QCL-based sensors for chemical kinetic applications

Aamir Farooq

Clean Combustion Research Center, King Abdullah University of Science and Technology, Jeddah, Saudi Arabia
aamir.farooq@kaust.edu.sa

ABSTRACT

Quantum cascade lasers (QCL) have revolutionized the spectroscopic investigations due to their unique capability of providing access to the *fingerprint* mid-infrared wavelength region. Laser absorption diagnostics based on QCLs thus enable quantitative, time-resolved species concentration and temperature measurements in complex chemically reactive systems. This talk will discuss some of the recent applications of QCLs to chemical kinetic studies.

First, a pair of pulsed QCLs, targeting the fundamental vibrational band of carbon monoxide, were implemented on an RCM to measure gas temperature during the two-stage ignition process. The down-chirp phenomenon resulted in large spectral tuning (~ 3 cm^{-1}) within a single pulse of each laser at a high pulse repetition frequency (100 kHz). The wide tuning range allowed the application of two-line thermometry technique, thus making the sensor quantitative and calibration-free.

Second, a diagnostic was developed for measuring trace concentration of CO using a pulsed QCL and an off-axis cavity. The duty cycle and pulse repetition rate of the laser were optimized for increased tuning range, high chirp rate and increased line-width to achieve effective laser-cavity coupling. This enabled spectrally resolved CO line-shape measurements at high pressures (P ~10 bar) and moderate temperatures (600 - 1000 K). A gain factor of 133 and time resolution of 10 μs were demonstrated. This represents the first application of a cavity-enhanced absorption diagnostic in an RCM.