Dynamic recrystallization and mechanical behavior of Mg alloy AZ31: Constraints from tensile tests with in-situ EBSD analysis

Gaetan Boissonneau[1], Maurine Montagnat[2], Andrea Tommasi*[1], Marco Antonio López Sánchez[3], and Fabrice Barou[1]

[1]Géosciences Montpellier – Institut National des Sciences de l'Univers, Centre National de la Recherche Scientifique, Université des Antilles, Université de Montpellier – France

[2]Institut des Géosciences de l'Environnement – Institut de Recherche pour le Développement, Institut National des Sciences de l'Univers, Centre National de la Recherche Scientifique, Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement, Université Grenoble Alpes, Institut polytechnique de Grenoble - Grenoble Institute of Technology, Institut Polytechnique de Grenoble - Grenoble Institute of Technology – France

[3]Universidad de Oviedo [Oviedo] – Spain

Abstract

We conducted tensile tests on AZ31 samples with in-situ SEM-EBSD acquisition at 250∘C and 10-3 s-1 to study the evolution of dynamic recrystallization and its effect on the mechanical behavior. To investigate the entire deformation range up to failure, at 65-67% engineering strain, stepwise experiments were conducted with in-situ EBSD acquisition at 2-5% strain intervals and re-polishing of the samples at 15% strain intervals. All experiments show a consistent mechanical behavior characterized by a transition from hardening to quasi-steady state at _˜10% strain, followed by softening for strains greater than 35%. The bulk intragranular misorientation, quantified by the mean kernel average misorientation, increases steadily. Analysis of the EBSD maps shows that the quasi-steady state is associated with dominant dislocation reorganization (polygonization), whereas the onset of softening is linked to a net and continuous increase in the recrystallized fraction. In situ EBSD mapping documents the local discontinuous nature of continuous dynamic recrystallization: (1) nucleation of strain-free grains by bulging and subgrain rotation, (2) grain growth, (3) re-accumulation of dislocations substructures and formation of new nuclei. Analysis of the textures shows that dynamic recrystallization changes significantly the texture evolution relative to that predicted by a viscoplastic self-consistent simulation without recrystallization: the texture is dispersed rather than strengthened and its rotation rate is slower. Comparison between the mechanical behavior observed in the experiments, to that predicted by VPSC for a monotonic traction test, and with instantaneous tensional stresses predicted using VPSC for the textures measured at different strains documents that geometrical weakening due to slower texture evolution in the experiments could explain the quasi steady-state bulk mechanical behavior, but not the softening observed for strains > 35%, which requires microstructural (dislocation-related) softening.

*Speaker

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