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Effects of rapid thermal annealing on the local environment, electronic structure and magnetic properties of Mn doped TiO₂ thin films

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Abstract

In this report, nanostructure thin films of Ti_{0.97}Mn_{0.03}O_{2-δ} were deposited on Si (001) substrate by pulsed laser deposition (PLD) technique, followed by rapid thermal annealing (RTA) in different ambient gases; O₂, N₂ and Ar. The RTA treatment dramatically affected the surface defects, local environment, electronic structure and magnetic properties of the films, where, annealing of the film in O₂ gas recovered the dislocated atoms of oxygen vacancy (Vo) at the surfaces and induced a diamagnetic phase, whereas the annealing of film in N₂ gas introduced Vo, reduced the valence state of Ti⁴⁺ (TiO₂) into Ti³⁺ (Ti₂O₃) and induced ferromagnetic (FM) signal. Therefore, the change in the local atomic defects of Vo at the surface texture is likely to be responsible for the magnetic response. The presence of oxygen vacancy has been traced by means of Raman scattering and near edge X-ray absorption fine structure (NEXAFS) spectroscopy measurements. The NEXAFS spectra were carried out in synchrotron facility at Ti/Mn L_{3,2} and O-K edges. The spectral feature at Ti L_{3,2} edges revealed the rutile phase of TiO₂. The asymmetry of *t*_{2g} and *e*_g bands at the O-K edge confirmed the formation of Vo and reflected the modification in the O coordination around Ti⁴⁺ cations. The Mn L_{3,2} edges revealed the incorporation of Mn ions in the TiO₂ network with Mn²⁺ and Mn³⁺ mixed valence states. This different valence states (Mn²⁺ and Mn³⁺) is the basis for the ferromagnetism induced by Stoner spin-splitting of the local density of defects state at Fermi level (E_F). The change in

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