

EFFECTS OF SINTERING TEMPERATURE ON THE MAGNETORESISTANCE AND MICROSTRUCTURE OF THE MIXTURE OF Fe_3O_4 AND Cu -FERRITE POWDER

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Fe_3O_4 is one of the most common oxides which studied over past 50 years. There has been increased interest in the magnetotransport properties of the half-metallic Fe_3O_4 recently due to its potential for applications in spin-dependent devices. However, it was difficult to get large magnetoresistance (MR) ratio of Fe_3O_4 at room temperature. In this work, we mixed the Fe_3O_4 powder with Cu -ferrite powder then sintering at various temperatures and investigated the effects of sintering temperature (T_s) on the microstructure and MR ratio of the sintered ferrite.

The Fe_3O_4 powder was mixed with various amounts of Cu -ferrite powder (0~30 mol%). The mixed powder was compressed into a 10 mm diameter, 1 mm thick pellet under a pressure of 3757 kg/cm², and then sintered in argon atmosphere at temperatures between 1000 °C and 1250 °C for 4 hours. The MR ratio of the sintered sample was measured with the four-probe method at room temperature and the applied magnetic field was parallel to the direction of current.

Fig. 1(a), 1(b), and 1(c) show the SEM micrographs of the sintered samples with different T_s . The Cu -ferrite content is 7.28 mol% for all samples. We can see that the average grain size and densification of the samples increase with T_s . From the Cu element mapping of these samples, we can know that the Cu -ferrite is uniformly dispersed in the sintered sample.

Fig. 2 shows the Magnified X-ray diffraction pattern of the sintered sample with 31.01 mol% Cu -ferrite after sintering at 1200 °C. We can observe that the two phases, Fe_3O_4 and tetragonal phase $CuFe_2O_3$, coexisted in the sintered sample.

Fig. 3 shows the variations of the MR ratio with T_s of the sintered samples with different Cu -ferrite contents at room temperature. We can see that the maximum MR ratio is obtained around 1200 °C for most of samples. The maximum MR ratio of about 7.3 % can be obtained after sintering at 1200 °C as the Cu -ferrite content is 7.28 mol%. The MR curve of this sintered sample is shown in Fig. 4. Negative MR has been observed at 8.8 kOe.

Fig. 5 is the variations of electrical resistivity (ρ) with temperature of the sintered samples with various Cu -ferrite contents. It was found that the $\log \rho$ vs. $T^{-1/2}$ curves of all the samples exhibit a linear relationship between 80 K and room temperature. This implies that the MR effect is spin-dependent tunneling dominant [1] where the electrons flow through insulating barriers of Fe_2O_3 , $CuFe_2O_4$, or $CuFe_2O_{4-x}$. From the current (I) versus voltage (V)

curve of the sintered sample with 7.28 mol% Cu ferrite at room temperature, the I-V curve is deviated from Ohm's law as the voltage is higher than 0.3 Volt. It shows nonlinear relationship. This suggests that the MR mechanism in the sintered sample is the spin-polarized tunneling effect [2].

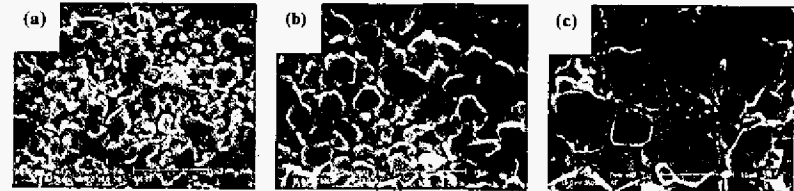


Fig. 1 SEM micrographs of the sintered samples with various T_s at (a) 1000 °C, (b) 1100 °C and (c) 1200 °C.

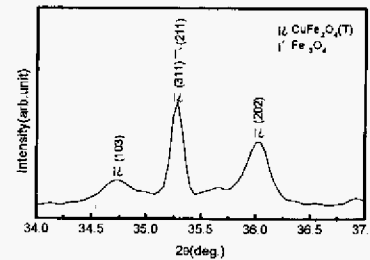


Fig. 2 X-ray diffraction pattern of the sintered sample with 31.01 mol% Cu -ferrite.

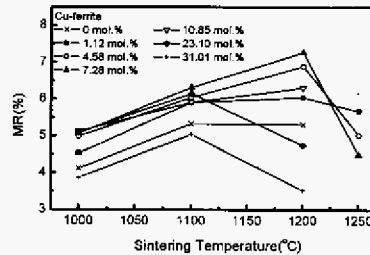


Fig. 3 The variation of the MR ratio with T_s of sintered samples with various Cu -ferrite contents.

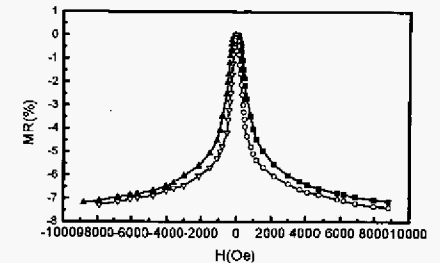


Fig. 4. The MR curve of the sintered sample with 7.28 mol% Cu -ferrite.

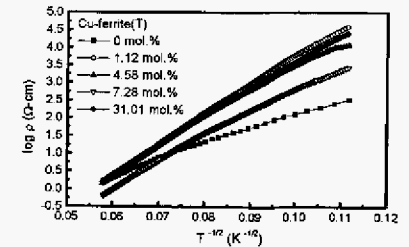


Fig. 5. $\log \rho$ vs. $T^{-1/2}$ of various samples which sintered at 1200 °C for 4 hours.

References

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- [2] C. L. Platt, B. Dieny, and A. E. Berkowitz, J. Appl. Phys. 81 (1997) 5523.