NANOSTRUCTURE AND MAGNETIC PROPERTIES OF Mn DOPED ZnO, A RT MAGNETIC SEMICONDUCTOR?

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Ferromagnetic semiconductors with Tc above room temperature are needed for a realistic implementation of a variety of spintronic devices. Mn doped ZnO has been considered a possible candidate on theoretical predictions [1]. More recently, it has been claimed [2] that, by mixing and compacting appropriate amounts of MnO_2 and ZnO powders and subjecting this mixture to 500 ºC 12h thermal treatment, a RT ferromagnetic phase can be obtained. We have fabricated Mn doped ZnO following the above procedures and we have characterized the resulting material with the aim to correlate the observed exotic magnetic properties with the nanoscale structure. Ceramic samples were prepared following standard processing of oxide particles. Thermal treatment at 500 ºC is not enough to promote sintering, thus the thermal treated compact shown brittle characteristics of poorly densified ceramic samples. However, we observe clear modifications both in the nanostructure (TEM) and the magnetic properties (SQUID measurements) of thermally treated powders. A variety of MnO_2, MnO and ZnO nano-powder precursors of different particle sizes have been explored. Scanning electron microscopy and X-ray analysis reveal the appearance of a new phase, most probably related to the diffusion of Zn into MnO_2 oxide nanocrystals. The magnetic properties deviate considerably from what it would be expected on an unreacted mixture of ZnO (diamagnetic) and MnO_2 particles (paramagnetic above 100K and anti-ferromagnetic below that temperature), exhibiting a ferromagnetic like behavior from 5K to 300K and beyond mixed with a paramagnetic component. EPR resonance experiments from 100K to 600K reveal also a ferromagnetic to paramagnetic like transition at temperatures of the order of 350K for these materials.

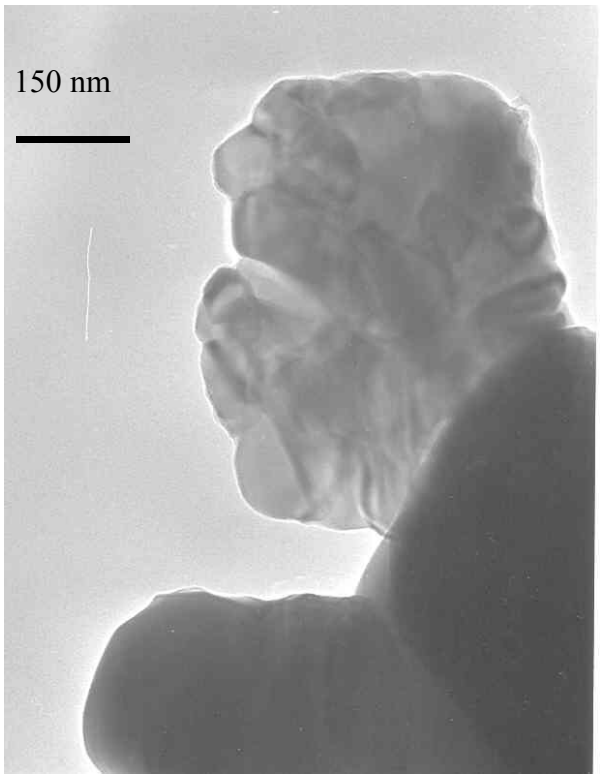

Fig.1 New phase observed after annealing ZnO and MnO_2 powders at 500ºC

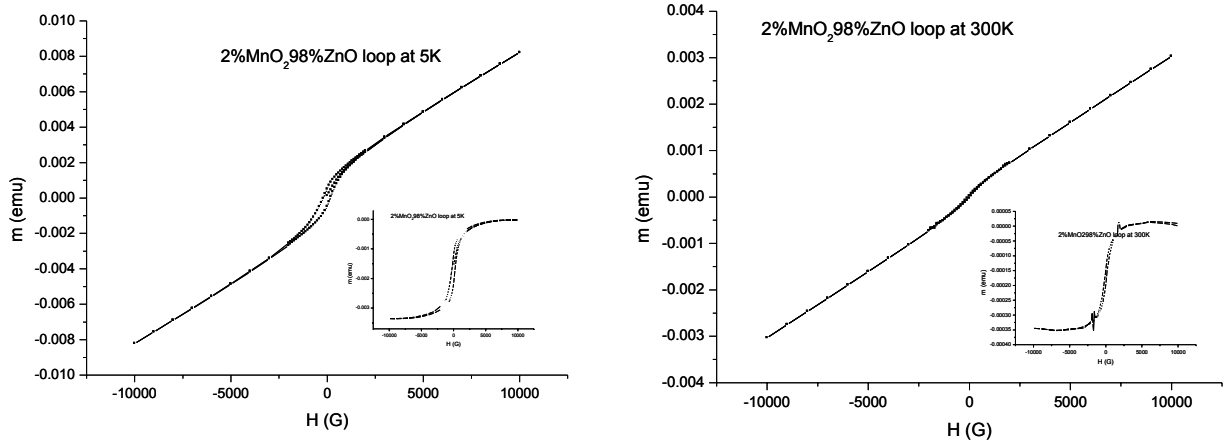

Fig.2 Hysteresis loop at 5 and 300K of 2%MnO_2 98%ZnO ceramics powders heat treated at 500ºC. The insets show the result of substracting the paramagnetic component from the loops

[1] Dietl, T., Ohno, H.,Matsukura, F.,Cibert, J. & Ferrand,D. Zener model description of ferromagnetism in zinc-blende magnetic semiconductors. *Science* **287,** 1019–1022 (2000).
[2] Ferromagnetism above room temperature in bulk and transparent thin films of Mn-doped ZnO P. Sharma, A. Gupta, K.V. Rao, F.J. Owens, R. Sharma, R. Ahuja,O. Guillén, B. Johansson and A. Gehring. Nature Materials 21 Sept. 2003