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Mode-hop free wavelength scanning of a broadly tunable thermoelectrically cooled cw quantum cascade laser in external cavity configuration

Gerard Wysocki[a*], Robert F.Curl[a], Frank K. Tittel[a], Richard Maulini[b], Jean-Marc Bulliard[b], Jérôme Faist[b]

[a] *Rice Quantum Institute, Rice University, 6100 Main St., Houston, TX 77005, USA*
[b] *Institute of Physics, University of Neuchâtel, 1 A.-L. Breguet, CH-2000 Neuchâtel, Switzerland*

A widely tunable external cavity cw quantum cascade laser based on a piezo-activated mode tracking system is reported. Mode-hop free tuning of ~1.2cm^{-1} and a 35cm^{-1}coarse tuning suitable for high resolution spectroscopy was demonstrated for a .laser operating at 5.2 μm.

SUMMARY:

The development of laser spectroscopic techniques strongly relies on increasing the availability of new tunable laser sources. For applications in the mid-infrared (mid-IR) molecular fingerprint region quantum cascade lasers (QCLs) have proved to be convenient and reliable light sources for the spectroscopic detection of trace gases [1 and references therein]. Spectroscopic applications require single mode operation. This is usually achieved by introducing a distributed feedback (DFB) structure into the QCL active region. Although DFB QCLs show high performance and reliability, the range of wavelength tuning is limited by the limited tuning range of the DFB structures (typically the tuning range of ~10 cm^{-1} is achieved by varying either the temperature of the chip or the laser injection current). One of the disadvantages of thermal tuning is that it affects the effective gain of the QCL, which consequently causes a decrease of the optical power with increasing temperature of the QCL chip.

The QCL gain can provide sufficient amplification to achieve laser action over a much broader spectral range. In order to take advantage of this broadband tunability potential an external cavity (EC) configuration can be applied for wavelength selection [2]. EC lasers require an efficient reduction of the gain chip cavity finesse to enable mode-hop free wavelength tuning. This is usually obtained by deposition of an anti-reflective (AR) coating on the laser output facet. However it is very difficult to find AR coating materials with the right refractive index and optical properties that also have similar thermal expansion coefficients as the laser substrates. As a result, upon thermal cycling the AR coating tends to flake off.

Recently several groups have reported progress in the development of continuous wave (CW) QCLs operating at temperatures accessible with thermoelectric cooling [], which significantly reduces the problem of AR coating degradation by thermal cycling. In particular the development of bound-to-continuum QC lasers [4] has greatly alleviated both of these impediments to wide frequency tuning. Bound-to-continuum QC lasers have an intrinsically broader gain profile because the lower state of the laser transition is a relatively broad continuum.

Exploiting this development, this work reports on the development of a QC laser spectrometer for high resolution spectroscopic applications and multi species trace-gas detection in the mid-IR based on the design and implementation of a novel EC-QCL architecture (see Fig.1) [5]. The instrument employs a piezo-activated cavity mode tracking system for mode-hop

* Tel.: 713 348 2614, gerardw@rice.edu