Optical properties of ZnO nanorods grown by hydrothermal method as a function of solution pH level – a cathodoluminescence study

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ZnO nanomaterials attract considerable interest due to possible applications in optoelectronic and photonic systems as well as due to interesting light-confinement phenomena which may occur in them. Microresonators based on various self-assembled low-dimensional systems belong to those most intensively studied with particular emphasis on interdependence between their structure, size, crystalline perfectness and optical properties in near band-gap or defect-related luminescence band.

In this paper we studied ZnO nanorods prepared by a microwave hydrothermal method from zinc acetate solutions at three different values of pH: 7, 7.5 and 8. A proper pH levels were obtained by adding sodium hydroxide solution. The samples were grown on nearly lattice matched GaN/sapphire templates at a temperature of 70°C. Next the as-grown samples were annealed at a temperature of 350°C.

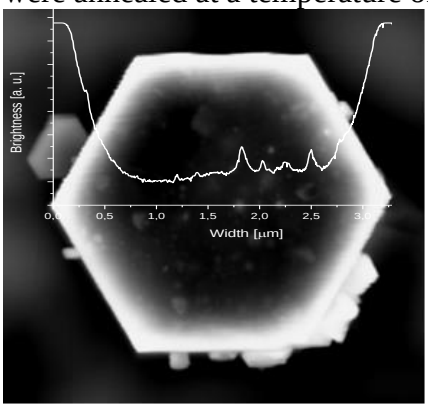

Fig. 1. *CL map of the upper surface of ZnO nanorod obtained from solution of pH=7.*

The light emission properties of ZnO nanorods were investigated by spatially resolved cathodoluminescence (CL) spectroscopy with use of the field emission scanning electron microscope Hitachi SU-70 equipped with the GATAN MONO CL3 system. SEM and CL measurements were performed at the temperature of 5 K. The CL signal was measured for photon wave length range of 200-900 nm, comparable with the diameter of the nanorods.

A comparative CL study of individual nanorods obtained from solutions of pH=7, 7.5 and 8 showed systematic increase of emission in the broad band with wave length of 500-600 nm with increase of pH. As this feature corresponds to emission involving defects (e.g. oxygen vacancies, zinc vacancies or zinc interstitials [2]), we could directly relate the crystal quality of individual nanorods with pH value kept during the growth process. The structures grown for pH=7 exhibit mainly near band-gap luminescence (at =375 nm) with negligible defect-related emission.

The nanorods grown at pH=7 exhibit strong localization of CL emission close to the side walls of the structure (Fig. 1). Interpretation of this CL distribution as a manifestation of whispering gallery mode conditions occurring for the near band-gap luminescence in the hexagonal resonator [3] is discussed.

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