

Spectroscopic study of the neutral gas temperature of silicon based DC MHCD in various gases close to atmospheric pressure

S. Iseni¹, R. Michaud¹, P. Lefauchaux¹, V. Schulz-von der Gathen², G. B. Sretenovic³, R. Dussart¹

¹GREMI, UMR7344 CNRS/Univ. Orléans, 45067 Orléans, France

²Ruhr-Univ. Bochum, Experimental Physics II, 44801 Bochum, Germany

³Faculty of Physics, Univ. of Belgrade, P.O. Box 44, 11001 Belgrade, Serbia

1. Introduction

Micro hollow gas discharges (MHCD) have been on high interest to produce highly ionized gas while keeping the gas temperature close to room temperature[1]. The first concept of MHCD reactors was introduced in the late 90's and has been developed over the past decade to support a large amount of applications[1]. For instance one can mention the production of (V)-UV radiation, lightening, gas purification, surface activation, material and volume decontamination via the production of biologically active reactive chemical species (O , O_3 , $O_2(a^1\Delta_g)$). Although several designs and geometries have been developed to produce micro-cavities, MEMS fabrication technologies offer several advantages. For example, a silicon (Si) based MHCD allows for reducing significantly the electrode gap ($8\ \mu\text{m}$ SiO₂ layer) and the cavity size (typically from 50 to $200\ \mu\text{m}$ diameter, $30\ \mu\text{m}$ depth)[2,3]. Operated in DC at pressure ranges from $2 \cdot 10^4$ to 10^5 Pa, the plasma ignites in the cavity and operates in the so-called *quasi-normal* regime. Transition to the abnormal regime leads to an expansion of the plasma out of the cavity. Although Si-based MHCD operating in DC used to suffer from their short lifetime[4], recent advances on the MHCD design allow for extending their lifetime to several days of operation[5].

2. Motivation

This study focuses on the accurate measurement of the gas temperature inside and outside the micro-cavity in order to support other diagnostic techniques which require values of the gas temperature but also to better understand the plasma chemistry. Knowing the gas temperature will help to understand the material modifications and the development of new micro-reactors.

3. Approach and Results

The study of the gas temperature is carried out by means of space resolved optical emission spectroscopy. Two approaches are used depending on the gas mixture (He, Ar and N₂).

The profile of resonant atomic lines taking in to account the Van der Waals broadening is thoroughly analyzed to infer the gas temperature. Figure 2 presents an example of a spectral line dominated by the resonant broadening compared to a transition with a line-shape resulting mainly from the Van der Waals interactions and the instrumental function. The reevaluation of the value of a dedicated constant will be discussed.

A complementary approach based on the determination of the N₂(C-B) rotational temperature is considered. Discrepancies regarding the rotational temperatures of different vibrational band are reported. Limitations of the latter approach will be discussed specifically.

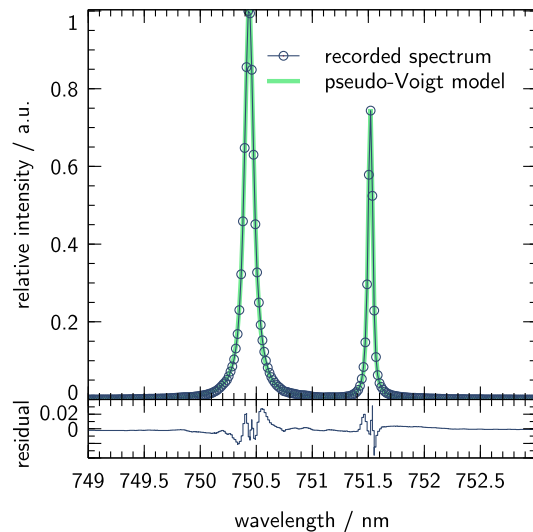


Fig. 1: Comparison of a dominated resonance broadening transition with a resonance-free lineshape in Ar spectrum.

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