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Impact of Interface Diffusion and Doping Segregation on Transport Characteristics in THz Quantum Cascade Lasers

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Abstract. Quantum cascade lasers (QCLs) are unipolar semiconductor lasers with flexible emission wavelengths that can be engineered by variation of semiconductor layer thicknesses and composition. QCLs were first demonstrated in 1994. [1] and are typically created by molecular beam epitaxy. Due to the high temperature of the molecular beam at which this growth occurs, the created interfaces between different materials are not abrupt, which is a common approximation, but are rather subject to the diffusion of the barrier material, which changes the material composition of the interfaces. It was recently shown that this compositional (interface) diffusion can have a prominent effect on the maximum operating temperature of a THz QCL [2]. Doping segregation, that is the diffusion of the charged dopants, is an effect that is also present in real QCLs and can be of interest when modelling QCLs as it changes the Hartree term in the total effective potential energy, and in turn the electronic structure. In this work we investigate the impact of interface diffusion and doping segregation on transport characteristics, such as material gain and current density in THz QCLs, while varying the externally applied electric field along the growth direction. For calculating the transport characteristics, we used the density matrix model presented in [3]. Diffusion was modelled by numerically solving Fick's law with the finite distance method, and the results were in agreement with the analytical error function results presented in [4].

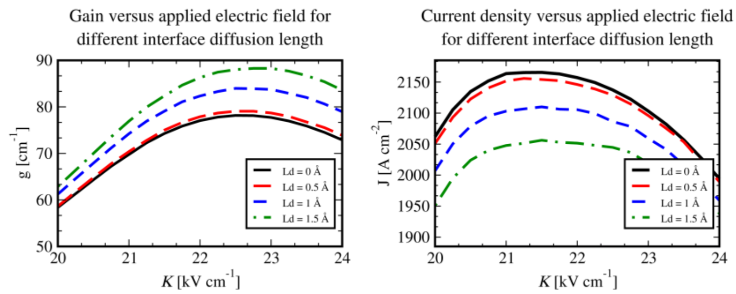

FIGURE 1. Effect of interface diffusion on material gain and current density in quantum cascade laser

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