Influence of the waveguide construction on fundamental mode confinement and optical losses of the quantum cascade laser

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Quantum cascade laser (QCL) is a unipolar device based on intersubband transitions [1]. Due to the possibility of emitting wavelengths in the mid-infrared range, InGaAs/AlInAs heterostructures lattice-matched to InP substrate are most commonly used [2]. Construction of QCL is very sophisticated, thus its deposition technology needs a sub-nanometer precision. One of possible technique is metal-organic vapour phase epitaxy (MOVPE), providing precise process control and possibility of high volume production. Emission properties of QCL are function of scheme and dimensions of its active core, rather than material system. Factors that influence fundamental mode distribution and optical losses the most are thickness and doping profile of the cladding layers. Series of theoretical calculations was conducted in order to determine the optimal design of the laser claddings. Influence of dimensions and doping profile of claddings for two wavelengths 5 and 9 µm was subject of the present studies.

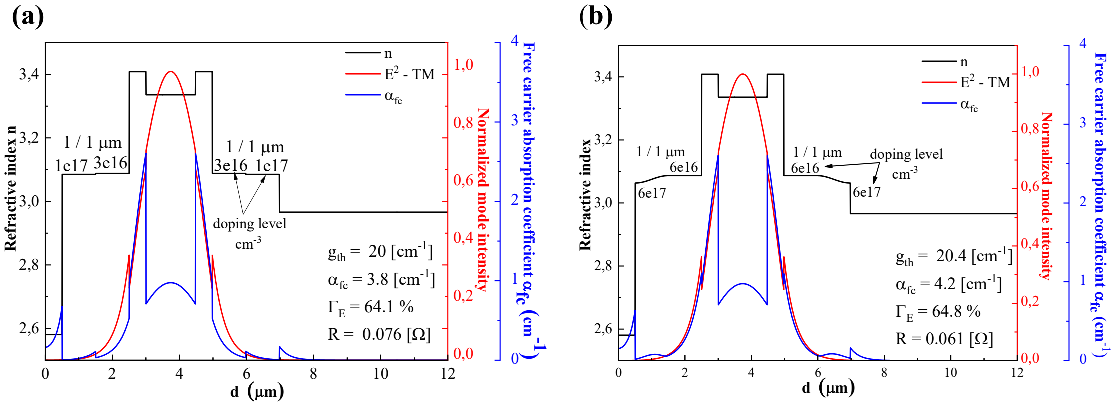

Fig.1 Profiles of the refractive index, fundamental mode and optical losses on free carriers distribution in the case of (a) step-like and (b) gradient cladding schemes, calculated for $\lambda = 5$ µm.

In Fig.1 is shown that doping profile of cladding layers is the key parameters concerning fundamental mode confinement and optical losses within cascade laser structure. Higher doping level in the surrounding of active region causes higher confinement factor but also optical losses increases what finally influences on the threshold gain.Moreover, reduction of doping level can decrease optical loses, but strongly influences on electrical properties, like resistance of the device. Thus, many optical and electrical parameters have to be optimised. Results of those calculations for two wavelengths 5 and 9 µm will be presented and discussed.

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