NANOVEA
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A Better Look at Paper

Paper has played a large role in information distribution since its invention in the 2nd century [1]. Paper consists of intertwined fibers, typically obtained from trees, that have been dried into thin sheets. As a medium for information storage, paper has allowed the spread of ideas, art, and history over long distances and through passing time.

Today, paper is commonly used for currency, books, toiletries, packaging, and more. Paper is processed in different ways to obtain properties to match their application. For example, the visually appealing, glossy paper from a magazine is different compared to rough, cold-pressed watercolor paper. The method in which paper is produced will affect the surface properties of the paper. This influences how ink (or other medium) will settle onto and appear on the paper. To inspect how different paper processes affects surface properties, Nanovea inspected the roughness and texture of various types of paper by conducting a large area scan with our 3D Non-Contact Profilometer.

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The Importance of Measuring Surface Roughness of Paper

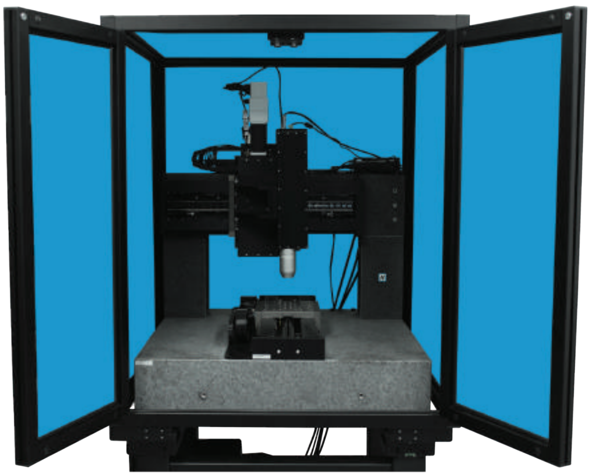
Surface roughness is an important property for paper since it affects print quality [2]. The roughness from macroscale features (e.g. poor fiber dispersion) and microscale features (e.g. particle size distribution) both affect the properties of the paper.

The conventional method for paper roughness measurements is called the Parker Print-Surf method. Different pressures are applied to the paper with a 51µm wide ring, and the measured airflow between the surface of the paper and the ring is used to obtain roughness. The key disadvantage to this method is its inability to detect microscale features that can influence printing quality.

Nanovea's 3D Non-Contact line sensor profilometer, however, is able to detect both macro and microscale features with its fast scanning abilities and high resolution. Large areas can be scanned and using the obtained height data, roughness can be obtained by calculating the arithmetic mean height (Sa). Paper is sensitive to deformation due to its thin nature. The non-contact technology of our line sensor ensures surface deformation will not influence the height data.

Equipment Featured

NANOVEA HS2000



High Speed Inspection & Precision Flatness Measure

Advanced Automation

Customizable Options

High Speed

Precision Flatness Measurement

Rigid and Stable Structure

https://nanovea.com/instruments/?p=profilometers

Measurement Objectives

In this study, Nanovea conducted Non-contact 3D Profilometry large area scans on various papers. Linen, copy, premium, matte and gloss paper were used as test specimens for this study. The height parameters arithmetic mean height (Sa) and root-mean-square arithmetic mean height (Sq) values will be used to compare the roughness of the samples in both macro and microscales. Please visit our measurement principle page (nanovea.com/profilometry-measurement-principles) for more information on height parameters.

Measurement Parameters

Table 1: Test parameters for profilometry measurements on various papers

Test Parameter	Value
Instrument	Nanovea HS2000L
Optical Sensor	LS1 Lens (200µm Z-range)
Scan size (mm)	50mm x 50mm
Step size (µm)	5µm x 5µm
Scan time (h:m:s)	00:06:43

A large 50mm x 50mm scan was conducted on all types of paper to obtain a quantifiable roughness parameter on the macroscale range. A small area of 2mm x 2mm was extracted from the original 50mm x 50mm scans for each paper specimen to observe their microscale details as well.

Since different features are being observed, the macro and microscale areas had to undergo different filtering operators to remove noise and form. In the large area scan, a S-L filter was applied to obtain its roughness parameter. A Gaussian filter of 0.03mm and 5mm were used on the large scans as a high and low pass filters, and the extracted area had a Gaussian filter of 0.25mm applied to remove local waviness.

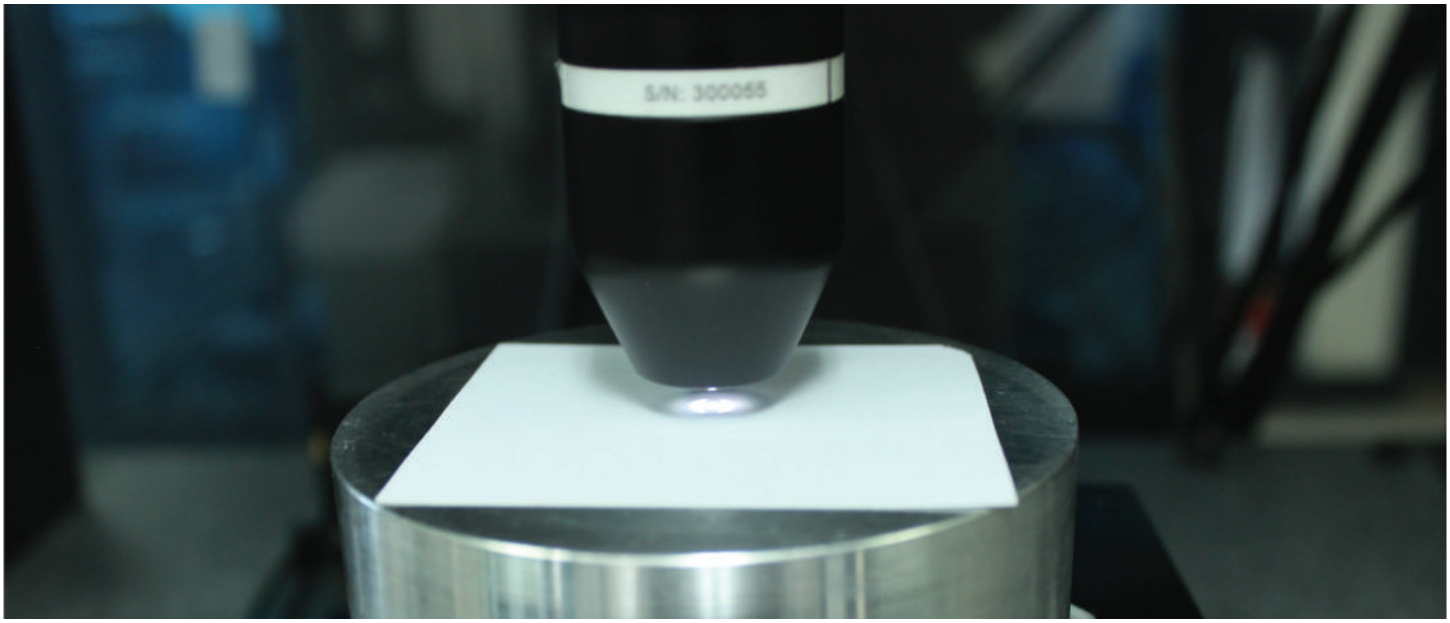
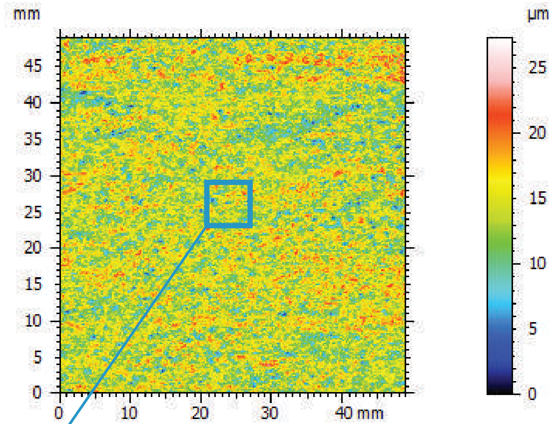


Image of Premium paper sample under HS2000 LS1 Pen

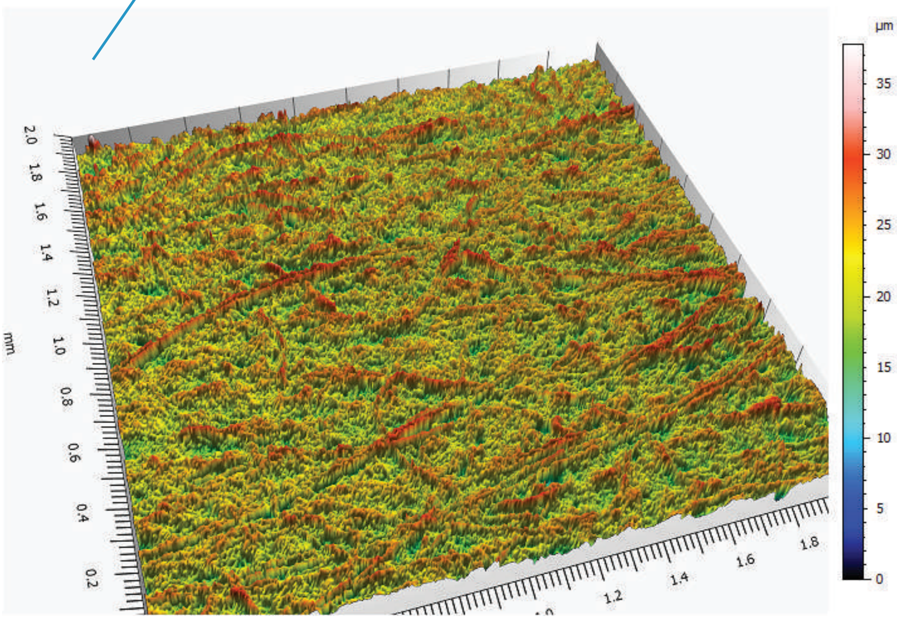
Copy Paper

Copy paper is uncoated for multipurpose use. The Sa and Sq values between the large area scan and the extracted area were not significantly different. The paper's fibers can be seen in detail when observing the 2mm x 2mm extracted area.



ISO 25178		
Height Parameters		
Sa	2.288	µm
Sq	2.893	µm
Ssk	-0.3177	
Sku	3.307	
Sz	27.34	µm
Sp	13.33	µm
Sv	14.02	µm
Other 3D Paramet...		
Miscellaneous		
Sdar	2402	mm²
Spar	2401	mm²

Figure 1: False-color view with height parameters for Copy Paper

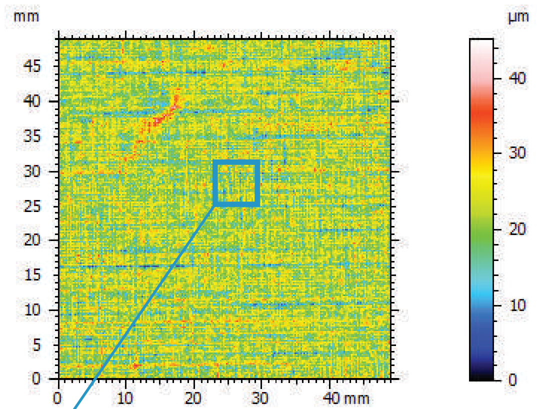


ISO 25178		
Height Parameters		
Sa	2.531	µm
Sq	3.244	µm
Ssk	-0.428	
Sku	3.966	
Sz	37.82	µm
Sp	15.91	µm
Sv	21.92	µm
Other 3D Paramet...		
Miscellaneous		
Sdar	4.594	mm²
Spar	4.000	mm²

Figure 2: 3D view of extracted area for Copy Paper

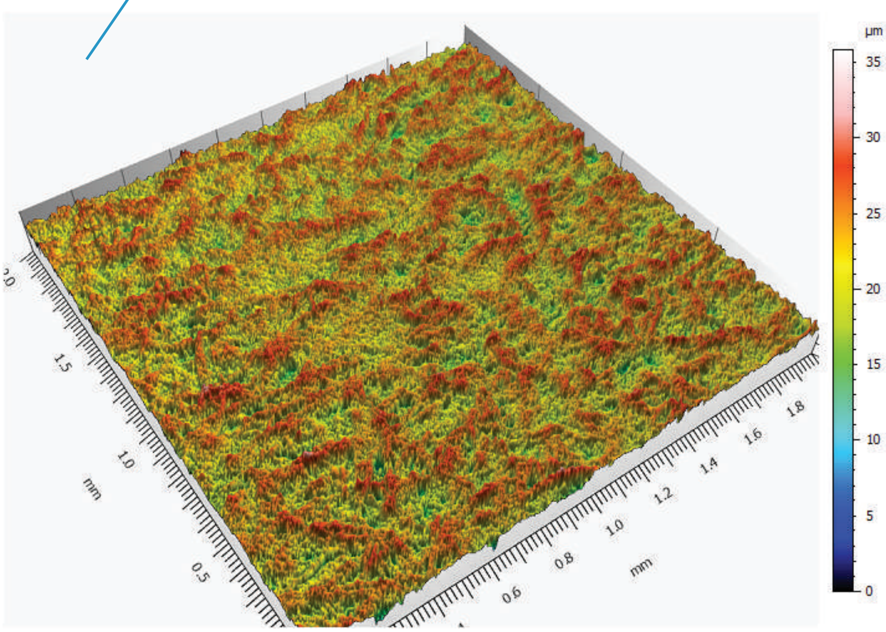
Linen Paper

Linen paper is primarily used for aesthetic purposes. Its uncoated, embossed crosshatch finish gives off a feeling of natural linen. The directional texture of the paper can be clearly seen in the large area scan. Due to its embossed, textured surface, the surface roughness is higher than copy paper. While the texture is clearly visible at the macroscale, the texture in the extracted area is not apparent.



ISO 25178		
Height Parameters		
Sa	3.503	µm
Sq	4.450	µm
Ssk	-0.303	
Sku	3.378	
Sz	45.17	µm
Sp	23.20	µm
Sv	21.98	µm
Other 3D Paramet...		
Miscellaneous		
Sdar	2403	mm²
Spar	2401	mm²

Figure 5: False-color view with height parameters for Linen Paper

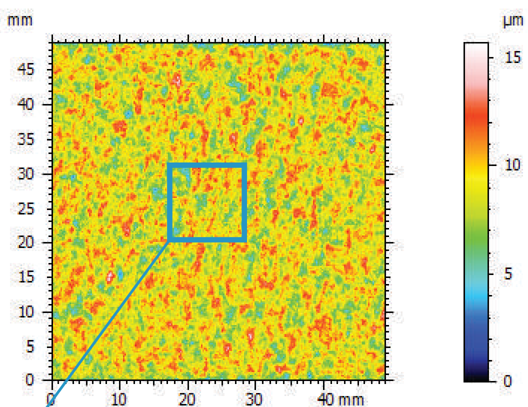


ISO 25178		
Height Parameters		
Sa	2.209	µm
Sq	2.829	µm
Ssk	-0.5016	
Sku	4.161	
Sz	35.85	µm
Sp	13.58	µm
Sv	22.27	µm
Other 3D Paramet...		
Miscellaneous		
Sdar	4.372	mm²
Spar	4.000	mm²

Figure 6: 3D view of extracted area for Linen Paper

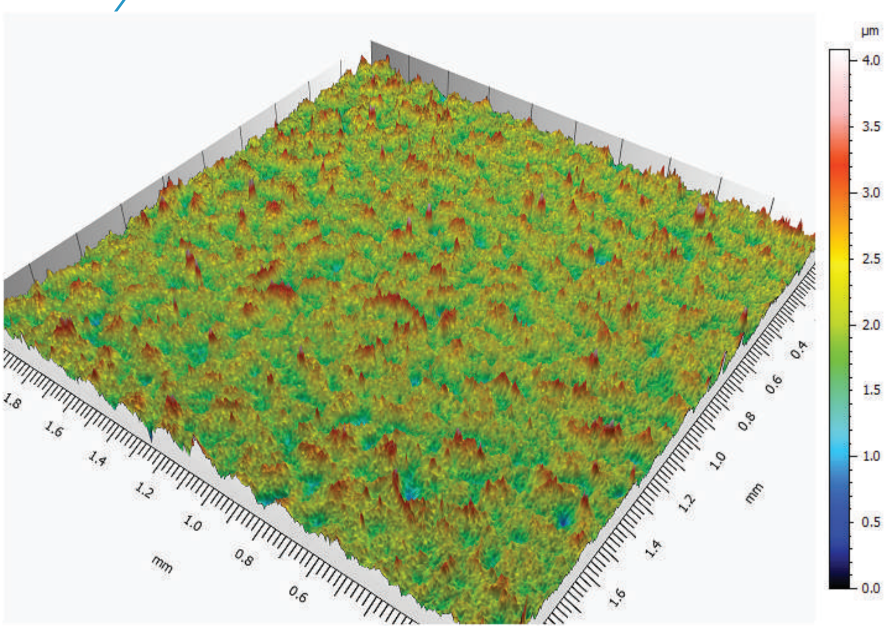
Matte Coated Paper

A matte coat on paper is used to give off a subtle shine while decreasing its degradation from dirt, moisture or wear [3]. The shine of the paper is caused by this coating. The coating's surface roughness influences how light is reflected off the surface and as a result, influences the shine of the paper. The macroscale roughness is observed to be much higher than its microscale variant.



ISO 25178		
Height Parameters		
Sa	1.255	µm
Sq	1.569	µm
Ssk	-0.106	
Sku	2.951	
Sz	15.70	µm
Sp	6.691	µm
Sv	9.007	µm
Other 3D Paramet...		
Miscellaneous		
Sdar	2402	mm²
Spar	2401	mm²

Figure 7: False-color view with height parameters for Matte Coated Paper

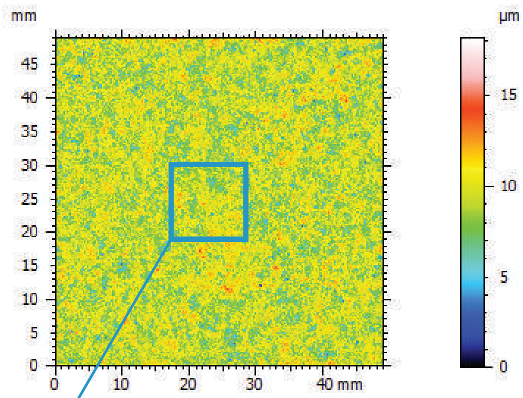


ISO 25178		
Height Parameters		
Sa	0.2783	µm
Sq	0.3591	µm
Ssk	0.1011	
Sku	4.112	
Sz	4.086	µm
Sp	1.975	µm
Sv	2.111	µm
Other 3D Paramet...		
Miscellaneous		
Sdar	4.010	mm²
Spar	4.000	mm²

Figure 8: 3D view of extracted area for Matte Coated Paper

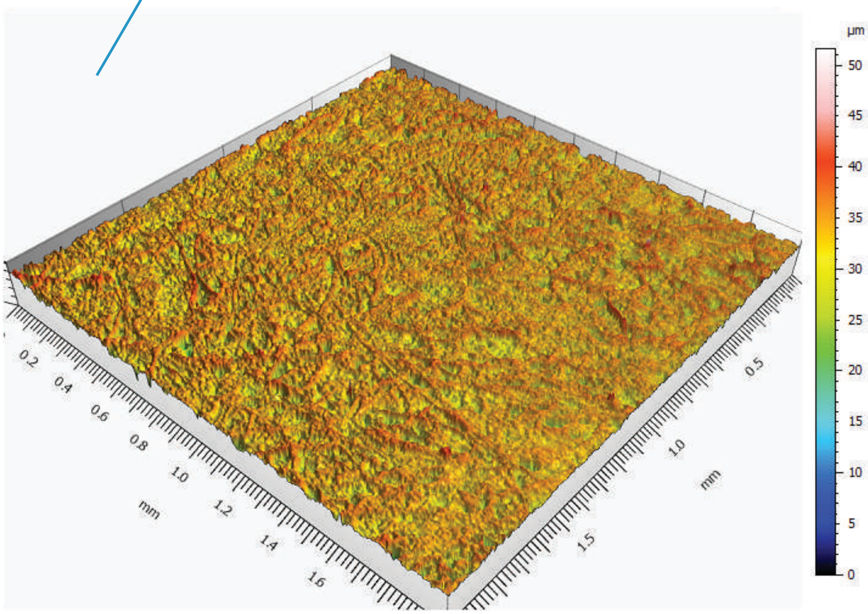
Premium Paper

Premium paper is advertised to be brighter and more ink absorbent than copy paper. While both papers are uncoated, premium paper was found to have lower roughness than copy paper. The 2mm x 2mm extracted area on the premium paper analysis shows that the paper fibers are more numerous and smaller when compared to copy paper fibers.



ISO 25178		
Height Parameters		
Sa	1.098	µm
Sq	1.401	µm
Ssk	-0.5178	
Sku	3.762	
Sz	18.16	µm
Sp	8.883	µm
Sv	9.276	µm
Other 3D Paramet...		
Miscellaneous		
Sdar	2401	mm²
Spar	2401	mm²

Figure 3:False-color view with height parameters for Premium Paper

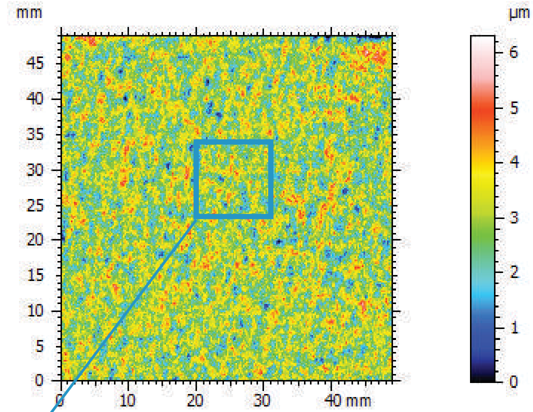


ISO 25178		
Height Parameters		
Sa	1.891	µm
Sq	2.629	µm
Ssk	-1.62	
Sku	9.231	
Sz	51.62	µm
Sp	18.09	µm
Sv	33.52	µm
Other 3D Parame...		
Miscellaneous		
Sdar	4.470	mm²
Spar	4.000	mm²

Figure 4: 3D view of extracted area for Premium Paper

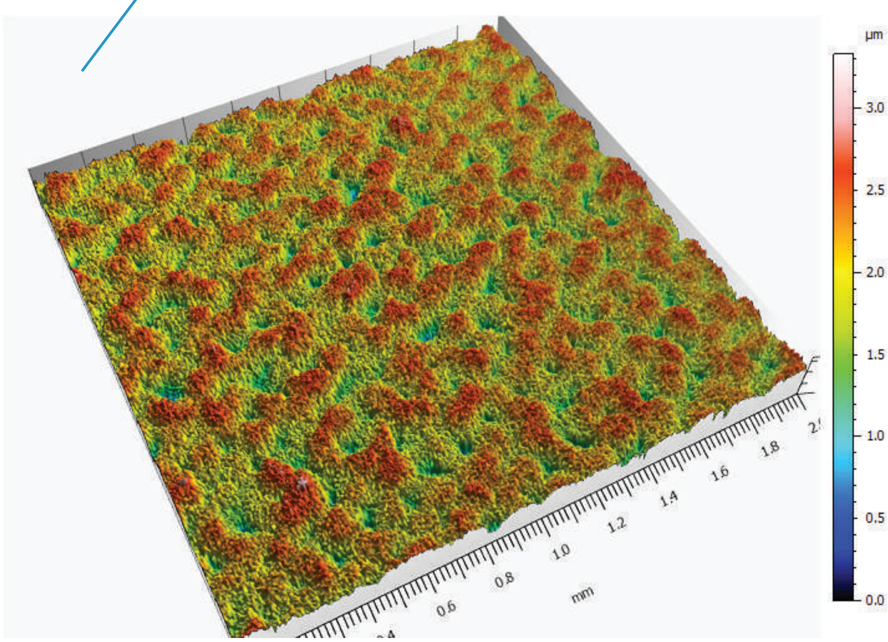
Gloss Coated Paper

Used in covers or magazines, gloss coat is typically applied to paper to give shine. Gloss coatings typically have low roughness to reflect light and give paper a shiny finish. This holds true with the gloss coat specimen that was scanned. Both the macro and microscale roughness are lower than the matte coat. The microscale features do not have outstanding peaks; the surface appears to be smooth and consistent.



ISO 25178		
Height Parameters		
Sa	0.5904	µm
Sq	0.7403	µm
Ssk	-0.09473	
Sku	3.069	
Sz	6.320	µm
Sp	3.346	µm
Sv	2.974	µm
Other 3D Paramet...		
Miscellaneous		
Sdar	2401	mm²
Spar	2401	mm²

Figure 9: False-color view with height parameters for Gloss Coated Paper



ISO 25178		
Height Parameters		
Sa	0.2454	µm
Sq	0.3184	µm
Ssk	-0.805	
Sku	4.699	
Sz	3.330	µm
Sp	1.294	µm
Sv	2.036	µm
Other 3D Paramet...		
Miscellaneous		
Sdar	4.005	mm²
Spar	4.000	mm²

Figure 10: 3D view of extracted area for Gloss Coated Paper

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Conclusion

A total of 6 different types of paper were analyzed with Nanovea's 3D Non-contact profilometer. The overall roughness is ranked from highest to lowest as follows: Linen, copy paper, premium paper, matte coat, and gloss coat.

With the line sensor's ability to quickly scan large areas at a high resolution, both macro and microscale features can also be observed in a single scan. Microscale roughness can be locally obtained by extracting a small area from the large scan. The roughness values between micro and macro scale were observed to be drastically different between some paper types. The macro and microscale surface roughness of the paper can be used as a quantifiable variable in print quality and in the case of coated samples, gloss quality. With Nanovea's 3D Non-contact profilometer, measuring micro or macroscale roughness on paper is a quick and easy task.

References

• [1] Tsien, Tsuen-Hsuin (1985). Needham, Joseph, ed. Paper and Printing. Science and Civilisation in China, Chemistry and Chemical Technology. V (part 1). Cambridge University Press.
• [2]Xu, Renmei, et al. "The effect of ink jet paper roughness on print gloss." Journal of imaging science and technology 49.6 (2005): 660-666.
• [3]"Paper Types & Finishes." California State University, Northridge. Accessed February 20, 2019. http://www.csun.edu/~pjd77408/DrD/resources/Printing/PaperFinishes.html

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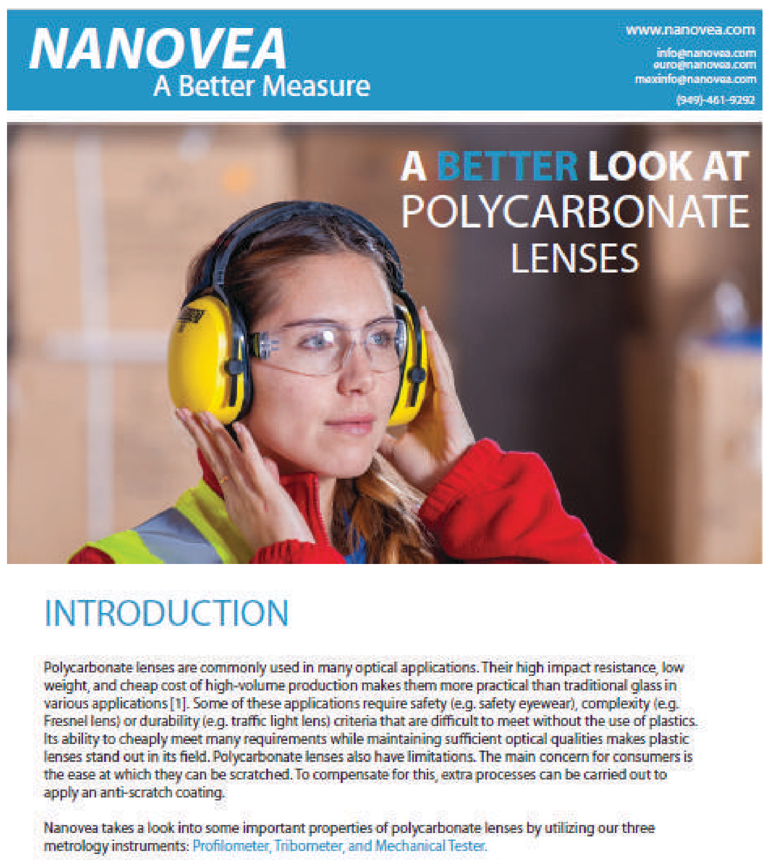
Recommended Reading

Check out our other application note where we conduct an extensive investigation on the materials property of Polycarbonate Lenses!

https://nanovea.com/investigating-the-properties-of-plastic-lens/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A BETTER LOOK AT POLYCARBONATE LENSES

INTRODUCTION

Polycarbonate lenses are commonly used in many optical applications. Their high impact resistance, low weight, and cheap cost of high-volume production makes them more practical than traditional glass in various applications [1]. Some of these applications require safety (e.g. safety eyewear), complexity (e.g. Fresnel lens) or durability (e.g. traffic light lens) criteria that are difficult to meet without the use of plastics. Its ability to cheaply meet many requirements while maintaining sufficient optical qualities makes plastic lenses stand out in its field. Polycarbonate lenses also have limitations. The main concern for consumers is the ease at which they can be scratched. To compensate for this, extra processes can be carried out to apply an anti-scratch coating.

Nanovea takes a look into some important properties of polycarbonate lenses by utilizing our three metrology instruments: Profilometer, Tribometer, and Mechanical Tester.