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The Preparation and Investigation of Magnetic Properties of Magnesium Zinc ferrites

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Abstract: $Mg_{0.7}Zn_{0.3}Fe_2O_4$ (MZF) is a ferrites material, displaying interesting magnetic properties. It has a wide range of magnetic coils and electronic devices. In this research, MZF ceramics was prepared by solid state reaction route and interested on sintering temperature that have effective on phase formation of MZF, microstruce and magnetic properties. The phase identification of ceramic ferrites was performed using X-ray diffraction technique (XRD). It has been found that the dense of MZF ceramics were successfully obtained for sintering at 1300 ^oC. Moreover, the microstructure of MZF ceramics were examined by scanning electron microscopy (SEM) and showed that the sizes of grain from 0.65-19.87 μm. The highly dense of MZF ceramics were obtained the magnetic permeability medium (μ) as 14.38×10^{-14} N/A^2.

Key words: $Mg_{0.7}Zn_{0.3}Fe_2O_4$, magnetic properties, XRD, permeability

INTRODUCTION

The important of ferrite is well realized in the fields of electronics and communication which has a wide range of magnetic coils and electronic devices [1]. Magnesium-Zinc ferrite ($Mg_{0.7}Zn_{0.3}Fe_2O_4$); MZF is ferromagnetic oxides known as ferrite. MZF is considered a candidate material for high-frequency engineering. The crystal structures of these materials control their physical properties. Therefore, the crystal structure and cation distribution were studied using the Mossbauer spectra and x-ray diffraction patterns [2]. MZF are widely studied for their magnetic structures [3-5]. However the magnetic properties are dependent on several factors including the sintering temperature, method of preparation. Even through many works were studied on ferrite ceramics [6-9] but information on MZF sintering temperature that have effect on phase, microstructure and magnetic properties is still limited. The influence of a difference in the condition of sintering temperature of MZF ceramics on phase formation, microstructure and magnetic properties is reported in this research.

EXPERIMENTAL

The ferrite $Mg_{0.7}Zn_{0.3}Fe_2O_4$ were synthesized by conventional ceramics processing route. The stating materials used in the experiments were iron oxide, magnesium oxide, and zinc oxide. They were weighed according to the required stoichiometric proportion, mixed in absolute ethanal followed by Ball milling for 24 h and then dried in air. After drying, the mixture was calcined at 1100 ^oC for 2 h. The calcined powders with 5% of polyvinyl alcohol (PVA) were pressed into toroid samples. The samples were different sintered at 1100, 1200, 1300, 1400, and 1500 ^oC at 2 h with heating/cooling rate 5 ^oC/min. MZF ceramics were characterized for the following: (1)The phase analysis were determined with x-ray diffraction;XRD (Philips PW 1729 diffractometer). (2) The density was measured by the Archimedes method. (3) The microstructure were examined with scanning electron microscopy ; SEM (JEOL JSM-840A).(4) The magnetic behavior was studied by M-H curve.
according to the required conditions.

RESULTS AND DISCUSSION

X-ray diffraction patterns of MZF ceramics formed at various sintering temperature ranging from 1100-1500 ^oC are given in Figure 1.The formation of MZF ceramics were confirmed by x-ray diffraction patterns. The main refractions from planes (220), (311), (400), (422), (511), and (440) with consistent with other works [1, 4, 9, 10]. The analysis of XRD patterns indicated that

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the studied Mg-Zn ferrite ceramics have spinal cubic structures with single phase. By increasing the sintering temperature from 1400 to 1500 ^{o}C, the some majority refraction as (400) and (422) are decreased for intensities and it was found that some refraction (220) is splitting at this temperature.

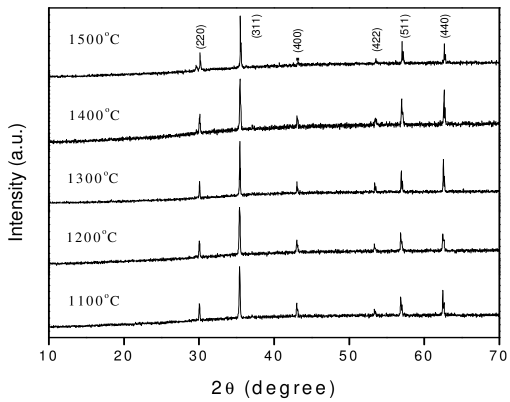

Fig. 1: XRD patterns of MZF ceramics sintered at various temperatures for 2 h with heating/cooling rates of 5 ^{o}C/min.

Density data of all MZF ceramics sintered at various temperature are given in Fig. 2. It is observed that a density of about 3.79-4.59 g/cm^3 The maximum density was obtained only in the samples sintered at 1300 ^{o}C for 2 h with heating/cooling rates of 5 ^{o}C/min. From Fig. 2, the observed slightly fall-off in density at higher temperature is probably concerned with peak of splitting and decreasing of intensities in XRD patterns.

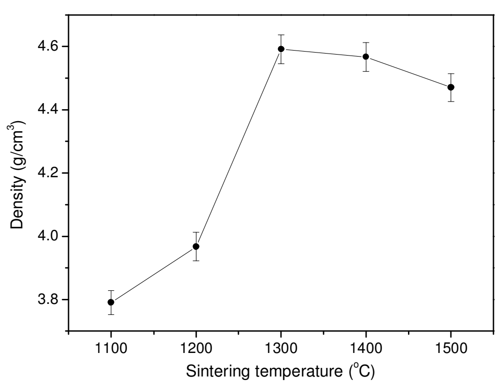

Fig. 2: Dependence of density in MZF ceramics sintered at various sintering temperatures.

Figure 3 shows the effect of temperature on microstructure of MZF ceramics and Figure 4 obtains the information of grain sizes of the ceramics as function of sintering conditions. The results indicate that average grain size (calculated by linear intercept technique) tends to increase with sintering temperature. SEM micrographs of MZF ceramics (Fig. 3(a), Fig. 3(b)) with sintering at 1100 and 1200 ^{o}C showed porosity at grain boundaries. On the other hand, the micrograph of MZF ceramics with sintering up to 1200 ^{o}C (F3(c), Fig. 3(d), Fig. 3(e)) shows a well-packed and continuous grain structure, with agreement with densification results. It is to be noted that there is obvious of porosity and small hole at grain in MZF ceramics with sintering at 1400 and 1500 ^{o}C, although it is likely to correspond to the influence of some peak splitting and decreasing intensities in some peak indicated by XRD results.

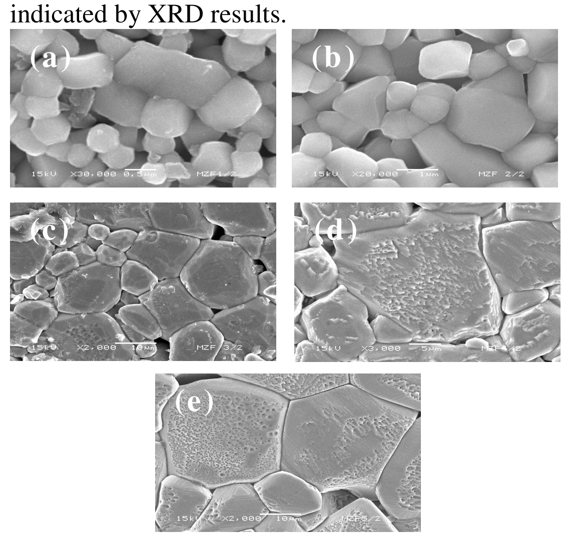

Fig. 3: SEM micrographs of free surfaces of MZF ceramics sintered at (a) 1100 ^{o}C, (b) 1200 ^{o}C (c) 1300 ^{o}C, (d) 1400 ^{o}C, and (e) 1500 ^{o}C for 2 h with heating/cooling rates of 5 ^{o}C/min.

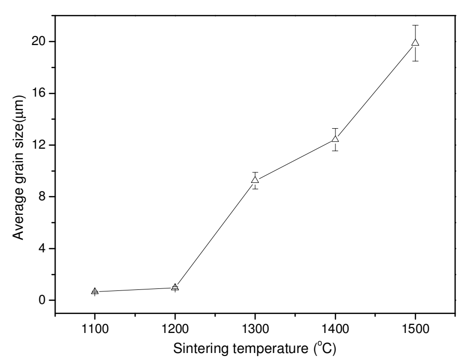

Fig. 4: Average grain sizes of MZF ceramics sintered at various temperature

Table 1: Chemical compositions of the MZF ceramics from EDX analysis

Sintering temperature (^oC)	Compositions (at%)			
	Mg(K)	Zn(K)	Fe(K)	O(K)
1100	11.46	4.46	29.60	54.48
1200	11.13	4.01	28.08	58.78
1300	11.32	3.74	27.25	57.70
1400	11.15	2.77	29.27	56.81
1500	11.45	2.27	29.73	56.55

Moreover, their corresponding EDX spectra are given information where the composition (at%) of Mg : Zn : Fe is revealed in Table 1. The composition is nearly constant in Mg and Fe but decrease in Zn with higher temperature. It is to be note that the EDX results strongly support for XRD pattern, SEM micrographs and densification results. Fall-off in density at higher temperature is probably due to ZnO loss impeding the sintering process. Figure 5 (a-e) display the M-H curves of MZF ceramics at different sintering temperature. The hysteresis loops were measured to determine parameters such as the remanent magnetization, M_r, and coercivity, H_c. The results are presented in Table 2. The coercivity tend to decrease with increasing sintering temperature. It is indicated the large grain influence to coerecivity values in agreement with earlier works[11]. The values of magnetic permeability of medium (μ) as function of sintering temperature are plotted in Fig. 6. It can be seen that μ values are obviously increased with sintering temperature as between 1100-1300 ^oC and slightly reduced at 1400-1500 ^oC. The maximum of μ values were obtained from MZF ceramics with sintering at 1300 ^oC. This work demonstrated that sintering temperature controlled on phase formation, densification, microstructure, and magnetic properties of MZF ceramics.

CONCLUSIONS

The study on the effect of sintering temperature to characterization of MZF ceramics as follow:

1. Phase formation have been found for all samples. It can be observed that reduced intensities in (400) and (422) planes and peak splitting in (220) for sintering temperature at 1400 and 1500 ^oC
2. Highly dense of samples are obtained in the firing conditions at 1300 ^oC
3. The degree of growth of grains increased with increasing sintering temperature
4. The large grain influence to coerecivity values and magnetic permeability of medium depend on sintering temperature
5. The optimal samples is found that sintered at 1300 ^oC.

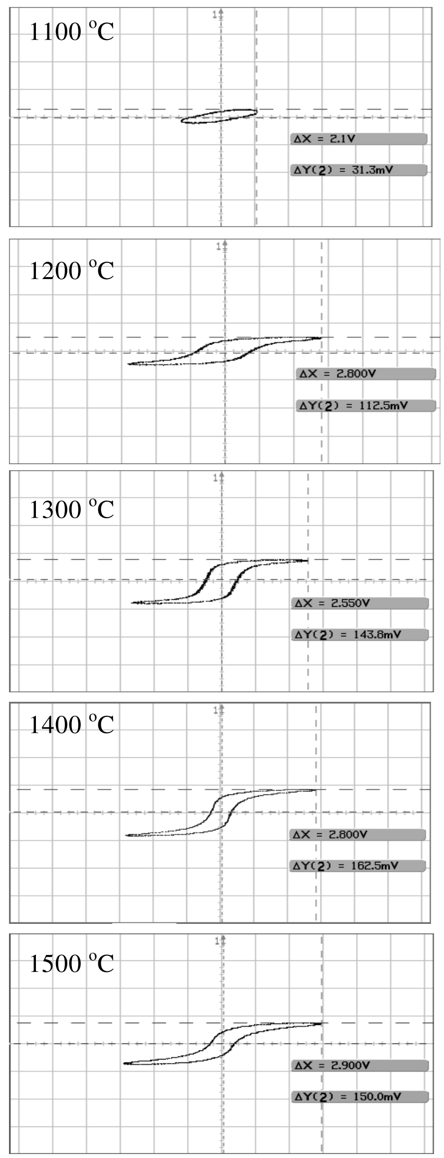

Fig. 5: M-H curves of MZF ceramics sintered at various temperature

Table 2: Magnetic parameters of MZF ceramics

Sintering temperature(°C)	Remanent magnetization; M_r (mT)	Coercivity H_c $\times10^2$(A/m)
1100	21.90	1.30
1200	87.50	0.70
1300	106.30	0.45
1400	100.10	0.28
1500	81.90	0.30

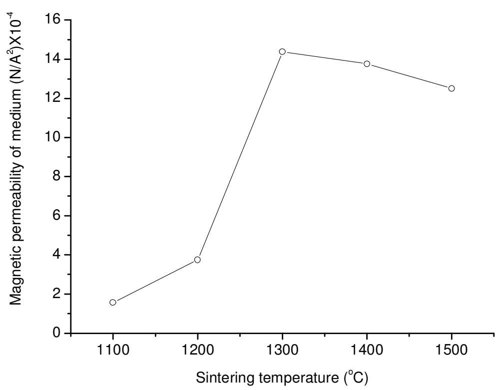

Fig. 6: The magnetic permeability medium (μ) of MZF ceramics sintered at various temperature.

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