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Epitaxial Electrodeposition of ZnO Nanowire Arrays on p-GaN for Efficient UV-Light-Emitting Diode Fabrication

O. Lupan, T. Pauporté, B. Viana, I. M. Tiginyanu,
V. V. Ursaki and R. Cortès

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Abstract

The electrochemical growth of ZnO nanowire arrays on p-type GaN (0001) single crystalline thin films supported on sapphire is demonstrated for the first time. The wires were directly epitaxially grown on the GaN with the relationship ZnO(0001)[10$\bar{1}$0]‖ GaN(0001)[10$\bar{1}$0]. By glancing-angle XRD experiments, the ZnO mosaicity was shown to be as low as 1.2°. The deposited ZnO-NWs exhibited a very low density of intrinsic defects as demonstrated by micro-Raman and photoluminescence (PL) experiments. The only significant PL emission of the heterojunction at room temperature was the near band edge one of ZnO at 382 nm. After integration of the heterostructure in a solid-state light-emitting diode device, a rectifying behavior was found with a forward current onset at 3 V. The diodes emitted an unique UV-light centered at 397 nm for either as-prepared or annealed samples. The emission threshold voltage was 4.4 V. The violet visible tail of the emission could be observed above 5–6 V with the naked eyes. The present results clearly state the remarkable quality of the electrochemical ZnO material and ZnO-NWs/p-GaN interface as well as the effectiveness of electrodeposited epitaxial ZnO as an active layer in solid-state UV-LED structure.