Ferromagnetism and Anomalous Hall Effect of TiO_2-based superlattice films for Dilute Magnetic Semiconductor Applications

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Abstract: For use in spintronic materials, dilute magnetic semiconductors (DMS) are under consideration as spin injectors for spintronic devices[1]. TiO_2-based DMS doped by a cobalt, iron, and manganese et al. was recently reported to show ferromagnetic properties, even at temperatures above 300K and the magnetic ordering was explained in terms of carrier-induced ferromagnetism, as observed for a III-V based DMS. An anomalous Hall effect (AHE) and co-occurance of superparamagnetism in reduced Co-doped rutile $TiO_{2-\delta}$ films have also been reported[2]. Metal segregation in the reduced metal-doped rutile TiO_2-δfilms still remains as problems to solve the intrinsic DMS properties.

Superlattice films have been proposed to get dilute magnetic semiconductor (DMS) with intrinsicroom-temperature ferromagnetism. For a TiO_2-based DMS superlattice structure, each layer was alternately doped by two different transition metals (Fe and Mn) and deposited to a thickness of approximately 2.7 Å on r-Al_2O_3(1102) substrates by pulsed laser deposition. The r-Al_2O_3(1102) substrates with atomic steps and terrace surface were obtained by thermal annealing. Samples of $Ti_{0.94}Fe_{0.06}O_2$(TiFeO), $Ti_{0.94}Mn_{0.06}O_2$(TiMnO), and $Ti_{0.94}(Fe_{0.03}Mn_{0.03})O_2$ show a low remanent magnetization and coercive field, as well as superparamagnetic features at room temperature. On the other hand, superlattice films (TiFeO/TiMnO) show a high remanent magnetization and coercive field. An anomalous Hall effect in superlattice films exhibits hysisteresis loops with coercivities corresponding to those in the ferromagnetic Hysteresis loops. The superlattice films composed of alternating layers of $Ti_{0.94}Fe_{0.06}O_2$ and $Ti_{0.94}Mn_{0.06}O_2$ exhibit intrinsic ferromagnetic properties for dilute magnetic semiconductor applications.