Oriented Growth of Ferromagnetic Semiconductor Cobalt-doped Titanium Dioxide Thin Film on Glass with Titanium Dioxide Buffer Layer

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Anatase $Ti_{1-x}Co_xO_2$ is a room-temperature ferromagnetic semiconductor.[1] So far, most of the previous studies have reported $Ti_{1-x}Co_xO_2$ epitaxial thin films on single crystal substrates, hampering its practical uses. In this study, we demonstrate synthesis of oriented anatase $Ti_{0.95}Co_{0.05}O_2$ thin films on TiO_2-buffered glass substrates.

Pulsed laser deposition was used to deposit $Ti_{0.95}Co_{0.05}O_2$ and TiO_2 thin films. 12-nm thick TiO_2 buffer layer was firstly deposited on alkaline-free glass at room temperature and an oxygen partial pressure (P_{O2}) of 3.00×10^{-3} Torr, followed by *in-situ* annealing at 600 °C to crystallize the buffer layer. The $Ti_{0.95}Co_{0.05}O_2$ main layer was then deposited on the TiO_2 buffer layer at 600 °C and $P_{O2} = 1.00 \times 10^{-6}$ Torr.

Figure 1 shows X-ray diffraction θ–2θ patterns for $Ti_{0.95}Co_{0.05}O_2$ thin films deposited on glass with and without the TiO_2 buffer layer. While the latter did not show any diffraction peak, the former showed clear 101 peak of anatase-type TiO_2 phase, indicating (101) oriented crystallization promoted by the TiO_2 buffer layer. Large grains with lateral size of about 30 μm were observed in the film by polarized optical microscope. The TiO_2 buffered $Ti_{0.95}Co_{0.05}O_2$ thin film showed a metallic electrical conduction above 100 K, indicating electron doping by oxygen vacancy (Figure 2). The resistivity, mobility, and carrier density at 300 K were 6.76×10^{-2} Ωcm, 5.13 $cm^2V^{-1}s^{-1}$, and 1.80×10^{19} cm^{-3}, respectively, being comparable to those of a $Ti_{0.95}Co_{0.05}O_2$ epitaxial thin film on single crystal substrate.[2] Anomalous Hall effect measurement at 300 K showed a magnetic hysteresis, confirming room temperature ferromagnetism of the $Ti_{0.95}Co_{0.05}O_2$ thin film.

[1] Y. Yamada *et al.*, *Science* **332**, 1065 (2011). [2] Y. Yamada *et al.*, *Appl. Phys. Lett.* **99**, 242502 (2011).

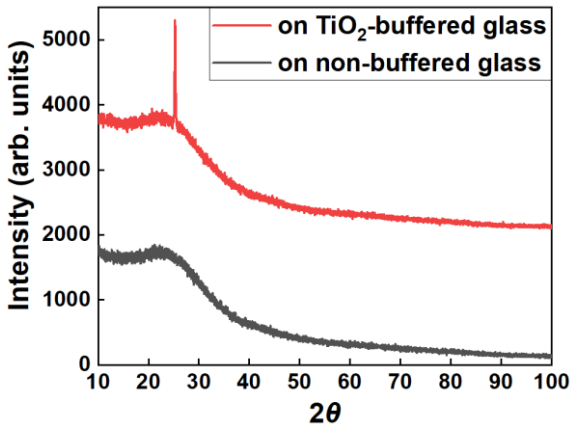

Figure 1. X-ray diffraction θ–2θ patterns for $Ti_{0.95}Co_{0.05}O_2$ thin films on glass with and without the TiO_2 buffer layer.

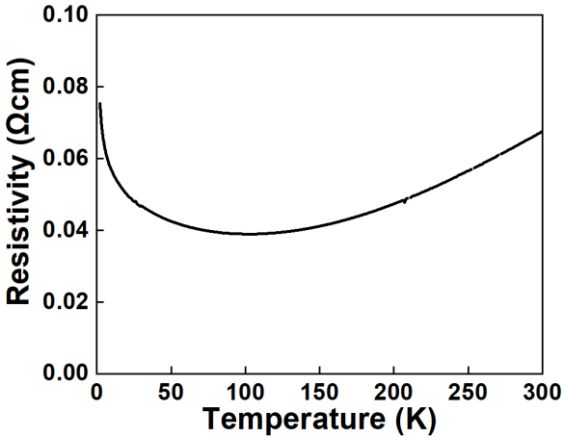

Figure 2. Temperature dependence of resistivity for $Ti_{0.95}Co_{0.05}O_2$ thin films on TiO_2 buffered glass at 300 K.