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in situ Force Measurements - the FIB/SEM as a Mechanical Characterization Tool

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Mechanically characterizing materials inside FIB/SEMs is a common task with a myriad of use cases in various fields of research.

In this work, the authors will present several examples of how in situ force measurements can be performed using different setups inside the FIB/SEM's chamber, thus utilizing the FIB/SEMs capability to modify, customize or otherwise prepare samples for testing as well as image samples from different angles for a more comprehensive set of images for later analysis.

Examples include bending FIB cut beams and comparing EBSD results obtained prior to and post bend (Fig. 1), flat punch experiments for elucidating forging properties of novel superalloys (Fig. 2), characterizing nanowires, CNTs, and other structures (Fig. 3), etc.

The described measurements are achieved using one of three setups: 1. Smallest forces - in the range of some nN - can be measured using self-sensing, piezo-resistive AFM cantilevers. 2. Another option is to utilize moveable sample holders with precisely calibrated spring constants. In this manner the deflection observed in the FIB/SEM can be used to calculate the applied force. By choosing from spring loaded sample holders with varying spring constants, a wider range of forces can be addressed. 3. Force transducers can be used to measure large forces up to several N.

Each approach has its own distinct use cases, advantages, and disadvantages. These will be discussed, as well.

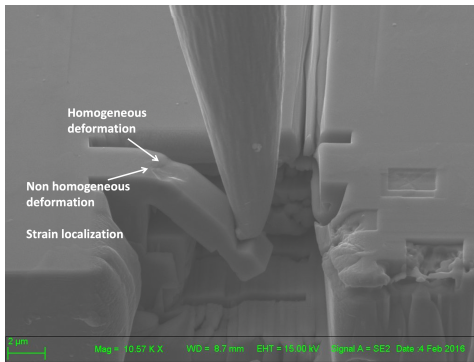


Fig. 1: FIB cut beam after bending failure (courtesy Archie, MPIE)

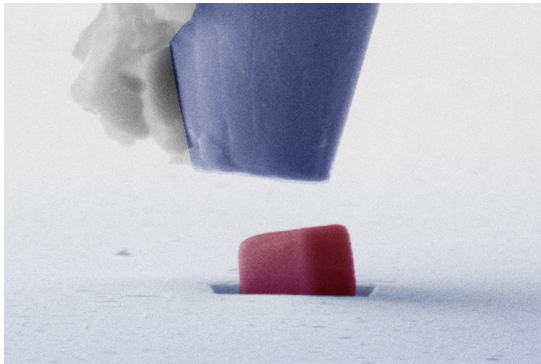


Fig. 2: Flat punch of a super alloy cube set in a FIB-cut base (courtesy Roesler, TU Braunschweig)

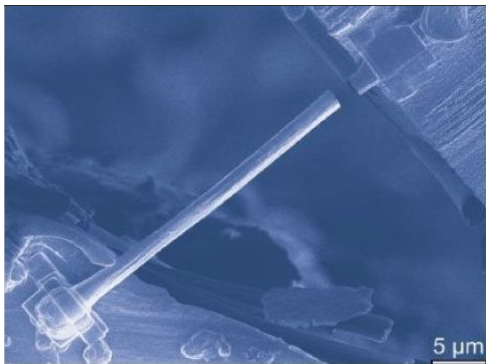


Fig. 3: Tensile test on a biological structure (courtesy Wegst, MPI Stuttgart)