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In-situ X-ray Diffraction Studies on Age Hardening of Mg alloys

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Precipitates influence the relative hardening of slip and twin in magnesium alloys. The current work employs in-situ synchrotron X-ray diffraction to investigate the role of precipitate shape (e.g. plates and spherical precipitates) on the strengthening of Mg alloys. The critical resolved shear stresses (CRSS's) of dislocation slip and deformation twinning and the subsequent changes following aging are evaluated during uniaxial compression deformation. By application of a high-angular resolution diffraction experiment, the effect of precipitates on the age hardening is investigated based on the lattice strain response of the precipitate and bulk Mg matrix phase.

In this study, wrought Mg AZ91 and Mg-Sn-Zn-Na (MSZN) alloys were aged at 200C for ~12 h to produce basal plate and near spherical precipitates. In-situ compression tests were performed in the twin dominated strain paths – compression along the rolling direction in case of rolled AZ91 alloy and compression along the extrusion direction in case of extruded MSZN alloy. Based on the in-situ measurement of the lattice strain evolution with load, the CRSS for basal slip was determined. It was observed that the strengthening of basal slip is low (~5 MPa) in case of basal plate precipitates in agreement with literature, and the spherical precipitates strengthened the basal slip by ~15 MPa. The CRSS for deformation twinning was calculated from the drop in the intensity of parent grains. In the case of basal plate and spherical precipitates, the twins are hardened in the range of 30 – 35 MPa, despite the differences in the precipitate morphology and their elastic lattice strain changes in response to the applied deformation. By application of line profile analysis methods, the apparent area weighted twin size and dislocation density during twin onset was determined.

Primary author(s) : KADA, Sitarama R.; Dr LYNCH, Peter (Deakin University); B. MOTLAGH, Ehsan (PhD candidate, Institute for Frontier Materials (IFM), Deakin University, Australia); Dr ARMSTRONG, Nicholas (Defence Science and Technology); KIMPTON, J. A. (Australian Synchrotron); Prof. BARNETT, Matthew R. (Deakin University)

Presenter(s) : KADA, Sitarama R.

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