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Widely Tunable External Cavity Quantum Cascade Laser for High Resolution Spectroscopy and Trace-gas Detection

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Quantum cascade lasers (QCLs) have proved to be robust light spectroscopic sources for mid-infrared (mid-IR) spectroscopic applications[1,2]. Recently QCL devices, which have the advantage of operating in continuous-wave (CW) mode at temperatures accessible with thermoelectric cooling, have been reported.[3] This feature makes them suitable for applications which require compact, sensitive, liquid-nitrogen free spectroscopic sources. Single mode operation of QCLs required for high resolution spectroscopic measurements is usually achieved by introducing a distributed feedback (DFB) structure into the QCL active region. Although DFB QCLs show high performance and reliability, wavelength tuning of the emitted laser radiation can be performed within a limited range by varying either temperature of the chip or the laser injection current. Typically the maximum thermal tuning range of DFB-QCLs is of ~10 cm^{-1}. An important drawback of this method is associated with a strong decrease in laser power with increasing operating temperature. The usual gain curve of the QCLs can provide sufficient amplification to achieve laser action within a much broader spectral range e.g. a luminescence spectrum of 297 cm^{-1} FWHM (full width at half maximum) at room temperature was observed for $\lambda \approx 10$ μm QC devices employing bound-to-continuum transitions.[4] In order to take advantage of this broadband tunability potential an external cavity (EC) configuration can be applied for wavelength selection.[4,5,6] In this work an EC-QCL configuration with the gain medium fabricated using a bound-to-continuum design and operating at ~ 5.2 μm will be reported. The EC architecture employs a piezo-activated cavity mode tracking system for mode-hop free operation suitable for high resolution spectroscopic applications and multi species trace-gas detection. The parameters of the current gain chip allow coarse single mode tuning over 35 cm^{-1} (see Fig. 1) and the mode-hop free fine tuning range of ~ 1.3 cm^{-1}. Fig.2 shows an example of a wide wavelength range, high resolution (see inset) spectrum of nitric oxide (NO). The designed mode-tracking system is very flexible and allows its application virtually at any wavelength without changing the EC-QCL configuration.

KEYWORDS: quantum cascade laser, external cavity diode laser (ECDL), extended cavity, mid-IR spectroscopy

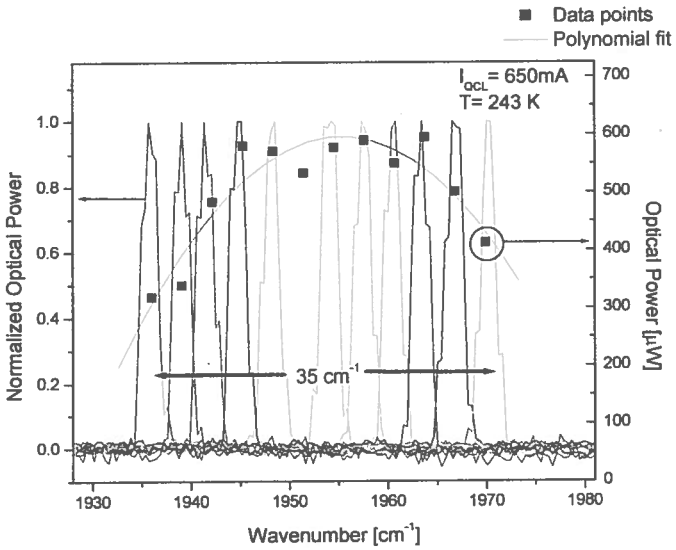

Fig.1 Single mode tuning range of the EC-QCL.

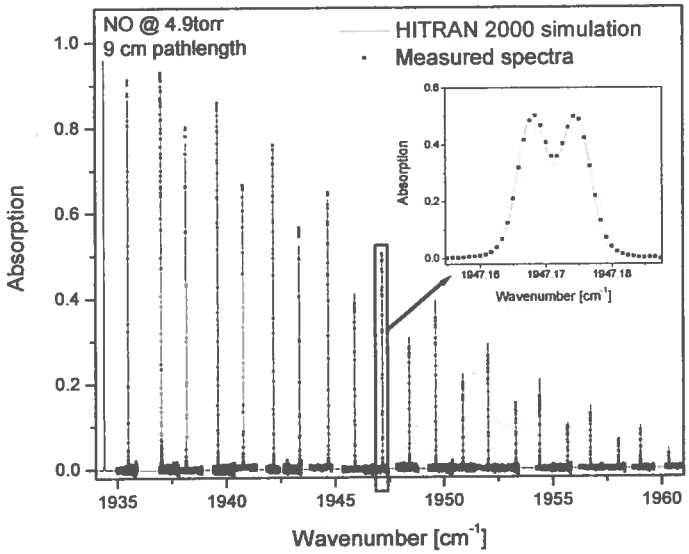

Fig.2 High resolution NO spectrum at 5.2 μm acquired with a broadly tunable EC-QCL.

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