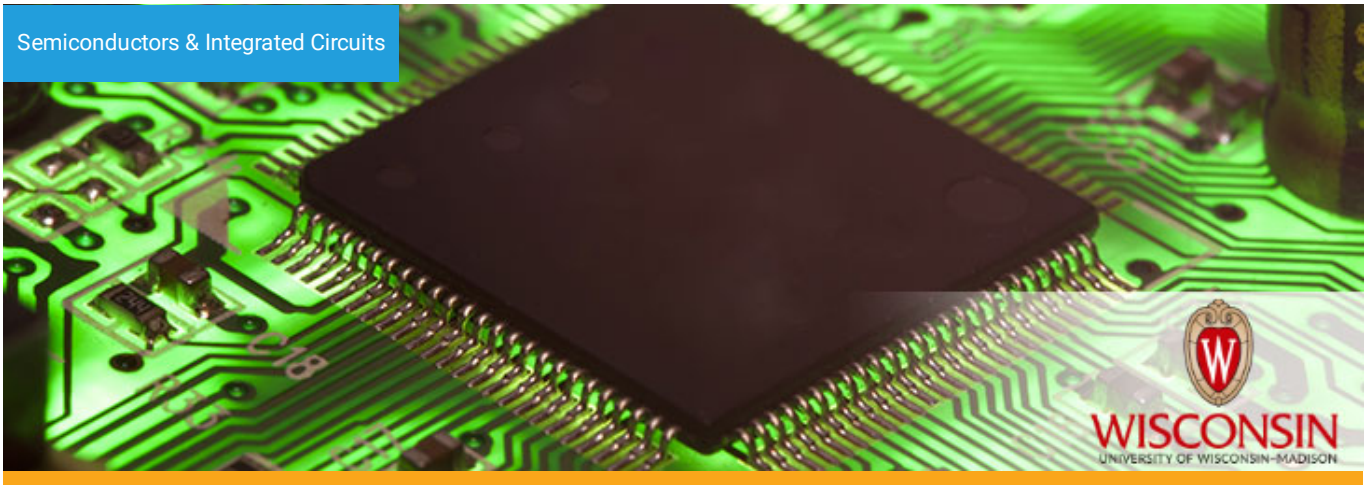
Semiconductors & Integrated Circuits



A Novel P-Type Contact Scheme for Nitride-Based Light-Emitting Diodes

View U.S. Patent No. 10,347,790 in PDF format.

WARF: P170282US02

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The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in novel light-emitting devices, including blue and deep-ultraviolet LEDs.

Overview

Semiconductor deep-ultraviolet (DUV) light-emitting diodes (LEDs) operating at sub-250 nm wavelengths are of interest due to their applications in areas such as sterilization, biosensing, medical treatment and lithography. Aluminum gallium nitride (AlGaN) is widely used for commercial UV LEDs, but challenges arise at sub-250 nm wavelengths, including degrading crystal quality, low conductivity and poor carrier injection, and compromised light extraction.

The Invention

UW-Madison researchers have developed novel light-emitting devices with a multiple quantum well (MQW) pin diode structure that show improved conductivity and hole injection. The devices include a multilayered p-type contact composed of a heavily p-type doped hole injection layer and a thin p-type group III-nitride layer. The materials of the hole injection layer and the p-type group III-nitride layer are separated by a layer of a material that allows current tunneling through the heterogeneous junction formed between the lattice mismatched materials.

The p-type contact can be fabricated using a thin film transfer and bonding process that allows the material of the hole injection layer to be selected independently from the GaN material of the p-type contact layer and also from the intrinsic semiconductor materials of the device's active region. The current tunneling layer is formed of an inorganic material having a bandgap that is wider than the bandgaps of the hole injection layer material and the p-type GaN of the contact layer.

Placing a layer of p-GaN between the heavily p-type doped hole injection layer and the active region of the device can be advantageous because the p-GaN contact layer can improve hole injection in embodiments where the valence band offset between the material of the hole injection layer (for example, silicon) and the p-GaN is smaller than that between the material of the hole injection layer and the nitride semiconductor of the active region (for example, AlGaN or AlN). In addition, because some nitride semiconductors, including high Al-content AlGaN, readily oxidize, the p-GaN can be used to avoid or minimize undesired oxidation of the exposed surface of the active region during device fabrication.

Applications

- Biosensors, medical treatment applications and lithography
- Can be adapted for blue and deep-ultraviolet LEDs

Key Benefits

- Addresses issues around poor conductivity and hole injection found in commercial AlGaN UV LEDs

- Passivates the surfaces of the layers of semiconductor materials with which it is in contact, minimizing or eliminating dangling bonds and interface states
- Simple to implement with higher performance
- Can be adopted more easily than other schemes

Additional Information

For More Information About the Inventors

- Zhenqiang Ma

Tech Fields

- Semiconductors & Integrated Circuits : Design & fabrication

For current licensing status, please contact Jeanine Burmania at jeanine@warf.org or 608-960-9846