

Multiplexed Sensor for Synthesis Gas Composition and Temperature

#DE-FG26-04NT42172 Program Manager: Robie Lewis

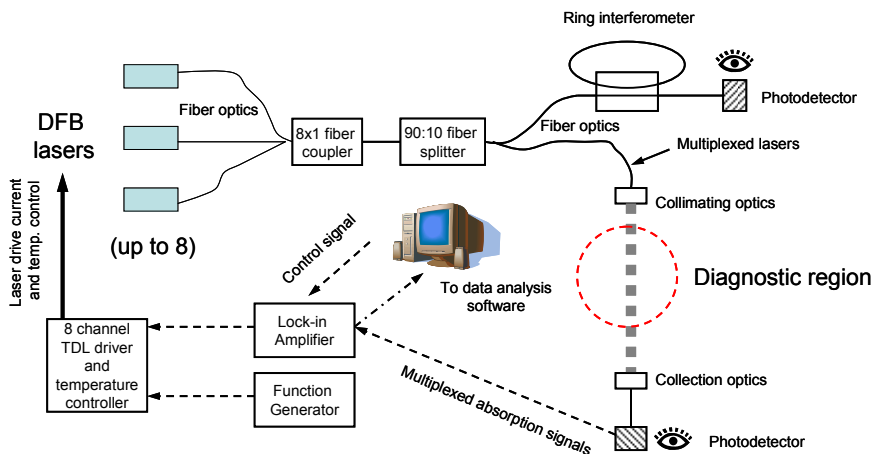
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Objectives

The overall goal of this project is to develop a highly sensitive, multiplexed TDL-based sensor for CO₂, CO, H₂O (and temperature), CH₄, H₂S, and NH₃. Such a sensor will be designed with so-called “plug-and-play” characteristics to accommodate additional sensors, and will provide *in situ* path-integrated measurements indicative of average concentrations at speeds suitable for direct gasifier control. The project will develop the sensor and culminate in a real-world test of the sensor. The products of this research are expected to have a direct impact on gasifier technology and the production of high-quality syngas, with substantial broader application to coal and other energy systems.

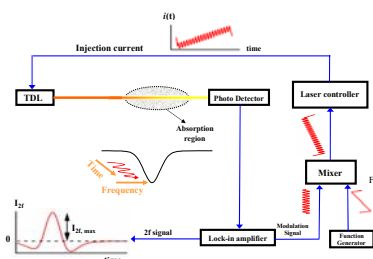
Hardware and Software



Several lasers can be simultaneously multiplexed down a single transmission fiber, captured on a single detector, and demodulated in software.

Method - WMS

- Modulation of the laser(s) followed by lock-in detection of laser signal(s) rejects noise and yields 1-2 orders of magnitude improvement in sensitivity over direct absorption.
- Several lasers can be multiplexed in a single fiber and demultiplexed using frequency- and phase-sensitive detection.
- Proven using our UCSD laboratory and in field settings.



Modulation scheme

Advanced Labview™ software controls system

Control of laser parameters

Control of graphical output

Ability to save spectra

1st harmonic (column)

2nd harmonic (column)

Four channels showing H₂O, CO₂, CH₄, and CO spectra

Flexible software written using National Instruments' Labview™ allows adjustment of parameters and saving of data.

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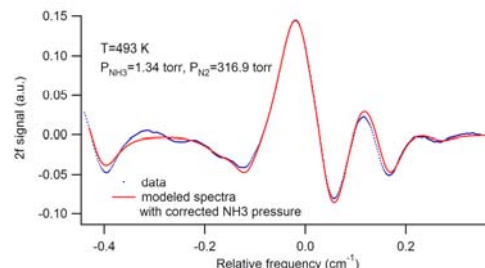
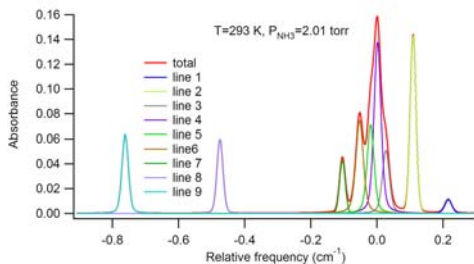
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Spectroscopy

- Measurement of a) Line location, b) line strength (function of T), and c) broadening coefficients for multiple bath gases
- Accomplished for CO, CO₂, CH₄, H₂O, H₂S, and NH₃

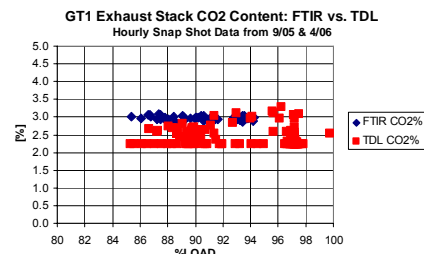
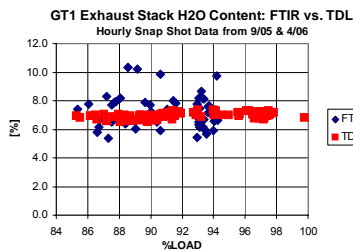
Line	ν_0 (cm ⁻¹)	ν_a (cm ⁻¹)	ν_b (cm ⁻¹)	S_0 (cm ⁻² atm ⁻¹)	σ_a	σ_b
1	6612.937	-	-	0.0031	0.001	0.0003
2	6612.831	6612.827	-	0.0386	0.000	0.0003
3	6612.748	-	6612.734	0.0194	0.000	0.0002
4	6612.723	6612.718	6612.723	0.0503	0.000	0.0010
5	6612.702	-	6612.695	0.0291	0.001	0.0006
6	6612.669	6612.667	-	0.0316	0.001	0.0009
7	6612.617	-	6612.615	0.0102	0.000	0.0006
8	6612.248	-	-	0.0173	0.000	0.0002
9	6611.961	-	-	0.0205	0.001	0.0002



Spectroscopy example for NH₃: Line locations (left), measurement of multiple lines (with overlap) of NH₃, modeled and measured spectrum at nearly stack conditions.



Tests



Field trial comparing FTIR and TDL measurements in UCSD power plant gas turbine stack. Photo at left, data above.

Accomplishments

Good progress has been made on this project.

Significant accomplishments include:

- Innovations in sensor design and instrument development, the subject of several disclosures to the UCSD technology transfer office;
- Continuous improvements in our understanding of the high-temperature near-infrared spectroscopy related to the molecules under study; and
- Demonstration of a flexible multi-gas sensor with numerous potential applications.



Integrated laser control box

References

M. Gharavi and S.G. Buckley, "Pressure broadening parameters of H₂O absorption transitions of 2v₁ and 2v₂+v₃ bands at elevated temperatures," submitted, Journal of Quantitative Spectroscopy & Radiative Transfer.

M. Gharavi and S.G. Buckley, "Calibration-free wavelength modulation spectroscopy for temperature and H₂O concentration measurement using a single diode laser," submitted, Applied Optics

"Patent pending"

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