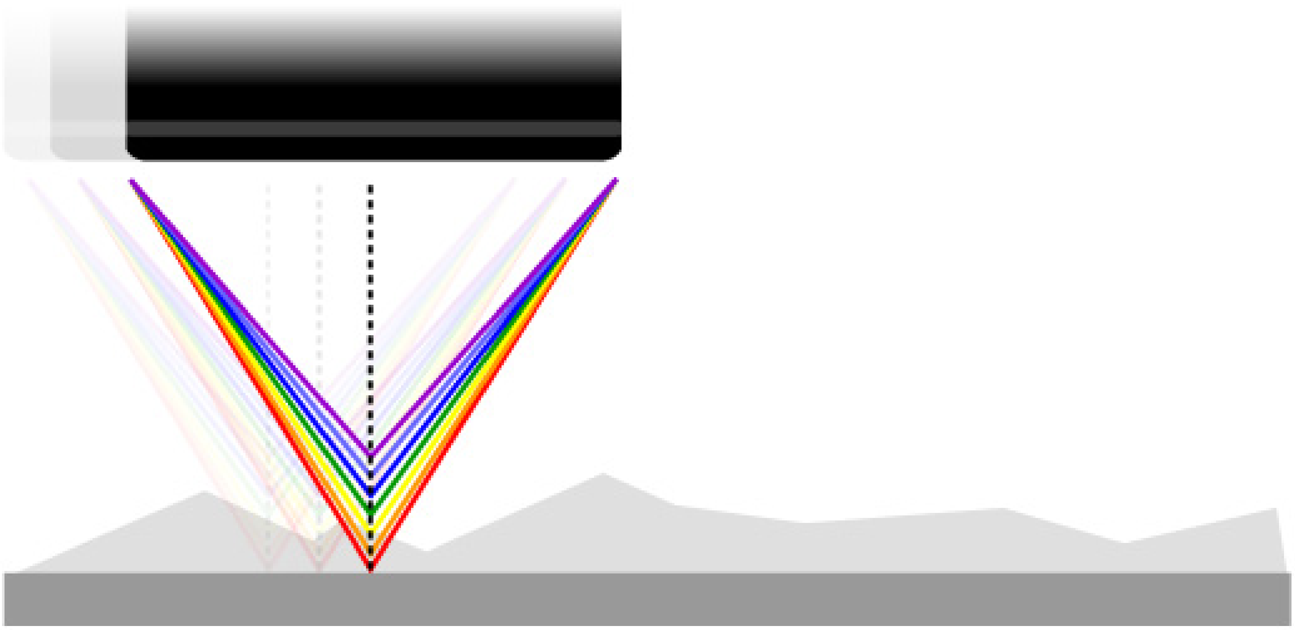
In this application, we have showcased that the Nanovea ST400 3D Non-Contact Profilometer is an ideal tool for analyzing and comparing the surface finish of anodized aluminum samples. The size of the plateaus on the sample surface plays an important role in the reflectivity of the anodized aluminum. The surface texture of larger plateaus is preferable to provide a better luster. The high resolution scan and comprehensive analysis tools including 3D and grain size analyses by Nanovea profilometer enable comprehensive and quantitative evaluation of the surface finish of metal samples, which is critical in assessing the quality and optimizing the appearance of products.

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