Zero-field-cooled and Field-cooled Magnetization of Plasma Treated $SrRuO_3$ Thin Films on $SrTiO_3$(001)

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1. Introduction

Bulk $SrRuO_3$ has a $GdFeO_3$-type perovskite structure with Pbnm space group and Curie temperature (T_c) of about 160 K[1]. However, $SrRuO_3$ thin films on $SrTiO_3$(001) have shown the suppressed T_c~150 K and the saturated moment of 1.4~1.6 μB/Ru with low resistivity of 230 μΩ cm at room temperature[2]. Briefly speaking, $SrRuO_3$ system is considered to be an itinerant electron magnet system with enhanced ferromagnetic spin fluctuation which plays a crucial role of using $SrRuO_3$ either as bottom electrode or as metal oxide junction in heterostructure devices.

Nevertheless, up to date, there is no report showing the spin fluctuation behavior due to plasma treatment on the $SrRuO_3$ thin film samples. Therefore, in this report, we focus on the zero-field-cooled (ZFC) and field-cooled (FC) magnetization of both as-deposited and plasma treated $SrRuO_3$ thin film samples. We also propose a modified empirical model to analyze the ZFC magnetization behavior. Furthermore, using this model we might explain various ZFC magnetization behaviors.

2. Experimental

25-nm of epitaxial $SrRuO_3$ thin film was grown by pulsed laser deposition with a KrF excimer laser(248 nm, 34 ns) on a 3x3 mm^2 as-received $SrTiO_3$(001) substrate. Films were deposited at a substrate temperature of 750℃, and under a pressure of 120 mTorr of pure oxygen. The growth rate is about 0.01 unit cell/pulse with a repetition rate 4 Hz. After films deposition, the films were placed into the rf plasma chamber with plasma power of 40 W. The temperature was maintained at 680℃ under 80 mTorr of plasma gas pressure (O_2 and H_2) with 10 SCCM of flowing gas. The magnetic properties were measured in zero field cooled (ZFC) and field cooled (FC) modes using superconducting quantum interference device (SQUID) magnetometry (MPMS system of Quantum Design).

3. Results and Discussion

In the case of magnetization behavior in FC process as shown in Fig. 1, the spin moments are ordered parallel to the direction of applied field and the samples showed non-zero magnetization below Tc. However, the O_2 plasma treated $SrRuO_3$ shows ~0.6 μB/Ru magnetization, which is smaller value than that of as-grown sample. The atomic disorder due to induced O_2 plasma ions might be considered as the cause of the reduced magnetization. As a comparison, the H_2 plasma treated $SrRuO_3$ shows the nearly paramagnetic behavior even in

the FC process. The reason is related to the deep penetration depth of H_2 plasma ions compare to that of O_2 ions, which in turn may cause higher degree of atomic disorder of pseudocubic $SrRuO_3$ crystal on $SrTiO_3$ substrate.

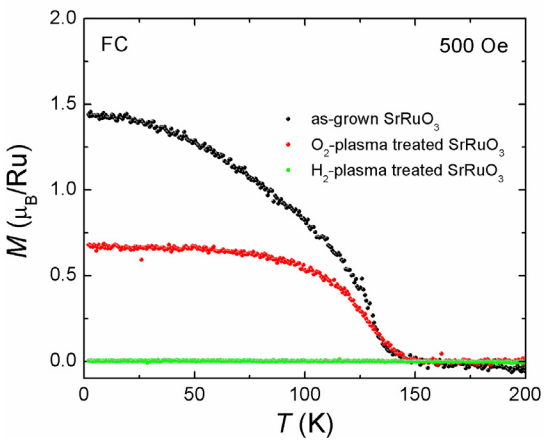

Fig. 1. FC magnetization for 3 different $SrRuO_3$ thin films on $SrTiO_3$(001) as a function of temperature measured at 500 Oe.

In ZFC process, for both as-deposited and O_2-plasma treated $SrRuO_3$ films, we observed of around ~0.25 μ B/Ru magnetization peak at about 120 K, but there was no observed magnetization peak for H_2-plasma treated $SrRuO_3$.

4. References

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