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Mössbauer studies on athermal martensite formation in an Fe–Ni–Mn alloy

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Abstract. In this study, austenite–martensite phase transformations which are formed by cooling effect in Fe–30% Ni–0·2% Mn alloy are investigated with Mössbauer spectroscopy and scanning electron microscopy. The single peak of the paramagnetic phase and the six peaks of the ferromagnetic phase of Fe–30% Ni–0·2% Mn alloy were observed in the Mössbauer spectrum. The internal magnetic field strength of ferromagnetic martensite phase was determined as 33·8 *T* and the isomer shift values were determined as – 0·11 mm·sec^{-1} and – 0·06 mm·sec^{-1}, respectively, for the austenite and martensite phases. In this alloy, athermal transformation was observed. The results obtained are in agreement with literature.

Keywords. Austenite–martensite; Mössbauer spectroscopy; scanning electron microscopy; isomer shift.

1. Introduction

It is well known that there is a strong correlation between the magnetic behaviour of Fe based alloys and their austenite to martensite phase transformation. In spite of the paramagnetic nature of the austenitic parent phase in these alloys, martensitic product phase exhibits a distinctive ferromagnetic character (Korenko and Cohen 1979; Yang *et al* 1992; Tamarat *et al* 1993; Varma *et al* 1994).

In some Fe alloys both athermal and isothermal type of martensite formations may occur (Yang *et al* 1984; Kakeshita *et al* 1993). Fe–Ni–Mn alloys are known as the typical examples of such materials and it was explained earlier that although the isothermal transformation is considered as the general type, athermal transformations may be described as a special case with a very short incubation time (Kurdjumov and Maximova 1950). Athermal and isothermal transformation behaviour was found to be quite sensitive to the alloy composition by Kakeshita *et al* (1993). In the present work, the Mössbauer spectroscopic and scanning electron microscopic techniques were used to investigate some physical properties of the athermal martensite formation in Fe–30% Ni–0·2% Mn alloy.

The application of Mössbauer spectroscopy is to reveal several physical aspects of the martensitic transformations in different Fe alloys and valuable results can be obtained with Mössbauer effect measurements in such alloys (Akgün *et al* 1982; Durlu 1992; Zhangtao *et al* 1996).

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2. Experimental

Thin foils of Fe–30% Ni–0·2% Mn alloy specimens were prepared by mechanical and chemical thinning procedures and used in Mössbauer spectroscopic and scanning electron microscopic experiments. Foil samples for Mössbauer spectroscopy and SEM were thinned by using double-jet polishing technique with a solution of 5 ml HF, 65 ml H_2O and 30 ml H_2O_2 and the foils were austenized at 1000°C for 14 h in argon atmosphere. The samples were kept in liquid nitrogen (– 196°C) for 5 s to obtain an athermal martensitic transformation. The Mössbauer spectroscopy was carried out at room temperature by using 50 mCi ^{57}Co source diffused in Rh and the foils were examined in a JEOL-JSM-5600 SEM operating at 30 kV. The Mössbauer spectra were calibrated with respect to α-Fe. The isomer shifts were given relative to the centre of the α-Fe spectrum.

3. Results

Figure 1a shows a SEM micrograph of austenite matrix. The grain boundaries of the austenite matrix are also shown. Figure 1b shows martensitic transformation after the sample was kept in liquid nitrogen (– 196°C) for 5 s. The type of this transformation is 'Lath martensites' which can be seen in figure 1b.

Figure 2 shows the Mössbauer spectra of Fe–30% Ni–0·2% Mn prior to and after the martensite formation. Figure 2a is a typical single peak of paramagnetic phase of the same sample. Figure 2b is the Mössbauer spectrum of Fe–30% Ni–0·2% Mn after cooling which exhibits a

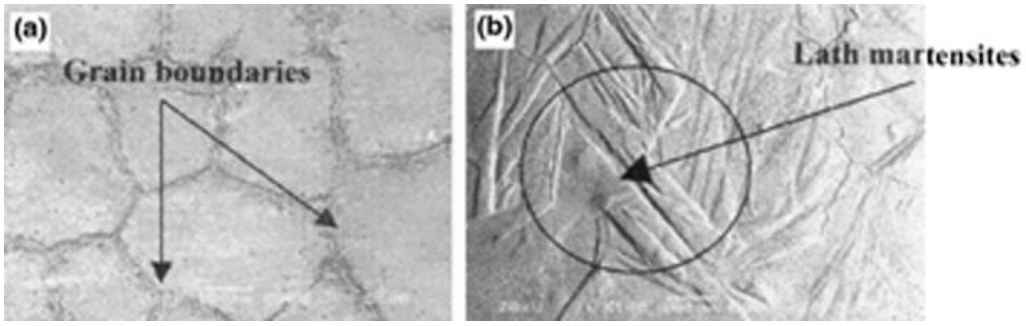

Figure 1. SEM micrograph of (**a**) austenite and (**b**) martensite matrix.

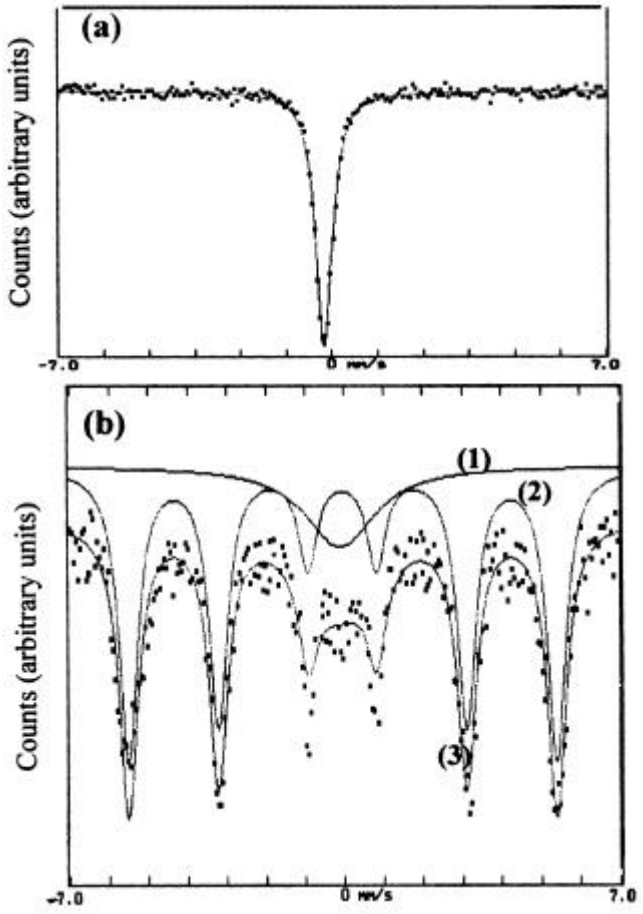

Figure 2. Mössbauer spectra of (**a**) austenite, and (**b**) athermal martensite and retained austenite. Line (1) which has a single peak represents the austenite matrix, line (2) which has a six-line spectrum represents the martensite matrix and line (3) is the total spectrum.

typical six-line spectrum of the ferromagnetic structure and also a singlet corresponding to the austenite.

The volume fraction of martensite was measured as 81·2% for the sample kept in liquid nitrogen for 5 s. The measured experimental values are given in table 1. The isomer shift values of the austenite matrix and product phases were measured as $-0{\cdot}11$ mm·sec^{-1} and $-0{\cdot}06$ mm·sec^{-1}, respectively, with a standard deviation of $\pm 0{\cdot}01$. The internal magnetic field value of the martensite was measured as 33·8 *T* after the Mössbauer analysis.

Table 1. The measured values for Fe–30% Ni–0·2% Mn alloy.

	Room temperature	Liquid nitrogen (– 196°C)	
	Austenite	Austenite	Martensite
Isomer shift (mm·sec^{-1}) (± 0·01)	– 0·19	– 0·11	– 0·06
Volume (%)	100	18·8	81·2
BHF (*T*)	–	–	33·8

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