



Testing Coatings

Application Note

Coatings can provide excellent wear, corrosion and environmental resistance to a wide range of materials, but understanding the behavior of coatings is key to their success.

The most important aspect of a coating is that it is firmly bonded to the underlying material and that it is hard enough to not be worn away in service. Common coatings include paint and electroplatings, such as chrome that have been used for decades. More recently these have been joined by polymer coatings used in food containers to keep food fresher for longer, as well as high performance ceramic thermal barrier coatings that are used in jet engine turbines. The coating shown above is a 'hydrophobic' coating that causes water to bead on the surface and is the technology behind 'self-cleaning' windows.

As coatings cannot be tested in the same way as bulk materials, DAGE Materials Testers offer a specialist test to show how a coating performs.

Scratch Testing

Adhesion of a thin coating to a surface is critical to the performance of the coating, but difficult to test because the coating will tend to break in tension if you attempt to peel it off the surface. Instead, adhesion can be demonstrated using a scratch test:

1. A hard indenter is drawn across the surface of the material with increasing load;
2. At a critical force, the coating will either delaminate from the substrate or the indenter will cut through to the substrate, depending on the coating properties and the indenter used;
3. The critical force can then be determined by optically inspecting the scratch, as the position can be matched to the load at that point by the material tester.

Testing Coatings

Application Note

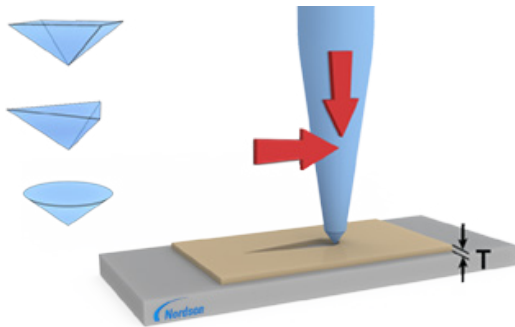


Figure 1. The scratch tool is progressively loaded as it travels across the surface; different tips are available (shown on the left) to test different materials.

The advantage of a scratch test is that it is quick and simple to carry out on a wide range of coatings. Scratch testing demonstrates adhesion by compressing the bulk material as the scratch is created, as well as the coating. If the underlying material has a lower yield strength, then the coating will delaminate as it is stretched over the valley created in the bulk material. If the underlying material has a higher yield strength, then the coating will be squashed against it and will stretch in the x and y directions, therefore delaminating as it expands. While a scratch test does not provide absolute values in the same way that a tensile test does, it can allow different combinations of materials or processes to be compared and the scratch is much more realistic than a tensile test for coating materials.



Figure 2. A DAGE Paragon™ Materials generated fully stitched image of a scratch test, allowing the user to look for changes in behaviour with increasing load.

While it is possible to drag an indenter or scraping tool across a surface to provide some indication of the coating properties, it is necessary to have a load measurement that is independent of drag induced load to achieve a truly quantitative assessment of the coating adhesion. The DAGE Materials Testers use a calibrated load cell that is proven to provide repeatable measurements of the downward force across the full length of the test scratch.

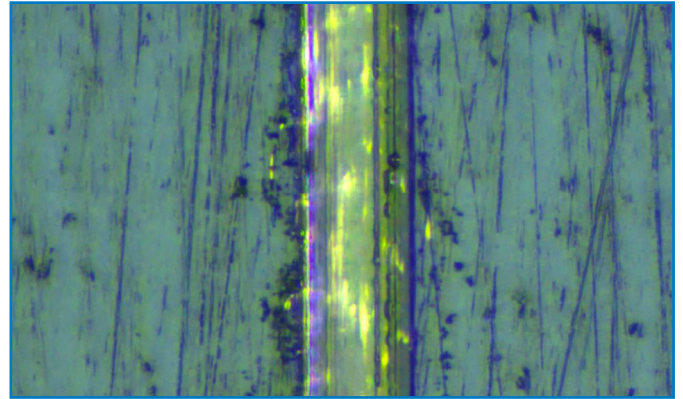


Figure 3. Multi-focus image of a scratch, taken using DAGE Paragon Materials Software; the yellow patches are delaminated areas of a hard coating that have lifted above the substrate.

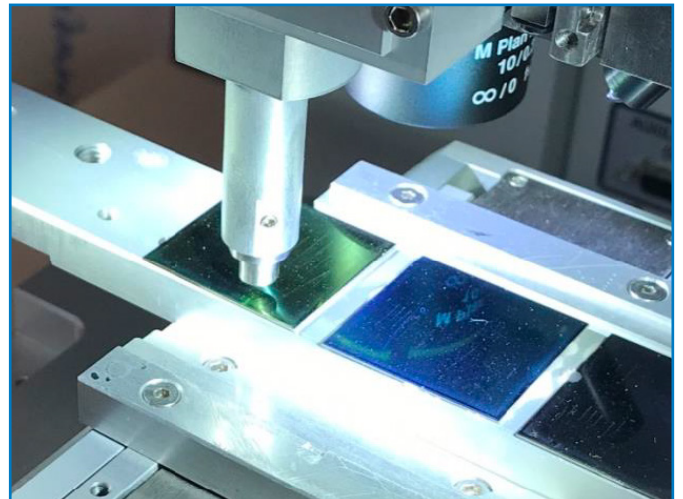


Figure 4. Scratch testing set-up on a ceramic coating.

Testing Coatings

Application Note

Hardness Testing

Hardness testing is typically performed by pressing an indenter into a material surface and measuring the dimensions of the indent. While hardness testing has been used for one hundred years for bulk materials (the original Stanley P Rockwell patent application was made in September 1919), testing of coating materials requires higher precision machines. When bulk materials, such as hardness testing calibration blocks, are tested the load should make a minimal impact on the results as the material hardness is consistent to a depth far below the indent.

Most hardness testing machines are set up to use indentation loads of several kilograms to create large indentations that are easy to measure optically. The problem with this approach is when these loads are used for testing coatings, the indenter is influenced by the layer below the coating. If the indenter completely pierces the coating, then the actual hardness value will mostly be due to the hardness of the underlying material.

DAGE Materials Testers feature the PP50G cartridge that can carry out 5 g load hardness tests, ideal for precious metal or polymer coatings. For very hard and thick coatings, the materials tester is capable of carrying out 100 kg hardness tests, using the PP100KG cartridge. These cartridges can be switched in a matter of moments.

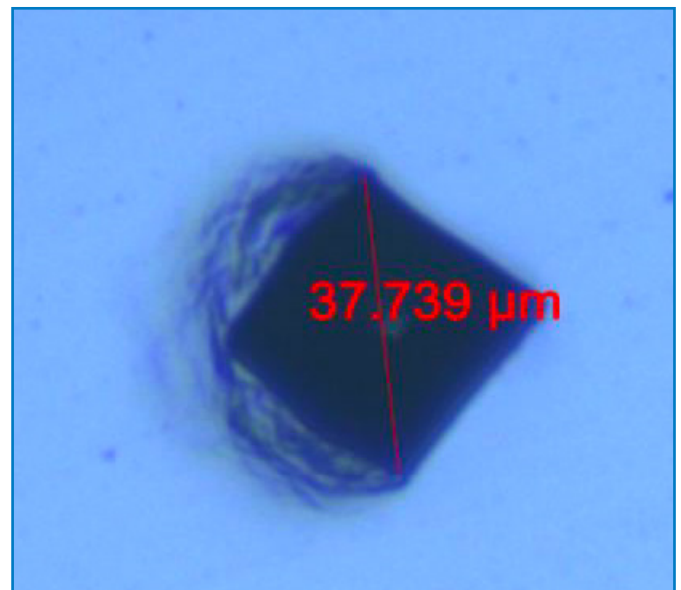
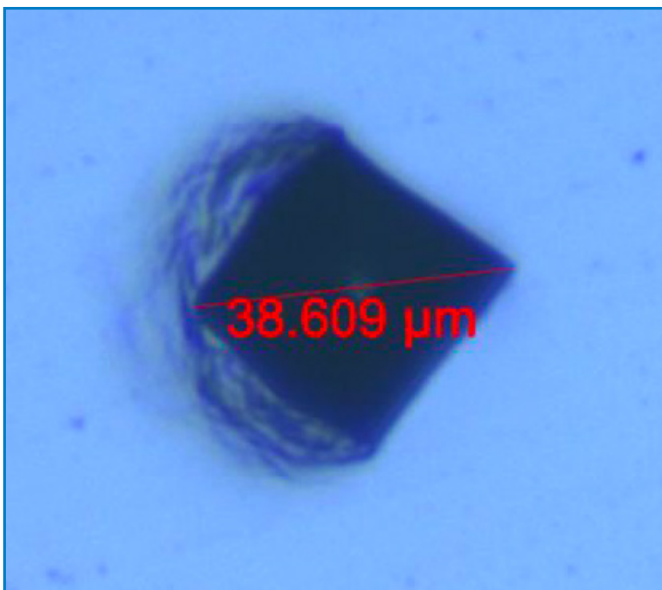


Figure 5. A vickers hardness indent in a polished calibration block, carried out using a PP500G cartridge and x20 objective lens.

Testing Coatings Application Note

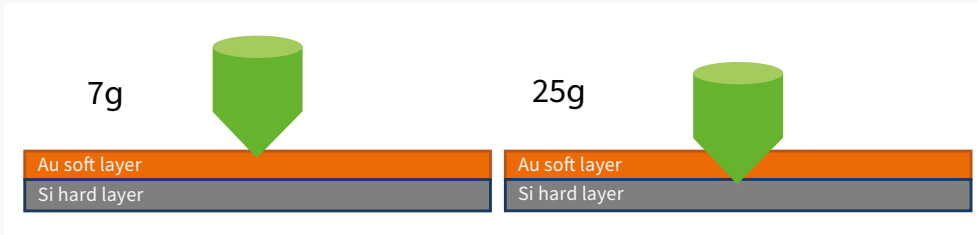


Figure 6. Testing the hardness of a soft gold coating on a hard-underlying material requires very low indentation loads to prevent misleading readings.

DAGE Materials Testers feature a precision XY stage which makes it easy to make maps of hardness points, as the nudge function can be set up by the user to move the sample exact spacings, such as 1.00 mm at the press of a single button. All results are stored on the DAGE Paragon™ Materials database and the images can be stored for later evaluation and interpretation. The long z-axis travel of the materials tester allows components of a range of sizes to be tested.

Conclusion

Testing adhesion and hardness of coatings requires a different approach to testing bulk materials.

DAGE Prospector™ from Nordson provides the flexibility required to perform accurate coating adhesion tests, and the sensitivity to perform hardness tests without interference from the bulk material.



Prospector Micro Materials Tester covers a wide range of test scenarios for the most advanced failure analysis applications.

For more information, speak with your Nordson representative or contact your Nordson regional office

Americas

+1 760 930 3307
sales@nordsondage.com

Europe

+44 1296 317800
globalsales@nordsondage.com

China

+86 512 6665 2008
sales.ch@nordsondage.com

Germany

+49 89 2000 338 270
sales.de@nordsondage.com

Japan

+81 120 537 555
sales.jp@nordsondage.com

Korea

+82 31 462 9642
korea.at.cs@nordson.com

South East Asia

+65 6552 7533
sales.sg@nordsondage.com

Taiwan

+886 2 2902 1860
globalsales@nordsondage.com

United Kingdom

+44 1296 317800
globalsales@nordsondage.com