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Photoluminescence in the ZnO synthesized by the Domestic Microwave Hydrothermal Method

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Abstract – Zinc oxide nanostructures were synthesized by the Hydrothemal Microwave Method at 100 °C for 15 and 60 min. The ZnO samples crystallized with a wurtzite structure. A high photoluminescent emission was observed with a behavior depending on the solvent and the alkaline agent, NH_4OH and NaOH. The emission band occurred in the green-yellow range with dislocation of the bands due to the structural order/disorder, that led to deep and shallow defects in the material band gap.

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Zinc oxide (ZnO) is a promising n-type semiconductor, with important technological application due to its properties, as gas sensor, transparent conductor substrate for solar cells sensitive to dyes, optoelectronic and piezoelectric devices, varistors and others [1-3].

In this work, ZnO was synthesized using a domestic microwave assisted hydrothermal method, with heating at 100 °C for 15 and 60 min. Characterization of the materials was done by X-ray diffraction (XRD), Raman spectroscopy and photoluminescent emission (PL).

All samples showed a high PL emission in the visible region at room temperature, as showed in Figure 1. PL emission peak was centered at 600 nm (orange emission) for samples synthesized for 15 min, except for samples synthesized in NaOH, in ethanolic/aqueous media and in NH_4OH in ethanolic media, which presented an emission at a smaller wavelength. For samples synthesized during 60 min, a meaningful decrease in the maximum emission region was observed, with the peak centered at about 550 nm (green region), except for the sample synthesized in NH_4OH in ethanolic/aqueous media, which was centered at 580 nm. XRD patterns showed that all samples were crystallized with hexagonal wurtzite structure, with diffraction peaks indexed by JCPDS 1397 index card. No meaningful difference was observed among the XRD patterns obtained for different synthesis conditions. In relation to Raman spectra, the peaks observed were characteristic of ZnO samples with low amounts of oxygen vacancies, interstitial zinc ions and free charge carriers, indicated by the absence of E_1(LO) mode at 537-584 cm^{-1}. A meaningful decrease in the intensity of all peaks was observed for higher synthesis periods. It may also be observed that the A_{1T} band, around 380 cm^{-1} band, assigned to the order/disorder degree, disappeared after 60 min of synthesis for all samples. Only the sample with emission peak centered at 580 nm did not show this behavior. This way, PL emission in the orange region was related to a higher short range disorder when synthesis was done during smaller periods, leading to lower energy transitions. This disorder was probably assigned to ZnO_3 polyhedra besides ZnO_4 ones [3], favoring PL emission with lower energy values.

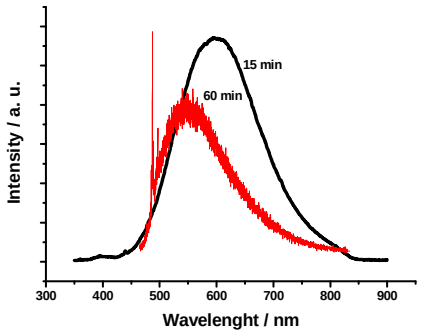

Figure 1: PL spectra of ZnO synthesized in Ethanol and alkalinized by NaOH

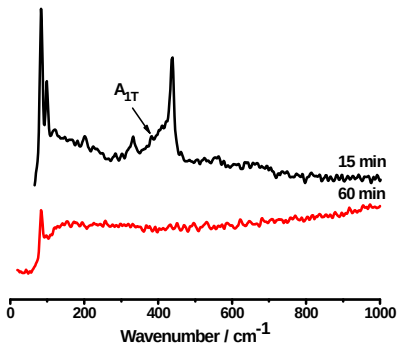

Figure 2: Raman spectra of ZnO synthesized in Ethanol and alkalinized by NaOH

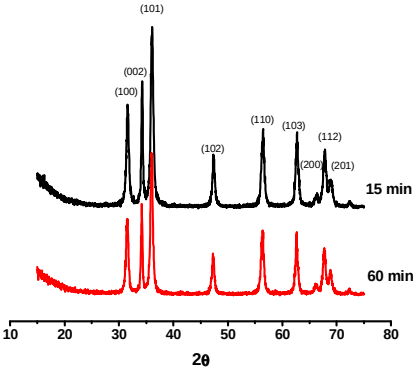

Figure 3: XRD Patterns of ZnO synthesized in Ethanol and alkalinized by NaOH

References

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