

NUMERICAL SIMULATION OF ATMOSPHERIC PRESSURE TOWNSEND DISCHARGES IN NITROGEN WITH HYDROGEN GAS ADMIXTURES

Jánský J.¹, Trunec D.¹, Navrátil Z.¹, Brandenburg R.² and Wagner H.-E.³

¹Masaryk University, Faculty of Science, Department of Physical Electronics,
Kotlářská 2, 602 00 Brno, Czech Republic

²INP Greifswald e.V., Leibniz-Institute of Plasma Science and Technology,
Felix-Hausdorff-Str. 2, D-17489 Greifswald, Germany

³University of Greifswald, Institute of Physics, Felix-Hausdorff-Str. 6, D-17489 Greifswald, Germany

Abstract. In this contribution the influence of hydrogen admixture on an Atmospheric Pressure Townsend Discharge (APTD) in nitrogen is investigated by means of numerical modelling and experiments. The numerical model is a one-dimensional fluid model. Electron emission from dielectrics by a diffusion flux of metastable molecules and photoemission are incorporated in the model. The secondary emission due to ions is neglected. The results are compared with measured electrical parameters (ignition voltage, voltage necessary for causing the transition to the filamentary regime and current evolution). The measured and simulated current profiles of discharge in nitrogen-hydrogen mixture are similar for applied voltages close to ignition voltage. The simulations give a qualitative explanation for the measured current profiles in pure nitrogen and for small admixtures of hydrogen. The results indicate that the influence of hydrogen on the APTD is due to the quenching of the main metastable state $N_2(A^3\Sigma_u^+)$ by hydrogen molecules and atoms. Generally a APTD typical one-peak current structure is caused by secondary electron emission by nitrogen metastable molecules, a current pulse with multiple peaks is caused mainly by secondary emission of ions or photoemission.

1. INTRODUCTION

Dielectric barrier discharges (DBD) also referred to as silent discharges or dielectric barrier discharges usually operate in the filamentary mode at atmospheric pressure, i.e. the plasma consists of the large number of individual microdischarges or filaments with short duration and small diameter. The coverage of the surface by the filamentary plasma is non-uniform and thus filamentary DBD are often seen to be unfavorable for surface treatment applications. But at specific conditions uniform DBD plasma, the so-called diffuse DBD can be generated [1, 2]. So far diffuse BDs were found to exist in two different modes, namely as Atmospheric Pressure Glow Discharge (APGD) and Atmospheric Pressure Townsend Discharge (APTD). The latter is observed commonly in nitrogen. APTD existence was found to be very sensitive to gas impurities or admixtures, e.g. to precursor gases. Therefore a profound knowledge on the discharge processes and the effect of gas admixtures is needed in order to develop new applications.

Within the last years several applications of diffuse DBD were demonstrated [3, 4]. However, the discharge formation processes are still a subject of controversial discussions. First hypothesis explained the existence of diffuse DBD by memory effects, caused by presence of active species (e.g. metastable or charge carriers) in the discharge gap before the breakdown. Furthermore, the role of surface processes like electron desorption and secondary electron emission by metastables was discussed [4, 5], since quenching of metastables leads to a considerable weakening of the memory effects. Another hypothesis taken into account was interaction between the plasma and the power supply [6]. The aim of this paper is to clarify the conditions for the generation of diffuse DBD in nitrogen with small hydrogen admixture and to find the elementary discharge formation processes of diffuse DBD on the background of the influence of different operation parameters.

¹Electronic address:trunec@physics.muni.cz