Semiconductor Quantum Dots

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Abstract. *In this tutorial the physics of semiconductor quantum dots and their application to optoelectronic devices will be presented.*

The three-dimensional electronic confinement in semiconductor nanostructures ("quantum dots", QDs) produces discrete energy levels, much like in atoms. This gives rise to unique physical properties, with potential advantages over well-established bulk or quantum well active regions for lasers and other optoelectronic devices. Defect-free, nanometer-sized QDs with excellent optical properties are routinely obtained by self-assembled growth methods, using the strain in lattice-mismatched heterostructures as the driving force for nucleation (e.g. in the InAs/GaAs and InAs/InP material systems). High-performance and reliable lasers have been demonstrated in the entire 800-1600 nm wavelength range. Nevertheless, QD lasers have fallen short of original predictions in terms of gain, modulation frequency and temperature characteristics. In this tutorial, after a brief overview of growth methods and physical properties, the state-of-the-art of QD lasers will be presented. The main limiting factors in the laser modulation bandwidth and temperature performance will be analysed. Additionally, it will be shown that the unique features of QDs can find application in other optoelectronic devices, such as amplifiers, superluminescent diodes, mode-locked lasers and single-photon sources.