Magnets with properties intermediate between Nd-Fe-B and Ferrite

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The rare earth elements neodymium, samarium, terbium and dysprosium are predominantly mined in China (>95%) and prices fluctuate widely as a result of Chinese government policies. We need a new magnet with little or no rare earth to fill the gap magnet between ferrite and Nd-Fe-B to be used for intermediate energy applications. [1]. In this work, ball-milled Co based alloys have been investigated and a several for new ternary and Mn- based compounds has been carried out.

The magnetic and structural properties of bulk, ball-milled $La(Co_{5-x}Fe_x)$ and ball-milled $La_2(Co_{7-x}Fe_x)$ were studied. The highest coercivity (1.08 T) was obtained at room temperature for ball-milled $LaCo_{4.8}Fe_{0.2}$ after annealing in a preheated furnace at 800 °C for 3 min and subsequently quenching. Iron doping up to x = 1 increased the saturation magnetization by up to 20% without any deterioration of coercivity. For $La_2(Co_{7-x}Fe_x)$, the highest coercivity (1.2 T) at room temperature and (1.92 T) at 4 K was obtained for ball-milled La_2Co_7 after annealing in the preheated furnace at 850 °C for 3 min and subsequently quenching. Unlike Fe-doped $LaCo_5$, iron doping in La_2Co_7 did not enhance the saturation magnetization[2].The hysteresis of ball-milled Fe-doped YCo_5 powder has been optimized by controlling the temperature and time for rapid annealing under vacuum and argon. The crystallite size is only 25 nm yet it has been possible to field-align YCoFe powder with a 5-20 μm grain size in a 5 T field to obtain a remanance ratio of 0.65. This demonstrates that there is a considerable degree of texture already in the ball-milled powder. The measured energy product of the powder is 140 kJ/m^3 which is the highest value reported for YCo_5 alloys. This intermediate magnet could fill the gap between oriented ferrite 34 kJ/m^3 and oriented Nd-Fe-B 350 kJ/m^3 [2]. However, the maximum energy product for sintered magnet is always lower compared that of annealed powder. In order to achieve this goal, a special magnet array is designed using ring magnets for pressing the powders under magnetic field in order to achieve magnetic alignment. A dramatic increase in magnetization is observed for magnetically aligned $YCo_{4.8}Fe_{0.2}$ pressed ingots [3].

Mn-Ga based alloys and compounds are currently of the focus of two interconnected topics in magnetism; permanent magnets and spintronics. Particulary Mn_8Ga_5 also often appears as a secondary content that can significantly influence the formation and magnetic properties of the $L1_o$ phase. The structural and magnetic properties of the binary Mn_8Ga_5 are investigated experimentally and by using density functional theory for the first time. Crystal structure is found in Cu_9Al_4- type ($P\bar{4}3m$) which is The most stable ordered atomic configuration strongly resembles that of the layered tetragonal $L1_0$ structure. Ferrimagnetic order with a magnetization that is highly sensitive to antisite-type atomic disorder is predicted and confirmed experimentally [4].

A high-throughput approach with computational screening has the potential to identify those alloys that have a sufficiently high magnetocrystalline anisotropy, show tetragonal distortion and meet the criterion of being sufficiently low cost. Among these fifteen Heusler alloys Co_2MnTi and Rh_2FeSn have magnetization of 109 and 53 Am^2/kg at 4 K which are coherent with theoretical values of 125 and 57 Am^2/kg respectively. Co_2MnTi has a cubic structure but tetragonal distortion is obtained for Rh_2FeSn with the secondary cubic RhSn phase. None of these compounds has competitve permanent magnet properties [5].

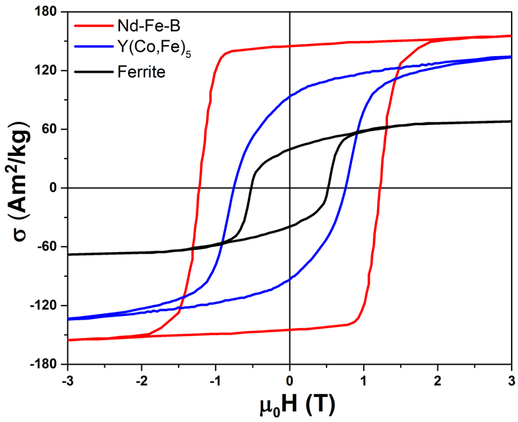

Figure 1: Room temperature hysteresis curves of a ferrite, a strong rare-earth magnet and our gap magnet.

References

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