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Achieving Ultra-Low Wear with Stable Nanocrystalline Alloys

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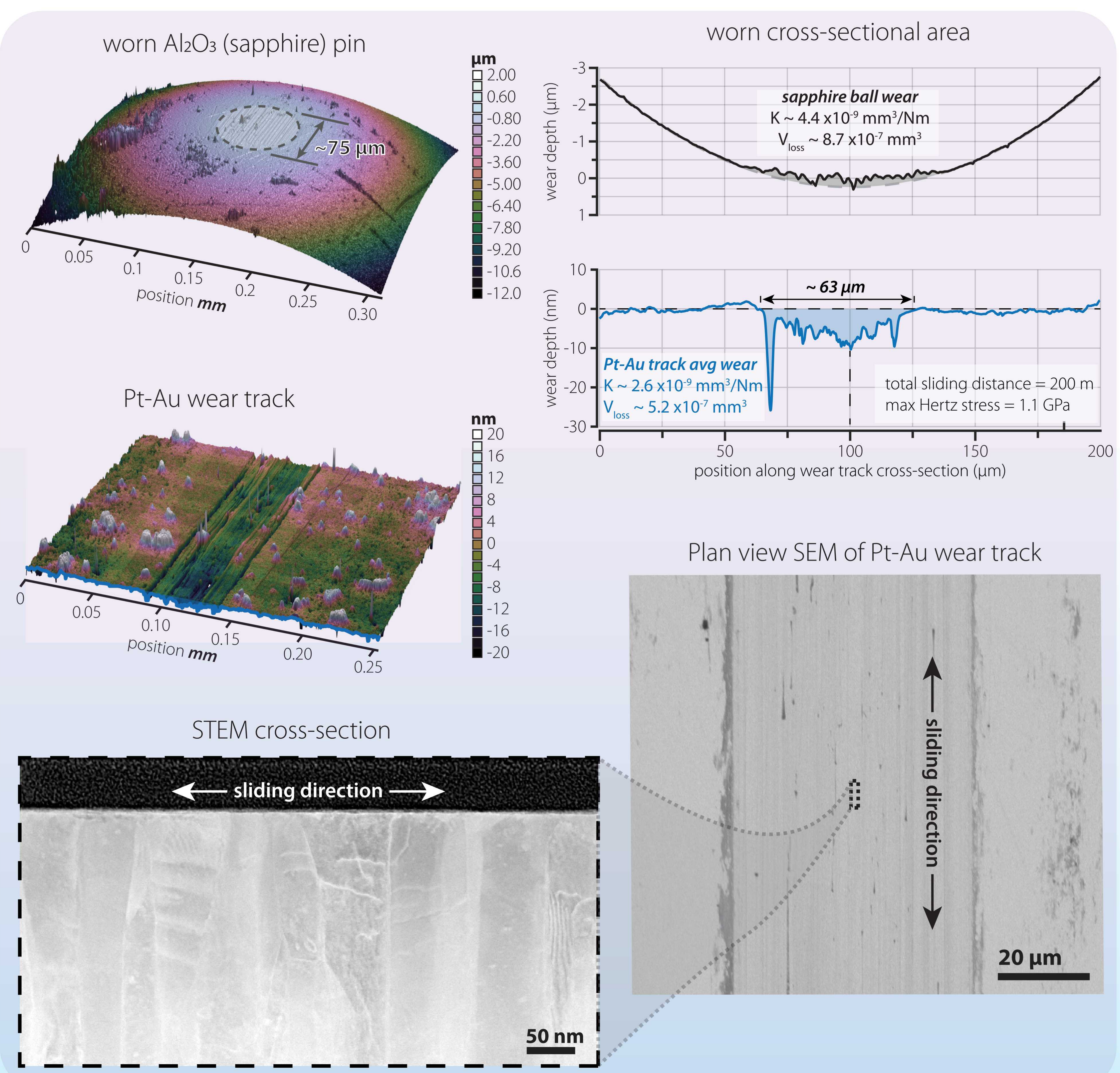
Abstract

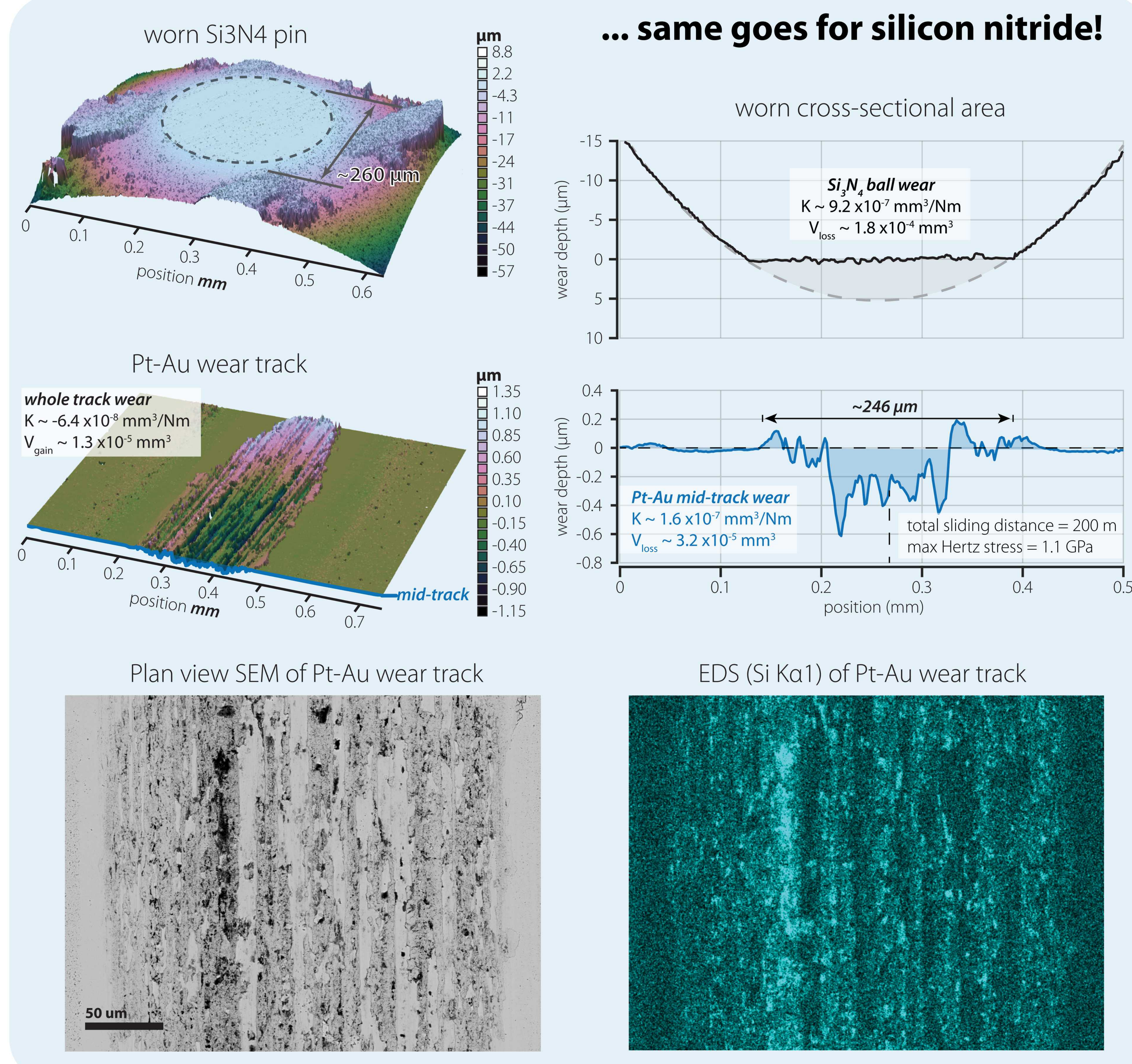
We show that Pt-Au, a proposed stable alloy consisting of two noble metals, exhibits extraordinary resistance to wear. Ultra-low wear rates, less than a monolayer of material removed per sliding pass, were measured for Pt-Au thin films at a maximum Hertz contact stress of up to 1.1 GPa. This is the first instance of an all-metallic material exhibiting a specific wear rate on the order of 10^{-9} mm^3/N-m, comparable to diamond-like carbon and sapphire. Remarkably, the wear rate of sapphire and silicon nitride probes used in wear experiments were either higher or comparable to that of the Pt-Au alloy, despite the substantially higher hardness of the ceramic probe materials.

Scissor Beats Rock

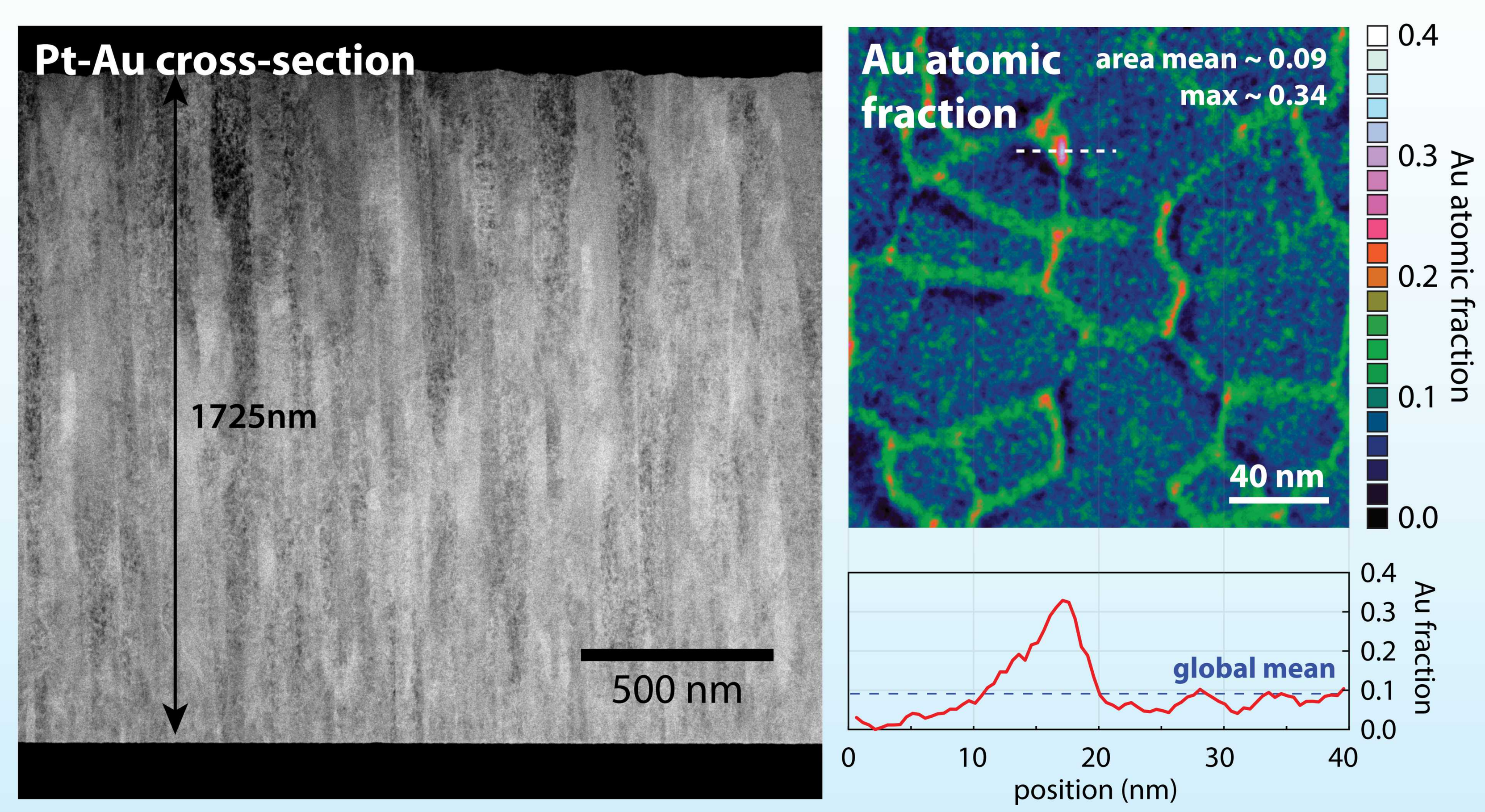
Remarkably, the wear rate of sapphire probes used in wear experiments were either higher or comparable to that of the Pt-Au alloy, despite the substantially higher hardness of the ceramic probe materials.



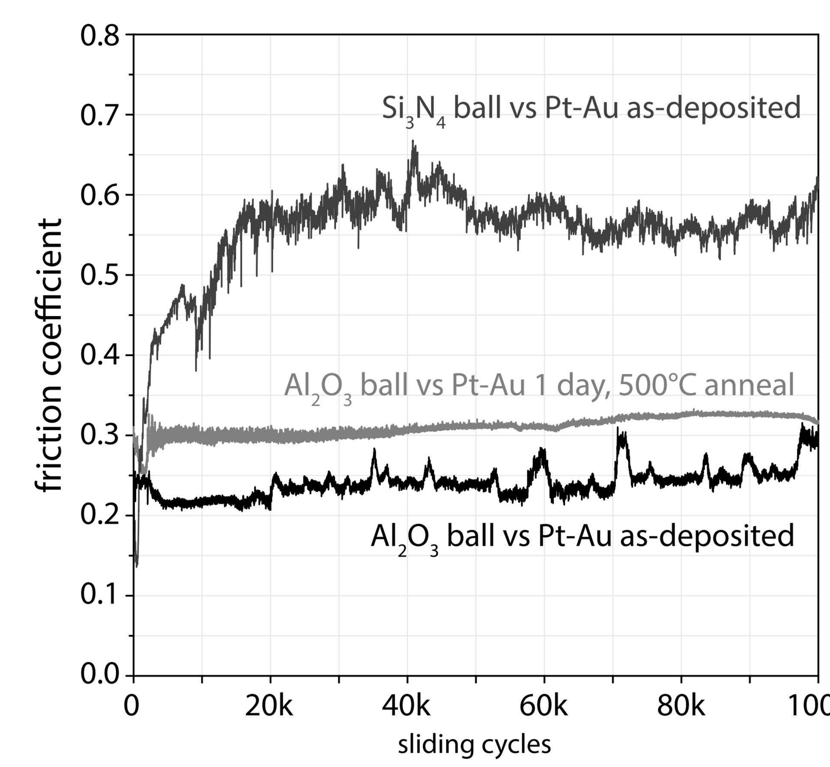
... same goes for silicon nitride!

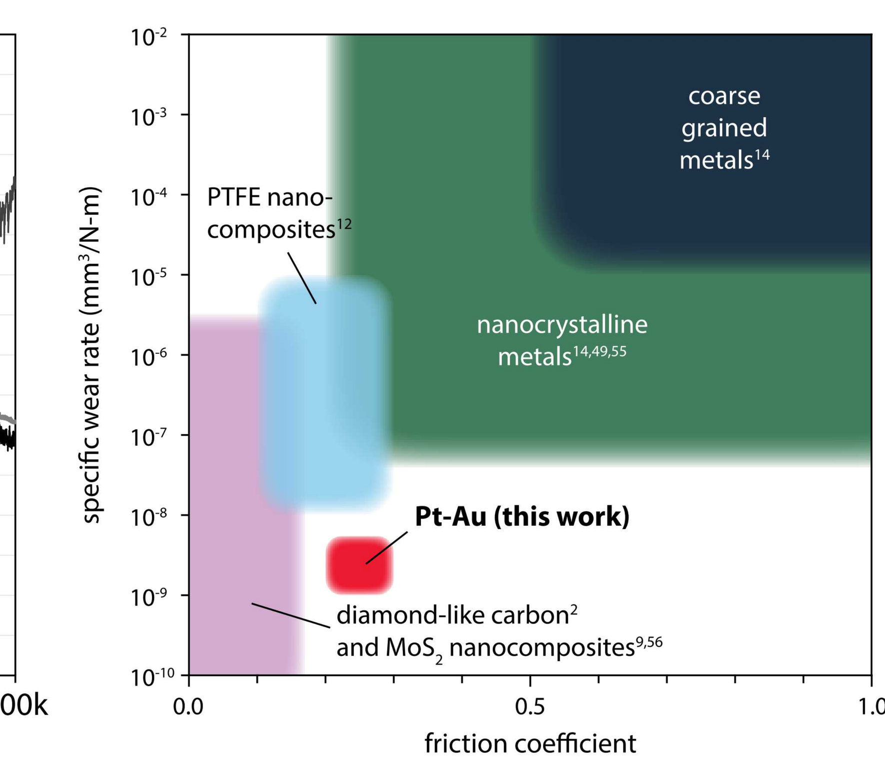


Pt-Au Structure & Composition

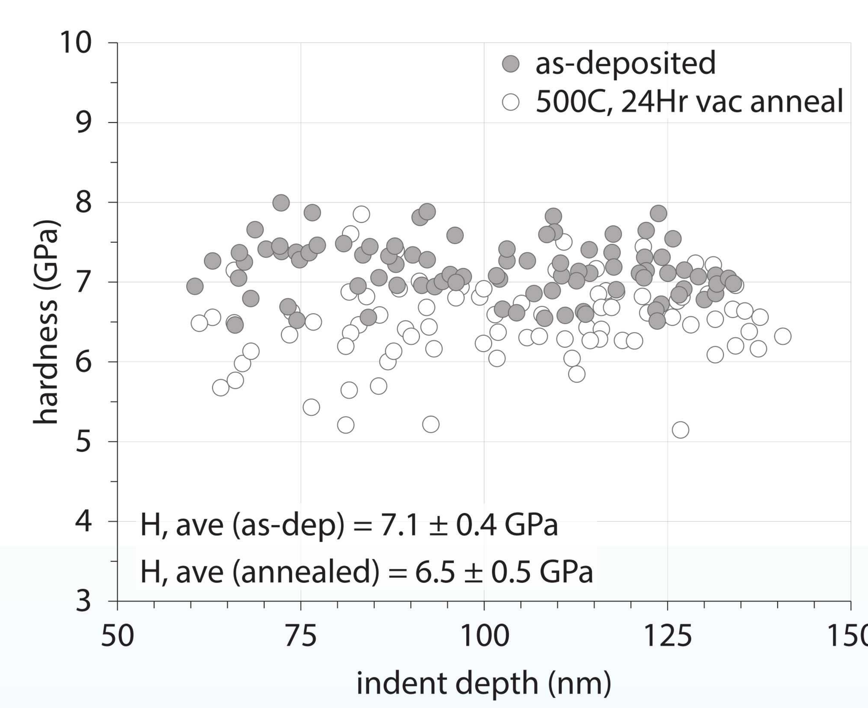


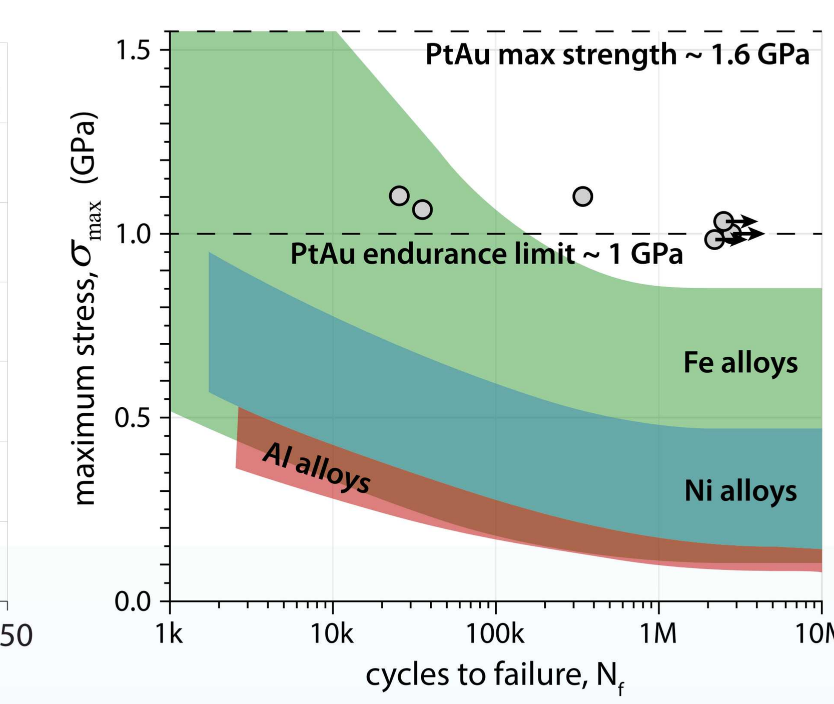
Friction & Wear Performance





The maximum Hertzian contact stresses of about 1.1 GPa in friction experiments are approximately equal to, or just below, the fatigue endurance limit of these Pt-Au films, and well below the measured nanoindentation hardness of 7.1 ± 0.4 GPa





Conclusion

Ultra-low wear rates on the order of 10^{-9} mm^3/N-m were measured for highly stable nanocrystalline Pt-Au thin films in lab air. The demonstration of a noble metal alloy with an extremely low wear rate in unlubricated sliding and extraordinary thermo-mechanical stability has far reaching implications, particularly in an electrical contact industry driven by increasing demand for greater efficiency in the use, storage and transmission of energy. This demonstration of fatigue resistance and high strength of a stable nanocrystalline alloy also suggests promising opportunities for this class of alloys as structural material.

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