Electromagnetic Wave Absorption Characteristics of Y-type Barium Ferrite Prepared by the Glass-ceramic Method

Hiroki Miki[1,a], Chinatsu Hori[1,b], Masahiro Nagae[1,c] and Tetsuo Yoshio[1,d]

[1]Graduate School of Environmental Science, Okayama University, Okayama 700-8530, Japan
[a]gev17372@cc.okayama-u.ac.jp, [b]gev18372@cc.okayama-u.ac.jp
[c]nagae@cc.okayama-u.ac.jp, [d]yoshio@cc.okayama-u.ac.jp

Abstract

Y-type barium ferrite ($Ba_2Me_2Fe_{12}O_{22}$; Me=Zn, Co, Cu) expected as an electromagnetic wave absorber were prepared by the glass-ceramic method. The glasses with composition of $0.1ZnO \cdot 0.9(xB_2O_3 \cdot yBaO \cdot (1-x-y)Fe_2O_3)$ were prepared. Single-phase powders of Y type barium ferrite were obtained with the composition $0.1ZnO \cdot 0.9(0.2B_2O_3 \cdot 0.5BaO \cdot 0.3Fe_2O_3)$. The shape of Y-type crystals depended strongly on the heating temperature and changed from a plate-like hexagon to a complex polyhedron with increasing heating temperature. Correlation was recognized between saturation magnetization and crystal shape. Electromagnetic wave absorption characteristics was affected by the saturation magnetization and crystal shape.

Keywords : Y-type barium ferrite, glass-ceramic method, electromagnetic wave absorber

1. Introduction

Y-type hexaferrite has been attractive for application in microwave devices. The application of Y-type hexaferrite depends on their magnetic properties which were decided by the chemical composition and grain size.[1]

We showed recently that Y-type barium ferrite ($Ba_2Zn_2Fe_{12}O_{22}$) powder, which has the potential to serve as an electromagnetic wave absorber in GHz band, was obtained by the glass-ceramic method.[2] The advantages of the glass-ceramic method are that the target crystal forms at a low temperature than it does in the case of a solid-state reaction and that controlling the starting composition and grain size is relatively easy. The aim of this study is to investigate the influence of grain size and magnetic properties on electromagnetic absorption properties.

2. Experimental Procedure

Reagent-grade $BaCO_3$, ZnO, Fe_2O_3, and B_2O_3 were mixed at a composition of $0.1ZnO \cdot 0.9(0.2B_2O_3 \cdot 0.5BaO \cdot 0.3Fe_2O_3)$. The mixture was melted in platinum crucibles at 1623 K. The melts were poured onto a stainless-steel plate and pressed immediately to obtain BaO-ZnO-Fe_2O_3-B_2O_3 glasses. In order to precipitate crystalline phases, the glass specimens were heated at temperatures between 1083 and 1273 K for 2-10 h in air. After crystallization, the glass matrix was leached with a dilute HCl solution, and the resultant powder was washed thoroughly with distilled water. X-ray diffraction (XRD) with CuK radiation and scaning electron microscopy (SEM) were used for phase identification and morphology characterization, respectively. A vibrating samples magnetmeter (VSM) was used to measure the saturation magnetization and coercive force. The electromagnetic wave absorption properties were examined with using the vector network analyzer system.

3. Results and Discussion

Fig.1 shows XRD patterns of specimens leached with a dilute HCl solution after heating at various temperatures for 2 h. Single-phasic Y-type was obtained at temperatures above 1123 K. This is about 200 K lower than the formation temperatures in the case of the conventional solid-state reaction.

Fig. 2 shows SEM images of specimens heated at various temperatures for 2 h. XRD results suggest that the plate-like crystals in the specimen heated at 1083 K is a mixture of Y-type and M-type and those heated at 1123, 1173, 1273 K are single-phasic Y-type. The shape of Y-type crystals was strongly dependent on heating temperature. The thickness of Y-type crystals increased with increasing heating temperature, and the shape changed from plate-like hexagon to a complex polyhedron.

Fig. 3 shows temperature dependence of saturation magnetization. For heating at temperatures up to 1133 K, saturation magnetization decreased with increasing heating temperature. This is because M-type ferrite content decreased with increasing heating temperature. In the case of specimens heated at 1173-1273 K, saturation magnetization increased with increasing temperature. This is presumably due to the change of crystal shapes.

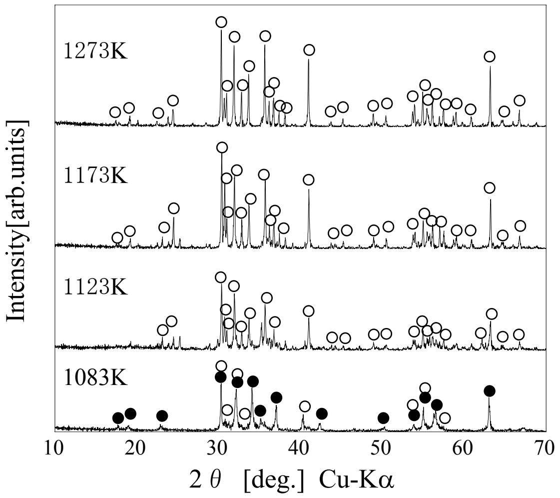

Fig. 1. X-ray diffraction patterns of specimens leached with a dilute HCl solution after heating atvario us temperatures for 2 h.

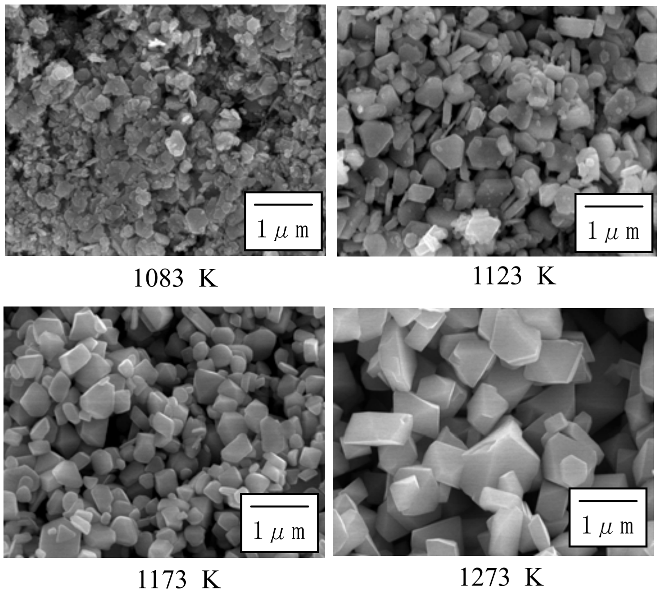

Fig. 2. Scaning electron microscopy images of specimens heated at various temperatures for 2 h.

Fig.4 shows frequency dependence of reflection loss for specimens heated at 1173, 1223 and 1273 K for 2 h. Enough amount of absorption was observed for all specimens at frequencies between 5 and 8 GHz. The absorption frequency range shifted slightly to the high frequency side with increasing heating temperature.

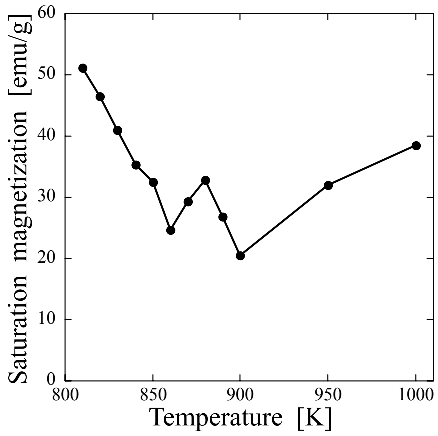

Fig. 3. Temperature dependence of the satureation magnetization.

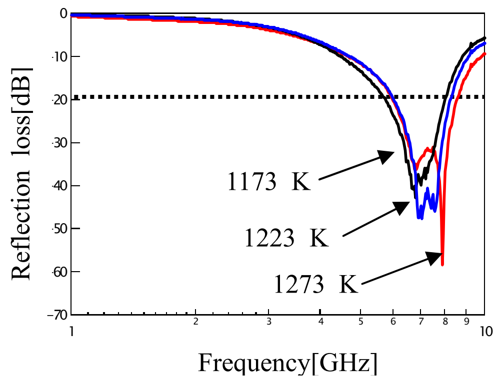

Fig. 4. Frequency dependence of reflection loss for specimens heated at 1173, 1223 and 1273 K

4. Summary

- The shape of Y-type crystals changed from plate-like hexagon to a complex polyhedron with increasing heating temperature.
- Saturation magnetization was strongly dependent on crystal shapes.
- Slight shift of absorption frequency range was observed resulting from increment in grain size of Y-type crystals.

5. References

1. Y. Bay, J. Zhou, Z. Gui, Z. Yue, L. Li, "Preparation and magnetic characterization of Y-type hexaferrites containing zinc, cobalt and copper," *Mater. Sci. Eng. B,* 99, 266-269(2003)
2. M. Nagae, T. Atsumi, and T. Yoshio, "Preparation of Y-type Barium Hexaferrite by the Glass-Ceramic Method," *J. Am. Ceram. Soc.,* 89[3]1122-1124(2006).