DEFORMATION TWINNING IN Cr_2AlC MAX PHASE SINGLE CRYSTALS: A NANOMECHANICAL TESTING STUDY

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In a recent study [1], we observed and characterized for the first time deformation twinning in the Ti_2AlN MAX phase deformed at high temperature (800°C) by Berkovich nanoindentation. Since plastic deformation in these nanolayered materials was believed to be governed only by basal plane dislocations involved in kink band mechanisms, this result has shed a new light on the mechanical behavior of MAX phases. In order to go further in the understanding of twinning deformation mechanisms in MAX phases, we performed a study in Cr_2AlC single crystal, deformed at room temperature by spherical nanoindentation and by micropillar compression tests, in such an orientation that the basal plane was edge on, to inhibit basal dislocations and to promote twinning. The deformation microstructure has been analyzed by combining observations at the surface by Atomic Force Microscopy (AFM) and in the volume by Transmission Electron Microscopy (TEM) performed on thin foils prepared by Focussed Ion Beam in cross section through the indents (cf. fig. 1). Localized and isolated $\{11\bar{2}4\}$ deformation twins have been observed below the indents, and characterized by Automated Crystal Orientation Mapping in the TEM. The combination of AFM surface observation, TEM characterization and ACOM ASTAR orientation maps in a same region has provided a full 3D characterization of these twins. The TEM observations also revealed original dislocation structures with cross slip in a $(1\bar{1}03)$ plane initiated at a $\{11\bar{2}4\}$ twin boundary.

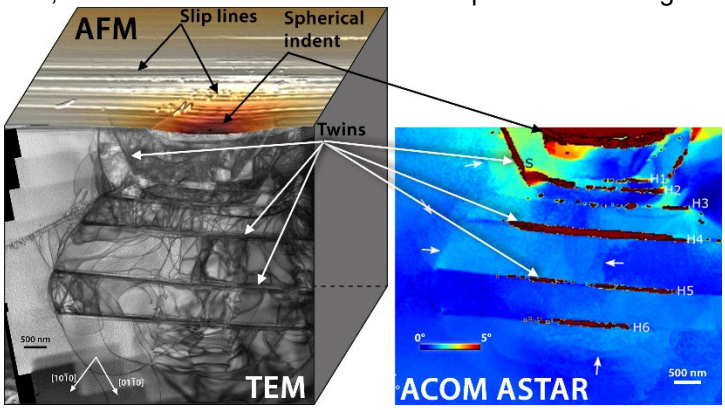

Fig. 1: Spherical indent in Cr_2AlC observed by AFM and TEM (left side) and corresponding ACOM ASTAR misorientation map (right side) revealing $\{11\bar{2}4\}$

These results have been confirmed by micropillar compression test performed in situ in a scanning electron microscope (SEM) followed by EBSD analysis of the local misorientation generated through the deformation twins and by TEM analysis in thin foils extracted from the deformed micropillars (cf. fig 2).

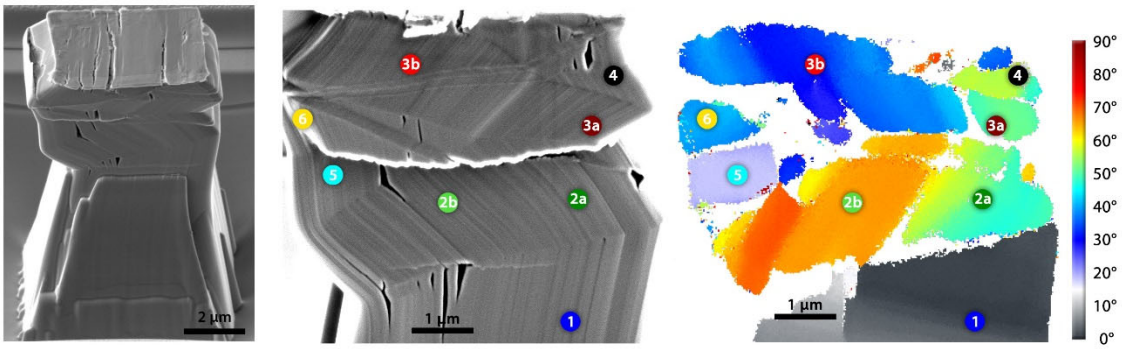

Fig. 2: Micropillar compression test in Cr_2AlC (basal plane edge on), and corresponding EBSD misorientation

[1] C. Tromas, S. Parent, W. Sylvain, L. Thilly, G. Renou, C. Zehnder, S. Schröders, S. Korte-Kerzel, A. Joulain, Nanoindentation-induced deformation twinning in MAX phase Ti2AlN, Acta Materialia. 227 (2022) 117665.