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III-nitride-based vertical light emitting diodes fabricated on the transparent and conductive Ga_2O_3 substrates

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We demonstrate a state-of-the-art high-efficiency III-nitrides-based vertical light-emitting diode (VLED) grown on a transparent and conductive (-201)-oriented (β-Ga_2O_3) substrate by metalorganic vapour phase epitaxy. The VLED fabrication was a straightforward growth process that eliminates the need for a complicated lift-off and structure-transfer process. We show that the low treading dislocation density in the GaN grown above the (-201)-oriented (β-Ga_2O_3). The high-resolution scanning transmission electron microscopy (STEM) images confirm that we produced high quality upper layers, including a multi-quantum well (MQW) grown on patterned SiNx on β-Ga_2O_3 substrate. The role of SiNx mask is to reduces significantly the threading dislocations, improve the light extraction and to enhance the conductivity of the interface. STEM imaging also shows a well-defined MQW without InN diffusion into the barrier. Electroluminescence (EL) measurements at room temperature indicate that we achieved a very high internal quantum efficiency (IQE) of ~80%; at lower temperatures, IQE reaches ~ 86%. The photoluminescence (PL) and time-resolved PL analysis indicate that, at a high carrier injection density, the emission is dominated by radiative recombination with a negligible Auger effect; no quantum-confined Stark effect is observed. At low temperatures, no efficiency droop is observed at a high carrier injection density, indicating the superior VLED structure obtained without lift-off processing, which is cost-effective for large-scale devices.

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