Growth and characterization of Mn- doped ZnO/TiO_2 multilayered nanostructures grown by pulsed laser deposition

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During last years diluted magnetic semiconductors (DMS) caused considerable attention due to their possible application in spintronics. Spintronics with semiconductors is very attractive as it can combine the potential of semiconductors (control of current by gate, coupling with optics, etc.) with the potential of the magnetic materials (control of current by spin manipulation, nonvolatility, etc.) [1-3]. DMS is obtained by doping a non-magnetic semiconductor with transition-metal elements. In this aspect, ZnO doped with transion-metals as Mn, Co, V, Cr, etc has the especial interest. First of all, these materials are predicted to have the ferromagnetism above room temperature [4] that is a prerequisite for practical use. Moreover, being low-cost, wide-band gap semiconductor, ZnO itself has been focus of renewed research for applications such as UV light-emitters, transparent high-power electronics, surface acoustic wave devices, piezoelectric transducers and window materials for display and solar cells [5-6]. Whereas transion-metal doped ZnO multilayers have been extensively studied last years, the nanocrystals as well as multilayered stuctures based on these DMS have been away of interest, however, they have a strong potential from application point of view. In this work we prepared Mn-doped ZnO/TiO_2 multilayerd structures and studied their structure properties.

The multilayered structures were prepared by pulsed laser deposition (PLD) techniques equipped with multitarget carousel system that allowed growing of alternating layers without breaking the vacuum. The deposition was performed with help of KrF laser (248 nm) in the oxygen atmosphere (10^{-3} mbar) and at substrate temperature of 300 ^{o}C. The used targets were TiO_2 of 99.99% pure (bought at KurtLesker Co.) and 2% Mn doped ZnO prepared follow the solid state reaction route. Post growing annealing was performed to improve the crystallization of ZnMnO nano-layers. The set of nanostructures with alternating MnZnO and TiO_2 layers (up to 20 layers) were prepared with different sets of thicknesses (from 1 to 3 for MnZnO and from 10 to 15 for TiO_2).

The samples were structurally characterized by Wide Angle X-ray Scattering (WAXS), Grazing Incidence Small angle X-ray Scattering (GISAXS) at SAXS beamline (with the energy of the beam of 8 keV) in the Elettra Synchrotron Facilities (Trieste, Italy). The Rutherford backscattering (RBS) measurements were made at 2 MeV with 4He as well as PIXE analyse was performed. The Raman scattering was performed with help of the Jobin–Yvon T64000 spectrometer equipped with a cooled CCD detector, using the 514.5 nm excitation wavelength of an Ar^+ laser in the back scattering geometry.

The WAXS of as-deposited MnZnO/TiO_2 multilayer nanostructure showed pure crystallization of Mn-doped ZnO and amorphous TiO_2. The GISAXS illustrated well-resolved layered structure. The alternation of composition in the layers was confirmed by RBS study. The as grown sample shows low Raman signal. Annealing considerably improves the crystalline structure of MnZnO and leads to crystallization of TiO_2. The multilayer structure was maintained after annealing which was evidenced by GISAXS and RBS techniques. The analysis of annealing conditions on structure properties has been performed and the results will be reported.

References:

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Figures:

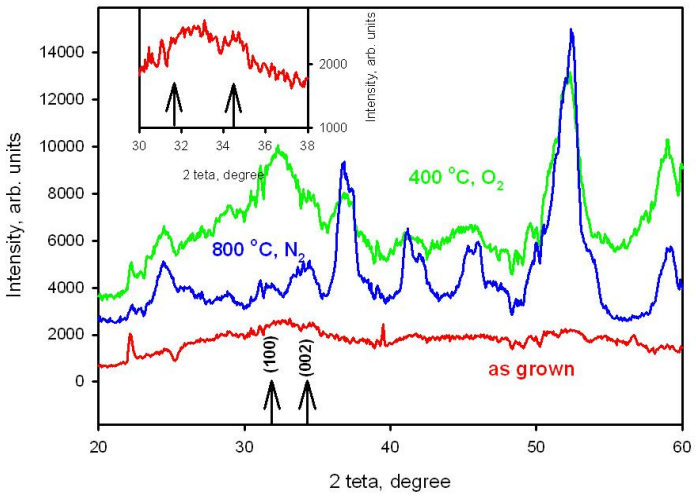

Fig.1. WAXS results of Mn-doped ZnO/TiO2 multilayers annealed at different conditions

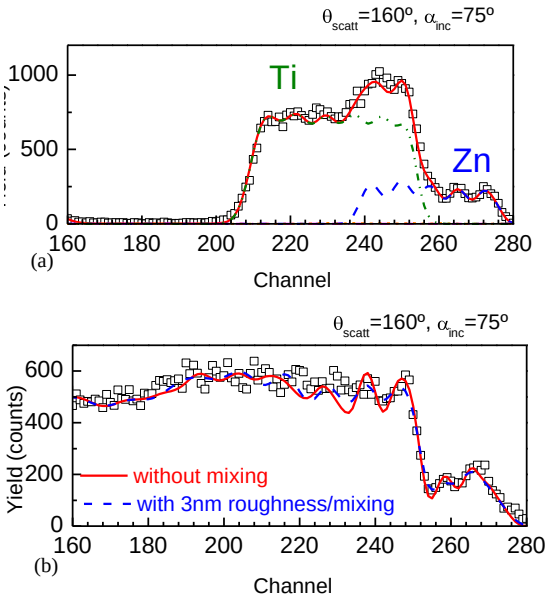

Fig. 2. RBS spectra of Mn-doped ZnO/TiO_2 nanostructures: as grown (a) and annealed at 600 °C (b).

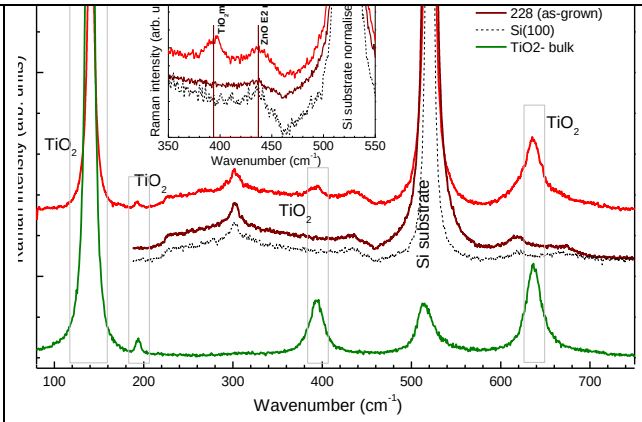

Fig. 3. Raman spectra of Mn-doped ZnO/TiO2 multilayers annealed at different conditions