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Topic of Research: The Control of Metal-Insulator Transition in Vanadium based Oxide.

Finding

The study of spintronic materials such as transition metal doped metal oxide and multi-ferrite is one of the most prominent and attractive areas in science and technology. In order to clarify the origin of magnetization in these spintronic devices, it is important to study the electronic and magnetic structure. In this dissertation we have investigated the electronic and magnetic properties of spintronic materials using synctrotron based advanced X-ray spectroscopic techniques such as X-ray absorption spectroscopy and X-ray magnetic circular dichroism techniques.

The tunability of magnetic properties of VO_2 has fascinated substantial attention in the first generation of spintronics-related applications such as read head sensors for hard disk drives and magnetic random-access memory. In this work, we focus on Cr doped VO_2, $V_{1-x}Cr_xO_2$ ($0 \leq x \leq 0.3$) (VCO) thin films and study the effect of Cr-substitution on the structural, electronic and magnetic properties. The VCO films were deposited on R-sapphire substrates using a pulse laser deposition method. Soft X-ray absorption spectroscopy (XAS) and soft X-ray magnetic circular dichroism (XMCD) studies of VCO thin films were performed to reveal and understand the origin of magnetization and their enhancement with Cr-substitution. The XAS spectra suggest that the valences of V ions are in tetra and pentavalent states and Cr ions in the trivalent state. The XMCD spectra imply that the V and Cr ions are ferromagnetic at room temperature. These results also indicate that the VCO films are in the ferromagnetic insulating state and charge-ordered at the V and Cr sites. These results are consistent with the first principle density functional theory calculations.

Further, the electronic structures of these compounds were investigated by X-ray photoemission spectroscopy (XPS), and also the electrical transport measurements by four-probe electrical resistivity along with the Hall effect measurements. The XPS study shows that the valency of the Cr ions in the VCO films is 3+ and the V ions are in the mixed states of 4+ and 5+. From the Resistivity-Temperature (R-T) measurements, the metal-to-insulator transition, T_C, of VO_2 increases significantly upon Cr doping, while the hysteresis width and resistivity follow a gradual decrease. These findings will pave the way for the usage of VO_2 films in solar and electrical device applications where larger critical temperatures than pristine VO_2 are required to produce a feasible and promising solution.

Finally, we studied the electronic and transport properties of ion irradiated VO_2 thin films. Thin films of VO_2 at 300 K were irradiated by Fe and Ni ions with energy ~150 KeV at beam fluences of 1E14, 1E15, 5E15, and 1E16 ions/cm^2 . The effect of ion irradiation were characterized by using grazing incidence X-ray diffraction (GIXRD), Raman measurement, X-ray photoemission spectroscopy (XPS), X-ray absorption spectroscopy (XAS), Photo-Electron Spectroscopy (PES), Temperature dependent resistivity measurements (R-T) and Hall effect measurement. GIXRD and Raman measurement suggested monoclinic phase of VO_2. The XPS and XAS study revealed that Vanadium is in mixed state of 3+, 4+ and 5+. The PES measurement indicating the metallization of VO_2 thin films occurs by ion irradiation. R-T measurement authenticate that transition temperature decreases with increase ion fluence. Carrier concentration and hence conductivity of VO_2 thin films increases with increase in ion fluence. Modification in the transition temperature and Transport properties due to ion irradiation has been discussed in details.