Tribological Characterization of Ti-WS2 Coating

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INTRO

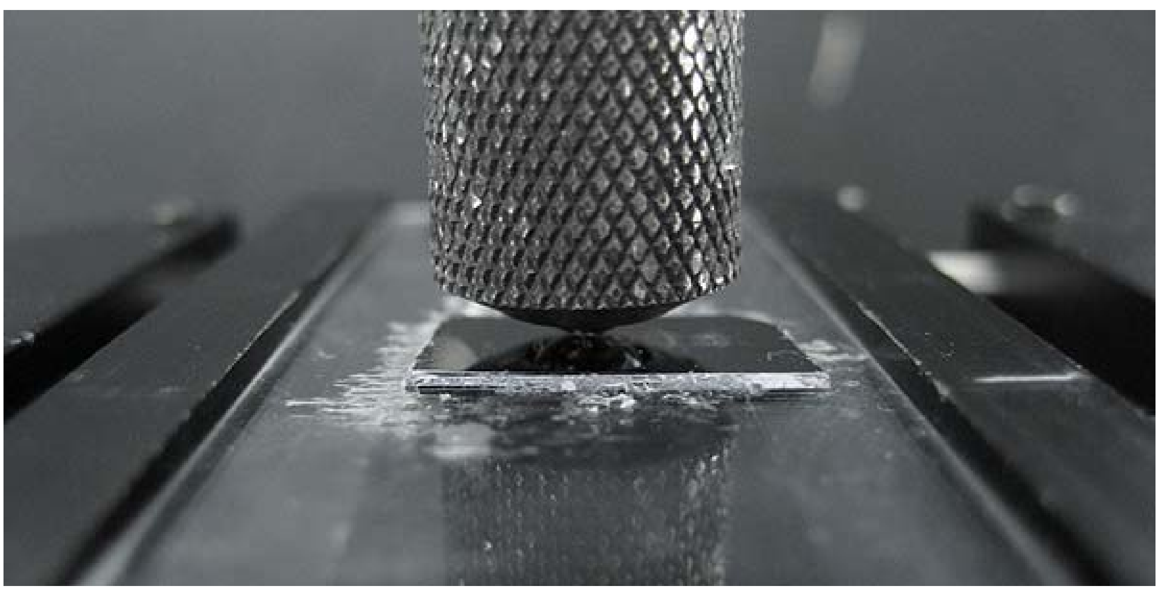
Transition metals, such as WS2 and MoS2, are well known for their solid lubricating behavior especially critical for aerospace applications and others when fretting wear is present. Compared with MoS2, WS2 exhibits higher thermally stability and provides a ~100 °C increase in maximum operating temperature. In the WS2 layered structure, a sheet of tungsten atoms is sandwiched between two hexagonally packed sulphur layers. The bonding within the S–W–S sandwich is covalent, while weak Van Der Waals forces hold the sandwich together resulting in interlamellar mechanical weakness. Thus, under a shearing force the basal planes slide over one another by intracrystalline slip and transfer to the rubbing counterface.

IMPORTANCE OF TRIBOLOGY FOR QUALITY CONTROL

Tribological characterization is critical especially when they are intended to decreased friction and reduced wear as to increase life and performance of materials. This is particularly important in industries such aerospace, tooling, automotive and others where failure can be catastrophic. The direct benefit in improving material surfaces pushes the need for good quantifiable testing.

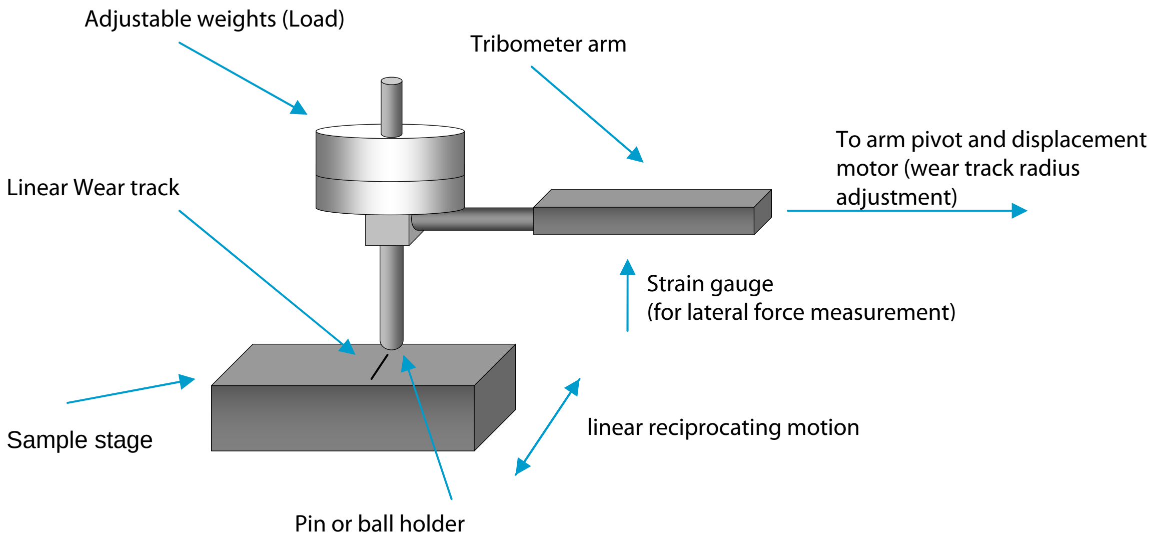
MEASUREMENT OBJECTIVE

In this report we will review the tribological behavior of Ti-WS2 coating deposited by Magnetron Sputtering technique. The friction and wear coefficient will be obtained with the Tribometer in reciprocating mode and an integrated optical profiler will be used to obtain wear rate.



TRIBOMETER PRINCIPLE:

A flat or a sphere shaped indenter is loaded on to the test sample with a precisely known force. The indenter (a pin or a ball) is mounted on a stiff lever, designed as a frictionless force transducer. As the plate slides in a linear reciprocating motion the resulting frictional forces acting between the pin and the plate are measured by very small deflections of the arm using a strain gage sensor. Wear rate values for both the pin and sample may also be calculated from the volume of material lost during a specific friction run. This simple method facilitates the determination and study of friction and wear behavior of almost every solid state material combination, with varying time, contact pressure, velocity, temperature, humidity, lubrication, etc.



TEST PROCEDURE

The instrument base is first leveled in the horizontal position by screwing or unscrewing the adjustable rubber pads at each corner. A ball-holder containing a 3 or 6 mm diameter ball is held in the load arm and placed at a height that allow the tribometer arm to be leveled horizontally when resting on the sample to ensure that normal load will be applied vertically. The arm is then balanced with counter weights to ensure that the arm and ball holder initially apply no force on the sample surface. Finally, weights corresponding to the load required for the test are finely placed on the arm over the ball holder. Through software, the test is then launched and the test is performed at a specified speed for a specified duration, and the frictional force is recorded over time.

TEST CONDITIONS

Test parameters

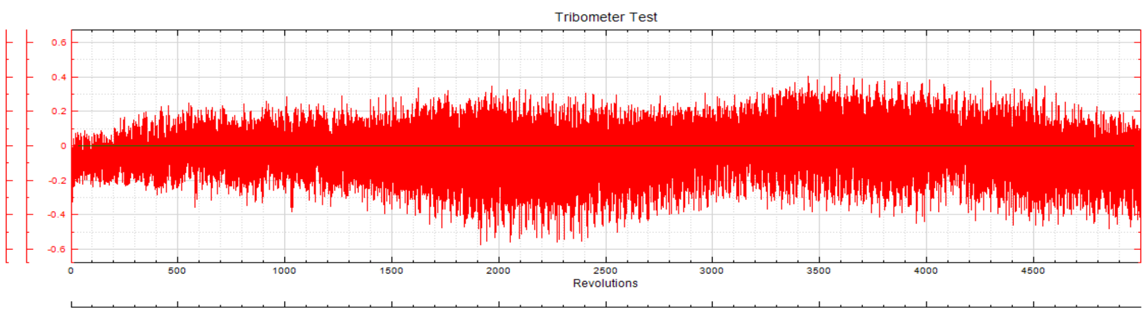
Normal Force	1N, 2N, 3N
Speed	300 RPM
Distance test	1.50mm
Distance	20 m
Time test	16.67 min
Oscillations	5000 cycles
Pin Characteristics	Al2O3 ball diameter 6mm
Materials tested	Ti-WS2 deposited by magnetron Sputtering, thickness 600nm, Hardness 5Gpa

Environmental conditions

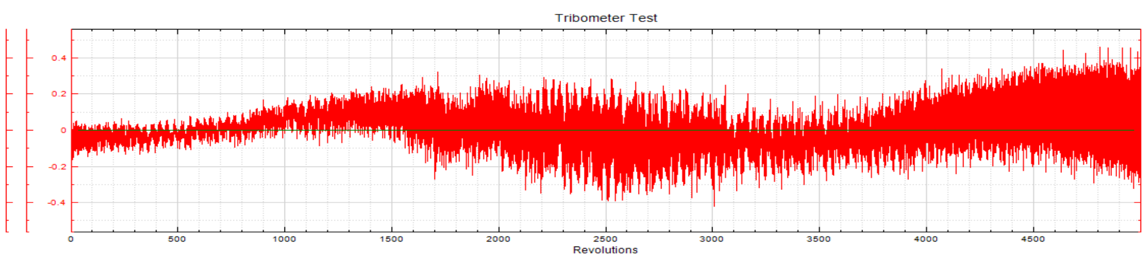
Lubricant	None
Atmosphere	Air
Temperature	23°C (room)
Humidity	35%

RESULTS

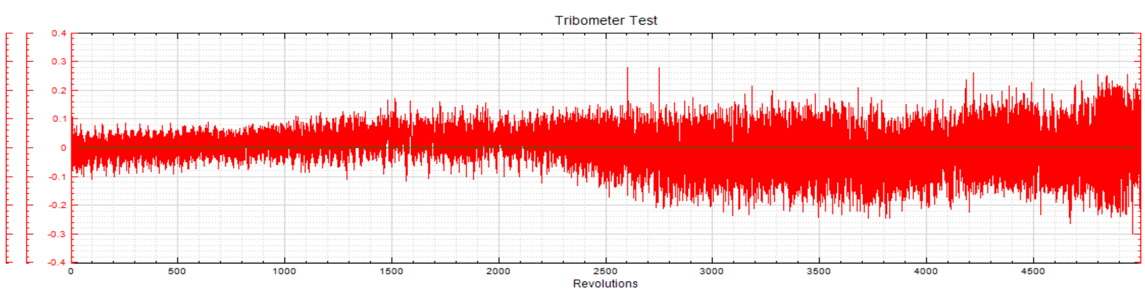
Load 1N



Load 2N

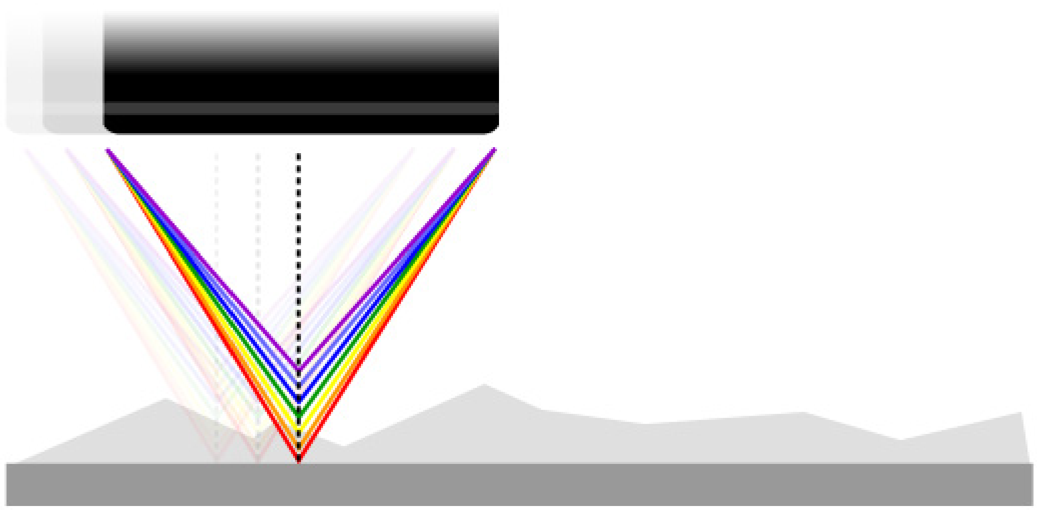


Load 3N



PRFOILOMETER 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.



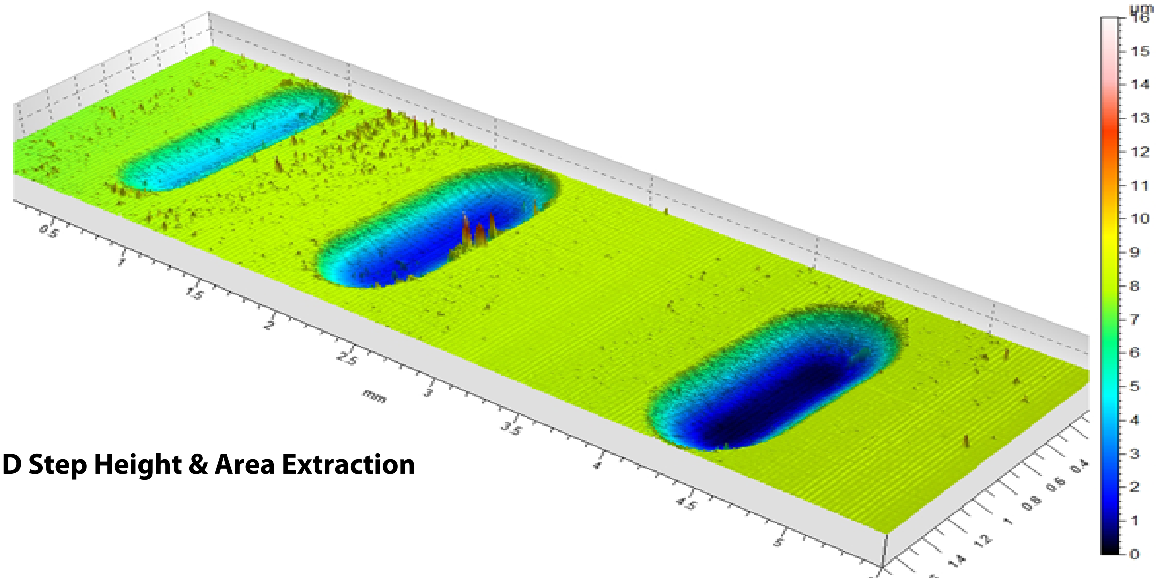
Nanovea optical pens have zero influence from sample reflectivity. Variations require no sample preparation and have advanced ability to measure high surface angles. Capable of large Z measurement ranges. Measure any material: transparent or opaque, specular or diffusive, polished or rough.

MEASUREMENT SET-UP & TIPS:

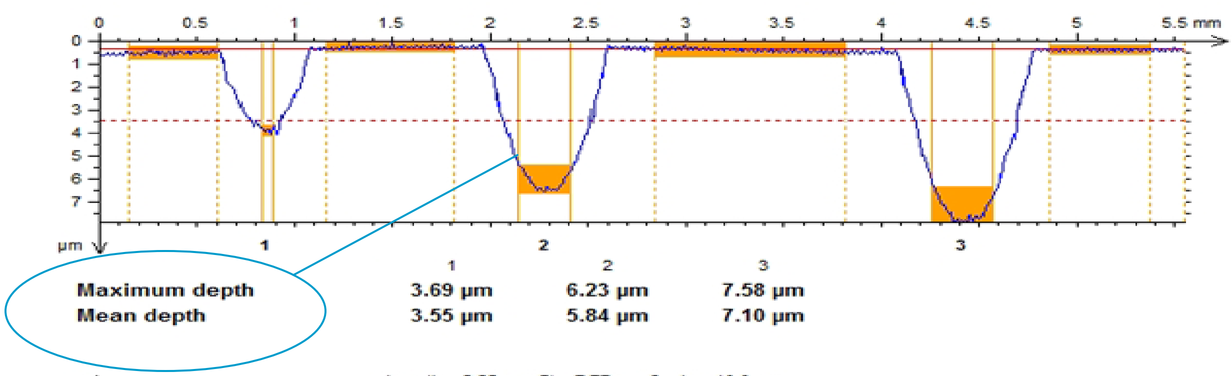
Measurements area randomly selected on the sample, drastic changes in surface topography are not an issue for Nanovea Profilometers. Small height variation down to nanometers up to 27mm of height variation can easily be measured.

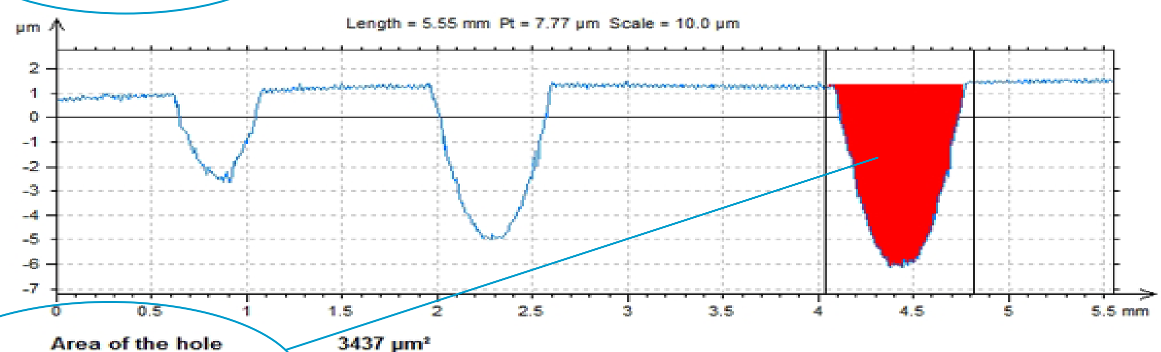
RESULTS

3D Profile



2D Step Height & Area Extraction





Wear Rate Results

	1N	2N	3N
Wear Coefficient(mm³/N.M)	9.200E-06	7.000E-06	4.467E-06

CONCLUSION

As we have seen here, the Nanovea Tribometer has provided reliable coefficient of friction and wear results between the Al_2O_3 ball tip and the Ti-WS_2 coated sample. The test was performed through a linear mode, although, the Nanovea Tribometer could also provide rotational mode. The linear mode simulated a fretting condition and showed that the friction coefficient decreased when the load increased while the wear rate increased. With this data, the software calculated an average, the maximum and minimum of friction coefficient to determinate the range of each test. This allowed to us to determine that the increase in load produced a decrease in friction due to increase in shear stress. The integrated optical profiler provided a quick and reliable method of volume loss measurement used to calculate the wear rate. Many of the test parameters can be varied to meet specific applications requirements. To simulate real-life applications, it might be necessary to test at high temperature, in liquid or under atmosphere control.