# In situ experiments across real and reciprocal space aided by crystal plasticity simulations

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## Abstract

Design and development of new metallic materials and processes for various engineering applications involve understanding the effect of structure and microstructure on their mechanical properties and the underlying deformation and damage micro-mechanisms. In situ or in operando experiments offer a direct evidence of operative micro-mechanisms during thermomechanical treatment that have traditionally been deciphered by post mortem characterization. Different micro-mechanisms of deformation in crystalline metals and alloys leave a trail by altering the structure and/or microstructure and this has been monitored using diffraction and microscopy respectively. Therefore, in situ deformation experiments have focused on carrying out thermo-mechanical testing with simultaneous microscopy and diffraction using visible radiation in optical microscope or electrons in a scanning and transmission electron microscope as well as X-ray, synchrotron or neutron radiation in diffraction experiments.

In situ electron backscatter diffraction experiments provide real time data in the real and reciprocal space to provide in depth information about micro-mechanisms of deformation. The effect of initial texture on anisotropic commercially pure titanium, aerospace grade Ti6Al4V and aluminium magnesium silicon alloy have been investigated to develop fundamental understanding of processes operative for monotonic, reverse and cyclic loading as well as recrystallization. A fundamental understanding of twinning which is an additional shear mechanism in deformation of hexagonal close packed titanium that plays an important role in strain hardening and failure was developed. Similarly the effect of precipitate dislocation interaction in strain hardening response of aluminium magnesium silicon alloy was fully established in monotonic loading and load reversal. In situ EBSD experiments were complimented with synchrotron diffraction and coupled with mean field and full field crystal plasticity simulations to develop a fundamental understanding of deformation and build comprehensive modelling schemes to cut down on further experiments thus establishing the dexterity of high throughput in situ experiments combined with crystal plasticity simulations for rapid process and material development.