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Nanomechanical testing of thin films to 950 °C

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Nanomechanical testing has been a revolutionary technique in improving our fundamental understanding of the basis of mechanical properties of thin film systems and the importance of the nanoscale behaviour on their performance. However, nanomechanical tests are usually performed in ambient laboratory conditions even if the coatings being developed are expected to perform at high temperature in use. It is important to measure nanomechanical and tribological properties of materials under test conditions that are closer to their operating conditions where the results are more relevant. We can then better understand the links between properties and performance and design advanced materials systems for increasingly demanding applications. However, high temperature nanomechanics is highly challenging experimentally and a high level of instrument thermal stability is critical for reliable results. To achieve this stability the NanoTest Vantage has been designed with (i) active heating of the sample and the indenter (ii) horizontal loading to avoid convection at the displacement sensor (iii) patented stage design and thermal control method. By separately and actively heating and controlling the temperatures of both the indenter and test sample there is minimal/no thermal drift during the high temperature indentation and measurements can be performed as reliably as at room temperature. Illustrative results are presented for TiAlN, TiFeN, DLC and MAX-phase coatings. Above 500 °C it is necessary to use Argon purging to limit oxidation of samples and the diamond indenter, although the efficiency of this decreases over 750 °C. To test at higher temperatures without indenter or sample oxidation an ultra-low drift high temperature vacuum nanomechanics system (NanoTest Xtreme) has been recently developed. Results with the vacuum system are presented up to 950 °C.

Keywords
high temperature nanomechanics
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