I*n-situ* and 3D HR-EBSD techniques to assess deformation mechanism of materials at small scale.

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Understanding deformation mechanisms of materials at the sub-micron scale requires advance characterization techniques capable of measuring microstructural changes, strains, stresses and lattice defects evolution during deformation. High angular resolution electron backscatter diffraction technique (HR-EBSD), coupled with SEM *in-situ* mechanical testing using a nanoindenter, is capable of characterizing all these features with a sub-100nm resolution, at successive deformation steps and while the material is under load, making it ideal to study small-scale mechanics. However, HR-EBSD is a near surface technique, where only the first few tens of nm are probed underneath the surface, which may not be characteristic of the entire volume of the materials. 3D HR-EBSD technique using FIB tomography has been developed to answer this issue and to characterize the crystal defect and residual stress distributions in the deformed materials with a sub-100nm^3 voxel resolution. We applied this combination of techniques to study crystal orientation and strain rate effects in deformation twinning mechanisms in magnesium. The result show the importance of the activation of specific type of dislocation for the twin initiation and propagation mechanisms. We also apply this combination of techniques to study fracture mechanics and plasticity in semi-brittle bcc refractory metals.

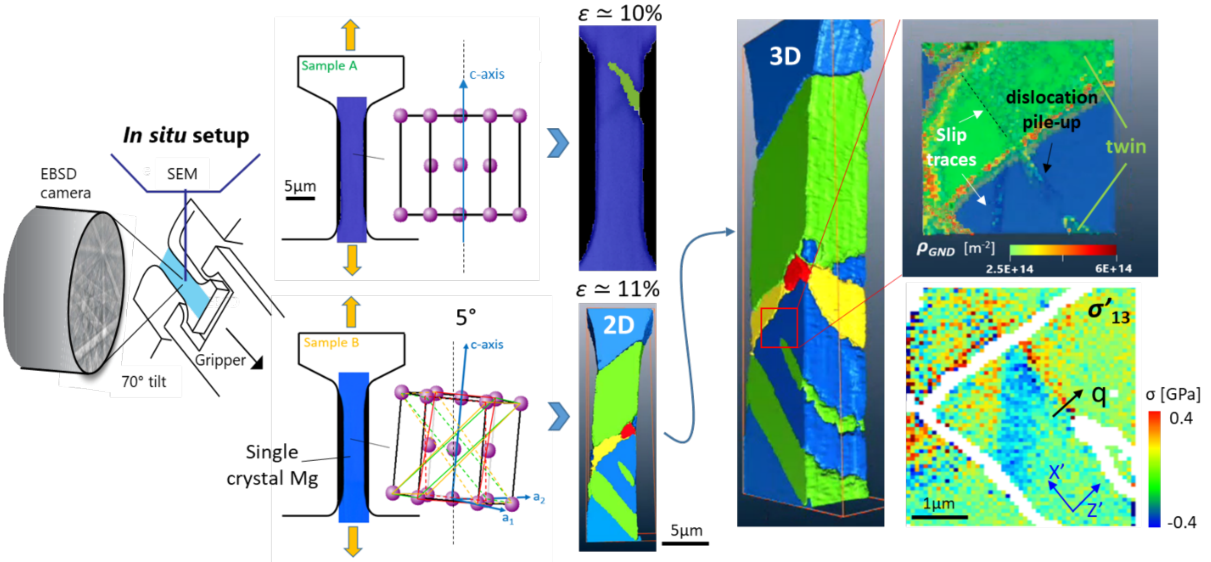

Fig: In-situ tensile tests of two single crystal magnesium micron-scale T-bars with different orientations. 3D HR-EBSD reconstruction of one of the deformed T-bars showing extensive twin formation. GNDs and shear stress maps (here in the invariant twin plane) can be extracted from the middle of the deformed structure (modified from Della Ventura et al. 2021, Materials & Design; https://doi.org/10.1016/j.matdes.2020.109206).

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