Investigation of Uniaxial Induced Anisotropy in $\text{Co}_{0.02}\text{Ni}_{0.58}\text{Cd}_{0.20}\text{Fe}_{2.20}\text{O}_4$ and $\text{Co}_{0.02}\text{Ni}_{0.58}\text{Cd}_{0.20}\text{Cr}_{0.20}\text{Fe}_2\text{O}_4$ Ferrites

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N. Huong, D. Minh, B. Cong, N. Chau. Investigation of Uniaxial Induced Anisotropy in $\text{Co}_{0.02}\text{Ni}_{0.58}\text{Cd}_{0.20}\text{Fe}_{2.20}\text{O}_4$ and $\text{Co}_{0.02}\text{Ni}_{0.58}\text{Cd}_{0.20}\text{Cr}_{0.20}\text{Fe}_2\text{O}_4$ Ferrites. Journal de Physique IV Proceedings, 1997, 07 (C1), pp.C1-229-C1-230. 10.1051/jp4:1997187 . jpa-00255134

HAL Id: jpa-00255134

<https://hal.science/jpa-00255134>

Submitted on 1 Jan 1997

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Investigation of Uniaxial Induced Anisotropy in $\text{Co}_{0.02}\text{Ni}_{0.58}\text{Cd}_{0.20}\text{Fe}_{2.20}\text{O}_4$ and $\text{Co}_{0.02}\text{Ni}_{0.58}\text{Cd}_{0.20}\text{Cr}_{0.20}\text{Fe}_2\text{O}_4$ Ferrites

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Abstract : The NiCd ferrites with Fe excess in comparison with stoichiometry composition and with Fe excess amount substituting by Cr, moreover containing small amount of Co are prepared. The formation of preminvar effect and uniaxial induced anisotropy in these ferrites are examined under the heat treatment with and without magnetic field. The appearance of uniaxial induced anisotropy causes unexpected changes of some magnetic and electric properties of ferrites.

1. INTRODUCTION.

A lot of ferromagnetic alloys exhibits the induced anisotropy and their properties are very sensitive with magnetic heat treatment. It was found that the uniaxial induced magnetic anisotropy (UIMA) is also presented in iron-excess nickel ferrites with doping of Co. The directional order theory and single - ion theory suggested by Néel [1], Taniguchi and Yamamoto [2], Chikazumi [3] and Slonczewski [4] are used to explain these phenomena.

The perminvar effect and the magnetic annealing treatment (MAT) of iron-excess NiZnCo [5] and NiCdCo [6,7] ferrites have been investigated.

In this paper, the influence of UIMA on the magnetic and electric properties of iron-excess NiCd and NiCdCr ferrites with small doping of Co is examined.

2. EXPERIMENT.

The ferrite samples with compositions :

N°1 $\text{Co}_{0.02}\text{Ni}_{0.58}\text{Cd}_{0.20}\text{Fe}_{2.20}\text{O}_4$

N°2 $\text{Co}_{0.02}\text{Ni}_{0.58}\text{Cd}_{0.20}\text{Cr}_{0.20}\text{Fe}_2\text{O}_4$

are prepared by conventional ceramic technology.

The toroid and parallelepiped samples are sintered at 1280°C and the isothermal keeping time is 3 hours. They are slowly cooled from sintering temperature to room temperature with rate $60^\circ \div 80^\circ\text{C/h}$. Then they are annealed with $T_{an} = 0.9T_c$ in magnetic field $H_{an} > 10H_c$.

The crystallographic structure of materials was checked by X-ray diffractometer Siemens D5000, magnetization and hysteresis loop parameters are measured by VSM and ballistic galvanometer respectively. The tensor-sensor technique is used to measure the longitudinal and transversal magnetostriction.

3. RESULTS AND DISCUSSION

After slowly cooling, the local anisotropy in both ferrites is appeared with characteristic perminvar hysteresis loop (Fig.1). During the suitable MAT, uniaxial anisotropy is induced in the sample and hysteresis loop becomes rectangular (Fig.2). Obviously, this UIMA causes the variation in some magnetic, electric properties of samples : the decreasing of initial permeability μ_0 and of its temperature coefficient; the increasing of the Curie temperature, maximum permeability μ_m , coercivity H_c , remanent and maximum induction as well as rectangular coefficient (see Tab.1). Moreover magnetostriction and galvanomagnetic effects are influenced by MAT.

The substitution of iron-excess amount (in sample N°1) by Cr (in sample N°2) leads qualitatively to the same influence on ferrites but Curie temperature T_c and magnetization are decreasing whereas specific resistance as well as activation energy are increasing. It could be explained that the substitution of Fe by Cr ions, the Fe^{2+} and Fe^{3+} concentrations in octahedral

sublattice are decreasing and this brings to reduction of magnetization of B sublattice and electron hopping between Fe^{2+} and Fe^{3+} also.

Especially the strong increase of dielectric constant ϵ (for one order) after MAT has been observed. One can suggest that the MAT applied in prepared ferrites creates not only magnetic polarization but also the electric polarization of ion pairs with identical valency (magnetic dipoles) or with different valencies (magnetic dipoles and pseudo-electric dipoles) in octahedral sublattice.

Figure 1. Hysteresis loop of slowly-cooled sample N°2

Figure 2. Hysteresis loop of slowly-cooled sample N°1 after MAT

Table 1. Some characteristics of samples N°1 and N°2 before and after MAT

Samples	Parameters	μ_0	μ_m	B_r (G)	B_m (G)	H_c (Oe)	T_c (°C)	E_p (eV)	σ_s at 77K (emu/g)	a (Å°)
N°1 slowly cooled		37	127	180	810	1	512	0.26	80	8.4047
N°2 slowly cooled		47	118	238	560	1.5	495	0.34	76	8.3996
N°1 subjected MAT		30	1900	2900	3000	1	526	0.17	91	8.3928
N°2 subjected MAT		38	1100	2600	2700	1.5	500	0.23	80	8.3924

4. CONCLUSION

After annealing in magnetic field, the uniaxial induced anisotropy is created in iron excess NiCd and NiCdCr ferrites containing small doping of Co. The substitution of Fe excess by Cr has remaining general behaviour of ferrites like perminvar effect and UIMA but some parameters are strongly changed. The strong influence of above mentioned anisotropy on the dielectric constant probably determined by us for the first time.

Acknowledgments

The authors are grateful to Dr N.X.Phuc from Materials Science Institute (NCNST) for magnetization measurement and to National basic research program on Natural Sciences for financial support.

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