# EFFECT OF Mn-SUBSTITUTION ON MAGNETIC PROPERTIES OF Co-Si-B AND Co-Fe-Si-B AMORPHOUS ALLOYS

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# EFFECT OF Mn-SUBSTITUTION ON MAGNETIC PROPERTIES OF Co-Si-B AND Co-Fe-Si-B AMORPHOUS ALLOYS

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## ABSTRACT

The addition of Mn to Co-base Si-B amorphous alloys which have higher crystallization point (Tx) than the Curie point (Tc) has been investigated, aiming an enhancement of magnetic induction. It is found that the addition of the small amount of Mn, $0<Mn<3$ at %, enhances the magnetic induction. The Tx is increased with the Mn content whereas the Tc is decreased. Thus, we have an improved amorphous alloy having a wide (Tx - Tc) with a large magnetic induction.

## INTRODUCTION

The rapidly quenched Co-base Fe Si B amorphous alloys, which have nearly zero magnetostriction[1] and high permeability, are suitable materials for a magnetic core operated in high frequencies. To response on high coercive force of the magnetic recording media, the magnetic head core materials having a high magnetic induction are urgently required for attaining a good recording performance. To obtain high magnetic induction, a few authors have studied the alloy compositions of Co-base amorphous alloys[2], [3]. We have studied with the addition of Mn. In this report, we shall deserибe the results of the addition of Mn to the alloys on magnetization, magnetostriction, Curie point and crystallization point.

## EXPERIMENTAL

Amorphous alloy ribbons in 40μm thick and 20mm width were prepared by rapidly quenching method using a single role. Amorphous state of the ribbons was examined by x-ray diffraction analysis. Saturation magnetization ($\sigma_s$) at room temperature was measured with a sample vibrating magnetometer, magnetostriction ($\lambda_s$) with a bonded strain gage (Type S104K-M) and Curie point (Tc) with a magnetic balance. Determination of crystallization point (Tx) was done by DTA.

## RESULTS AND DISCUSSIONS

The effect of a partial substitution of Co with Mn on $\sigma_S$ of Co-Si-B and Co-Fe-Si-B amorphous alloys has been examined. Figures 1 and 2 show the results. It can been seen that as the Mn content is increased, $\sigma_S$ is increased and then decreased through the maximum $\sigma_S$ at about 2.5 at %. Mizogushi has observed the similar results with the magnetic moment in the (Co-rich Mn)$_{80}P_{10}B_{10}$ amorphous alloy[4].

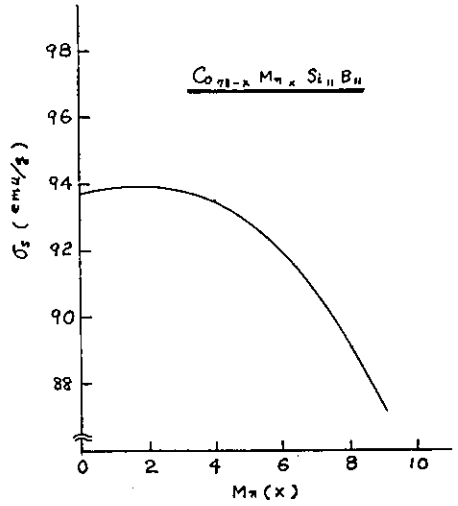


Fig 1. Saturation magnetization ($\sigma_S$) at a room temperature as a function of Mn-content in Co-Si-B amorphous alloy.

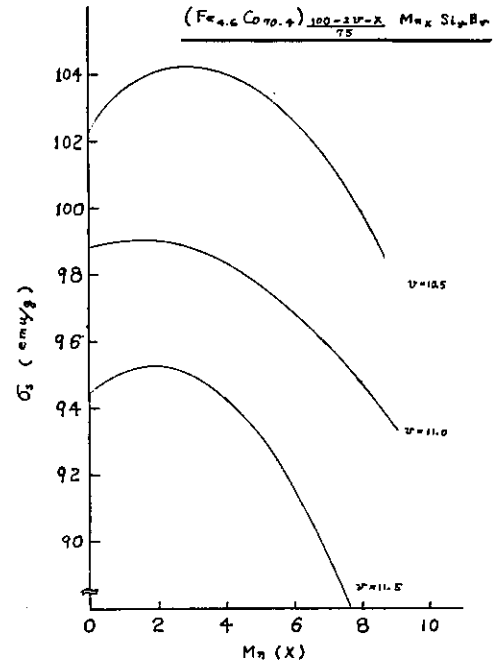


Fig 2. Saturation magnetization ($\sigma_S$) at a room temperature as a function of Mn-content in Co-Fe-Si-B amorphous alloy.

The results of Tc are shown in Figures 3 and 4. It may be said that Tc is decreased monotonically with increasing Mn content in both systems.

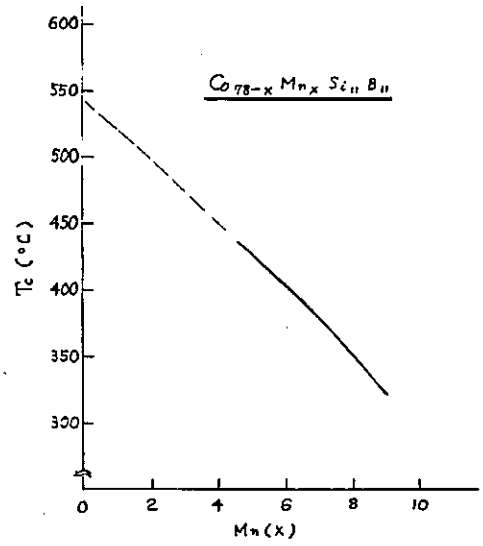


Fig 3. Curie point (Tc) plotted against Mn-content in Co-Si-B amorphous alloy.

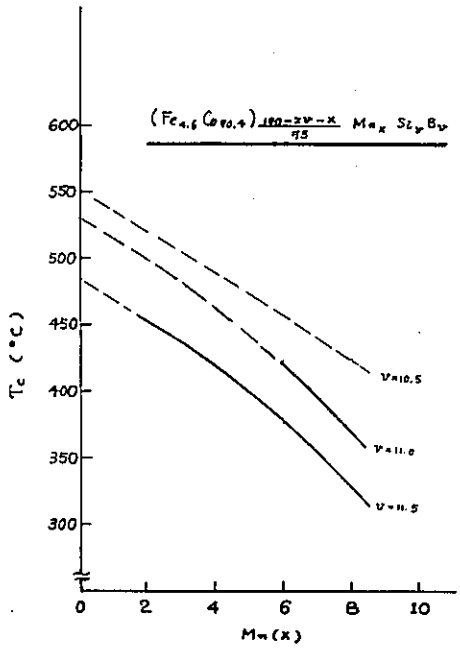


Fig 4. Curie point (Tc) plotted against Mn-content in Co-Fe-Si-B amorphous alloy.

In contrast with Tc, Tx is increased monotonically with Mn content in both systems. These results are shown in Figures 5 and 6.

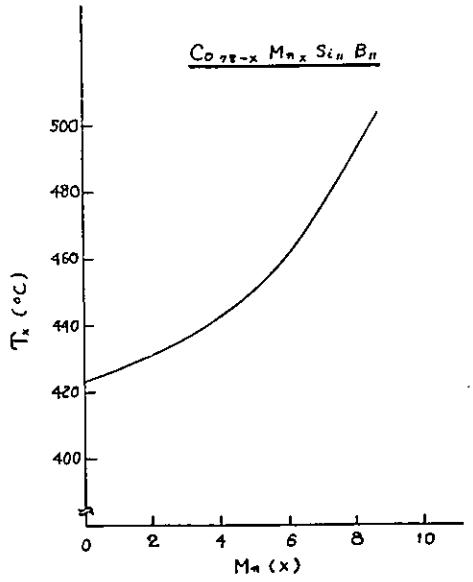


Fig 5. Crystallization point (Tx) vs. Mn-content in Co-Si-B amorphous alloy.

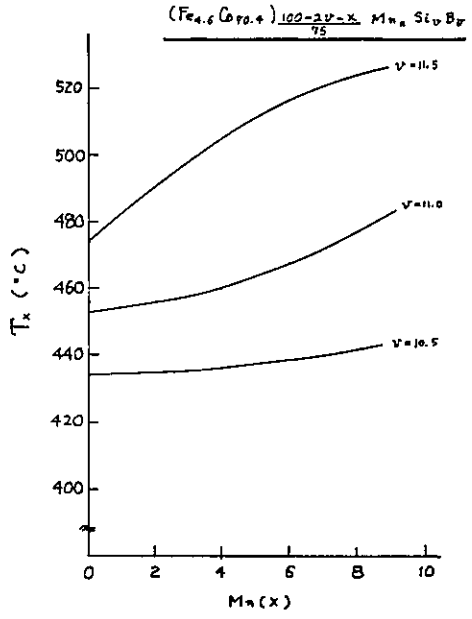


Fig 6. Crystallization point (Tx) vs. Mn-content in Co-Fe-Si-B amorphous alloy.

Figure 7 shows the change in $\lambda_S$ with Mn content in $Co_{78-x}Mn_xSi_{11}B_{11}$ amorphous alloy. It may be seen that the $\lambda_S$ value moves to positive side with the Mn content, however, the effect by Mn is small as compared with that by Fe in Co-Fe-Si-B amorphous alloy.

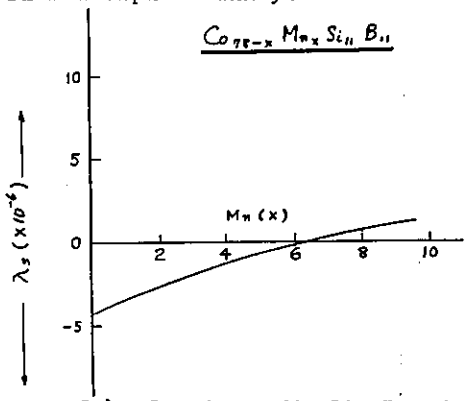


Fig 7. The change of $\lambda_S$ for $Co_{78-x}Mn_xSi_{11}B_{11}$ is plotted as a function of Mn (x).

As-quenched amorphous alloys usually have a large internal stress and exhibit a very low permeability. The low permeability is improved when the alloys are annealed at a temperature ($T_A$) between Tc and Tx if Tc < Tx. If the alloys have Tc > Tx, i.e. $T_A$ < Tc, the permeability do not be improved, rather deteriorated, by a conventional annealing technics because a small anisotropy is induced with atom-rearrangement driven by internal magnetic moment. The amorphous alloys in high magnetic induction range, in general, are characterized by Tc > Tx. This is demonstrated in Figure 8 with the shadow area.

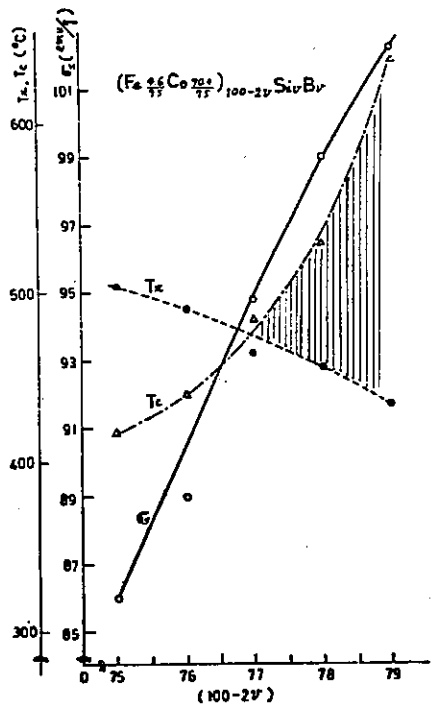


Fig 8. Saturation magnetization ($\sigma_S$) at room temperature, Curie point, and crystallization point as a function of total transition metal's content in Co-Fe-Si-B amorphous alloy.

Figure 9 shows the values of (Tx - Tc) in $(Co\ Fe)_{100-2\nu}Si_\nu B_\nu$ and $(Co\ Fe\ Mn)_{100-2\nu}Si_\nu B_\nu$, which the (Tx - Tc) values are plotted as a function of transition metal's content, corresponding to Bs.

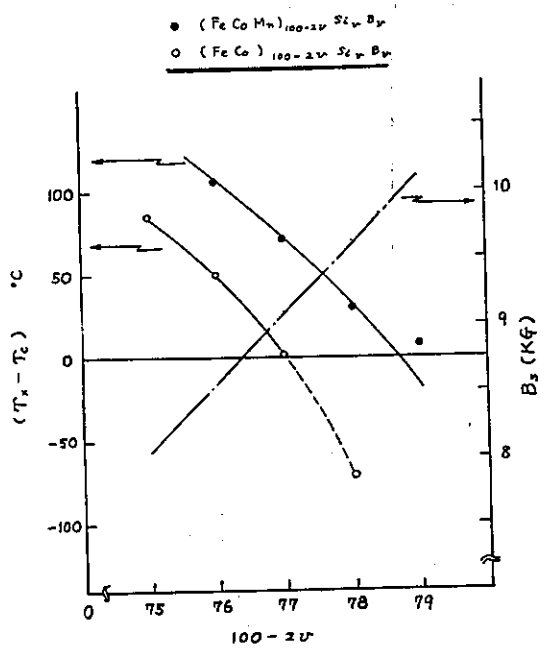


Fig 9. The value of (Tx - Tc) for Co-Fe-Si-B and Co-Fe-Mn-Si-B amorphous alloys plotted against total transition metal's content having the same magnetic induction.

Considering the above results, one may allow us to draw a conclusion that the addition of Mn improves $\sigma_s$ value of the amorphous alloys as well as extending (Tx - Tc).

## CONCLUSIONS

We have studied the magnetic properties of Co-Mn-Si-B and Co-Fe-Mn-Si-B amorphous alloys as a function of the Mn content. It is found that the addition of the adequate amount of Mn (2～4 at %) extends the (Tx - Tc) value of amorphous alloys, with the improved magnetic induction. With the wide temperature range of (Tx - Tc), the permeability of the alloys is easily improved by the conventional annealing technique.

## REFERENCES

(1) H.Fujimori, M.Kikuchi, Y.Obi and T.Masumoto, Sci. Rep. RITU, 26 (1976) 36

(2) 猪俣浩一郎, 長谷川迪雄, 島貫專治, 小林啓二, 電子通信学会技報, 79 No.108 p.21, MR79-12-14 (1979)

(3) 佐納治文, 榊間博, 広田栄一, 日本応用磁気学会, 第3回 日本応用磁気学会学術講演概要集, p.71 (1979)

(4) T.Mizoguchi, Supplement to Sci. Rep. RITU, A, June, p.117 (1978)