Temperature Dependence of Electrical Resistivity and Phase Transformation Studies of Amorphous Fe76Nd4B20 alloy

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***Abstract*- The temperature dependence of electrical resistivity and phase transformation studies of amorphous Fe76Nd4B20 alloy have been done in the temperature range 300 K - 950 K. From the resistivity measurements, the resistivity of the amorphous Fe76Nd4B20 alloy at 300 K, ρ(300) is found to be 186 μΩ-cm. The Curie Temperature (TC), the first step of crystallization (TX1) and the second step of crystallization (TX2) of the amorphous sample are found to be 600 K, 800 K and 910 K, respectively. The temperature coefficient of resistivity (TCR), α and the Debye temperature (ϴD) of the amorphous sample are found to be 8.065 X 10-4 K-1 and 408 K, respectively. The results are compared with those of the published other similar systems and discussed to understand the crystallization behavior and thermal stability of amorphous Fe76Nd4B20 alloy.**

Index Terms- amorphous ferromagnetic alloys, hard Ferro magnets, thermal stability, temperature coefficient of resistivity, Debye temperature

INTRODUCTION

Amorphous ferromagnetic alloys have attracted wide attention because of their excellent magnetic, mechanical and electrical properties. Some of them show high saturation induction, low coercivity and reasonably high resistivity. These are soft ferromagnets used in tape recorder heads, communication equipment, transformer and electromagnetic industries. On the other hand, some of the amorphous alloys show high saturation induction, high coercivity and large energy product. These are generally hard ferromagnets used to make permanent magnets. The demand of these magnets is increasing because these magnets are indispensable for high performance motors in electrical vehicles. These magnets show sufficient thermal stability since the properties of these materials significantly change by the onset of crystallization and crystallization is associated with nucleation and growth process. Also, as the cost is lowered due to the substantial reduction of the rare-earth content, it therefore accounts for a new generation of permanent magnetic materials [1,2].

Neodymium– iron–boron (Nd–Fe–B) magnets with prominent magnetic properties have been generated using rapidly solidified melt-spun technique in the ribbon form[3–5].

Detailed investigations on transport properties of solids provide valuable information about the eletronic structure and various scattering processes that are responsible for the electronic transport. Among the various transport coefficients, electrical resistivity is the one which provides valuable information on the electronic transport. It is a sensitive probe to study structural disorders and various scattering processes that occur in a given material and to study phase transformations.

In this paper, we mention the temperature dependence of electrical resistivity and phase transformation studies of amorphous Fe76Nd4B20 alloy in the temperature range 300 K - 1000 K. The results are compared with those of the published other similar systems and discussed to understand the crystallization behavior and thermal stability of amorphous Fe76Nd4B20 alloy.

EXPERIMENTAL

Amorphous Fe76Nd4B20 alloy ribbon has been produced by melt spinning technique. The ribbon samples are obtained from our other researchers. The thickness of the sample is about 30 μm and the width is about 1 mm. Four probe resistance apparatus was used to make resistivity measurements in the temperature range 300 K – 950 K. The amorphous nature of the fresh sample was checked using X-ray Diffraction (XRD).

RESULTS AND DISCUSSION

Figure 1 shows the variation of electrical resistivity, ρ(T) of amorphous Fe76Nd4B20 alloy with temperature, T(K) in the temperature range 300 K – 950 K. As in Fig 1, resistivity of the amorphous alloy linearly increases from 300 K to 550 K.
From 550 K the resistivity slowly decreases showing a small dip at 600 K. The small dip in the resistivity of the amorphous sample shows the Curie temperature (TC) of the amorphous sample which is 600 K. Increase of temperature from 600 K increases the resistivity of the sample upto 700 K and from there the resistivity decreases rapidly up to 800 K.

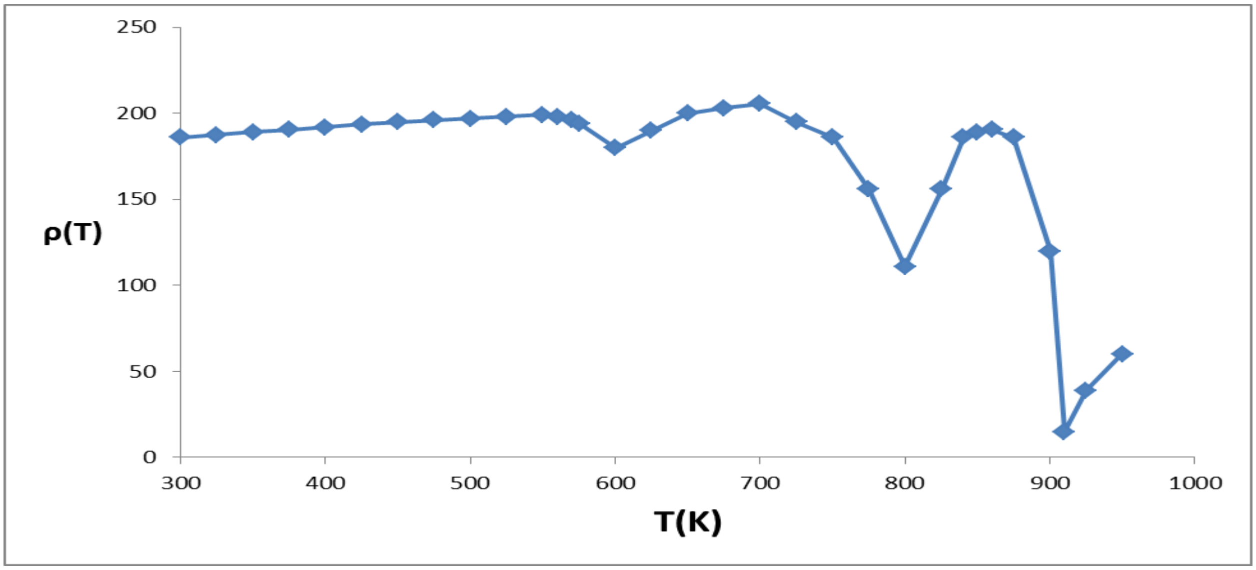

Figure 1 Resistivity, ρ(Ω) versus Temperature, T(K) of amorphous Fe76Nd4B20 alloy

From 800 K, the resistivity more or less sharply increases up to 850 K. Thus, drop in the resistivity at 800 K gives the first step of crystallization (TX1) in the amorphous sample. This occurs due to structural relaxation due to a variety of atomic rearrangement and growth of a primary crystalline phase. Similarly, in Fig.1, the resistivity suddenly drops at 910 K representing the second step of crystallization (TX2) which occurs due to massive nucleation and the growth of another crystalline phase. . From 910 K, the resistivity rapidly increases with increase in temperature. Thus, amorphous Fe76Nd4B20 alloy undergoes two step crystallization processes. This gives wide temperature interval between the two crystallization stages. Observation of two step crystallization is more common in some amorphous ferromagnetic materials and metallic glasses. Thus, as spun samples of Fe76Nd4B20 alloy crystallize in two steps to a final microstructure consisting of Fe14 Nd2B and α-Fe phases [6]. Fe14 Nd2B particles are surrounded by the bcc-Fe and amorphous phases which act as a magnetic exchange coupled medium [7,8]. Comparison of our results with the published other similar systems reveals that amorphous Fe76Nd4B20 alloy has good thermal stability for applications in the industries.
From the resistivity measurements, the temperature coefficient of resistivity (TCR), α and the Debye temperature (ϴD) of the amorphous sample are found to be 8.065 X 10-4 K-1 and 408 K, respectively.

CONCLUSIONS

From the resistivity measurements, the resistivity of amorphous Fe76Nd4B20 alloy at 300 K is found to be 186 μΩ-cm. The Curie Temperature (TC), the first step of crystallization (TX1) and the second step of crystallization (TX2) of the amorphous sample are found to be 600 K, 800 K and 910 K, respectively. The temperature coefficient of resistivity (TCR), α and the Debye temperarure (ϴD) of the amorphous sample are found to be 8.065 X 10-4 K-1 and 408 K, respectively. The amorphous as spun samples of Fe76Nd4B20 alloy crystallize in two steps to a final microstructure consisting of Fe14 Nd2B and α-Fe phases. Comparison of these results with the published other similar systems reveals that amorphous Fe76Nd4B20 alloy has good thermal stability for applications in the industries.

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