Twinning is a very important deformation mechanism in hexagonal metals, such as magnesium. The most commonly observed twin is {10-12} type twin, followed by {10-11} type twin, depending on the direction of stress. {10-11} type twin is often followed by a re-twinning of {10-12} type, forming a double twin, which also leads to fracture. Complex interactions between dislocation slip and twins occur in hexagonal systems. Nucleation of twins is also a subject of intense investigations. Atomistic simulations show that nucleation of {10-12} twins most likely occur on grain boundaries, especially with low angle misorientations [1]. In the present work twin-dislocation interactions and twin nucleation have been examined in a deformed Mg-Zn alloy.

An extruded Mg-2.4at%Zn alloy with grain size of 1-3μm was fractured by three-point bending test. A specimen below the crack surface was sampled by focused ion beam technique, and studied by a JEOL 4000EX transmission electron microscope, operated at 400 kV. Complex structure of twinning and slip was observed beneath the crack surface. Relatively away from the surface, an array of {10-11} type twins was observed, with width of about 200 nm. Diffraction contrast showed extensive basal and prismatic slips. Dislocation pile-ups occurred on the twin boundaries. Twins re-twinning to form {10-11}-{10-12} double twins. Repeated twinning with the help of slip activity led to finer twin domains, with final sizes of about 50 nm, whose boundaries were no longer planar. Three domains A, B and C related by double twinning are shown in Fig. 1. Basal slip activity in B, and its interaction with B-C twin boundary is observed.

Nucleation of twinning was observed on single tilt grain boundaries (STGB), such as in Fig. 2. Grains P and Q are tilted about 24-29° about <11-20> zone axis. An array of dislocations forming a 2° low sub-boundary (at Q’) interacts with the STGB, creating a twin nucleus N, which makes a {10-11} type twin with the matrix grain Q. This nucleation process is an experimental example of that shown for {10-12} twin by simulation [1]. An array of {10-11} type nano-sized twins of less than 50 nm in size was observed in the matrix with high level of basal and prismatic slip activity [2]. These are first examples of nucleation of {10-11} type twins, mediated by dislocations. These dislocation-twins interactions and nucleation of twins will be described and discussed in the presentation.

References:

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Fig. 1: Nano-domains related by twinning, all oriented along a <11-20> zone axis. Lines on basal planes are drawn. A and B are related by (10-12) type twinning (ideal angle 86°). B and C are related by (10-11) twinning (ideal angle 56°). B and D are related by (10-12) twinning. A 16° boundary exists between C and E. A-B-C make a double twin.

Fig. 2: Nucleus N of a twin on single tilt grain boundary between grains P and Q. All are oriented along a <11-20> zone axis. A array or a pile-up of dislocations is observed at Q'.