

APPLICATION NOTE

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USING THE NANO VISION™ OPTION TO DETERMINE FRACTURE TOUGHNESS

APPLICATION

INTRODUCTION

Determining the mechanical properties of thin films and small volumes is important to the many fields of science and technology. MTS Nano Instruments has provided equipment for nanomechanical testing for years, but a new instrument option was recently developed to increase the measurement capabilities of these instruments. With the addition of NANO **Vision™**, a quantitative imaging package, the fracture toughness of thin films and small volumes can accurately be determined without involving subsequent microscopy after indentation.

EXPERIMENTAL PROCEDURE: INDENT & SCAN

To create an indent in fused silica, a cube-corner indenter tip was used in the **XP** head of a nanoindentation system. An Indent and Scan Displacement Limit method was also used, which allows the user to specify a specific indent depth, scan length factor, and the number of indent-scan cycles to be performed. The system runs the entire series of indents and scans automatically, and high-precision capacitive feedback stages allow the exact location of an indent to be pinpointed, indent after indent. Here, an indent depth of 1200 nm was selected along with a scan length factor of 20 to make the size of the scan 24 x 24 μm . Immediately following the indent, the sample was scanned while applying a very small load to the tip to keep the indenter in contact with the surface during the entire scan. The image was then examined to determine the length of a crack propagating from the corners of the indent. A simple calculation was performed and the fracture toughness of the fused silica was determined.

RESULTS

All of the results shown are straight from the **TestWorks®** review page. **Figure 1** is the scanned image of the indent, rendered as lights to more easily see the cracks.

Figure 2 is identical to **Figure 1** except only certain heights on the scanned image are shown to accentuate the cracks coming from the corners of the indent.

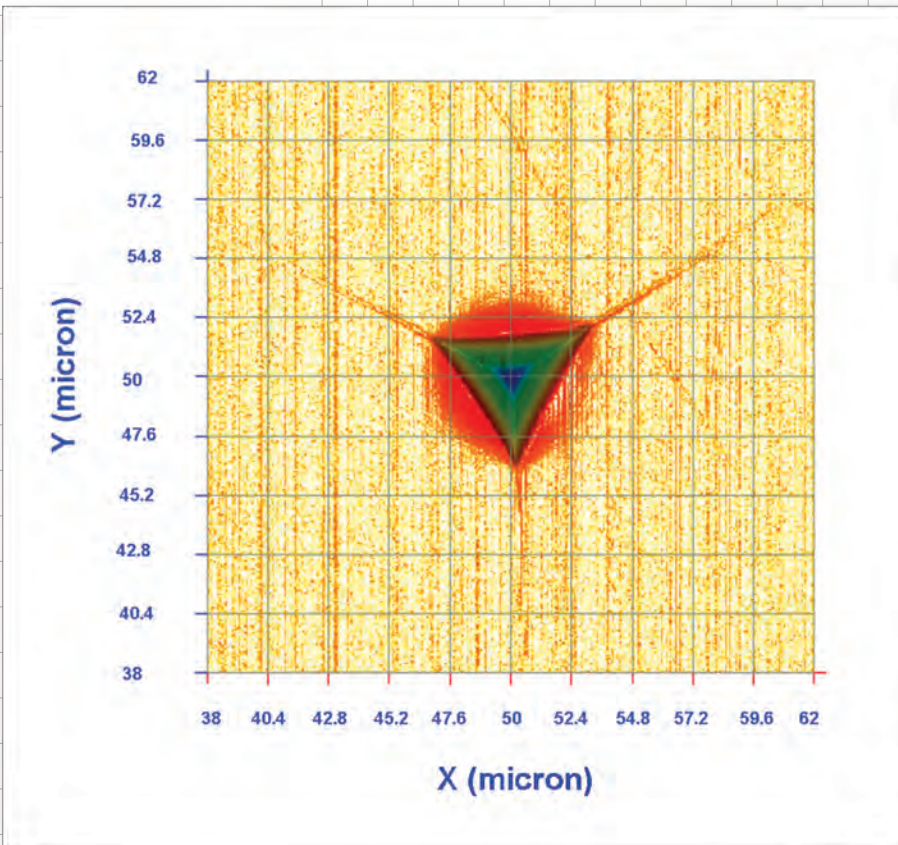


Figure 1: A 24 X 24 μm scan of a 1200 nm deep indent in silica

RELATED PRODUCTS:



This is a **TestWorks** feature and it allows the user to specify what range of heights should be viewable.

The geometry of the indenter is taken into account with an empirical constant, α ; and for a cube-corner indenter, $\alpha = 0.032$. The values of elastic modulus, E, and hardness, H, can be obtained with the same indentation system by indenting the sample with a Berkovich tip prior to beginning the Indent and Scan Method to

Figure 3 is an enlarged version of figure 2 enabling the user to more easily see the crack and measure the crack length. The ability to zoom in on the scanned image is another feature in **TestWorks**.

CONCLUSION

The crack length, denoted in Figure 3 by "c", can be determined from Pythagorean's Theorem. The lengths of the perpendicular legs of the triangle can be closely estimated from the grid lines, thus allowing the length of the hypotenuse, or crack length, to be determined. Once the crack length is known, the following empirical formula can be applied to calculate the fracture toughness, K_c , of fused silica [1].

$$K_c = \alpha \left(\frac{E}{H} \right)^{\frac{1}{2}} \left(\frac{P}{c^2} \right)$$

determine fracture toughness. The applied load, P, is read straight from the **TestWorks** review page. From the indents and scans performed for this experiment, the fracture toughness of fused silica is calculated to be ~0.67 MPa√m, which is only slightly higher than reported values. However, this is a nice estimate especially considering the ease in which the measurement was obtained.

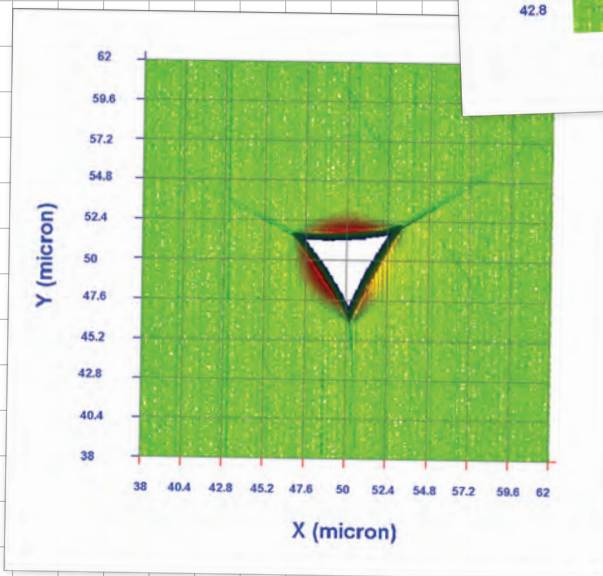
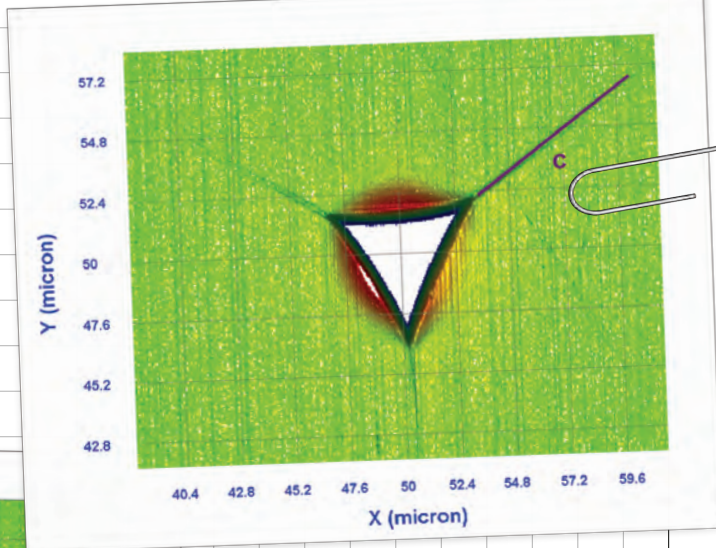


figure 2 (left): Same image as Figure 1 with the crack features accentuated
figure 3 (above): An enlarged image of the indent taken straight from the TestWorks review page

Without the use of the **NANO Vision** Indent and Scan capabilities, the sample would have to be indented, removed, and taken to a separate microscopy instrument in order to do the same measurement.

NOTES

[1] Pharr, G.M., Harding, D.S., and Oliver, W.C., (1993) Measurement of fracture toughness in thin films and small volumes using nanoindentation methods, *Mechanical Properties and Deformation Behavior of Materials Having Ultra-Fine Microstructures*, 449-461.



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Inspired science.

Characterizing surfaces down to the level of a few nanometers has become increasingly important for a wide range of manufacturers and researchers. Properties at the nano scale can affect the performance of a variety of scientific and consumer products. **NANO Indenter** systems from **MTS NANO INSTRUMENTS** use the most advanced technology available to acquire fast, accurate mechanical data on a variety of surfaces at the submicron scale.