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MICROCRYSTALLINE Fe-Si-Al-B THIN RIBBON

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Abstract-By means of adding B into Sendust alloy (Fe-Si-Al) with state of amorphous ribbon, mechnical properties of alloy was improved effectively, and magnetic properties didn't decrease obviously. The optimum adding quantity of B is 0.015-0.03 wt%. The adding of B was thought to give rise to reduction of ordering degree of $Fe_3(Si,Al)$ phase of Sedust alloy(Fe-Si-Al-B) and result in improvment of embrittlement of this alloy.

Ⅰ.INTRODUCTION

The embrittlement of Sendust alloy(Fe-Si-Al) at room temperature has limited its application. Although improved thoughness has been obtained in recent years in newly developed microcrystalline Fe-Si-Al thin ribbons by rapid quenching(1-4), there is still a long way to go for practical uses.

In order to improve the toughness of this alloy to a higher degree, the authors studied the effect of small amount of B addition and heat-treament on the embrittlement and magnetic properties of Fe-Si-Al-B Sendust alloy. Fe-Si-Al-B ribbons prepared are 1~50mm wide and 0.015~0.06mm thick, and have been applied in a telemetry magnetic head with a good performance.

The mechanism of improvement of embrittlement by means of adding B is was also investigated in this paper.

Ⅱ. EXPERIMENT

B of 0.01wt% to 0.2wt% was added into the Sendust alloy. The thin ribbons were prepared by single roll melt spinning and then annealing in vaccum. The D.C. and A.C. magnetic properties were measured by ballistic galvanometer and three voltage method respectively. The grain and structure were observed by means of transmission electron microscopy, X-ray diffraction and mossbauer spectrum.

Ⅲ. RESULTS AND DISCUSSION

(1) Magnetic properties

The Table1 shows the effect of B addition(0.01~0.2wt%) on D.C. magnetic properties of 1# 9.6Si-5.2Al-0.015~0.025B-85Fe, 2#9.4Si-5.2Al-0.1~0.12B-85Fe, 3#9.4Si-5.2Al-0.16~0.18B-85Fe, 4# 9.6Si-5.4Al-85Fe (wt%) alloys. There is almost not obvious effect on

Table1. D.C. magnetic properties of Fe-Si-Al-B alloys

№	Bs (T)	Br (T)	μ_o ($\times 10^4$)	Hc (A/m)	μ_m ($\times 10^4$)
1.	1.06	0.69	1.8	4.0	7.2
2.	1.0	0.64	1.3	4.9	7.0
3.	0.94	0.70	1.1	6.2	5.9
4.	1.1	0.67	2.3	3.84	9.5

embrittlement of the alloys at room temperatue when the B content is less than 0.01wt%. Conversely, the magnetic properties become deteriorated when the B content exceeds

0.1wt%. A large number of experiments proved that the embrittlement of the alloys at room temmperature can be effectively improved as the B content is in the range of 0.015 to 0.03wt% with magnetic properties as good as that of the alloy without B addition.

Fig.1 shows how μe depends on frequency(f) and annealing temperature(Ta). It can be found that maximum μ corresponds Ta of 950°C to 650°C when f is from 10kHz to 1MHz. This means that the optimum Ta is different with f.

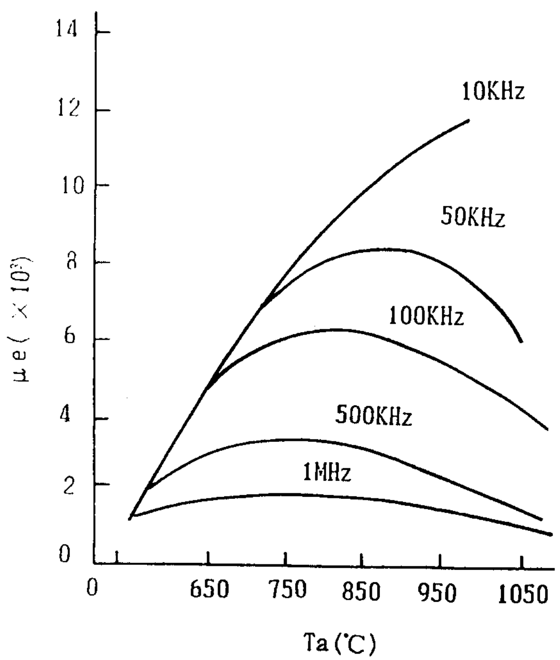

Fig 1. The μ_e dependence of the frequency(f) and annealing temperature(Ta) for Fe-Si-Al-B alloy

Power loss(P) of the thin ribbon with frequency f was shown in Fig.2. The powe loss at different frequency decreases with increase of the B content. Generally, the relation between P and f can be expressed as $P \propto f^{\alpha}$. In the case of alloy with B addition α=1.1~1.25 which is less than 1.85 for alloy without B addition.

(2) Mechanical properties

The minimum curvature radius of the alloy containing B is from 2.5 to 3.5mm, which is

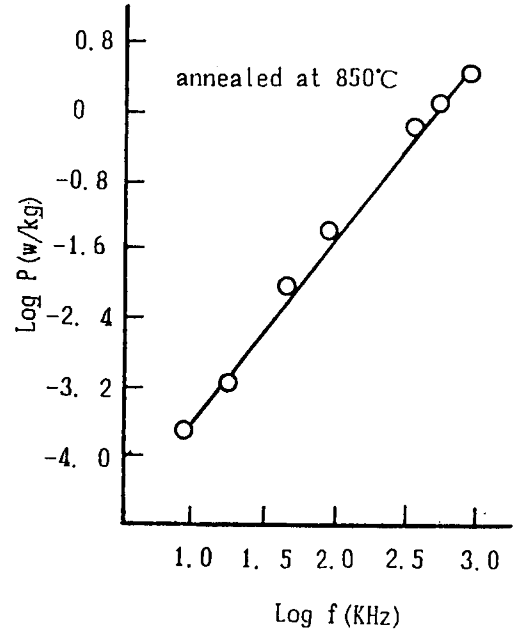

Fig.2 Change in the loss as a function of frequency for Fe-Si-Al-B alloy

less than the valve of 4 to 5mm for Sendust alloy(Fe-Si-Al) without B. Compare with conventional Fe-Si-Al alloy, the improvemen on the embrittlement of thye ribbon by means of adding B is obvious. On the other hand, the fracture strain ε of Fe-Si-Al-B alloys was also measured. The valuves was shown below:

Fe-Si-Al-B $\varepsilon=9.3\times10^{-3}$

Fe-Si-Al $\varepsilon=5.75\times10^{-3}$

Table2 shows the resistivity and hardness of Fe-Si-Al-B alloys. It is found that resistivity and hardness increase with increase of B content.

Table2. The resistivity and hardness of Fe-Si-Al-B alloy

No	1	2	3	4
μ Ω-cm	124	133	138	119
Hv	520	534	550	537

The B addition raised effectively the

resistance to embrittlement of Fe-Si-Al-B alloys. Magnetic head made by this kind of alloys have been applied to recorder. Fig.3 shows the repeat property at 3.04m/s of tape.

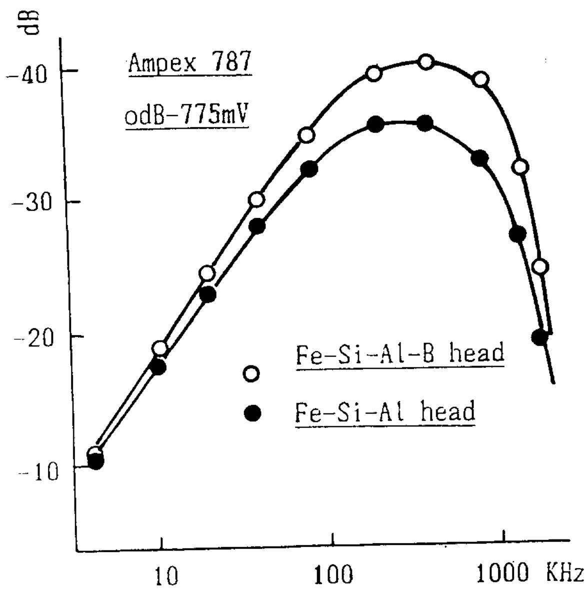

Fig.3 The repeat property at 3.04m/s of tape made by Fe-Si-Al-B alloy

(3) Discussion

X-ray diffraction of the Sendust alloys shows that there is mainly $Fe_3(Si,Al)$ phase, which belongs to DO_3 type metallic cubic structure. The deforming strain of DO_3 type metallic compound is very high. According to the relationship between the fracture strain and ordering parameter with B content(Fig.4), when small amount of B is added into the Fe-Si-Al alloy, the state of first and second neighbour atom pairs of DO_3 superlacttice changes. That results in reducing of the ordering degree of DO_3 phase and increasing of fracture strain, which gives rise to the improvement of embrittlement of this alloys. There is not significant effect on magnetic properties due to small B addition which make the composition of Fe-Si-Al-B alloys deviate from the standard Sendust alloy very little.

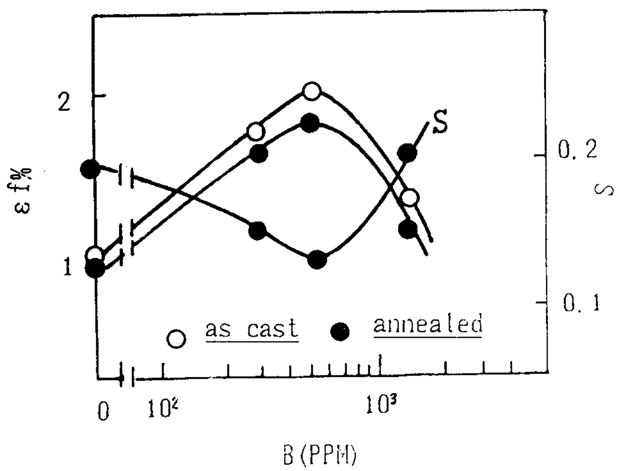

Fig.4 the dependence of the fracture strain ε and ordering parameter S with the B content for Fe-Si-Al-B alloy

Ⅳ. CONCLUSIONS

(1) Magnetic head made by a new type of Fe-Si-Al-B Sendust alloy have been applied magnetic recorder with good magnetic and mechnical properties.
(2) The optimum adding quantity of B is 0.015~0.03wt%.
(3) The minimum curvation diameter of ribbon of Fe-Si-Al-B alloy is 2.5~3.5mm which is less than 4~5mm of conventional Sendust alloy.
(4) The fracture strain $\varepsilon=9.3\times10^{-3}$ of new this type of alloy, which is higher than $\varepsilon=5.73\times0^{-3}$ of conventional Sendust alloy.

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