Structural, Morphological, and Optical Analysis of High-Purity ZnO Microrods

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Zinc oxide (ZnO) microrods were successfully synthesized using a hydrothermal method in an alkaline aqueous medium optimized for high purity and morphological uniformity. The resulting structures were characterized using scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS), X-ray diffraction (XRD), and Photoluminescence (PL) spectroscopy to comprehensively investigate their structural, morphological, and optical properties. SEM analysis revealed the formation of ZnO microrods with hexagonal cross-sections, suggesting well-controlled anisotropic growth. At low magnification, the microrods are seen to be uniformly distributed across the surface. At higher magnification, individual micro-rods exhibit well-defined hexagonal facets and smooth sidewalls, with diameters typically ranging from 1 to 2 μm and lengths extending to several micrometers. These features highlight the high morphological uniformity and directional growth along the c-axis. Elemental analysis using EDS confirmed the high purity and near-stoichiometric composition of the ZnO microrods, with no detectable secondary phases. Structural analysis by XRD confirmed a single-phase hexagonal wurtzite structure, consistent with zincite. The sample exhibited sharp diffraction peaks with refined lattice parameters of *a = 3.2511 Å*, *c = 5.2108 Å*, and a crystallite size of 110 nm, indicating a polycrystalline origin of the individual microrods. The Raman and PL measurements provide complementary insights into its structural and optical properties. The Raman spectrum displays a prominent peak around 435 cm^{-1}, characteristic of ZnO's crystalline phonon modes such as E_2 and A_1(TO), along with a broad background extending beyond 1000 cm^{-1}, suggesting the presence of structural defects or multi-phonon processes. The PL spectrum reveals a sharp but relatively weak UV emission around 380-390 nm, indicating near-band-edge excitonic recombination, while a several orders of magnitude stronger and broader visible white emission covering the range of 400-700 nm points to a high concentration of intrinsic defects like oxygen or zinc vacancies and interstitials. Along with the highly uniform rod-like morphology and good crystallinity, combining these rods with ultrafast cesium lead bromide having about 2.5 eV bandgap can result in the new generation of ultrafast scintillators engineering.

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