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Formation Mechanism of Y-type Barium Ferrite Prepared by the Glass-ceramic Method

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Abstract

Y-type barium ferrite ($Ba_2Zn_2Fe_{12}O_{22}$) was prepared by the glass-ceramic method. Glasses with composition of 0.1ZnO ・ 0.9(0.3Fe_2O_3 ・0.5BaO ・0.2B_2O_3) were prepared, and the precipitation behavior of Y-type ferrite from the glass matrix was investigated by heating glass specimens at various temperature. α-$BaFe_2O_4$ which is a precursor of M-type ferrite ($BaFe_{12}O_{19}$) was precipitated at about 813 K and an unknown compound, phase X, was precipitated at about 850 K. M-type ferrite and Y-type ferrite started to form at about 923 K and 1103 K, respectively. The formation of Y-type ferrite was int erpreted as the result of the reaction of M-type ferrite with a melt of phase X.

Keywords : Y-type Ba-hexaferrite, glass-ceramic method, formation mechanism

1. Introduction

The glass-ceramic method is used for precipitating crystalline phases in glass matrix by heating the glass. The advantages of this method are that the crystal forms at a lower temperature than it does in the case of a solid-state reaction and that controlling the grain size is relatively easy. In the case of ferrites, the idiomorphic fine powder of the target crystal is obtained by leaching a glass matrix with a dilute HCl solution after the heat treatment for crystallization.

We showed recently that Y-type barium ferrite ($Ba_2Zn_2Fe_{12}O_{22}$) powder was obtained by the glass-ceramic method.[1] However, the details of the formation mechanism were not fully clarified. The purpose of the present study is to present basic data on formation mechanism of Y-type Ba-hexaferrite prepared by the glass-ceramic method.

2. Experimental Procedure

The glass composition used in this study was 0.1ZnO・0.9(0.3Fe_2O_3・0.5BaO・0.2B_2O_3). The glass was prepared from reagent-grade $BaCO_3$, ZnO, Fe_2O_3, and B_2O_3 by melting the mixture in a platinum crucible at 1623 K for 2 h in air. The melt was poured onto a stainless-steel plate and pressed immediately with a stainless-steel iron to obtain glass flakes. The glass transition temperature (T_g) and crystallization temperature of the glass samples were estimated by the differential thermal analysis (DTA). The glass specimens were heated at temperatures between 823 and 1173 K for 2 h in air. The crystalline phases precipated by heating glass specimens were identified by X-ray diffraction (XRD) with CuK radiation. In addition, High temperature X-ray diffraction (HT-XRD) was used for phase identification at elevated temperatures between 293 and 1123 K.

3. Result and Discussion

Fig. 1 shows the DTA curve obtained from a glass specimen. Three exothermic peaks and an endothermic peak were clearly visible above the glass transition temperature, T_g. The three exothermic peaks between 813 and 973 K suggested precipitation of at least three kinds of crystalline phases. The endothermic peak at 1073 K suggested the melting of crystalline phases that precipitate at low temperatures.

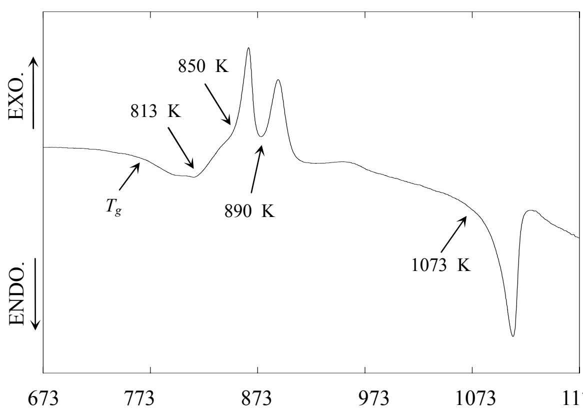

Fig. 1. Differential thermal analysis curve of a glass Specimen.

In order to investigate the formation mechanism of Y-type Ba-hexaferrite (hereafter “Y-type”) by the glass-ceramic method, glass specimens were heated at various temperatures. Fig. 2 shows XRD patterns of non-leached specimens heated for 2 h. The specimen heated at 823 K was composed of -$BaFe_2O_4$. The specimen heated at 883 K was composed of -$BaFe_2O_4$ and an unknown compound, which we shall refer to as phase X. The two exothermic peaks below 890 K were because of precipitation of these compounds. No compounds matching the diffraction pattern of phase X were found in the JCPDS data files. The exothermic peak at 890 K was ascribed to the formation of M-type Ba-hexaferrite (hereafter “M-type”), which was detected at 923 K. It appears that -$BaFe_2O_4$ is a precursor of M-type. The precipitation of Y-type started around 1073 K, coexisting with M-type and phase X. The peak intensity of M-type decreased gradually with increasing peak intensity of Y-type above 1073 K. A liquid phase was identified in the specimens heated at temperatures above 1073 K.

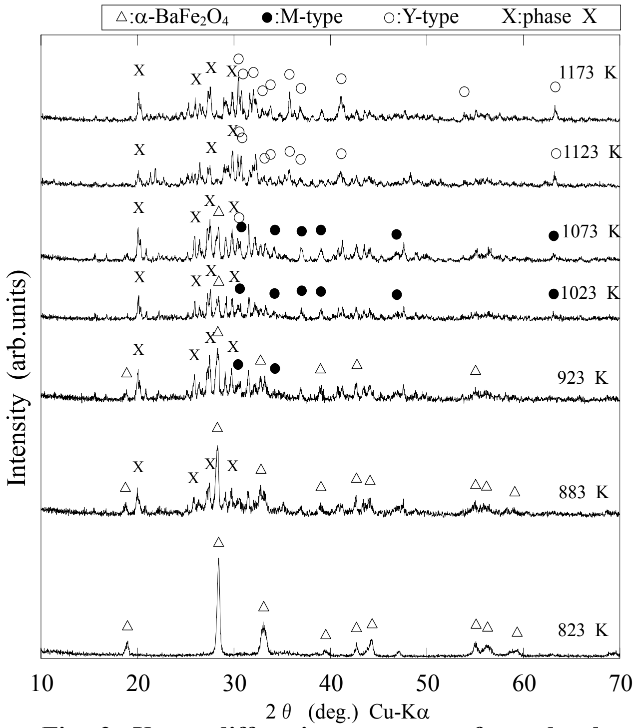

Fig. 2. X-ray diffraction patterns of non-leache dspecimens heated at various temperatu res for2h.

Fig. 3 shows HT-XRD patterns of a glass specimen. The peak intensity of M-type and phase X decreased gradually with increasing peak intensity of Y-type with increasing

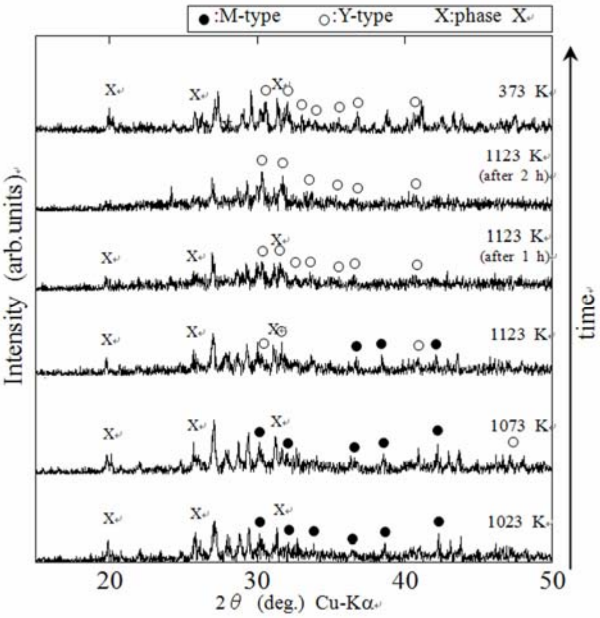

Fig. 3. High temperature X-ray diffraction patterns of a glass specimen.

heating time at 1073 K. After the specimen was cooled down, the peak of phase X was detected again. These results indicate that the endothermic peak is because of the melting of phase X and that Y-type forms basically through the reaction of M-type with a melt of phase X.

4. Summary

The formation behavior of Y-type Ba-hexaferrite in the glass-ceramic method was studied. Glasses with composition of $0.1ZnO \cdot 0.9(0.3Fe_2O_3 \cdot 0.5BaO \cdot 0.2B_2O_3)$ were heated at various temperatures and precipitated crystalline phases were identified. An unknown compound, phase X, was precipitated at about 850 K. The precipitation of M-type ferrite was detected at about 923 K. The formation of Y-type ferrite was explained by the reaction of M-type ferrite with a melt of phase X.

5. References

1. M.Nagae, “Preparation of Y-type Barium Hexaferrite by the Glass-Ceramic Method” J. Am. Ceram. Soc., 89[3] 1122-1124 (2006).