HL 2 Symposium THz-quantum cascade lasers

Time: Monday 10:15–12:45 Room: HSZ 01

Keynote Talk HL 2.1 Mon 10:15 HSZ 01

Designing the emission of THz Quantum Cascade Lasers with surface plasmon photonic structures — •Alessandro Tredicucci — NEST CNR-INFM , Scuola Normale Superiore, Piazza dei Cavalieri 7, 56126 Pisa, Italy

The development of quantum cascade lasers operating at terahertz frequencies is proceeding at a very rapid pace. For their successful practical implementation, specific requirements have now to be addressed, particularly concerning the properties of the emitted radiation. Single-mode THz lasers with distributed feedback resonators have been achieved and a new technique involving surface plasmon gratings has been demonstrated to improve performances. The latter also offers the possibility of constructing distributed Bragg gratings as a replacement for high-reflection coatings or to implement vertical emitting devices. Solutions allowing broad tuneability are examined, either relying on external cavity set-ups or more unconventional external electrical control.

Keynote Talk HL 2.2 Mon 10:45 HSZ 01

THz generation and mixing using Quantum Cascade Lasers — •Carlos Sirtori — Matériaux et Phénomènes Quantiques, Université Denis Diderot - Paris 7, Paris, France

THz quantum cascade (QC) lasers are electrically pumped semiconductor devices based on electronic intersubband transition in quantum wells. Recently, we have been investigating lasers with emission frequency at 3THz and 1.9THz ($\lambda = 100\mu$m and $\lambda = 160\mu$m). The latter is the longest wavelength ever achieved in QC lasers without the help of a magnetic field. At 3THz we were able to obtain 100mW of peak power and a maximum operating temperature of 100K. After a brief introduction on the state-of-the-art, I will present our results on novel THz waveguide structures, allowing "buried"structures and ultra-low threshold currents. Finally, I will introduce a scheme in which a beam at telecom frequencies can be injected into a QC lasers for coherent THz modulation and up-conversion.

Keynote Talk HL 2.3 Mon 11:15 HSZ 01

Progress in single frequency and long wavelength quantum cascade lasers — •Jerome Faist[1], G. Scalari[1], L. Sirigu[1], L. Ajili[1], C. Walther[1], M. Giovannini[1], A. Dunbar[2], and R. Houdre[2] — [1]University of Neuchâtel, Switzerland — [2]EPFL Lausanne, Switzerland

The realization of terahertz QC lasers has attracted much attention because of its potential applications in imaging and spectroscopy. Spatial and spectral control of the mode profile are therefore of paramount importance. Single mode distributed feedback, as well as devices with photonic crystal mirrors will be demonstrated. Electrically switchable, multi-color emission based on magnetic confinement with a record low frequency of 1.39 THz will also be discussed. Finally, results with InP-based terahertz quantum cascade will be described.

Keynote Talk HL 2.4 Mon 11:45 HSZ 01

Growth and Processing of GaAs quantum cascade lasers — •Gottfried Strasser, Aaron Maxwell Andrews, Tomas Roch, Gernot Fasching, Alexander Benz, Sebastian Golka, Maximilian Austerer, Christian Pfluegl, Werner Schrenk, and Karl Unterrainer — TU Wien, Zentrum für Mikro- und Nanostrukturen, Floragasse 7, 1040 Wien

We report on growth and processing of GaAs-based quantum cascade lasers above and below the reststrahlenband. Despite the advances in mid-infrared (MIR) QCLs, THz QCLs remain difficult to fabricate. The tolerances in alloy composition, layer thickness, and doping are lower for THz QCLs than their MIR counterparts. Processing of GaAs QC lasers at THz frequencies isin spite of the relaxed dimensions, still a demanding task. This is particularly true for micro cavities. Double plasmon waveguides, single plasmon and double metal waveguide scenarios will be discussed. We will report about various THz resonators [1] (circular and ring shaped micro cavities) as well as surface emitting concepts (2nd order dfbs), where smart dfb designs can be used for wavelength selection of e.g. surface SHG [2] versus facet fundamental light output.

[1] G. Fasching, A. Benz, K. Unterrainer, R. Zobl, A.M. Andrews, T. Roch, W. Schrenk, G. Strasser; "THz Microcavity Quantum Cascade Lasers"; Appl. Phys. Lett. 87, (21.11.2005)

[2] C. Pflügl, M. Austerer, W. Schrenk, G. Strasser; "Second-harmonic generation in GaAs-based quantum-cascade lasers grown on <100> substrates"; Electron. Lett., in print (2005)

Keynote Talk HL 2.5 Mon 12:15 HSZ 01

GaInAs/AlAsSb quantum cascade lasers: a new approach towards 3-to-5 μm semiconductor lasers — •Joachim Wagner, Quankui Yang, Christian Manz, Wolfgang Bronner, Christian Mann, and Klaus Köhler — Fraunhofer-Institut für Angewandte Festkörperphysik (IAF), Tullastrasse 72, 79108 Freiburg, Germany

Quantum cascade (QC) lasers based on the GaInAs/AlInAs-on-InP materials combination yield high-performance devices in the 5-to-10 μm wavelength range. These lasers can be operated in cw mode up to room-temperature and in pulsed mode up to 400-500K. Towards shorter wavelengths GaInAs/AlInAs QC laser performance rolls off due to insufficient carrier confinement caused by the limited available conduction- band offset, which is in the 500-700 meV range. A more than twofold increase in con-duction band offset can be achieved when using lattice matched AlAsSb rather than AlInAs as barrier material. For the GaInAs/AlAsSb materials combination the offset for the direct conduction band minimum amounts to 1.6 eV. Compared to alternative con-cepts for large conduction band offset QC structures, such as the GaN/AlN or InAs/AlSb materials combinations, the present approach has the significant advantage to make use of the mature fabrication technology available for InP-based lasers.

In spite of the challenges in materials growth, GaInAs/AlAsSb and even quaternary barrier GaInAs/AlGaAsSb QC lasers emitting in the 4-4.5 μm range have been grown by molecular-beam epitaxy. In pulsed mode operation, GaInAs/AlAsSb QC lasers ex-hibit a peak output power of up to 900 mW room-temperature, while their maximum operating temperature lies above 400 K. Furthermore, GaInAs/AlAsSb DFB QC lasers have been demonstrated, showing single-mode emission at 4.08 μm for pulsed mode room-temperature operation.