Sensitivity Enhancement in Off-Axis Integrated Cavity Output Spectroscopy

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In cavity-enhanced techniques the absorption path length can be increased up to several kilometers, hence enhancing the sensitivity significantly. The development of off-axis integrated cavity output spectroscopy (OA-ICOS) offered mechanical robustness and relatively simple alignment for field measurements, being used for race gas detection in numerous studies during recent years, such as atmospheric studies and breath analysis. The method can straightforward be implemented, making it less technically demanding and more cost effective than other laser-based methods. A major drawback of OA-ICOS is the significantly reduced cavity transmitted power due to highly reflective mirrors, which impact on the sensitivity of the sensor. It becomes critical when low power lasers and room-temperature detectors with limited detectivity are the only suitable or available devices for the designed system. To overcome this drawback, we report on a model of a three mirror OA-ICOS setup that re-injects the light reflected by the optical cavity. We present a detailed model on how the optimization process can be performed to achieve optical enhancement. The influence of different re-injection parameters and their effect on the signal-to-noise ratio (SNR) are presented and compared to the experimental results of real-time detection of ethylene with a pulsed distributed feedback Quantum Cascade Laser at a wavelength of 10 micrometer.