

THZ QUANTUM CASCADE LASERS WITH TWO-PHOTON DESIGN

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The possibility of implementing two radiation transitions in the gain module for THz QCL has been shown many times [1,2]. However, the activation of these transitions is achieved at different bias points, which corresponds to the optimal alignment of energy levels for each transition. We propose to add an additional step to the ladder of energy levels in the gain module, equal to the energy of THz photon. Due to the low energy of THz photon, it becomes possible to design the gain module based on the conventional GaAs/Al_{0.15}Ga_{0.85}As heterojunction with two-photon emission at one bias point.

A new lasing scheme with sequential two-photon emission in the gain module for terahertz quantum cascade laser (THz QCL) is proposed and experimentally demonstrated. Unlike the conventional lasing scheme with only one pair of laser levels, here electrons pass through an additional laser level, which is the lower laser level for the first radiation transition and upper laser level for the second one, forming a sequence “resonant tunneling — photon — photon — phonon” (see Fig. 1). The presence of two-photon emission in the gain module reduces the gain saturation with an increase in photon density, which should potentially increase the radiation power. An optimized two-photon design based on GaAs/Al_{0.15}Ga_{0.85}As As four-quantum wells was developed using the balanced equation method [3,4] and grown by two epitaxial techniques — molecular beam epitaxy (MBE) and metal organic chemical vapor deposition (MOCVD). THz QCLs based on both MBE and MOCVD structures have a lasing frequency of 3.8 THz (see Fig. 2) and maximum operation temperature around 100 K.

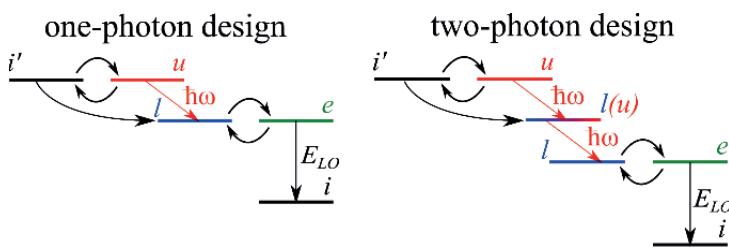


Fig. 1. Schematic diagram of one- and two-photon designs with resonant phonon depopulation mechanism of lower laser level.

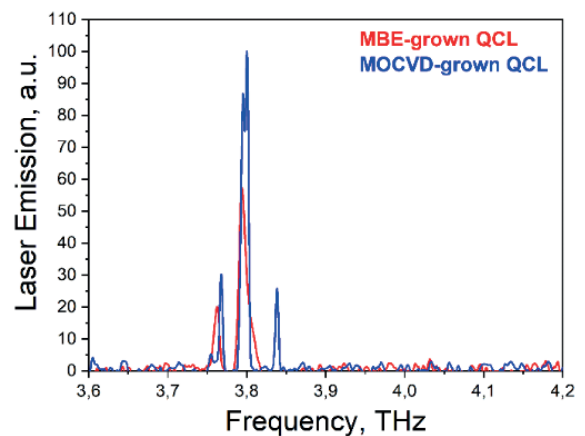


Fig. 2. Emission spectra of MBE- and MOCVD-grown THz QCLs with two-photon design.

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