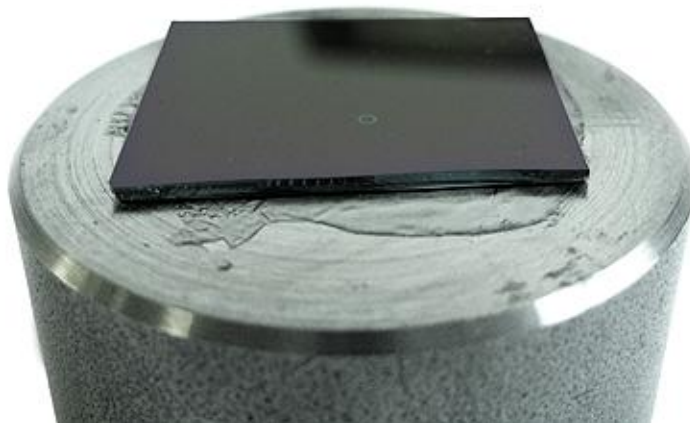


Nano Wear Testing
Polymer Coated Glass



Prepared by
Jorge Ramirez

INTRO

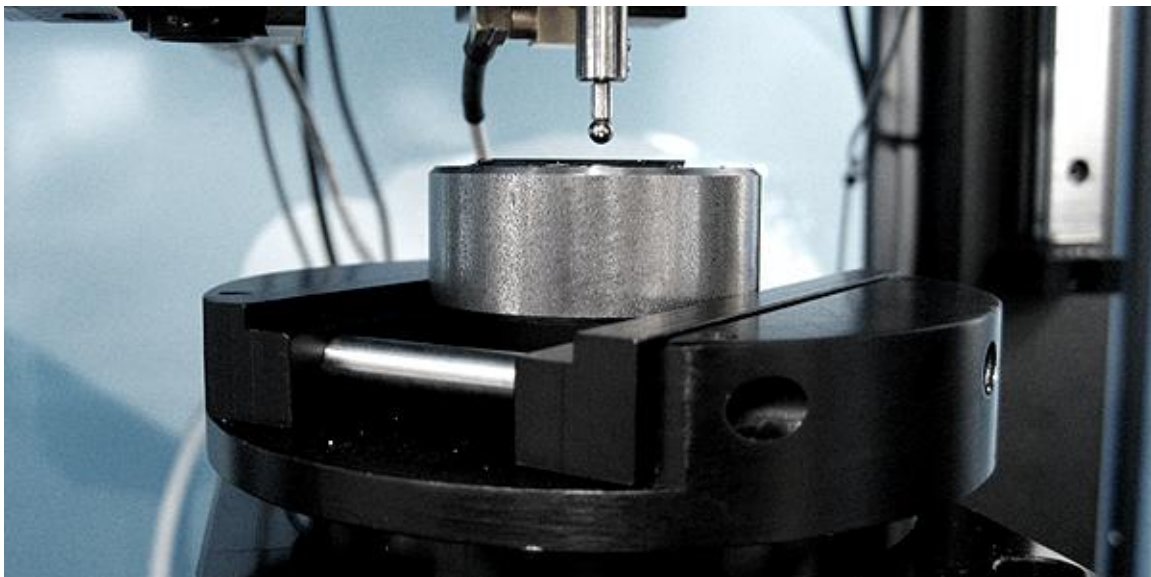
New advancement in technology continues to alter component size and their surface properties across practically all industries. In particular, advances with biomedical and microelectronic components and the crucial understanding of their surface interaction. For industries requiring the precision of sensitive surface structure, it is vital that modification of the material surface is controlled and provides the intended surface interaction. Sensitive component surfaces and or their size, has made tribological study difficult, enabling proper identification of wear/friction results for research and quality control purpose. Thus, furthering the need for reliable identification of wear/friction surface interaction at smaller loads and on smaller applications.

IMPORTANCE OF NANO WEAR TESTING FOR RESEARCH & QUALITY CONTROL

A major concern with medical device design is the amount of wear created during contact on the body or other materials or parts that come in contact with each other. Precise wear measurement provides control to reduce wear which can cause problematic internal scenarios such as inflammation or infection. Where as Microelectronics require reliable understanding of surface interaction to ensure electronic function. Quantifiable, reproducible and reliable wear measurement is therefore crucial to ensure intended performance of small and sensitive component surfaces.

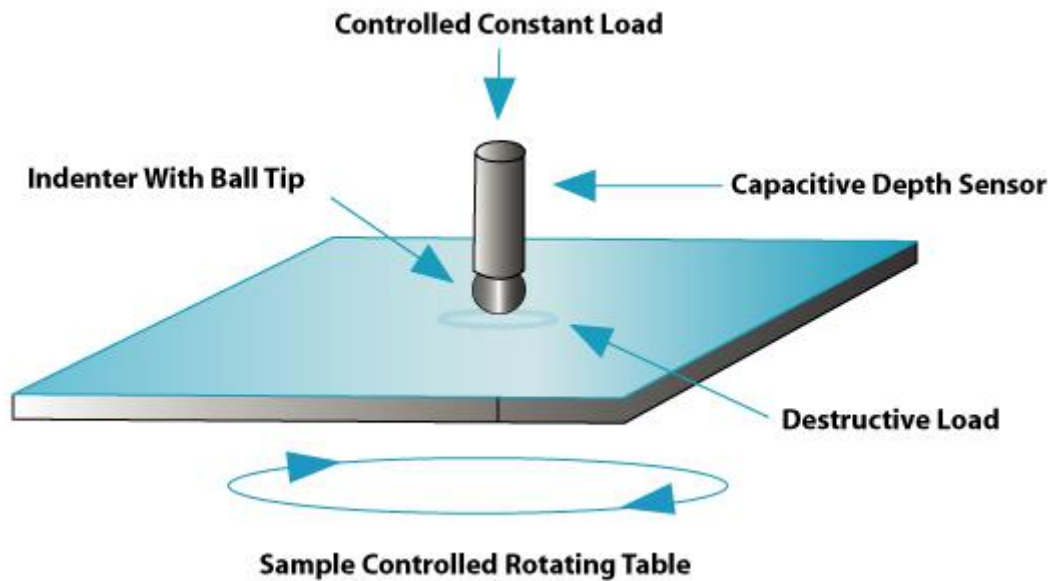
MEASUREMENT OBJECTIVE

To measure the surface wear of sensitive surface, we must apply a precisely controlled low load between the ball tip and soft sample. For most sensitive surface applications, controlled low load wear capability requires the precision of nano mechanical testing. An integrated 3D non contact profiler will also be used to obtain surface roughness and surface volume/area measurement to study their correlation to wear results. Additionally, because many applications are used in lubricated conditions; it is important that the system also be capable to test properties while the sample is lubricated and or immersed in liquids. This was not the case in our application here, but the process is optional.



WEAR MEASUREMENT PRINCIPLE:

During the test, the indenter makes contact with the surface at a very low controlled load. The table starts rotating at a constant speed. The nano module uses the fast piezo electric system and a load cell to quickly adjust the ball position as to keep a constant applied load.



Additional Tools Related to Wear Measurement

Depth Sensing

Using a sensitive capacitive sensor, depth information pre and post scratch can give information on plastic versus elastic deformation during the test.

Friction Sensing

Friction is measured from the deformation of a very sensitive spring inside the base table. The deformation of the spring is measured using a precision LVDT sensor. Measuring friction allows showing of variation with time and also transitions when for example coatings are removed.

Microscopic observation

Used to define test area and to observe and measure wear track surface.

Optical 3D Non Contact Profile

Used to measure the wear profile and roughness caused by the ball passing on the surface of the sample.

Atomic Force Microscope

Same as for Optical 3D Profiler but measures at higher resolution and smaller area.

Test parameters

Sample	Polymer on wafer
Load	30 mN
Speed rate	20 rpm
Track radius	1 mm
Ball Diameter	3 mm
Ball Material	440 SS

Lubricant	n/a
Atmosphere	Air
Temperature	23°C (room)
Humidity	35%

Results

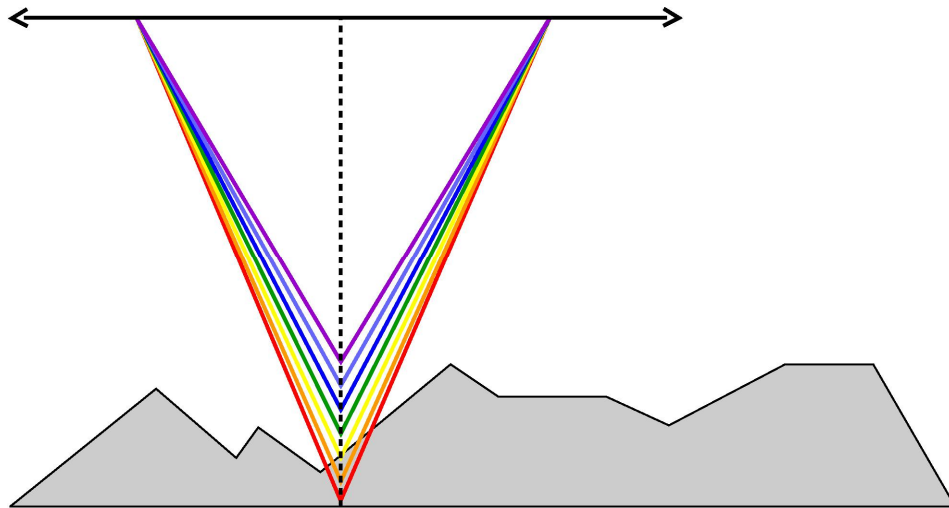
Wear Rate

Polymer on Wafer	Wear Rate (mm^3/Nm)
Test 1	0.029



OPTICAL PROFILER MEASUREMENT PRINCIPLE:

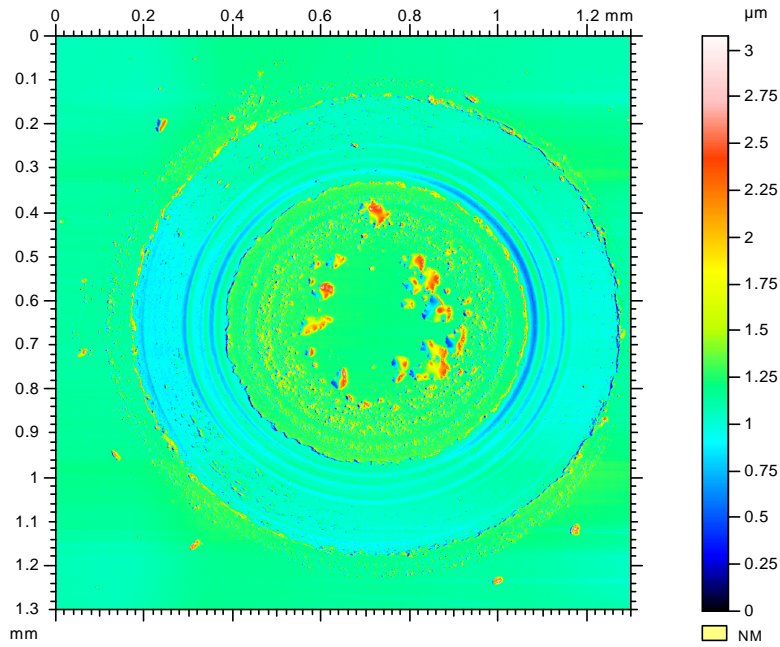
The axial chromatism technique uses a white light source, where light passes through an objective lens with a high degree of chromatic aberration. The refractive index of the objective lens will vary in relation to the wavelength of the light. In effect, each separate wavelength of the incident white light will re-focus at a different distance from the lens (different height). When the measured sample is within the range of possible heights, a single monochromatic point will be focalized to form the image. Due to the confocal configuration of the system, only the focused wavelength will pass through the spatial filter with high efficiency, thus causing all other wavelengths to be out of focus. The spectral analysis is done using a diffraction grating. This technique deviates each wavelength at a different position, intercepting a line of CCD, which in turn indicates the position of the maximum intensity and allows direct correspondence to the Z height position.



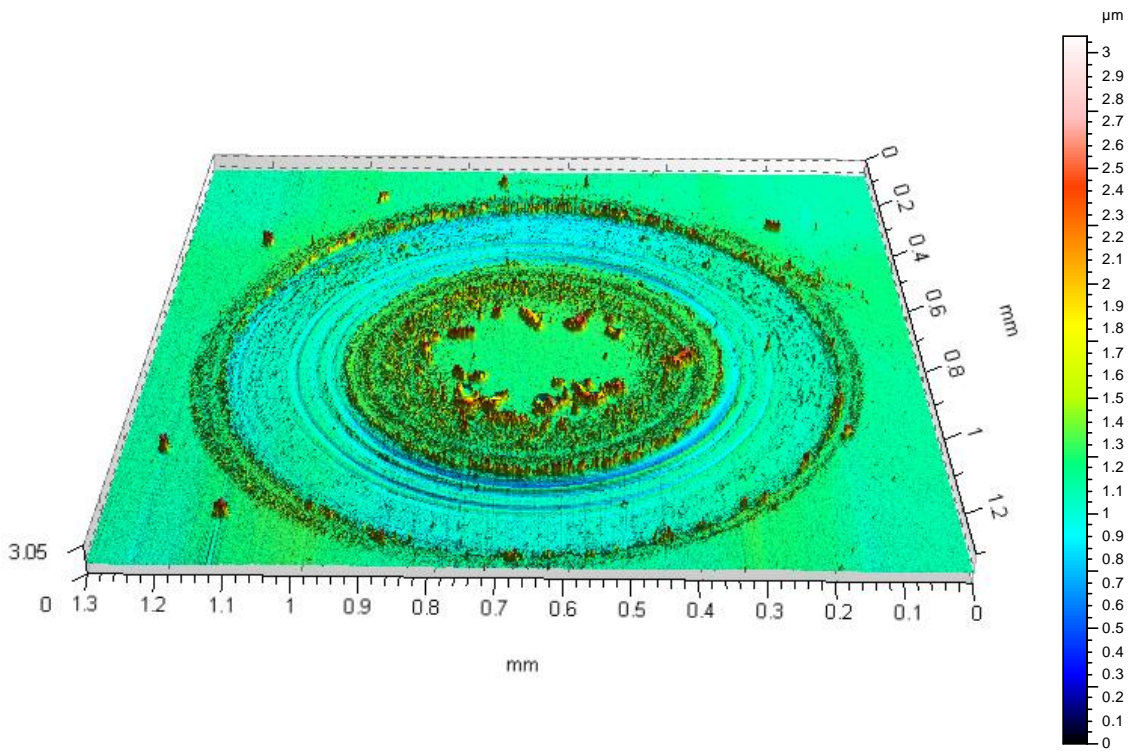
Nanovea optical pens have zero influence from sample reflectivity. Variations require no sample preparation and have advanced ability to measure high surface angles. Capable of large Z measurement ranges. Measure any material: transparent/opaque, specular/diffusive, and polished/rough.

Results

Wear Rate

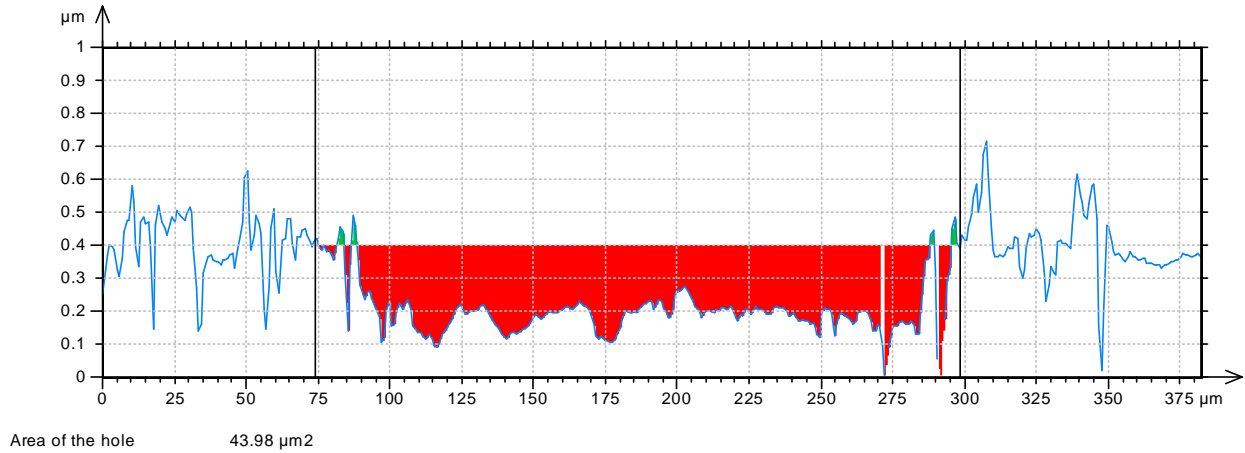


Top Surface View of Polymer on Wafer

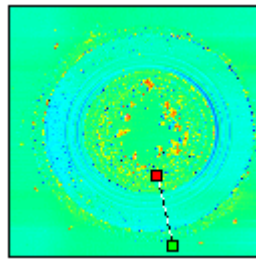


3D Image of Polymer on Wafer

Profile Extracted From Polymer on Wafer



Profile extracted from:



Conclusion

The Nanovea Mechanical Tester, in nano wear testing mode, is ideal for Tribological wear rates small and or sensitive surfaces. The advantage of using balls up to 3mm or even 6mm in diameter with forces down to 1mN, or even below, allows mimicking more closely low friction applications in a real setting. To better understand the level of pressure that is applied, it is worth comparing with an AFM which is known for its very low forces. For example, it is reported that with a 0.2nN and with a Si₃N₄ tip with a radius of 50nN, the pressure on the surface is in the range of 200MPa. With the 30mN applied with a radius of contact surface at 0.1mm, the calculated pressure is 2.5MPa. Therefore the pressures applied are 80times lower. With forces that can be down to 1mN or less, pressure can be down to 0.08MPa or less with larger contact area. Furthermore, the control loop of the force between the load cell and the piezo allows excellent control of the load applied even at fast rpm. It is very important to match the pressure of an application with the pressure applied by the tool used. Friction sensor or/and capacitive depth sensor (not used in this study but available on the same system) would allow the exact point when the coating was removed to be determined directly from a change in frictional force or from a stabilization of the depth when the ball reaches the substrate. The high resolution capacitor can measure changes of depth down to 0.1nm. Because of the width of the wear track, the optical profiler was the chosen tool to measure the wear track after the test. The AFM would be the tool of choice for smaller wear track of 100micron or less.