Programme and Abstracts

International Conference on the Applications of the Mössbauer Effect

LE CORUM
Conference Centre

Esplanade Charles de Gaulle
Montpellier, France
A STUDY OF THE EFFECTS OF Fe IN TiO$_{2.8}$ THIN FILMS

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We have investigated Fe-doped TiO$_{2.8}$ thin films grown by sol-gel method on Al$_2$O$_3$(0001) substrates by X-ray diffraction, Hall effect measurement, vibrating sample magnetometry (VSM), X-ray photoelectron spectroscopy and conversion electron Mössbauer spectroscopy (CEMS). The films have been found to be transparent ferromagnets at room temperature. The present anatase and rutile Fe-doped TiO$_{2.8}$ thin films exhibited p-type electrical conductivity while the undoped film n-type conductivity. As shown in Fig. 1, anomalous magnetic moments were observed for highly resistive Fe-doped anatase TiO$_{2.8}$ samples at room temperature with the saturation magnetic moment of $-2 \mu_B$/Fe and $-1.5 \mu_B$/Fe for 2.4- and 5.8-at.% Fe, respectively. This room-temperature ferromagnetism is explicable with a direct ferromagnetic coupling between two Fe$^{3+}$ ions via trapped electron in oxygen vacancy. XPS and CEMS measurements on the Fe-doped TiO$_{2.8}$ films reveal that Fe ions have Fe$^{3+}$ ionic valence mostly, substituting the octahedral sites of TiO$_{2.8}$. CEMS spectra on the TiO$_{2.8}$:Fe films also reveal the change of the magnetic properties with Fe composition and thickness of the films as shown in Fig. 2.

* This work was supported by grant No. R01-2003-000-10293-0 from the Basic Research Program of the Korea Science & Engineering Foundation


Figure 1. Hysteresis curves of anatase Fe$_x$Ti$_{1-x}$O$_{2.8}$ ($x=2.4$ and $5.8$ at.%) films.

Figure 2. CEMS spectra of Fe$_x$Ti$_{1-x}$O$_{2.8}$ film ($x=5.8$ at.%).