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Magnetic properties and exchange interactions in amorphous and crystalline Y–Fe alloys

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The effects of pressure on the magnetization and ac susceptibility of amorphous $Y_{0.19}Fe_{0.81}$ alloy and crystalline Y_2Fe_{17}. The results show that two phase transitions para–ferromagnetic–spin-glass-like state transform under pressure to the single phase transition paramagnetic–spin glass in amorphous $Y_{0.19}Fe_{0.81}$ alloy. The temperature range within which pressure induces the noncollinear ordering of Fe magnetic moments in crystalline Y_2Fe_{17} compound was obtained.

1. Introduction

Despite extensive studies of the Invar problem, many uncertainties remain. It is clear, however, that anomalous physical properties of Invar alloys are determined by their magnetic nature [1,2]. Most Invar alloys contain γ-Fe, and they may be either crystalline [3,4] or amorphous [5,6]. The Invar properties of γ-Fe-based alloys are usually observed near the γ–α phase transition boundary. The second components most often used are Ni, Pt, Pd and Pauli paramagnetic Y [7]. The amorphous alloys $Y_{1-x}Fe_x$ have been prepared in a wide concentration range (10–60 at% Y) and their magnetic properties investigated [8–13]. These alloys are not collinear ferromagnetics, as are crystalline Y–Fe compounds, but have complicated magnetic structures. At the same time, some correlations between the magnetic properties of crystalline compounds and amorphous alloys could be expected since exchange interactions in the γ-Fe subsystem play a major role.

In the present study the effects of pressure on the magnetization and ac susceptibility of amorphous $Y_{0.19}Fe_{0.81}$ and crystalline Y_2Fe_{17} alloys are reported. The purpose of this work is to compare the effects of pressure on their magnetic structures.

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2. Experimental techniques

The magnetization was measured in the temperature range 80–300 K in magnetic fields up to 14 kOe at various hydrostatic pressures up to 10 kbar [14]. The ac susceptibility was investigated in 70 Hz and 3 Oe magnetic field in the same temperature and pressure ranges.

The magnetization at atmospheric pressure was measured in the temperature range 4.2–300 K by means of a vibrating-sample magnetometer.

The same of amorphous $Y_{0.19}Fe_{0.81}$ alloy about 40 μm thick was prepared by ion sputtering onto a nitrogen-cooled Al substrate. The amorphous nature of the sample was established by X-rays. The composition was determined using an X-ray microprobe analyzer MS-46. Inhomogeneities along the surface were less than 1%.

The polycrystalline compound Y_2Fe_{17} was prepared by arc-melting in an Ar atmosphere. The content of the other phases was less than 4%.

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