

Nanomechanics, Inc.  
NanoBlitz 3D Mechanical Property Mapping User  
Instructions

SKYD-1252-0

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# 1 Introduction – Nanomechanics, Incorporated

## 1.1 A Word About Us

Nanomechanics, Inc. is comprised of scientists and engineers with unparalleled expertise in Materials Science, Precision Mechanical Design, and Advanced Instrumentation Software. Over the last 20 years, our staff has stayed at the forefront of technology focused on nano-scale mechanical testing. We take a comprehensive approach to developing quality solutions for our customers.

We are dedicated to improving technologies in mechanical testing, force and displacement measurements, and evaluating the mechanical performance of materials. We do this through the research and development of test techniques and data management, design and manufacturing, and through our state-of-the-art analytical services laboratory. Our engineers specialize in nanomechanical transducer design, testing techniques, data acquisition, system integration, and software development.

Our principle mission is to enable our customers to evaluate and understand the mechanical performance of their materials on the micro- and nano-scales. With field experts in nanomechanical testing, data acquisition, and system integration, we are well positioned to provide the most accurate results along with leading edge characterization.

## 1.2 Getting More Information About NanoMechanics, Inc. and Our Products

To find out more about NanoMechanics, Inc. and our products, visit the NanoMechanics, Inc. website at <http://www.insem.com/>.

An online [Contact Us form](#) can be obtained at this link – one of our application engineers will contact you regarding your request within 24 hours.

For **direct contact by phone**, call 1-877-386-6262.

Additionally, **you may email us at:** [info@insem.com](mailto:info@insem.com).

**Our mailing address is:**

Nanomechanics, Inc.  
105 Meco Lane, Suite 100  
Oak Ridge, TN 37830

**You can find us on social media at:**

**Facebook:**

<https://www.facebook.com/pages/Nanomechanics-Inc/124992837512793>

**Twitter:**

<https://twitter.com/Nanomechanics>

**LinkedIn:**

<http://www.linkedin.com/company/549484?trk=tyah&trkInfo=tas%3AAnanomechani%2Cidx%3A1-1-1>

**YouTube** – our channel on YouTube is titled **NanoInSEM:**

<http://www.youtube.com/user/NanoInSEM>

## 1.3 Contacting Technical and Sales Support

### 1.3.1 What You Will Need Before You Call

Before calling for technical support, have the following information on hand:

- Machine number
- Description of problem
- Data from Automatic Test Motion
- Method
- Tip or Grip
- Sample Information

Contact our technical support by email at [support@nanomechanicsinc.com](mailto:support@nanomechanicsinc.com), [support@insem.com](mailto:support@insem.com), or by phone at 877-386-6262

### 1.3.2 A Note to Our Overseas Customers

Overseas customers should contact their local representative first.

To access a list of representatives, you may email us at [info@insem.com](mailto:info@insem.com), or go to the [Contact Us](http://www.nanomechanicsinc.com/contact-us) (<http://www.nanomechanicsinc.com/contact-us>) page on our website.

### 1.3.3 Training Classes

Nanomechanics Inc. offers periodic training classes for our products as well as training by request. Basic training is provided when your system is installed. For more information regarding our training services, visit our website training information page:

<http://www.nanomechanicsinc.com/training>

## 2 About NanoBlitz 3D Mechanical Property Mapping

NanoBlitz 3D is a high-speed indentation testing technique that allows for rapid mapping of material properties. NanoBlitz 3D works by applying a specified load on the sample and measuring the resulting indentation depth and contact stiffness. The measured values are then converted to hardness and elastic modulus through the Oliver-Pharr indentation model. On flat surfaces, the indentations are performed in under 1s, and up to 10,000 indentations are possible in a single test. It is important to note that NanoBlitz 3D is not a scanning contact technique. Rather, NanoBlitz 3D executes individual indentation tests, ensuring that the assumptions and mechanics behind the measurements are correct.

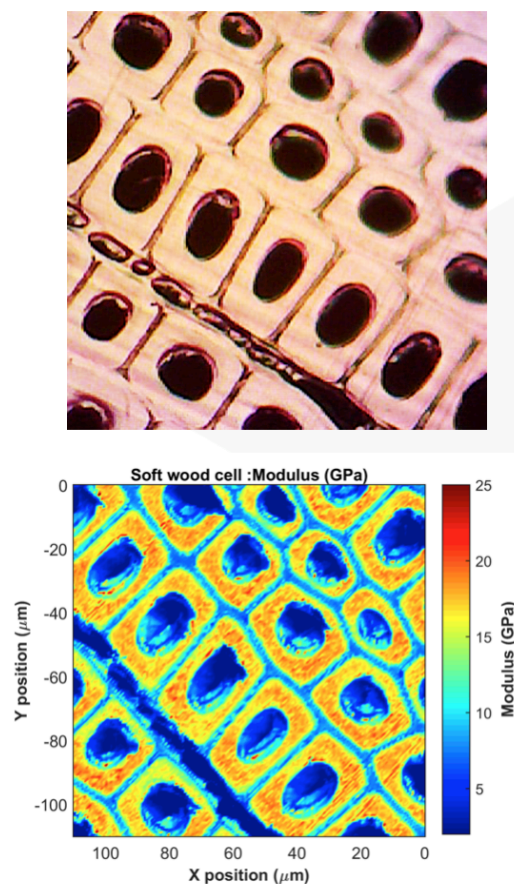


Figure 1 - Examples of NanoBlitz 3D results

### 2.1 Specifications of NanoBlitz 3D

- Materials with modulus greater than 3GPa
- Indent speed <1s
- Up to 10,000 indents (300 x 300 array)
- Minimum indentation spacing (NanoFlip): 200nm
- Minimum indentation spacing (iNano, iMicro): 2μm

## 3 Getting Started with NanoBlitz 3D

### 3.1 Installing NanoBlitz 3D

There are no hardware modifications required for NanoBlitz 3D. The high-speed testing technique is enabled through unique and proprietary methods incorporated into Nanomechanics' InView software and InQuest controller.

If you have purchased an instrument with NanoBlitz 3D, proceed to Section 3.2 of these instructions, as the instrument will be configured with NanoBlitz 3D before it is shipped from Nanomechanics.

NanoBlitz 3D is provided with an installation file and a license key. Shut down any running programs on the CPU of your instrument, including InView and InView Review, and then run the installation file. Follow the directions on the screen and enter the license key when prompted.

### 3.2 Sample Mounting for the iNano and iMicro Systems

NanoBlitz 3D is a high-speed indentation technique. Therefore, smooth, flat specimen will provide the best set of data and fastest results. Nothing special is required beyond the normal indentation specimen mounting procedures. Ensure that specimen are mounted even with the safety posts on the sample tray in the iNano or iMicro and do your best to eliminate any slope in the specimen, using either the "visual method" described in Section 4.2.2 of the iNano or iMicro Operating Instructions, or the "mechanical method" described in Section 4.2.3.



Figure 2 - The iNano Sample Tray

Note that, in the case of rough or sloped surfaces, NanoBlitz 3D will still perform. However, there will be some changes to the default method inputs as described later in these instructions.

### 3.3 Sample Mounting for the NanoFlip System

NanoBlitz 3D is a high-speed indentation technique. Therefore, smooth, flat specimen will provide the best set of data and fastest results. Nothing special is required beyond the normal indentation specimen mounting procedures. Ensure that the specimen size fits within the central area of the NanoFlip specimen mount and do your best to eliminate any slope to the specimen.

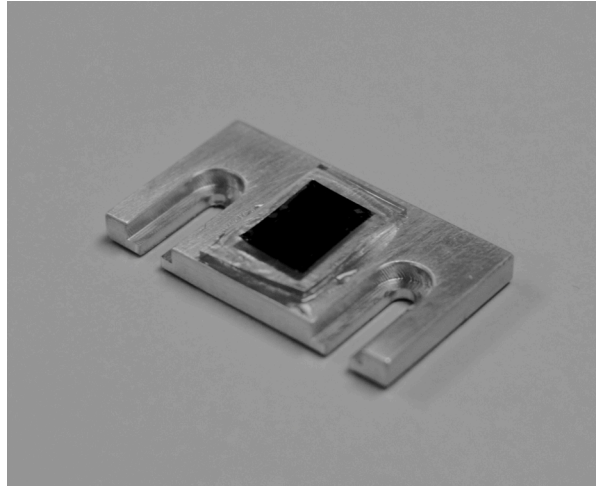


Figure 3 - The NanoFlip Specimen Mount

Note that, in the case of rough or sloped surfaces, NanoBlitz 3D will still perform. However, there will be some changes to the default method inputs as described later in these instructions.

## 4 Starting a Test Using NanoBlitz 3D

### 4.2 Loading NanoBlitz 3D in InView

Once the software has been installed and the specimen have been mounted, NanoBlitz 3D is operating just like the standard test methods available on your system. Simply open the NanoBlitz 3D method file in InView.

From the Top Bar icon, select Test Method > Open.

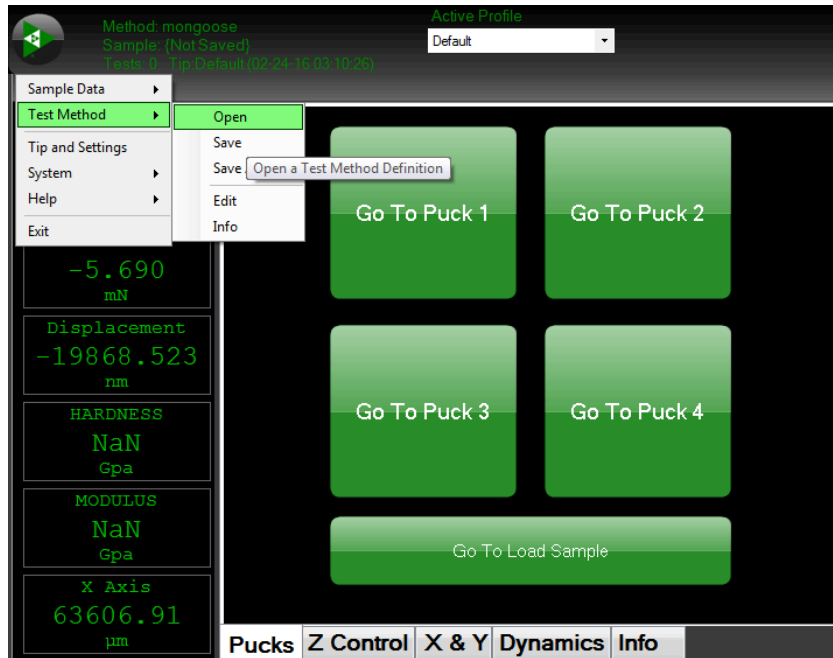


Figure 4 - Opening the NanoBlitz Method

By default, the software should navigate to the Methods folder. In this example, there is a Profile called “Default”, and the NanoBlitz method is located in the Methods folder under this profile. If you have switched to a new profile, you should be able to locate the NanoBlitz method under the new profile. The file path in this example is:

Users/Public/Public Documents/Nanomechanics/Profiles/Default/Methods

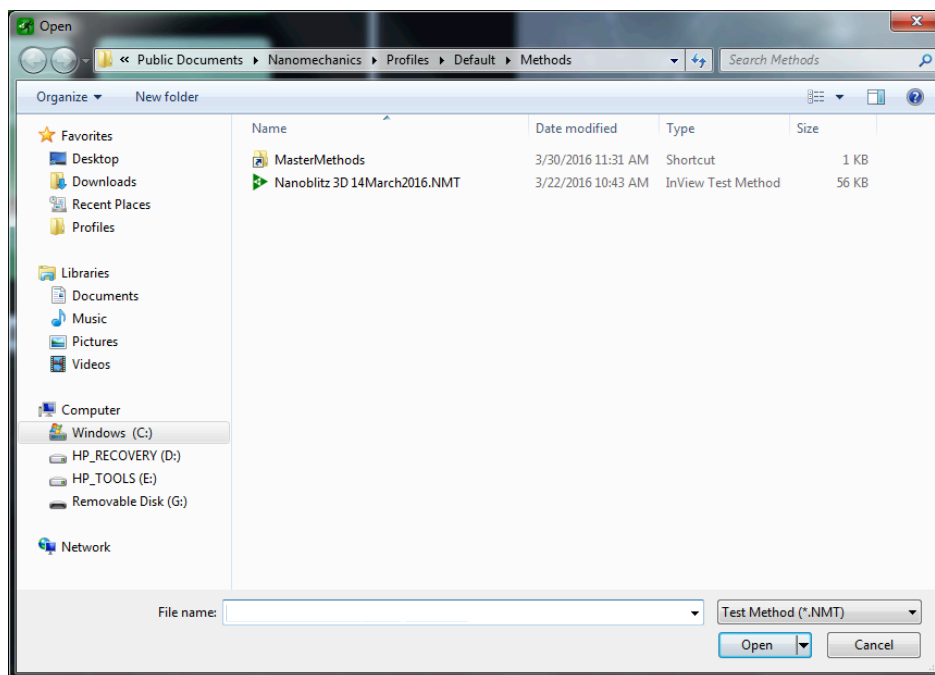


Figure 5 - Selecting the NanoBlitz Method

Select the NanoBlitz 3D Method (in this example, it is named Nanoblitz 3D 14March2016.NMT)

### 4.3 Creating a New Sample

Project and Sample creation can be found on the right-hand side of InView. Ensure that you are operating in MultiSample Mode (see the iNano User Manual Section 6.3.7). Enter a new project name or select an existing name from the dropdown list and click the (+) button to create a new sample within that project directory.

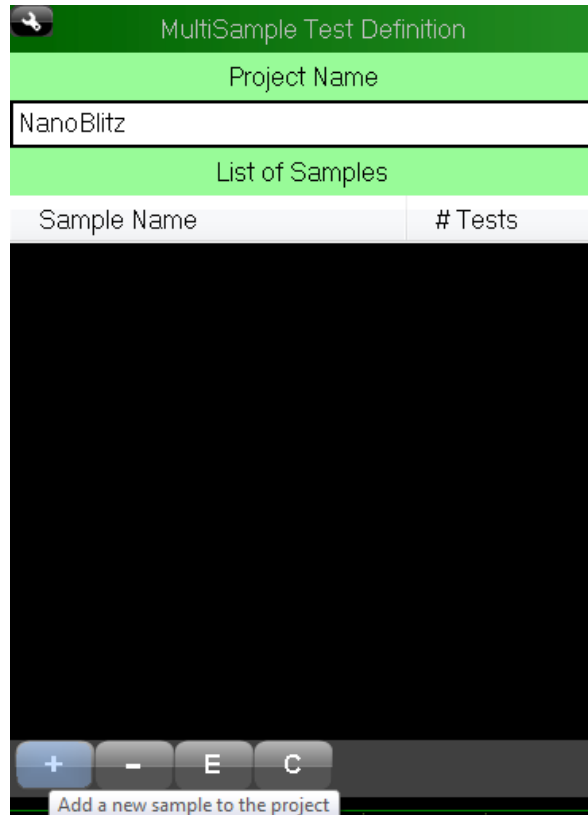


Figure 6 - Entering the Project Name

Give the sample a name, and ensure that the correct method is loaded (Nanoblitz 3D 14March2016, in this example).

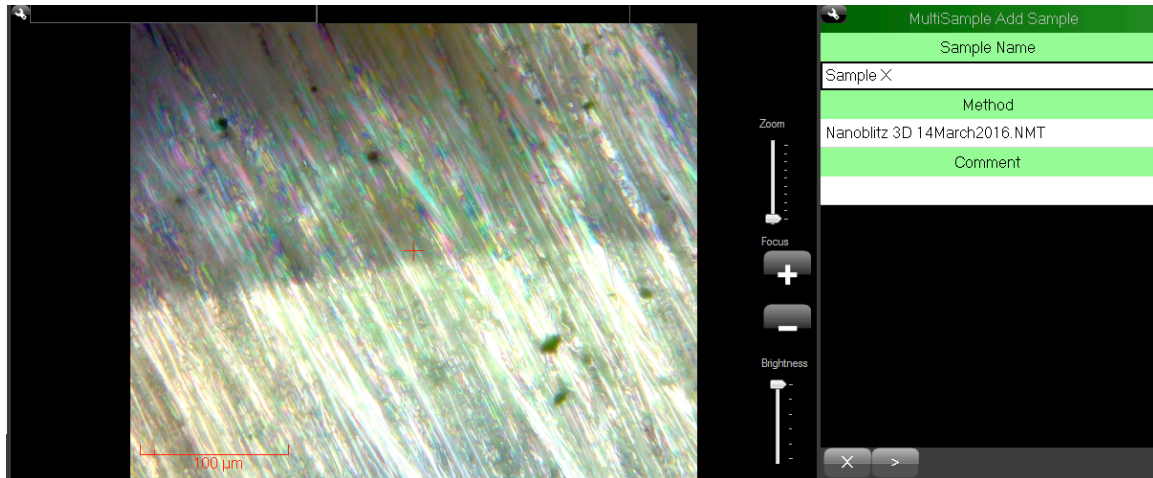


Figure 7 - Naming the Sample

Once you have given the sample a name, click on the (>) button, and the following list of user inputs will appear:

#### 4.4 NanoBlitz 3D User Inputs

The following user inputs can be changed prior to the test:

**Poisson's Ratio of Sample:** The Poisson's ratio used in the Oliver-Pharr calculations of elastic modulus and hardness. This value can be changed post-test in the review software.

**Target Load:** The maximum load applied in the test. This load will be applied to the first indent in the NanoBlitz array. Successive indentation loads in the array will depend on the "Decrement Factor" as described in the user inputs (minimum value: 50  $\mu$ N).

**X Length:** The dimensional size of the array in the x-direction (minimum value: 10  $\mu$ m).

**X Points:** The number of indents in the x-direction, i.e., the number of columns in the NanoBlitz array (minimum value: 10 points).

**Y Length:** The dimensional size of the array in the y-direction (minimum value: 10  $\mu$ m).

**Y Points:** The number of indents in the y-direction, i.e., the number of columns in the NanoBlitz array (minimum value: 10 points).

**Feature Height:** An additional distance that the indenter will pick-up before each indentation in the array. This is useful for rougher samples or sample with known features on the surface (minimum value: 0).

Load Decrement: The first indent in the NanoBlitz array will have a load of “Target Load.” The load of each successive indent will be modified by the Load Decrement. For example, for a Target Load of 1.0mN and a Load Decrement of 0.9, the first indent will be 1.0mN, the second indent will be 0.9mN, the third indent will be 0.81mN, etc. (maximum value: 1).

#### 4.5 Considerations Regarding Indentation Spacing

The “resolution” of a NanoBlitz array is based on the size of the array and the number of indentations. The more indentations are present for a given size array, the better the resolution. Finer details can become visible that would otherwise be obscured by the linear interpolation between indentation points.

#### **INSERT IMAGE SHOWING A HIGH VS LOW RESOLUTION IMAGE FROM NANOBLITZ 3D**

There is a practical limit to indentation spacing, however, which is based on ensuring that an indentation is not placed within the plastic-affected zone of a neighboring indentation. For a Berkovich indenter, the diameter of contact is approximately seven (7) times the depth of the indentation. A good rule of thumb is to space the indentations by a multiple of three (3) times the diameter of contact. For example, for an indentation depth of 1 $\mu$ m, the diameter of contact would be approximately 7 $\mu$ m, and the recommended indentation spacing would be 21 $\mu$ m. For an indentation depth of 100nm, the diameter of contact would be approximately 700nm, and the recommended spacing would be 2.1 $\mu$ m.

#### **INSERT FIGURE GRAPHICALLY DEMONSTRATING THIS CONCEPT**

For some materials, the plastic-affected zone at peak-load may not be a concern, but it is generally desirable to avoid a case in which subsequent indentations overlap the residual (plastic) indentation itself. In such cases, the residual depth of the indentation can be used, rather than the peak depth, to determine the proper spacing. For example, a peak indentation depth of 1 $\mu$ m may only leave an indentation of 100nm residual depth. If the plastic-affected zone at peak load is not of concern, then indentations can be placed at a spacing of 2.1 $\mu$ m rather than the 21 $\mu$ m proscribed by the peak load.

#### **INSERT FIGURE GRAPHICALLY DEMONSTRATING THIS CONCEPT**

This spacing could be further reduced if the factor of safety in the “three times the contact diameter” rule of thumb is compromised, but, for this example, reducing the spacing to less than 700nm would result in overlap of the residual indentation impression.

#### **INSERT IMAGE OF OVERLAPPED INDENTATIONS**

As the NanoBlitz 3D method is a load-limited method (that is, a Target Load is specified rather than a Target Depth), planning your NanoBlitz 3D array requires some knowledge of the expected depth of penetration for a given load.

Fortunately, the NanoBlitz 3D arrays are generated so quickly that a trial array can be very useful in setting up the experiment. The data from a trial array can be used to determine the peak and residual depth of the indentation. Using the rules of thumb described above will then suggest an appropriate indentation spacing.

Further, a trial array can help determine if indentations are spaced too closely, by examining the evolution of measured properties as a function of indentation spacing. If the first indentation in an array has significantly different results from subsequent indentations, you may consider increasing the spacing to see if the properties become more uniform with a larger separation.

Finally, it should be noted that there is a minimum recommended indentation spacing, based on the performance of the motion systems in the instrument. For the iNano and iMicro systems, the minimum indentation spacing is 250 nm with a recommended Target Load of 0.05 mN. For the NanoFlip system, there is no recommended minimum indentation spacing, as the resolution of the NanoFlip X-Y motion system (1 nm) is below the realistic separation of indents (a 135 picometer indentation would have a contact diameter of 1 nm).

#### 4.6 Order of Indentation

It is important to understand how the NanoBlitz array is arranged relative to the selected location for the start of the array. The start location of the array, selected by the crosshairs on the Video Pane, will be the lower left corner of the array. However, the first indentation is actually placed at the top left corner of the array. Figure XXXX shows the order of indentations in the array.

**INSERT IMAGE OF INDENTATIONS WITH ARROWS SHOWING THE ORDER**

#### 4.7 Performing the Tests

Having defined the user inputs, navigate to a position on the specimen that you wish to test. Left-click the (+) button to add a NanoBlitz array at the position of the cross-hair. Note: only the position of the bottom-left of the NanoBlitz array is shown.

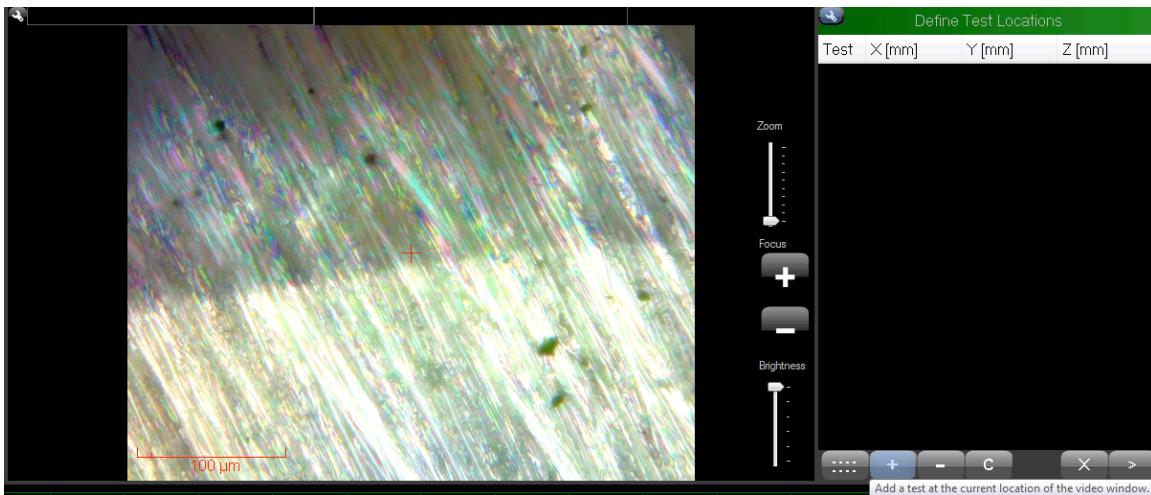


Figure 8 - Navigating to the Test Area

Finish the sample definition and click on the (>) button. You are now ready to start the NanoBlitz test. Press the green “Run” button to begin.



Figure 9 - Finishing the Sample Definition

The length of the test depends on the number of indentations being performed (the size of the array). Once the array is complete, the data becomes available in the InView Review program.

## 5 Reviewing NanoBlitz 3D Data

### 5.2 Understanding the InView Review Program Screen

When NanoBlitz 3D data is displayed in the InView Review Program screen, each of the window panes on the screen can be changed and moved according to user preferences, as described in Section 6.4 of your system’s Operating Instructions.

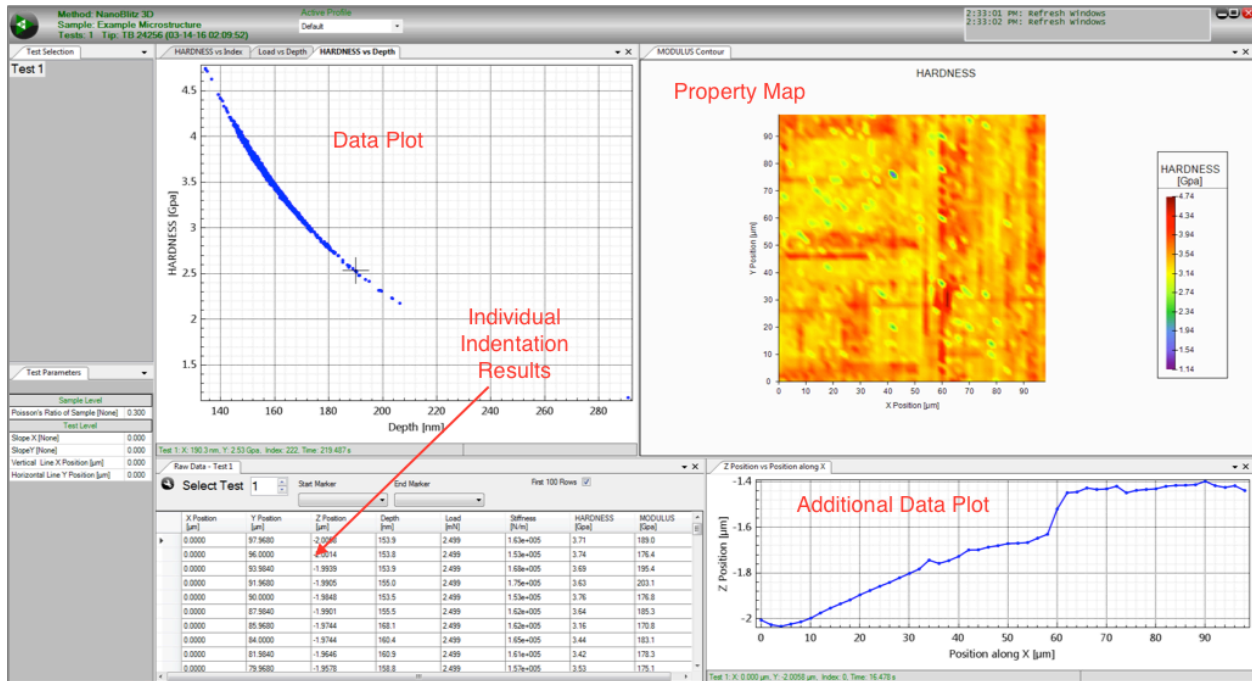


Figure 10 - Features of the InView Review Program screen

### 5.3 Property Maps

Right-clicking on the center of the Property Map allows for plotting any channel data collected over the course of the test as a function of X Position and Y Position.

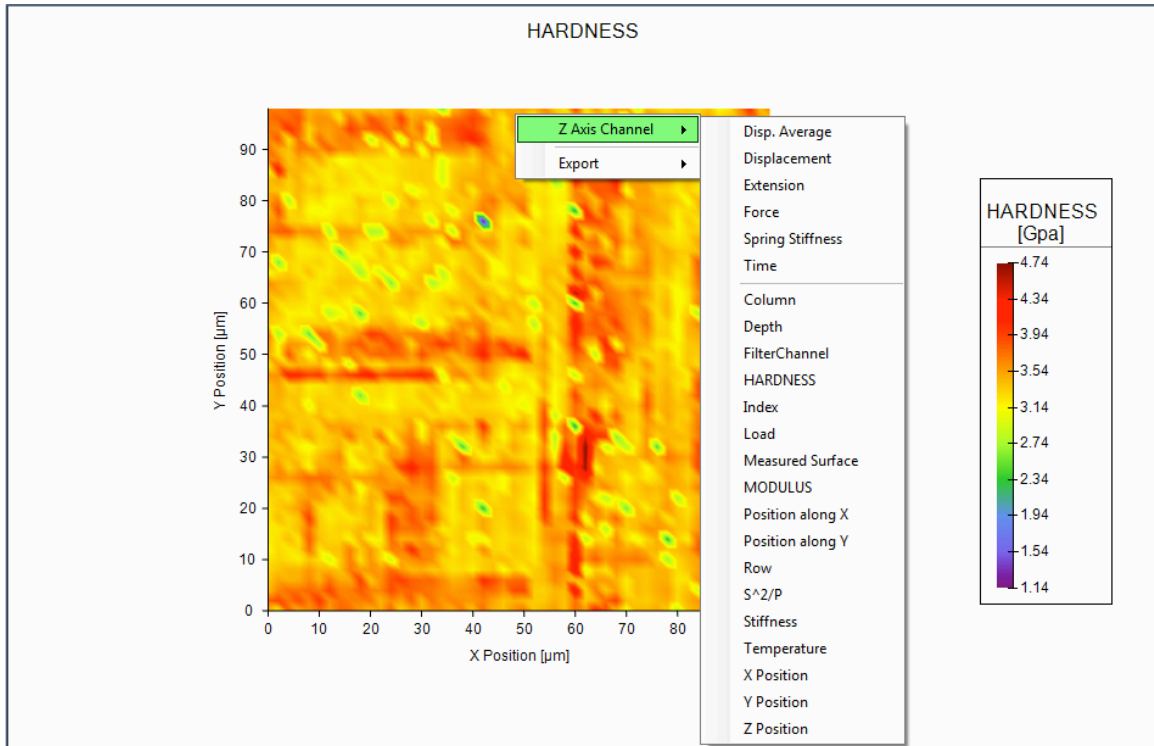


Figure 11 - The Right-Click menu on the Property Map

Property Maps are linearly autoscaled to the minimum and maximum data points within a channel. The plot is filled-in through linear interpolation of the data.

The channel data can always be exported to a Microsoft Excel file or a .csv file for plotting in your preferred program. To export the data, right-click on the Map and select “Export” from the menu.

#### 5.4 Filtering the Data

As with any indentation test, surface imperfections can give rise to spurious data. This can especially be observed over the course of thousands of indentations. Note on the Property Map and the data plot in this example, that there are a few outlying data points. InView Review gives you the opportunity to filter these data points from the results.

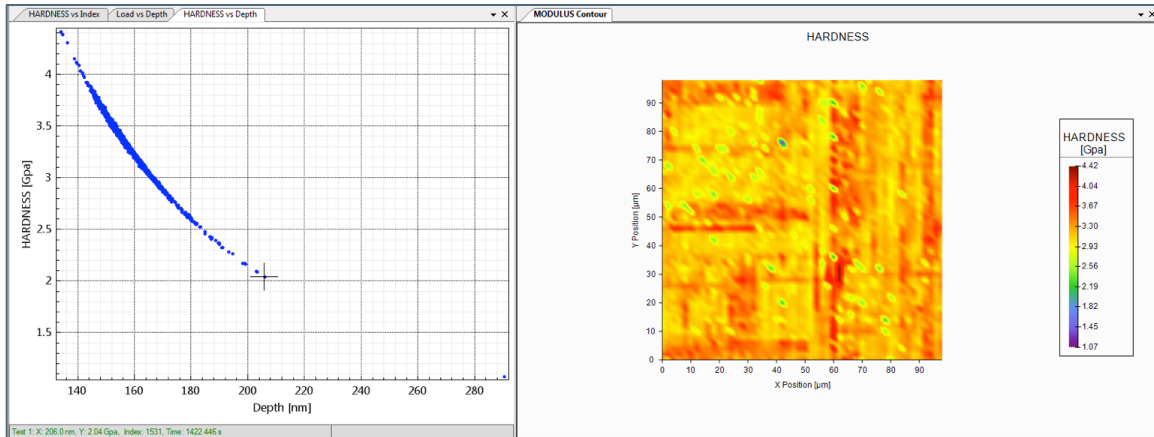


Figure 12 - Outlying data points on the Property Map

Simply highlight a set of data on any data plot to keep or remove the selected data. Right-click on the graph to Filter the data. The results will be recalculated automatically.

The Filter Data function eliminates all results associated with a filtered datapoint. For example, the points removed in the previous slide have also been removed in the modulus property map shown in Figure 13.

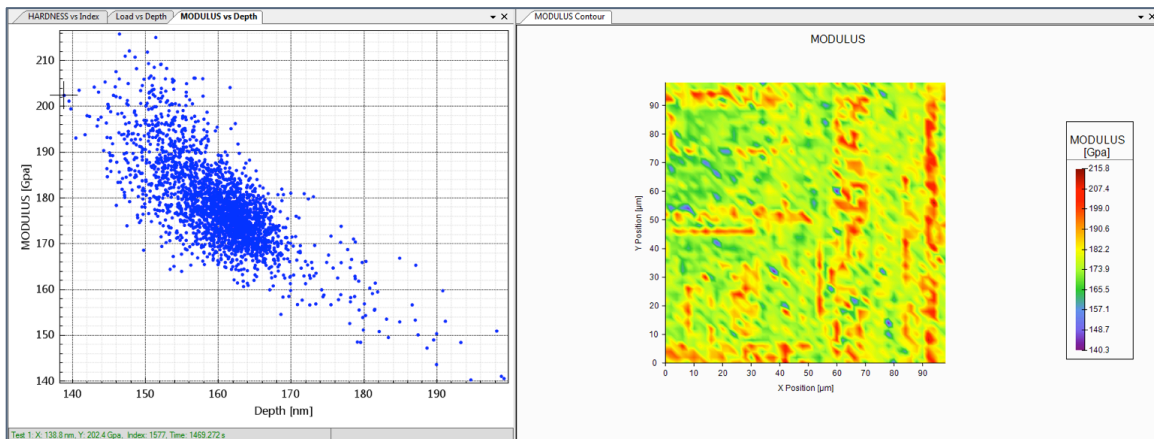


Figure 13 - A Filtered Property Map

The Filter can be reset at any point of the data analysis. The filtered data is not permanently deleted. Note that the Property Map always uses linear interpolation to fill the map, even when a data point has been filtered from the Map. It is recommended that you export the data to your preferred graphing program for advanced analyses.

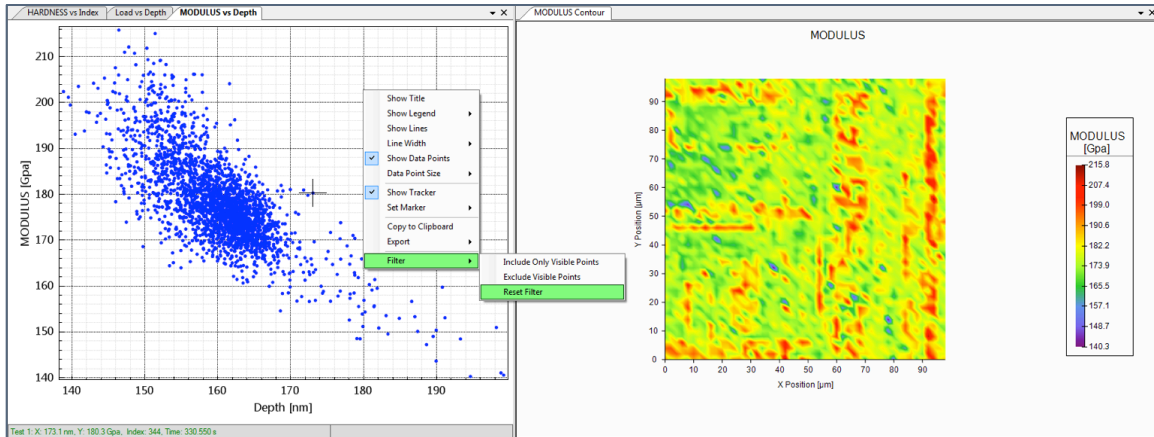


Figure 14 - Resetting the Filter

### 5.5 Topographical Functions

InView Review includes very simple functionality for looking at the topography of a surface. For example, you can remove the slope of a surface. The plot shown below is the Z-position (the surface position) as a function of the X-position. The slope in the plot is the Slope X of the sample surface

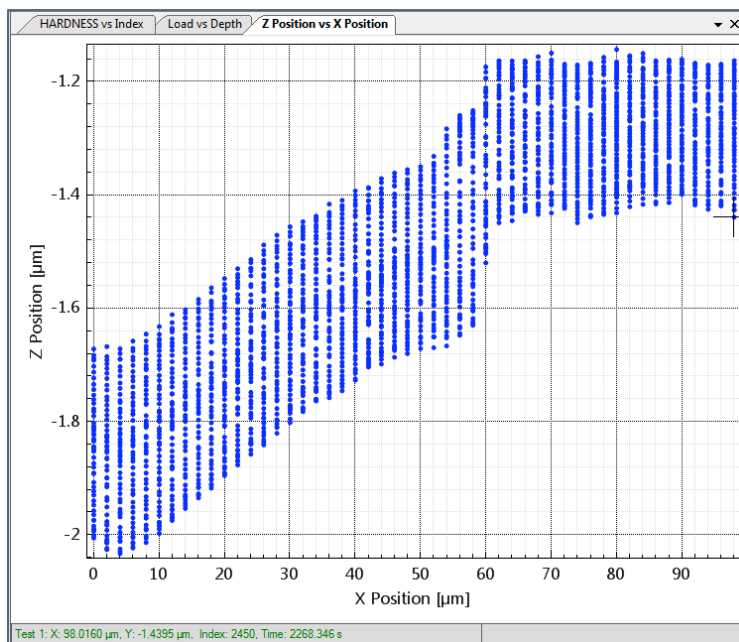


Figure 15 - An example of a surface slope

The user can input a Slope X into the Test Level Inputs in the InView Review Program to remove the slope observed in the X direction.

Sample Level	
Poisson's Ratio of Sample [None]	0.300
Test Level	
Slope X [None]	-0.007
Slope Y [None]	0.000
Vertical Line X Position [ $\mu\text{m}$ ]	0.000
Horizontal Line Y Position [ $\mu\text{m}$ ]	0.000

Figure 16 - Changing the Slope X value

Recall, after any changes to inputs, you must recalculate the sample for the changes to take effect

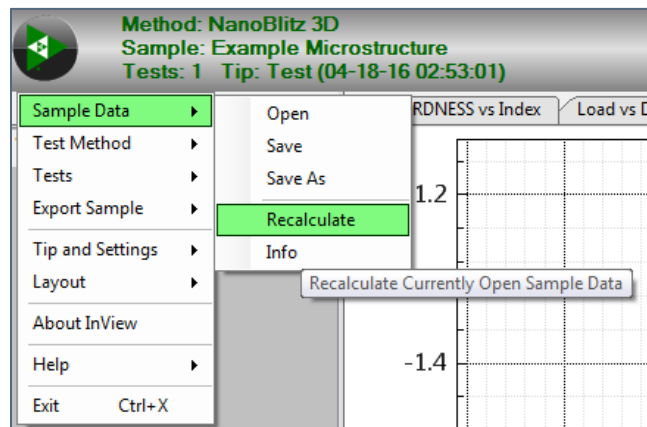


Figure 17 - Recalculate Sample

The plot of Z-position vs. X-position has now been updated and flattened. Be careful when correcting topography. Not all surface height changes can be associated with specimen tilt or slope.

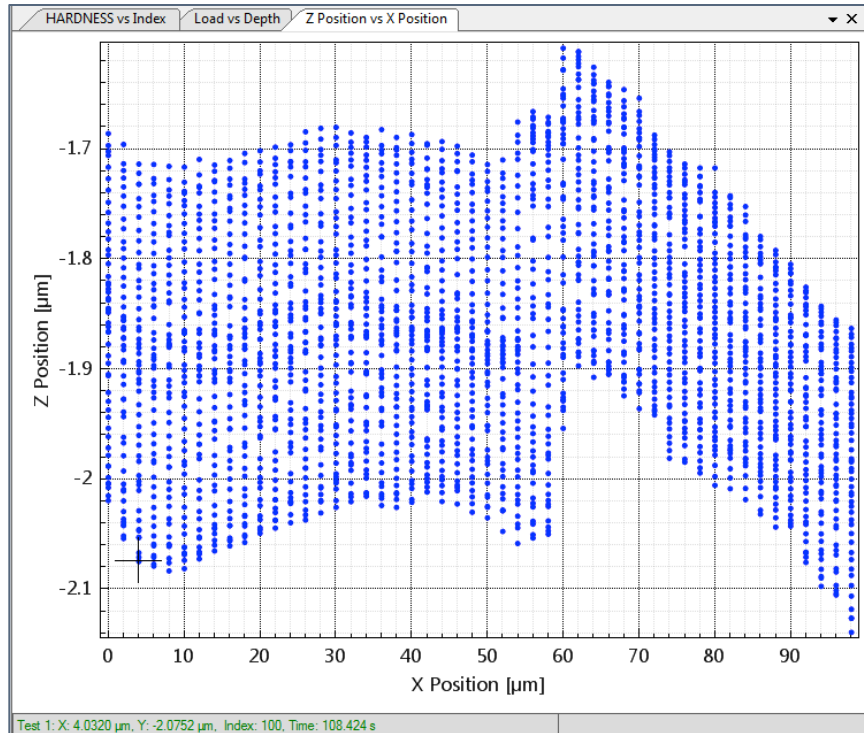


Figure 18 - A slope-corrected plot

Similarly, the slope in the Y direction can be eliminated by plotting Z-position as a function of Y-position and changing the Slope Y Test Input.

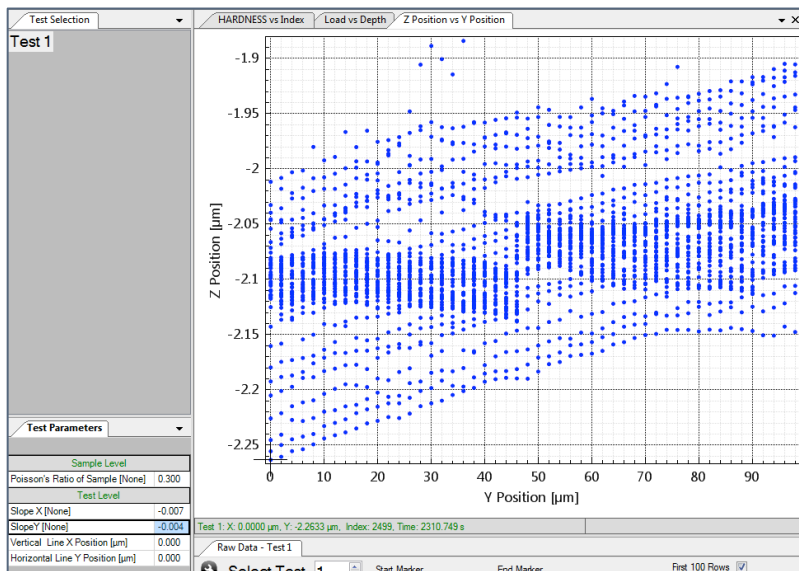


Figure 19 - Y-position slope

Plotting Z-position vs. “Position along X” or “Position along Y” gives line profiles of surface height. The line positions can be changed in the Test Level Inputs as shown in the bottom left of Figure XXXX.

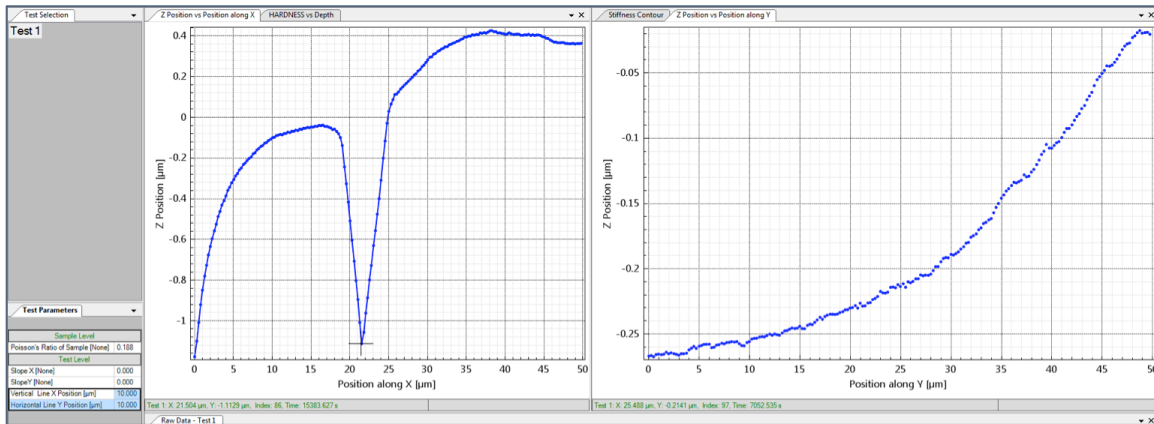


Figure 20 - Line profiles of the surface

## 5.6 Histograms

Histograms of indentation results can be plotted by adding a New Histogram of Channel Data layout.

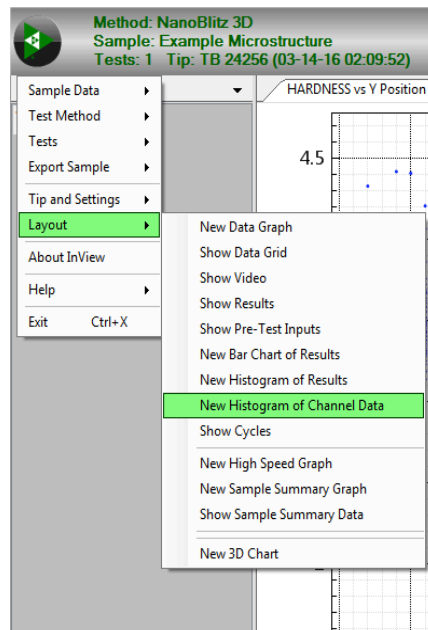


Figure 21 - Plotting a Histogram

Histograms are also affected by filtering.

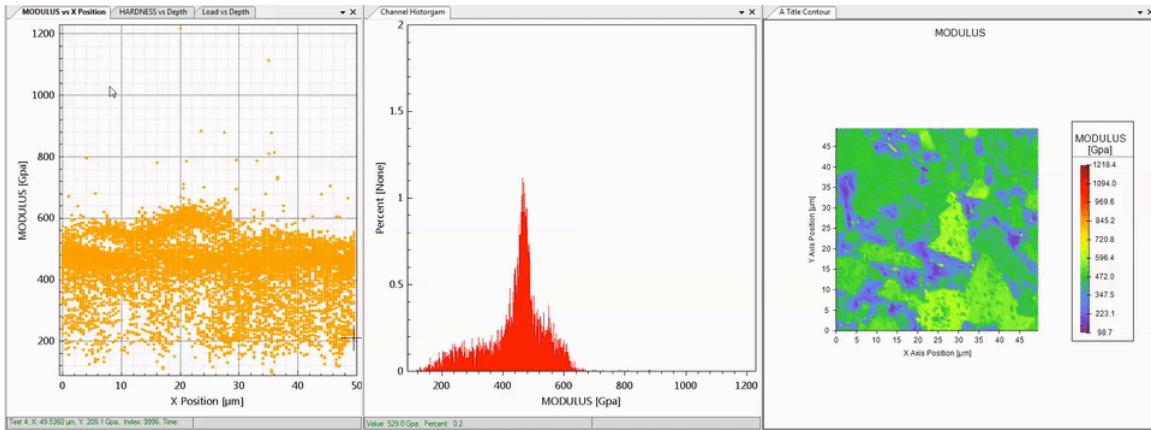


Figure 22 - Example of a histogram

## 6 Summary

NanoBlitz 3D is designed to generate precise and accurate high-speed indentation results. The statistical aspect of high-speed testing provides unique insight into the properties of surfaces. Our goal at Nanomechanics, Inc. is to provide a simple and user-friendly experience while maintaining a commitment to the quality of every single data point in the indentation process.

Don't hesitate to contact Nanomechanics with any questions.