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Optical and Structural Properties of Arrays of Mn-doped ZnO Nanorods Prepared by a Low Temperature Hydrothermal Method

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Metal doping of ZnO nanocrystals has great potential to increase the performance of advanced semiconductor devices such as gas sensors. The oxygen gas sensitivity of pure ZnO can be improved by Manganese (Mn) addition. In our report arrays of Mn-doped ZnO nanorods were synthesized by a hydrothermal method at a temperature as low as 60°C. The low temperature makes our method applicable on a variety of substrates including polymer materials. In addition, our process does not require pH surveillance as previous works do. Forests of Mn-doped ZnO nanorods were synthesized on silicon substrates and their morphology was visualized by taking their cross section and top SEM images. The results show that substrate surface coverage and the nanorods uniformity were improved by Mn addition. Moreover, the nanorods aspect ratio increased from 6.5 to 10.2 for pure and Mn-doped ZnO nanorods, respectively. The crystallinity of the ZnO nanorods due to Mn doping was thoroughly investigated according to their X-ray Diffraction (XRD) patterns. The crystal structure of the Mn-doped ZnO nanorods remains unchanged as compared to pure ZnO, while their lattice constants have slightly increased. More detailed analysis on the effect of incorporation of Mn into ZnO crystal was done by micro-Raman spectroscopy. Raman spectra also confirmed the single wurtzite crystal structure for both pure and Mn-doped ZnO, while some of the common peaks were slightly shifted towards higher frequency due to lattice distortion. The average atomic percentage of Mn across the ZnO nanorods was measured to be 5% by using X-ray photoelectron spectroscopy (XPS). Finally, the band gap shift and defect related emission were measured by a photoluminescence set up (PL) at room temperature. The near band edge emission of Mn-doped ZnO nanorods red-shifted for 5 nm in comparison to pure ZnO nanorods, implying a band gap shrinkage by Mn addition. Our results show that low-temperature hydrothermal growth of Mn-doped ZnO nanorods is a feasible technique for obtaining high-quality material.

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