

## Fe valence states and ferromagnetism occurring in reduced anatase $\text{Ti}_{0.97}\text{Fe}_{0.03}\text{O}_{2-\delta}$

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Fe-doped anatase  $\text{TiO}_2$  polycrystalline films and powders have been prepared by the sol-gel method. Air-annealed film shows paramagnetic behavior at room temperature. However, when the film is further annealed in a vacuum, the ferromagnetic properties are strongly enhanced with the magnetic moment of  $0.42 \mu_B/\text{Fe}$  at 5 kOe. Mössbauer spectrum of air-annealed film at 295 K shows a single doublet of  $\text{Fe}^{3+}$ . On the other hand, the absorption spectrum after vacuum annealing exhibits two doublets, in which one is the same component with air-annealed case and the other is a new doublet corresponding to  $\text{Fe}^{2+}$  state. The temperature dependence of absorption linewidth and quadrupole splitting for the  $\text{Fe}^{2+}$  doublet indicates that  $\text{Fe}^{2+}$  ions are not paramagnetic and their magnetic interaction exists also at 295 K. © 2007 American Institute of Physics. [DOI: [10.1063/1.2710459](https://doi.org/10.1063/1.2710459)]