

Ultrasound assisted synthesis of ZnO nanostructures in ionic liquids

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Abstract

Zinc oxide (ZnO) nanomaterials have gained substantial interest in the scientific community due to their unique optical and electrical properties. Basically, ZnO is classified as a wide band gap semiconductor (3.37eV) in group II-VI with a high electron-hole binding energy (60 meV). The hexagonal wurtzite structure enabled ZnO to exhibit excellent piezo- and pyro-electric properties. The enhanced properties of ZnO enabled its use in sensors, piezoelectric transducers, optoelectronics, field emitters, UV lasers and solar cells [1].

Zinc oxide nanostructures with different morphologies are typically produced using the solid-vapor phase thermal sublimation, hydrothermal methods, electrochemical deposition, molecular beam epitaxy, decomposition of zinc precursor compounds and chemical solution methods [2-4]. During the last 10 years there is a great interest on the use of ionic liquids as media to synthesize ZnO nanoparticles [5-6]. Room-temperature ionic liquids (RTILs) have gained considerable attention since they provide an environmentally friendly alternative for the synthesis of ZnO structures.

In the present work, the RTIL 1-butyl-3-methylimidazolium chloride (Bmid^+Cl^-) was used as solvent in a sonochemical reaction of zinc chloride (ZnCl_2) with sodium hydroxide (NaOH). A detailed study was applied on the effect of precursor concentration and irradiation time, on the morphology of the ZnO products. The operation parameters used are listed in Table 1. The structural and morphological characteristics of the ZnO nanoparticles were assessed by X-ray diffraction (XRD), transmission electron microscopy (TEM) and scanning electron microscopy (SEM).

Table 1: Process parameters used in the synthesis of ZnO nanostructures

Group	Samples	ZnCl ₂ (mmol)	NaOH (mmol)	[Bmid] ⁺ Cl ⁻ (ml)	Time (min)
1	I (B)	0.4	2	1	6
	II (F)	1.0	2	1	12
	III (K)	2.0	16	2	12
2	I (B)	0.4	2	1	6
	II (C)	0.4	2	1	12
	III (D)	0.4	2	1	15
3	I (F)	1.0	2	1	12
	II (E)	1.0	2	1	6

The results showed that the XRD patterns of all ZnO samples agreed to the wurtzite type of ZnO (JCPDS card 36-1451). The morphological characteristics of the ZnO samples of Group 1, revealed nanoflakes accompanied with nanoparticles, and flower-like microstructure with 1D nanocombs on their edges. Group 2 and 3 showed the presence of nanoflakes of average width around 150 – 200 nm, length near 250 – 300 nm and height

between 25 and 30 nm, together with nanoparticles of average diameter of 50 – 150 nm. In Groups 2 and 3 it was revealed that an increase of the parameters values resulted in a slight increase on the dimensions of the nanoflakes and nanoparticles. In concluding, synthesis of ZnO nanostructures in the ionic liquid (Bmid⁺Cl⁻) assisted with ultrasonic radiation showed important aspects on the growth of ZnO along the α -axis (lateral direction) or the c -axis (vertical direction).

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