変態誘起塑性ハイマンガン鋼の組織構造と減衰能力の評価

Structure and damping capacity of TRIP high-Mn steel

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Abstract: The microstructure evolution, accumulation of defects and internal stresses in the Fe-26Mn-4Si alloy with different engineering strain are investigated by neutron diffraction, TEM, SEM-EBSD, DSC and mechanical spectroscopy. Transmission electron microscopy shows that lots of dislocations and stacking faults are formed in both martensitic and austenitic phases in the Fe-22Mn-3Si samples. The microstrain and dislocation density increase in HCP-martensite and FCC-austenite in the annealed Fe-26Mn-4Si alloy with increasing tensile strain.
Keywords: TRIP high-Mn steel, neutron diffraction, damping capacity, texture analysis

1. Research Purposes

High-Mn steels have a high damping capacity and good shape memory effect. In this work, the deformation microstructure and bulk texture evolution as a function of tensile strain in TRIP high-Mn steel Fe-26Mn-4Si was carefully investigated together with the effect on damping capacity and martensitic transformation parameter.

2. Experimental Procedures

Tensile tests were carried out with the strain rate of 5 mm/min at room temperature. The gauge length was 70 mm, thickness, 3 mm and width, 10 mm. Scanning and transmission electron microscopes (SEM and TEM) were used to investigate deformation microstructure evolution with increasing tensile deformation. We employed a TESCAN VEGA LMH microscope operating at 20 kV with a LaB6 cathode equipped with electron backscatter diffraction (EBSD), which was made on the NordlysMax2 detector. The EBSD measurements were carried out at a step size of 0.5 μm. The samples for SEM observation were electro-polished at 16 V for 50 s in a solution of 90% glacial acetic acid (CH_3COOH) and 10% perchloric acid ($HClO_4$), and were etched with a 1.2% $K_2S_2O_5$ aqueous solution.

To evaluate change in the phase volume fraction, residual stress, microstrain and dislocation density, five Fe-26Mn-4Si (wt.%) samples with different engineering strain (ε = 0, 6, 12, 18.5, 22%) and annealed Fe-26Mn-4Si powder (hcp, a ≈ 2.5403 Å, c ≈ 4.1136 Å; fcc, a ≈ 3.5970 Å) were analysed at room temperature with Prof. Bokuchava's help using FSD time-of-flight Fourier diffractometer at the IBR-2 reactor (Dubna, Russia). The change in microstrain and dislocation density in HCP-martensite and FCC-austenite in the annealed Fe-26Mn-4Si alloy with increasing tensile strain is presented in Fig.2. Consequently, we apply to use angle dispersive neutron diffraction at JRR-3 to study the effect of tensile deformation on crystallographic texture of Fe-26Mn-4Si alloy.

3. Results and discussion

The neutron diffraction results obviously demonstrate distinct texture evolution in the Fe-26Mn-4Si before and after tensile deformation. The microstrain and dislocation density increase in HCP-martensite and FCC-austenite in the annealed Fe-26Mn-4Si alloy with increasing tensile strain (Fig. 2). The damping capacity increases with increasing tensile strain, attains a maximum at strain of 12%, and decreases with further tensile strain.

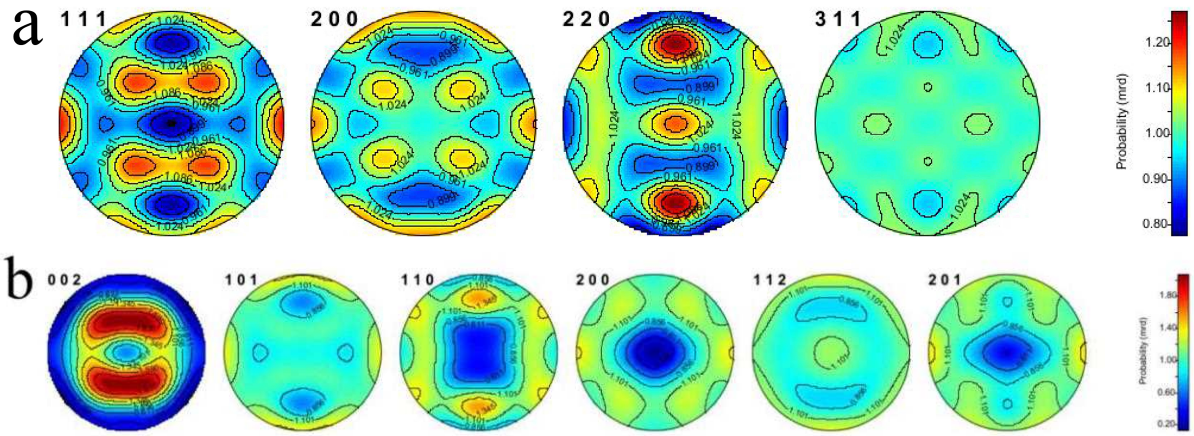

Fig. 1. Reconstructed pole figures of austenite (a) and martensite (b) of annealed Fe-26Mn-4Si alloy.

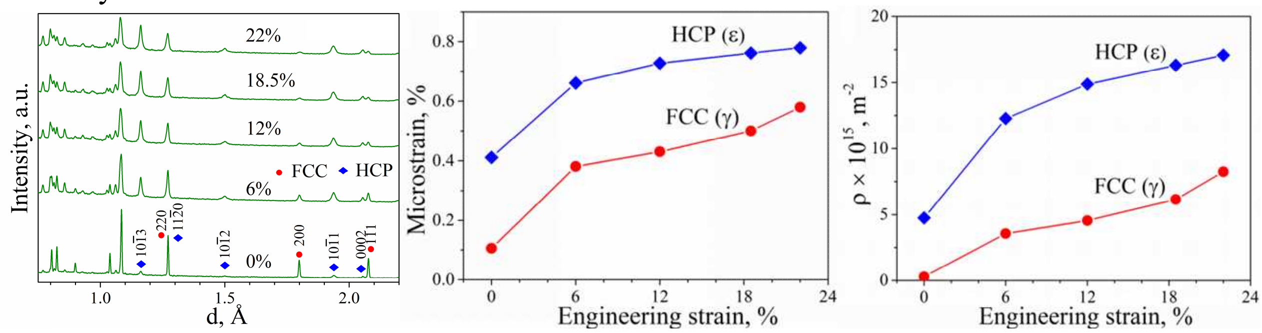

Fig. 2. High-resolution neutron diffraction patterns (a), microstrain (b) and dislocation density (c) of annealed Fe-26Mn-4Si alloy with increasing tensile strain.

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