

# A continuous wave terahertz molecular laser pumped by a quantum cascade laser

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**Abstract**— We demonstrate a new approach to realize a continuous wave (CW) THz laser source that can be used as a local oscillator. It is based on a molecular gas optically pumped by a mid-infrared beam. Generally optically pumped terahertz lasers (OPTL) are pumped by CO<sub>2</sub> discharge lasers. They are bulky and have a low efficiency. Here we demonstrate for the first time the use of a solid-state mid-IR quantum cascade laser (QCL) as an OPTL pump laser [1]. The main advantage of the QCL is its continuous tunability compared to CW CO<sub>2</sub> lasers which are only tunable on discrete lines. It allows a larger degree of freedom in the choice of the molecule and in the transitions. Small molecules with large electric dipoles are good candidates to realize high efficiency and compact OPTL. Here, the active medium of the laser is made of low-pressure NH<sub>3</sub> gas enclosed in a cylindrical metallic waveguide closed by two flat mirrors. The mid-infrared QCL work at room temperature and its beam is focused in the cylindrical cavity through an input coupler. It is tuned to a transition between a ground state level and a  $\nu_2 = 1$  excited state level of the NH<sub>3</sub> molecule. Population inversion is achieved between excited state levels. The molecules de-excite by stimulated emission on pure inversion “umbrella-mode” quantum transitions. These transitions are allowed by the tunnel effect and their frequencies are close to 1 THz [1,2]. We have already demonstrated a CW output power of 0.35 mW at 1073 GHz. More than ten other laser lines can be also obtained around 1 THz. The generated power is sufficient to pump HEB or Schottky diode mixers. We believe that this source can be used as a local oscillator for heterodyne receiver applications.

[1] A. Pagies, G. Ducournau, and J.-F. Lampin, *Low-threshold terahertz molecular laser optically pumped by a quantum cascade laser*, APL Photonics **1**, 031302 (2016).

[2] A. Pagies, G. Ducournau, and J.-F. Lampin, *Continuous wave terahertz molecular laser optically pumped by a quantum cascade laser*, 41<sup>st</sup> International Conference on Infrared, Millimeter, and Terahertz Waves (2016).