Positive and negative magnetoresistance in granular $Zn_xCd_{1-x}GeAs_2$ + MnAs composites

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Granular systems are perspective materials for spintronics applications. These structures consist of magnetic particles embedded into non-magnetic material. The system can be switched by the external magnetic field. Without external magnetic field the magnetic moments of the magnetic inclusions are oriented randomly and the resistance of the structure is high. With applying the external magnetic field, the magnetic moment of the inclusion becomes co-oriented and resistance of the systems decreases.

In our early investigations we reported about negative magnetoresistance in $ZnGeAs_2$ [1] and positive magnetoresistance in $CdGeAs_2$ [2] doped with Mn. The magnetic properties of these compounds are explained by the magnetic MnAs nanoclusters. Both compounds crystallized in chalcopyrite structure and have Curie point around 367 and 355 K, respectively [3]. The phase diagram of $ZnGeAs_2$-$CdGeAs_2$ was also investigated in [4]. The solid solutions are present in all range of concentrations above 440°C. Below this temperature the decay region of solid solution of $Zn_{1-X}Cd_XGeAs_2$ is observed in the range of concentrations x=0.19-0.92 at room temperature.

In this work we prepared the solid $Zn_xCd_{1-x}GeAs_2$ solutions with different concentrations of MnAs. The magnetic properties of these compounds were investigated by magnetization measurements. The identification of the samples was done with x-ray, microstructure and SEM. X-ray proved, the samples consist from solid solutions and MnAs. Solid solutions rich with zinc have negative magnetoresistance, increasing with manganese antimony concentration. The samples of solid solutions rich with cadmium have positive magnetoresistance increasing with increasing MnAs concentration. We found that the tendency of magnetoresistance we observed in early works [1, 2] is saved in the structures based on solid solutions. The SEM investigations showed that there are different types of interaction in these systems. Ever, both structures were eutectic type, but the compounds rich with Zn have eutectic point shifted to the semiconductor and we observed negative magnetoresistance. Structures where eutectic point shifted to the middle part of the phase diagram chalcopyrite – ferromagnetic (rich with Cd) had positive magnetoresistance. If the eutectic point is situated in the middle part of the diagram, the needles eutectic will be formed in the structure. Such type of eutectic causes the formation of percolation cluster.

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