ON THE MAGNETIC PROPERTIES AND STRUCTURE OF NICKEL FILMS OBTAINED BY A CHEMICAL METHOD

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Abstract

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Physics

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The magnetic properties of nickel obtained by a chemical method depend to a high degree on the conditions under which the deposit is formed and on its subsequent treatment ([1–4]). The difference in the magnetic properties of nickel films should be determined both by the phosphorus content in the deposits formed and by the internal structure of the films obtained.

The authors of a number of works ([1,4]) found that freshly prepared specimens of chemically reduced nickel in all the cases they investigated have an amorphous structure, which, upon appropriate heat treatment of the specimens, becomes crystalline. In the present work it was found that freshly prepared specimens may have not only an amorphous but also a crystalline structure; moreover, ferromagnetic properties were not found in specimens with an amorphous structure, whereas specimens with a crystalline structure possess these properties.

The form of the specimens, the method of obtaining them, and the study of their magnetic properties are analogous to those described in ([3]). Table 1 gives the specimen data. Initiation of deposit formation was carried out by touching the copper substrate with a nickel wire. The deposition time for each specimen was 20 min. To average the results and to form layers of more homogeneous structure in the magnetic sense, the solution was replaced every 5 min of bath operation by a freshly prepared one. The bath temperature in obtaining specimens was 87°; the bath volume was 150 ml ([3]).

Table 1

Specimen No.	Nickel sulfate	Sodium hypophosphite	Sodium acetate	Thickness, μ	I_m, gauss	H_c, oerst.
	Solution composition, g/l					
1	30	10	15	3.6	–	–
2	30	10	12	5.1	35.2	7.95
3	30	10	10	5.2	66.3	12.5

Specimen No.	Nickel sulfate	Sodium hypophosphite	Sodium acetate	Thickness, μ	I_m, gauss	H_c, oerst.
4	30	10	8	6.6	71.8	3.96
5	30	10	6.5	7.4	–	–
6	30	10	5	5.8	–	–

In accordance with Table 1, Fig. 1 gives the hysteresis loops of the specimens, recorded from an oscillograph. All loops were obtained at a frequency of 50 Hz, with a field amplitude of 84 oerst. As can be seen from the figure, specimens Nos. 2, 3, 4, and 5 possess ferromagnetic properties.

(Figure: X-ray diffraction patterns of samples Nos. 1, 4, 6)

Fig. 2. X-ray diffraction patterns of samples Nos. 1, 4, 6

(Figure: X-ray diffraction patterns of samples thicker than 20 μ)

Fig. 3. X-ray diffraction patterns of samples with thickness above 20 μ

Studies carried out in stronger fields showed that sample No. 1 also has a hysteresis loop; consequently, a field of 84 Oe is too weak to reveal its ferromagnetic properties.

(Figure: Fig. 1.)

Fig. 1.

X-ray structural studies of the deposits were carried out. Samples for structural studies were obtained on copper wires 0.6 mm in diameter simultaneously with the samples used for recording the hysteresis loops. Figure 2 presents the X-ray diffraction patterns of samples Nos. 1, 4, and 6, taken in unfiltered Fe radiation. In all the X-ray diffraction patterns, in addition to the diffraction pattern corresponding to nickel, narrow lines of the copper substrate are visible.

The copper lines disappear when the thickness of the films is increased beyond 20 μ. Figure 3 gives X-ray diffraction patterns of such samples, corresponding in composition to samples Nos. 4 and 6.

In the X-ray diffraction patterns of samples Nos. 1 and 4 it is seen that the nickel deposits give a diffraction pattern with broadened lines, corresponding to the crystalline structure of β-Ni. The degree of line broadening increases with increasing reflection angle in proportion to the secant of the angle, which makes it possible to conclude that the deposits are finely dispersed. In the X-ray diffraction patterns of sample No. 4 a diffraction pattern is visible that is characteristic of "amorphous"bodies, with a diffuse line ("halo") corresponding to an interplanar spacing $d = 2.03$ Å and somewhat shifted relative to the center of the (111) line for cubic Ni. From comparison of the X-ray diffraction patterns

it can be seen that samples not possessing ferromagnetic properties have an "amorphous" ("liquid-like") structure. Studies carried out at our request by colleagues of Perm University, B. N. Varskii and L. P. Zvonareva, showed that nickel deposits having a crystalline structure possess a texture with the [111] axis; the degree of perfection of the order is 15°. Annealing of the samples leads to a change in the structure of the samples and a change in their magnetic properties. In particular, sample No. 6 changes from "amorphous" to crystalline and becomes ferromagnetic.

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REFERENCES

1. K. M. Gorbunova, A. A. Nikiforova, *Physicochemical Foundations of the Process of Chemical Nickel Plating*, Publishing House of the Academy of Sciences of the USSR, 1960.

2. N. V. Kotelnikov, V. I. Gachegov, *Izv. AN SSSR, Ser. Fiz.*, **25**, No. 5, 655 (1961).

3. N. V. Kotelnikov, N. A. Korenev, T. D. Ermolina, *DAN*, **143**, No. 4, 908 (1962).

4. V. P. Moiseev, *Izv. AN SSSR, Ser. Fiz.*, **26**, No. 3, 378, 384 (1962).

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