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In-situ neutron diffraction of a quasicrystal-containing Mg alloy interpreted using a new polycrystal plasticity model of hardening due to {10.2} tensile twinning

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Abstract

Due to the excellent balance of strength and ductility exhibited by some Mg-Zn-RE (Y subgroup rare earth element) alloys, which contain icosahedral quasicrystalline precipitates, it is of interest to examine their deformation mechanisms. The internal strain evolution Mg-3at%Zn-0.5at%Y with 4 vol% i-phase was measured using in-situ neutron diffraction. The extruded samples exhibit an initially weak <10.0> || extrusion direction "rod texture," distinct from the normally strong texture of extruded Mg alloys, but the grain size is unexceptional (16.7 ± 2.1 μm). The initially weak texture contributes to a nearly symmetric yielding response between tension and compression. The hardening responses are asymmetric, however, since {10.2} extension twinning is significantly more active during compressive straining, despite the initially weak texture. In-situ neutron diffraction tension and compression experiments parallel to the extrusion direction, together with elasto-plastic self-consistent (EPSC) crystal plasticity modeling, reveal the strength and hardening behavior of individual slip and twinning modes. The previously published twinning-detwinning (TDT) model is implemented within the EPSC framework, and it is proven effective for describing the observed, mild tension-compression asymmetry. This is not possible with previous EPSC-based models of twinning. Finally, the description of hardening within the TDT model is modified, in order to accurately describe the evolution of internal strains within the twins.

Keywords: precipitation, quasicrystal, icosahedral, twinning, neutron diffraction, internal stress

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