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Microstructure evolution and nitriding behaviors of Sm-Fe alloys in rapid solidification process

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Rapid solidification technology is used widely to fabricate micro-crystalline and amorphous alloys. Compared to the alloys produced under equilibrium solidification conditions, smaller grain size and more grain boundaries in rapidly solidified alloys are undoubtedly beneficial for the diffusion of atoms in heat treatment process. In traditional nitriding process of coarse-grained Sm-Fe alloys, it is hard to further increase the nitrogen content and improve the uniform of nitrogen distribution. Therefore, the nitriding behaviors and microstructure evolution of rapidly-solidified Sm-Fe alloy ribbons with micro-crystalline and amorphous structure were investigated in this work. Several Sm-Fe alloy ribbons with a nominal chemical composition of 30% (wt., %) were manufactured by melt spinning technology at Ar atmosphere. Microstructure of these rapidly solidified Sm-Fe alloys manufactured under different rotating velocities was characterized with OM, SEM and XRD. The nitrogen content penetrated in rapidly solidified Sm-Fe alloys was examined and the morphologies of nitrogen were investigated. Results indicate that with the rotating velocity of wheel increases from 6 m/s to 36.5 m/s, the thickness of Sm-Fe alloy ribbon decreases by one order of magnitude, i.e. from 107.70 μm to 18.93μm, and the cooling rate increases by approximately six times, i.e. from 1.86×105 K/s to 1.08×106 K/s, microstructural characteristics transform from coarse dendrites to cellular crystal, microcrystal, mixture of crystal and amorphous phase. Moreover, Sm and Fe elements in alloy ribbons tends to uniform compare with the as-cast alloys according to the laser ablation inductively coupled plasma mass spectrometry map. The size of all grains is still less than 10μm although the crystalline grains grew during nitriding process of rapidly solidified Sm-Fe alloy at 420^{0}C. This result suggests that smaller grain size and more grain boundaries of rapidly solidified Sm-Fe alloy could provide more locations for atomic nitrogen absorption in the nitriding process, and then improve the diffusion of nitrogen atoms. However, most nitrogen penetrated in rapidly solidified Sm-Fe alloys are distributed on the boundaries of cellular grains in the forms of nitrogenous compounds. A quickly quenched Sm-Fe alloy ribbon with a stable near-stoichiometric Sm_2Fe_{17} phase and amorphous matrix in microstructure was fabricated successfully when the rotating velocity of wheel was greater than 34 m/s. After nitridation of quickly quenched Sm-Fe alloy ribbons, the constitutional phases are crystalline $Sm_2Fe_{17}Nx$ and α-Fe, and amorphous nitrides. This phenomenon indicates that nitrogen atoms are distributed not only in crystalline phase but also in amorphous matrix. The nitrogen content in Sm-Fe alloy ribbons is up to 4.155%, which indicated the microstructure characteristics of quickly quenched Sm-Fe alloy is helpful for the improvement of nitrogen absorption.

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