Full length article

The effect of milling time on structural, optical and photoluminescence properties of ZnO nanocrystals

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The crystallite size of commercial ZnO nanocrystals was tuned from 22.5 to 13.8 nm by ball-milling technique. X-ray diffraction patterns of mechanically milled ZnO nanocrystals reveal that milled samples possess the wurtzite-type hexagonal structure of ZnO. Increasing milling time results in the decrease of crystallite size and reduction of lattice parameters due to a slight increase of internal compressive strain and dislocation density. Scanning electron microscope images demonstrate the appearance of large agglomerated particles with ambiguous edges due to large aggregation tendency with slight variation in the particle size at milling time 8 h. Analysis of the optical absorption spectra at different milling time indicates the blue shift of exciton absorption peak and optical gap photoluminescence spectra reveal that mechanical milling of ZnO NCs leads to quenching of emission intensity due to the creation of nonradiative centers via increasing thermal strain and mechanical deformations produced during the milling process.

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1. Introduction

Ball milling technique is a room temperature promising technique for large mass production of nanostructured materials that used in many important applications because safety, economic consumption of energy [1]. Structural and interfacial properties of nanomaterials such as a crystallite size, orientation, and morphology, defects, lattice strain strongly affect its optical absorption and photoluminescence characteristics. The need for mass production of desirable size-dependent optical and optoelectronic properties for technological applications with reasonable low cost, make the mechanical milling preferable method for obtaining various nanostructured materials such as ZnO. An N-type semiconductor such as ZnO with a large band gap of 3.3 eV and high exciton binding energy of 60 meV [2], has unique properties such as low cost, non-toxicity, abundance in nature, suitability for doping [3] as well as the high thermal and chemical stability. This makes ZnO extensively used in many applications such as gas sensors [3], solar cells [4], luminescent materials [5], light emitting devices [6], UV photodetectors [7], piezoelectric devices [8], spintronics [9], and cancer treatment [10]. Moreover, ZnO nanostructures revealed dramatic changes in their structural, electronic and optical properties compared to those of their bulk [11,12]. It is well known that lowering of grain size enhances the grain-surface region in the material. Such regions are rich by defect [13] and the nature and abundance of these defect centers play a crucial role in controlling the physical properties of ZnO [14,15].

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