HONEYCOMB PANEL SURFACE FINISH USING 3D PROFILOMETRY

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INTRODUCTION

Honeycomb structure is widely used in the aerospace industry, thanks to its minimal density and relative high strength. It is featured in aircrafts and rockets in the form of different materials, including aluminum, fiberglass and advanced composite. The surface texture, roughness and porosity of the honeycomb panel play important roles in its quality and paintability. Honeycomb panel surfaces with a proper homogeneous texture provide stronger strength and adhesive force to protective paints. It enhances corrosion and wear resistance and improves cosmetic effects of the honeycomb panel.

IMPORTANCE OF 3D PROFILOMETER FOR HONEYCOMB PANEL FINISH INSPECTION

Roughness, porosity and texture of the honeycomb panel surface is critical in the final product quality. It communicates aesthetic and functional characteristics and product quality. A better understanding of the surface texture and porosity allows optimizing the processing and control measures. Quantitative, precise and reliable surface inspection of the honeycomb panel is in need to control surface parameters for application and painting requirements. 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 equipped with an optical line sensor is used to measure and compare two honeycomb panel samples with different surface finish. We showcase that Nanovea non-contact profilometer provides fast and precise 3D profile measurement and comprehensive in-depth analysis of surface finish.

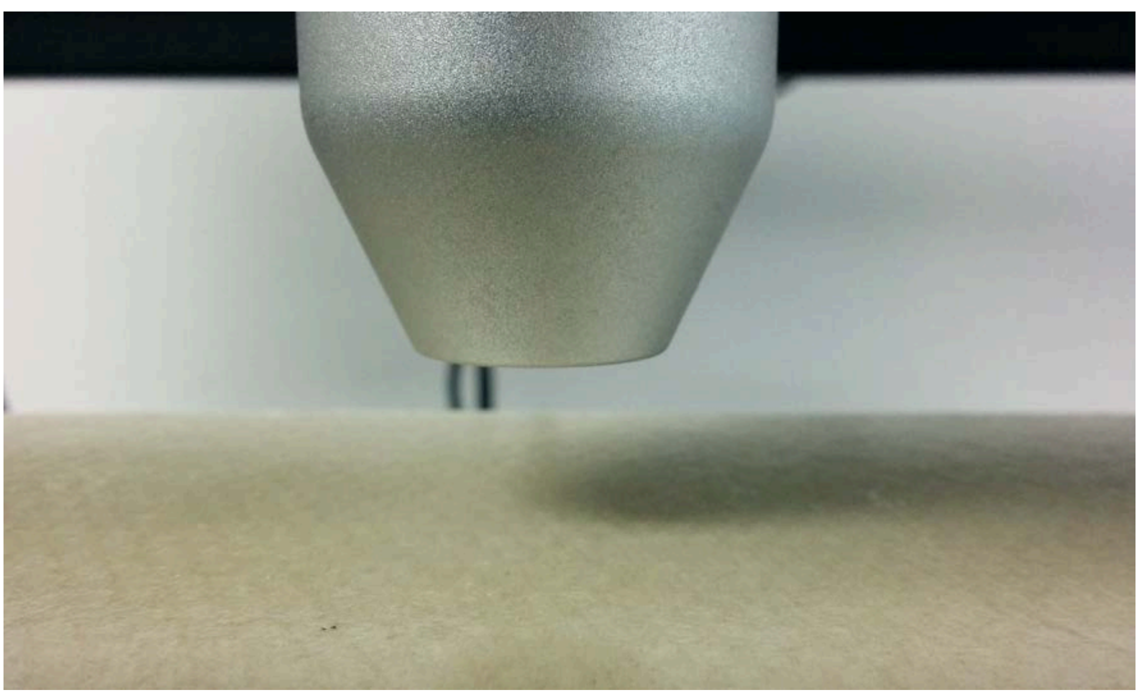


Fig. 1: Optical line sensor above the honeycomb panel sample.

RESULTS AND DISCUSSION

The surface of two honeycomb panel samples with different surface finish, namely Sample 1 and Sample 2, were measured by Nanovea ST400 profilometer. The false color view and the 3D view of the surface of Samples 1 and 2 are shown in Fig. 2 and Fig. 3, respectively. The roughness and flatness values calculated by the analysis software are compared in Table 1. Sample 2 exhibits a more porous surface compared to Sample 1. As a result, Sample 2 possesses a higher roughness S_a of 14.7 µm, compared to a S_a value of 4.27 µm for Sample 1.

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

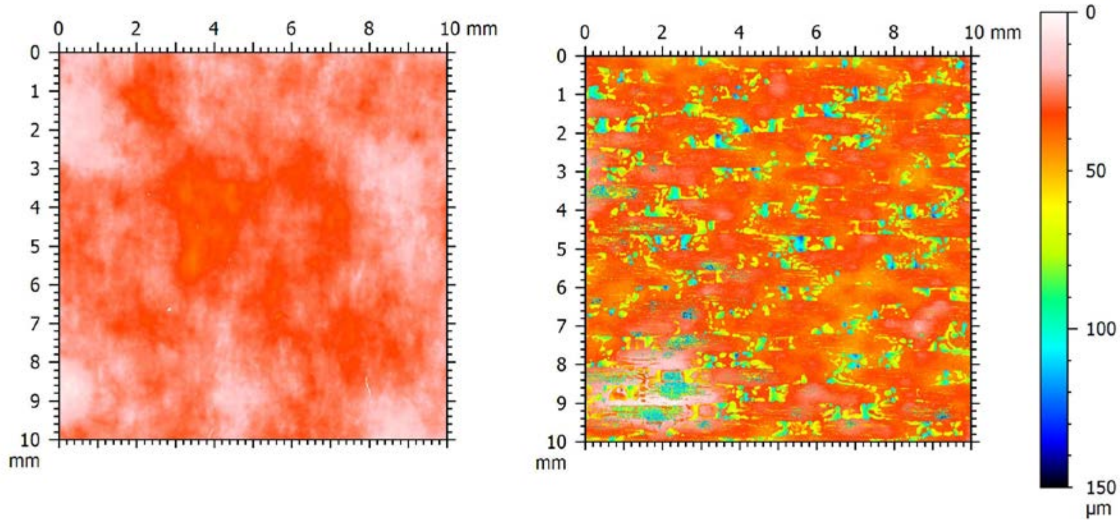
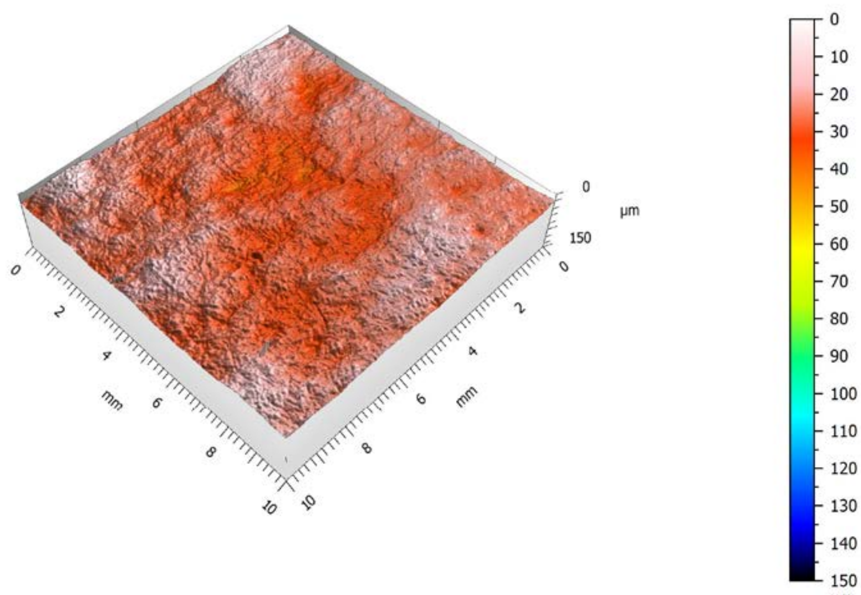


Fig. 2: The false color view of the honeycomb panel surfaces.

(a) Sample 1:



(b) Sample 2:

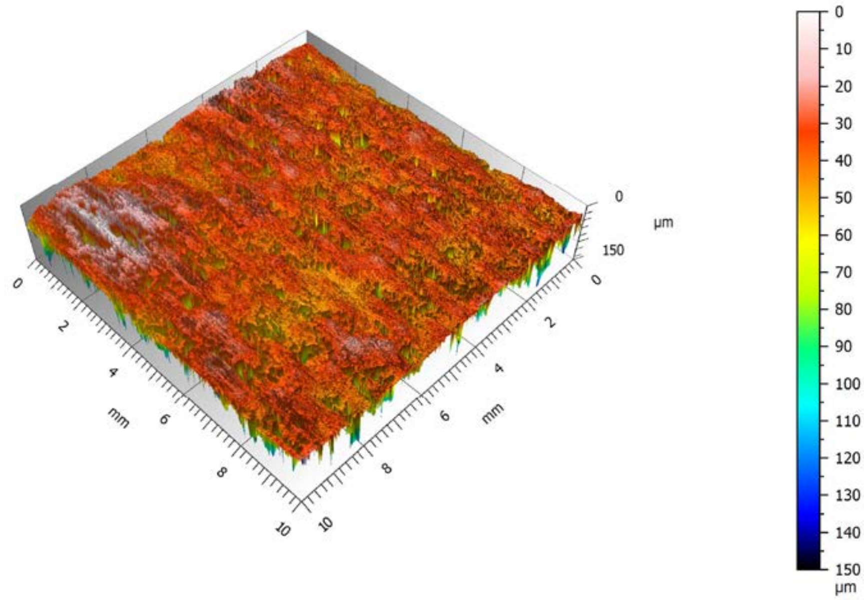


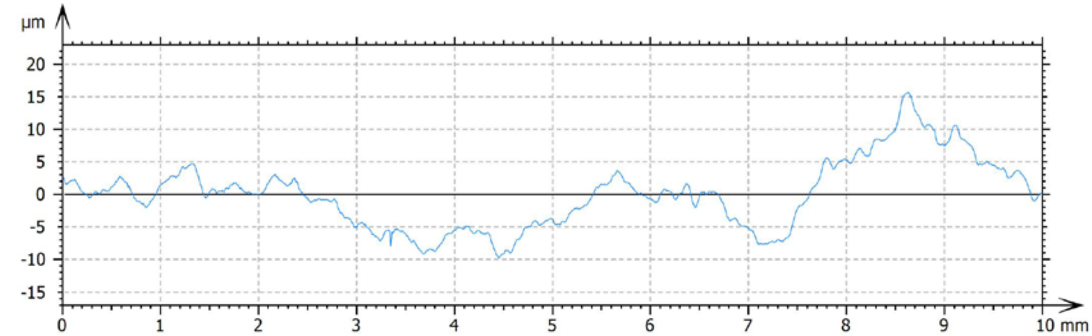
Fig. 3: 3D view of the honeycomb panel surfaces.

		Sample 1	Sample 2	
ISO 25178: Roughness				
Sq	µm	4.96	21	Root-mean-square height
Sz	µm	0.288	230	Maximum height
Sa	µm	4.27	14.7	Arithmetic mean height
ISO 12781: Flatness				
FLTt	µm	28.1	73.5	Peak-to-valley flatness deviation of the surface
FLTp	µm	16.3	16.9	Peak-to-reference flatness deviation
FLTv	µm	11.8	56.6	Reference-to-valley flatness deviation
FLTq	µm	4.43	9.66	Root-mean-square flatness deviation

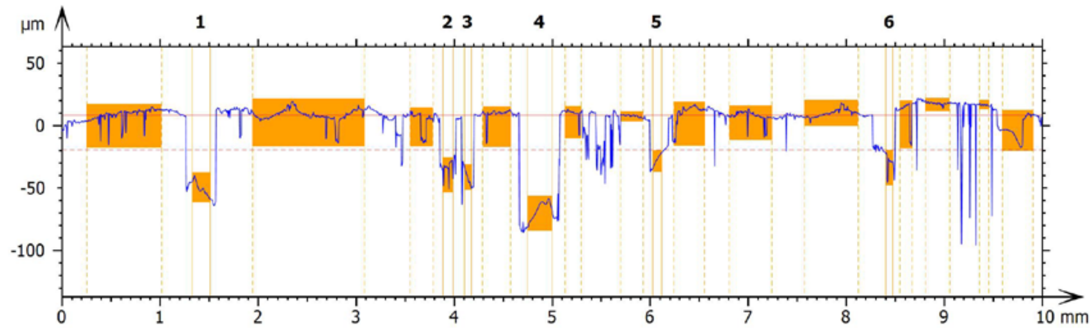
Table 1: The Roughness and Flatness values of the honeycomb panel surfaces.

The 2D profiles of the honeycomb panel surfaces are compared in Fig. 4, allowing users to have a direct view of the height change at different locations of the sample surface. We can observe that Sample 1 has a height variation of ~25 µm between the maximum height and depth in the profile. On the other hand, Sample 2 exhibits several deep pores across the 2D profile. The powerful Nanovea analysis software automatically locates and measures the depth of six relatively deep pores as shown in the table of Fig. 4b. The deepest pore among the six possesses a maximum depth of nearly 90 µm.

(a) Sample 1:



(b) Sample 2:



Parameters	Unit	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
Width	mm	0.185	0.100	0.070	0.255	0.090	0.075
Maximum depth	µm	67.1	59.3	57.2	89.9	42.7	53.8
Mean depth	µm	58.3	41.6	49.8	75.7	35.9	38.7

Fig. 4: Cross section view of the honeycomb panel surfaces.

In order to further investigate the pore size and distribution of Sample 2, porosity evaluation was performed and discussed in the following section. The sliced view is displayed in Fig. 5 and the results are summarized in Table 2. We can observe that the pores, marked in blue color in Fig. 5, have a relatively homogeneous distribution on the sample surface. The projected area of the pores constitutes 18.9% of the whole sample surface. The volume per mm^2 of the total pores is ~0.06 mm^3. The pores have an average depth of 42.2 µm, and the maximum depth is 108.1 µm.

Parameters	Unit	Void
Projected area	mm^2	18.9
Volume	$\mu m^3/mm^2$	6313393
Mean Depth	µm	42.2
Maximum Depth	µm	108.1

Table 2: Result summary of the porosity analysis.

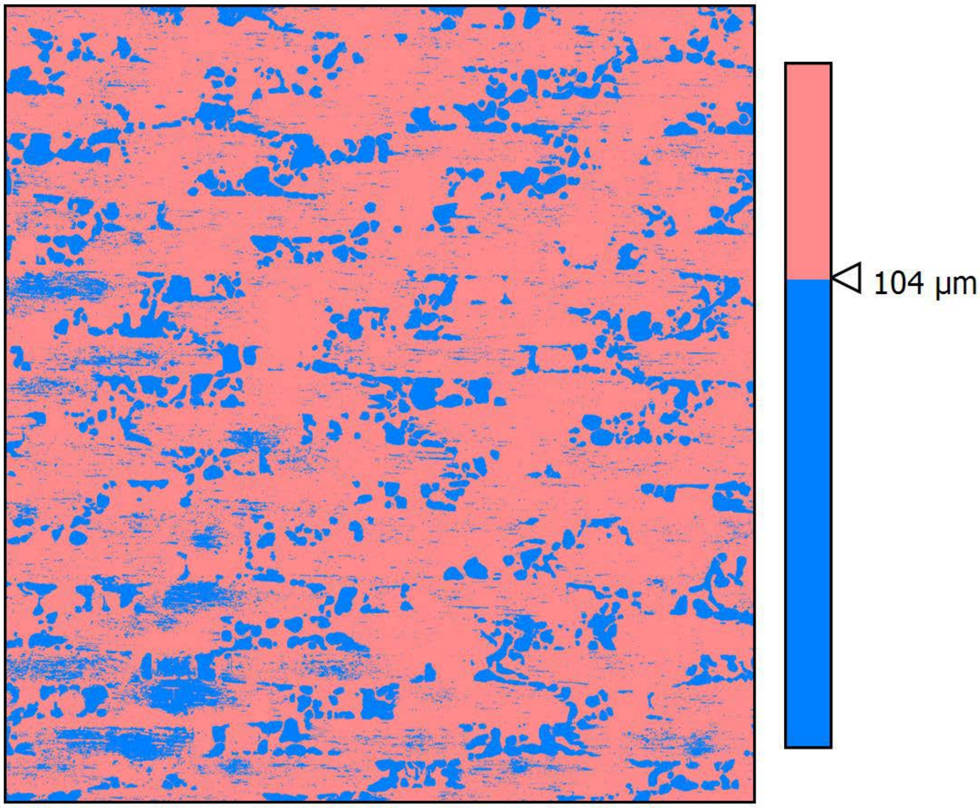


Fig. 5: Porosity analysis.

CONCLUSION

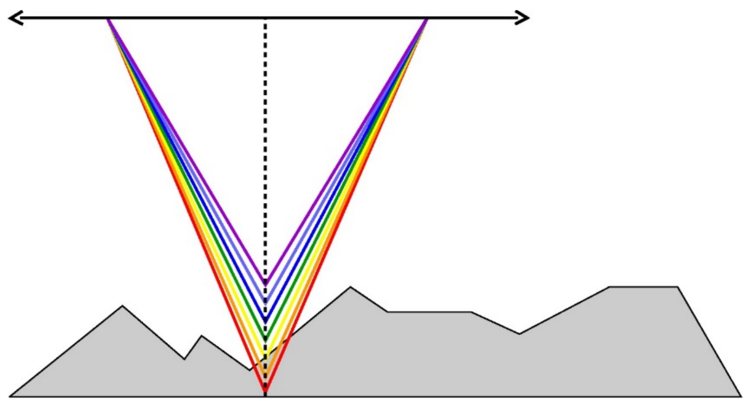
In this application, we have showcased that the Nanovea ST400 3D Non-Contact Profilometer equipped with an optical line sensor is an ideal tool for analyzing and comparing the surface finish of honeycomb panel samples in a fast and precise manner. The porosity on the sample surface plays an important role in the quality and paintability of the honeycomb panel. The high resolution scan and analysis tools including 3D and porosity analyses by Nanovea profilometer enable comprehensive and quantitative evaluation of the surface finish of honeycomb panel samples.

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 (LED) that passes through a series of lenses, called an optical pen, which has a high degree of chromatic aberration. The refractive index of the lenses will vary the focal distance of each wavelength of the white light.



In effect, each separate wavelength of the white light will focus at a different distance from the optical pen, creating the measurement range. When a surface of interest is within the measurement range a single wavelength of the white light will be in focus while all others will be out of focus. The white light is then reflected back through the optical pen, then through a pin hole filter that allows only the focused wavelength to pass through to a CCD spectrometer. The CCD will indicate the wavelength in focus, which corresponds to a specific distance for a single point. The physical wavelength measured uses no algorithms providing the highest accuracy independent of form, roughness level, illumination and measurement speed. There is no special leveling procedure required. And while others make claims of resolutions Nanovea provides high accuracy.