ACTIVE SPECIES GENERATION OF HOMOGENEOUS DBD IN N2: EXPERIMENT AND MODELLING

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Abstract. Two regimes of DBD discharges, uniform Townsend and filamentary one, was studied in nitrogen at atmospheric pressure. The aim is to help in the understanding of the processes that take place in the two regimes. Attention has been paid to the chemical kinetic occurring in the gas phase. The discharge was characterized through electrical measurements, coupled with optical diagnostics. One interesting result is that while the electron density is much lower in the APTD than in the filamentary discharge, the Townsend discharge is really efficient for the creation of N atoms: densities as high as 3×10^{14} cm^{-3} has been measured. These measurements are used to validate direct numerical simulation in 0D, taking into account the surface processes which appear to have an important role.

1. INTRODUCTION

Due to their relatively low cost, their robustness, and the low-temperature in which they operate, Dielectric Barrier Discharges (DBD) at high pressures (typically atmospheric pressure) have great potential for a variety of applications, such as ozone generation, depollution, plasma display panels, biological application, actuators flow control and large-scale surface treatment and material processing [1].

Depending on the operating conditions, such as the electrical excitation, the gas atmosphere and the electrode configuration, the DBD can operate in two discharge regimes: filamentary or homogenous. Concerning the filamentary regime, the discharge consists of a multitude of micro-discharges (diameter~100 µm, time duration=10-100 ns), also referred to as filaments, in which the electron and ion density can reach values of 10^{13}/cm^3 for a courant density about 100-1000A/cm^2 [1,2]. For the homogeneous regime, the discharge is uniform along the electrode surfaces and no filament is observed. In nitrogen, the homogeneous DBD is called Atmospheric Pressure Townsend Discharge (APTD) or Townsend DBD (TDBD) [3,4,5]. Indeed, it presents several features which are typical for the dark Townsend discharge known at low-pressure: it is characterized by the presence of a uniform positive space charge in between the 2 electrodes, the electric field is uniform from the anode to the cathode, and the density of charged particles is very low (10^8/cm^3 for electrons, 10^{10}/cm^3 for positive ions) [3]. Looking to the visual aspect of the APTD, the light intensity is located near the anode. The electrical characteristics consist on a periodic discharge current with only one large pulse per half-period (time duration ~100 µs) and low amplitude (mA/cm^2).

It is known that DBDs can be an efficient a source of active species, such as O_3, NO, N, O, OH [1,6,7,8,9,10,11,12,13]. Due to their high reactivity, these species play a key role in the plasma chemistry and also in the surface chemistry. However, most of the density measurements are done in the afterglow region and only a few are done inside the discharge area. Concerning the APTD, to our knowledge, only one paper deals with such in-situ measurements, for the $N_2(A^3\Sigma_u^+)$ detection [14].

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