

Ferromagnetic Properties of Ni-Doped Rutile $\text{TiO}_{2-\delta}$

Young Ran PARK, Seung-li CHOI, Jung Han LEE and Kwang Joo KIM*

Department of Physics, Konkuk University, Seoul 143-701

Chul Sung KIM

Department of Physics, Kookmin University, Seoul 136-702

(Received 10 August 2006)

Ni-doped rutile $\text{TiO}_{2-\delta}$ thin films grown by using the sol-gel method exhibited ferromagnetic and semiconducting properties at room temperature. The ferromagnetic strength of the $\text{TiO}_{2-\delta}:\text{Ni}$ films was found to vary with Ni doping (x). The Ni-doped films had p -type electrical conductivity for small x (≤ 5 at.%) with the hole density increasing with x while the undoped ones had n -type conductivity. Formation of Ni clusters was detected for large x (≥ 6 at.%) by using X-ray diffraction, X-ray photoelectron spectroscopy (XPS), and Hall effect measurements. The Ni ions in $\text{TiO}_{2-\delta}:\text{Ni}$ were found to have valences of +2 and +3 by using XPS, with the latter having a larger density. The room-temperature ferromagnetism for $x \leq 5$ at.% is not attributable to mobile holes but to magnetic polarons formed around electrons trapped in oxygen vacancies.

PACS numbers: 75.70.Ak, 75.50.Pp, 75.30.Hx

Keywords: Rutile, Doping, Ferromagnetism, Semiconductor