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MÖSSBAUER STUDY OF THE $Ni_3Fe(^{119}Sn)$ ORDERING[1]

ИЗУЧЕНИЕ УПОРЯДОЧЕНИЯ В $Ni_3Fe(^{119}Sn)$ ПРИ ПОМОЩИ МЕССБАУЭРОВСКОЙ СПЕКТРОСКОПИИ

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The ^{119}Sn Mössbauer spectroscopy was shown to be a sensitive tool for the study of the ordering process of the Ni_3Fe alloy (Permalloy). Room temperature Mössbauer spectra and electric resistivity were measured for the Ni_3Fe-1 at. % Sn(^{119}Sn enriched) alloy annealed gradually from 550 down to 460 °C. Around 510 °C striking changes of the magnetic hyperfine field were found.

A previous work [1] has shown the ^{57}Fe spectroscopy to be quite insensitive to the study of the $L1_2$ type atomic ordering in Ni_3Fe in comparison with the DO_3 one in the Fe — nontransitive metal alloys. This is due to small changes in the nearest neighbourhood of iron and also the magnetic moment itself of nickel. In this paper we report on the ^{119}Sn Mössbauer measurements of a Ni_3Fe-1 at. % Sn doped alloy around the critical ordering temperature. As shown in [2, 3] this proved to be more sensitive. Simultaneously resistometric measurements were done.

Sample preparation and both the Mössbauer and specific resistivity measurements were essentially the same as described previously [3]. The ordering anneal in the temperature interval from 550 °C down to 460 °C was prolonged to 168 hrs.

The influences of short and long time annealing on the long range order determined by the temperature dependence of the resistivity is shown in Fig. 1. As noted in [3] the addition of tin influences not only the magnitude of the electric resistivity, but also increases the critical ordering temperature of about 10 K against Ni_3Fe. One can see that the annealing time has no essential influence on the character of the $\varrho(T)$ curve by increasing further the critical temperature by 5 to 10 K. Higher values of the electric resistivity above the critical temperature are likely to be caused by different initial states of the samples. An abrupt resistivity increase at 480 °C was caused by the sample oxidation so that the series was interrupted.

Mössbauer spectra were least-squares decomposed into four Zeeman components and the corresponding ^{119}Sn ground state splittings g_0 (along with the intensity distribution) were determined. In Fig. 2 the temperature dependence of the average $\bar{g}_0$ is plotted. The prolongation of annealing from 24 to 168 hrs diminished the temperature interval of the remarkable change of $\bar{g}_0$ from 15 down to 10 K and simultaneously further increased the critical temperature of ca 5 to 10 K in accordance with the above $\varrho(T)$ change.

We suggest the higher sensitivity of the ^{119}Sn spectroscopy to be caused by the fact that the Sn atom has no magnetic moment and the hyperfine field is therefore completely determined by the magnetic surroundings via the electron polarization effects. The ^{119}Sn hyperfine fields, i.e. the splittings g_0, vary in a broad range from those of diluted Sn in Ni (1.2 mm/s) up to 50 % higher than Sn in α-Fe (6.7 mm/s)

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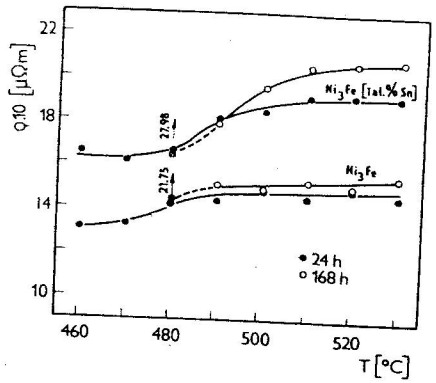

Fig. 1. Specific electric resistivity ϱ vs. annaeling temperature T.

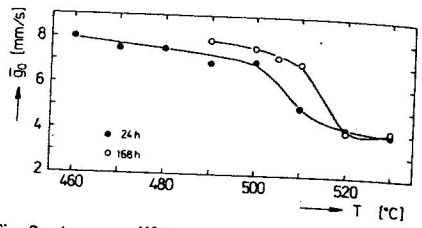

Fig. 2. Average ^{119}Sn splitting $\bar{g}_0$ vs. annealing temperature T.

due to the higher coordination number in the fcc structure and a closer packing. Hence strong changes of measured g_0 are to be expected due to the variations of the ^{119}Sn surroundings, i.e. with the state of the Ni_3Fe order. To find a right model explaining the anomalous temperature dependence it is important to know the character of the g_0 distribution.

We therefore tried to find a model-independent distribution of g_0. The measured spectrum as a function of velocity v is given by a superposition of lorentzian six-line patterns

$$L_6(v, g_0) = \sum_{i=1}^{6} L_i(v)$$

in the form

$$\int_{g_{0\,min}}^{g_{0\,max}} p(g_0)\, L_6(v, g_0)\, \mathrm{d}g_0 \cong \sum_{i=1}^{n} p_i(g_0) L_6(v, g_0).$$

In the latter approximation, the above decomposition into four components gave the probability coefficients $P_i(g_0)$ for $n = 4$. The resulting histograms for both the short and the long time anneals are

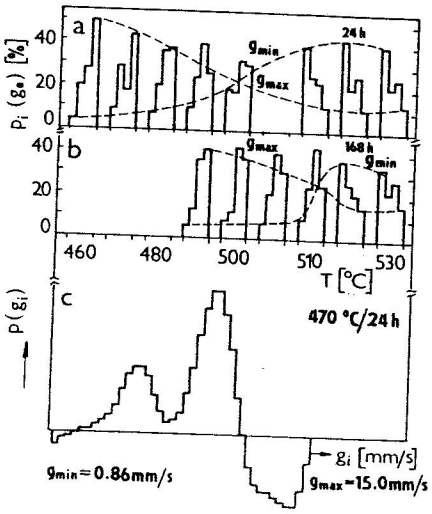

Fig. 3. Magnetic splitting distribution in an Ni_3Fe (1 at. % Sn) alloy: a, b — four components, c — forty components.

shown in Fig. 3a, b. The character of the changes was again substantially the same, longer anneals giving steeper changes in the critical region. It is obvious that the cause of the strong $\bar{g}_0$ changes lies in the fast diminishing of the lowest g_0 component just below the critical temperature in favour of a slower increase of the higher components up to a strongly prevailing one with $g_0 = 9.8$ mm/s in the ordered state. This, together with the increasing ordering temperature of Ni_3Fe by adding Sn, supports the explanation that tin atoms serve as ordering nuclei in the disordered lattice.

Because of the diversity of tin surroundings when counting for at least two coordination shells, the found components can hardly be ascribed to given configurations. Instead of this structure model approach we tried to find an analogy of the hyperfine field distribution known, e.g., from the study of amorphous alloys. By the Hesse-Rübartsch procedure [4] a similar histogram was found for $n = 40$ as shown in Fig. 3c. Despite the oscillations at extreme g_0, the distribution character is reproduced (comp. Fig. 3a, 2nd left and 3c), and we intend to follow the g_0 distribution changes in more detail.

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