The TestWorks Software and The Nanoindenter XP:
Ideal for MEMS Testing

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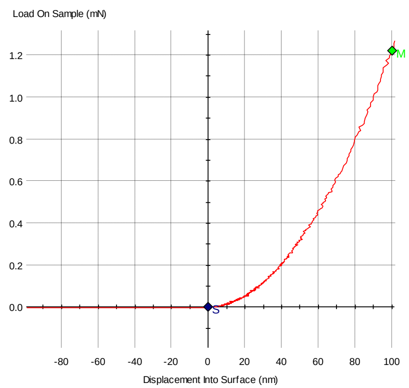
Control and Measure in TestWorks

- The control of any experiment can be based on:
  - Basic channels (load, displacement, stiffness, time)
  - Calculated channels (strain rate, contact area…)
- The measurements are done continuously
  - “REAL TIME” data during the test
  - All measurements (including approach data) are available during review of the results after the test
- Possibility to create new calculations after the test and get the results (no need to run another test)
- Flexibility is the key

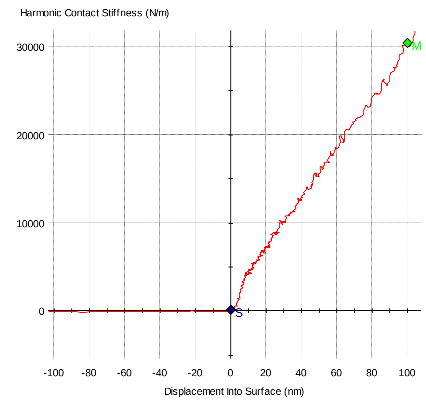
Flexibility: The Surface Find

- **If the user wants to manually choose the surface location, TestWorks has the flexibility to make it simple-the system auto recalculates all results upon selection**

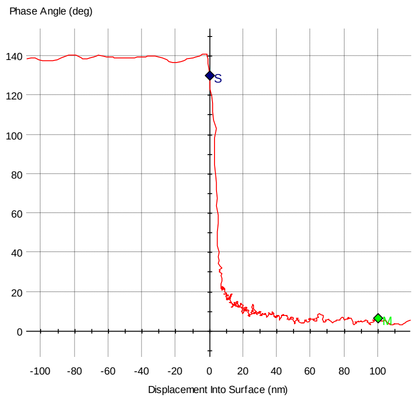
Load vs. Displacement



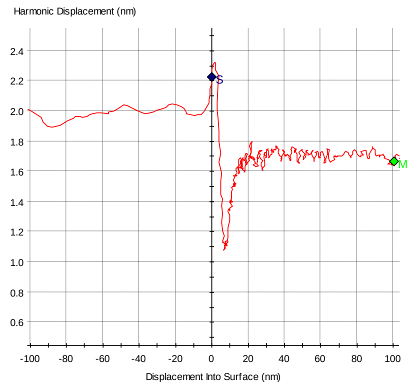
Stiffness vs. Displacement



Phase angle vs. Displacement



Oscillation Amplitude vs. Displacement



TestWorks Explorer

- Gives the user the capability to design their own test methods
- The instrument can be controlled off any desired channel (load, displacement, time, phase angle, harmonic displacement, etc.)
- The open architecture of TestWorks Explorer is a user interface. One does not have to have knowledge of programming (e.g. C++) to learn how to use it

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The Power in the Box

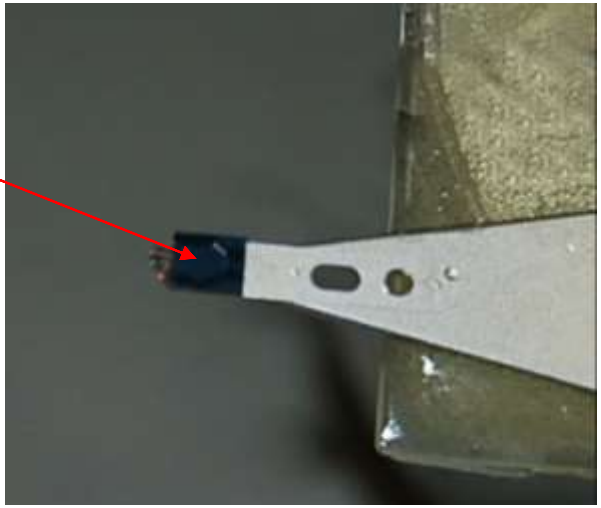
- Easy to use
- Only ONE window open
- Step-by-step interface that makes the test set-up easy
- Control on basic OR calculated channels
- Recording of ALL the channels (but only the data you want)
- Real-time display of the data
- Open architecture of TestWorks Explorer allows user to design new experiments

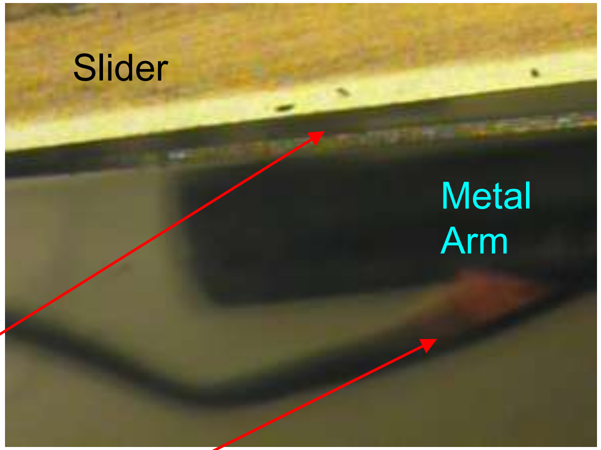
No other commercially available system offers this degree of flexibility and control

Stiffness Profile of a Hard-Disk Read-Head Gimbal Device

Loading Arm with Slider Attached

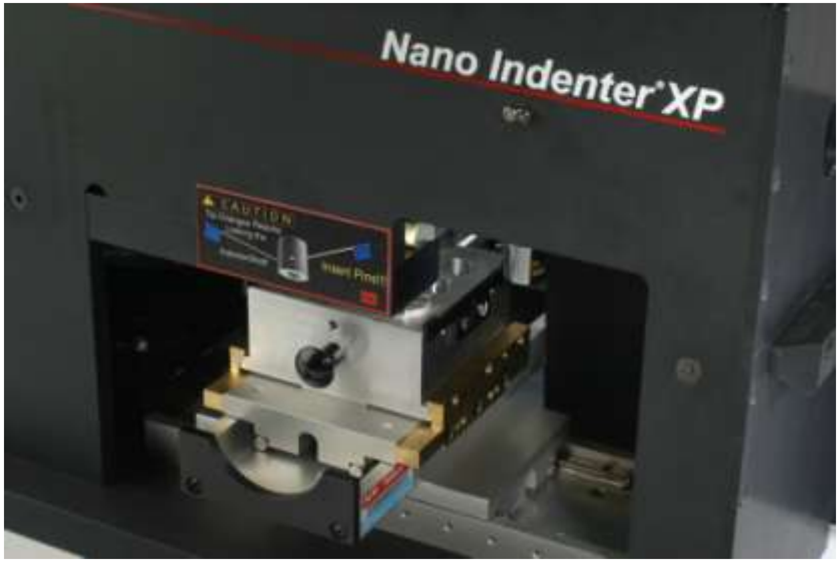
- A slider travels along the disk surface and reads the disk
- The slider is attached to a flexure or “gimbal” that is able to make the small corrections necessary to maintain the slider parallel with the disk surface
- The part is glued down above the loading arm and the HGA (Head Gimbal Assembly) is cantilevered for stiffness profiling. This ensures that only gimbal displacement is measured.





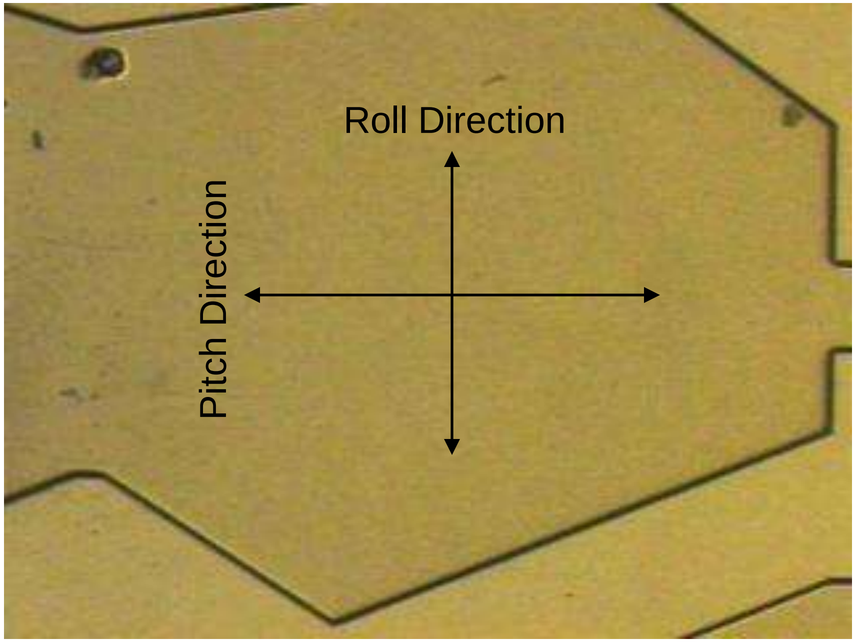
XP Indentation Head Assembly:

- Max Force*: 500 mN
- Max Displacement: 2 mm
- Mass: 11 gm
- Static stiffness: 100 N/m
- Damping: 4-6 Ns/m
- Resonant frequency: 12 Hz



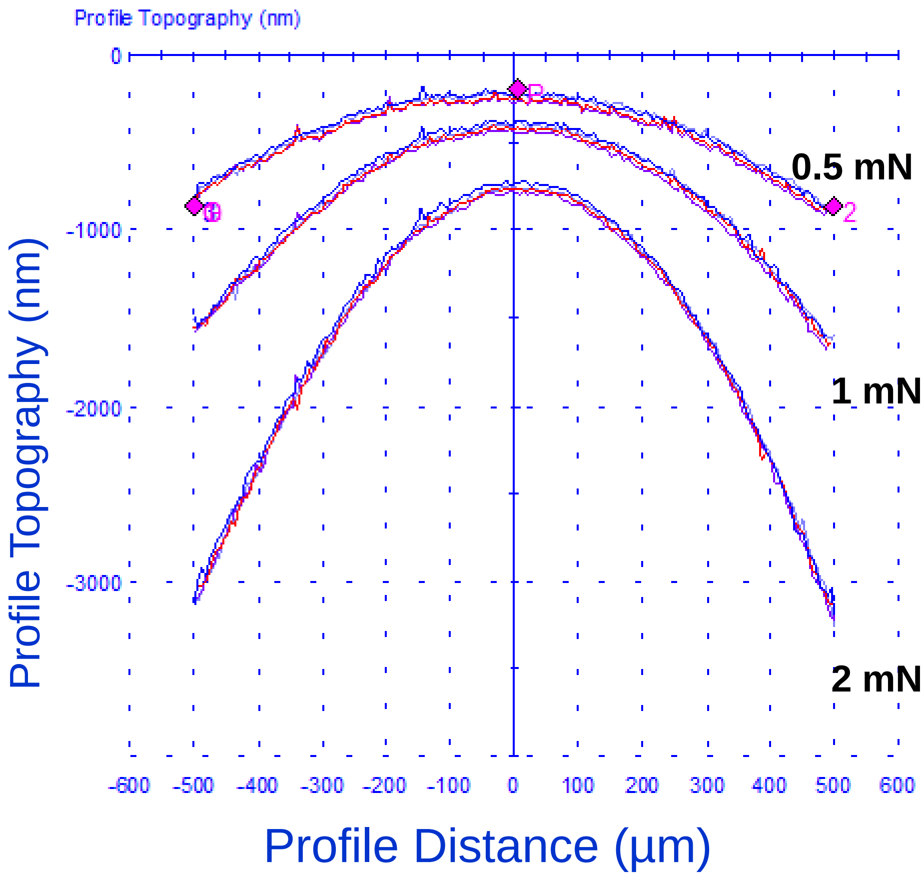
Test Method

- Slider surface is shown to the right
- The arrows designate both the pitch and roll directions for the HGA
- A 90° diamond cone with a 2μm diameter is brought down onto the surface of the slider and a constant load is applied. With this constant load the indenter is traced and re-traced across the part. After each full pass the load is increased and another pass is made. This is done three times for three separate loads of 0.5 mN, 1 mN, and 2 mN, respectively.



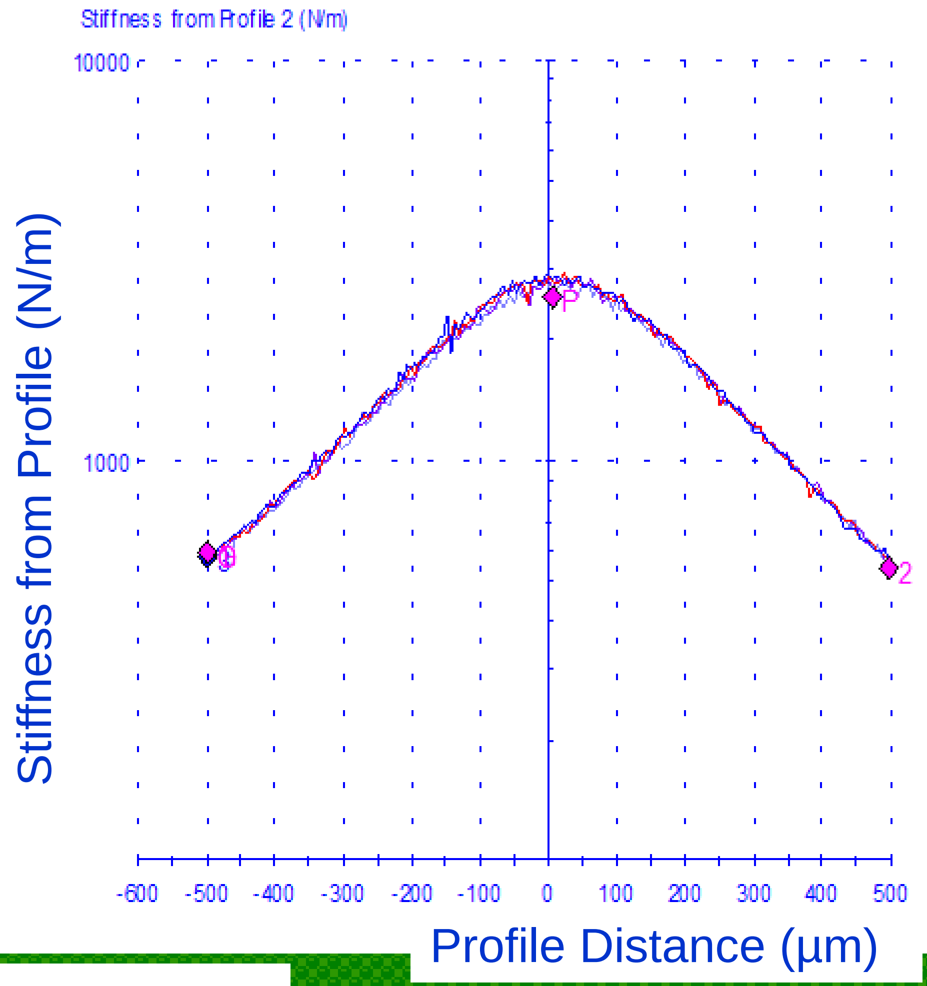
Displacement Profiles of Gimbal/Slider

- Four separate tests can be seen for the gimbal.
- nm in Z – mm in X.
- Not possible with a tub scanner.



Stiffness Profile of Gimbal Device

- A stiffness profile of the gimbal as a function of profile distance can be seen to the right. The y-axis is logarithmic. The stiffness drop from peak is linear and symmetrical. The center portion of these curves represent where the indenter is directly over the dimple. This stiffness profile represents the pitch scan direction. The stiffness at the outer edges of the scan is ~500 N/m.



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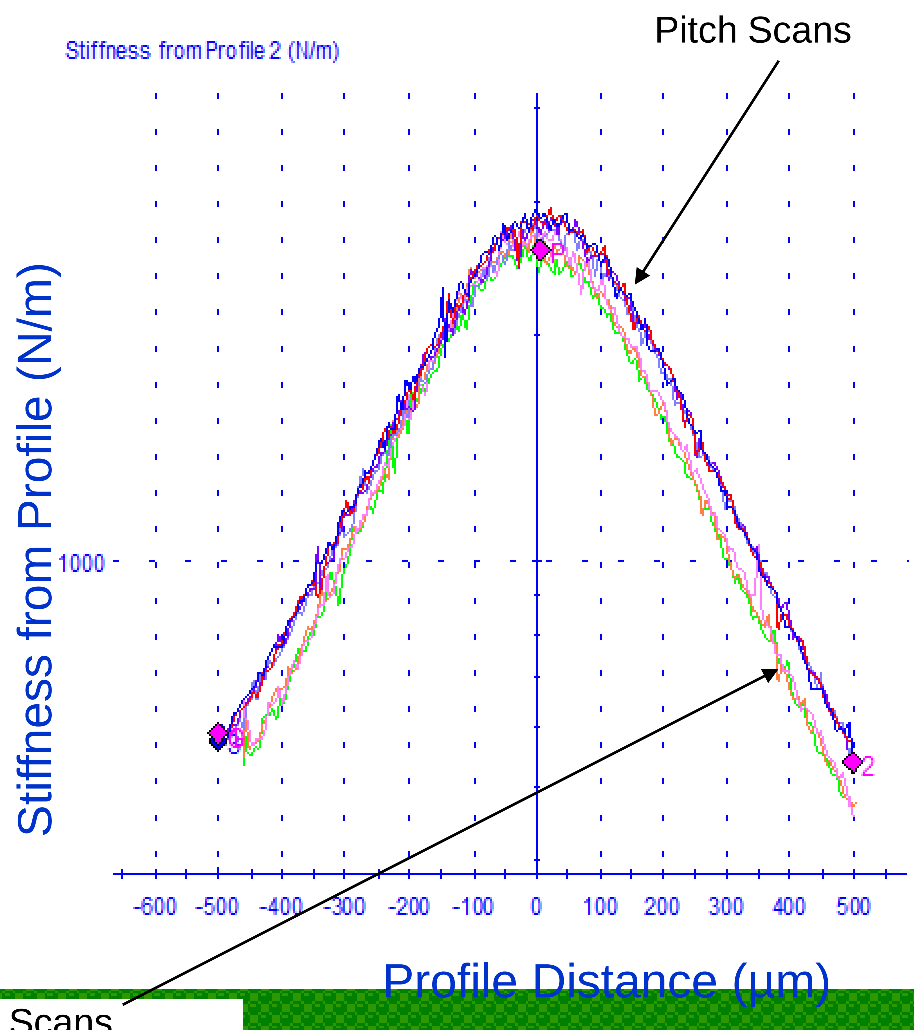
Pitch/Roll Scan Stiffness Comparison

- The roll scans exhibit a lower stiffness than the pitch scans..
- What if one wanted the measurement in terms of **mN*mm/deg**? Units are handled in a simple way.
- For Head Gimbal Assemblies, the magnitude of the elastic stiffness is a representation of how well they will perform



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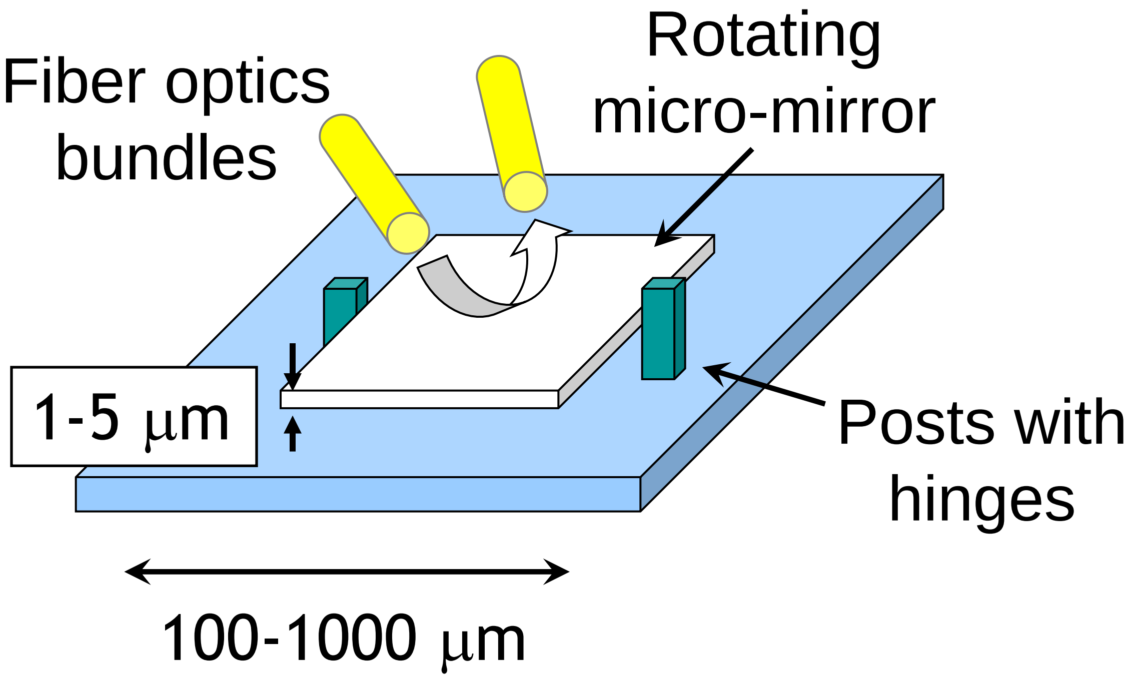
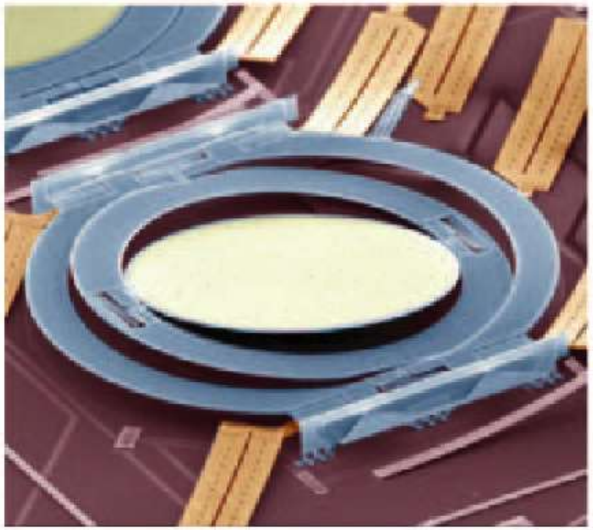
Micro Mirrors



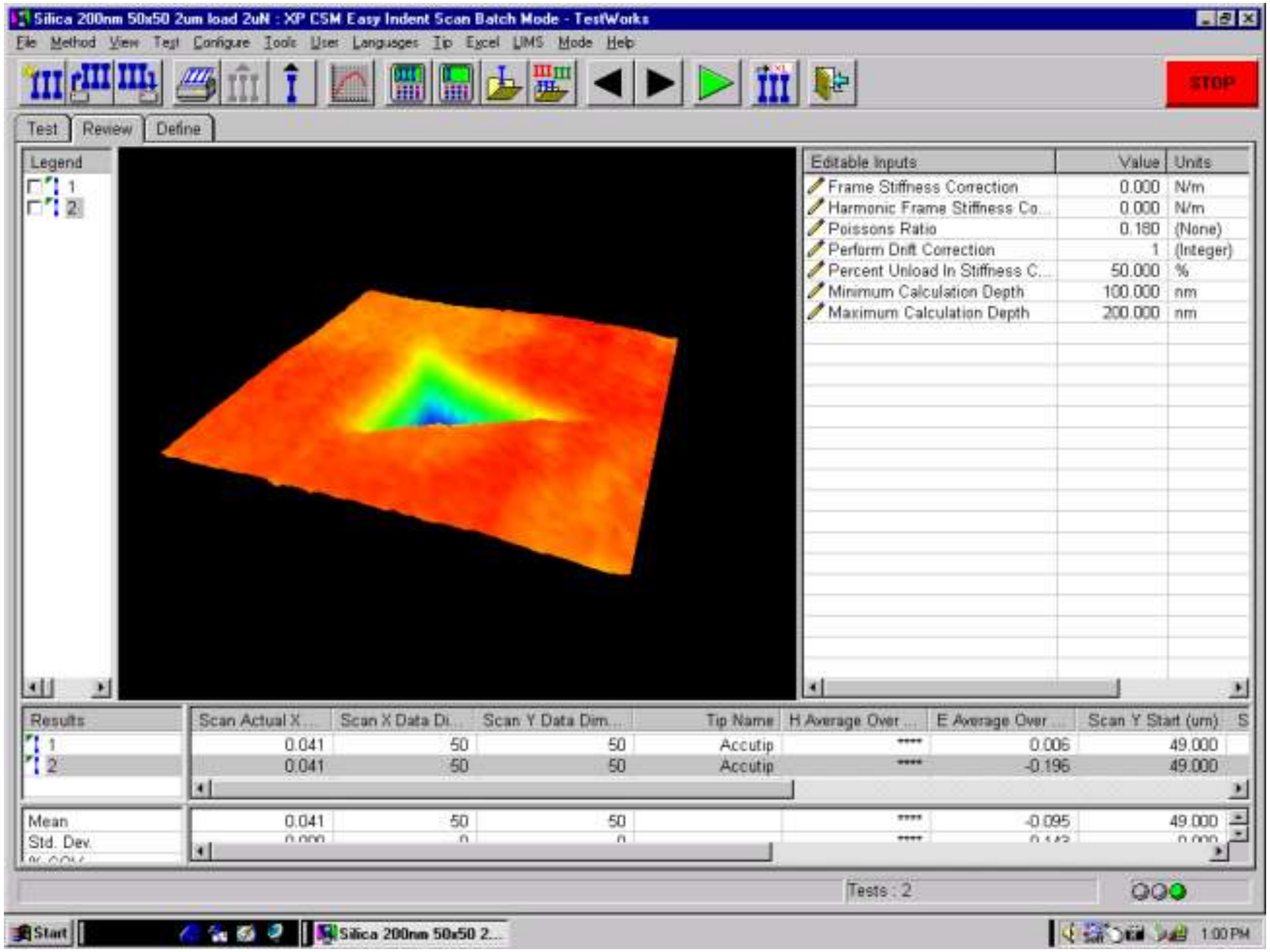


Hinged Micro-mirror

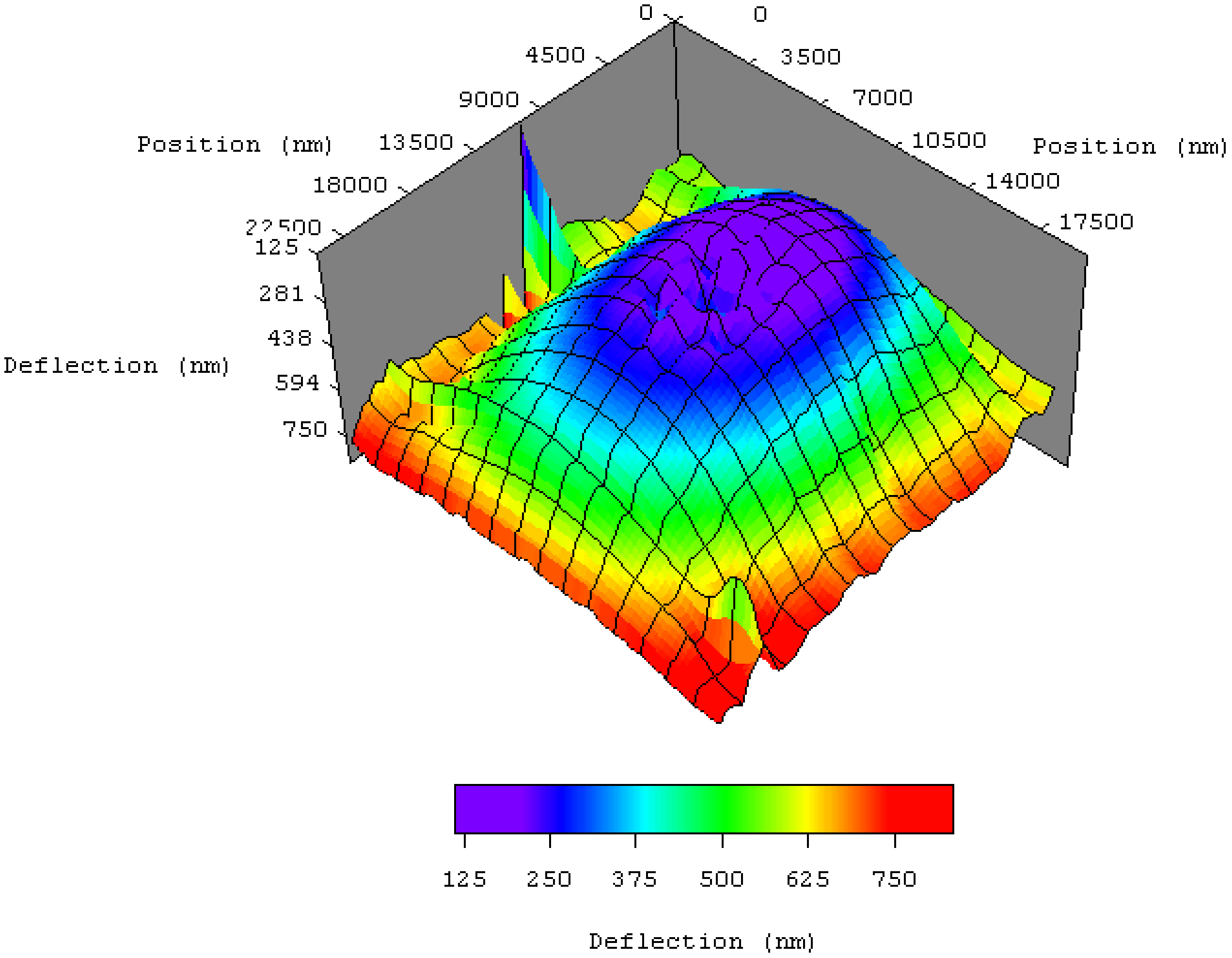
Nanovision Stage

Travel: 100 μm x 100 μm
Resolution/Noise: 2 nm
Flatness of travel: 1-2 nm
Accuracy: 0.01 %
Settling Time: 2 ms-
Capacitive feedback control

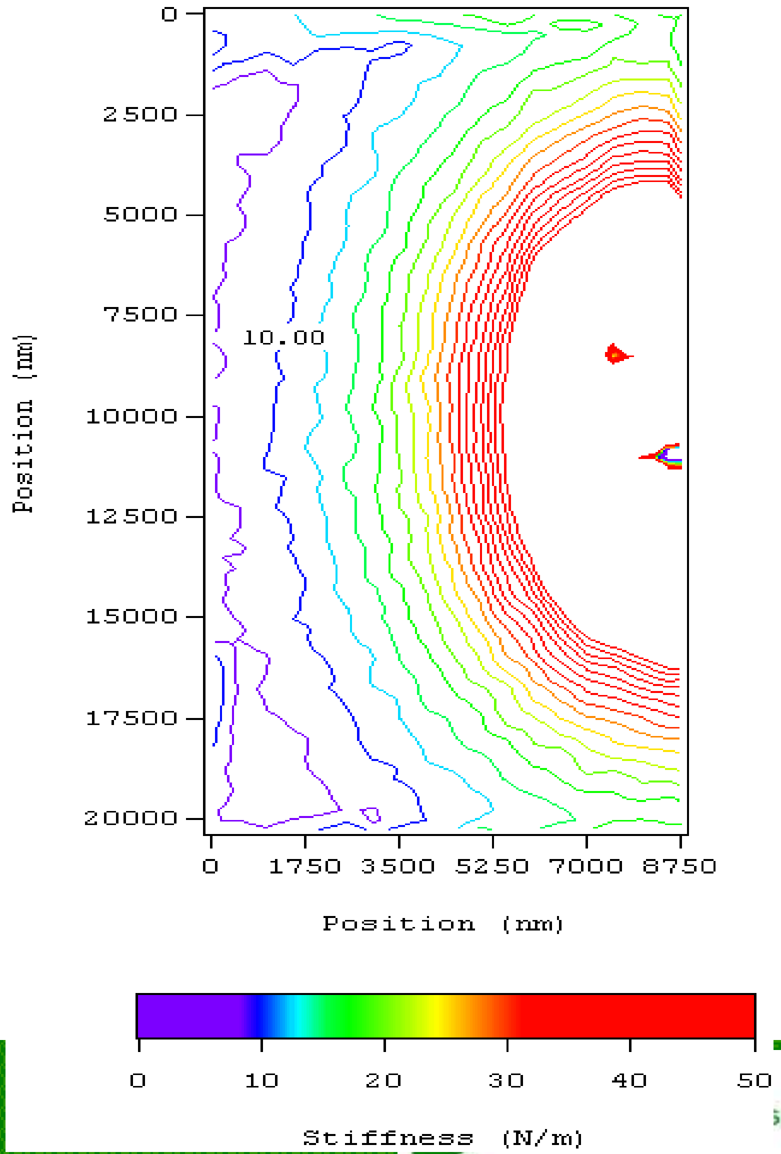
Automated Indent and Scan



Micro Mirrors



Stiffness Mapping of Micro Mirrors



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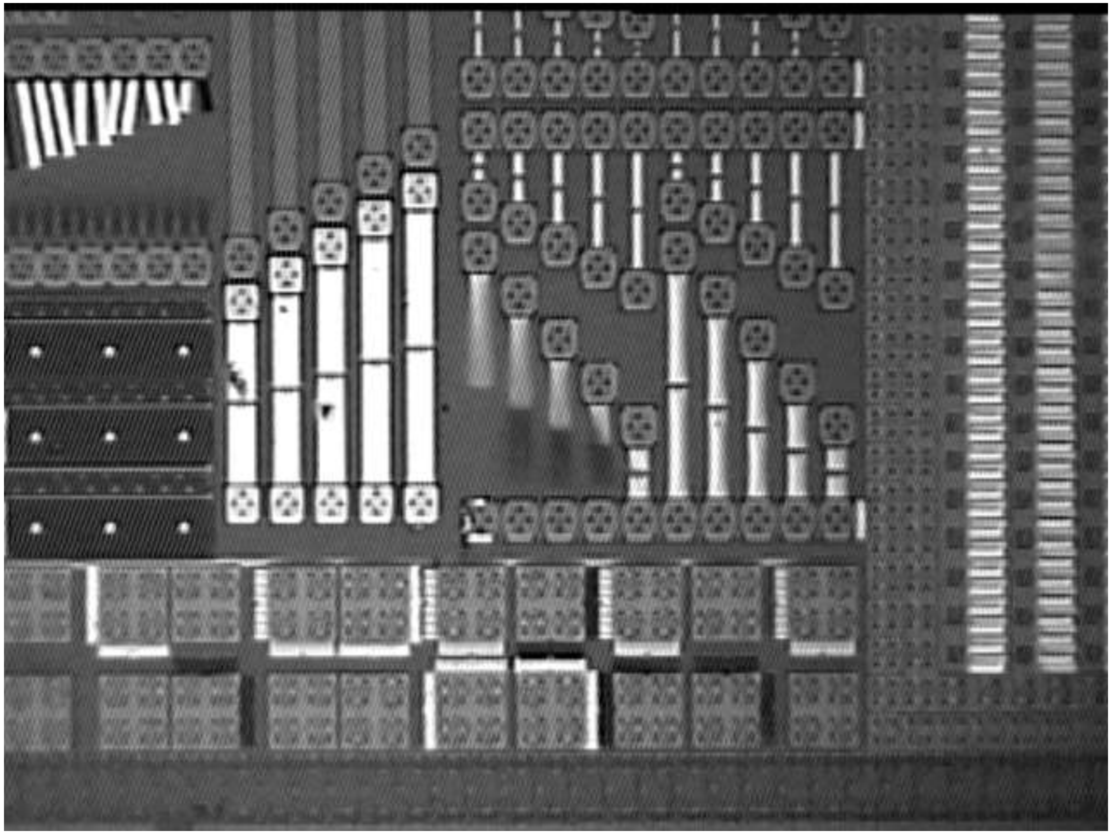
Uniaxial Testing of Free Standing Films



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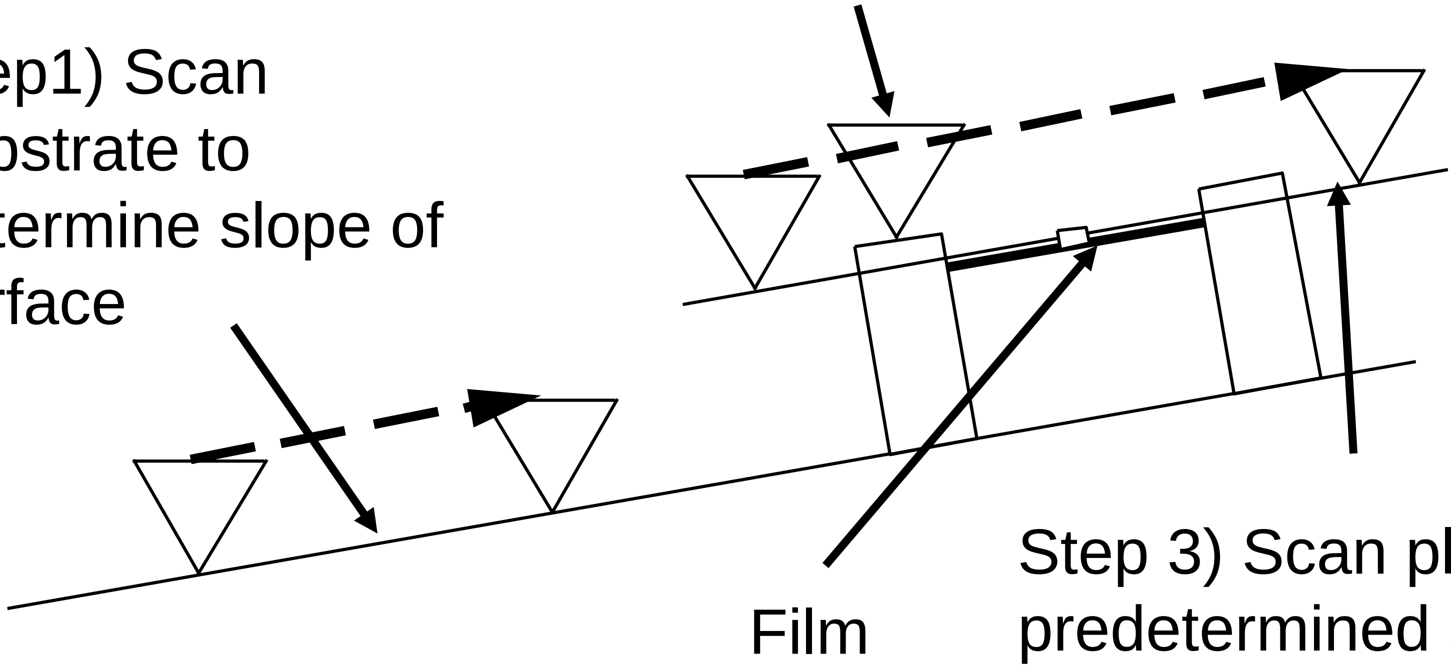
Scan Procedure

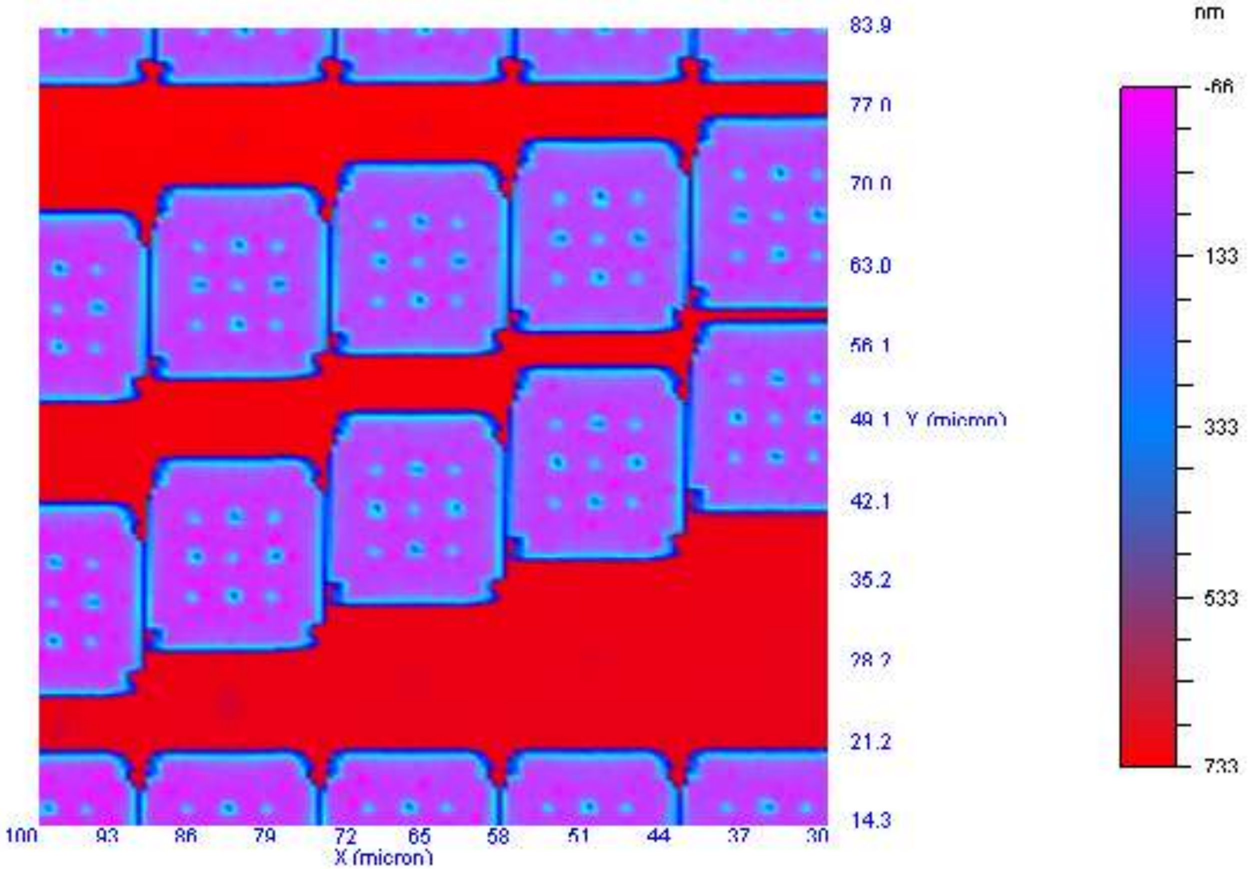
Step 2) Find top of post

Step1) Scan substrate to determine slope of surface



Step 3) Scan plane of predetermined slope just below top of post, but above film

Leveled Targeting Scan



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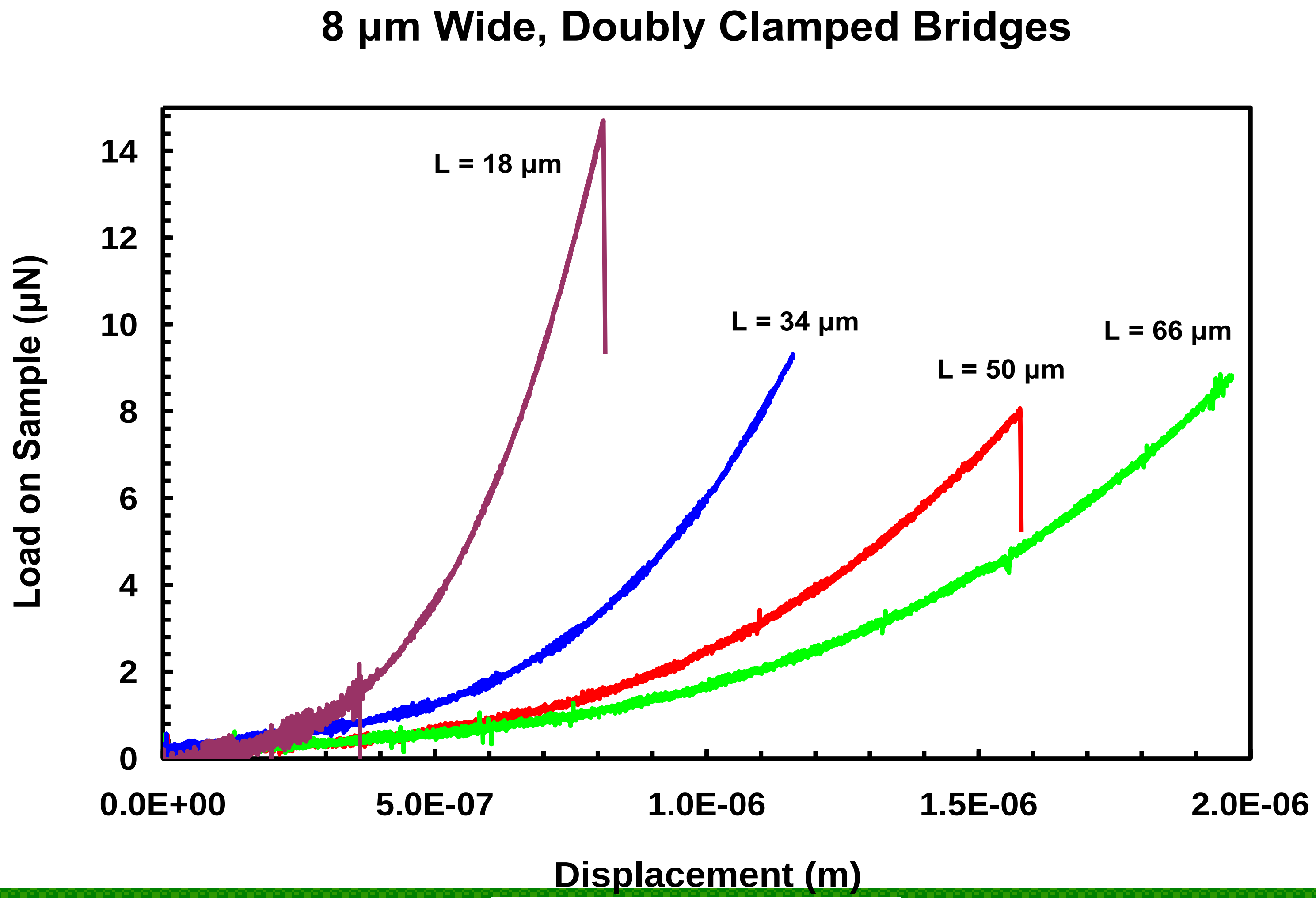
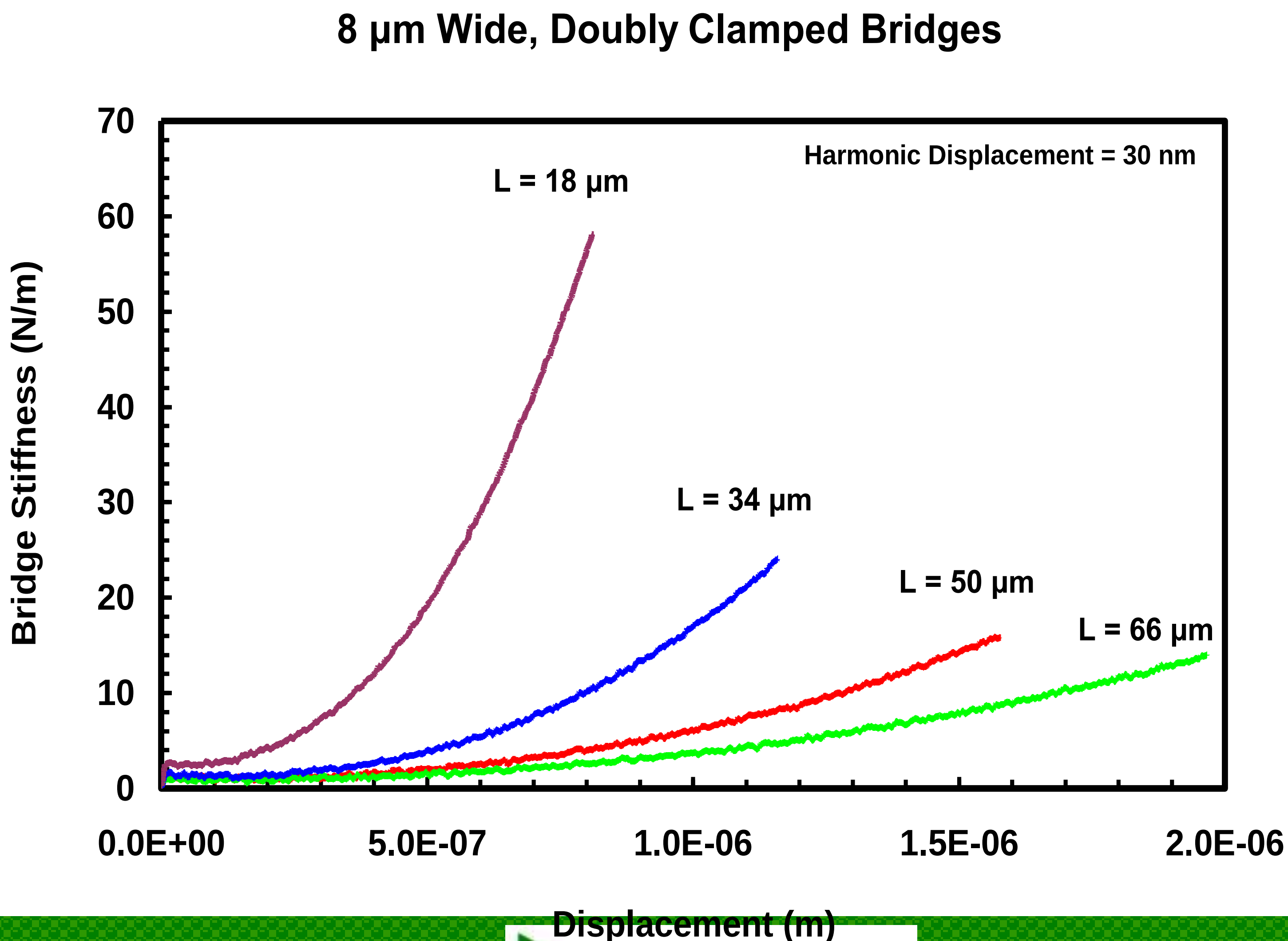
Load Displacement Curves



Stiffness Displacement Curves



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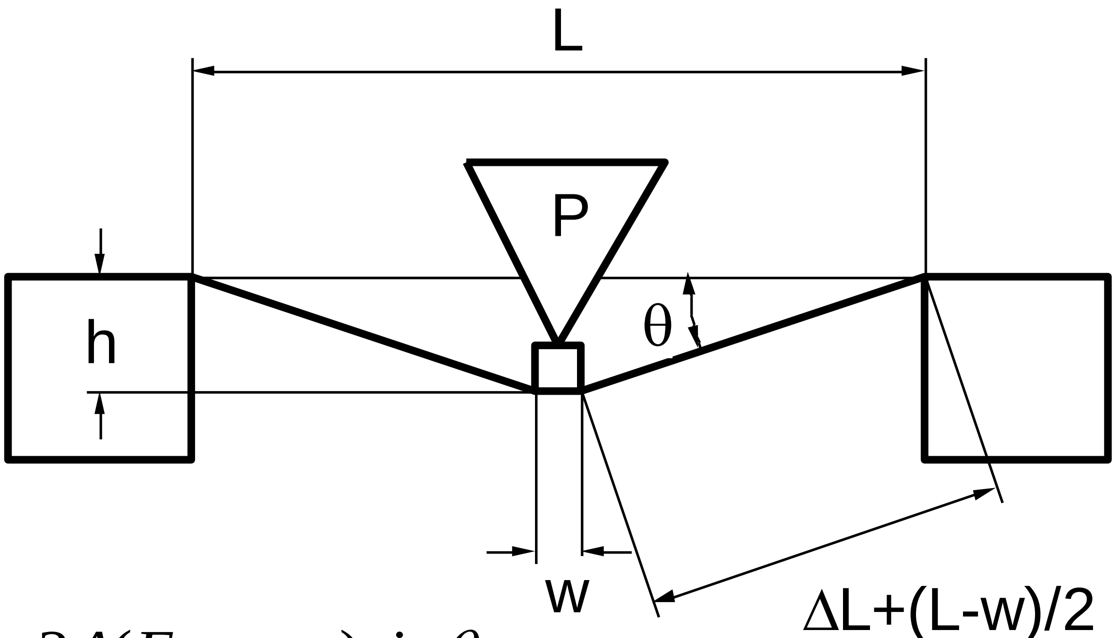
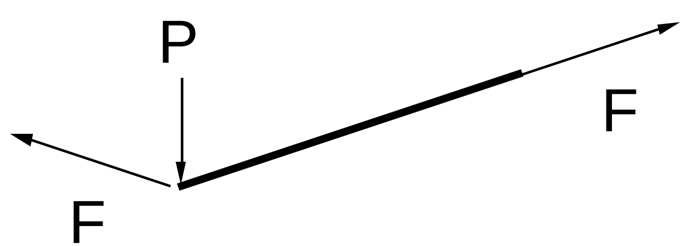
Describing Bridge Tensile Specimens



$$P = 2F\sin\theta = 2A(E\varepsilon + \sigma_r)\sin\theta$$



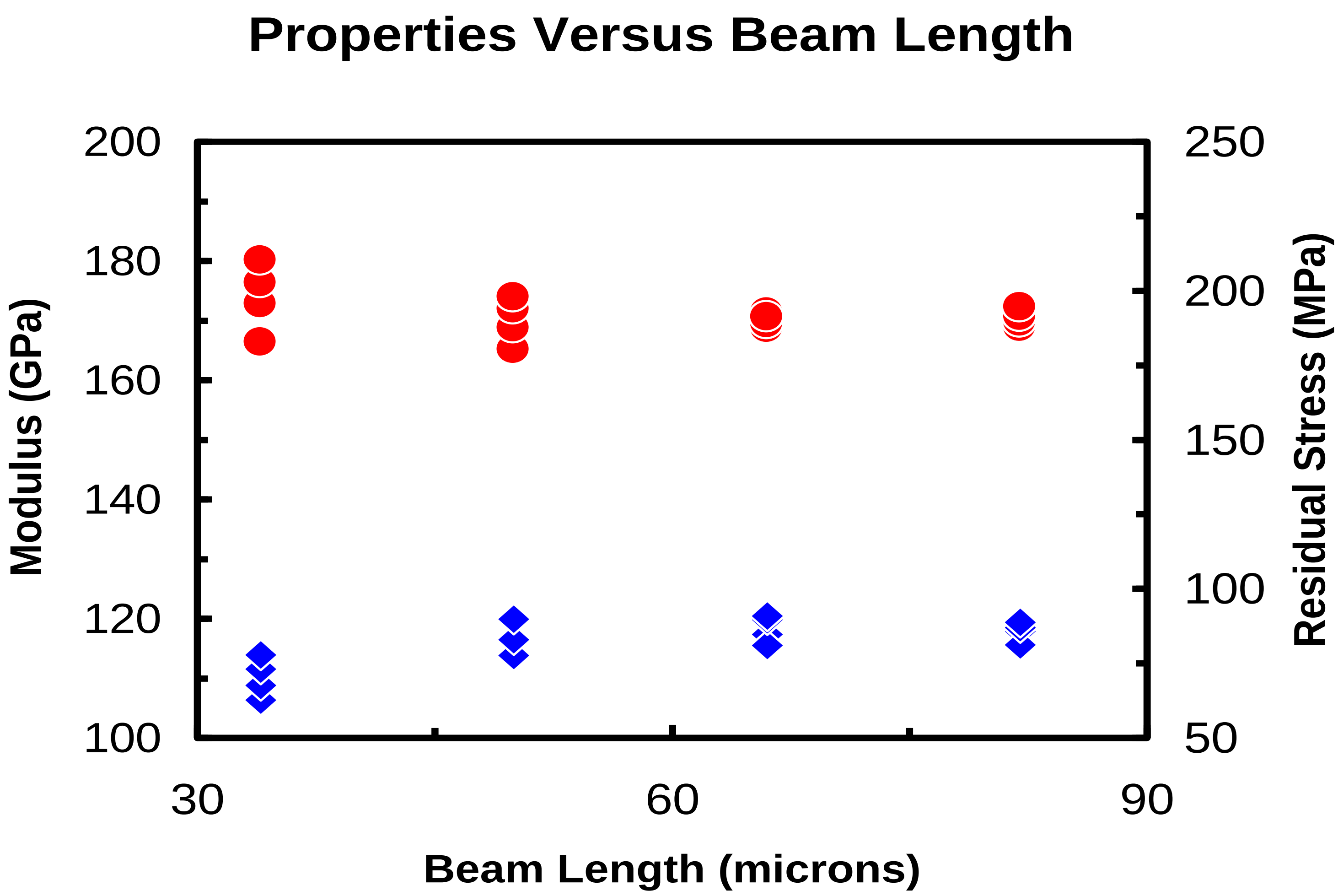
The Stiffness Displacement Relationship:

$$P = \frac{4AEh}{(L-w)} + 2A\sin\left[\tan^{-1}\left(2h/(L-w)\right)\right](\sigma_r - E)$$

For not quite so small angles $\sin\theta = \theta - \frac{\theta^3}{3!}$ $\tan^{-1}\theta = \theta - \frac{\theta^3}{3}$

$$\frac{dP}{dh} = \frac{4A\sigma_r}{(L-w)} + \frac{24A(E-\sigma_r)h^2}{(L-w)^3}$$

Increased Scatter for Shorter Beams ?



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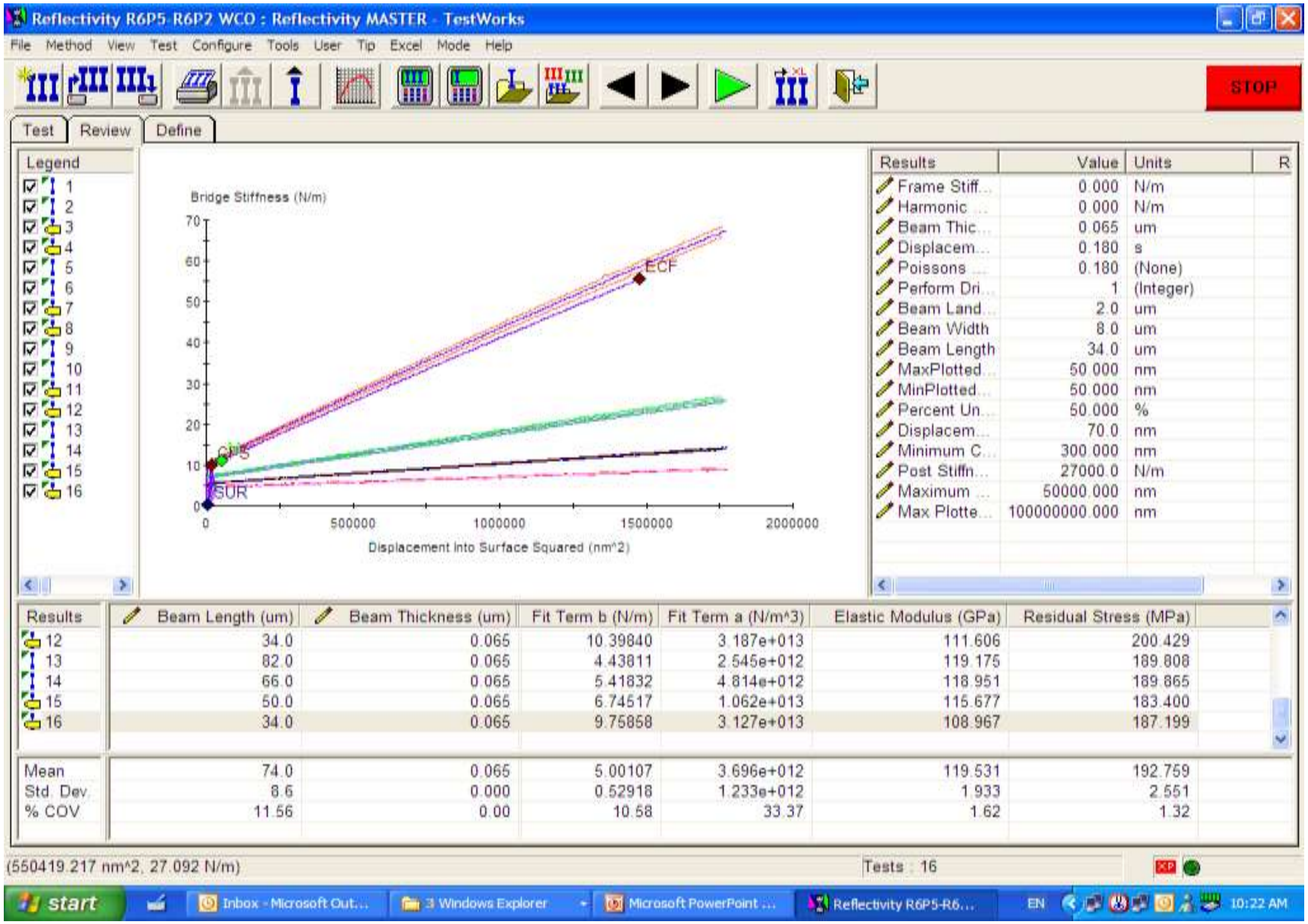
Testworks: A Complete Solution



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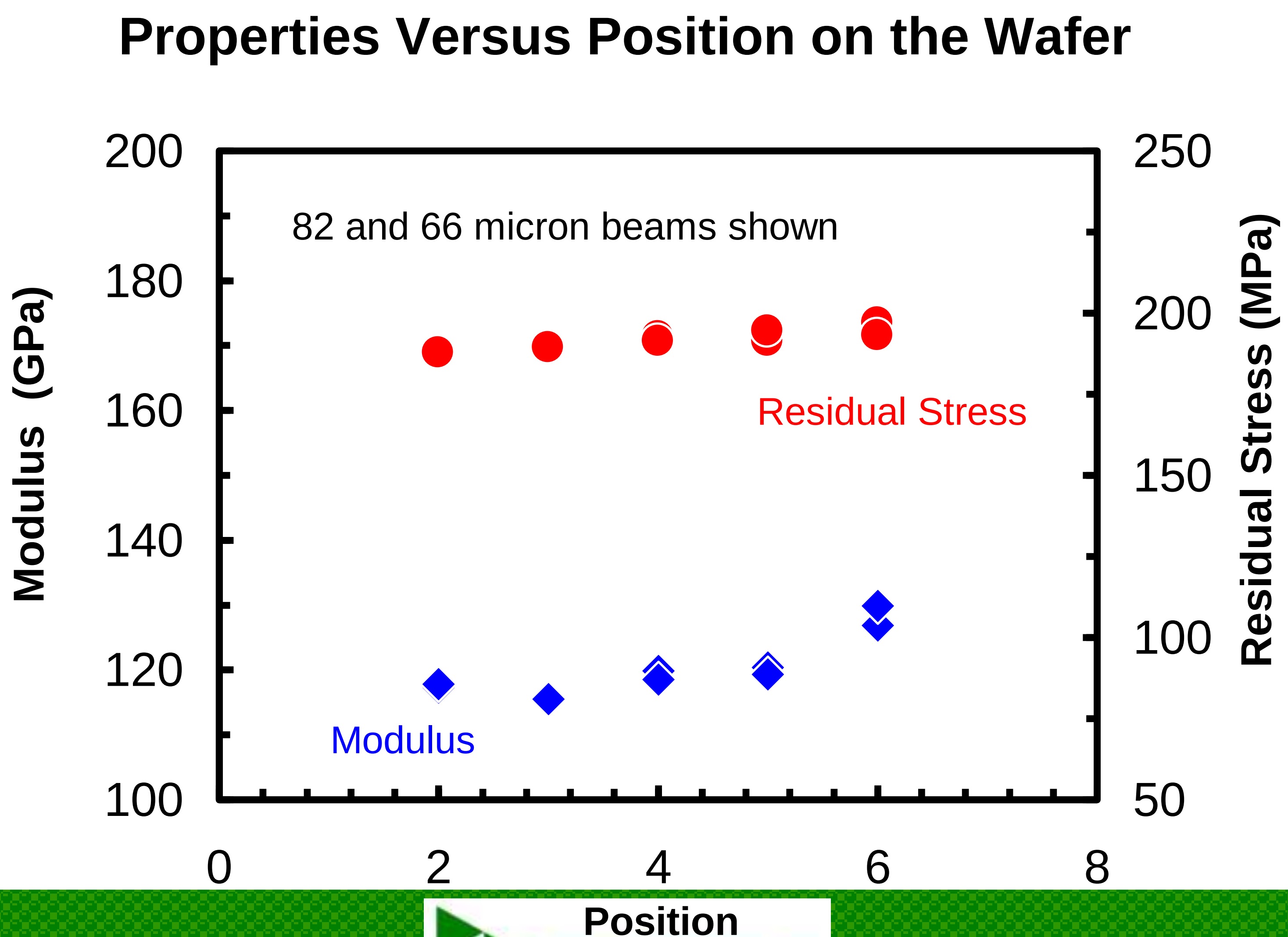
Now it gets Interesting



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TestWorks and the Nano Indenter XP

- Design of MEMS structural experiments was easily done with the flexibility and control offered by the TestWorks software
- TestWorks provides a user interface that facilitates the design of new (i.e. MEMS) and novel experiments without the need to have knowledge of C++ programming
- The Nano Indenter XP system can provide this information quickly and reproducibly, offering manufacturers an attractive tool for product development

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