Magnetic behavior in multinary Dy–$(Mn,Fe)_6$–$(Ge,Al)_6$ amorphous system by Mössbauer effect investigation

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Current theoretical models suggest that metallic glasses gain their stability through specific structural units, *i.e.* stable nearest-neighbor clusters [1, 2]. Therefore, the right type of alloy component (one or more) must be added for a good glass forming ability (GFA). Experimental search for multinary alloys with GFA has usually started with compositions in binary and ternary alloy systems, which already form metastable amorphous states [3, 4]. During rapid solidification from the melt, the amorphous states compete with the nucleation of ternary intermetallic compounds. The amorphous states in our melt-spun Dy–$(Mn,Fe)_6$–$(Ge,Al)_6$ cannot be classified by the usual rules developed for multinary metallic glasses [5].

In the amorphous Dy–$(Mn,Fe)_6$–$(Ge,Al)_6$ the chemical interactions are very important as the elements have similar sizes. In partcular, also repulsive pair-interactions play a prominent role to frustrate the formation of crystalline nuclei in this alloys systems. For compositions between parent crystalline compounds ($DyFe_6Al_6$ and $DyMn_6Ge_6$) the formation of crystalline stable o metastable phases during rapid quenches is suppressed and the formation of amorphous structures is observed. This process is accompanied by slight changes in magnetism of these alloys. For example, the observed structure in as-quenched $DyMn_3Ge_3Fe_3Al_3$ to $DyMn_{3.5}Ge_{3.5}Fe_{2.5}Al_{2.5}$ ribbons are mixed and fully amorphous, respectively, but there is no significant change in the measured magnetization *versus* temperature besides a slight decrease of magnetization, which can be related to the substitution effect. In the Mn-richer sample, more Fe atoms are in a paramagnetic state because more of the neighbor atoms are nonmagnetic. Mössbauer effect study give a complementary results. By substitution of Fe with Mn, the sextets from magnetic components are suppressed and vanish. The hyperfine structure of Mössbauer spectra recorded at 300 K and at 77 K is discussed on the basis of different model approaches, involving either a discrete number of quadrupolar and magnetic components or quadrupolar splitting and hyperfine field distribution at ^{57}Fe sites. To discuss the structural aspects of the present studied compounds, the distributions are then compared to those expected in the case of random packing of hard spheres as proposed by Czjzek *et al.* [6].

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