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FERROMAGNETIC PROPERTIES OF ANATASE $Ti_{1-x}Fe_xO_{2-\delta}$ THIN FILMS GROWN BY SOL-GEL METHOD

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Magnetic and electronic properties of Fe-doped anatase $TiO_{2-\delta}$ thin films grown on $Al_2O_3(0001)$ substrates by a sol-gel method have been investigated by vibrating-sample magnetometry (VSM), conversion electron Mössbauer spectroscopy (CEMS), and Hall effect measurements. Anatase $Ti_{1-x}Fe_xO_{2-\delta}$ thin films were found to exhibit ferromagnetism at room temperature by VSM. The saturation magnetic moment of the ferromagnetic films are ~2 and ~1.5 μ_B per Fe ion for x = 2.4 and 5.8 at.%, respectively. The isomer shifts in CEMS measurements are 0.26-0.28 mm/s, indicating a ferric character. The Mössbauer spectra also revealed that Fe^{3+} ions mostly substitute the octahedral Ti^{4+} sites of $Ti_{1-x}Fe_xO_{2-\delta}$. The $Ti_{1-x}Fe_xO_{2-\delta}$ films exhibited poor electrical conductivity with p-type character. The ferromagnetism in the present $Ti_{1-x}Fe_xO_{2-\delta}$ films can be interpreted in terms of a direct ferromagnetic coupling between two neighboring Fe^{3+} ions via an electron trapped in oxygen vacancy [1]. The reduction of the net magnetization by the increase of the Fe content in the film can be explained in terms of an antiferromagnetic superexchange interaction between two neighboring Fe^{3+} ions via O^{2-} ion.

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[1] J. M. D. Coey, A. P. Douvalis, C. B. Fitzgerald, and M. Venkatesan Appl. Phys. Lett. **84**, 1332 (2004).

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