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Magnetic resonance study on boron substituted amorphous FeZrMn alloys

A.N.Ulyanov, Sheng-Bo Tian, Kyeong-Sup Kim, V.Srinivas, Seong-Cho Yu*

Department of Physics, Chungbuk National University, Cheongju, 361-763, Korea

Amorphous magnetic materials with competing magnetic interactions are the subject of current interest. Critical behaviour studies have been performed in order to understand the nature of the phase transition at the Curie point (T_C) and type of magnetic ordering below the T_C. In some cases there exists a temperature interval in which the magnetic system consists of ferromagnetic grains separated by the paramagnetic interlayers. Magnetic properties of nanoparticles embedded in amorphous matrix also are the subject of recent interest. While these materials exhibit excellent soft magnetic properties at room temperature, some of them have been found to be superparamagnetic in the temperature range above the T_C of the matrix [1,2]. Thus the role of different magnetic phases in the intergrain magnetic coupling can possibly be taken apart in a sufficiently broad temperature range and investigated separately. In particular materials with competing magnetic exchange interactions show characteristics of enhanced magnetoresistance and softer magnetic properties when magnetic nanocrystals are dispersed in amorphous matrix [1]. We expect careful magnetic measurements in the vicinity of T_C would throw some light on magnetic behaviour of above materials. We present here the FMR analysis of $Fe_{82}Mn_{8-x}B_xZr_{10}$ alloy near the Curie point.

Amorphous $Fe_{82}Mn_{8-x}B_xZr_{10}$ (x=0-8) alloy ribbons of 2-3 mm width and 20-40 μm thickness were prepared by melt-spinning technique from high purity elemental constituents under argon atmosphere. Magnetic resonance study was carried out at 9.2 GHz with Jeol JES-TE300 ESR spectrometer. The measurements were performed on the squared 1mmx1mm samples in field parallel to their planes. Magnetic measurements in the temperature range 5-400 K showed that as boron content increased (i) the Curie temperature increased from 185 K to 350 K for x=0 and x=8 compositions, respectively; (ii) the soft magnetic properties improved. We present here the FMR results for the x=6 (T_C =295 K) and x=8 alloys, which can be useful for application.

Figure 1 shows the FMR spectra in the vicinity of Curie temperature for x=6 sample. It can be noticed that at temperature close to T_C the line shape is broad and complex (dashed). As the temperature is increased the FMR spectra showed at least two distinct line shapes. First of them (sharp one) increased as temperature raised, second one decreased and disappeared completely at 363 K. It is possible that the first and second peaks could be due to the paramagnetic and superparamagnetic states respectively. According to ferromagnetic (FM) cluster model [3], in the temperature range well below T_C there is a FM coupling between the spins that make up the spin clusters is stronger than that between the spins of the FM matrix. As the temperature increases towards T_C, the exchange interaction between the spins in the FM matrix weakens, while the FM coupling between the spins within the spin clusters are relatively strong. It means that only a small fraction of spins participate in the FM-PM phase transition at T_C. The FMR spectra for x=8 sample showed similar behaviour, but the superparamagnetic clusters were observed in wider temperature interval above T_C than in the case of x=6 samples: a "pure" paramagnetic state was not achieved at temperatures higher for 123 K than the T_C point.

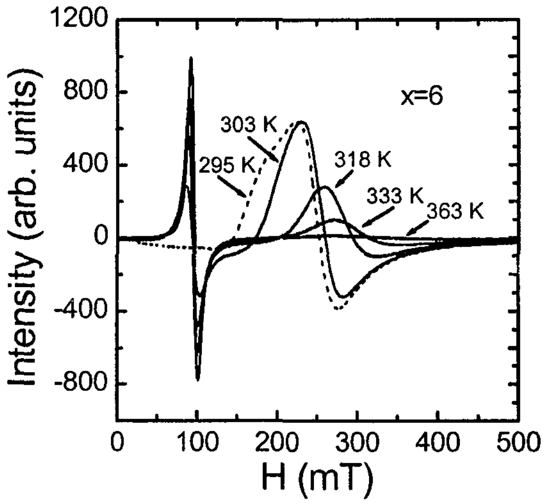

Fig. 1. Magnetic resonance spectra for x=6 alloy at different temperatures near the T_C.

In summary, the superparamagnetic clusters were observed in amorphous $Fe_{82}Mn_{8-x}B_xZr_{10}$ alloys at temperatures well beyond the Curie temperature by the magnetic resonance measurement. These observations could be qualitatively understood in terms of a finite spin clusters plus an infinite ferromagnetic matrix model.

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*) *Author to whom correspondence should be addressed; e-male*: scyu@chungbuk.ac.kr

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