Multiplexed Sensor for Synthesis Gas Composition and Temperature

Steven G. Buckley

University of California, San Diego
Department of Mechanical and Aerospace Engineering
9500 Gilman Drive; MS 0411
La Jolla, CA 92093-0411

858-534-5681 (phone)
858-534-5354 (fax)
buckley@ucsd.edu

Grant number DE-FG26-04NT42178
Performance Period : 9/1/04 – 10/31/06

Objectives:
The overall goal of this project is to develop a highly sensitive, multiplexed TDL-based sensor for CO_2, CO, H_2O (and temperature), CH_4, H_2S, and NH_3. Additional gases may be considered based on availability of lasers. 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 sensor will work over a range of pressures and temperatures expected in an operating gasifier. 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.

Phase I of the project is devoted to finalizing both the spectroscopic and mechanical design of the sensor. Following design, Phase II will focus on construction and development of the probe for high temperature and high pressure measurements in a laboratory setting. Finally, Phase III of the project will involve testing of the sensor in a real-world setting.

Accomplishments to date:
Phase I of this project was nearly completed as of late March 2005. Diagnostic wavelengths corresponding to measurement of CO, CO_2, H_2O, CH_4, NH_3, and H_2S have been selected, and lasers for each of these gases have been ordered. The H_2O and CH_4 sensors, products of previous work, have been completely characterized over a range of temperatures from room temperature to 1000 ºC. The lasers for CO and CO_2 have already been received, and spectroscopy for these molecules is being characterized (Fig. 1). Additional glass spectroscopic cells for NH_3 and H_2S, which present handling challenges due to their toxicity and their stickiness, are being fabricated.

Considerable effort has gone into investigation of hardware for data processing; we have selected a National Instruments high speed data acquisition system that can provide the high frequency lock-in modulation necessary for the high speed measurements, while performing the lock-in detection in programmable (Labview™) software. This system, which was ordered in March, will allow modular and controllable multiplexing with lock-in detection, which significantly enhances the measurement sensitivity and stability.

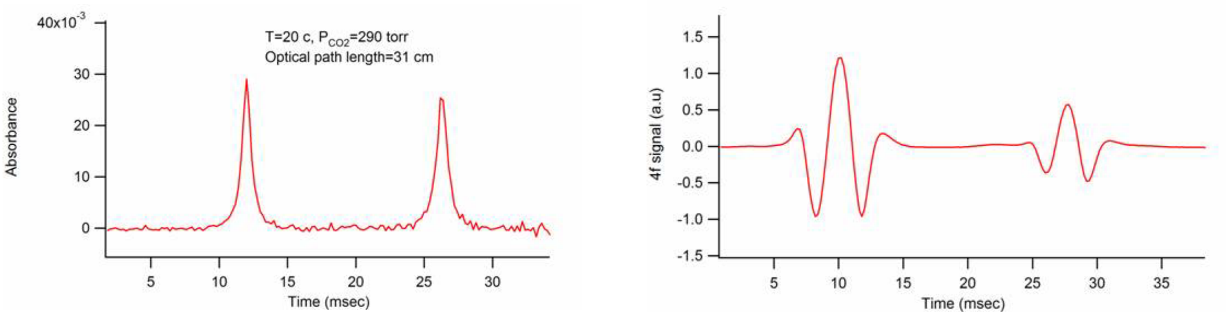

Figure 1: Direct absorption and 4th harmonic wavelength modulation spectroscopy signals corresponding to CO_2 at room temperature.

Preliminary Labview™ software has been developed to perform real-time measurements with wavelength modulation spectroscopy using existing lock-in amplifiers. Currently, this is being modified to incorporate software lock-in detection in preparation for receipt of the new National Instruments hardware.

Future work:
The bulk of this project remains ahead of us. Characterization of the high temperature spectroscopy of CO, CO_2, NH_3, and H_2S, along with the pressure effects on the spectrum, will be the bulk of the next year's laboratory work in Phase II. Concurrently, software development will proceed to allow real-time measurement of multiple species with the multiplexed sensor in conjunction with the new data acquisition hardware.

Initial contacts have been made to facilitate the Phase III field test, with further progress toward defining this event expected in the next six months.

Papers in preparation (partially or fully supported by this grant):
M. Gharavi and S.G. Buckley, **Diode Laser Absorption Spectroscopy Measurement of Line Strengths and Pressure Broadening Coefficients of H_2O,** to be submitted to *Journal of Quantitative Spectroscopy and Radiative Transfer.*

Students / trainees supported under this grant:
Dr. Mohammadreza Gharavi (post-doctoral researcher)
Ariel Schuger (graduate student)
Geoff Rapoport (undergraduate)