Engineering of type II quantum wells for a broad range of mid infrared emission in interband cascade lasers

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Semiconductor lasers emitting in the mid-infrared (MIR) spectral range of 3-8 μm are required for applications in environmental pollution monitoring, medical diagnostics, infrared countermeasures, laser surgery, and gas leakage detection. There exists at least several competing concepts of sources of coherent radiation in MIR including common laser diodes base on type quantum wells (QWs), quantum cascade lasers (QCLs) and interband cascade lasers (ICLs). The main advantage of the latter is combining the potentially possible broad tuning range of the emission, minimized influence of the Auger related carrier losses, and a very low power consumption [1]. However, in order to realize that many parameters of these multilayer structures must be optimized, especially on the side of the active region which is composed of a cascade of type II QWs made of a broken gap materials.

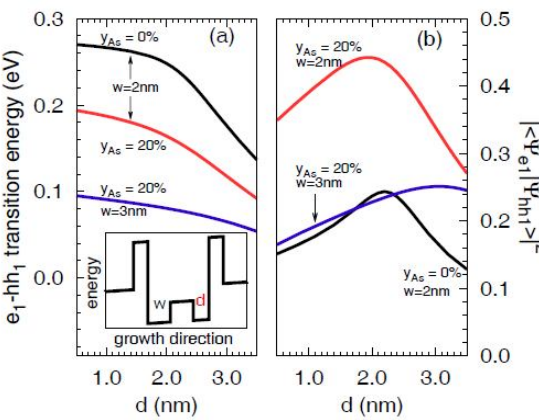

Fig. 1 Effect of type II QW asymmetry (as shown in the inset) and separating barrier composition on the fundamental e1-hh1 transition energy (a), and squared wave function overlap integral.

In this work, we discuss a few possibilities of implementing type-II W-design QW, which allows to preserve the large optical matrix elements in spite of indirect in the real space character of the optical transition. We concentrate on the InAs/GaIn(As)Sb QWs and calculate their fundamental electronic structure properties with respect to the final device performance [2-3]. The calculations are performed within the eight-band k·p theory. We demonstrate the broad range of tunability via the structure parameters modifications, and including the effect of the electric field in order to simulate the operational device conditions. We show that the transition oscillator strength can still be efficiently optimized for wavelengths even beyond 8 μm, if the composition of the separating barrier, which is simultaneously the well for holes, is chosen properly, and for the given range of thickness of InAs layers confining electrons, and the exactly matched structure asymmetry in order to compensate for the effect of the electric field existing in the ICL device. Eventually, detailed prescriptions of the optimized QW designs for certain emission wavelengths are given.

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