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RAPIDLY QUENCHED Fe-Si-Sb AND Fe-Si-Co ALLOYS [1]

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Microcrystalline Fe-6.5wt.%Si, Fe-6.5wt.%Si-0.08wt.%Sb and Fe-6.5wt.%Si-1.0wt.%Co ribbons were prepared by single roller technique on a steel wheel. The microstructure, crystallographic texture and magnetic properties of these alloys were studied. A more perfect crystallographic texture and better magnetic properties were obtained for the alloys with Sb and Co in comparison with the binary Fe-Si alloy.

1. Introduction

Fe-6.5wt.%Si alloys prepared by rapid quenching from the melt are intensively studied for their advantages over classical Fe-Si steels [1-4]. They have lower values for the magnetocrystalline anisotropy K_1 and magnetostriction λ_s and the technology of production is simpler. They show better thermal stability compared to amorphous FeSi alloys.

Some elements (Sb, Al, P) in classical silicon steels are known to improve the magnetic properties [5-7] and by adding Co the value of the saturation magnetic polarization can be increased [8-9].

Therefore, in this paper we study the influence of a small Sb and Co content upon the structure and magnetic properties of microcrystalline Fe-6.5wt.%Si alloys.

2. Method

Fe-6.5wt.%Si, Fe-6.5wt.%Si-0.08wt.%Sb and Fe-6.5wt.%Si-1.0wt.%Co samples are obtained by planar flow rapidly quenching technique on a steel wheel. The purity of the components was 4N for the Fe and Sb, and 4N5 for the Si and Co. The microcrystalline ribbons were 10 mm wide and 30 to 45 μm thick.

The microstructure of the ribbons was analysed by optical micrography.

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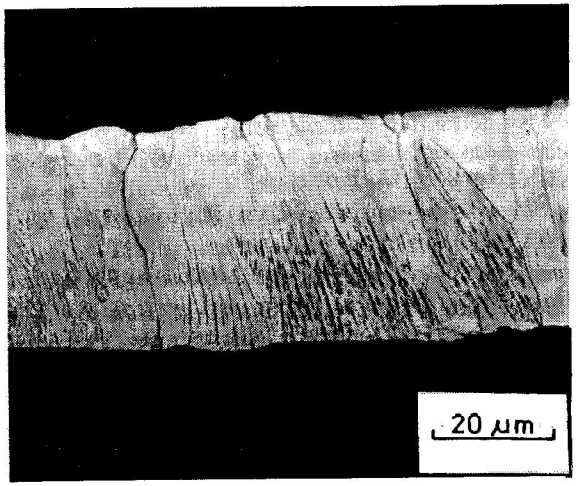

Fig.1. Cross-section of the Fe-6.5%Si- 0.08%Sb alloy in the as-quenched state.

The X-ray texture measurements were carried out in the reflection mode using a pole figure goniometer Kristalloflex IV made by Siemens.

The coercive force H_c was measured by a dc hysterograph with an accuracy of 1 %. The saturation magnetic polarization J_s was measured using a vibrating sample magnetometer with an accuracy of 1 %.

The as-quenched ribbon samples were annealed at 1100 °C for 1 hour in argon atmosphere.

3. Results and discussion

The metallographic analysis of the investigated ribbons revealed a microcrystalline structure with a grain dimension of 8-10 μm in the plane parallel to the ribbon surface. The cross section of the ribbons consists of uniaxial columnar grains oriented according to the thermal gradient during quenching. The cross-section of the samples in the as-quenched state is shown in Fig.1.

Metallographic analysis of the samples after heat treatment (1100 °C/1h) showed a homogeneous microstructure, whereby the higher grain dimension was in the range of 60-80 μm. According to the cross section picture the grains have grown in the ribbon thickness as it is shown in Fig.2.

The microstructure of the samples studied is ferritic with the absence of precipitates. The analysis of the crystallographic texture was realised by X-ray diffraction using the Harris method for the measured crystallographic planes (110), (200), (211), (310) and (222). The intensity ratios were measured for every type of samples and calculated in the as-quenched state and after heat treatments. The results of the texture analysis are reported in Table 1. From these results it follows that the plane (200) has a more

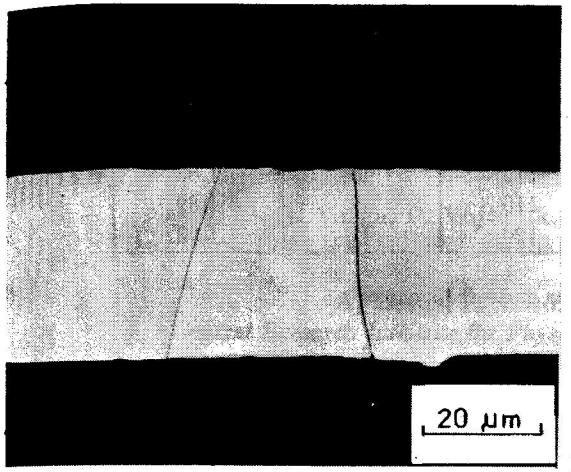

Fig.2. Cross-section of the Fe-6.5%Si- 1.0%Co alloy annealed at 1100 °C/1h.

Sample		Intensity ratios of reflections from plane				
		(110)	(200)	(211)	(310)	(222)
Fe-6.5%Si	q	0.66	1.51	1.14	0.75	0.94
Fe-6.5%Si	a	0.42	3.04	0.65	0.47	0.43
Fe-6.5%Si-0.08%Sb	q	1.08	1.31	1.04	1.17	0.40
Fe-6.5%Si-0.08%Sb	a	0.34	3.19	0.72	0.34	0.41
Fe-6.5%Si-1.0%Co	q	0.81	1.42	1.02	1.09	0.66
Fe-6.5%Si-1.0%Co	a	0.78	3.27	0.38	0.26	0.31

Table 1. The results of the X-ray texture analysis (q - as-quenched samples a - annealed samples (1100 °C/1 h))

perfect texture for the annealed samples and the additions of Sb and Co support the preferential representation of the plane (200).

The magnetic properties measured at room temperature are reported in Table 2. From the results it follows that the annealing decreases the coercive force by 61 % for the Fe-Si alloy, by 71 % for the sample with Sb and by 66 % for the sample with Co, in comparison with the as-quenched state. These results are in good agreement with X-ray texture measurements.

The saturation magnetic polarisation is 5 % higher for the sample with Co as compared with the binary Fe-Si alloy.

4. Coclusions

Based on the experimental results we can make the following conclusions:

Sample	H_c (Am^{-1}) as-quenched	H_c (Am^{-1}) annealed 1100 °C/1h	J_s (T)
Fe-6.5%Si	115	45	1.83
Fe-6.5%Si-0.08%Sb	110	32	1.89
Fe-6.5%Si-1.0%Co	120	41	1.93

Table 2. Magnetic characteristics of the measured samples

— The grains of all the alloys studied overgrew the whole thickness of the ribb after heat treatment.
— The outstanding (100)[0vw] texture was received after heat treatment of all the measured alloys.
— The coercive force of the annealed specimens was reduced by 28 % by addin antimony as compared to the Fe-Si ribbons.
— Additions of cobalt atoms to Fe-Si alloy increase the value of saturation magnetization by about 5 %.

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