

AN IN-SITU INDENTATION SYSTEM FOR HIGH DYNAMIC NANOMECHANICAL MEASUREMENTS

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Nanoindentation is typically confined to quasi-static strain rates of testing. This poster presents the development of an in-situ indenter designed to measure the response of materials at high strain rates and high oscillation frequencies at the nanoscale. This builds up on the previous work that was the first to report on in-situ nanoindentation in a SEM in 2004 which eventually resulted in the founding of the company Alemnis AG, today one of the key players in in-situ high temperature and high dynamic nanoindentation.

The motivation for variable strain rate studies is that this allows analysis of activation parameters of the physical deformation processes. Once the activation parameters are known, the deformation mechanism(s) can be determined and materials science approaches to improve materials performance can be developed. Ultra-high frequency nanoindentation enables high strain rate studies and high cycle fatigue tests that can be performed within reasonably short timespan.

Compared to other actuation principles, piezo actuators offers very fast response time and high force density and are compatible with vacuum environments. At the technological heart of this innovation is a transducer called "SmarTip" consisting of a diamond tip mounted on miniaturized and embedded three-axis piezo-actuators and sensors. The SmarTip allows a full range displacement of $1\mu\text{m}$ along the three axes and to measure forces up to 1N. The theoretical bandwidths are up to 10kHz and 40kHz for lateral and axial displacements respectively. We aim to reach strain rates as high as 10^5s^{-1} meaning that the speed of displacement must reach 60mm/s for a displacement of 600nm. With such high ambitions, several parameters have to be taken into consideration such as resonant frequencies of the indenter, self-heating and cabling inducing spurious capacitance. This poster will report on these design aspects, instrumentation and technique development in addition to presenting initial data on high strain rate and high cycle fatigue tests at the micron scale. It is hoped that the multi-axis capabilities of the SmarTip will result in additional breakthroughs for applications on nano-tribology, fretting and more generally on the translation of dynamic mechanical analysis (DMA) to the micro/nanoscale.

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