High-field Magnetization Measurements of Magnetic Complex Oxides

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Introduction

The $A_2BB'O_6$ double perovskites have been extensively studied due to their high spin polarization and Curie temperatures well above room temperature, both characteristics needed for practical spintronic applications. Sr_2CrReO_6 is considered a promising material for spintronics due to its high T_C of 635 K and predicted half-metallicity with an expected saturation magnetization (M_S) of 1 μ_B per formula unit (f.u.). When spin-orbit coupling is included Sr_2CrReO_6 becomes a pseudo-half-metal and the M_S increases to 1.28 μ_B/f.u. On the other hand, Sr_2CrOsO_6 has the highest Curie temperature of 720 K among magnetic oxides. Both materials exhibit very high magnetic anisotropy due to the strong spin-orbit coupling, thus, it requires very large magnetic fields to reach saturation magnetization. In addition, we recently synthesized Sr_2IrO_4 powder which is a canted antiferromagnet and needs a large field to saturate as well. The goal of characterizing these materials is to understand their magnetic properties and prepare for deposition of epitaxial films of these interesting magnetic complex oxides.

Experimental

Our experiment was carried out using the 35 T DC magnet in Cell 8 in September, 2012. We used both the DC transport and vibrating sample magnetometer (VSM) capabilities of the system. Magnetic hysteresis loops of bulk powders of Sr_2IrO_4, Sr_2CrReO_6, and Sr_2CrOsO_6, as well as epitaxial films of Sr_2CrReO_6 were measured in magnetic fields up to 35 T at various temperatures. DC resistivity and Hall measurements were also taken on the Sr_2CrReO_6 epitaxial films. We obtained nice hysteresis loops for all three bulk samples.

Results and Discussion

Fig. 1 shows the magnetic hysteresis loops of Sr_2IrO_4, Sr_2CrReO_6, and Sr_2CrOsO_6 powder samples taken in Cell 8 in magnetic fields up to 35 T at 4.5 K. It appears that both Sr_2IrO_4 and Sr_2CrReO_6 require a field of about 30 T to saturate, while Sr_2CrOsO_6 is nowhere near saturation even at 35 T. This result indicates that all three materials are magnetically very hard due to the strong spin-orbit coupling given by the 5*d* transition metals. The magnetic moments of 0.077 μ_B per Ir^{4+} ion in Sr_2IrO_4 agrees with what has been reported. The saturation magnetization of 0.80 μ_B/f.u. for Sr_2CrReO_6 is also similar to previous publication on high field measurements of bulk Sr_2CrReO_6, but is considerably smaller than the 1.29 μ_B/f.u. obtained in the epitaxial films of Sr_2CrReO_6 made by our group. This indicates epitaxial film growth is a promising route for producing high quality materials that would not be feasible in bulk. Fig. 1c shows the first high field hysteresis measurement on Sr_2CrOsO_6, which exhibits an extraordinarily large magnetic anisotropy. We will perform further characterization of these materials in the future.

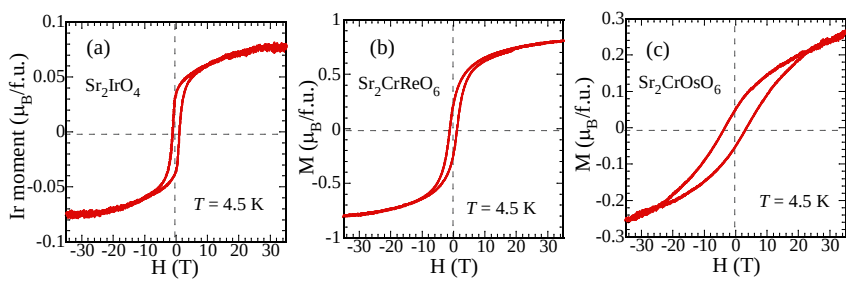

Fig. 1. Magnetic hysteresis loops of bulk (a) Sr_2IrO_4, (b) Sr_2CrReO_6, and (c) Sr_2CrOsO_6 in magnetic fields up to 35 T at a temperature of 4.5 K. The magnetic moment of Ir^{4+} ion, Sr_2CrReO_6, and Sr_2CrOsO_6 are determined to be 0.077 μ_B, 0.80 μ_B/f.u., and 0.26 μ_B/f.u., respectively.

Conclusions

The magnetic hysteresis measurements in high field provides valuable insights into the magnetic characteristics of the three magnetic complex oxides, revealing the very high magnetic anisotropy induced by the strong spin-orbit coupling in these 5*d* transition metal complex oxides.

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