n-type Ge/SiGe quantum cascade heterostructures for THz emission

D. Stark[1], L. Persichetti [2], M. Montanari[2], C. Ciano[2], L. Di Gaspare[2], M. De Seta[2], M. Zoellner[3], O. Skibitzki[3], G. Capellini[2,3], M. Ortolani[4], L. Baldassarre [4], M. Virgilio[5], T. Grange[6], S. Birner[6], K. Rew[7], D.J. Paul[7], J. Faist[1], G. Scalari[1]

1. ETH Zurich, Institute of Quantum Electronics, Auguste-Piccard-Hof 1, CH-8093 Zurich, Switzerland
2. Dipartimento di Scienze, Università Roma Tre, V.le G. Marconi 446, I-00146 Rome, Italy
3. IHP-Leibniz-Institut für innovative Mikroelektronik, Im Technologiepark 25, D-15236 Frankfurt (Oder), Germany
4. Dipartimento di Fisica, Università di Roma "La Sapienza", Piazzale A. Moro 2, I-00185 Rome, Italy
5. Dipartimento di Fisica "E. Fermi", Università di Pisa, Largo Pontecorvo 3, I-56127 Pisa, Italy
6. nextnano GmbH, Lichtenbergstr. 8, Garching b. München, D-85748, Germany
7. School of Engineering, University of Glasgow, Rankine Building, Oakfield Avenue, Glasgow G12 8LT, United Kingdom

Terahertz (THz) semiconductor based quantum cascade lasers (QCLs) represent powerful and compact integrated light sources. To date they have been realized with various III-V materials where LO phonon emission becomes very effective as the temperature is increased, limiting the maximum operating temperature to 200K. To overcome this limitation, non-polar material systems are attractive because of their weaker e-phonon interaction. Theoretical studies have indicated n-type Ge/SiGe heterostructures where transport is associated to L electrons, as the most promising architecture [1]. Experimentally, sharp intersubband transitions in n-type strain compensated Ge/SiGe QWs have been observed in the 20-50 meV region [2]. Recently, non-equilibrium Green's functions calculations proved to be efficient in optimising high temperature performance of GaAs/AlGaAs THZ QCLs [3]. In the effort of realizing a Ge/SiGe THz QCL, we present here a QCL structure designed by means of non-equilibrium Green's functions [4], whose the bandstructure is reported in Fig.1(a). Epitaxial growth of strain-compensated Ge/SiGe heterostructure (≈1.5 μm thick) has been carried out by means of UHV-CVD yielding very good sample quality as visible from Fig.1(b). Mesa devices for transport experiments have been fabricated by dry etching and metallization. In Fig.1(c) a series of I-V curves as a function of the heatsink temperature display a thermally activated behaviour with $E_{act} \simeq 10$ meV. From low temperature (4 K) magnetotransport [5] in a magnetic field parallel to the current direction shows characteristics oscillations. we can deduce an energy distance between the lasing states of E_{23} =19.5 meV, in good agreement with the theoretical calculation. Optical experiments are ongoing and experimental results will be presented.

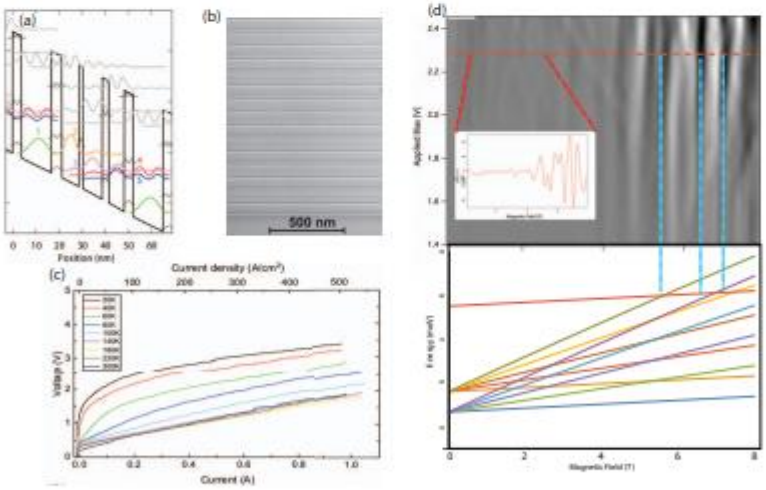

Fig. 1 (a): simulated bandstructure of one period of the 4QW Ge/SiGe QCL [2]. (b) TEM image of a Ge/SiGe QCL structure based on 5 QWs. (c): IV curves as a function of temperature for the 4 QW structure fabricated as a mesa structure. (d). Magneto-transport at 4K for the mesa structure of the 4QW design.

References

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