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## Quantum cascade lasers for sensitive trace gas sensing applications

**Esha Manne**

Lam Research Corporation, USA

The mid-infrared region of the spectrum has been of great interest to molecular spectroscopists for many years. This region, covering 2.5–16  $\mu\text{m}$ , is ideally suited for sensing applications since many gaseous compounds have fundamental vibrational absorption bands in this range. Various laser spectroscopic techniques have been developed and used for the quantification of trace gas species. Applications of pulsed quantum cascade (QC) lasers, along with the availability of room temperature detectors, promise better detection sensitivities in a cryogen free environment. These pulsed QC lasers have been used in many different ways for gas sensing applications. Noise reduction techniques include rapid sweep integration, modulation, balanced beam and zero-background subtraction methods. In addition, various signal enhancement methods based on long path lengths, employing multipass cells and cavity based techniques have been implemented. These include cavity ring-down spectroscopy (CRDS) and cavity enhanced methods, which lead to absorption paths up to several kilometers in length.

esha.manne@lamresearch.com