InGaAs/GaAsSb/InP Quantum Cascade Lasers


Center for Micro- and Nanostructures and Institute for Solid-State Electronics
Vienna University of Technology, Vienna, Austria

C. Deutsch, A. Benz, K. Unterrainer
Photonics Institute
Vienna University of Technology, Vienna, Austria

Abstract: We report on an aluminum free type II material system suitable for intersubband devices. QWIPs, MIR and THz quantum cascade lasers will be presented.

Quantum cascade lasers (QCLs) [1] cover a wide range of the mid-infrared (MIR) and terahertz (THz) [2] spectral regions. Presently efforts are made to design more efficient devices to allow higher optical output powers or slope efficiencies in the MIR and to reach higher operating temperatures for THz QCLs. In addition to design improvements of the active region itself and advancements in cavity designs, there are more favorable material combinations for specific applications [3]. The well-established In$_{0.53}$Ga$_{0.47}$As/In$_{0.52}$Al$_{0.48}$As material system, which is commonly used for state-of-the-art MIR QCLs, and the GaAs/Al$_x$Ga$_{1-x}$As material system, which allows both, MIR and THz designs. QCLs based on the material combination In$_{0.53}$Ga$_{0.47}$As/GaAs$_{0.51}$Sb$_{0.49}$ were demonstrated [4]. Both compounds can be grown lattice-matched to InP substrates, showing a type-II band alignment with a CBO of 360 meV and comparably low effective masses for electrons of 0.044 in the InGaAs wells and 0.045 in the GaAsSb barriers [5].

We present InGaAs/GaAsSb based QCLs for both, the MIR [4] and the THz [7] spectral regions. The InGaAs/GaAsSb material system is an interesting alternative to the GaAs/Al$_{0.15}$Ga$_{0.85}$As and In$_{0.53}$Ga$_{0.47}$As/In$_{0.52}$Al$_{0.48}$As material systems, where THz QCLs were realized so far [2,6]. The lower effective mass allows higher matrix elements compared to GaAs based designs, while the barrier thickness can still be kept at reasonable values due to the moderate CBO compared to InGaAs/InAlAs heterostructures. Presently the MIR QCLs show 1.2 W optical power at 11 µm with a threshold of 0.6 kA/cm$^2$. InGaAs/GaAsSb THz QCLs are operating at 80 µm with an maximum operating temperature of 135 K.


PQE-2011 Abstract Processed 01 December 2010 0