Influence of crystallographic orientation on the mechanical behaviors and microstructural evolution in a Mg alloy

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Because of their low density and high specific strength, Mg alloys have significant potential for a wide range of industrial applications. However, the relatively poor mechanical properties and formability of Mg alloys have severely limited their applications. It is well known that dynamic recrystallization (DRX) has a significant impact on the formability and the final microstructure that subsequently affect the mechanical behaviour of Mg alloys [1]. Strain rate and temperature affect significantly the development of DRX [2]. Crystallographic orientation also brings significant influence on DRX under high strain-rate deformation [3]. Therefore, it is important to understand how crystallographic orientation affect the mechanical behaviours and the corresponding microstructural evolution of Mg alloys during deformation under different strain rates and temperatures. This study aims to tackle this question using high strain-rate deformation and the electron backscatter diffraction (EBSD) technique. The outcomes may provide important insights into optimizing manufacturing processes of Mg alloys with specific crystallographic orientations to obtain desirable microstructures and mechanical properties.

A strongly textured Mg - 3Al - 1Zn (wt. %) alloy was used in the study. High strain-rate impact using the split Hopkinson pressure bar was conducted along three crystallographic orientations: 0°, 45° and 90° away from the c-axis of the Mg lattice (referred to as ND, 45ND, and 90ND, respectively). Deformation was carried out at strain rates of 1000/s and 1500/s, and at the ambient temperature and 300 °C. The results indicated that crystallographic orientation has remarkable influence on the mechanical behaviours. Figure 1 shows the high strain-rate stress - strain curves of all samples. The change of flow stress and strain of samples at different crystallographic orientations, temperatures and strain rates is significantly distinctive.

The microstructures of all samples were characterised using EBSD. Deformation at the ambient temperature showed little strain-rate effect on the microstructural evolution of all samples. However, a significant strain-rate effect on the microstructural evolution occurred for all samples deformed at 300 °C, as shown in Figure 2 for 45ND samples that were deformed to a same strain value of 14%. Bimodal grain-size structures existed in samples deformed at the strain rate of 1500/s, but not at 1000/s. Detailed microstructural analysis and the effect of the microstructures on the mechanical behaviours will be discussed.

References:

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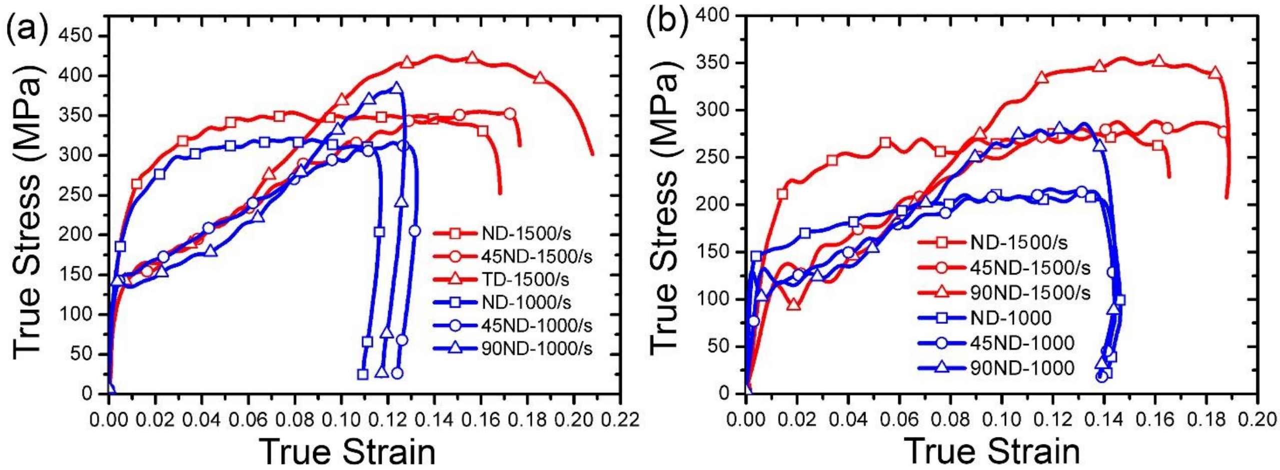

Figure 1. True high strain-rate compressive stress - strain curves for all samples at strain rates of ~1000/s and ~1500/s and at (a) the ambient temperature and (b) 300 °C.

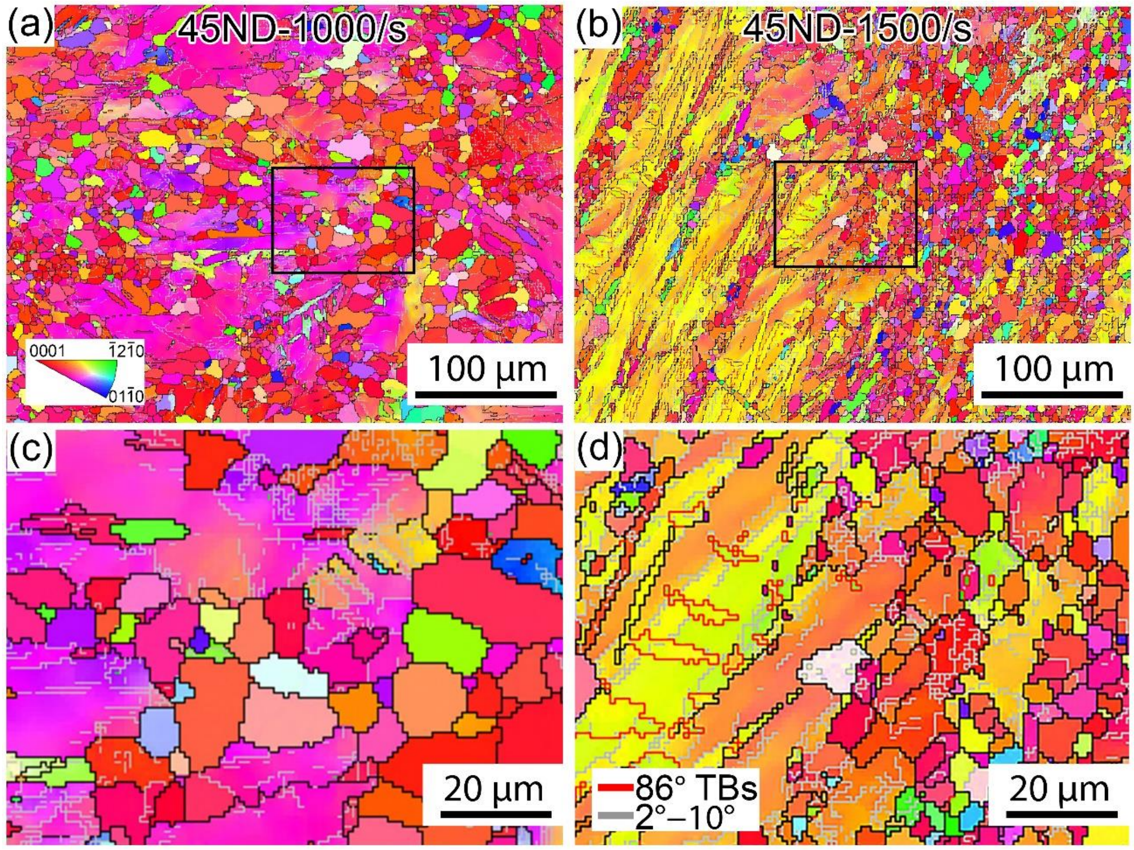

Figure 2. EBSD maps showing the microstructures of 45ND deformed at 300 °C and at strain rates of (a) ~1000/s and (b) ~1500/s. (c) and (d) are magnified images of part of (a) and (b), respectively.