# Research Highlights from Dr. Shirage and Group

Advanced Functional Materials Group in Metallurgy Engineering and Materials Science, lead by Dr. Parasharam Shirage, working on various aspects of materials for technological applications like solar cells, supercapacitors, gas sensors, etc. We have contributed in basic science and engineering of the materials. One of these contribution is origin of room temperature ferromagnetisms in ZnO. The origin of room temperature (RT) ferromagnetism (FM) in $Zn_{1-x}Ni_xO$ ($0<x<0.125$) samples are systematically investigated through physical, optical, and magnetic properties of nanostructure, prepared by simple low-temperature wet chemical method. Reitveld refinement of X-ray diffraction pattern displays an increase in lattice parameters with strain relaxation and contraction in Zn/O occupancy ratio by means of Ni-doping. Similarly scanning electron microscope demonstrates modification in the morphology from nanorods to nanoflakes with Ni doping, suggests incorporation of Ni ions in ZnO. More interestingly, XANES (X-ray absorption near edge spectroscopy) measurements confirm that Ni is being incorporated in ZnO as $Ni^{2+}$. EXAFS (Extended X-ray Absorption Fine Structure) analysis reveals that structural disorders near the Zn sites in the ZnO samples upsurges with increasing Ni concentration. Raman spectroscopy exhibits additional defect driven vibrational mode (at 275 $cm^{-1}$), appeared only in Ni-doped samples and the shift with broadening in 580 $cm^{-1}$ peak, which manifests the presence of the oxygen vacancy ($V_O$) related defects. Moreover, in photoluminescence (PL) spectra we have observed peak at 524 nm, indicating the presence of singly ionized $V_O^+$, which may be activating bound magnetic polarons (BMPs) in dilute magnetic semiconductors (DMSs). Magnetization measurements indicate weak ferromagnetism at RT, which rises with increasing Ni concentration. It is therefore proposed that effect of the Ni-ions as well as the inherent exchange interactions arising from $V_O^+$ assist to produce BMPs, which are accountable for the RT-FM in $Zn_{1-x}Ni_xO$ ($0<x<0.125$) system. **(*ACS Appl. Mater. Interfaces*, 2017, *9* (8), pp 7691–7700).**

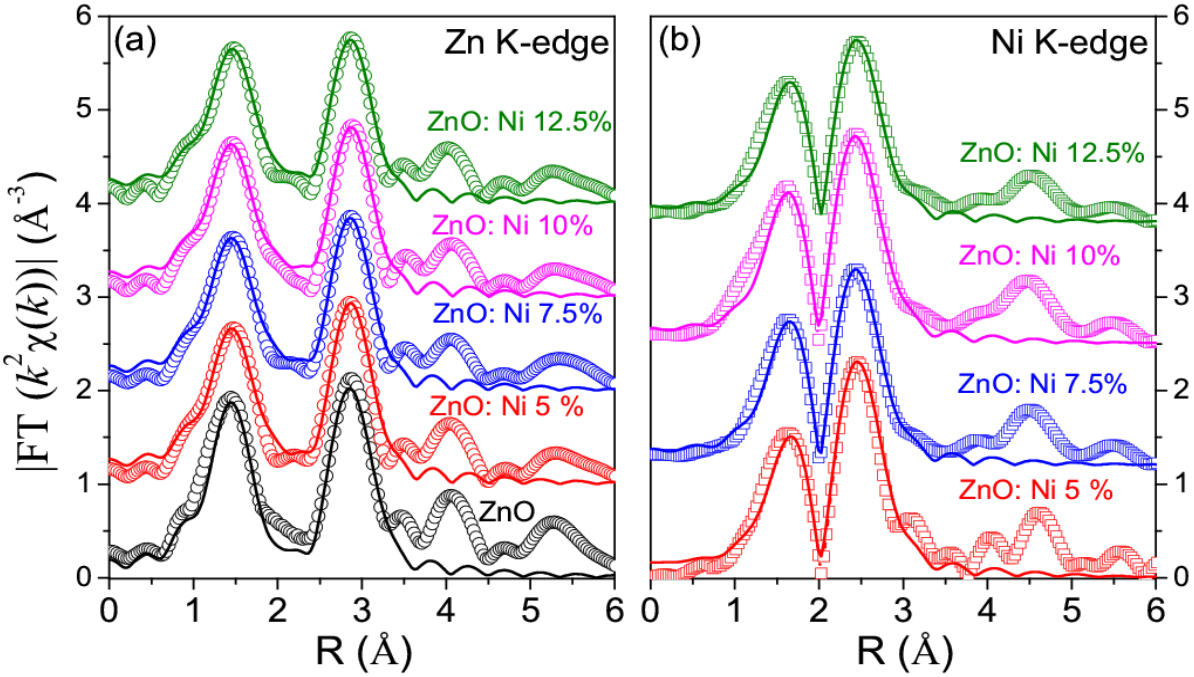


***Figure*** *(Colour online) Fourier transform of $k^2$-weighted of* ***(a)*** *Zn K-edge,* ***(b)*** *Ni K-edge, for Ni doped ZnO nanostructure. The symbol shows empirical data and solid lines are the best fitting data. The curves are vertically shifted for clarity.*