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ROOM-TEMPERATURE FERROMAGNETIC PROPERTIES IN Mn-DOPED RUTILE $\text{TiO}_{2-\delta}$ THIN FILMS

Kwang Joo Kim , Hee Kyung Kim, Young Ran Park¹ , Geun Young Ahn, Chul Sung Kim² and Jae Yun Park³

¹ Depart. of Physics, Konkuk Univ., Seoul 143-701, Korea ; ² Department of Physics, Kookmin University, Seoul 136-702, Korea ; ³ Depart. of Materials Science and Engineering, Univ. of Incheon, Incheon 402-749, Korea

A room-temperature ferromagnetic behavior was observed for Mn-doped reduced titanium dioxide ($\text{TiO}_{2-\delta}\text{:Mn}$) thin films with rutile structure synthesized by a sol-gel method. The $\text{TiO}_{2-\delta}\text{:Mn}$ films were found to be semiconducting with p-type electrical conductivity. The observed ferromagnetism is believed to be intrinsic but not related to free carriers such as holes. Oxygen vacancies are likely to contribute to the room-temperature ferromagnetism. The trapped carriers in oxygen vacancies can mediate a ferromagnetic coupling between neighboring Mn^{3+} ions. Spectroscopic ellipsometry measurements on the films revealed that the band-gap energy showed a red-shift by Mn doping. The red-shift can be understood in terms of spin-exchange interactions between the Mn^{3+} ion and the carrier.