Hyperfine Interactions in rutile and anatase structures of TiO_2 thin films

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Thin films of TiO_2 were investigated by perturbed γ-γ angular correlation (PAC) spectroscopy using ^{181}Ta as probe nuclei in order to study the behavior of the hyperfine parameters as a function of temperature for both the anatase and rutile phases. Because this oxide is a candidate for diluted magnetic semiconductor (DMS), the possible occurrence of room temperature ferromagnetism was also investigated. In order to investigate if the presence of oxygen vacancies could induces ferromagnetism, we carried out measurements as implanted and after annealing in vacuum. The structure, composition and surface morphology of the samples were investigated by x-ray diffraction, x-ray fluorescence, scanning electron microscopy, respectively. The magnetic properties of the samples were characterized by magnetization measurements..

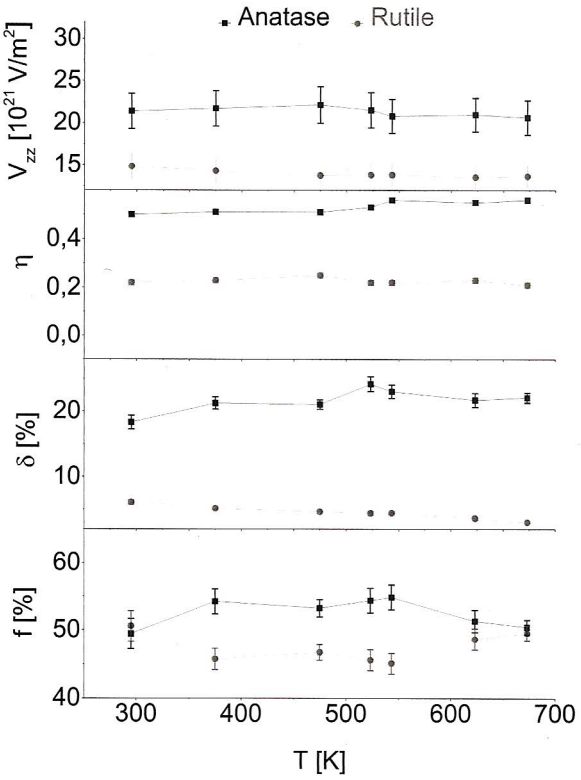

Fig. 1. Hyperfine parameters of TiO_2 measured using $^{181}Hf(^{181}Ta)$ as probe nuclei.

Magnetization results show no ferromagnetic behavior. The x-ray fluorescence results show no impurities, and the scanning electron microscopy results show that the particles are smaller than 10 nm. PAC results indicate the presence of two electric quadrupole interactions which were assigned to rutile and anatase phases [1]. One of them, with well-defined electric quadrupole frequency ($\delta < 5\%$) and asymmetry parameter $\eta \sim 0.2$, corresponding to an electric field gradient around 1.4×10^{22} V/m^2 was assigned to the rutile phase. The other interaction, with wide distributed electric quadrupole frequency ($\delta \sim 20\%$), with axial asymmetry ($\eta \sim 0.5$) corresponding to an electric field gradient around 2.1×10^{22} V/m^2 was assigned to the anatase structure. We conclude that, the absence of the ferromagnetism is because the absence of a magnetic transition metal dopant, which is responsible for the magnetic interaction, in accordance with the work of Dietl *et al* [2].

[1] D. D. Banerjee. et al., *Journal of Physics and Chemistry of Solids* **983-987**, 71 (2010).
[2] T. Dietl. et al., *Science* **1019-1022**, 287 (2000).

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