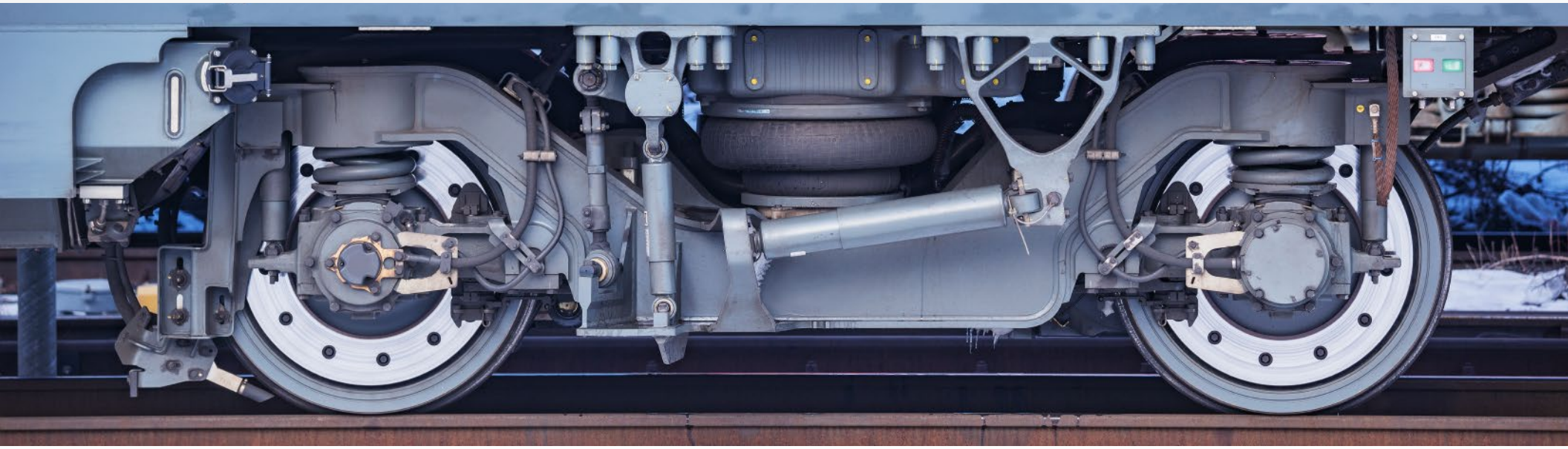
NANOVEA

HIGH TEMPERATURE SCRATCH HARDNESS

USING A TRIBOMETER



Prepared by

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INTRODUCTION

Hardness measures the resistance of materials to permanent or plastic deformation. Originally developed by a German mineralogist Friedrich Mohs in 1820, scratch hardness test determines the hardness of a material to scratches and abrasion due to friction from a sharp object[1]. The Mohs' scale is a comparative index rather than a linear scale, therefore a more accurate and qualitative scratch hardness measurement was developed as described in ASTM standard G171-03[2]. It measures the average width of the scratch created by a diamond stylus and calculates the scratch hardness number (HSP).

IMPORTANCE OF HARDNESS MEASUREMENT AT HIGH TEMPERATURES

Materials are selected based on the service requirements. For applications involving significant temperature changes and thermal gradients, it is critical to investigate the mechanical properties of materials at high temperatures to be fully aware of the mechanical limits. Materials, especially polymers, usually soften at high temperatures. A lot of mechanical failures are caused by creep deformation and thermal fatigue taking place only at elevated temperatures. Therefore, a reliable technique for measuring hardness at high temperatures is in need to ensure proper selection of the materials for high temperature applications.

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

2 *ASTM G171-03 (2009), "Standard Test Method for Scratch Hardness of Materials Using a Diamond Stylus"*

MEASUREMENT OBJECTIVE

*In this study, the **NANOVEA** T50 Tribometer measures scratch hardness of a Teflon sample at different temperatures from room temperature to 300°C.*

*The capability of performing high temperature scratch hardness measurement makes the **NANOVEA** Tribometer a versatile system for tribological and mechanical evaluations of materials for high temperature applications.*

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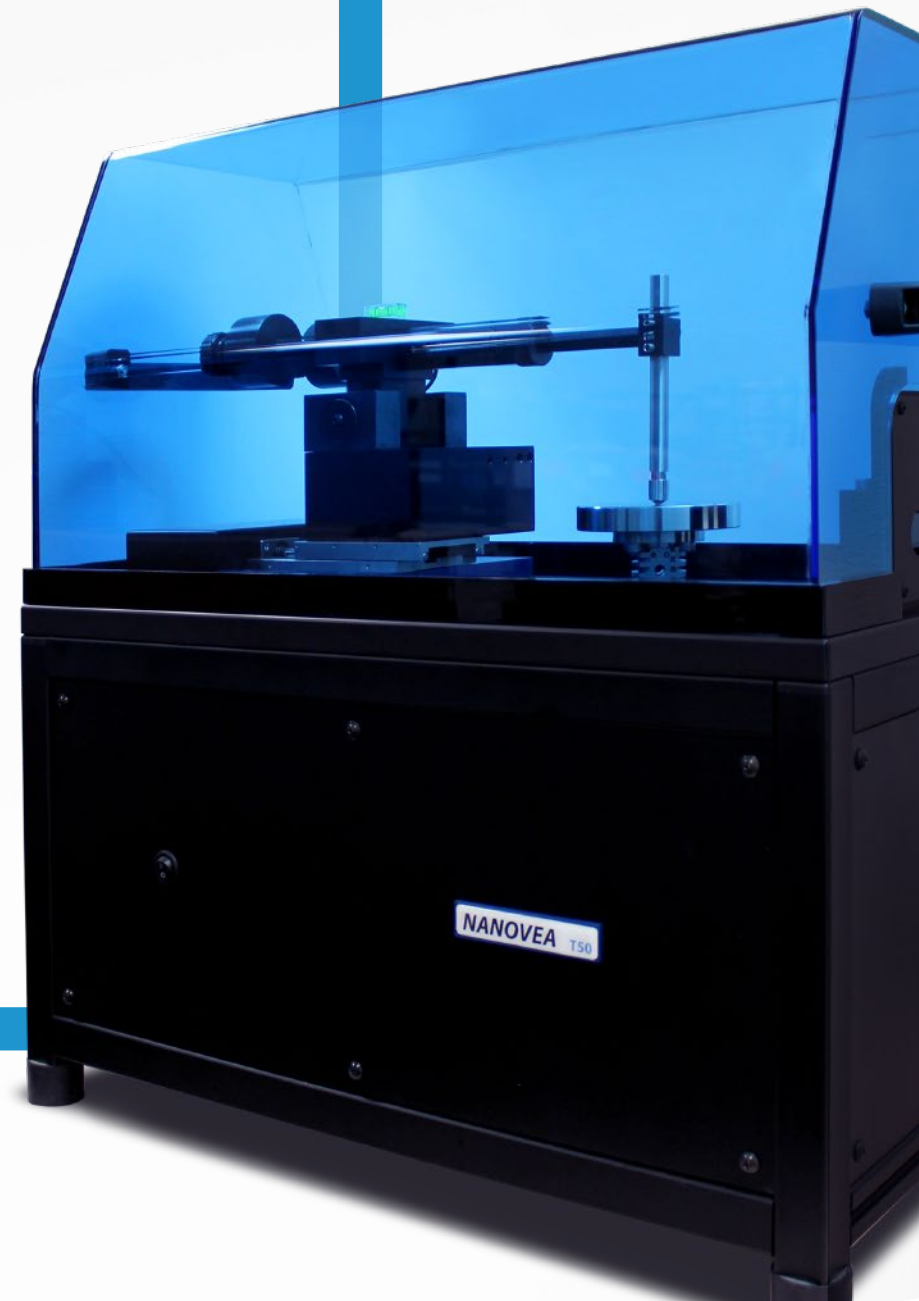
ABOUT THE INSTRUMENT

NANOVEA
T50



TEST CONDITIONS

The ***NANOVEA*** T50 Free Weight Standard Tribometer was used to perform the scratch hardness tests on a Teflon sample at temperatures ranging from room temperature (RT) to 300°C. Teflon has a melting point of 326.8°C. A conical diamond stylus of apex angle 120° with tip radius of 200 µm was used. The Teflon sample was fixed on the rotative sample stage with a distance of 10 mm to the stage center. The sample was heated up by an oven and tested at temperatures of RT, 50°C, 100°C, 150°C, 200°C, 250°C and 300°C.

TEST PARAMETERS

of the scratch hardness measurement.

NORMAL FORCE	***2 N***
SLIDING SPEED	***1 mm/s***
SLIDING DISTANCE	***8 mm per temp***
ATMOSPHERE	***Air***
TEMPERATURE	***RT, 50°C, 100°C, 150°C 200°C, 250°C, 300°C***

RESULTS & DISCUSSION

The scratch track profiles of the Teflon sample at different temperatures are shown in ***FIGURE 1*** in order to compare the scratch hardness at different elevated temperatures. The material pile-up on the scratch track edges forms as the stylus travels at a constant load of 2 N and ploughs into the Teflon sample, pushing and deforming the material in the scratch track to the side.

The scratch tracks were examined under the optical microscope as shown in ***FIGURE 2***. The measured scratch track widths and calculated scratch hardness numbers (HSP) are summarized and compared in ***FIGURE 3***. The scratch track width measured by the microscope is in agreement with that measured using the ***NANOVEA*** Profiler – the Teflon sample exhibits a wider scratch width at higher temperatures. Its scratch track width increases from 281 to 539 µm as the temperature elevates from RT to 300°C, resulting in decreased HSP from 65 to 18 MPa.

The scratch hardness at elevated temperatures can be measured with high precision and repeatability using the ***NANOVEA*** T50 Tribometer. It provides an alternative solution from other hardness measurements and makes ***NANOVEA*** Tribometers a more complete system for comprehensive high-temperature tribo-mechanical evaluations.

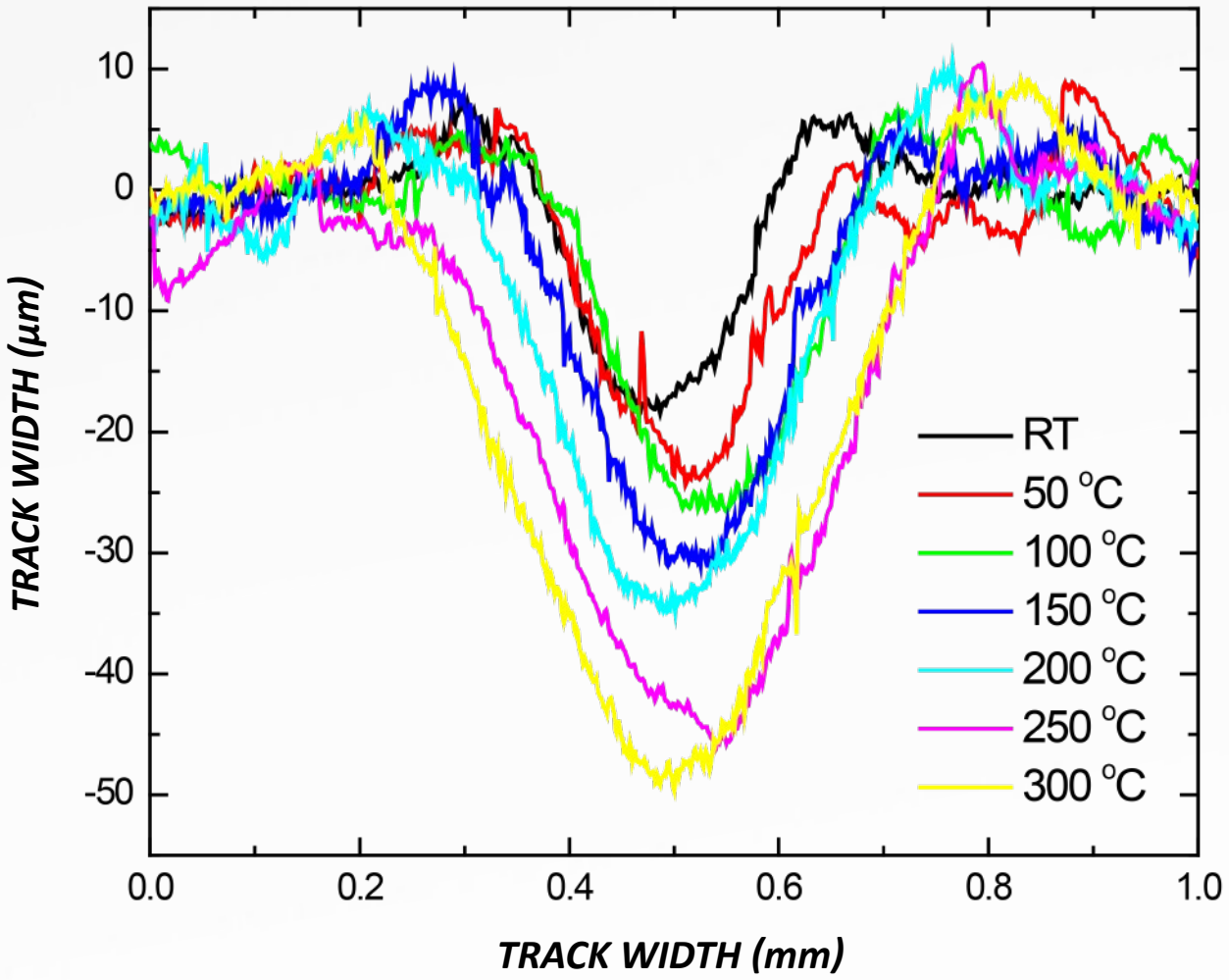
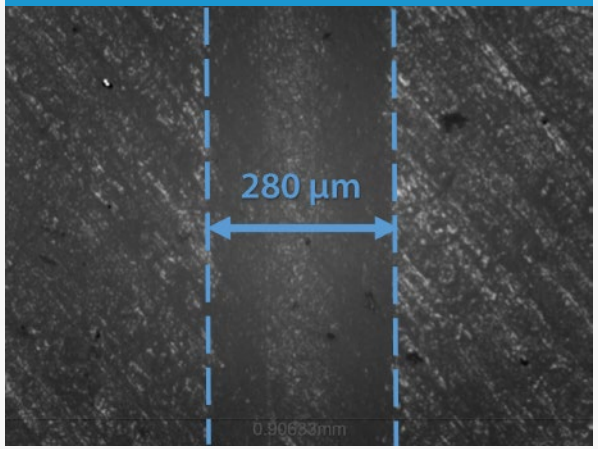
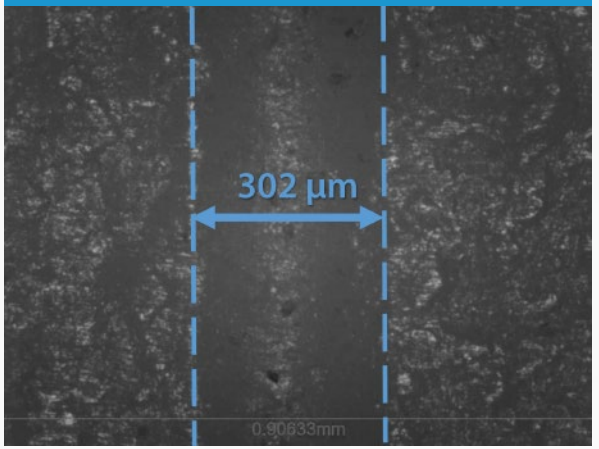


FIGURE 1: ***Scratch track profiles after the scratch hardness tests at different temperatures.***

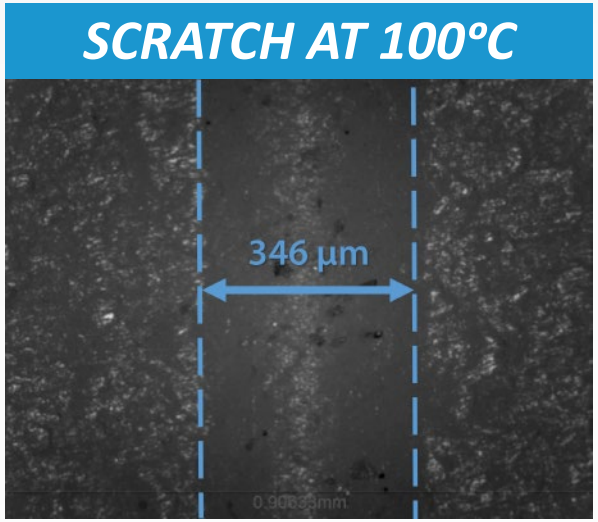
SCRATCH AT RT



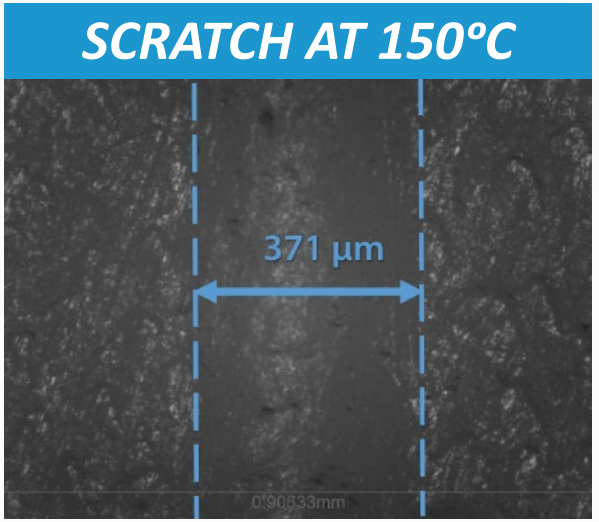
SCRATCH AT 50°C



SCRATCH AT 100°C



SCRATCH AT 150°C



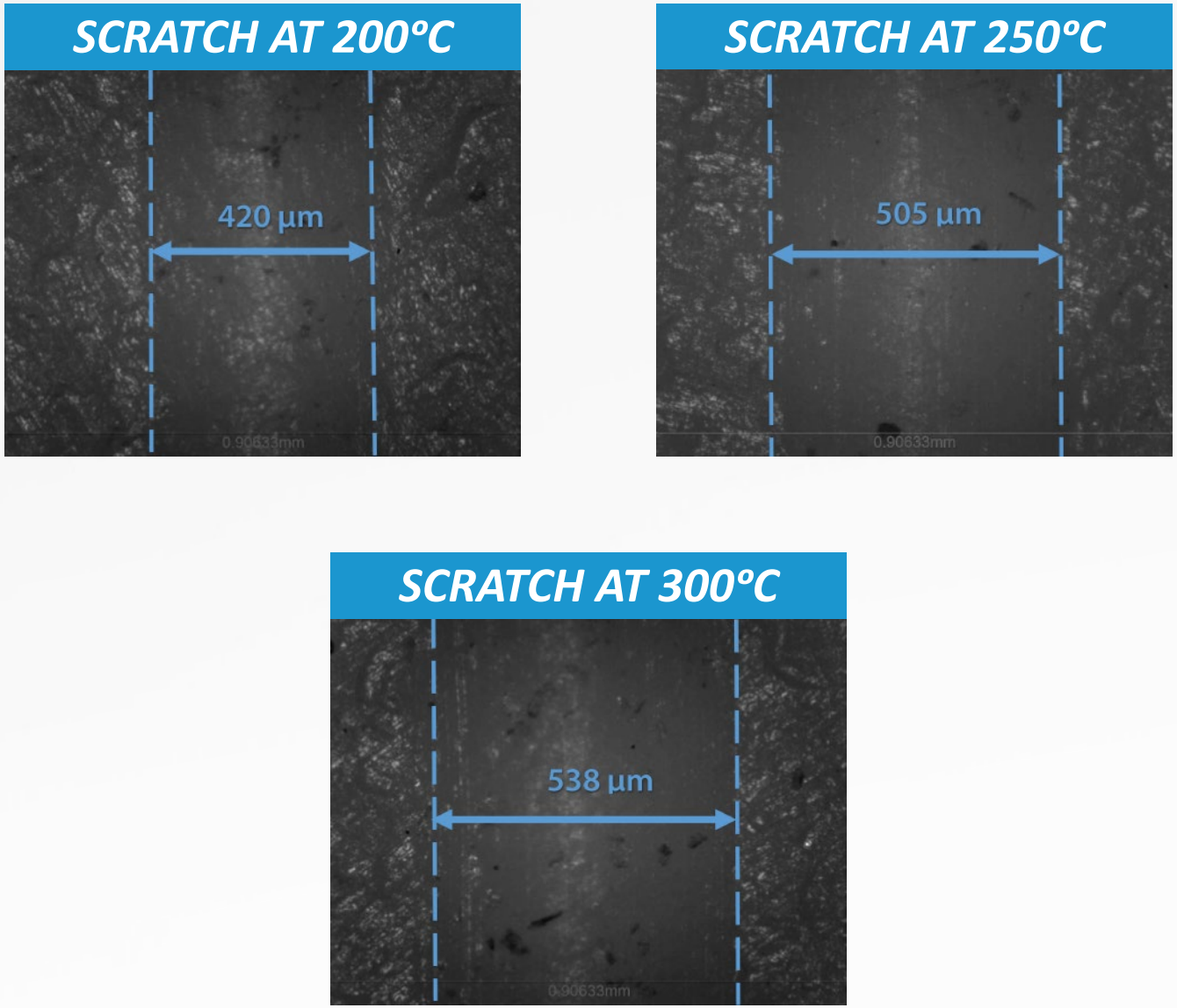


FIGURE 2: ***Scratch tracks under the microscope after the measurements at different temperatures.***

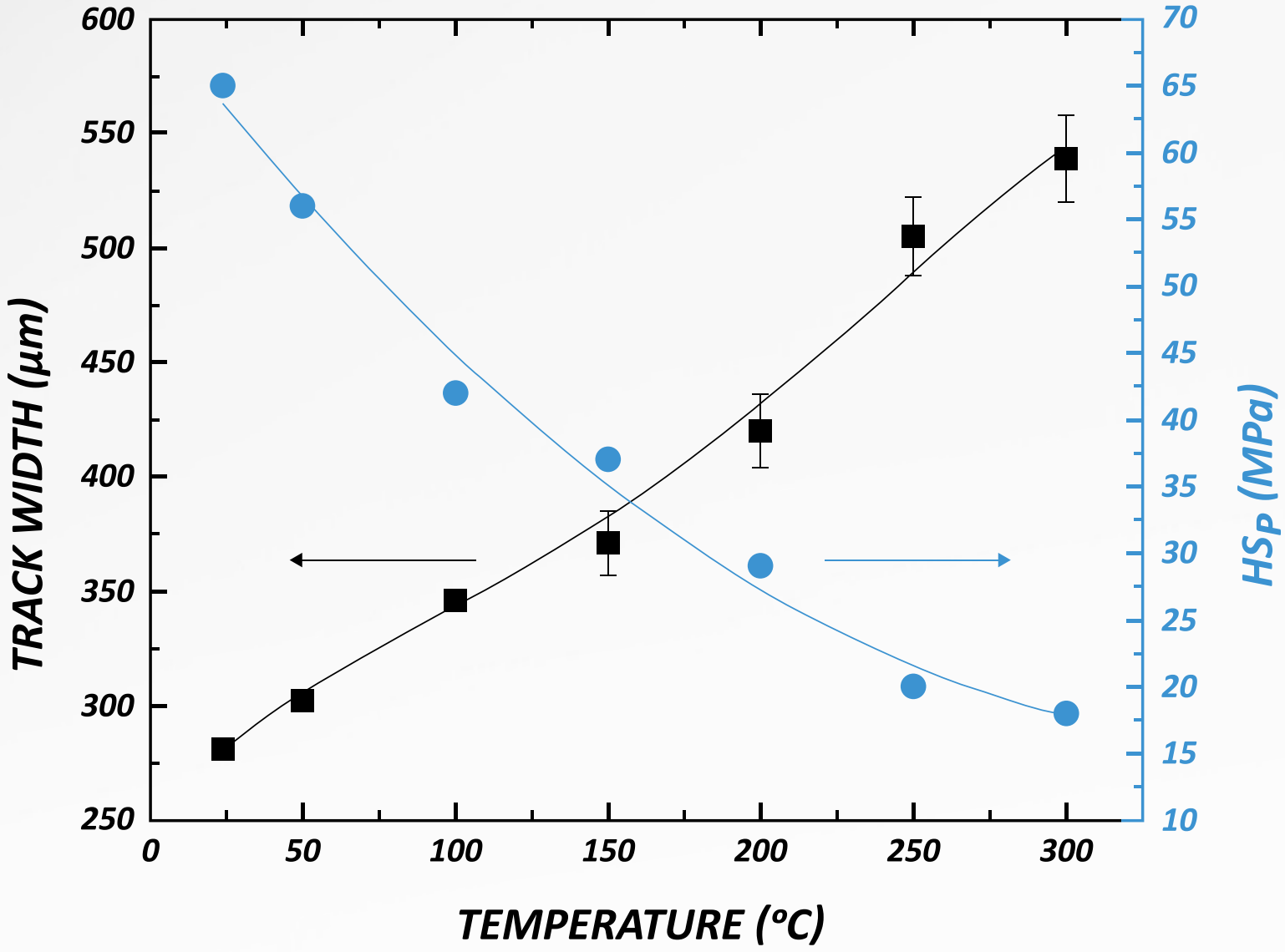


FIGURE 3: ***Evolution of the scratch track width and scratch hardness vs. the temperature.***

CONCLUSION

In this study, we showcase how the ***NANOVEA*** Tribometer measures the scratch hardness at elevated temperatures in compliance to ASTM G171-03. The scratch hardness test at a constant load provides an alternative simple solution for comparing the hardness of materials using the tribometer. The capacity of performing scratch hardness measurements at elevated temperatures makes the ***NANOVEA*** Tribometer an ideal tool for evaluating the high temperature tribo-mechanical properties of materials.

The ***NANOVEA*** Tribometer also offers precise and repeatable wear and friction testing using ISO and ASTM compliant rotative and linear modes, with optional high temperature wear, lubrication and tribo-corrosion modules available in one pre-integrated system. Optional 3D non-contact profiler is available for high resolution 3D imaging of wear tracks in addition to other surface measurements such as roughness.

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