Hard Magnetic Properties Observed in Bulk $Mn_{1-x}Ga_x$

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Introduction

As technology advances, strong permanent magnets play an increasingly large role in the progression and invention of many technologies we now find essential. Magnets provide the backbone of many products including computers, mobile phones, electric cars and wind-powered generators [1]. Currently the strongest permanent magnet contains rare earth metals, such as Nd, Dy and Sm in Nd2Fe14B type or SmCo5 type magnets for most of our magnetic applications because of the high energy product and coercivity [2, 3]. However, the constraints of rare earth suppliers, the environmental impact of the refining process, and price volatility have left consumers seeking alternative magnets for their applications [3]. This report outlines our effort in making $Mn_{1-x}Ga_x$ bulk materials that contain a non-rare earth elements.

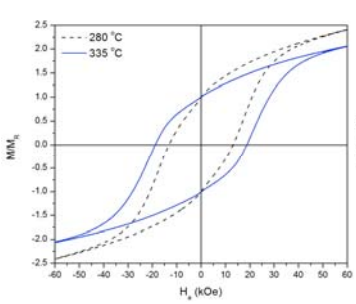
Experimental

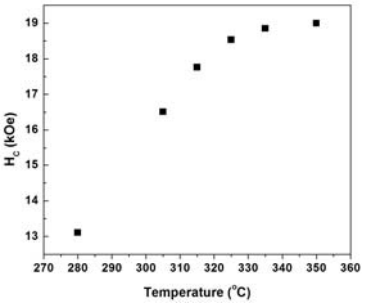
Samples were prepared through a high energy ball milling process. The milled powders were pressed, sealed in evacuated quartz tubes and heat treated for 2 h at temperatures ranging from 280 °C-350 °C with and without high magnetic field. Magnetic properties were investigated by a vibrating sample magnetometer (VSM) in a physical property measurement system (PPMS) (Quantum Design Model 6000) in magnetic fields up to 7.5 T (H_a) at a temperature of 30 °C.

Results and Discussion

Samples prepared with a nominal chemistry of $Mn_{1-x}Ga_x$ with x=20 were measured to have an average chemistry of Mn82Ga18 and a standard deviation of 7.25 at%.

The Mn82Ga18alloys have major phase with structure similar to Mn0.85Ga0.15 (space group of 213 (P4132)) and also an oxide identified as MnO. . The coercivity (H_c) and overall shape of the magnetization curves are sensitive to the annealing temperatures. The H_c values increase with the temperature of the heat treatment up to 350 °C and reach a plateau after 325 °C. The H_c achieves an average value of 18.8 kOe using the points from 325 °C to 350 °C. High magnetic field of 17 T has no significant impact on H_c. We are studying the impact of higher field on magnetic properties.





Conclusions

In summary, we were able to fabricate a bulk permanent magnet capable of reaching coercivities up to 18.8 kOe. We believe that the high-energy ball milling provides us an ideal precursor for later sintering so that an intermetallic compound forms resulting in a preferred magnetic ordering. An optimized sintering temperature was established in this alloy for best maximum energy product we are studying in details the magnetic field impact on phase transformation. This effort has allowed us to create rare-earth and noble-metal free magnets with coercivities that are competitive with Nd-Fe-B magnets.

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References

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