Interface Roughness in Quantum Cascade Lasers

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The quantum cascade laser (QCL) is a solid state device capable of generating the coherent mid-infrared and terahertz radiation. It is made from layers of different semiconducting materials. This layered structure gives rise to sub-bands, that are employed to achieve charge inversion necessary for lasing. However, the large number of interfaces that are not perfect strongly influences the operation of the device. In this work we study the influence of interface roughness (IFR) on the performance of the QCL. The program based on non-equilibrium Green's functions were used to simulated two realised terahertz lasers. These simulations provided current density dependence on bias per period and the gain spectrum as well as the energetically and spatially resolved charge density. The obtained data was analysed and compared with reference simulations in order to determine the dominant mechanisms the IFR scattering affects the operation of the QCL.

A number of phenomena were observed. One of them is the additive influence (superposition) of different interfaces on the current density.A shift or a decrease in an emission peak were also observed when interface roughness was altered.

By analysing results, it was determined that interface roughness affects both current and gain of the investigated quantum cascade lasers. It was determined by investigating spatially and energetically resolved electron density, that one of the main mechanisms the IFR affects the operation of the QCL is electron scattering into the lower energy sub-bands in the same well.