NANOVEA
A Better Measure.

INDENTATION HARDNESS
OF BULK MATERIALS

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INTRODUCTION:

The basic goal of hardness testing is to quantifiably measure the resistance of a material to plastic deformation. Hardness values offer a comparative measure of a material's resistance to plastically deform since different hardness techniques have different scales. The Vickers hardness test is a commonly used test due to its wide load range capability. In indentation, the hardness number is based on measurements made of the indent formed in the surface of the test specimen. Vickers hardness (HV) is calculated with an equation, where load (L) is in grams force and the mean of two diagonals created by the pyramidal indent (d) is in millimeters: A major benefit to using instrumented indentation over other methods is the amount of information that can be obtained through instrumented indentation. In addition to the basic hardness results given by all hardness testers, instrumented indentation can provide maximum depth, creep, and Young's Modulus to further assist in characterizing a material.

TEST METHOD:

The micro hardness test is based on the standards for instrumented indentation, ASTM E2546 and ISO 14577. It uses an established method where an indenter tip with a known geometry is driven into a specific site of the material to be tested, by applying an increasing normal load. When reaching a pre-set maximum value, the normal load is reduced until partial or complete relaxation occurs. This procedure is performed repetitively; at each stage of the experiment the position of the indenter relative to the sample surface is precisely monitored with an optical non-contact depth sensor.

For each indentation, the applied load value is plotted with respect to the corresponding position of the indenter. The resulting load/displacement curves provide data specific to the mechanical nature of the material under examination. Established models are used to calculate quantitative hardness and modulus values for such data.

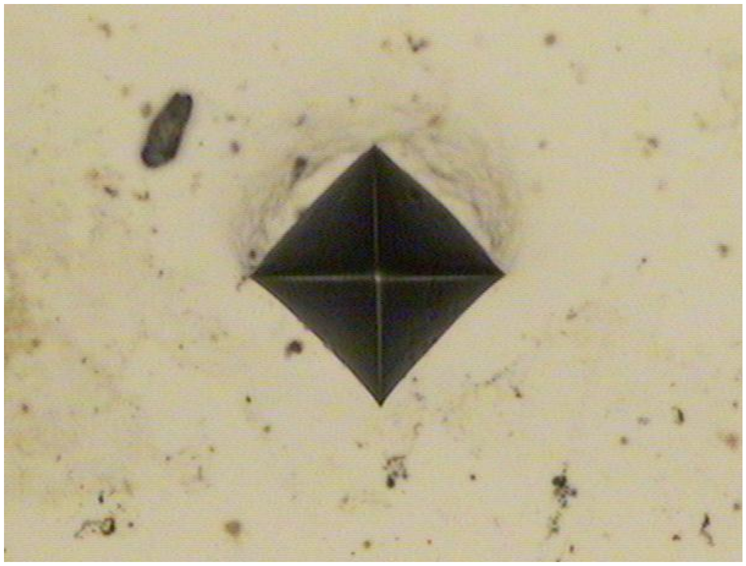
TEST PARAMETERS:

For this application, the test parameters used are the following:

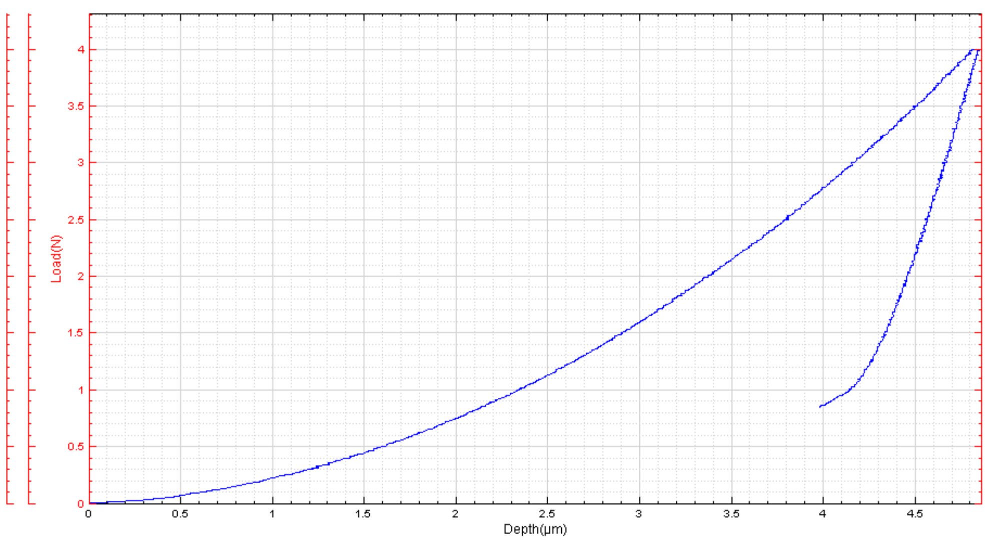
Maximum Load	4 N
Loading Rate	8N/min
Unloading Rate	8 N/min
Pause at Maximum	0 seconds
Contact Load	30 mN
Indenter Type	Vickers Diamond
Computation Method	Oliver & Pharr

TEST RESULTS:

In the following section the data gathered during the test is presented. This includes micrographs of the indentations, the graphs of load vs. depth, and the values of hardness and Young's modulus obtained.



The micrograph of the indent can help determine if the indent made was clean, but it also can provide insight into the type of material deformation taking place. In this case, the rippling along the sides of the indent suggests there is a significant amount of plastic deformation occurring and that the material has some degree of elasticity. On the other hand, if the cracking is visible, it is likely that the material is more brittle. While this information is helpful to a degree, deformation of material surrounding the indent will contribute slight errors in the measurement.

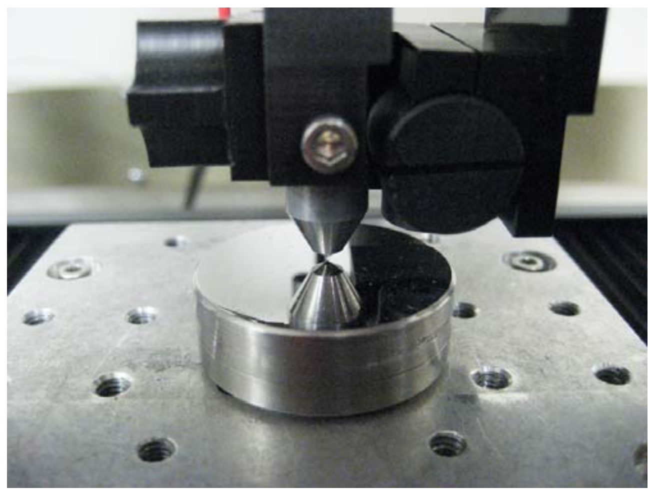


The graph of the load vs. depth curve shows how the material reacts as a load in progressively applied to reach a specified maximum, and how it reacts during the unloading.

	Hv [Vickers]	H [GPa]	E [GPa]	Max Depth [µm]
1	783.80	8.295	237.95	4.99
2	805.31	8.522	228.27	4.96
3	799.13	8.457	219.84	4.99
4	835.31	8.840	250.66	4.85
5	809.15	8.572	233.14	4.95
Average	**806.54**	**8.537**	**233.972**	**4.95**
Standard deviation	**18.76**	**0.199**	**11.481**	**0.06**

The results table above shows the data obtained from 5 indentations. Each indentation can provide hardness values, Young's modulus, and depth measurements. Natural variations occur during indentation testing, so the average and standard deviation of these values is included.

DISCUSSION:



Instrumented indentation enables a user to gain a broader perspective on the material properties of a sample. Rather than settling for a simple hardness reading, the Nanovea Hardness Tester can provide a wider range of data, including creep, depth, and Young's modulus. In addition to testing bulk materials, indentation also plays a vital role in characterizing coatings. The ability to control the specific load being applied allows for testing to be done on very thin coatings to bulk materials. The use of Vickers hardness in Nanovea Hardness Testers enables a broader variety of materials to be tested at the broadest range of loads.

CONCLUSION:

In conclusion, the Nanovea Mechanical Testers are able to produce indentations in a controlled and closely monitored fashion in order to measure hardness to use as a quantitative value for comparing a variety of samples. This test also shows that it can measure other characteristics, such as Young's modulus and maximum depth.