Measurement of the CH rotational temperature in DBD discharges in CH_4/CO_2/He mixtures and simulation of the gas temperature

N. Pinhão[1], J. Branco[2]

[1] *Instituto de Plasmas e Fusão Nuclear, Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal*

[2] *Centro de Ciências e Tecnologias Nucleares, Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal*

This work is dedicated to the measurement of the CH rotational temperature on micro-discharges in an atmospheric pressure DBD plasma in CH_4/CO_2/He mixtures. The rotational temperature is obtained from the optical emission of the CH (A $^2\Delta$ - X $^2\Sigma$) transition. The discharge is produced either by an ac or fast pulse generators. The CH rotational population shows a bimodal distribution with a high temperature tail and thermalized body. To evaluate if the rotational temperature is a good indication of the gas temperature, we have computed the gas temperature profile for a given input power through the simultaneous solution of the heat and Navier-Stokes equations. The modeling values are consistent with the rotational temperatures obtained.

1. Introduction

Non-thermal plasmas have been used for the conversion of methane/CO_2 mixtures into synthesis gas (CO/H_2) and higher hydrocarbons. In order to understand the chemical kinetics and build reliable models for these mixtures, it is necessary to know the gas temperature of the micro-discharges. Previous studies on CH_4 and CH_4/CO_2 mixtures [1] using the CH (A $^2\Delta$ – X $^2\Sigma$) transition have found rotational temperatures, T_r, between 50-200 degree higher on the micro-discharges than the volume averaged gas temperature. In this work we study the influence of the specific energy input, the dilution in helium, and the type of power supply on T_r. In order to assess the gas temperature distribution on the reactor and compare with the T_r, we build a model for the gas and heat fluxes along the reactor taking into account the input power, the chemical energy efficiency and the energy losses to the surrounding air.

2. Experimental set-up and modeling

The experimental system is described in [2]. It is a cylindrical DBD reactor powered by three type of generators: a sinusoidal generator with frequencies of 5-20 kHz and two pulse generators: (i) a solid state switch producing 1.2 µs width rectangular pulses with 80 ns raise time and repetition rate of 2-10 kHz and, (ii) a drift step recovery diode generator producing pulses with <4 ns rise time, 10 ns FWHM and repetition rate of up to 3.5 kHz. The CH rotational bands were monitored with a mini-optical spectrometer with a 1.7 nm resolution and cooled to -10 ºC. The numerical results were obtained with the Elmer multi-physics FEM code coupling the Navier-Stokes and the heat equations. The power input corresponds to the experimental values.

3. Results

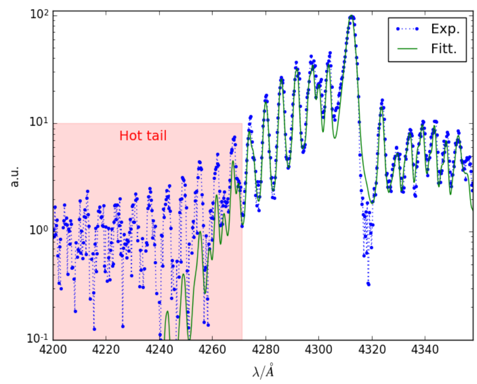

Figure 1: CH spectra showing the hot tail. Points: experimental results; lines: fit with LIFBASE

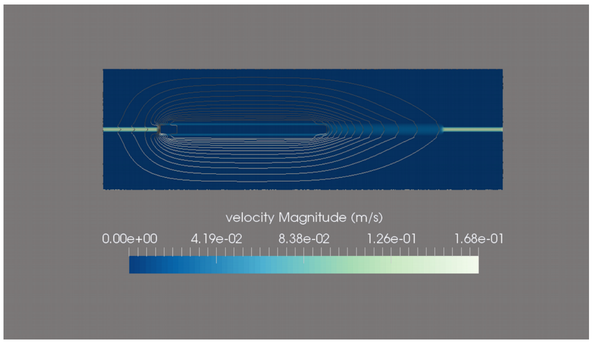

Figure 2: Color scale: Gas velocity on the reactor; Contour lines: temperature distribution from 300 K to 580 K with steps of 25 K

3. References

[1] J. Luque, M. Kraus, A. Wokaun, K. haffner, U. Kogelschatz and B. Eliasson *J. Appl. Phys.* **93** (2003) 4432-4438.

[2] N. Pinhão, A. Moura, J.B. Branco and J. Neves *Int. J. Hydrogen Energy* **41** (2016) 9245

Acknowledgments: This work was funded by Portuguese FCT – Fundação para a Ciência e a Tecnologia, under project UID/FIS/50010/2013.