ABSTRACT

In this work, an analytical model is presented that can successfully predict the strain hardening behaviour as well as the variations in twin volume fraction in polycrystalline Magnesium alloy Mg-3Al-0.3Mn that twins profoundly during deformation. The model is composed of three basic elements: (i) Twin fraction prediction, based on crystal plasticity elements, (ii) a two-phase composite model composed of the matrix and the twins by adopting the “Iso-work” hypothesis, (iii) a strain hardening approach inspired from a crystal plasticity model. The experiments include uniaxial compression tests for two different cases at ambient temperature. The microstructures were characterized at various strains up to fracture using the Electron Back-Scattered Diffraction technique in a FEG-SEM. The microstructural investigation revealed the formation of a lamellar structure of alternated layers of matrix and $\{10\bar{1}2\}\langle 10\bar{1}\bar{1}\rangle$-extension twin domains. With progressive deformation, the twins broadened and consumed the entire microstructure prior to fracture. The model could accurately reproduce the experimental twin-induced sigmoidal shape flow curve together with the twin volume fraction evolution. However, the effect of texture towards the twin-induced deformation was not taken into account in this analytical approach.

Hence, further investigation was undertaken by the “All Twin Variants (ATV)” approach incorporated in the VPSC model to account for the twin-induced deformation behaviour. Twinning was considered by employing all twin variants, and is referred to as ATV approach. The model treats each twin variants as a grain with increasing volume fraction transferred from the respective parent grain according to its pseudo-slip shear-rate. The slip and twin-induced strain hardening was simulated by adopting a classical phenomenological hardening model while assigning a higher hardening coefficient for the twins relative to the parent matrix. The visco-plastic self-consistent homogenization scheme combined with this ATV approach permitted to reproduce with high precision the experimentally measured strain hardening behaviour, crystallographic texture and twin volume fraction evolution. Beyond these average measures, the activities of twin variants in individual grains could be computed in good agreement with Electron Back-Scattered Diffraction measurements. The ATV approach permits also to examine the matrix and twin phases separately in terms of textures and misorientation distributions.