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ABSTRACTS

4Q-04. ANISOTROPIC INJECTION MOLDING OF STRONTIUM-FERRITE POWDER USING A PP/PEG BINDER SYSTEM. Suk Hee Lee, Won Young Jeung (Korea Inst. of Science and Technology, Metal Processing Research Center, 39-1, Hawolgok-Dong Sungbuk-Gu, Seoul, 136-791, South Korea)

Powder injection molding (PIM) process is used widely for the production of relatively complex small components with ceramic or metal powders. Most important features in this process, especially for the production of permanent magnet, are binder composition and debinding technique [1], because the carbon residue could be affect the magnetic properties. In this study, new binder system for anisotropic injection molding of Sr-ferrite was developed and a process for injection molding of Sr-ferrite was optimized. The feedstocks were prepared by mixing the 55 vol.% of Sr-ferrite powder with PP(Polypropylene)/PEG(Polyethyleneglycol) binder system. Samples were injection molded by a simple plunger type machine under a magnetic field. After progressive removal of each binder component, samples were sintered at various temperature under air for 1 hr. The developed binder system is composed of 30 vol.% PP, 60 vol.% PEG-20000 and 10 vol.% PEG-4000. PEG-20000 gives an enough compact strength and prevents binder separation during molding. PEG-4000 was used for lubricating and easy demolding. PP used provides enough strength to maintain the compact shape during water extraction and also gives a lower residual carbon content after thermal debinding. The extraction of PEGs by water was carried out at 70 'C. At this temperature, 95 % of PEGs could be removed by water extraction in 12 hrs. and open pore channels formed by the water extraction of PEGs consequently enables the subsequent thermal debinding process. Figure 1 shows the thermal decomposition behaviors under various atmosphere. Binder decomposition of molded compacts under argon and nitrogen showed two distinct steps of weight loss. The first step, between 300 and 400 'C, is originated from the decomposition of the most binders. The second step, between 400 and 450 'C, corresponds to decomposition range of PEG-20000. Binder decomposition of the compacts under air, however, showed a reduced decomposition range between 150 and 200 'C. The residual carbon content after thermal debinding under air is about four times lower than those under nitrogen and argon atmosphere. This is because the air atmosphere gives an oxidative debinding condition by reaction with the free radicals generated by thermal energy. Therefore, air may be the proper thermal debinding atmosphere for developed binder system. As shown in Fig. 2, remanent flux density increased to a certain extent with increasing the sintering temperature and decreased above 1280 'C. Coercivity decreased gradually with increase of sintering temperature. At 1260 'C, a magnet showed a remanent flux density of 4.13 kG, a coercivity of 3.3 kOe and a maximum energy product of 4.2 MGOe.

[1] R.M. German, Powder Injection Molding, MPRF, Princeton, NJ, 1990, pp.99.

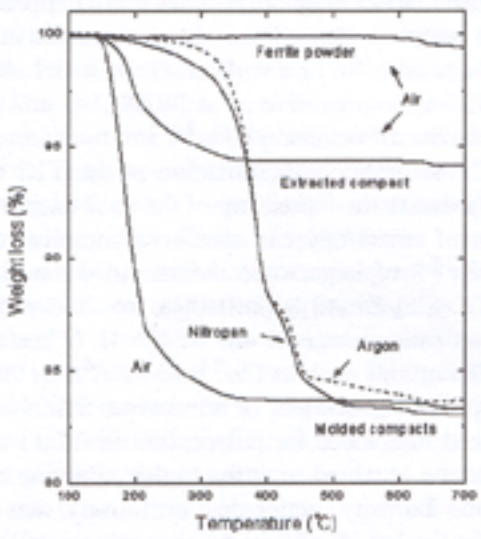

FIG. 1. TGA of powder and compacts under various atmosphere.

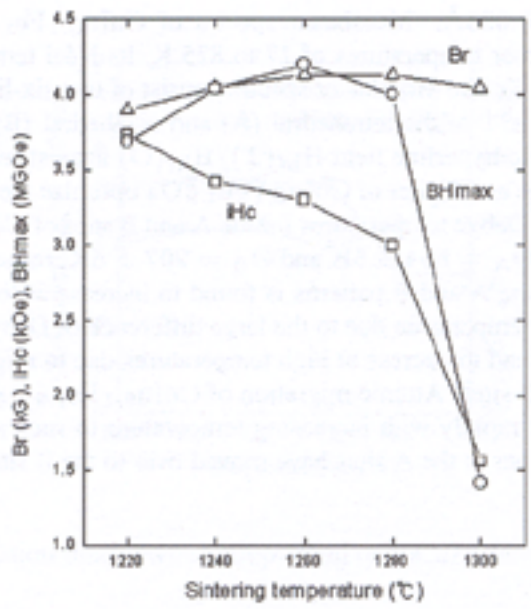

FIG. 2. Magnetic properties with sintering temperature.

4Q-05. MAGNETIC VISCOSITY IN CHROMIUM SUBSTITUTED Pb-M HEXAFERRITES. Jael Cristina Faloh-Gandarilla, Sergio Diaz-Castanon (Universidad de La Habana, Facultad de Fisica-IMRE, San Lazaro y L Vedado, La Habana, 10400, Cuba) and Fabrizio Leccabue (Istituto MASPEC, CNR, Campus Universitario Area delle Scienze, Parma, 43100, Italy)

In this work we present a magnetic viscosity study performed on Cr substituted Pb hexaferrite of composition $PbFe_{11}CrO_{19}$. Polycrystalline samples were prepared by a chemical coprecipitation method. X-ray diffraction and Mössbauer spectroscopy confirm the formation of the M-type hexagonal structure. Magnetic measurements were carried out at room temperature on a disk-shaped sample, applying the magnetic field parallel to the plane of the disk. The time variation of the total magnetization was recorded during 1000 s under constant applied fields Hap on the demagnetization curve of the hysteresis loop. Before each M(t, H_{ap}=constant) recording the sample was saturated at a maximum field of 1.6 T. The time dependence of the magnetization is well described by a simple logarithmic law in the H_{ap} range from -5500 Oe up to -2200 Oe; at lower and higher applied fields the so-called anomalous magnetic viscosity was detected. Since the coercive field H_c measured on the hysteresis loop (M=0) was of -3600 Oe, we expected to notice the higher viscosity effect at applied fields very close to this value. However, taking into account only the experimental data related to the observed "normal viscosity", we encountered a two-peak dependence of the viscosity coefficient S with the applied field. Processing carefully these experimental data, considering reversible susceptibility measurements and a M(H) curve at constant dM/dt in the irreversible susceptibility determination, the calculated activation volume as a function of the applied field shows two well defined zones. In the range closer to the coercive field the activation volume stays almost constant, with a value of about $1.710^{-17}cm^3$. As H_{ap} decreases the activation volume raises, increasing by a factor of about 2 at H_{ap} = -5500 Oe. The two-peak $S(H_{ap})$ dependence and the different zones observed in the activation volumes are related to the fact that the total susceptibility determined from the hysteresis loop exhibits also two local maxima, located at both sides of H_c. This is a strong suggestion of the presence of more than one magnetic phase on the sample, despite X-ray diffraction and even Mössbauer spectroscopy at different temperature analysis. It points to the fact that the viscosity study is sensible enough to characterize this system, encountering two apparently activation volumes. In addition, the anomalous viscosity that is not discussed here, is a well-known phenomenon that has been observed experimentally in two-phase magnets.

4Q-06. ATOMIC MIGRATION IN $CoIn_{0.1}Fe_{1.9}O_4$. Seung Wha Lee (Chungbuk National University, Dept. of Physics, Cheongju, Chungbuk, 361-763, South Korea) and Sung Yong An, Chul Sung Kim (Kookmin University, Dept. of Physics, 861-1, Songbuk-ku, Seoul, 136-702, South Korea)

$CoIn_{0.1}Fe_{1.9}O_4$ ferrite has been studied with Mössbauer spectroscopy, vibrating sample magnetometer(VSM) and x-ray diffraction. The crystal structure is found to be a cubic spinel with the lattice constant

$a_0 = 8.396 \pm 0.005$Å. Mössbauer spectra of $CoIn_{0.1}Fe_{1.9}O_4$ measured at various absorber temperatures of 17 to 825 K. Its Néel temperature T_N is found to be 765 K. The Mössbauer spectra consist of two six-line patterns corresponding to Fe^{3+} at the tetrahedral (A) and octahedral (B) sites. Plots of reduced magnetic hyperfine field $H_{hf}(T)/H_{hf}(O)$ aganist reduced temperature T/T_N for A and B sites of $CoIn_{0.1}Fe_{1.9}O_4$ optimize the Brillouin curve B(S) for S=5/2. Debye temperatures for the A and B sties of $CoIn_{0.1}Fe_{1.9}O_4$ are found to be $\Theta_A = 664 \pm 5$K and $\Theta_B = 207 \pm 5$K, respectively. The intensity ratio of the A and B patterns is found to increase at low temperatures with increasing temperatrue due to the large difference of Debye temperatures of the two sites and to decrese at high temperatures due to migration of Fe^{3+} ions from A to B sites. Atomic migration of $CoIn_{0.1}Fe_{1.9}O_4$ starts near 295 K and increases rapidly with increasing temperature to such a degree that 80 % of the ferric ions at the A sites have moved over to the B sites by 700 K.

4Q-07. COMPARISON BETWEEN FERROMAGNETIC RESONANCE AND MAGNETIC AFTER-EFFECT IN LiZnTiMn-FERRITES. Ana Garcia-Flores, Victor Javier Raposo-Funcia, Luis Torres-Rincon, Jose Ignacio Iñiguez (Univ. Salamanca, Fisica Aplicada, Plaza de la Merced s/n, Salamanca, 37008, Spain) and Arnaldo Gonzalez-Arias (Univ. de la Habana, Fisica Aplicada, Plaza de la Merced s/n, La Habana, 10400, Cuba) and Carlos de Francisco (Univ. Valladolid, Electricidad y electronica, Prado de la Magdalena s/n, Valladolid, 47071, Spain)

Ferromagnetic resonance linewidths at room temperature for $Li_{0.79}Zn_{0.25}Ti_{0.83}Fe_{1.08-k}Mn_{0.05}O_4$ polycrystalline ferrite sintered in oxygen atmosphere at 1050°C with k ranging from 0.00 to 0.10 are presented. The linewidth presented for these samples is comparable with most of commercial ferrites and decreases with increasing k. Consequently these ferrites are suitable for their use in low loses microwave applications. Magnetic after-effect spectra are also presented from 77 to 300 K. A relaxation process, which amplitude decreases with increasing k, is observed at 250 K. Same procedure is noticed in ferromagnetic resonance linewidth. A new relationship between ferromagnetic resonance linewidth and magnetic after-effect spectra is suggested.

4Q-08. MAGNETIC DISACCOMMODATION IN Sn SUBSTITUTED MAGNETITE. Pablo Hernandez-Gomez, Karim Bendimya, Carlos de Francisco, José Maria Muñoz, Oscar Alejos, Carlos Torres (Univ. Valladolid, Electricidad y Electronica, Prado de la Magdalena s/n, Valladolid, 47071, Spain)

The relaxation of the initial magnetic permeability has been measured in polycrystalline Sn-doped magnetite with nominal composition $Sn_xFe_{3-x}O_4$ with x ranging among x=0 and x=0.4. The samples have been sintered at 1400°C in a reducing CO_2 atmosphere and rapidly quenched to provide the presence of crystal vacancies. In the temperature range between 80 K and 500 K, the time decay of the initial permeability after sample demagnetization has been represented by means of isochronal curves. The isochronal disaccommodation spectra show the presence of different relaxation processes at 240 K (IV peak), 270 K (IV'), 300 K (III), 400 K (II) and 440 K(I). Regarding vacancy doped magnetite, a splitting of process III into three peaks (IV, IV' and III) is observed, and the peaks IV and IV' become preponderant with the increase of Sn amount in the structure. This behaviour is ascribed to the presence of Sn^{4+} cations in octahedral sites in the spinel lattice, in a similar way to the relaxations observed in Ti-doped magnetite. In addition, it has been observed that the II and I processes increase its amplitude with the Sn content, and this increase is more important than in Ti-doped magnetite. On the other hand, the maxima of these processes shifts towards higher temperatures with the addition of Sn. These effects are explained in terms of the existence of Sn-Fe pairs, as well as the long range diffusion of ferrous cations via lattice vacancies. The differences found regarding Ti-doped magnetite are ascribed to the different ionic radii of Sn^{4+} and Ti^{4+} cations.

4Q-09. REMANENCE PROPERTIES OF COPRECIPITATED COBALT FERRITE. Darío Bueno-Baqués, Angela Medina-Boudri, José Matutes-Aquino (Centro de Investigación en Materiales Avanzados, División de Materiales Cerámicos, Miguel de Cervantes #120 Complejo Industrial Chihuahua, Chihuahua, 31109, Mexico)

Isothermal Remanent Magnetization (IRM) and DC Demagnetization (DCD) curves of a coprecipitated cobalt ferrite sample were measured. From the IRM and DCD data the Henkel plot was obtained and analyzed in the Preisach model framework. The Henkel plot is below the Wohlfarth line, which indicates a dominant local disorder (demagnetizing-like effect). Forward and reverse switching field distribution curves were obtained from differentiation of the IRM and DCD curves. The peak values of these switching field distributions differ by a factor of about 2.7. The Rietveld refinement of the X-ray diffraction pattern of the cobalt ferrite sample revealed a spinel cubic crystal structure with a lattice parameter $a = 8.376\AA$, an oxygen parameter $\mu = 0.382\AA$ and an isotropic temperature coefficient $B = 1.17\AA^2$. The cation distribution $Co^{2+}_{0.4}Fe^{3+}_{0.6}[Co^{2+}_{0.6}Fe^{3+}_{1.4}]O_4$ was obtained from the Mössbauer spectrum fitting.

Permanent Address: Darío Bueno-Baqués. Laboratorio de Magnetismo. Facultad de Física - IMRE. Universidad de La Habana. San Lázaro y L. Vedado. Cuidad de La Habana 10400. CUBA.

4Q-10. MAGNETIC PROPERTIES AND MICROSTRUCTURES OF YIG THICK FILMS PREPARED BY SCREEN-PRINTING. Tae-Kyung Lee, Joong-Hee Nam, Jae-Hee Oh (Inha University, Department of Ceramic Engineering, 253 Yonghyun-Dong Nam-Ku, Inchon, 402-751, South Korea)

YIG ($Y_3Fe_5O_{12}$), a ferrimagnetic material also known as microwave ferrite, has been used in passive devices as thick film for MMIC(Monolithic Microwave Integrated Circuit). This study was focused the effect of the preparation process of thick film by screen-printing on microstructure and magnetic properties of $Y_{3-x}Ca_xFe_{5-x}Zr_xO_{12}$(x=0–0.4). In order to get a good densification of screen-printed thick film, the CIP(Cold Isostatic Pressure) processing as a mechanical pressure was applied in printing of paste on alumina substrate. The saturation magnetization of thick film increased constantly with the higher printing times as shown in Figure 1, but the lower FMR line width was observed. The saturation magnetization ($4\pi M_S$) appeared as maximum value of 1356 G for sample with the lower density sintered at 1300°C and the ferromagnetic resonance(FMR) line width(ΔH) at x=0.2 showed the lowest value of $\Delta H = 185$ for samples sintered at 1400°C as substitution of Zr^{4+}. The substitution behavior of octahedral Fe^{3+} ion by diamagnetic Zr^{4+} ion demonstrates that the saturation magnetization of the YIG thick film can be improved effectively due to the increasing of the total magnetic moment. Furthermore, reduction of anisotropy can also be accomplished by substitution of Fe^{3+} ions by Zr^{4+} of large ionic radius. In some different compositions of $Y_{3-x}Ca_xFe_{5-x}Zr_xO_{12}$ (x=0–0.4), low line width values can be presented for magnetization range of 488 to 185 G. When the simultaneous addition of two different ions such as Ca^{2+} and Zr^{4+} in this study, together with a charge compensating divalent or tetravalent cation is applied, can be obtained with reduced line width for polycrystalline YIG sample. The lower FMR ΔH value can be obtained with the higher sintering density and saturation magnetization. Porosity, rather than anisotropy, acts as the dominant role to the resonance line width of low-density polycrystalline YIG. In order to investigate the combined affects of thickness of the printed layer with printing times and its microstructure, the magnetic and sintering properties have been studied. As increasing of the thickness of printed thick film, the layer of thick film showed a better densification due to the reduction of interdiffusion between tetrahedral Fe^{3+} from the thick film and octahedral Al^{3+} ion from the substrate.