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AMORPHOUS PHASE IN YTTRIUM-COBALT-BORON SYSTEM

Seishi YAJIMA, Kiyohito OKAMURA, and Toetsu SHISHIDO
The Oarai Branch, The Research Institute for Iron, Steel and Other Metals,
Tohoku University, Oarai-machi, Ibaraki-ken 311-13

By rapid quenching of the melt, an amorphous phase of yttrium-cobalt-boron system was obtained. The phase is stable at room temperature, and its crystallization takes place in the vicinity of 700°C on heating at 10°C/min. Electrical resistivity of the amorphous phase is constant at about $10^{-3}\Omega$cm in the temperature range below 660°C; the variation in the resistivity with the transition from the amorphous to the equilibrium state was measured.

The glasses based on lanthanoid oxide (Ln_2O_3) were previously obtained in the system Ln_2O_3-Al_2O_3, Ln_2O_3-Nb_2O_5 and Ln_2O_3-Ga_2O_3 using the impact quenching apparatus.[1] In the present study, an attempt has been made to produce the glassy state of Y-Co-B system by the conventional piston hammer and anvil technique[2] using a laser beam melting furnace which provides high quenching rates in inert-gas atmosphere. The ternary rare earth boride YCo_2B_2 prepared by arc-melting method[3] in the authors' laboratory was used as a starting material.

The ingot of the compound prepared was cut into a block of about 2mm in diameter, melted using the laser beam and then rapid-quenched by the piston and anvil technique in pure argon gas atmosphere. The resulting foils were about 10mm in diameter and 10μ in thickness. X-ray diffraction patterns of the foils showed diffused halos characteristic of the amorphous state.

Crystallization process of the amorphous YCo_2B_2 was examined by DTA method. The sample (10mg) in a platinum cell was heated and cooled at 10°C/min in the range from room temperature to 1200°C in pure argon gas atmosphere. The DTA curves on heating and cooling are shown in Fig.1; the four exothermic peaks, (a), (b), (c), and (d), are observed at 672°C, 684°C, 804°C, and 822°C, respectively, on heating. On cooling no reaction is exhibited. To identify the crystalline products associated with the four exothermic peaks, the samples were heated up to 675°C, 700°C, 812°C, and 840°C, respectively, and then cooled down to room temperature.

X-ray diffraction patterns of the samples heat-treated were taken with FeKα radiation. No peak was observed in the diffraction pattern of the sample heated up to 675°C. It seems likely that the peak (a) is due to the two-glassy phase separation. The second exothermic peak (b) was attributed to the crystallization of a metastable-phase with an unknown structure.[4] The X-ray diffraction pattern of the sample heated up to 812°C showed broad peaks, which probably are due to YCo_2B_2. The pattern of the sample heated up to 840°C showed sharp peaks and could be indexed as YCo_2B_2.

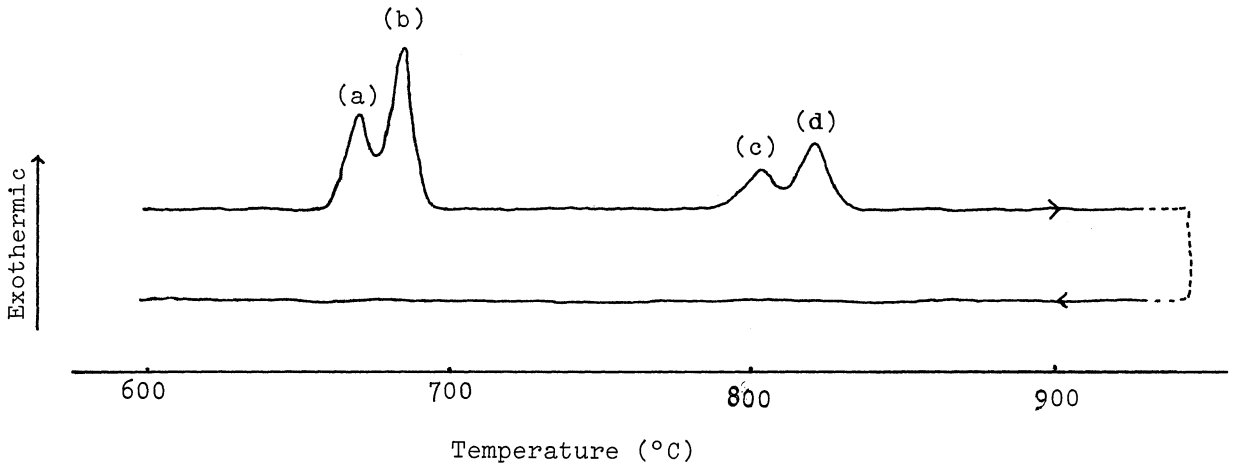

Fig.1 DTA curve of the amorphous YCo_2B_2 on heating and cooling

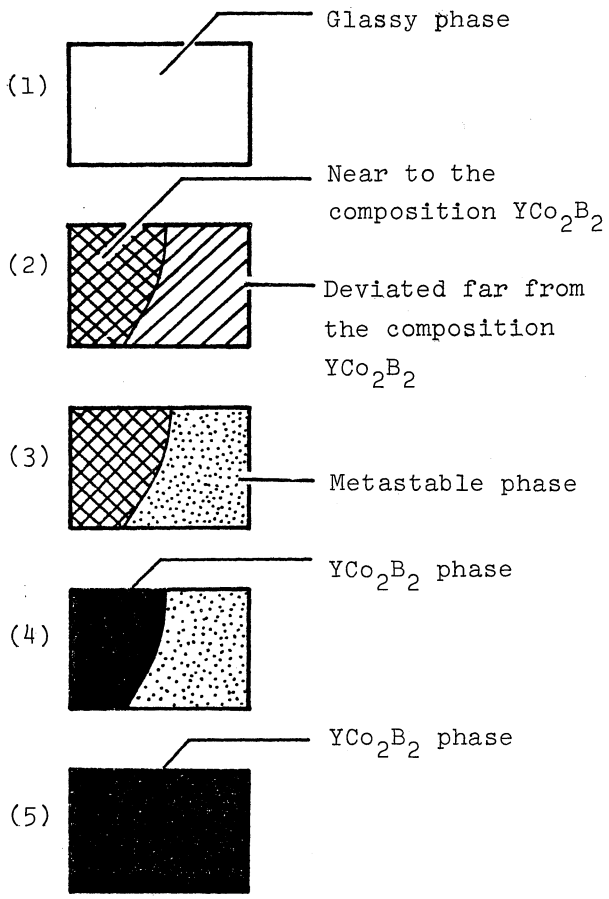

Fig. 2 Phase transformation process (1);Glass, (2);Two-glassy separation, (3);Glassy phase+metastable phase, (4);YCo_2B_2 crystallized +metastable phase and (5);YCo_2B_2 crystallized.

The phase transformation from the glass to the stable phase is thought as follows.

Two composition regions occur as shown in Fig. 2(2), as a result of the two-glassy phase separation. Figure 2(3) shows the metastable phase associated with the peak (b) and the glassy phase. The crystallization of the compound YCo_2B_2 associated with the peak (c) begins to occur in the black region in Fig. 2(4). The stable phase YCo_2B_2 associated with the peak (d) crystallizes as shown in Fig. 2(5).

On the other hand, micro Vickers hardness was measured of the amorphous YCo_2B_2, the amorphous YCo_2B_2 heat-treated up to 700°C and the compound YCo_2B_2 crystallized at 840°C. Their values were 1452, 1590, and 1939 Kg/mm^2, respectively. The hardness of the amorphous YCo_2B_2 is lower than that of the YCo_2B_2 crystallized.

Change of electrical resistivity of the amorphous YCo_2B_2 with temperature was measured to examine its crystallization process. The electrical resistivity, $\rho(\Omega cm)$, was measured by the four-probe method, using Conductive Silver Coating Materials of Du Pont No.4817 to connect the silver electrode with the specimen. The silica glass plate was used to hold the specimen. The specimen about 10mm in diameter and 10μ

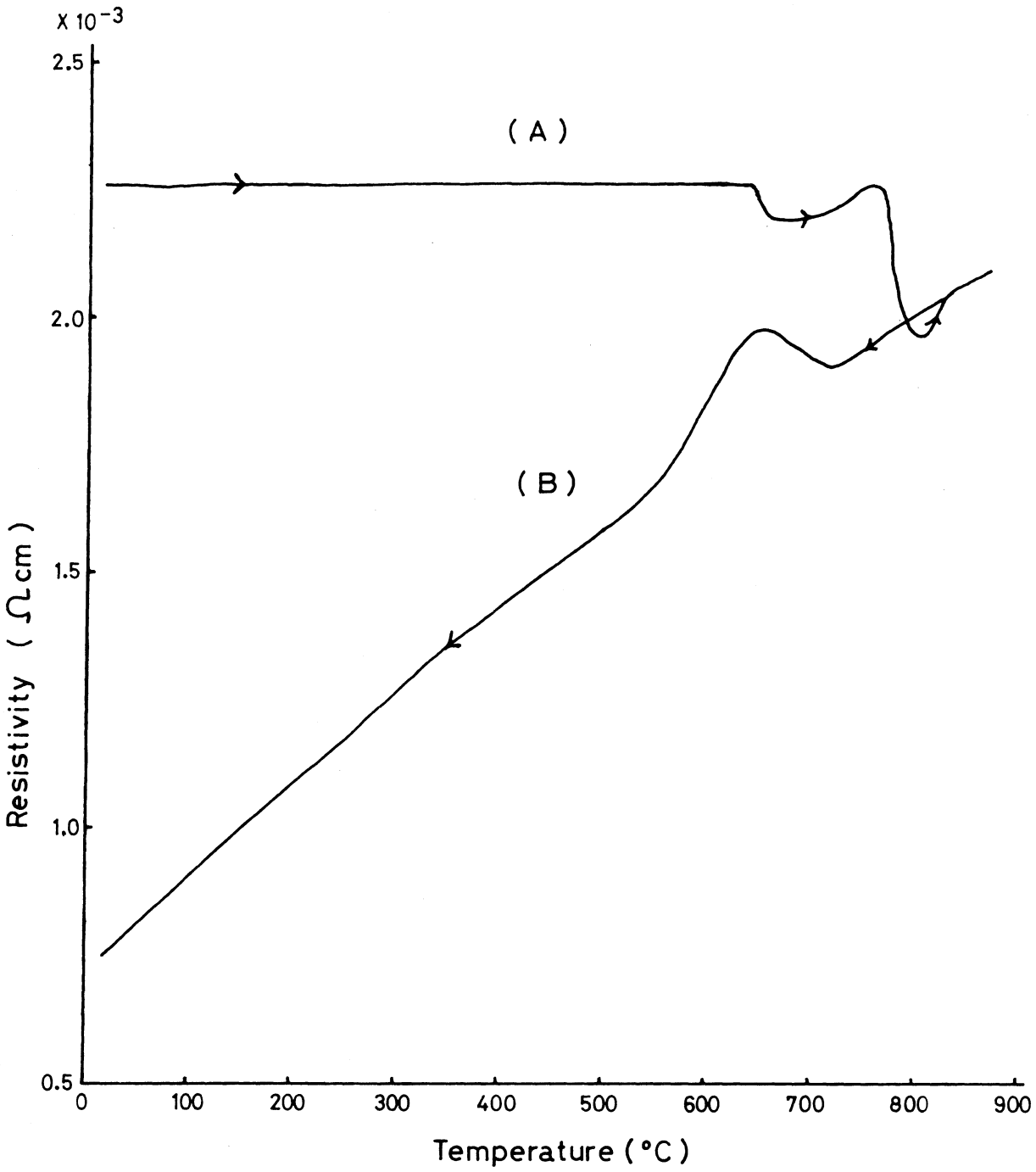

Fig.3
Temperature dependence of the electrical resistivity of YCo_2B_2 in the amorphous (A) and the crystalline state (B).

in thickness was connected in series with a 0.1Ω standard resistor and a constant dc voltage source. The measurement of ρ was made in pure argon gas atmosphere in a silica tube placed in the temperature-controlled furnace. The specimen was heated and then cooled at 10°C/min between room temperature and 900°C. The resistivity-temperature curves[5] obtained are shown in Fig. 3. Resistivity of the amorphous phase is nearly constant in the temperature range below 660°C, as shown by curve (A). The ρ-T curve drops slightly at 660°C, where two-glassy phase separation probably starts to take place. The resistivity of the specimen in which the unknown metastable phase already precipitated, increases slightly with temperature from about 670°C, then decreases steeply from 770°C, and finally join the resistivity of the stable compound YCo_2B_2 at about 850°C. The resistivity-temperature curve of the specimen obtained when cooled from 870°C to room temperature is shown by the curve (B) in Fig.3. In the curve, a small broad peak is observed in the vicinity of 650°C. Measurement of the resistivity was repeated several times on heating and cooling the specimen, which showed that the relation between ρ and T remained the same except for the region near the broad peak; the peak reduced on each heating and cooling. For comparison, resistivity of the compound YCo_2B_2 obtained by the arc-melting method was also measured. The ρ-T curve obtained was nearly the same as that of the boride crystallized from amorphous YCo_2B_2, but the small broad peak at about 650°C as shown in Fig.3 was not observed. The resistivity of the YCo_2B_2 crystallized from the amorphous state was at room temperature about one third of that of the amorphous boride.

The relation of the crystallization associatied with the exothermic peak (c) and (d), with the resistivity will be reported elsewhere.

Acknowledgement

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References

1) S. Yajima, K. Okamura, and T. Shishido, Chem. Lett., 741 (1973).
2) S. Yajima, K. Okamura, and T. Shishido, Chem. Lett., 1531 (1974).
3) K. Niihara, T. Shishido, and S. Yajima, Bull. Chem. Soc. Japan, 44, 3214 (1971).
4) The crystalline product due to the peak (b) could not be identified, because there are only three broad peaks in the X-ray diffraction pattern.
5) The shape of amorphous specimens could not be measured exactly, so the ρ(Ωcm) values in Fig.2 are derived from the values of the compound YCo_2B_2.

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