Recent developments to measure surface mechanical properties at high temperature and high strain rate

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Abstract

Accurate measurement of surface mechanical properties is crucial for understanding the deformation mechanisms occurring at the micrometer or nanometer scale, on material surfaces and thin films. Current micromechanical tools, such as nanoindentation, micropillar compression, and microtension, effectively address this need and are now commonly used, especially at room temperature and deformation rates ranging from 10-^{3} s^{1} to 1 s-^{1}. Over the past years, significant advancements have been made to enable reliable micromechanical measurements at high temperature and high strain rates. These developments aim to assess surface mechanical properties under conditions that closely mimic those encountered in real-world industrial applications, and particularly under tribological loadings, in our case.
In this talk, the latest developments made to reliably measure the mechanical properties of surfaces and thin films at very high temperature and high strain rates will be presented. The first development concerns the "High Temperature Scanning Indentation" (HTSI) method (1). This technique enables continuous measurement of near-surface mechanical properties of materials through nanoindentation during a complete thermal cycle. By correlating hardness evolution with microstructural changes, it provides valuable insights into microstructural transformations occurring during thermal cycling- information that is often challenging to obtain with conventional characterization techniques (2–4).The second development focuses on the micro-shear technique. This technique consists in compressing micropillars with two notches machined at a 45○ angle relative to the loading direction to induce shear (5). Initially designed to mimic tribological loading conditions, this technique also proves highly effective at high strain rates due to its geometry. Notably, this geometry enables an increase of one order of magnitude in strain rate in comparison to conventional micropillar compression. Thus, our micromechanical system reliably extracts mechanical properties via micro-shear testing at deformation rates up to 10ˆ4 s-^{1}.

This talk will detail these two techniques and highlight recent applications on various materials. Finally, future development prospects will be discussed.

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