Quantum Cascade Laser Absorption Spectroscopy (QCLAS) applied for a temperature study of low pressure pulsed dc plasmas

M. Hübner[1], D. Marinov[2], O. Guaitella[2], A. Rousseau[2], J. Röpcke[1]

[1]*INP Greifswald, Felix-Hausdorff-Str, 17489 Greifswald , Germany E-mail: huebner@inp-greifswald.de*
[2]*LPP, Ecole Polytechnique-91128 Palaiseau, France*

Quantum cascade laser absorption spectroscopy (QCLAS) has been used to measure the gas temperature during ms dc plasma pulses. The method is based on the intensity ratio of two absorption structures of NO. The influence of non-linear absorption phenomena in the low pressure range was considered by comparison with a simulated spectrum. The reliability of the method was validated at a heated gas cell without plasma ignition.

1. Introduction

Increased concerns about pollution control have led to growing interest in gas cleaning technologies. Plasma technology has proofed its ability to remove harmful gases from an air stream. For these experiments, an important parameter is the gas temperature.

In this contribution, a method is presented which applies quantum cascade laser absorption spectroscopy (QCLAS) to the measurement of the temperature of NO which has been used as a probe gas. This demonstrates the principal possibility to measure the temperature using QCLAS despite the strong disturbance of absorption structures. Such phenomena are caused by non-linear effects, e.g. rapid passage or saturation effects, due to the high tuning rate and intensity of the probing laser.

2. Experimental Setup

The experiments have been done in a tube reactor made of Pyrex with an inner diameter of 20mm and a length of 60cm [1]. QCLAS has been performed using a three channel spectrometer, TRIPLE Q [2], running in the Intra Pulse Mode with a pulse width of 150 ns and a pulse repetition frequency of 30 kHz. For the experiments, the single line absorption structure of NO at 1900.52cm^{-1}, NO($X_{3/2}$, υ = 0) → NO($X_{3/2}$, υ = 1): R6.5, and the double line absorption structure of NO at 1900.08cm^{-1}, NO($X_{1/2}$, υ = 0) → NO($X_{1/2}$, υ = 1): R6.5, of a gas mixture of 1% NO in air at 1.3 mbar initial pressure have been used.

The gas temperature has been calculated applying the line ratio method [3]. The ratio of the intensity of two absorption structures depends on the temperature. Consequently, the ratio has been used to study the gas temperature. However, the recorded spectra show huge distortions of the absorption structures due to non-linear absorption effects. These phenomena are not fully understood. There influence, however, has been compensated using simulated spectra with the help of the HITRAN database [4].

From the simulated spectra, a calibration factor has been determined which allows one to calculate the correct temperature from the disturbed spectra.

3. Results

As an example, the temperature at the end of a 5ms dc plasma pulse is given in figure 1. Four mean plasma currents have been applied.

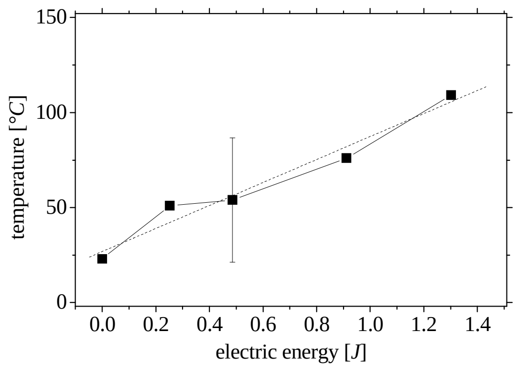

Fig. 1: *Calculated NO temperature of a pulsed dc plasma measured using the line ratio method. The electric energy corresponds to a mean pulse current of 25mA, 50mA, 100mA and 150mA, respectively. The dashed curve shows a linear fit.*

Acknowledgements

This work was supported by the French-German PROCOPE Project D/0502183 and the DFG SFB-TR 24.

References

[1] L. V. Gatilova et al.: PSST 16 (2007), 107

[2] M. Hübner et al.: Rev. Sci. Instrum. 82, (2011), 093102

[3] M.G. Allen: Meas. Sci. Technol. 9 (1998), 545

[4] HITRAN, 2012, http://www.cfa.harvard.edu /hitran/