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ScienceDirect

Superlattices and Microstructures 41 (2007) 132–137

Superlattices and Microstructures

www.elsevier.com/locate/superlattices

Dose dependence of magnetism in Co-doped TiO_2

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Received 28 June 2006; received in revised form 31 October 2006; accepted 3 November 2006
Available online 8 December 2006

Abstract

The dose dependence of magnetism in Co-implanted TiO_2 rutile was investigated using the magneto-optic Kerr effect method at room temperature. The (100)- and (001)-oriented single-crystalline rutile TiO_2 plates were used as substrates and implanted by Co ions with a varying dose range of 0.25–1.50 $\times$ 10^{17} ions/cm^2. We observed paramagnetic behaviour for the low dose doped samples, but obtain clear hysteretic-like behaviour for intermediate and high dose doped samples. For the intermediate implantation doses of Co, ferromagnetic behaviour can be explained by the F-center (oxygen vacancies) exchange mechanism, while for the highest implantation dose, in addition to Co substitution on Ti sites, formation of Co nanoclusters may take place within the TiO_2 irradiated region.

Keywords: Magnetic semiconductors; TiO_2 rutile; Magneto-optical Kerr effect; Ion implantation

The discovery of room temperature ferromagnetism in Co-doped anatase TiO_2 [1] has generated much interest in the Co:TiO_2 system as a potential oxide-based diluted magnetic semiconductor (DMS) [2–7]. In spite of rather extensive studies in this field, the origin of the observed ferromagnetism is still unclear. Several investigations explained that cobalt ions in thin TiO_2 films exist in a +2 oxidation state, consistent with ferromagnetism that originates from Co substitution on Ti sites [2], while in other publications the origin of ferromagnetism is reported to be due to the precipitation of cobalt metal clusters [8,9]. Recently, we have reported room temperature ferromagnetism and in-plane magnetic anisotropy of single-crystalline rutile

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doi:10.1016/j.spmi.2006.11.001