A multiscale, multimodal approach to studying static recrystallization in Mg-3Zn-0.1Ca

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High-strength lightweight magnesium (Mg) alloys have substantial potential for reducing the weight of automobiles and other transportation systems and, thus, for improving fuel economy and reducing emissions. However, compared to other structural metals, the development of commercial Mg alloys and our understanding of Mg alloy physical metallurgy are less mature, and enabling the widespread use of Mg alloys requires significant improvement in strength, fatigue, and formability. The low formability of Mg alloy sheet is due to its strong basal texture in the rolling direction. The addition of Ca and rare earth elements can result in a desired weaker texture. However, despite numerous studies, the mechanisms by which this texture reduction occurs remains unknown, and it is likely that several different mechanisms occur simultaneously or sequentially. This is the topic of this research.

A Mg-3Zn-0.1Ca alloy was deformed under hot plane-strain compression and samples were subjected to annealing on ID3A on ID3A at the Cornell High Energy Syncrhotron Source (CHESS) and ID06 at the European Synchrotron Radiation Facility (ESRF). In-situ far-field and near-field high-energy diffraction microscopy (ff- and nf-HEDM) characterization was performed at CHESS, and in-situ partial intermediate-field HEDM (if-HEDM) and dark-field X-ray microscopy (DFXM) was performed on ID06 at the ESRF. By combining the different modalities, we were able to characterize the microstructure evolution during annealing on different length scales, from the subgrain morphology of individual grains (using DFXM) to the aggregate behavior of several thousands of grains (using HEDM). Fig. 1 shows the different length scales represented in the raw data, and Fig. 2 illustrates the evolution of this data during the annealing process.

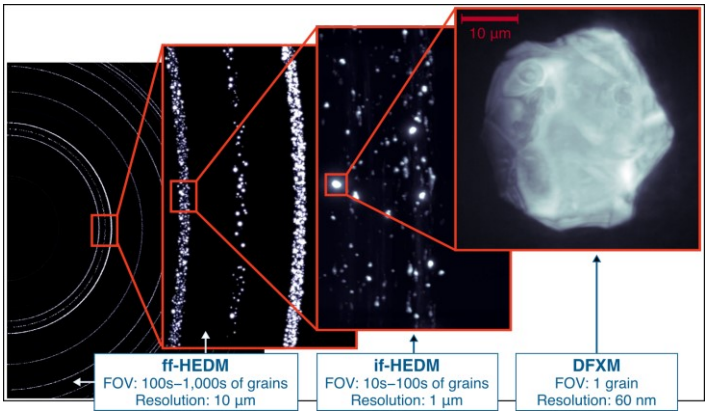

Figure 1. Raw data collected using ff-HEDM, if-HEDM, and DFXM, illustrating the different fields of view (FOV) and spatial resolutions.

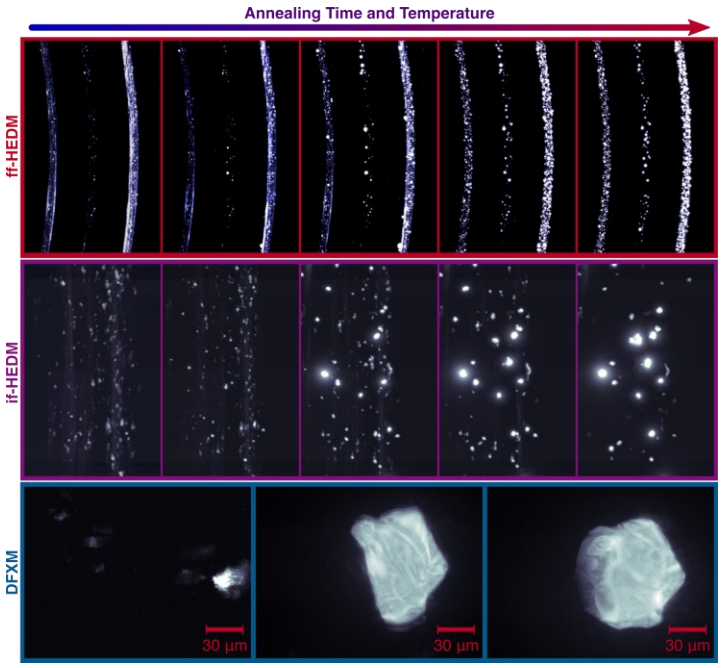

Figure 2. The evolution of the raw data from Fig. 1 during the annealing process.

Keywords: Magnesium; annealing; recrystallization; diffraction; imaging

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