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Abstract

Full Text

Physics

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STUDY OF THE Ni K_{β_5}-BANDS OF THE X-RAY SPECTRUM OF NICKEL IN ALLOYS OF THE Mn—Ni SYSTEM

(Presented by Academician N. V. Belov on 23 VI 1961)

The article gives results that are a continuation of studies of alloys of the Mn—Ni system by means of X-ray spectra ([1]). The form, width, intensity, and position of the Ni K_{β_5}-bands on the energy scale under the influence of changes in the composition, temperature, and magnetic transformations of the alloys were investigated. Some information concerning the Ni K_{β_1} line was also obtained. Alloys Nos. 2, 3, 5 ($\theta = 250.5^{\circ}$) and No. 6 ($\theta = 297.5^{\circ}$), containing respectively 51.3; 59.2; 86.21 and 92.43 wt.% Ni, were studied—the same alloy specimens as in work ([1]).

Fig. 1. Shape and position on the energy scale of the Ni K_{β_5}-band in alloys of the Mn—Ni system

The K-spectra of nickel were excited by the primary method and recorded with a short-wavelength tube spectrograph with a bent crystal* (the Cauchois method). The dispersion in the region of the K_{β}-group of the nickel spectrum was 3.92 X $\cdot$ mm^{-1}. The temperature of the alloys on the anode of the X-ray tube was monitored with the aid of indicator alloys ([1]). An experimental check of this method as applied to the short-wavelength spectrograph showed that the temperature of the specimen changes nonlinearly with increasing specific load on the X-ray tube. This method does not make it possible to control the specimen temperature more accurately than $\pm 20^{\circ}$; therefore, the spectra were recorded not in the immediate vicinity of the Curie "point," but in regions 50-60° away from it. By varying the dimensions of the focal spot and the specific load supplied to the tube, it was possible to reach readily the regions of the ferro- and paramagnetic states of the alloys.

Results. In Fig. 2, for illustration, a microphotogram of the K_{β}-group of the nickel spectrum in alloy No. 3 is shown. Consideration of the micro-

* Spectrograph of M. A. Blokhin ([2]) with a safe X-ray tube designed by V. A. Kazantsev.

photograms shows that the satellite Ni $K_{\beta'}$ is superposed on the long-wavelength branch of the line K_{β_1} and merges with it. For this reason, judgments about Ni $K_{\beta'}$ become impossible. No effect of temperature, nor of alloy composition, on the Ni K_{β_1} line was detected; its wavelength in all alloys retains the value 1497.2 ± 0.1 X. The satellite Ni $K_{\beta''}$ is not detected either in first-order spectra or in second-order reflection spectra.

Some results showing the dependence of various characteristics of Ni K_{β_5} on composition, temperature, and magnetic transformations of the alloys are given in the corresponding Tables 1–3. In all tables the following notation is adopted: λK_{β_5} is the wavelength of the intensity maximum of Ni K_{β_5} (error ± 0.04 X.U.); ΔE_{β_5} is the change in energy of the Ni K_{β_5}-photon (error 0.2 eV); $\Delta E^*_{1/2}$ is the width of Ni K_{β_5} at half the intensity maximum (error ± 0.5 eV); $I_{\max}$ is the relative intensity of the maximum of Ni K_{β_5} (accuracy 4%); I_i is the integral intensity in relative units (accuracy 8–10%); a_{β_5} is the asymmetry index of the Ni K_{β_5}-band; f.m. and p.m. are, respectively, the ferromagnetic and paramagnetic states of the alloys.

Table 1

Dependence of the characteristics of Ni K_{β_5} on the composition of alloys; all alloys are paramagnetic

Alloy No.	Alloy temp., °C	λK_{β_5}, X	$\Delta E_{1/2}$, eV	$I_{\max}$	I_i	a_{β_5}
2	~ 450	1485.70	13.4	0.85	1.2	1.06
3	120	1485.79	14.0	1.14	1.5	1.17
3	450	1485.41	13.5	1.00	1.2	1.13
5	450	1485.36	15.2	1.57	1.4	1.33

Analysis of the experiment leads to the following conclusions:

1. An increase in the nickel content in the alloys at low temperatures has no effect on the characteristics of Ni K_{β_5} $(\lambda, \Delta E_{1/2})$. Only an increase in the intensity of this band is observed, which is natural.

At high temperatures, the influence of the nickel content, in particular on λK_{β_5}, apparently does exist: the wavelength of Ni K_{β_5} decreases noticeably with increasing nickel content, while its width increases.

2. The transition of the alloys to the paramagnetic state, caused by an increase in the manganese content in the alloys, is accompanied by an increase in the energy of the Ni K_{β_5}-photon by an average of 2.2 eV. In this

case Ni K_{β_5} becomes more asymmetric. A noticeable increase in intensity and some increase in the width of this band are observed.**

3. The magnetic transformation that occurred under the influence of an increase in the temperature of the alloys is accompanied by an increase in the energy of the Ni K_{β_5}-photon by an average of 2.1–2.8 eV for different alloys. The emission band Ni K_{β_5} thereby becomes more intense and strongly asymmetric (see Fig. 1).

Taking into account the results of work (1), the following can be said concerning Mn K_{β_5} and Ni K_{β_5}. The transition of Mn—Ni alloys to the paramagnetic state, whether achieved under the influence of a change in alloy composition or under the influence of temperature (without a change in composition), leads to identical changes in the characteristics of the K_{β_5}-bands for manganese and nickel, respectively. The changes in the intensities and widths of the K_{β_5}-bands, as well as their shifts for manganese and nickel, proceed in opposite directions and are of the same order of magnitude. This makes it possible to suppose that the paramag-

Fig. 2. Microphotogram of the K_β-group of the nickel spectrum in alloy No. 3

* Without corrections for broadening during focusing from a bent crystal.
** Similar effects were found in Heusler-type alloys by E. E. Vainshtein and B. I. Kotlyar (3).

Table 2

Dependence of the characteristics of Ni K_{β_5} on the magnetic transformation occurring under the influence of changes in alloy composition

Alloy No.	Magnetic state	λK_{β_5}, X	$\Delta\lambda K_{\beta_5}$, X	ΔE_{β_5}, eV	I_{max}	I_i	$\Delta E_{1/2}$	a_{β_5}
6	f. m.	1485.78			1.00	1.0	13.7	1.08
5	p. m.	1485.39	−0.39	2.2 ± 0.2	1.37	1.4	15.0	1.32

Table 3

Dependence of the characteristics of Ni K_{β_5} on magnetic transformations of alloys occurring under the influence of temperature (transition through the Curie point)

Alloy No.	Magnetic state	λK_{γ_5}, X	$\Delta\lambda K_{\beta_5}$, X	ΔE_{β_5}, eV	I_{max}	I_i	$\Delta E_{1/2}$	a_{β_5}
5	f. m.	1485.76			1.00	1.0	14.0	1.12
5	p. m.	1485.39	−0.37	+2.1 ± 0.2	1.37	1.4	15.0	1.32

Alloy No.	Magnetic state	λK_{γ_5}, X	$\Delta\lambda K_{\beta_5}$, X	ΔE_{β_5}, eV	I_{max}	I_i	$\Delta E_{1/2}$	a_{β_5}
6	f. m.	1485.78			1.00	1.0	13.7	1.08
6	p. m.	1485.28	−0.50	+2.0± 0.2	1.33	1.3	14.6	1.24

—magnetic state of Mn—Ni alloys, regardless of the path by which it is reached, is characterized by a quite definite distribution of 3*d*, 4*sp*-energy states occupied by electrons in the lattice of the paramagnetic alloy.

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Note: Figure translations are in progress. See original paper for figures.