Optimization of InGaN laser diodes based on numerical simulations

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Green and blue laser diodes based on the gallium nitride are of interest to experimental and theoretical physicists. Growth methods of these devices and principles of their operation are the subject of studies at the present time. Applications result in requirement of powerful and effective lasers.

Simulations of blue and green laser diodes with InGaN quantum wells are presented. In these study, a particular emphasis on efficiency and optical power of the structures were placed. It is shown that polarization charges existing in AlInGaN heterostructures grown on GaN polar direction and low performance of magnesium acceptors lead to high resistance of these devices. These effects hinders the carriers from reaching an active zone and consequently it imposes high operating voltages. Also the quantum-confined Stark effect and band offsets lead to separation of electrons and holes in quantum wells and they reduce the rate of the radiative recombination process. Results of simulations focused on these problems are presented. It is shown how to reduce the negative impact of these effects on performance of gallium nitride laser devices by minor changes of an underlying structure, such as increased donor/acceptor doping. Effect of the aluminum content in an electron blocking layer on the electron overflow and efficiency is also discussed.

Density functional theory simulations were performed with SIESTA and VASP programs. Drift-diffusion simulations were based on a code developed by the authors.

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