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ABSTRACTS

GQ-05. Fe valence states and ferromagnetism occurring in reduced anatase $Ti_{0.97}Fe_{0.03}O_{2-\delta}$.

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Since the theoretical predictions of room temperature ferromagnetism (RT-FM) in the wide band-gap semiconductor with *p*-type doping, the various oxide semiconductor materials have been extensively investigated as the host matrices for spintronic devices. With many hopeful reports on the observation of RT-FM in these oxide systems, recently some experimental result have suggested that there is a strong correlation between the enhancement of FM and the oxygen deficiency [1-3]. In this work, to resolve the occurrence of FM after vacuum annealing, we have investigated the magnetic behavior of Fe ions in TiO_2 on atomic scale. Anatase $Ti_{0.97}Fe_{0.03}O_2$ polycrystalline thin films were grown on thermally oxidized Si substrate by a sol-gel method. Precursor films were annealed in air first and further annealed in vacuum ambience. Air-annealed insulating film showed paramagnetic (PM) behavior at RT. However, when the film was further annealed in a vacuum, the RT-FM was observed with the magnetic moment of 0.42 μ_B/Fe. The Hall effect data suggest that the carriers of vacuum-annealed film are *p*-type, which turns out to be independent of the observed FM. Conversion electron Mössbauer spectra of air-annealed film at RT show a single doublet, suggesting that the Fe ions are PM. Isomer shift value (δ) of the PM doublet is found to be 0.2 mm/s relative to the metallic Fe, which is consistent with the Fe^{3+} charge state. On the other hand, the absorption spectra after vacuum-annealing exhibit two doublets at RT, in which one is the same component with air-annealed film and the other is new doublet (δ= 0.81 mm/s) corresponding to Fe^{2+} state. We note that, after vacuum-annealing, the RT-FM occurred simultaneously with the new Fe^{2+} doublet. This result seems to indicate that Fe^{2+} ions created as a result of vacuum annealing are responsible for the observed FM in this system.