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A Better Measure

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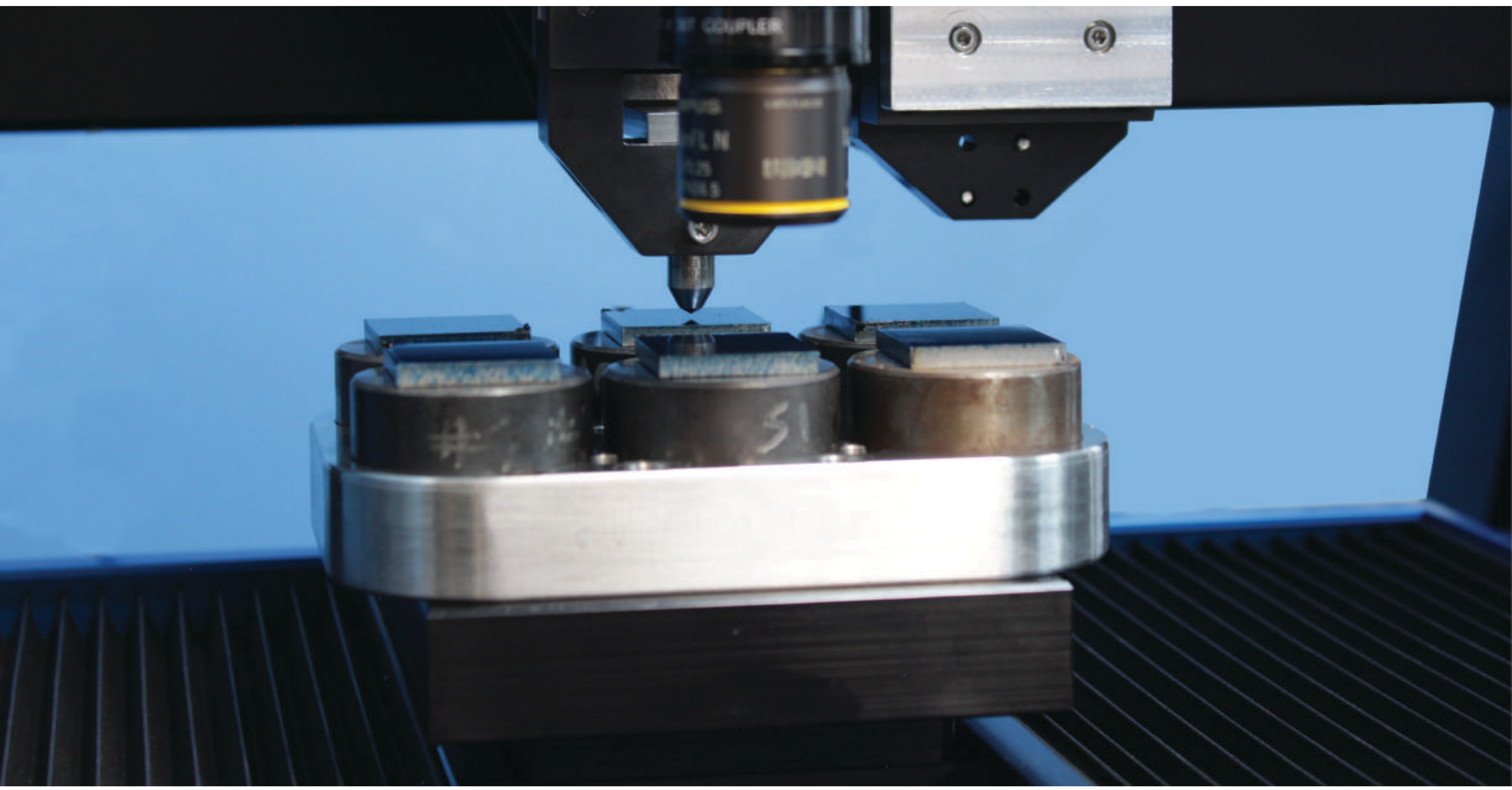
MULTI SCRATCH AUTOMATION

USING THE

PB1000 MECHANICAL TESTER



Prepared by

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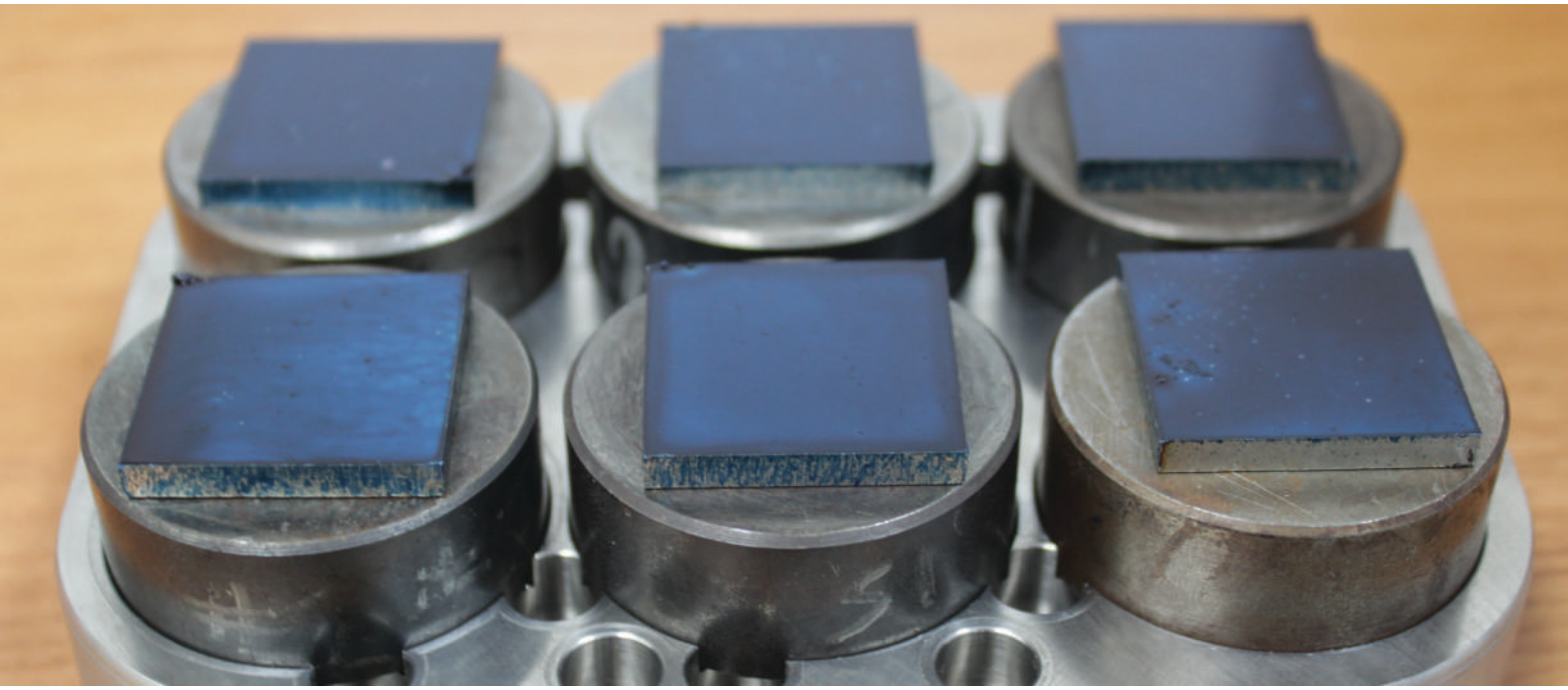


Introduction

Coatings are widely used in various industries because of their functional properties. A coating's hardness, erosion resistance, low friction, and high wear resistance are just some of the many properties that make coatings important. A commonly used method to quantify these properties is scratch testing, this allows for a repeatable measurement of a coating's adhesive and/or cohesive properties. By comparing the critical loads at which failure occurs, the intrinsic properties of a coating can be evaluated.

Importance of Automated Multi Scratch Testing for Quality Control

A scratch test is performed by sliding a stylus over a sample's surface while applying a specific load that is either constant or progressive. While the scratch test is conducted, the coating will begin to fail at specific applied loads, these points along the scratch are known as the critical loads. The critical load is a function of many factors, including stylus shape and radius, sliding speed, loading rate, coating thickness, and much more. By using identical test parameters for comparative evaluation between samples, variance in test results are reduced which leads to a higher degree of accuracy and consistency between samples.

Another important data set that can be recorded is a sample's acoustic emissions (AE). AE are elastic waves generated by the release of internal energy, which can give the operator insight towards what is occurring during the testing1. Automating the testing process can reduce errors from test set up and user operation. This is an indispensable feature for efficient and reliable quality control testing where multiple identical samples are to be tested.

Measurement Objectives

In this study we showcase the Nanovea PB1000 Mechanical Tester's ability to perform automated scratch testing on multiple samples. The tests were conducted on six different coated samples to exhibit the PB1000's efficiency and reproducibility.

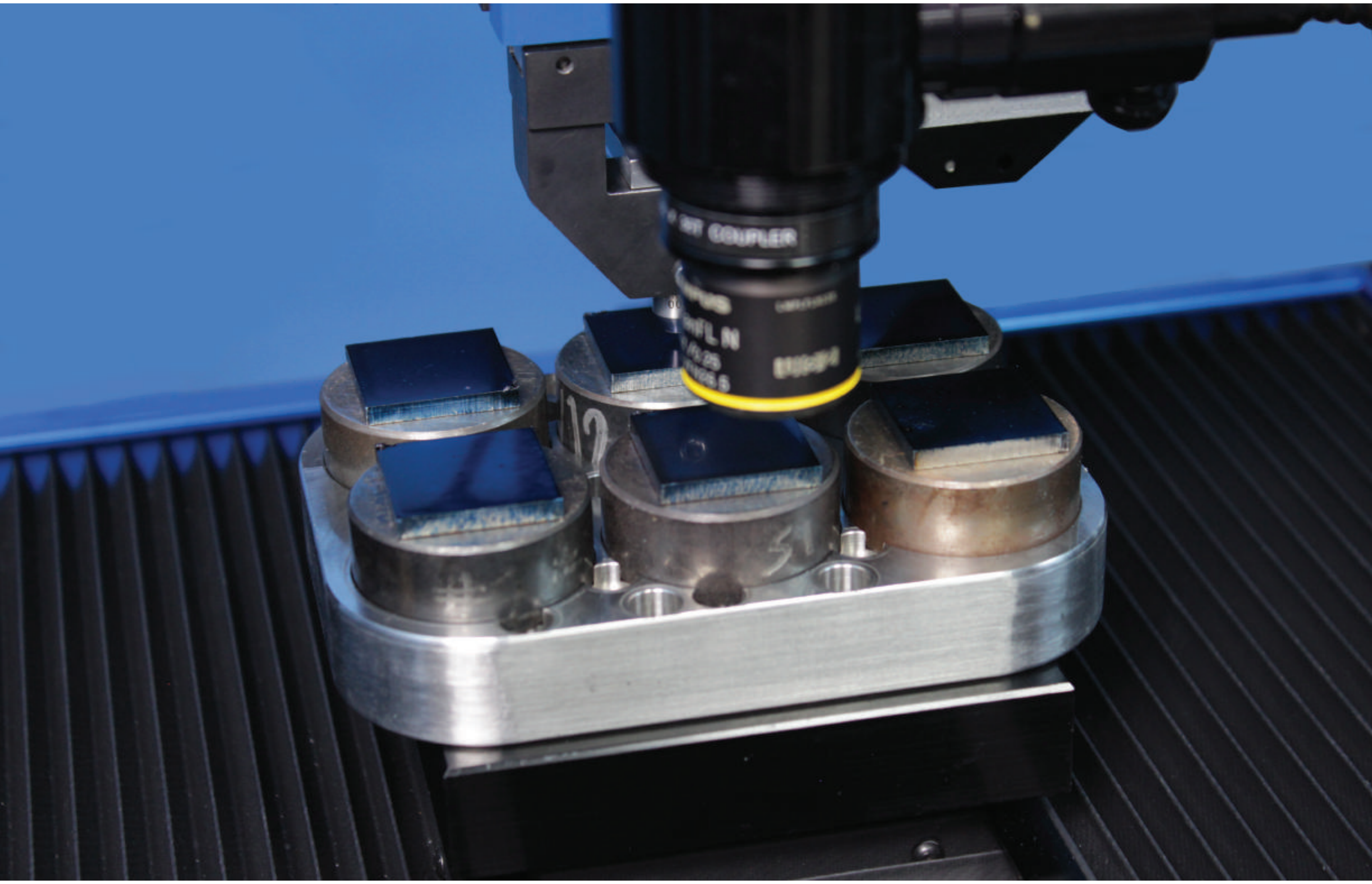


Fig. 1: Scratch tip and depth sensor on the test sample matrix.

Measurement Parameters

The Nanovea PB1000 Mechanical Tester was used to test six samples mounted in a puck holder using the test parameters summarized in Table 1. Three scratches were performed on each sample with the scratch map feature.

Test Parameters	
Load Type	**Progressive**
Initial Load	**5 N**
Final Load	**30 N**
Sliding Speed	**5 mm/min**
Sliding Distance	**10 mm**
Indenter Geometry	**Rockwell (120° cone)**
Indenter Material (tip)	**Diamond**
Indenter Tip Radius	**100 µm**
Atmosphere	**Air**
Temperature	**24 °C (room temperature)**

Table 1: Test parameters used

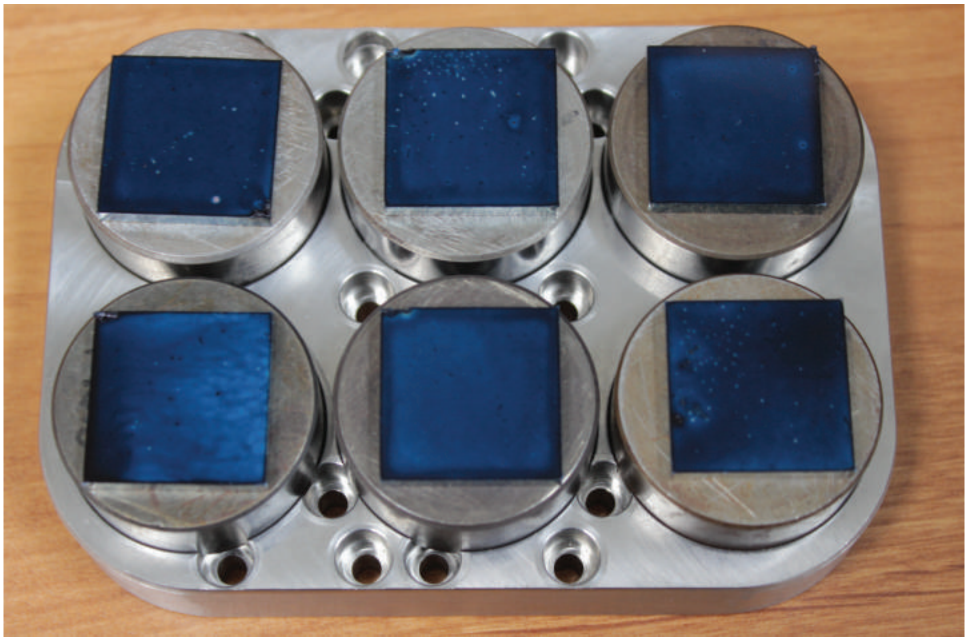


Figure 1: Six samples mounted on a puck holder

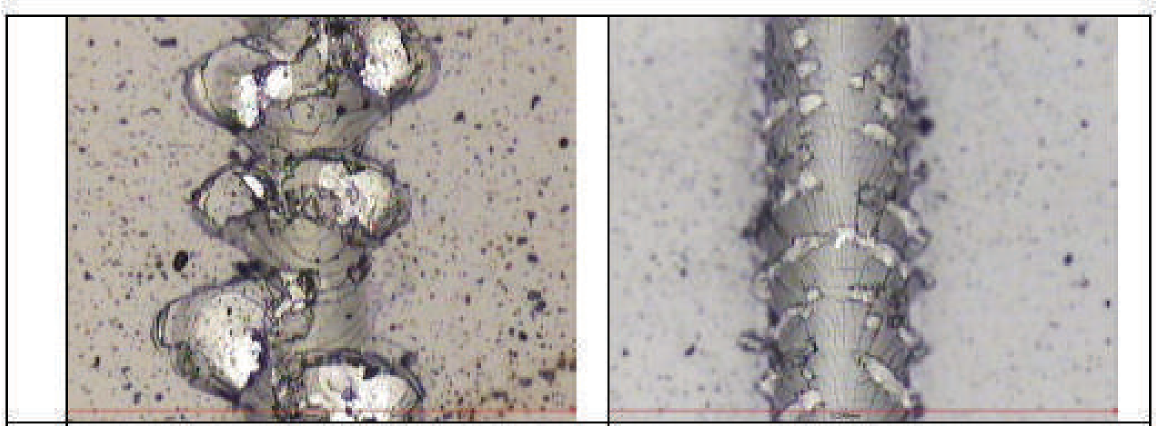
Results and Discussion

With the high precision position control of the Nanovea PB1000 Mechanical Tester, specific areas can be targeted for testing. A summary of the results from the six coatings can be found below in Table 2, where the Initial Delamination, LC1 , is defined as the critical load at which the first signs of adhesive failure occurred. While LC2, the Repetitive Delamination, is defined as the load at which repetitive adhesive failures had taken place. Looking at the data, it is evident that Sample B delaminated at a much lower load than its counterparts. While Sample F faired the best to the testing, having the highest LC1 and LC2 values.

Sample	Initial Delamination (L_{C1}) [N]	Repetitive Delamination (L_{C2}) [N]
A	10.7 ± 0.6	15.0 ± 0.9
B	9.4 ± 0.1	10.7 ± 0.3
C	12.2 ± 0.7	15.4 ± 0.3
D	12.4 ± 1.0	15.6 ± 0.3
E	11.6 ± 1.0	15.8 ± 0.6
F	13.0 ± 1.3	17.9 ± 0.1

Table 2 : Summary of critical load of the tested samples.

Figure 2 below shows a visual side-by-side comparison of the LC1 and LC2 microscope images for samples B and F. Before adhesive failure occurs, chevron cracking takes place. This is defined as small cracks with a 45° orientation relative to the scratch direction. Sample B's initial delamination occurred at a load of 9.4 N, catastrophic failure by way of annular cracks can be seen beyond the scratch width. This can be attributed to high compressive stress from the stylus and poor coating adhesion. Once the load reached 10.7 N, repetitive wedge failures can be seen on sample B. In comparison, Sample F exhibits a small buckling failure at LC1 and repetitive buckling failures at its respective LC2.



Results and Discussion

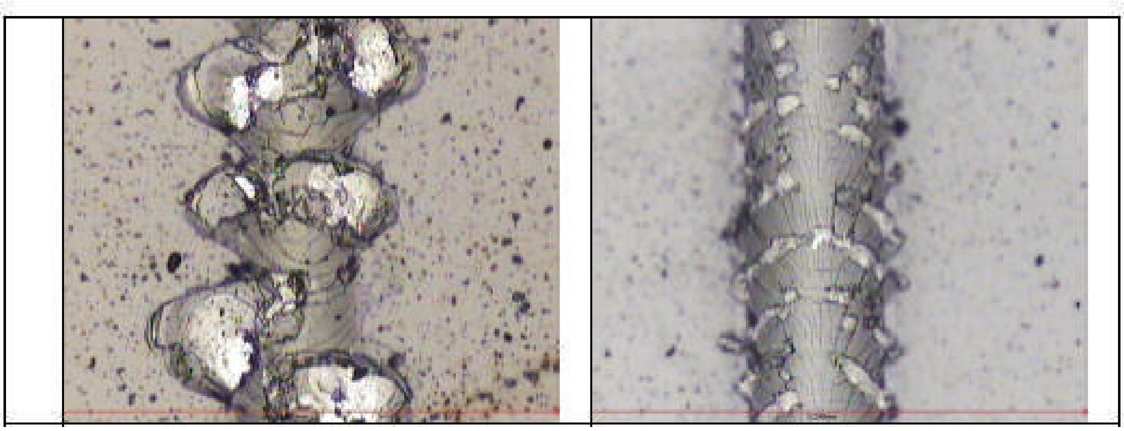
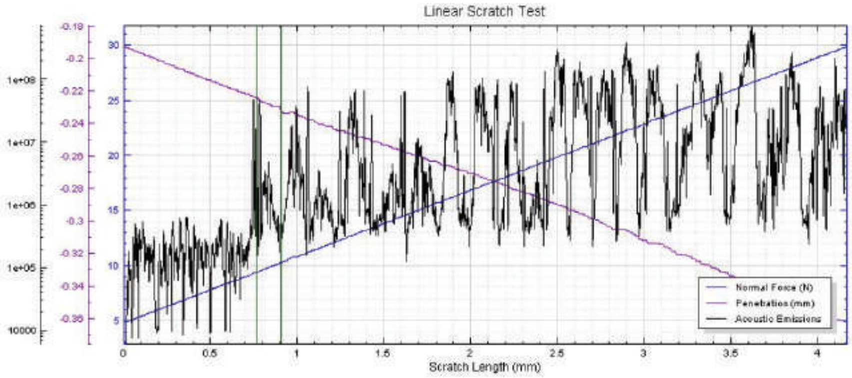


Figure 2 : Comparison of Sample B and Sample F at different critical loads.

The AE for each sample was also recorded during testing. **Figure 3** below depicts the scratch test graphs for both sample B and F. When looking at the graph for sample B, the very first spike of acoustic emissions were found at an early stage of the scratch test (~0.78mm). This is then followed by repetitive AE peaks, indicating continual similar failures as the test proceeded. Now looking at the graph for sample F, there is an initial spike at ~1.1mm, this corresponds with the first visual sign of chipping. As the load increased, the AE spikes continued to increase, correlating to continuous failures in the coating.



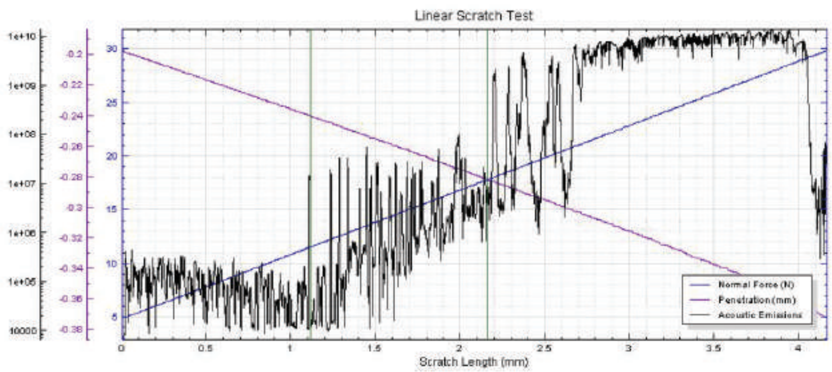
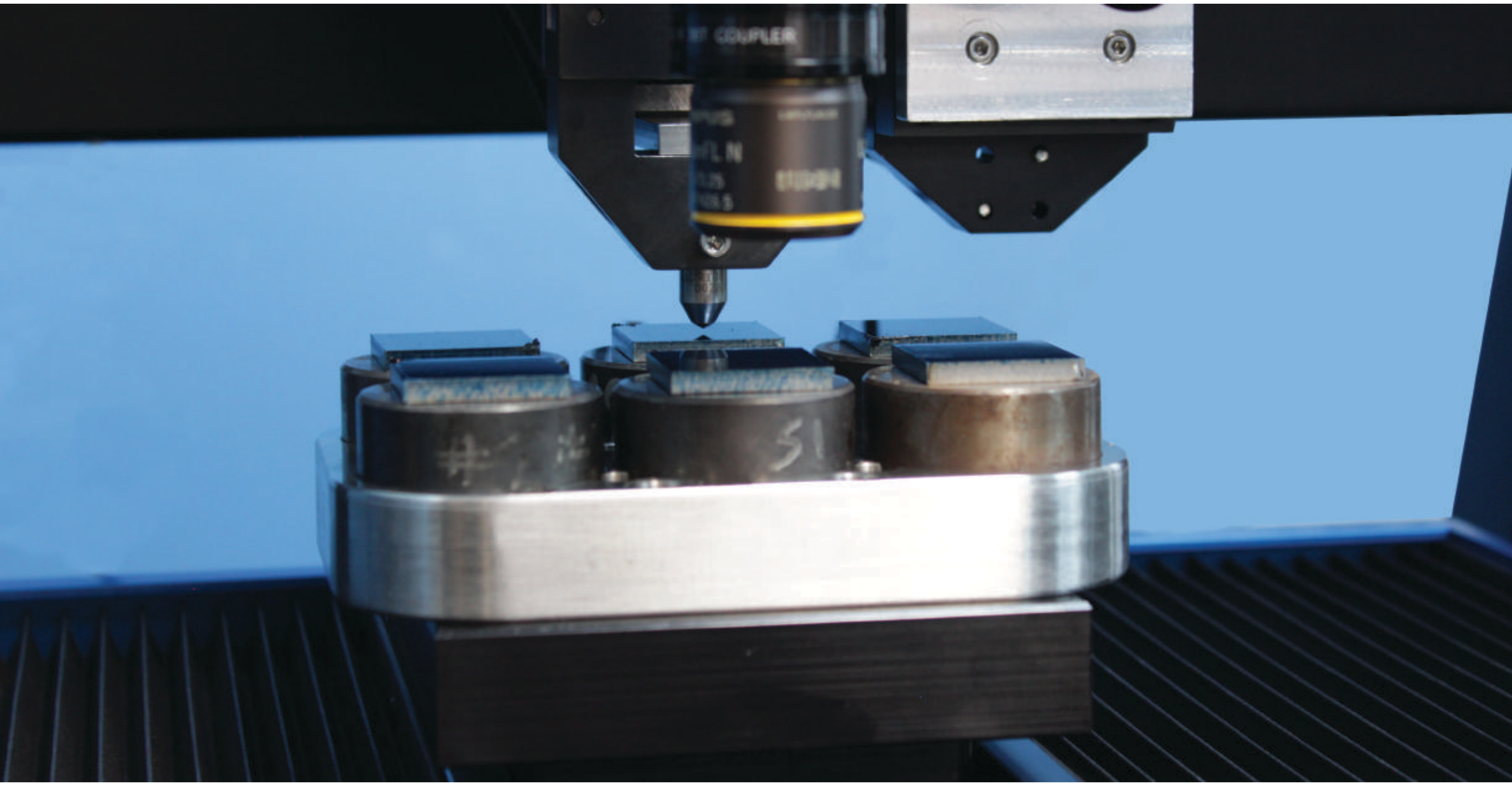


Figure 2: Normal force, penetration, and acoustic emissions of Sample B & F

The scratch test matrix was finished within minutes with minimum operator handling and superior efficiency and repeatability, thanks to the high precision sample stage and user-friendly software interface of the Nanovea Mechanical Tester. Compared to conventional scratch test procedure, the multi sample scratch test in this study can substantially cut the time and possible errors in sample handling and test setup.



Conclusion

In this study we were able to showcase the ability of the Nanovea PB1000 Mechanical Tester to perform multi sample scratching in a repeatable manner. Compared to conventional scratch test procedure, the multi scratch test in this study can substantially cut the time and error in sample handling and test setup. Demonstrating that the Nanovea PB1000 Mechanical tester is the perfect option for large volume quality control. Substantially reducing test set up time and increasing test efficiency.

To learn more about Nanovea Mechanical Tester or Lab Services.

Reference

1 Tomastik, Jan & Ctvrtlik, Radim & Bohac, Petr & Dráb, Martin & Koula, Václav & Cvrk, Karel & Jastrabík, L. (2015). Utilization of Acoustic Emission in Scratch Test Evaluation. Key Engineering Materials. 662. 119-122.

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PB1000

THE MOST POWERFUL MECHANICAL TESTER

Multi Module Platform

3 Testing Modes in 1 (Scratch/Indent/Wear)

Loading Ranges from 0.8uN to 400N

XYZ Motion with 0.20um Step Resolution

Fully Automated (Up to 100 indents in 15mins)

Integrated Imaging (AFM, Profilometer, Microscope)

Learn More about the PB1000!

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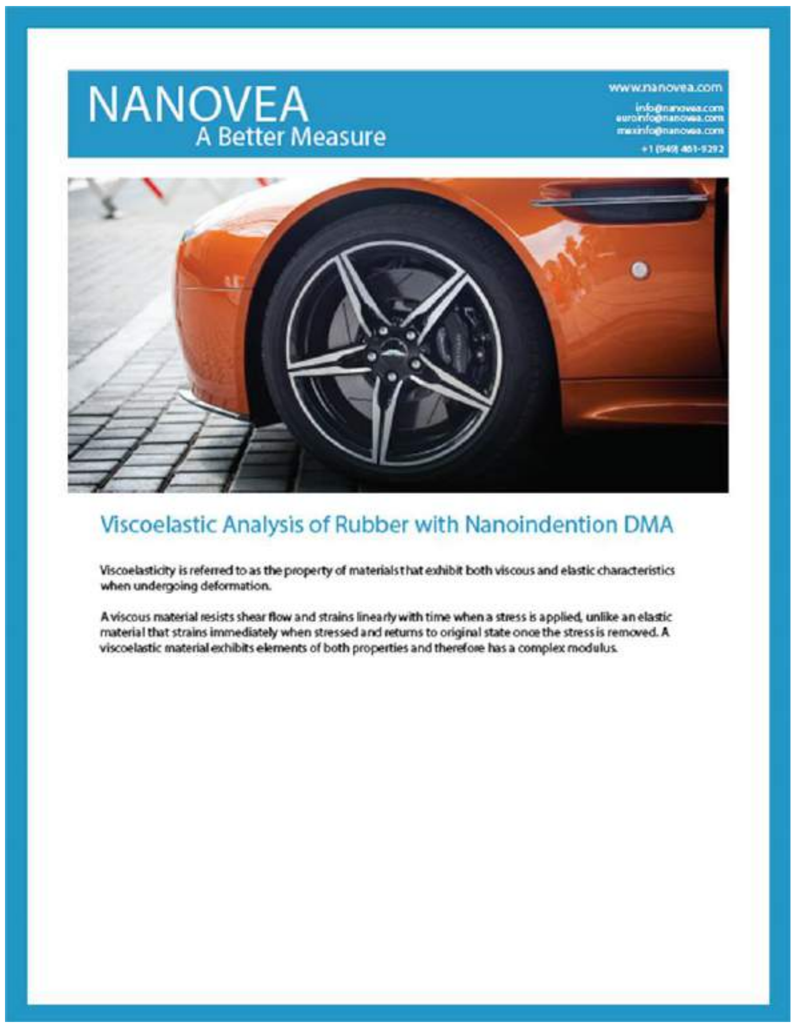
Recommended Reading

Check out our other application note where we conduct a Viscoelastic Analysis on Rubber with Nanoindentation

https://nanovea.com/viscoelastic-analysis-of-rubber/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Viscoelastic Analysis of Rubber with Nanoindention DMA

Viscoelasticity is referred to as the property of materials that exhibit both viscous and elastic characteristics when undergoing deformation.

A viscous material resists shear flow and strains linearly with time when a stress is applied, unlike an elastic material that strains immediately when stressed and returns to original state once the stress is removed. A viscoelastic material exhibits elements of both properties and therefore has a complex modulus.