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MÖSSBAUER EFFECT OF AMORPHOUS Fe-B ALLOYS

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Résumé.- Le système amorphe $Fe_{100-x}B_x$ (x variant de 8 à 23) a été étudié par spectrométrie Mössbauer. Pour x compris entre 14 et 23 le champ interne moyen et le déplacement isomérique augmente linéairement avec la concentration en bore. Les résultats obtenus sont discutés et comparés à l'influence de la concentration sur le moment magnétique.

Abstract.- The Mössbauer spectra of rapidly quenched $Fe_{100-x}B_x$ ($x=8\sim 33$) alloys have been observed and analysed by computer. It was found that the averaged internal field and the isomer shift for the amorphous samples with $x=14\sim 23$ increased linearly with the increase of the concentration of boron. The results were discussed in connection with the concentration dependence of the magnetic moment.

1. Introduction.- A recent experimental work on the concentration and temperature dependence of the magnetic moment in rapidly quenched amorphous Fe-B alloys [1] has shown that the magnetic moment of the alloys decreases and the Curie temperature increases with increasing boron concentration.

Also, the temperature dependence of the uniaxial magnetic anisotropy observed in the amorphous state of $Fe_{81}B_{19}$ alloy has exhibited a similar behavior to that of the magnetocrystalline anisotropy of crystalline Fe_2B compound [2].

However, little has been elucidated as to the relation between those averaged magnetic characteristics and the internal magnetic structure related to the arrangement of atoms. In view of this, a study of the Mössbauer effect for rapidly quenched Fe-B alloys has been carried out.

2. Experimental procedure.- The $Fe_{100-x}B_x$ ($x=8\sim 33$) alloy samples were made in a ribbon form (30 μ m thick and 1.2 mm wide) by rapid quenching from the melt at about 1300°C onto a rotating steel disk (150 mm in diameter; 4000 rpm). The X-ray diffraction patterns (Fe-K α radiation) for as-quenched samples with $x = 14\sim 23$ showed diffused-halo while the diffraction patterns for the alloys with $x\leq 12$ and $x\geq 25$ exhibit sharp rings corresponding to those for crystalline α -Fe, Fe_2B and Fe_3B alloys.

Measurements of the Mössbauer spectra have been carried out at room temperature by using a constant acceleration spectrometer and a 512-multichannel analyser. As a source of γ -ray, ^{57}Co (2.2 mCi) diffused in copper was used. As an absorber, about 20 ribbons (2 cm in length) were placed in parallel to each other within the window frame and the measure-

ments were performed with the standard transmission geometry. The radiation has been continued until the count of spectra reached to about 10^5 counts in each channel. An absorption line width of pure iron foil used as a standard sample was 0.31 mm/s in this apparatus.

3. Experimental results and discussion.- The Mössbauer spectra of as-quenched $Fe_{100-x}B_x$ alloys are shown in figure 1. The spectra for thus prepared crystalline alloys with $x=8, 12$ and 33 consist of sharp peaks corresponding to those of α -Fe and Fe_2B , and that for the crystalline alloy with $x = 25$ exhibits sharp peaks associated with Fe_3B and Fe_2B . On the other hand, the spectra for amorphous alloys with $x=14\sim 23$ consist of six broad peaks.

A computer fitting of the spectra has been carried out by assuming that the internal field distribution has the split Gaussian function [3] defined by

$$P(H) \propto \begin{cases} \exp[-(H-H_0)^2/2\Delta_1^2] & \text{for } H > H_0, \\ \exp[-(H-H_0)^2/2\Delta_0^2] & \text{for } 0 \leq H \leq H_0, \end{cases} \quad (1)$$

where $P(H)$ is normalized to satisfy $\int_0^\infty P(H)dH=1$. The values of Δ_0 , Δ_1 , H_0 , isomer shift δ , quadrupole splitting, and ratios of the absorption peak intensities are independently varied by the computer to produce the best fit to the spectrum. In this computer fitting the half-widths of the fundamental six lines of iron were taken to be 0.31 mm/s.

Figure 2 shows the distribution of internal field thus obtained. As seen in this figure, the functions for $x=14$ and 15 alloys are asymmetric with a tail at lower H , while the functions for $x\geq 17$ alloys become symmetric and narrow with increasing x .

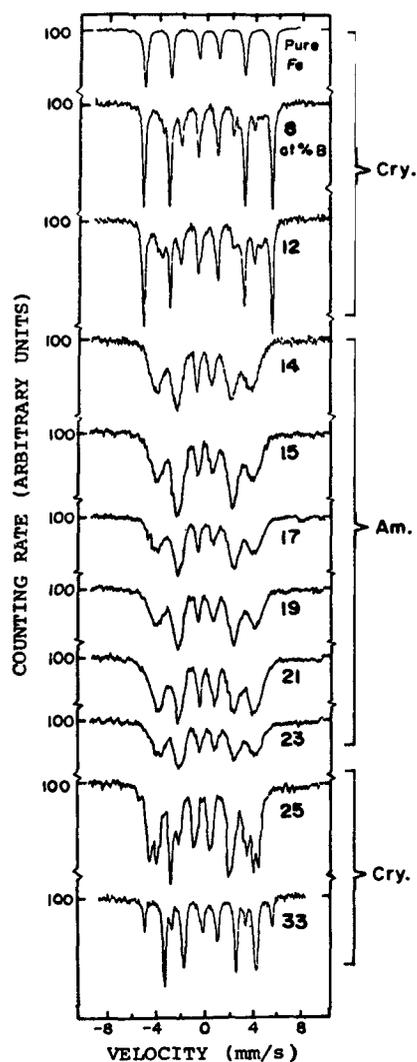


Fig. 1 : Mössbauer spectra of as-quenched $\text{Fe}_{100-x}\text{B}_x$ alloys and pure Fe (the sample with $x=25$ was made by using a Cu-disk).

However, a field corresponding to the maximum of $P(H)$, H_0 , is nearly constant and the $P(H)$ covers the range between about 150 and 320 kOe. The average value of internal field \bar{H} ($=\int_0^\infty P(H)HdH/\int_0^\infty P(H)dH$) is shown in figure 3, together with the magnetic moments at 0 K and room temperature, m_B (0 K) and m_B (R.T.), respectively, and the Curie temperature T_C , which have been obtained before /1/. As seen in figure 3, \bar{H} (R.T.) increases slightly and linearly against x , following an expression $234+0.62x$. The values of \bar{H} and m_B (R.T.) extrapolated to $x=0$, 25 and 33 deviate much from those of crystalline α -Fe, Fe_3B and Fe_2B , respectively. In figure 4(a), \bar{H}/m_B (R.T.) is shown as a function of x . The value of \bar{H}/m_B (R.T.) decreases linearly in x , following an expression $154-0.92x$. The value extrapolated to $x=0$ is $154 \text{ kOe} \cdot \mu_B^{-1}$, which corresponds to that for a crystalline α -Fe, while the extrapolated values at

$x=25$ and 33 are not exactly equal to that for Fe_3B and Fe_2B compounds, respectively.

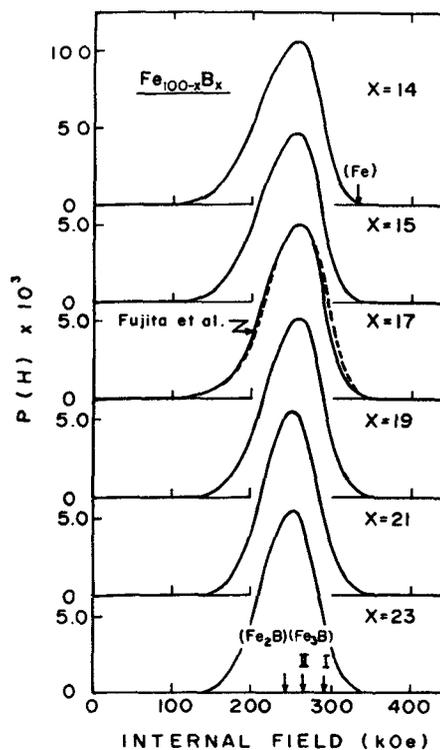


Fig. 2 : Concentration dependence of internal field distribution. Dashed line shows data by Fujita et al.[⊛]. Arrows indicate the internal field corresponding to those for α -Fe, Fe_2B and the sites I and II of Fe_3B .

[⊛]Oshima R., Fujita, F.E. and Masumoto, K., presented at the Meeting of the Japan Institute of Metals in Hiroshima, October 1977.

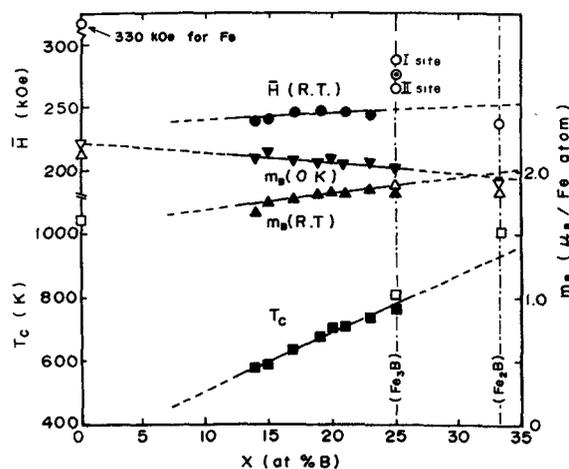


Fig. 3 : Average internal field \bar{H} , magnetic moments m_B (R.T.), m_B (0 K), and Curie temperature T_C vs boron concentration x (closed marks indicated the data for amorphous alloys, open ones are for crystalline alloys, and a open circle with a dot is the average value for the sites I and II of Fe_3B).

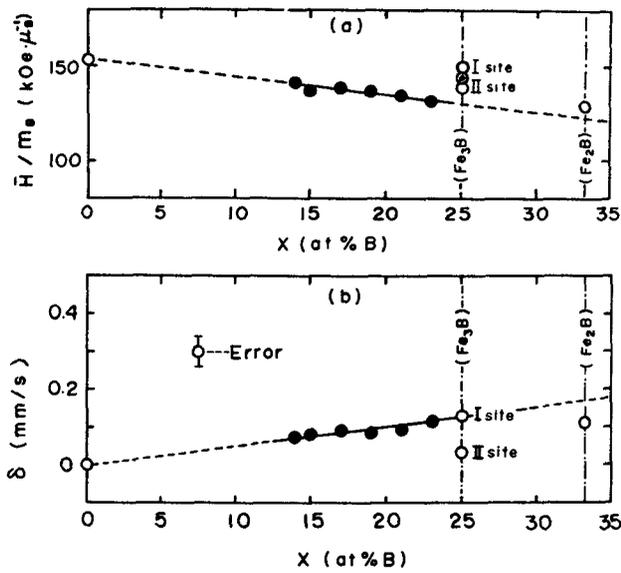


Fig. 4 : a) \bar{H}/m_B (R.T.) vs x (marks have the same meaning as that in fig. 3)
b) Isomer shift δ vs x .

It is interesting to note here that even though the extrapolated values of \bar{H} and m_B (R.T.) at $x=0$ are much different from that of $\alpha\text{-Fe}$, the ratio \bar{H}/m_B (R.T.) coincides with the value of $\alpha\text{-Fe}$.

The isomer shift δ is given in figure 4(b). The value of δ increases with x within the accuracy of measurements. If we simply assume from this result, that electrons transfer from boron to 3d holes of an Fe atom /4/, then it would be expected that m_B (R.T.) decreases with increasing x , in contradiction to the behavior of m_B (R.T.) shown in figure 3. This discrepancy could not be understood at present. Moreover, it should be investigated how the distribution of internal field is related to atomic arrangements in amorphous alloys, and also to the magnetic properties reported before /1/, /2/.

References

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