Growth of ferromagnetic semiconducting cobalt-doped anatase titanium thin films

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Heteroepitaxial and polycrystalline anatase $Ti_{1-x}Co_xO_2$ ($0.0 \leqslant x \leqslant 1.0$) thin films were prepared by soft chemical processing on $LaAlO_3$ (001) and thermally oxidized silicon substrates and the crystallinity and magnetic properties were investigated. X-ray diffraction (XRD) spectrum of the $Ti_{1-x}Co_xO_2$ films on $LaAlO_3$ (001) substrate shows (004) and (008) peaks of heteroepitaxy anatase without any impurity phase. The full-width at half maximum of the (004) peak rocking curve is 0.4°. The XRD patterns of thin films deposited on the $SiO_2/Si(001)$ substrate are anatase type polyscrystalline structure. Microstructural characterization on $Ti_{1-x}Co_xO_2$ thin film employing atomic force microscope showed island type grains in 20 nm in size and the surface roughness of typical thin films was 1.5 nm. Sharp hysteresis loops, indicating a well-ordered ferromagnetic structure, appeared in the magnetization versus magnetic field curves when the magnetic field was applied in the plane of the film. This result clearly indicates that the anatase $Ti_{1-x}Co_xO_2$ thin films fabricated on $LaAlO_3$ (001) by soft chemical process have crystal quality equivalent to high-vacuum technique. [DOI: 10.1063/1.1451880]