Microsc. Microanal. 21 (Suppl 3), 2015
doi:10.1017/S1431927615009630 Paper No. 0884

Optical and structural properties of rare earths-doped ZnO nanorods synthetized by sonochemical method.

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Nanostructured materials and semiconductors specifically seem to be important and promising in the development of next-generation electronic and optoelectronic devices [1]. In recent years, synthesis and properties of semiconductors such as TiO_2, SnO_2, ZnO, etc. have been investigated due to their potential and important applications in catalysis, bioimagining, wavelength tunable laser, solar cell [2, 3]. On the other hand, doping is a way to modify electronic, optical, and magnetic properties of bulk semiconductors.

Dopants can strongly influence optical behavior. The undoped nanostructures are highly luminescent and emit light with wavelength which depends on size and defects, however, lasers based on this emission are intrinsically inefficient. A possible solution to this situation is adding dopants that provide carriers. Doping of nanomaterials lead to new phenomena not found in bulk because their electronic states are confined to a small volume.

Luminescence phenomena are being investigated extensively in rare earths (RE) doped nanoparticles, due to RE- doped can emit light from the RE ions give rise to sharp emission through electrical injection. The intra-4f shell transitions of the RE ions give rise to sharp emission lines whose wavelengths are largely independent of both the host materials and temperature. This stability occurs because the filled outer 5s and 5p electron shells screen the transitions within the inner 4f electron shell from the interaction with the host [4].

RE-doped zinc oxide nanostructures have been synthetized using ultrasonic technique. It is a simple and cheap synthesis method which is based on acoustic cavitation phenomena. Zinc [Zn (NO_3)] and Na (NaOH) salts were used as precursor. Then 1.0 mol % $Dy(NO_3)_3$, $Er(NO_3)_3$, $Nd(NO_3)_3$ and $Eu(NO_3)_3$ were added in each zinc solutions for obtaining various samples. After to prepare the solutions with pH controlled (10), these were carried out a sonication process (200 W, 20 kHz) for 1h. Selected ZnO RE-doped samples were thermally annealed at 500 ºC in air.

Figure 1 present typical SEM images of RE-doped ZnO which shown particles agglomerated. It also shows the beginning of the formation of the clusters of nanorods. The nanorods formed have wide size distribution with diameter of 100-200 nm and lengths of 1-2 µm. The morphology did not change with others RE dopants. It is important to note that the morphology ZnO is directly related with sonication time. As this time increases, ZnO nanorods appeared well-defined. However, the aim is to determine the best conditions to grow ZnO using the least amount of energy in the synthesis.

On the other hand, figure 2 present Raman spectra of RE-doped ZnO which consist of four peaks located at about 96, 380, 437, and 580 cm^{-1}, which correspond to the E_{2L}, $A_1(TO)$, E_{2H}, and $A_1(LO)$ fundamental phonon modes of hexagonal ZnO, respectively. The Raman peak located at about 200 and 1150 cm^{-1} were assigned to the $2E_{2L}$ and $2A_1(LO)$ second-order phonon modes, respectively. Other Raman peak located at about 331 cm^{-1} could be assigned to the E_{2H} -E_{2L} multiphonon scattering modes, respectively. The Raman peak appeared at about 140 cm^{-1} has been assigned to B_{1L} silent phonon mode of ZnO. However, its origin is not yet clear.

In summary, RE-doped ZnO nanostructures have been successfully synthetized via an ultrasonic technique. The structure, morphology, luminescent properties and growth mechanism of nanostructures

are investigated in detail. The experimental part demonstrated that the RE-doped ZnO has a similar morphology which is independent of the element dopant. RE-doped ZnO nanostructures have an excellent structural properties and this research may provide guidance for synthesis of nanomaterials by a simple method.

References:

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Figure 1. SEM images RE-doped ZnO nanostructures synthetized by ultrasonic method.

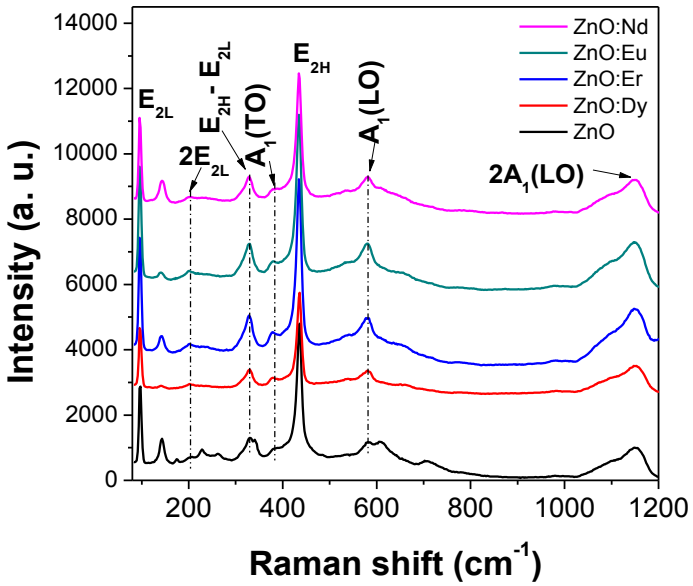

Figure 2. Raman spectra of RE-doped ZnO nanostructures synthetized by ultrasonic method.