ON THE MECHANISTIC ORIGIN OF THE ENHANCED STRENGTH AND DUCTILITY IN RARE EARTH BASED MG ALLOYS

Henry Ovri, Institute of Materials Research, Helmholtz Zentrum hereon, Geesthacht, Germany
henry.ovri@hereon.de
Jürgen Markmann, Institute of Materials Research, Helmholtz Zentrum hereon, Geesthacht, Germany
Hajo Dieringa, Institute of Material and Process Design, Helmholtz Zentrum hereon, Geesthacht, Germany
Erica T. Lilleodden, Institute of Materials Research, Helmholtz Zentrum hereon, Geesthacht, Germany

Key Words: short range order, ductility, magnesium alloys, microcompression, STEM

The applicability of classical wrought Mg alloys is limited by their comparatively poor room temperature ductility and low yield strength. Conversely, various experimental and computational efforts do confirm that low concentrations of rare earth (RE) in Mg significantly improves these properties. However, the mechanistic origin of these improvements are still been debated. In order to contribute to the discourse, we carried out in-depth comparison of deformation modes in single crystals of pure Mg and a homogenized Mg–0.75 at.% Gd alloy oriented for twinning, pyramidal- and basal-slip using a combination of microcompression testing, scanning transmission electron microscopy and small angle x-ray scattering technique. We observed a fivefold increase in basal CRSS and a fourfold decrease of the pyramidal/basal CRSS (P/B) ratio as a result of Gd addition. We also observed that slip was planar in the basal orientation of the alloy but wavy in pure Mg. Pyramidal slip and twinning activity in the two systems were however similar; an indication that the same mechanisms underlie deformation in these orientation. We show that the observed planar slip, increase in basal CRSS and decrease in P/B ratio are consequence of Gd-rich short-range ordered (SRO) clusters in the alloy. Our analysis show that these SRO clusters lead to significantly high strengths in the basal orientation since additional stress is required to destroy the ordering therein. This not only leads to a dramatic increase in yield strength, given the drastic reduction in P/B CRSS ratio, it should also significantly promote pyramidal slip activities in polycrystals and by extension ductility improvements.