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MR EFFECT OF MAGNETITE FILMS PREPARED BY ULTRASOUND-ENHANCED FERRITE PLATING

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This paper describes the MR effect of magnetite (Fe_3O_4) films prepared by the ferrite plating. We investigated the dependence of magnetic and electrical properties on the concentration of the oxidizing agent C_{ox}. The change of the ratio of Fe^{2+} ions to Fe^{3+} ions in the films resulted in the changes of the electrical properties. Resistivity increased with increasing C_{ox}. The MR ratio was about 5 % when C_{ox} was 1.45×10^{-3} – 14.5×10^{-3} mol/l. The saturation magnetization M_s was about 550 emu/cc. When C_{ox} was higher than 21.7×10^{-3} mol/l, the MR ratio and M_s decreased.

Key words: magnetoresistance, magnetite, ferrite plating

1. INTRODUCTION

Magnetroresistance (MR) has been attracting many researchers' interests, in particular, regarding applications of reproducing heads for hard disk drives.[1] While magnetic alloys or metals, such as NiFe, CoFe, or Co, have been used in almost all of their studies, there are few studies on ferrites. Thus, we investigated the MR effect of magnetite films prepared by the ferrite plating, which enables us to synthesize spinel ferrite films at low temperature below 100 °C from aqueous solutions.[2-4] Since this method is low temperature process, the ferrite-plated films are easy to apply magnetic devices.

2. EXPERIMENTAL

Figure 1 shows the ultrasound-enhanced ferrite-plating apparatus. The volumes of the apparatus was 15ml. Ultrasound waves (19.5 kHz , 600W) were applied by a horn (30mmϕ) to an aqueous reaction solution. The conditions of the solutions are listed in Table I . Both reaction and oxidizing solutions were supplied at the flow rate of 6.0 ml/min. The reaction temperature was 85°C. The ferrite films with thickness of 0.09~0.1 μm were deposited on glass substrates. The thickness of the films was determined with a scanning electron microscope. The structure and magnetic properties were analyzed by a X-ray diffractometer (XRD) and a vibrating sample magnetometer (VSM), respectively. The ratio of Fe^{2+} ions to Fe^{3+} ions was evaluated by a Co^{57}-Mössbauer spectrometer. The electrical resistance and MR characteristics were measured by the four-probe method.

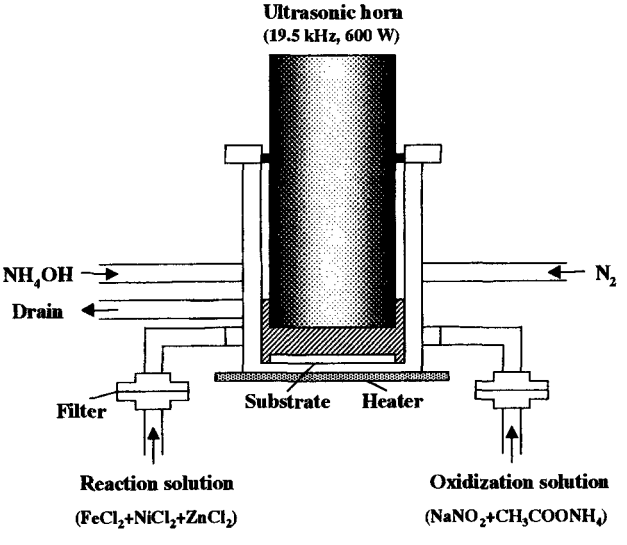


Fig.1 Ultrasound-enhanced ferrite plating apparatus

Table I Conditions for magnetite thin film

Reaction solution	$FeCl_2$	0.025mol/l
Oxidizing solution	$NaNO_2$	0.0014 ~ 0.0217 mol/l
	CH_3COONH_4	0.00058 mol/l

3. RESULTS AND DISCUSSION

Figure 2 shows the dependence of the electrical resistivity on C_{ox} when C_{re} was kept constant. The electrical resistivity increased from 5.9 to 72.8 Ωcm with increasing C_{ox}. Figure 3 shows the Mössbauer spectra at the concentration of $NaNO_2$ of (a) 0.00289mol/l and (b) 0.0217 mol/l. The ratio of $Fe^{2.5+}$ in A site to Fe^{3+} in B site decreased from 1.308 to 1.168 when C_{ox} increased from 0.0029 mol/l to 0.0217 mol/l. From the theory of the hopping-conduction of electrons between Fe^{2+} ions and Fe^{3+} ions, the electrical resistivity increases with increasing Fe^{3+} ions. These results indicate that Fe^{2+} ions decreased and Fe^{3+} ions increased with increasing C_{ox}, and the resistivity increased.

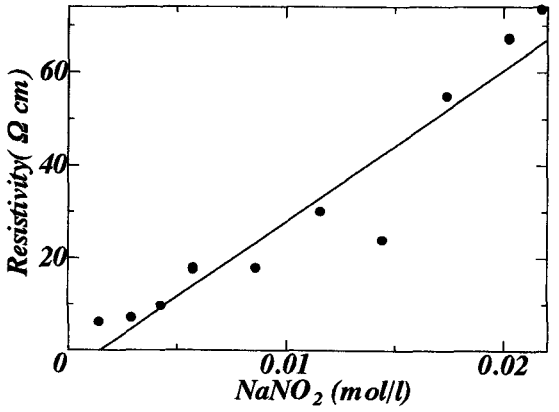
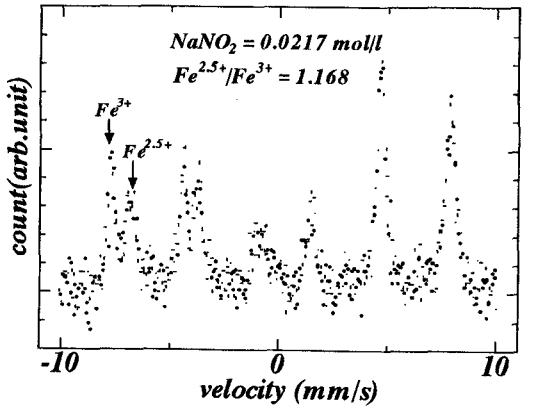
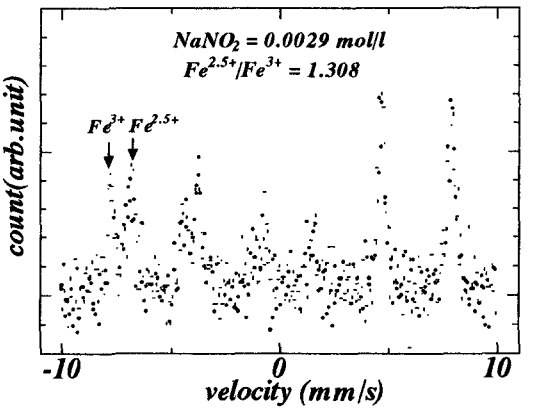


Fig.2 Electrical resistivity



(a) $NaNO_2$ = 0.0029 mol/l



(b) $NaNO_2$ = 0.0217 mol/l

Fig.3 Mössbauer spectra

Figure 4 shows the XRD diagrams at various concentration of $NaNO_2$. The thickness at the concentration of $NaNO_2$ of 0.0217 mol/l was 0.28 μm, and the others were 0.09~0.1 μm. These results indicate that crystallinity didn't change much when C_{ox} increased up to 0.0217 mol/l.

Figure 5 shows the dependence of the saturation magnetization M_s on the concentration of $NaNO_2$. M_s was almost constant when C_{ox} increased up to 0.0168 mol/l.

Figure 6 shows the dependence of MR ratio on the concentration of $NaNO_2$. The MR ratio was kept constant at about 5 % when the concentration of $NaNO_2$ was 0.00145 ~ 0.0145mol/l, and then drastically decreased with increasing the concentration of $NaNO_2$. These results suggest that γ-Fe_2O_3 phase increased with increasing, resulting in the increase of the electrical resistivity, and the decreases of the MR ratio and M_s.

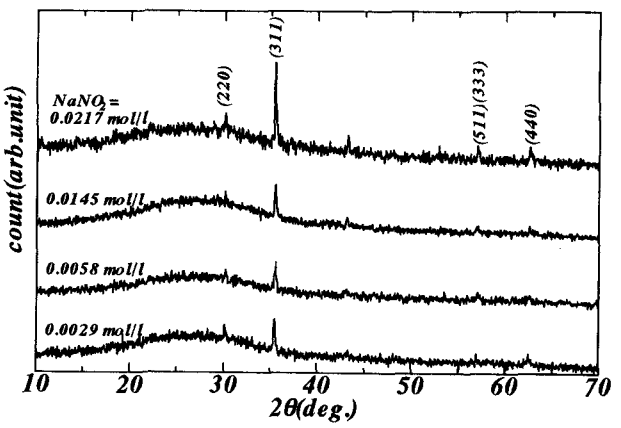


Fig.4 XRD diagram

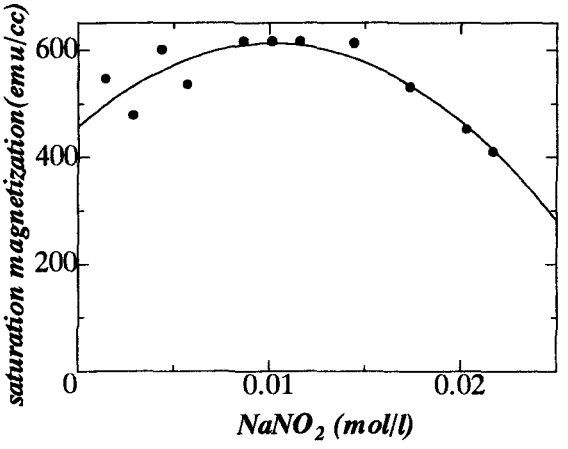


Fig.5 Saturation magnetization

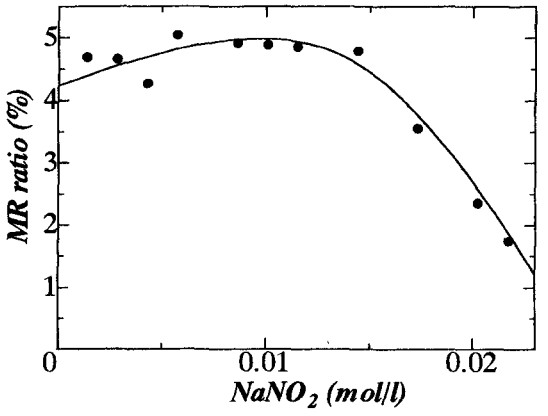


Fig.6 MR ratio

4. CONCLUSION

The electrical resistivity increased from 5.9 to 72.8 Ωcm with increasing the concentration of $NaNO_2$. The ratio of $Fe^{2.5+}$ ions in A site to Fe^{3+} in B site decreased from 1.308 to 1.168 when the concentration of $NaNO_2$ increased 0.0029 mol/l to 0.0217 mol/l. The saturation magnetization Ms of magnetite films took high value of about 550 emu/cc. MR ratio was kept constant at 5%. The Mössbauer analyses indicate that the increase of Fe^{3+} ions in the films led to the decrease of the MR ratio and M_s.

5. ACKNOWLEGMENTS

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6. REFERENCE

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