Quantum cascade laser: the source of choice for THz photonics?

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Laser action at THz frequencies was demonstrated one year ago in quantum cascade (QC) structures, thanks to the use of superlattice active material and to the implementation of a waveguide concept based on surface plasmon propagation. While the performance of these devices was already encouraging (mW peak output powers at 4.4 THz, 50 K maximum operating temperature), their development has proceeded very rapidly. Continuous wave operation is now a reality, output powers have been increased to about 10 mW, and operating temperatures have been improved to 70 K. Further emission frequencies have been achieved as well, down to about 3.5 THz with low threshold current densities of 100 A/cm^2. At the same time, new design concepts have been proposed and implemented by other groups, relying on optical phonon resonances or "bound-to-continuum" transitions. The latter have led to record high operating temperatures of 90 K. These advances are allowing the first QC-based THz applications to appear in various fields like chemical sensing, astronomy, and spectroscopy.

Despite this quick success, many fundamental questions still remain open. The most relevant regard obviously the possibility of reaching higher temperatures, ideally Peltier cooling or even room temperature. But other very significant issues are related to the interest for shorter frequencies (around 1 THz), and to the tunability of laser emission. The capability of answering these challenges in the near future will most likely determine the ultimate success of THz QC technology.

The present talk will analyse the latest achievements in this field and discuss existing limitations and their physical background. Strategies and routes, both in quantum design and fabrication, towards further developments in the above areas will be examined as well.