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Magnetic Properties of $SrRuO_3$ thin films grown on $SrTiO_3$(001), (110), and (111) substrates

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1. Introduction

$SrRuO_3$ (SRO) is an itinerant ferromagnet with Tc = 163 K and saturated magnetization of about 1.6 μB/Ru.[1,2] Due to its low resistivity and chemical stability, the compound has been frequently used as an metallic electrode in capacitors and ferroelectric devices with all perovskite hetero-epitaxial structure.[3] As for magnetic devices, tunneling junctions have been realized.[4,5] Structural modification due to epitaxial strain in thin films modulates its magnetic properties significantly as have been studied previously.[6] In this work, in-plane compressive strain in SRO coherently grown on $SrTiO_3$ (STO) (001) substrate has the magnetic easy axis normal to the surface and suppressed Tc of about 150 K.[6] Here we have grown $SrRuO_3$ thin films on STO(001), STO(110), and STO(111) substrates and compared their magnetic properties

2. Experimental

SRO thin films were grown by using a pulsed laser deposition method with KrF excimer laser pulses focused on stoichiometric ceramic targets. The substrate temperature and the oxygen partial pressure during the deposition were 760 °C and 60 mTorr. Crystal structure of the grown films were identified by using a x-ray Θ-2Θ measurement and magnetic properties were obtained by using a superconducting quantum interference device (SQUID).

3. Result

Figure 1. shows x-ray Θ-2Θ scan for the SRO films. The data shows that phase pure high quality SRO films were grown without impurity. [note the y-axis is in log-scale.]

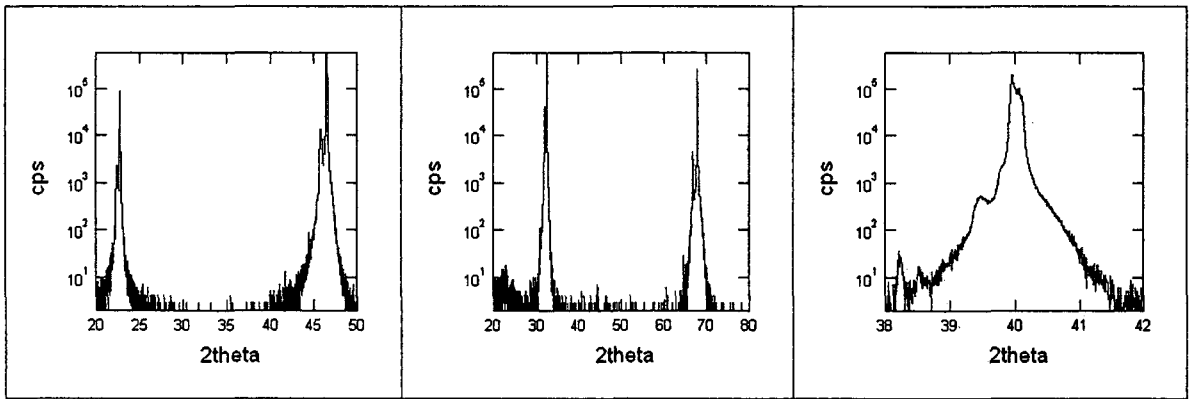

Figure 1. X-ray Θ-2Θ scan for SRO on STO (001), (110), and (111) substrates.

Figure 2. shows the magnetic properties for the above films. Magnetization measurement for was done at 500 Oe after 7 T field cooling to 5 K. This shows that the film showed ferromagnetic transition at temperature of about 150 K which is about 10 K smaller than that for bulk value.[1] One common thing is that magnetic easy axis is along the surface normal direction for all SRO films. The decrease of ferromagnetic transition tempeature and the direction of magnetic easy axis might be due to the epitaxial strain from the substrates. Note that in-plane lattice mismatch for all three cases is less than about 0.5 % which is small enough for the coherent growth behavior.[7]

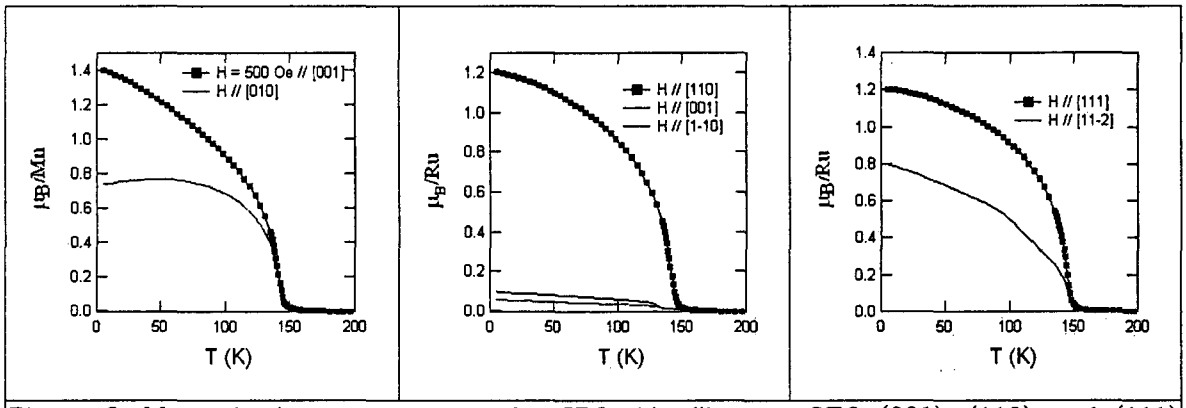

Figure 2. Magnetization measurement for SRO thin films on STO (001), (110), and (111) substrates.

4. Conclusion

We investigated the magnetic properties of $SrRuO_3$ thin films grown on STO(001), STO(110), and STO(111) substrates. Thin films were grown by using a pulsed laser deposition method at T ~ 750 °C and p(O2)~ 60 mTorr. Magnetic easy axis was found to surface normal direction for all three kinds of films, which could be explained by the compressive epitaxial strain.

5. References.

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[7] Lattice constants of SRO are a = 5.567 (3.936×√2) Å, b = 5.5304 (3.9106 ×√2) Å, and c = 7.8446 (3.9223×2) Å and those for STO are a = b= 5.523 (3.905×√2) Å c= 7.81 (3.905×2) Å