<u>My first 16 years with Quantum Cascade Lasers</u>

<u>Carlo Sirtori</u>
Matériaux et Phénomènes Quantiques, Université Paris Diderot and CNRS - UMR 7162,
75205 Paris Cedex 13, France
carlo.sirtori@univ-paris-diderot.fr

The quantum cascade (QC) laser is based on artificial potentials made of a sequence of nanometric semiconductor layers. The electronic and optical properties of this device are dependent on the potential design and can be tailored by choosing the appropriate layer sequence [1]. In this device there is no electron-hole recombination across the bandgap as the laser transition occurs between conduction band states arising from size quantisation in quantum wells. A direct consequence is that the emission wavelength does not depend on the band gap of the constituent materials and can be tuned by tailoring the thickness of the quantum wells.
More than 16 years ago I have contributed to the conception and first realisation of Quantum Cascade Lasers. During the years I have witnessed and contributed to the continuous performance improvements and now this semiconductor technology is an attractive choice for the fabrication of infrared lasers for spectroscopic and security applications. Presently, the best performances are obtained in the 4 – 12□m wavelength range, where continuous-wave room temperature operation is routinely achieved with Watt level optical power [2]. Conversely, in the far infrared (□ > 70□m) quantum cascade lasers operate only up to 160K.
After an introductory part on the principles of operation, I will present the state-of-the-art and performances of these devices. I will then comment on the fundamental physical challenges that still hold in this domain, pointing out some of our recent results on high frequency modulation and laser stabilisation [3,4]. I will conclude with a perspective on how these devices could be exploited in well established technologies for short range datacom transmission or spectroscopy.

References

[1] C. Sirtori, R. Teissier, "Quantum Cascade Lasers: Overview of Basic Principles of Operation and State of the Art" in *Intersubband Transitions in Quantum Structures*, pages 1-64, Mc Graw Hill.
[2] Y. Bai, S. Slivken, S. Darvish, M. Razeghi, "Room temperature continuous wave operation of quantum
cascade lasers with 12.5% wall plug efficiency," *Appl. Phys. Lett*. **93**, 021103 (2008).
[3] S. S. Dhillon, C. Sirtori, J. Alton, S. Barbieri, A. de Rossi, H. E. Beere, and D. A. Ritchie, "Terahertz transfer onto a telecom optical carrier," *Nature Photonics* **1**, 411 (2007)
[4] S. Barbieri, W. Maineult, S.S. Dhillon, C. Sirtori, J. Alton, H.E. Beere, and D.A. Ritchie, "13 GHz direct modulation of terahertz quantum cascade lasers," *Appl. Phys. Lett.*, **91,** 143510 (2007).