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A Comparison of ZnO Nanowires and Nanorods Grown Using MOCVD and Hydrothermal Processes

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A comparison of ZnO nanowires (NWs) and nanorods (NRs) grown using metalorganic chemical vapor deposition (MOCVD) and hydrothermal synthesis, respectively, on *p*-Si (100), GaN/sapphire, and SiO_2 substrates is reported. Scanning electron microscopy (SEM) images reveal that ZnO NWs grown using MOCVD had diameters varying from 20 nm to 150 nm and approximate lengths ranging from 0.7 μm to 2 μm. The NWs exhibited clean termination/tips in the absence of any secondary nucleation. The NRs grown using the hydrothermal method had diameters varying between 200 nm and 350 nm with approximate lengths between 0.7 μm and 1 μm. However, the NRs grown on *p*-Si overlapped with each other and showed secondary nucleation. x-Ray diffraction (XRD) of (0002)-oriented ZnO NWs grown on GaN using MOCVD demonstrated a full-width at half-maximum (FWHM) of 0.0498 (θ) compared with 0.052 (θ) for ZnO NRs grown on similar substrates using hydrothermal synthesis, showing better crystal quality. Similar crystal quality was observed for NWs grown on *p*-Si and SiO_2 substrates. Photoluminescence (PL) of the NWs grown on *p*-Si and SiO_2 showed a single absorption peak attributed to exciton–exciton recombination. ZnO NWs grown on GaN/sapphire had defects associated with oxygen interstitials and oxygen vacancies.

Key words: ZnO, nanowires, nanorods, MOCVD, hydrothermal, photoluminescence

INTRODUCTION

ZnO has a direct energy band gap of 3.37 eV, a relatively large exciton energy of 60 meV, and longitudinal optical (LO) phonon energy of 72 meV, making it suitable for optoelectronic applications[1] including quantum cascade lasers (QCLs),[2] ultraviolet (UV) light-emitting diodes (LEDs),[3] and UV detectors.[4] ZnO nanowires (NWs) and nanorods (NRs) have been found to exhibit large spontaneous and strain-induced piezoelectric polarizations, enabling them to be harnessed for energy harvesting applications.[5] In addition, the thermoelectric property of ZnO NWs has been utilized by fabricating nanoscale devices for energy scavenging.[6] Furthermore, ZnO is chemically stable and biocompatible, making ZnO NW/NR-based devices suitable for biosensing applications.[7]

ZnO NWs have been grown using various methods, including molecular-beam epitaxy (MBE), metalorganic chemical vapor deposition (MOCVD), and hydrothermal synthesis. MBE allows monitoring of the structural quality while the NWs are being grown. However, this type of growth requires the use of catalysts such as gold as a seed layer,[8] which can introduce undesired defects into the structure, affecting the crystal quality.[9] MOCVD provides control over the morphology and orientation of NWs by allowing adjustment of temperature, gas flow, and pressure without requiring the use of catalysts.[10–12] The effect of growth temperature on MOCVD using

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