Field induced magnetic structure transition of $LaSrFeO_4$

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Abstract

We report the spin flop transition on $LaSrFeO_4$. A single crystal of $LaSrFeO_4$ has been prepared by the floating-zone method. The Mössbauer spectrum below 370 K consists of a single Fe^{3+} hyperfine sextet. We observed a magnetization jump around 1.8 Tesla in the magnetization curve below 20K. From the analysis of the transision field on [1,0,0] and [1 1 0] direction, we found the magnetization jump coresponds to the spin flop transition in the antiferromagnetic ground state of [1 1 0] and [-1 1 0] spin direction in the c plane.

Key words: single crystal;magnetic spin flop;$LaSrFeO_4$;

1. Introduction

It is well known that the transition-metal oxides display a wide variety of exotic behaviors. The physical properties of the oxides of the 3d transition metals such Fe, Co and Mn having a single layered perovskite structure (K_2NiF_4 type) have been studied with interest not only because of the similarity of these oxides with the superconducting Cu oxides, but because there is much to be learnt about the underlying Mott-Hubbard physics per se. In the review by Imada et al. [1] a complete map of these compounds with 3d electron numbers from 1 to 9 and for electron and hole dopings (viz. increase and decrease of band filling respectively of the parent correlated insulator) has been presented and the properties of some of these compounds have also been discussed. One of these interesting compounds is the Fe based layered perovskite oxide, $LaSrFeO_4$, whose atomic and magnetic structure were first studied by by Souberoux et al. using X-ray diffraction, Mössbauer spectroscopy and neutron diffraction in the polycrystalline state [2]. This study as well as earlier papers reported its structure to be orthorhombic (a $\sim 3.87 \AA$ and c $\sim 12.7 \AA$) with space group I4/mmm. The magnetic order was determined to be antiferromagnetic with a saturation moment of 4.6 μ_B for the high spin S=5/2 state of the $3d^5$ ionic configuration of Fe^{3+}. Small differences in lattice parameters observed by different groups were attributed to the presence of traces of Fe^{4+} in the compound. In this paper we report detailes of temperature dependence magnetizaion curves on this system. We found that the magnetic ground state has antiferromagnetic order with spins of [1 1 0] and [-1 1 0] direction in the c plane.

2. Experimental

The samples were synthesized using 4N purity $SrCO_2$, La_2O_3, and Fe_2O_3 as starting materials. Calcination was carried out at 700°C for 3 hours followed by sintering at 1100°C after pressing the samples into pellets. The pellets were ground and pressed into 5 mm diameter rods by the application of hydrostatic pressure. Single crystals were grown at the speed of 3 mm/hr in an infra-red furnace using the floating zone method. The growth conditions were given in Ref.

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[4]. The single crystals examined in the present study has a platelet shape with dimensions 2 x 2 x 1 mm^3. The magnetization measurements on single-crystal $LaSrFeO_4$ using SQUID magnetmeter were performed between 5K and 350K up to 5 T. The magnetization measurements at low temperature were performed after heating at 350K.

3. Results and Discussions

A magnetization curve with [1 1 0] field direction at 5 K is shown in Fig.1. The magnetization monotonously increases up to 1.8 T , and shows a discontinuity at a transition magnetic field of H_c =1.8 T. Above this field the magnetizasion linealy increases and the exztrapolation to the low field passes through the origin. A hysteresis of the magnetization is found in a magnetization curve around the magnetic transition field.

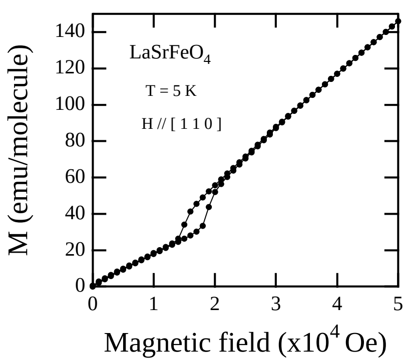

Fig. 1. Magnetic moment plotted against the applied magnetic field.

Fig. 2 shows a differential curve of a magnetization with every measurement temperature. A obvious peak in the differential magnetization curve is found at the transition field of 1.8 T at 5 K. Furthermore, a small peak that may suggest a change of magnetic structure in 3 T was observed. In the temperature dependence of differential magnetization curve, the main peak shows a maximum value of 2.5 T at 30 K. And then the peak magnetic field becomes small with increasing temperature, and around 100 K it disappeares.

In this sample,the spins lie on the [1 1 0] direction. A [1 1 0] domain and a perpendicular [-1 1 0] domain equally exist at a low temperature in low magnetic field. The magnetic spins parallel to the magnetic field turn to vertical to the applied field with increase of magnetic field, and then all the magnetic spins become perpendiculer to the magnetic field at transition field H_c. So it occurs spin flop transition at H_c.The magnetization jump at 1.8 T corresponds to this spin flop transition in the antiferromagnetic state. Therefore, the temperature dependence of the spin flop field reflects the change of magnetic anisotropy. These results support a consequence of neutron diffraction experiment that $LaSrFeO_4$ orders antiferromagnetically with the magnetic reflections indexed by a propagation vector q=(1/2, 1/2, 0) at room temperature.

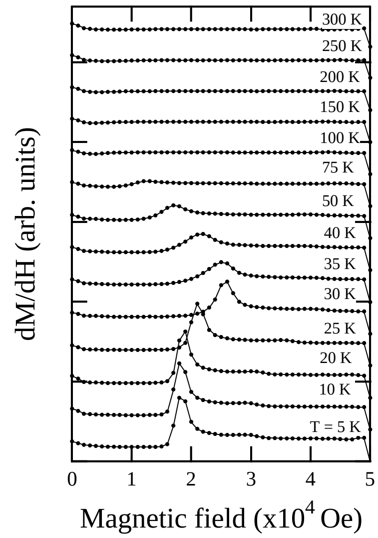

Fig. 2. Differential magnetization curves plotted against the applied magnetic field.

4. Conclusions

Single crystals of $LaSrFeO_4$ were prepared by the floating-zone method. We observed the spin flop transition at 1.8 Tesla, in magnetization process at 5 K. The spin flop transition field has a strong temperature depsendens and disapear around 100 K.

Acknowledgements

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