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Magnetic Properties and Crystallization Behavior of Al-Co-Ce(Dy) Amorphous Ribbons

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Abstract. Magnetic and electric properties as well as the structure (by X-rays) and DSC of $Al_{91}Co_2Ce_7$ and $Al_{89}Co_5Dy_6$ alloys in amorphous and crystalline states are studied. For both ribbons crystallization goes into two stages. In case of $Al_{91}Co_2Ce_7$ composition it starts with the formation of Al nanoparticles; after that $Al_{11}Ce_3$ and Al_9Co_2 compounds appear. For $Al_{89}Co_5Dy_6$ ribbon the situation is vice versa – the crystallization of Al_3Dy compound takes place at the first stage whereas crystallization of aluminum matrix arises at the second stage only. The effective magnetic moments per Ce (Dy) atoms were found to be smaller than for R^{3+} ions suggesting that rare-earth atoms create directed bonds with aluminum atoms.

Keywords: magnetic susceptibility, electric resistivity, DSC, aluminum-based alloys, amorphous ribbons

INTRODUCTION

In recent decades, aluminum alloys with 3*d*- and 4*f*-elements have been attracting attention of researchers due to their unique physical properties, especially in the amorphous and nanocrystalline states. Al–TM–REM amorphous alloys exhibit good mechanical characteristics combining high strength and plasticity [1-5]. An important feature of these alloys is the excellent corrosion resistance and heat resistance, which enable one to consider them for use as protective coating materials in aviation and space industry [6,7]. Further improvement in the mechanical properties has been reached by partial crystallization of amorphous structures, forming a precipitation of nanometer-sized fcc-Al phase in the amorphous matrix [8,9].

However, magnetic properties of these alloys were not studied precisely and there is no common opinion about the magnetic state of 3d-transition and rare-earth elements in disordered aluminum matrix. For example, Chen et al found that Gd-based Gd-Fe-Al bulk amorphous cylinders with a diameter of 1 mm exhibit superparamagnetism at room temperature, while the amorphous ribbons of the same composition show paramagnetism [10]. The effective magnetic moment per Gd atom in Al-based Al-Fe-Gd composition was determined to be 7.62 μ_B that is close to the ionic value of 7.94 μ_B [11]. Magnetization studies showed $Al_{65}Gd_{15}Cu_{20}$ amorphous alloy to be paramagnetic with a localized gadolinium moment of (8.0 ± 0.2) μ_B, whereas $Al_1Gd_1Fe_1$ demonstrates ferromagnetic behavior, with T_c = 275 K and a saturation magnetization of 124 emu/g [12]. On contrary to the results mentioned above, G. Li et al declared that Al-Ni(Co)-La(Ce) amorphous alloys display a diamagnetic behavior at room temperature [13]. At the same time Ce atoms in glassy $Al_{87}Fe_9Ce_4$ show large valence instability, yielding an effective moment of 1.37 μ_B at room temperature to ~ 0.25 μ_B at 5 K. The similar results were obtained in