Bidirectional light-emitting diodes for alternating current operation

The GaN-based light emitting diodes (LEDs) coated with phosphor are the most efficient white light sources for domestic and outdoor lighting. However, standard LEDs require the direct current (DC) supply, while the power in the electric grid is distributed as alternating current (AC). AC/DC converters are often bulky and always a few percent of energy is lost to current rectification. Substantial effort was put to fight with this inconvenience and different approaches to directly AC driven light emitting devices were proposed. First of them is based on merging several LEDs in a sophisticated way to form rectifiers inside an AC LED chip. Nonetheless, under AC condition only a part of devices in the circuit emit light at a given time, which reduces the surface power density received from the AC driven chip. The second approach is a symmetric structure, where the organic emissive layer is sandwiched between two dielectric barriers. However, a proper balance of injected carriers is difficult to achieve and thus those devices suffer from high driving voltages and low power efficiencies.

Taking into account the advantages and disadvantages of the above-mentioned solutions, the ideal AC-driven visible light source should meet the following requirements:

- light emission in both directions of the bias;
- light emission from the entire surface of the device;
- high power efficiency;
- stable operation at high AC power.

Addressing these demands, we propose a novel device - a direct AC-powered bidirectional light-emitting diode (BD LED), which properties are based solely on a specially designed epitaxial structure. We focus on the symmetric structures shown in Fig. 1, in which efficient III-nitride quantum wells (QW) constitute the active region and are surrounded by two tunnel junctions (TJs) on each side for carrier injection. **The proof-of-concept device shows very promising characteristics i.e. we have obtained light emission for both directions of current flowing through BD LED.** Therefore it is essential to continue this research in order to fully explore the physics of BD LEDs and understand the impact of each element of the epitaxial structure on the optoelectronic properties of BD LEDs, so that the novel class of light-emitting devices could be developed.

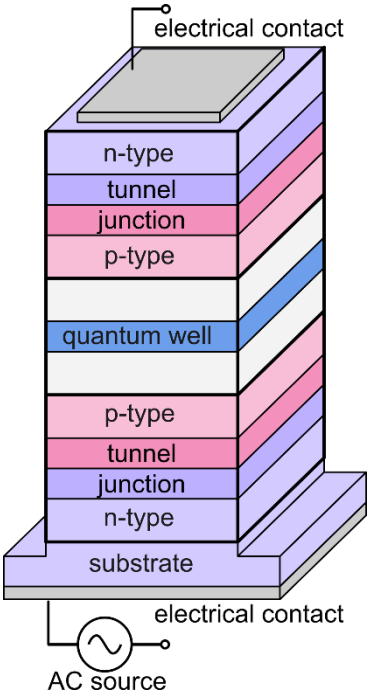

Fig. 1 Schematic structure of BD LED.

In this project, we will investigate BD LEDs as a new class of semiconductor light sources dedicated to direct AC operation. The main part of this project will be devoted to studying the active region in BD LED structures, in particular how the built-in electric field affects the optoelectronic properties of these devices under DC and AC power conditions. In order to do that, in the first task, we will optimize doping in TJs to reduce operating voltages of single BD LED. We will test the feasibility of stacking multiple BD LEDs to meet high-power applications. Finally we will examine the BD LED switching dynamics to determine the limiting factors of carrier supply to the active region.