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Editorial

Processing and Characterization of Magnesium-Based Materials

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Mg-based materials have become increasingly attractive for industries, where weight saving is of importance (e.g., automotive, aerospace). Their low density and good specific properties qualify them to substitute heavier materials. Their macroscopic property profile, however, needs to be improved in order to meet all the requirements these applications demand.

One approach to improve the mechanical properties of Mg is to introduce a secondary phase with a reinforcement capacity by the addition of alloying elements. The combination of transition metals and rare-earth elements under favorable processing conditions leads to the formation of long-period stacking order (LPSO) structures, providing outstanding room- and elevated-temperature strength. Garcés et al. [1] investigated the deformation behavior of an extruded Mg90Y6.5Ni3.5 alloy with an almost fully LPSO structure at different temperatures by means of in situ synchrotron radiation diffraction during compression. The results show an anisotropy in strength between the extrusion and the transversal direction. This could be explained by the orientation dependence at the activation of basal slip. When basal slip is hindered, kinking becomes the main deformation mechanism. At elevated temperature, where more deformation mechanisms could be activated, this anisotropy decreases.

Drozdenko et al. [2] also investigated the deformation behavior of Mg (WZ) alloys containing an LPSO structure with in situ neutron diffraction during cyclic loading. The study found that in the alloy with the lowest volume fraction of LPSO, the twinning–detwinning mechanism found in non-DRX α-Mg grains affects the overall deformation. On the other hand, the increase in the volume fraction of LPSO allows an increased load transfer into the second phase. Therefore, slip and kinking of LPSO dominate the plastic deformation and the twinning–detwinning mechanism only plays a minor role.

In situ diffraction is a unique experimental technique to follow the changes in the different phases in the microstructure during deformation and to determine the main operating deformation mechanism under load. This technique was utilized by Buzolin et al. [3] when investigating the deformation in ZK40 alloys with the addition of Ca and Gd during elevated-temperature compression. The results show that besides dislocation slip, twinning, dynamic recrystallization and dynamic recovery take place, and the latter is the predominant mechanism. The addition of Ca and Gd impedes dynamic recrystallization compared to the ZK40 without alloying additions.

Besides alloying, the microstructure design and consequently the design of the property profile can be conducted by optimizing the processing of the material as well. Henseler et al. [4] investigated the deformation properties of AZ31 sheets at different temperatures produced via different processing routes by in situ SEM investigations. The authors obtained experimental values of parameters used in the Gurson–Tvergaard–Needleman (GTN) model to be further used in finite element simulations.

Similar to the latter study, Zhang et al. [5] investigated the microstructure evolution and the mechanical properties of AZ31 sheets prepared by low-speed extrusion between 350 and 450 °C. The results show that the resulting grain size of the extruded material decreases, while the maximal basal texture intensity decreases with the increase in temperature. Extrusion at 350 °C yielded the best overall mechanical properties.

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AZ31 modified with up to 3 wt.% Ca was prepared by disintegrated melt deposition and investigated by Rao et al. [6] to obtain processing maps. Three domains could be identified on the processing map for AZ31-3Ca, where in Domain I, basal and prismatic slip associated with dynamic recovery; in Domain II, grain boundary sliding promoted intercrystalline cracking; and in Domain III, dynamic recrystallization by non-basal slip and recovery by climb occurred.

The effect of the initial texture on the deformation behavior of AZ31 was investigated by Su et al. [7] with EBSD and visco-plastic self-consistent (VPSC) modeling. The study shows how the initial texture plays a major role in the texture evolution during mechanical loading, leading to mechanical anisotropy.

This Special Issue provides insight into the forefront of magnesium research where the improvement in the mechanical property profile along with the corrosion resistance is of great importance to promote the widespread application of Mg-based materials.

Conflicts of Interest: The author declare no conflict of interest.

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