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BROADLY TUNABLE EXTERNAL CAVITY QUANTUM CASCADE LASERS AND APPLICATIONS

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The mid-infrared (mid-IR) spectral region (~3-20 μm) is of particular importance for high sensitivity concentration measurements of chemical species in vapor phase, because many gases have their strongest ro-vibrational transitions in this spectral range. Application of tunable lasers, which enable measurements on and off resonance with a spectral absorption feature, allows for selective and sensitive spectroscopic measurements and for precise real time quantification of trace gas concentrations often without any sample preparation.

Quantum cascade lasers (QCLs) have proved to be robust tunable semiconductor laser sources for mid-IR spectroscopic applications [1]. Continuous wave, room-temperature QCL devices are now available for applications that require compact, high power (>100 mW), liquid-nitrogen free, mid-infrared spectroscopic sources [2, 3]. Spectroscopic applications of conventional, narrowly tunable QCLs are primarily limited to target absorption lines of molecules with well resolved rotational-vibrational structure. In this work we focus on development of widely tunable mid-IR QCL sources based on external cavity configuration, which allow for high resolution spectroscopic measurements of multiple molecular species including complex molecules with wide absorption spectra. Several examples of broadly tunable EC-QCL sources exhibiting tunability of up to 15% of the center wavelength, >100mW cw optical output powers, and capability of mode-hop-free tuning with spectral resolution of <30MHz will be presented.[4]

A number of spectroscopic sensing applications that were enabled by the EC-QCL technology will be reported. Examples will include high resolution spectral measurements of small molecules (e.g. nitric oxide, ammonia) at atmospheric and reduced pressures, as well as detection of broadband absorbers with unresolved rotational structure (such as acetone, Freon, and ethanol) [5, 6]. These examples will also demonstrate capabilities of the EC-QCL technology used in combination with different spectroscopic measurement methods such as direct laser absorption spectroscopy, quartz enhanced photoacoustic spectroscopy (QEPAS), laser heterodyne radiometry, and Faraday rotation spectroscopy.

References to a Journal publication:
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