Copper and Magnesium - doped Zinc Oxide Nanorods for Device Applications

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Abstract - **In this paper we present an experimental approach to study copper and magnesium-doped zinc oxide nanorods and their integration in wavelength-tunable light-emitting diodes (LEDs).**

Keywords - **Nanorod, zinc oxide, deposition bath, light-emitting diodes.**

I. INTRODUCTION

Tuning properties of zinc oxide to realize a specific functionality became an important research field. An important step is controlled doping in ZnO at nanoscale. The type of dopant could determine properties of material to find use in specific applications. Copper and magnesium -doped zinc oxide ($Zn_{1-x}Cu_xO$ and $Zn_{1-x}Mg_xO$) nanowires/nanorods are important for wavelength-tunable light-emitting diodes (LEDs) [1,2]. Also, it is of great interest due to the importance of dimensionality, large aspect ratio and quantum confinement effect. In this work we present dopping effects on zinc oxide properties.

II. EXPERIMENTAL

We present an experimental approach to study $Zn_{1-x}Mg_xO$ and $Zn_{1-x}Cu_xO$ nanorods (NRs) and their integration in LED structures. $Zn_{1-x}Mg_xO$ and $Zn_{1-x}Cu_xO$ NRs were deposited on p-GaN substrates by hydrothermal growth. Low-dimensional doped structures have been obtained from Magnesium sulfate ($MgSO_4$), copper chloride ($CuCl_2$) concentration in the deposition bath lower than 6 μM, whereas at higher concentration crystallized CuO appears and the aspect ratio of the rods decreased. Accordingly to SEM observations the $Zn_{1-x}Cu_xO$ have a nanorod morphology. Structural analyses indicates that the ZnO nanomaterial is doped with the Cu (Fig.1) or Mg(Fig.2) incorporated within ZnO NWs.

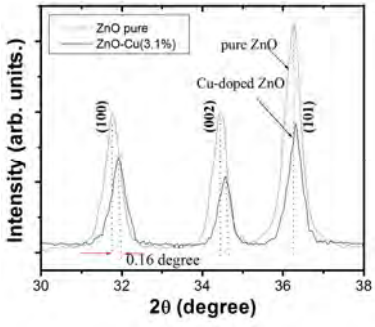

Fig.1 XRD patterns of the ZnO and $Zn_{1-x}Cu_xO$ nanomaterials: The slow scans.

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The X-ray diffraction XRD study of the crystal structure indicates only ZnO peaks in pure and in Cu-doped ZnO NRs, along with the reflections from the substrate GaN. The pattern matches the lattice spacing of wurtzite ZnO (space group: $P6_3mc$(186); a = 0.3249 nm, c = 0.5206 nm). The data are in agreement with the Joint Committee on Powder Diffraction Standards (JCPDS) card for ZnO (JCPDS 036-1451).

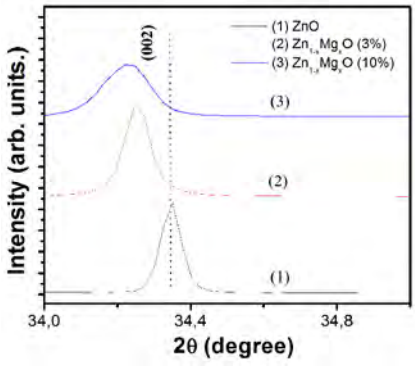

Fig.2 XRD patterns of the ZnO and $Zn_{1-x}Mg_xO$ nanomaterials: The slow scans are presented for better view of the (002) peaks taken of the pure and Mg-alloyed ZnO nanowires.

In the light of previous works on ZnO NW based LEDs,[1,2] we have explored the applicability of the n-type $Zn_{1-x}Mg_xO$ NWs as the light emitters in *n*-$Zn_{1-x}Mg_xO$ /*p*-GaN heterojunction LED structure. Room-temperature electroluminescence (EL) spectra (not shown) demonstrated a short wavelength emission shifted in the range with Cu or Mg-doping of ZnO.

III. CONCLUSION

We have demonstrated a new soft procedure for achieving copper/magnesium doping in ZnO nanorods which permits tuning of the properties of the nanostructures. It has been used to construct the ZnO:Cu nanorod/*p*-GaN and *n*-$Zn_{1-x}Mg_xO$ /*p*-GaN heterojunction-based LED structures.

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