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In-situ deformation characterization of Nd-containing Mg alloys

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ABSTRACT

An in-situ characterization technique combining mechanical testing inside a scanning electron microscope (SEM) with electron backscatter diffraction (EBSD) analysis was employed to study the tensile deformation behavior of Nd-containing Mg alloys over the temperature range of 50-250°C. EBSD data were collected before and after the experiments. The active slip and twinning systems were identified from the secondary electron SEM images and EBSD orientation data using a MATLAB code with the input of grain Euler angles [1]. The critical resolved shear stress (CRSS) ratios between the different deformation systems were estimated based on the distribution of identified deformation modes and texture according to the methodology described in Ref. [2]. Details of this testing technique and the results obtained on Mg-1Mn-*x*Nd (wt.%) [$0 < x < 1$] alloys in the as-cast and extruded conditions will be presented. Rare-earth additions to Mg alloys tend to reduce the strong basal texture exhibited by conventional wrought Mg alloys [3, 4]. Compared with other RE elements, neodymium (Nd) has proven to be a stronger texture modifier [4]. The alloys were gravity cast to produce billets of 125 mm diameter and then machined to a diameter of 93 mm. The billets were homogenized at 350°C for 15 hours prior to extrusion. Indirect extrusion was carried out to produce round bars of 17 mm diameter. The billets were extruded at temperatures between 275°C and 300°C and between 5.6 mm/s and 8.3 mm/s. The tensile strength of the as-cast materials was lower than that of the extruded materials. For the material containing 1wt.%Nd, both the as-cast and extruded materials exhibited superior high temperature strength retention compared with conventional alloys [5]. This is expected to be the result of the Nd addition. In the case of the extruded materials, basal slip, prismatic slip, and pyramidal slip were active at all temperatures. Extension twinning was also observed at all temperatures for the 275°C extruded Mg-1Mn-1Nd(wt.%) alloy; however, it was not observed at 250°C for the same alloy extruded at 300°C. The extent of twinning decreased with increasing temperature and basal slip was the major deformation mode at 150°C and 250°C. Basal slip was associated with high Schmid factors in all cases. Extension twinning was distributed over the entire Schmid factor range suggesting that extension twinning does not follow Schmid law. The estimated CRSS ratio of extension twinning with respect to basal slip was <1, suggesting that the addition of Nd results in an increase in the CRSS of basal slip. In the case of the as-cast Mg-1Mn-1Nd (wt.%) alloy, basal slip and extension twinning were observed at 50°C. Nonbasal slip activity was observed at 150°C.

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