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Electrodeposition of Cu-doped ZnO nanowire arrays and heterojunction formation with p-GaN for color tunable light emitting diode applications

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Abstract

Copper-doped zinc oxide (ZnO:Cu) nanowires (NWs) were electrochemically deposited at low temperature on fluor-doped tin oxide (FTO) substrates. The electrochemical behavior of the Cu–Zn system for Cu-doped ZnO electrodeposition was studied and the electrochemical reaction mechanism is discussed. The synthesized ZnO arrayed layers were investigated by using SEM, XRD, EDX, photoluminescence and Raman techniques. X-ray diffraction analysis demonstrates a decrease in the lattice parameters of Cu-doped ZnO NWs. Structural analyses show that the nanomaterial is of hexagonal structure with the Cu incorporated in ZnO NWs probably by substituting zinc in the host lattice. Photoluminescence studies on pure and Cu-doped ZnO NWs shows that the near band edge emission is red-shifted by about 5 or 12 nm depending on Cu(II) concentration in the electrolytic bath solution (3 or 6 μmol l−1). Cu-doped ZnO NWs have been also epitaxially grown on Mg doped p-GaN single-crystalline layers and the (ZnO:Cu NWs)/(p-GaN:Mg) heterojunction has been used to fabricate a light-emitting diode (LED) structure. The emission was red-shifted to the visible violet spectral region compared to pure ZnO. The present work demonstrates the ability of electrodeposition to produce high quality ZnO nanowires with tailored optical properties by doping. The obtained results are of great importance for further studies on bandgap engineering of ZnO, for color-tunable LED applications and for quantum well preparation.