MÖSSBAUER STUDIES OF AMORPHOUS (FexNi1-x) 80B20
C. Chien, D. Musser, F. Luborsky, J. Walter

To cite this version:

HAL Id: jpa-00218642
https://hal.archives-ouvertes.fr/jpa-00218642
Submitted on 1 Jan 1979

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
MÖSSBAUER STUDIES OF AMORPHOUS \((FexNi1-x)80B20\)†

C.L. Chien, D. Musser, F.E. Luborsky* and J.L. Walter*

Department of Physics, The Johns Hopkins University, Baltimore, Maryland 21218, U.S.A.
*General Electric Research and Development Center, Schenectady, New York 12301, U.S.A.

Abstract.-Magnetic ordering temperature \(T_C\) and the magnetic hyperfine interaction of amorphous \((FexNi_{1-x})80B20\) \((0.375 \leq x \leq 1)\) have been determined by \(57\)Fe Mössbauer spectroscopy. The average exchange interaction of \(J_{FeNi} = 1.5 J_{FeFe}\) and \(J_{NiNi} = 0\) have been deduced. The hyperfine field distributions \(P(H)\) are well-defined and show only a slight asymmetry about \(H_{peak}\). The peak value of \(P(H)\), \(H_{peak}\), and \(\langle H\rangle = \langle H \rangle / H_{peak}\) decrease whereas the average isomer shift increase as \(Fe\) concentration is reduced. A noticeable amount of \(Fe\) atoms have a saturation field higher than 340 kOe, the saturation value for crystalline \(\alpha\)-Fe.

1. Introduction.- Most of the amorphous magnetic solids studied to date fall into two categories: rare earth-transition metal systems and transition(TM)-metalloid systems /1/. In the case of the latter the TM concentration typically is about 80 ± 5 at.%. It is tempting to compare the behavior of the TM-metalloid system with that of crystalline TM alloys and several have been done so. In this work, amorphous samples of \((FexNi_{1-x})80B20\) have been studied. It is shown that the properties of the \((Fe-Ni)\)-metalloid samples are quite different from those of Fe-Ni alloys.

2. Experimental.- Amorphous samples of \((FexNi_{1-x})80B20\) were prepared by the rotating drum method /2/. Samples with \(Fe\) concentration much less than 30 at.\% could not be made amorphous. The "as-prepared" samples were used in the \(57\)Fe Mössbauer spectroscopy measurements.

3. Results and discussion.- 3.1. Curie Temperatures \(T_C\).- The magnetic ordering temperatures \(T_C\) of \((FexNi_{1-x})80B20\) have been determined by the onset of the magnetic hyperfine interaction. These values are shown in figure 1 as a function of \(Fe\) concentration. The values for samples with \(x=0.75\) and 0.875 have larger errors due to the proximity of crystallization to \(T_C\). These values are in good agreement with those of Becker et al. /3/ determined from magnetic measurements.

For comparison, the values of \(T_C\) for amorphous \((Fe_{x}Ni_{1-x})80P14B6\) /4/ are also shown in figure 1.

Fig. 1: \(H_{peak}\) (the peak of \(P(H)\)), \(\langle H\rangle = \langle H \rangle / H_{peak}\) /4/, average isomer shift (relative to \(\alpha\)-Fe at 4.2 K) and the magnetic ordering temperature of amorphous \((Fe_{x}Ni_{1-x})80B20\) as a function of \(Fe\) concentration. The values of \(T_C\) for amorphous \((Fe_{x}Ni_{1-x})80P14B6\) are also shown for comparison.

The values of \(T_C\) decrease drastically from the \(Fe\)-rich samples to the \(Ni\)-rich samples. Magnetically,
while ferromagnetism occurs in most of the concentration range, spin-glass behavior occurs in the samples with low Fe content \((x \leq 0.15)\)/5/. These features are substantially different from those of crystalline Fe-Ni alloys /6/. Although low Fe concentration samples are not available for amorphous \((Fe_xNi_{1-x})_5B_20\), their behavior would be similar to that of other Fe-Ni glasses with similar Fe-Ni contents.

The average exchange interaction among Fe and Ni of \(J_{FeFe} = 680\) K, \(J_{FeNi} = 1.5\) \(J_{FeFe}\) and \(J_{NiNi} = 0\) have been determined using the results from a coherent potential calculation /7/. The very different values of \(J_{FeNi}\) and \(J_{NiNi}\) are clear from the concentration dependence of \(T_c\). The larger value of \(J_{FeNi}\) comes from the fact that the curve shown in figure 1 has a maximum in the mid-Fe-concentration range.

3.2. Magnetic hyperfine interaction. - The magnetic hyperfine spectra of \((Fe_xNi_{1-x})_5B_20\) at 4.2 K are shown in figure 2. The distributions of hyperfine fields \(\{P(H)\}\) contained in these spectra have been analysed using the Fourier series method developed by Window /7/. The reliability and the shortcomings of this method have been described elsewhere /9,10/.

Of considerable interest is the value of \(H_{max}\) at which \(P(H)\) approaches zero. A number of \(P(H)\) analyses of amorphous Fe-metalloid systems have indicated that at room temperature, \(H_{max}\) is less than that of crystalline \(\alpha-Fe(330\) kOe) /1,11/. This implies that no appreciable amount of Fe atoms could have hyperfine field values higher than that of \(\alpha-Fe\). However, it appears that this is not the case for the saturation \(P(H)\) measured near 0 K. As shown in figure 2, for the Fe-rich samples, \(H_{max}\) is about 380 kOe; there are a noticeable amount of Fe atoms which have hyperfine fields higher than 340 kOe, the saturation value for \(\alpha-Fe\). Previously, Bernas et al. /12/ have indicated that the conduction electron contribution to the hyperfine field is much less important in crystalline Fe-B interstitial compounds. The present results of a larger \(H_{max}\) is consistent with this conclusion since the conduction electron contribution has an opposite sign to that of the core polarization.

![Fig. 2: Magnetic hyperfine spectra and field distribution \(\{P(H)\}\) of amorphous \((Fe_xNi_{1-x})_5B_20\) at 4.2 K.](image)

Since the spectra are very symmetric about the centroid, we have assumed in these analyses a single average isomer shift and no effective quadrupole interaction. The \(P(H)\) obtained from these spectra are quite structureless and slightly asymmetrical. For samples with decreasing Fe concentration, the \(P(H)\) shifts to lower \(H\) values. The values of \(H_{peak}\) (the peak of \(P(H)\)), \(<H> = \int H P(H) dH\) (the average hyperfine field) and the average isomer shift determined are shown in figure 1 as a function of Fe content. The isomer shift values are relative to that of crystalline \(\alpha-Fe\) at 4.2 K. Both \(H_{peak}\) and \(<H>\) increase monotonically with Fe content whereas the average isomer shift decreases with Fe content. Unlike the behavior of \(T_c\), \(H_{peak}\) and \(<H>\) show no maximum in the mid-Fe-concentration range. These features are also similar to those of other (Fe-Ni) metallic glasses /4,10/.

Since the spectra are very symmetric about the centroid, we have assumed in these analyses a single
References


