In situ TEM – Using state-of-the-art imaging approaches to follow mechanically and thermally induced processes in nanocrystalline metals and metallic glasses

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In situ transmission electron microscopy (TEM) techniques have developed tremendously during the last decade providing the possibility to use the full power of electron microscopy to follow the structural, chemical and morphological changes during reactions and processes, thus providing direct insight into the related mechanisms. In particular, thermally, electrochemically or mechanically induced transformations/reactions have been studied extensively with the advances of MEMS based *in situ* setups for electron microscopy. This has resulted in a significantly improved materials understanding. With this presentation, I will introduce some of our recent results to highlight the possibilities *in situ* TEM provides for understanding processes in nanocrystalline metals and metallic glasses focusing on crystallization, grain growth and segregation/precipitation phenomena. I will illustrate how *in-situ* TEM can be combined with ACOM-STEM, EFTEM or PDF analysis to quantitatively follow different aspects of these processes. As part of this, effects of the electron beam and the environment inside the TEM on *in situ* measurements, both in terms of structure, materials properties and kinetics, will be critically discussed.

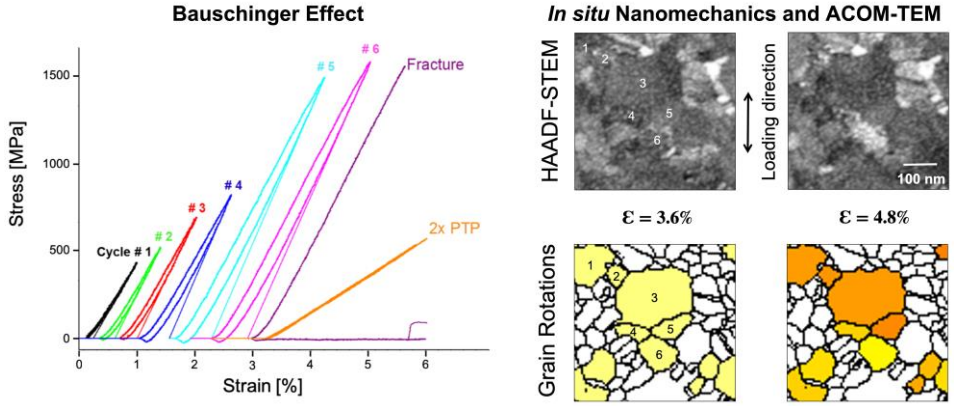

Figure 1: *In-situ* mechanical testing of nanocrystalline Pd: mechanical response indicating a strong Bauschinger effect and successive (partially) reversible grain rotation in response to the mechanical deformation.

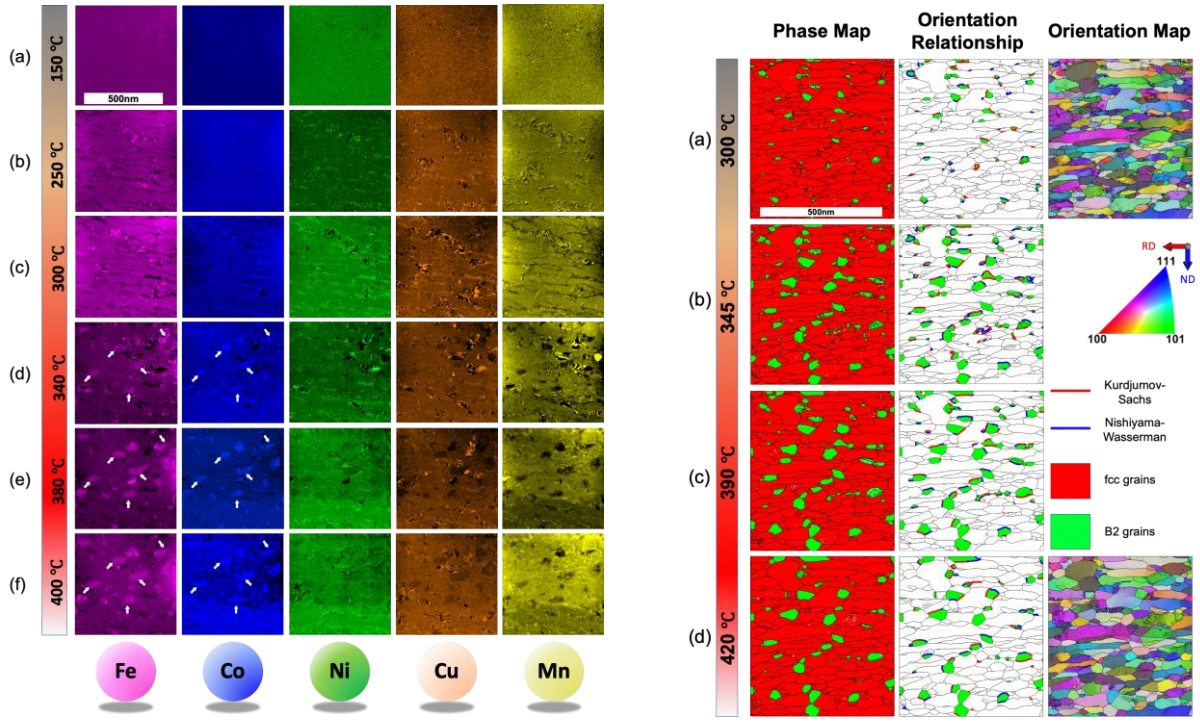

Figure 2: *In-situ* TEM annealing of a HPT-deformed HEA: EFTEM-SI analysis of the complex segregation of precipitation process and ACOM-STEM analysis of the corresponding crystallographic changes.