Impact of current flow direction on the distribution of carriers in multiple, color-coded InGaN quantum wells

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Unique properties of group III-nitride semiconductors allow for the design of high-efficiency and high-power optoelectronic devices. However, not all of these properties are advantageous. The fact that the internal quantum efficiency (IQE) tends to drop for high current densities, caused by significant Auger recombination and decreased injection efficiency is one of its negative characteristics [1]. The straightforward solution to this problem is to increase the number of quantum wells (QW), but III-nitrides pose strong built-in, spontaneous and piezoelectric fields ($\overrightarrow{F_P}$). This, together with the low mobility of holes in comparison to electrons, leads to the asymmetric carrier distribution and injection in the active region with multiple QWs, where in standard structures the QW closes to the p-type region tends to dominate [2].

To assess this implication, two LEDs with current flow direction ($\vec{J}$) parallel to built-in polarization (Fig. 1 c-d), and two with $\vec{J}$ anti-parallel to $\overrightarrow{F_P}$ (Fig1. a-b) are compared. This is achieved on bulk Ga polar substrate by using the buried tunnel junction (TJ) [3,4]. In addition, all LEDs consist of double 2.6nm QW where the position of the blue- and green-emitting active region was varied with respect to the p-type region, resulting in structures where electrons firstly flow to the shallow blue QW, for LEDs in Fig. 1 a, d, or deeper, green QW, for LEDs in Fig. 1 b, c.

By measuring the relation between emission peaks from green- and blue-emitting QW in a wide range of current densities we investigated the impact of the polarization on the carrier distribution in double, color-coded InGaN-based QW LEDs.

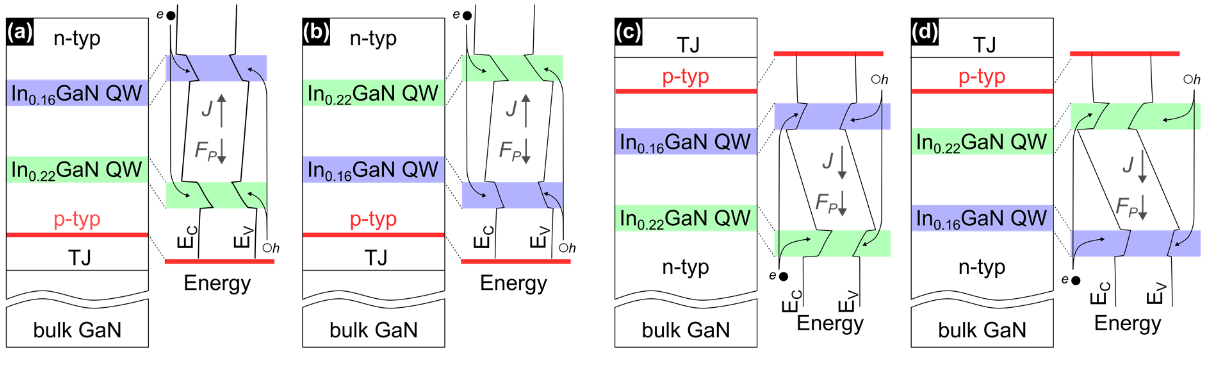

Fig. 1 Schematic structures and band structures at ~100 A/cm^2 for LEDs with (a-b) p-type down, (c-d) p-type up.

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