Low Field Microwave Absorption and Magnetic Anisotropy in TM Co-Doped ZnO System

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Abstract : Electron spin resonance (ESR) study at 9.45 GHz and a field modulation frequency of 100Hz was performed on bulk polycrystalline samples of Mn:TM (Fe/Ni) and Mn:RE (Gd/Sm) co doped ZnO samples with composition Zn1-xMn:TM/RE)xO synthesised by solid state reaction route and sintered at 500 0C temperature. The room temperature microwave absorption data collected by sweeping the DC magnetic field from -500 to 9500 G for the Mn:Fe and Mn:Ni co doped ZnO samples exhibit a rarely reported non resonant low field absorption (NRLFA) in addition to a strong absorption at around 3350G, usually associated with ferromagnetic resonance (FMR) satisfying Larmor's relation due to absorption in the full saturation state. Observed low field absorption is distinct to ferromagnetic resonance even at low temperature and shows hysteresis. Interestingly, it shows a phase opposite with respect to the main ESR signal of the samples, which indicates that the low field absorption has a minimum value at zero magnetic field whereas the ESR signal has a maximum value. The major resonance peak as well as the peak corresponding to low field absorption exhibit asymmetric nature indicating magnetic anisotropy in the sample normally associated with intrinsic ferromagnetism. Anisotropy parameter for Mn:Ni codoped ZnO sample is noticed to be quite higher. The g values also support the presence of oxygen vacancies and clusters in the samples. These samples have shown room temperature ferromagnetism in the SQUID measurement. However, in rare earth (RE) co doped samples (Zn1-x (Mn: Gd/Sm)xO), which show paramagnetic behavior at room temperature, the low field microwave signals are not observed. As microwave currents due to itinerary electrons can lead to ohmic losses inside the sample, we speculate that more delocalized 3d electrons contributed from the TM dopants facilitate such microwave currents leading to the loss and hence absorption at the low field which is also supported by the increase in current with increased micro wave power. Besides, since Fe and Ni has intrinsic spin polarization with polarisability of around 45%, doping of Fe and Ni is expected to enhance the spin polarization related effect in ZnO. We emphasize that in this case Fe and Ni doping contribute to polarized current which interacts with the magnetization (spin) vector and get scattered giving rise to the absorption loss.

Keywords : co-doping, electron spin resonance, hysteresis, non-resonant microwave absorption
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