NANOVEA

SCRATCH HARDNESS MEASUREMENT

USING A MECHANICAL TESTER

Prepared by

DUANJIE LI, PhD

INTRODUCTION

In general, hardness tests measure the resistance of materials to permanent or plastic deformation. There are three types of hardness measurements: scratch hardness, indentation hardness and rebound hardness. A scratch hardness test measures a material's resistance to scratch and abrasion due to friction from a sharp object[1]. It was originally developed by German mineralogist Friedrich Mohs in 1820 and is still widely used to rank the physical properties of minerals[2]. This test method is also applicable to metals, ceramics, polymers, and coated surfaces.

During a scratch hardness measurement, a diamond stylus of specified geometry scratches into a material's surface along a linear path under a constant normal force with a constant speed. The average width of the scratch is measured and used to calculate the scratch hardness number (HSP). This technique provides a simple solution for scaling the hardness of different materials.

[1] *Wredenberg, Fredrik; PL Larsson (2009). "Scratch testing of metals and polymers: Experiments and numerics". Wear 266 (1 2): 76.*

[2] *Encyclopæ dia Britannica. 2009. Encyclopæ dia Britannica Online. 22 Feb. 2009 "Mohs hardness."*

MEASUREMENT OBJECTIVE

*In this study, the **NANOVEA** PB1000 Mechanical Tester is used to measure the scratch hardness of different metals in compliance with ASTM G171-03.*

*Simultaneously, this study showcases the capacity of the **NANOVEA** Mechanical Tester in performing scratch hardness measurement with high precision and reproducibility.*

CLICK HERE TO LEARN MORE ABOUT THE INSTRUMENT

NANOVEA
PB1000

TEST CONDITIONS

The ***NANOVEA*** PB1000 Mechanical Tester performed scratch hardness tests on three polished metals (Cu110, Al6061 and SS304). A conical diamond stylus of apex angle 120° with tip radius of 200 µm was used. Each sample was scratched three times with the same test parameters to ensure reproducibility of the results. The test parameters are summarized below. A profile scan at a low normal load of 10 mN was performed before and after the scratch test to measure the change of the surface profile of the scratch.

TEST PARAMETERS

NORMAL FORCE	TEMPERATURE
10 N	24°C (RT)

SLIDING SPEED	SLIDING DISTANCE	ATMOSPHERE
20 mm/min	10 mm	Air

RESULTS & DISCUSSION

The images of the scratch tracks of three metals (Cu110, Al6061 and SS304) after the tests are shown in ***FIGURE 1*** in order to compare the scratch hardness of different materials. The mapping function of the ***NANOVEA*** Mechanical Software was used to create three parallel scratches tested under the same condition in an automated protocol. The measured scratch track width and calculated scratch hardness number (HS_P) are summarized and compared in ***TABLE 1***. The metals show different wear track widths of 174, 220 and 89 µm for Al6061, Cu110 and SS304, respectively, resulting in a calculated HSP of 0.84, 0.52 and 3.2 GPa.

In addition to the scratch hardness computed from the scratch track width, the evolution of coefficient of friction (COF), true depth and acoustic emission were recorded in situ during the scratch hardness test. Here, the true depth is the depth difference between the penetration depth of the stylus during the scratch test and the surface profile measured in the pre-scan. The COF, true depth and acoustic emission of Cu110 are shown in ***FIGURE 2*** as an example. Such information provides insight of mechanical failures taking place during scratching, enabling users to detect mechanical defects and further investigate the scratch behavior of the tested material.

The scratch hardness tests can be finished within a couple of minutes with high precision and repeatability. Compared to conventional indentation procedures, the scratch hardness test in this study provides an alternative solution for hardness measurements, which is useful for quality control and development of new materials.

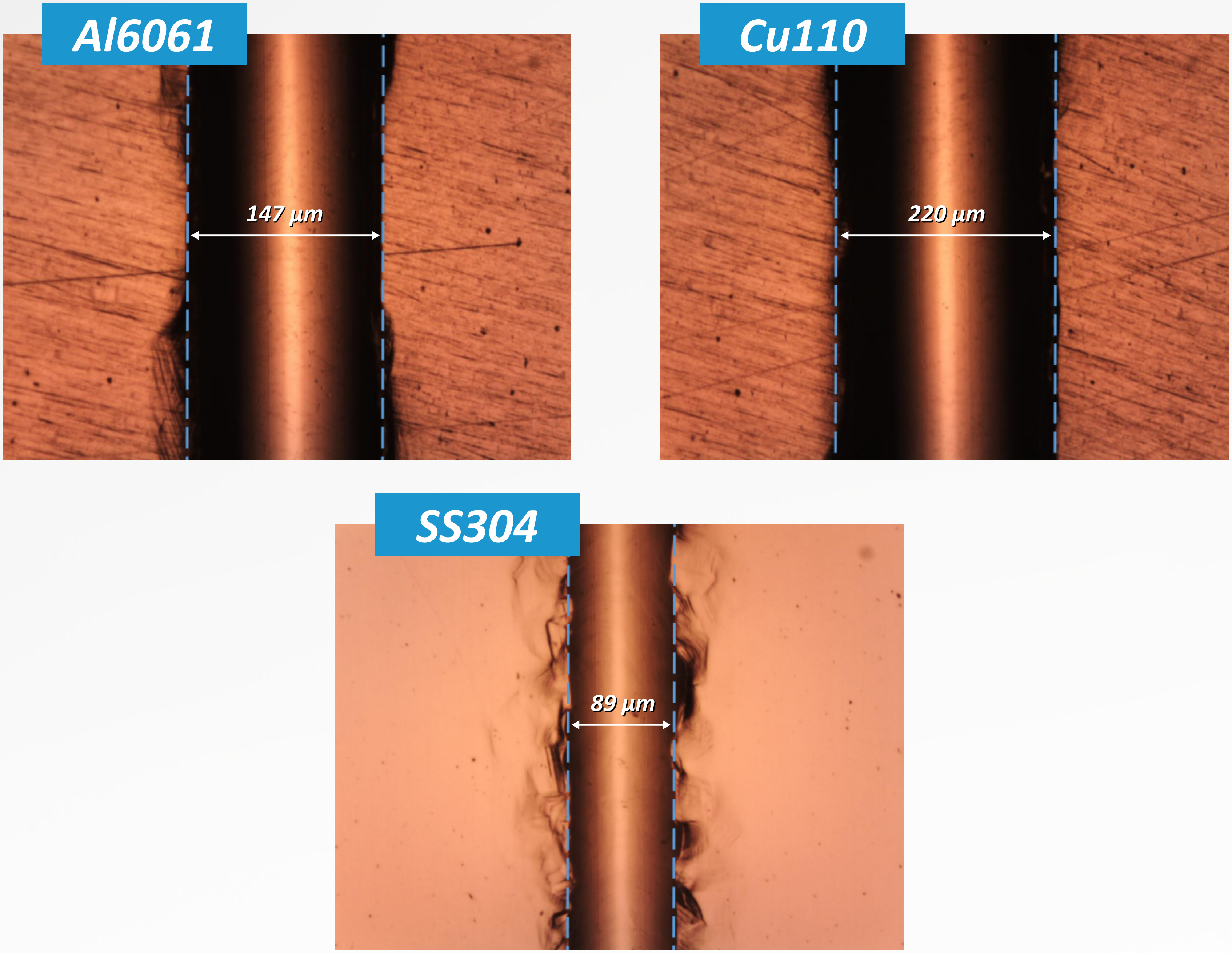
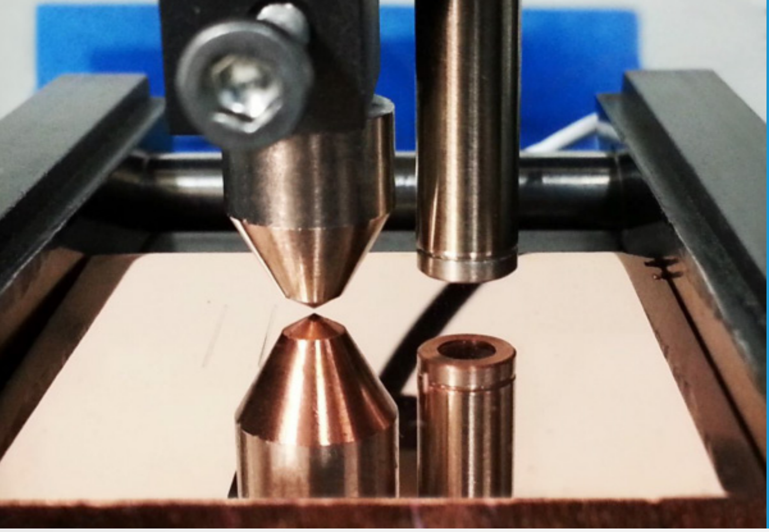


FIGURE 1: ***Microscope image of the scratch tracks post test (100x magnification).***



	Scratch track width (μm)	HS_P (GPa)
Al6061	174±11	0.84
Cu110	220±1	0.52
SS304	89±5	3.20

TABLE 1: *Summary of scratch track width and scratch hardness number.*

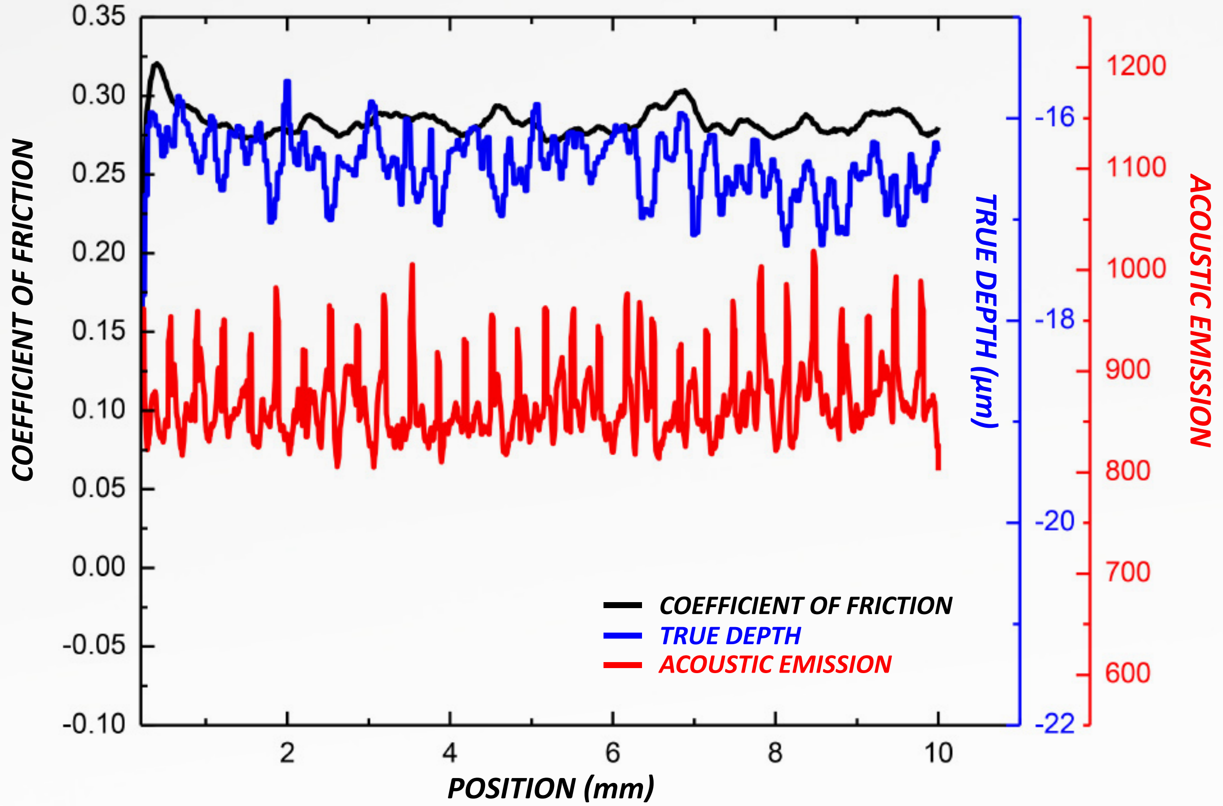


FIGURE 2: *The evolution of coefficient of friction, true depth and acoustic emissions during the scratch hardness test on Cu110.*

CONCLUSION

In this study, we showcased the capacity of the ***NANOVEA*** Mechanical Tester in performing scratch hardness tests in compliance to ASTM G171-03. In addition to coating adhesion and scratch resistance, the scratch test at a constant load provides an alternative simple solution for comparing the hardness of materials. In contrast to conventional scratch hardness testers, ***NANOVEA*** Mechanical Testers offer optional modules for monitoring the evolution of coefficient of friction, acoustic emission and true depth in situ.

The Nano and Micro modules of a ***NANOVEA*** Mechanical Tester include ISO and ASTM compliant indentation, scratch and wear tester modes, providing the widest and most user-friendly range of testing available in a single system. ***NANOVEA***'s unmatched range is an ideal solution for determining the full range of mechanical properties of thin or thick, soft or hard coatings, films and substrates, including hardness, Young’s modulus, fracture toughness, adhesion, wear resistance and many others.