Synthesis, processing and characterization of FeMnGa nanoparticles for permanent magnet applications

Abstract

In recent years, there is a great demand in materials suitable for permanent magnets which led to shortages in the supply of rare earth elements, a basic ingredient of high performance magnets. Research for rare earth free magnetic materials is considered as a viable alternative. Various Heusler alloys are investigated as possible candidates. Among them, the binary compound Mn_XGa has gained interest. A method of improving the magnetic properties of intermetallic compounds is the introduction of a magnetic atom like Fe in replacement of a 3d metal, in our case, by replacing a quantity of Mn with Fe. In this study $Mn_{0.4}Fe_{0.3}Ga_{0.3}$ alloys were prepared in a high purity Ar atmosphere with the arc-melting technique followed by melt-spinning in order to get nanostructured ribbons. The samples were further treated (annealing, ball milling) in order to tune the microstructure and obtain single phase samples with optimum magnetic properties. Magnetization measurements were performed by using a Vibrating Sample Magnetometer (VSM), versus temperature and field. The structure of the samples was studied by X-ray diffraction patterns (XRD). The $L1_2$ structure was observed for the first time, among the other ones $D0_{19}$ and $L2_1$ which are already observed in Mn_3Ga studies. A deeper study was performed with a Scanning Electron Microscope (SEM). Saturation magnetization of the basic material was measured at 81.4 Am^2/kg while remanence and coercive field were measured at 14.7 Am^2/kg and 0.3 T, respectively. The effect of the grain size on the magnetic properties, due to ball milling, is discussed.