ELSEVIER

Applied Energy 65 (2000) 107–113

APPLIED ENERGY

www.elsevier.com/locate/apenergy

Diode laser sensor for process control and environmental monitoring

Y. Zaatar [a,*], J. Bechara [a], A. Khoury [a], D. Zaouk [a], J.-P. Charles [b]

[a] *Lebanese University, Faculty of Science II, Physics Department, APolLos Laboratory, BP: 90656 Jdeidet, Fanar, Lebanon*

[b] *University of Metz, L.I.C.M. — CLOES — Supélec de Metz, 52, rue E. Berlin, 57058 Metz, France*

Abstract

Absorption spectroscopy with tunable diode lasers (TDLAS) in the infrared region is a well-known technique for the chemical analysis of gas mixtures. The laser provides a high selectivity, which is important in industrial environments such as in-line stack monitoring, where complex gas mixtures are present. A wavelength tunable diode laser in the near infrared region has been utilized as a light source in absorption measurements of air pollution resulting from energy usage for industry. The emission frequency can be varied over a relatively wide spectral range by changing the current and temperature of the diode.

Keywords: Methane; Modulation; Pollution; Spectroscopy; Tunable diode laser

1. Introduction

Atmospheric pollution has become one of the most important environmental problems facing international society. The composition of the Earth's atmosphere is changing rapidly resulting from energy usage for industry and lack of control of industrial emissions in most countries.

Some atmospheric pollutants, such as ozone, SO_2, volatile hydrocarbons, CFCs and nitrogen oxides, can have a large impact on our environment, even in small concentrations. Major environmental problems such as acid rain, formation of

* Corresponding author. Tel.: +961-1-681-553; fax: +961-3-291-644.

E-mail addresses: lusc2@cnrs.edu.lb and yzaatar@technologist.com (Y. Zaatar), charles@ese-metz.fr (J.-P. Charles).

0306-2619/00/$ - see front matter
PII: S0306-2619(99)00090-2

smog, and the destruction of the ozone layer are due to the increasing concentration of these pollutants in the atmosphere. The detection of these pollutants, the identification of their sources and the surveillance of their evolution in the atmosphere, require analytical techniques of high sensitivity for real time and in situ measurements. All these features make TDLAS important for industries and environmental control agencies.

A tunable diode laser absorption spectroscopy system has been constructed at the Lebanese University (Faculty of Science II) and preliminary studies have been carried out with methane as the reference gas.

One of the most useful features of this diode laser is wavelength tunability. It can most conveniently be accomplished by changing its temperature. Small temperature changes, for fine tuning, can be made by varying the injection current through the diode.

Near-infrared (NIR) diodes have power outputs in the mW range and operate at or near room temperature, which permits the use of small thermoelectric devices for temperature control. Diode lasers which emit in the wavelength regions 0.76–0.9, 1.28–1.35, 1.48–1.56 μm are used in telecommunication and consumer products and are, therefore, relatively inexpensive, readily available and generally of high quality [1] (Table 1).

For these molecules, the relatively low price and ability to operate at, or near room temperature, permit the construction of compact inexpensive systems. Diode lasers with wavelengths suitable for measuring other molecules, are currently more difficult to obtain and more expensive

2. Description of the system

The laser is selected according to three criteria:

- absorption line sufficiently strong to obtain maximum sensitivity;
- mode characteristics of the laser emissions as clean and narrow; and
- absence of interference from other gases.

The temperature stabilization and the current of the laser are driven by an OEM (Opto-Electronic Module) from Melles Griot. Once the temperature of the diode laser is stabilized, its wavelength is tuned by a current ramp; this ramp being

Table 1
Some species detected by a tunable diode laser at different wavelengths

H_2O, HF, CH_4	1.33 μm
CO_2	1.57 μm
CO	1.57 μm
C_2H_2, NH_3	1.53 μm
NO_2	0.79 μm