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Effect of microwave-hydrothermal rapid treatment in the ZnO nanostructures

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Abstract – Zinc Oxide nanostructures have been prepared by microwave-hydrothermal process under conditions of low temperature, short reaction times and rapid heating rate. Crystalline ZnO samples were characterized by X-ray diffraction and different morphologies were observed by field emission gun scanning electronic microscopy (FEG-SEM) images. Strong photoluminescence emission in the green region was observed for the sample obtained in the different reaction times. PL emission intensity depends on different types of defects generated by possible configuration arrangement interconversion in solution during the ZnO growth.

Different authors have demonstrated that hydrothermal conditions can be used to successfully grown ZnO single crystals [1-2]. Particles with a controllable size and shape, highly crystalline and low agglomeration can be obtained using this synthetic route. A variation of this technique, hydrothermal synthesis using microwave, was used in this study. ZnO nanostructures with different morphologies and photoluminescent properties were obtained at low temperature (130 °C) using rapid heating rate of 130 °C/min heating and short reaction times. In the synthesis process was used the $Zn(CH_3COO)_2.2H_2O$ and NaOH solution precursors, and polyethylene glycol (M_w 400) as surfactant. The resulting solution was transferred into a sealed autoclave and annealed at 130 °C for 2, 4, 8, 16 and 32 min. The microwave-hydrothermal process accelerates the crystallization process, increasing the nucleation rate and, hence, leads to the formation of fine particles with homogeneous distribution. X-ray diffraction, Figure 1, indicated that all the ZnO samples are referent to hexagonal wurtzite structure with P63 mc space group and a = 3.250 Å, c = 5.207 Å, according to JCPDS 36-1451. The intensity of the relative peaks indicated the high purity of the ZnO hexagonal phase of the samples and good crystallinity, demonstrating that ZnO powders obtained by hydrothermal conditions present a long-range order. FEG-SEM images revealed different morphologies in the ZnO nanostructures. In Figure 2 are presented the samples images obtained after 2 and 32 min of microwave-hydrothermal treatment. When the ZnO samples were excited using 488 nm excitation wavelength there was predominance of the green photoluminescent emission band. A shift to blue region was observed with the increase of treatment time, indicating an order structural change. Green emission have been reported in both nanocrystals and bulk crystals, and they are associated with different defects produced during the synthesis process and are found to be influenced by several factors, such as reaction temperature and presence of oxygen. The defects generate localized electronic levels above the valence band are associated with a symmetry breaking process, i.e., to the Zn displacement in the wurtzite ZnO type structure.

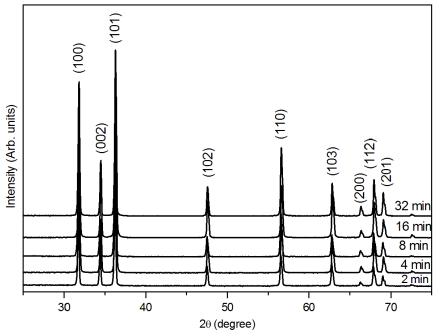

Figure 1: X-ray patterns of the ZnO samples obtained by microwave-hydrothermal process for different reaction times.

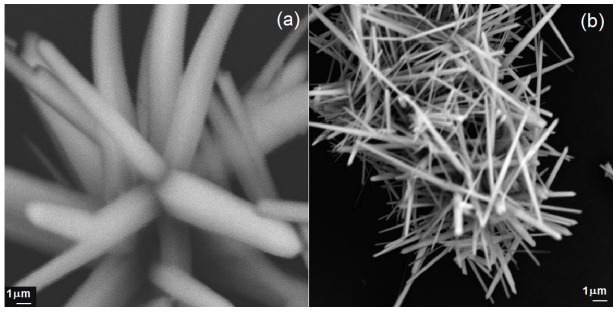

Figure 2: FEG-SEM images of the ZnO samples obtained by microwave-hydrothermal process (a) after 2 min of treatment (b) after 32 min of treatment.

References

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