

The Influence of La_2O_3 Substitution on the Structure and Properties of Sr Hexaferrite

N.K. Dung, D.L. Minh, B.T. Cong, N. Chau and N.X. Phuc*

Faculty of Physics, Natural Science University, 90 Nguyen Trai, Dong Da, Hanoi-Vietnam

* Institute of Materials Science, National Center for Natural Sciences and Technology, Nghia Do, Tu Liem, Hanoi-Vietnam

Abstract : The influence of La substitution on the structure, magnetic and electric properties of Sr hexaferrite is examined in isotropic and anisotropic samples. High quality hard ferrite is obtained with 1 weight % of La substitution (for SiO_2 doping samples as well).

1. INTRODUCTION

The doping of small amount of rare earth (RE) oxides in barium ferrite was examined by Summergrad and Bank [1], Deschamp and Bortant[2] very early but the negative influence of RE oxides was found. The magnetic properties of Ba ferrite have been improved firstly by Fransevich and Tulczinski [3] using small addition of La_2O_3 . In our works [4,5] the influence of La_2O_3 substitution on the properties of Ba hexaferrite is systematically investigated. The aim of this paper is to examine the effect of La_2O_3 substitution on the structure, magnetic and electric properties of Sr hexaferrite.

2. EXPERIMENT

Hexagonal Sr ferrite with compositions : $(\text{SrO})_{1-x}(\text{La}_2\text{O}_3)_{x/2}5.3\text{Fe}_2\text{O}_3$ ($x = 0.00 \div 0.12$) with/without SiO_2 addition were mixed and milled by wet method using vibrating mill, presintered at 1250°C for 2h and sintered at $1220^\circ\text{C} \div 1260^\circ\text{C}$ for $0.5 \div 2$ h.

The crystallographic structure and phase components were examined by DTA, DTG and X-ray diffraction, TEM and SEM. Some physical parameters of materials like magnetization, coercivity, remanent induction, maximum energy product, Curie temperature, specific resistance, dielectric constant, density etc. were determined.

3. RESULTS AND DISCUSSION

From X-ray analysis we could remark that all samples are single hexagonal phase with a little increase of lattice parameters ($a = 5.8788\text{\AA} \div 5.8816\text{\AA}$, $c = 23.0421\text{\AA} \div 23.0514\text{\AA}$).

Figure 1 shows for example the X-ray diffraction pattern for composition with $x = 0.04$. The DTA and DTG analyses exhibit the general behaviour that with increasing of La_2O_3 content, the ferritization reaction is shifted to higher temperature (from 950°C to 1200°C).

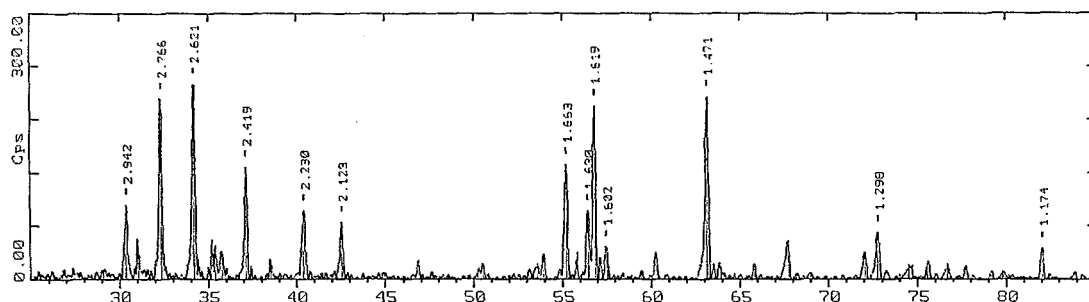


Figure 1 : X-ray diffraction pattern for composition with $x = 0.04$ (sample S3)

Table 1 shows the changing of some physical parameters of Sr ferrite versus La_2O_3 substitution concentration. Beside the strong variation of specific resistance ρ of samples on x , the rest parameters are changing undesirable (Tab.1). The fast

decrease of ρ on x could be explained by the fact that when La^{3+} content is increasing, a part of Fe^{3+} changed to Fe^{2+} and this leads to the strengthening of electron hopping process between Fe^{3+} and Fe^{2+} ions in octahedral sites.

Table 1 : Some physical parameters of isotropic samples depending on x

Sample	x	$a(\text{\AA})$	$c(\text{\AA})$	$d(\text{g/cm}^3)$	$\rho(\Omega.\text{cm})$	σ_s at 77K (emu/g)	$T_c(\text{°C})$
S1	0.00	5.8788	23.0421	4.89	$7.9 \cdot 10^7$	90	465
S2	0.02	5.8812	23.0429	4.94	$6.4 \cdot 10^7$	92	465
S3	0.04	5.8812	23.0436	4.92	$1.14 \cdot 10^7$	100	468
S4	0.06	5.8816	23.0428	4.94	$3.6 \cdot 10^5$	95	466
S5	0.08	5.8816	23.0514	4.90	$2.1 \cdot 10^4$	91	465
S6	0.10	5.8816	23.0447	4.94	$1.9 \cdot 10^4$	88	464
S7	0.12				$1.5 \cdot 10^3$	85	463

Table 2 shows the dependence of hard magnetic characteristics of isotropic samples versus x at different sintering temperatures.

Table 2 : Hysteresis loop parameters of Sr isotropic samples depending on x

Sample	x	Sintered at 1220°C /1h			Sintered at 1240°C /1h			Sintered at 1250°C /1h		
		Br (G)	B_{Hc} (Oe)	$(BH)_{max}$ (MGOe)	Br (G)	B_{Hc} (Oe)	$(BH)_{max}$ (MGOe)	Br (G)	B_{Hc} (Oe)	$(BH)_{max}$ (MGOe)
S1	0.00	2270	1760	1.10	2340	2040	1.14	2500	1980	1.30
S2	0.02	2280	1800	1.10	2360	2080	1.21	2510	1990	1.32
S3	0.04	2410	1860	1.23	2450	2160	1.36	2570	2060	1.42
S4	0.06	2390	1850	1.20	2460	2130	1.24	2520	2050	1.31
S5	0.08	2330	1845	1.13	2460	2050	1.20	2450	1980	1.19
S6	0.10	2350	1800	1.02	2490	1900	1.18	2430	1980	1.16
S7	0.12	2360	1760	1.02	2470	1830	1.14	2470	1920	1.17

It could be concluded that the substitution of La for Sr with $x=0.04 \div 0.06$ (about 0.7-1.0 weight %) is evidently improve hard magnetic properties of ferrites. The similar behaviour is obtained for anisotropic samples (for instance Fig.2) and maximum energy product could reached the relative high value of 4.5 MGOe for sample with $x = 0.04$. The sample S_9 with $x = 0.04$ and SiO_2 addition has very high magnetic parameters : $B_r = 4500$ G, $B_{Hc} = 3140$ Oe, $(BH)_{max} = 5.25$ MGOe. That is strongest hard ferrite samples we have ever had (See Fig.3).

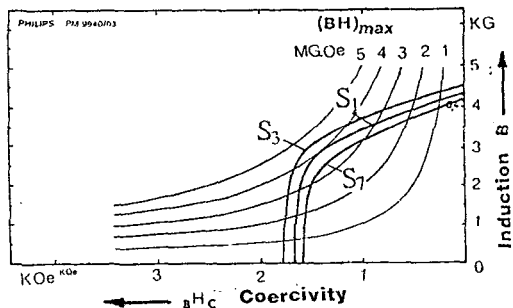


Figure 2 : Demagnetization curve for anisotropic samples N° S1, S3, S7

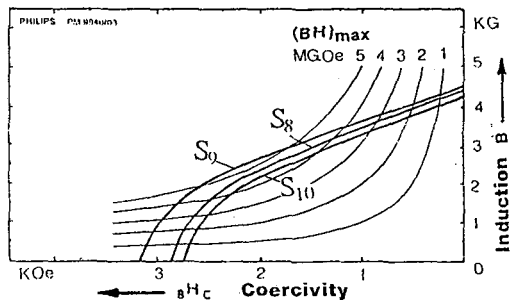


Figure 3 : Demagnetization curves for anisotropic samples N° S8, S9, S10 (The same composition like S1, S3, S4 but containing SiO_2 dopant, respectively)

4. CONCLUSION

A serie of parameters of Sr hexaferrite is investigated depending on the La_2O_3 substitution amount. The magnetic properties of our samples are improved desirably with x around 0.04 \div 0.06.

REFERENCES

- [1] Summergrad R., Bank E., J.Phys. Chem.Sol. 132 (1957) 2
- [2] Deschamp A., Bortant E., C.R.Acad.Sci.Paris 224 (1957) 3069
- [3] Fransevich L.N., Tulczinski L.N., Powder metallurgy (in Russian) N°2 (1971) 63
- [4] N.Chau et al., J.Science of the Hanoi Univ., Physics 3 (1990) 48
- [5] N.Chau et al. Proceedings of the 2nd International Workshop on Materials Science (IWOMS'95) Hanoi Oct.1995. p 426-431.
- [6] Wohlfarth E.P., "Ferromagnetic Materials.", North-Holland Publishing Company, Vol.3, (1982) p 328 and p 538.