Absence of Magnetic Ordering in High Quality Bulk Co-doped ZnO

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Abstract – Bulk Co-doped ZnO samples were synthesized via standard solid-state reaction route with cobalt molar concentration of 5, 9, 12, 15 and 21%. XRD shows only diffraction peaks from wurtzite ZnO without secondary phases. Raman spectroscopy reveals also the no existence of secondary phases and the absence of vibrational modes associated to structural defects. Both analyses confirm the high crystallinity quality of the samples. SQUID magnetometry demonstrates paramagnetic Curie–Weiss behavior with antiferromagnetic interactions. Based on the structural and magnetic properties, it is argued that the observed paramagnetism is due the absence oxygen vacancies and defects at zinc sites.

The interest in Zinc Oxide (ZnO) doped with transition metal has been attracted much attention in the last years since it was predict a long range magnetic ordering above room temperature in such systems [1]. In spite of the extensive studies on Co-doped ZnO, the origin of its magnetic properties still remains a controversial issue. Some recent theoretical and experimental results have been shown that magnetic ordering depends on defects, such as oxygen vacancies, created during the sample preparation [2, 3].

We report on the studies of the correlation between the magnetic properties and microstructure of five Co-doped ZnO samples with cobalt molar concentration of 5, 9, 12, 15 and 21% prepared using a standard solid-state reaction. The precursor specimens consist of Co_3O_4 and ZnO powders. The two kinds of powders were first mixed and ball-milled. The resulting powder was then made block (60 MPa) and sintered for 4 h in oxygen atmosphere at 1400° C. The crystal structures of the samples were characterized using x-ray diffraction (XRD) and scanning electron microscope (SEM). Magnetic measurements were performed by using a superconducting quantum interference device (SQUID) magnetometer. The composition distributions were also characterized by an energy dispersive x-ray spectrometer (EDX) mapping. Raman scattering was used to study of dopant incorporation and its resulting defects and lattice disorder in host lattice.

The observed peaks in the diffraction pattern correspond to those of polycrystalline wurtzite ZnO with relative narrow line-width revealing a good crystallinity quality for all samples. No cobalt clusters and secondary phases were detected in the SEM and EDX measurements. The Raman spectra ranging from 200 to 800 cm^{-1} were taken at room temperature, all the recorded peaks can be also assigned to wurtzite ZnO structure and no peaks associated to lattice defects or to other Raman-actived secondary phase were detected. SQUID magnetometry demonstrates paramagnetic Curie–Weiss behavior with antiferromagnetic interactions. We conclude that the observed paramagnetic behavior is in some extension due the absence of structural defects in the host matrix. *The authors are grateful to FAPEMIG and CNPq for financial support.*
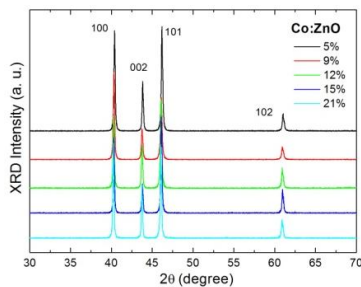

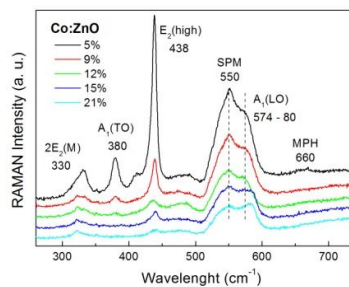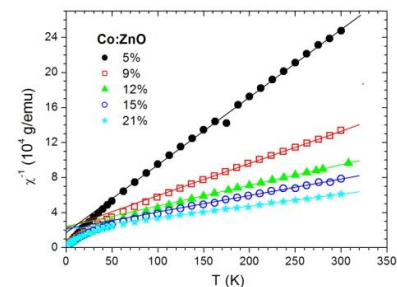**Figure 1:** X-ray diffraction pattern.

Figure 2: Raman spectra.

Figure 3: Inverse of the susceptibility.

References

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