Mechanisms of improved crystal plasticity and grain refinement in a magnesium alloy during high strain-rate deformation

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Magnesium alloys continue to emerge as scientifically interesting and technologically important materials for structural engineering. Research that improves their mechanical properties generally, and their plasticity in particular continues to attract increasing interest. Many fundamental questions remain and new processing methods continue to be developed. In our recent previous research (Acta Mater. 82 (2015) 344-355), we reported on the way that high strain-rate rolling (HSRR) is strikingly effective at producing high quality Mg alloy sheets with ultrafine grained microstructure and excellent properties. Here, we have used a variety of advanced electron microscopy techniques to elucidate the details of the underlying microstructural mechanisms for the improved plasticity and grain refinement during the HSRR process in a Mg - Zn - Zr alloy.

The electron microscopy techniques evolved in this work include electron backscatter diffraction (EBSD), transmission Kikuchi diffraction (TKD) and conventional and high-resolution transmission electron microscopy (TEM), which provides both statistical and detailed atomic-level data for the same sample. In particular, the TKD and TEM observations were conducted at the same site of the specimen, enabling the integrated analysis of grain orientation and crystal defects.

We will elucidate the influence of twinning on the formation of stacking faults, identify the inter-play between twinning and stacking faults on the enhanced plasticity, and propose a mechanism for how twinning and stacking faults influence the nucleation of the dynamical recrystallised grains.

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