In situ deformation observation via EBSD during high temperature tensile testing

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Abstract. Tensile testing is the backbone of mechanical characterization for materials science. The possibility to combine mechanical testing with advanced imaging and characterization methods and the option to operate at high temperatures up to 800°C opens a large variety of possibilities for materials research. In this work in situ annealing experiments are shown, where the grain growth is observed via EBSD over the course of the experiment. Different annealing states can be achieved and tested after cooling to room temperature. Using the EBSD information, high Schmid factor grains can easily be identified and monitored during the in situ tensile experiment and therefore even the first yielding grains are captured. Further in situ high temperature tensile tests on steel samples up to a temperature of 800 °C are presented. An example of a tested steel specimen is shown in Figure 1. Here, slip band formation is easily observable in BSD contrast. By enabling feature tracking, the chosen region of interest remains in the field of view and is imaged throughout the whole deformation process, enabling full automation of the whole experiment.

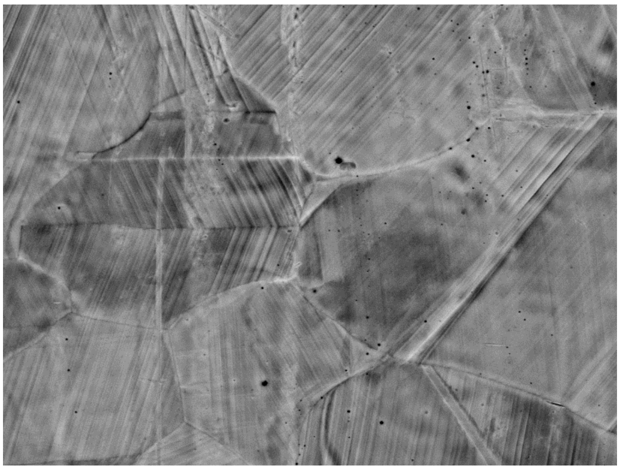

Figure 1: *Slip band formation in stainless steel during in situ experiment in BSD contrast*

In addition, investigations on TRIP (Transformation induced plasticity) steels are presented. In their pristine state, a certain amount of remaining austenite is present within the microstructure. By applying a mechanical load, the austenite tends to transform into martensite. This transformation process is closely captured by using the automated capabilities of the ZEISS In-situLab, where an EBSD map is taken after each deformation step, revealing the amount of remaining and already transformed austenite within each deformation interval. This unique insight offers the possibility to get the most information from a single experiment, since the whole deformation behavior is captured with just one investigation. By performing the experiments at different temperatures, the temperature dependency of the process is captured. Transformation rates can be calculated for the respective temperatures, revealing the overall transformation behavior.

Such experimental capability pave the way for high throughput material data collection to build up a database of microstructural characteristics in combination with macroscale material performance. This work describes a number of use cases demonstrating the new automated capabilities.