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High-temperature THz quantum cascade lasers: novel designs and MBE growth challenges

D. Ushakov[1], A. Afonenko[1], O.Yu. Volkov[2], I.N. Dyuzhikov[2], V.V. Pavlovskiy[2], A. Dolgov[3], R. Galiev[3], S. Pushkarev[3], D. Ponomarev[3], R. Khabibullin[3]

1. Belarusian State University, Minsk, Belarus

2. Institute of Radio-Engineering and Electronics of RAS, Moscow, Russia

3. V.G. Mokerov Institute of Ultra-High Frequency Semiconductor Electronics of the Russian Academy of Sciences, Russia,

khabibullin@isvch.ru

Over the past two decades, the operation temperature of terahertz quantum cascade lasers (THz QCLs) has continuously increased from cryogenic level to the current record value of 250 K (about -23ºC) [1]. Here we review the state-of-the-art and future prospects of THz QCL designs with two-quantum wells in active module based on conventional heterojunction GaAs/AlGaAs and alternative material system HgCdTe [2]. We have analyzed the temperature dependence of the peak gain and predicted the maximum operation temperatures of the given designs.

THz QCL is one of the spectrally brightest solid-state source at THz frequencies with a potentially wide range of practical applications in high-resolution spectroscopy [3,4] and imaging systems [5]. The main barrier to the use of THz QCL “outside the laboratory” is their low operating temperatures. The limiting factors for increasing the operation temperatures of THz QCLs are associated with strong optical phonon scattering, the presence of parasitic current channels and the formation of electric field domains as was shown in [6,7]. Recently, the mode loss spectra for THz QCLs with double metal waveguide (DMW) were demonstrated in [8]. It was shown the high level of propagation loss of THz radiation in DMW, which exceeds 30 cm^{-1} for room temperature. Thus, to improve the high-temperature performance of THz QCLs it is needed to develop new concepts of active region designs and to reduce losses in DMW.

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