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THE DIFFERENT TYPES OF DIELECTRIC BARRIER DISCHARGE IN GAS MIXTURES

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In this paper results of electrical and optical diagnostics of dielectric barrier discharges operating in different gas mixtures are presented. Discharges burning in pure nitrogen, in mixtures of nitrogen and argon, nitrogen and carbon dioxide, nitrogen and 1,3-butadiene, argon and 1,3-butadiene, argon and carbon dioxide were studied. The investigations were focused on the influence of different admixtures and on the finding of the conditions for the generation of diffuse dielectric barrier discharges.

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1 Introduction

It is well know that dielectric barrier discharges (DBD) can be operated at special conditions in a diffuse mode (often called homogeneous mode), the so-called atmospheric pressure glow discharge (APGD). It was found that APGD can be generated in helium [1], nitrogen [2] and neon [3]. Furthermore the significant influence of small admixtures of other gases to the above mentioned gases on the APGD behaviour was observed [4, 5].

From the technological point of view nitrogen or argon are the most suitable gases for the generation of an APGD. However, Brandenburg et al have shown by systematic measurements, that already very small admixtures of oxygen (i.e. hundreds of ppm) to nitrogen leads to the generation of filamentary DBD-mode instead of APGD [4]. It was also argued that impurities etched from the dielectrics into the discharge can influence the APGD in nitrogen [2]. On the other hand, Kozakov et al [6] have generated APGD in mixtures of nitrogen and argon with up to 70 % of argon content and Okazaki et al [7] have generated APGD in mixture of argon and acetone. We studied DBD in mixtures of various gases in order to select the conditions leading to the generation of an APGD. The discharge voltage and current were measured and spatio-temporally resolved optical emission spectroscopy was performed.

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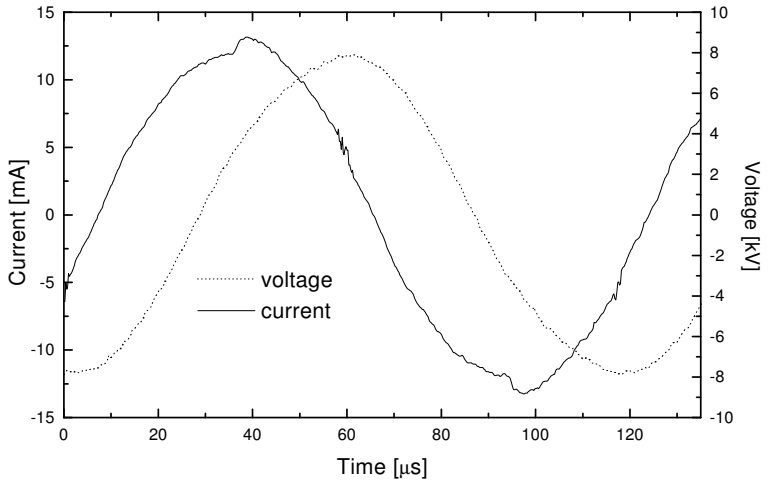

Fig. 1. Temporal evolution of voltage and current of an APGD in pure nitrogen.

2 Experimental set-up

The electrical measurements were realized in a discharge reactor with plane metal electrodes, both covered with Simax glass, 2 mm thick. The diameter of bottom electrode was 150 mm, the diameter of top electrode was 80 mm. The spatio-temporally resolved emission spectroscopy was performed for a discharge burning between two semispherical electrodes covered by glass, 1.5 mm thick [4]. The discharge gap was always 1 mm. Before starting the experiments the discharge chamber was pumped down to 1 kPa and then filled by working gases to pressure of 101 kPa. The frequency of the power supply was about 6 kHz.

3 Results

APGD were operated in pure nitrogen and in mixtures of nitrogen and argon. Besides the electrical characteristics the emission spectra of these discharges have been investigated. The measurements of the discharge voltage and the current in pure nitrogen APGD are presented in Fig. 1. It was found that in the mixture of nitrogen and argon an APGD can be generated for argon content up to 70 %. The ignition voltage decreases with increasing argon content. The voltage at which the APGD changes to filamentary DBD decreases also with increasing argon content and the interval of voltages for the APGD-existence become narrower. In pure argon an APGD could not be generated. The APGD in the mixture of nitrogen and argon is very similar to that one in pure nitrogen. However, regular oscillations in the discharge current were found at higher argon content and at higher voltages, see Fig. 2. These oscillations occur at voltages just before the transition to the filamentary mode.

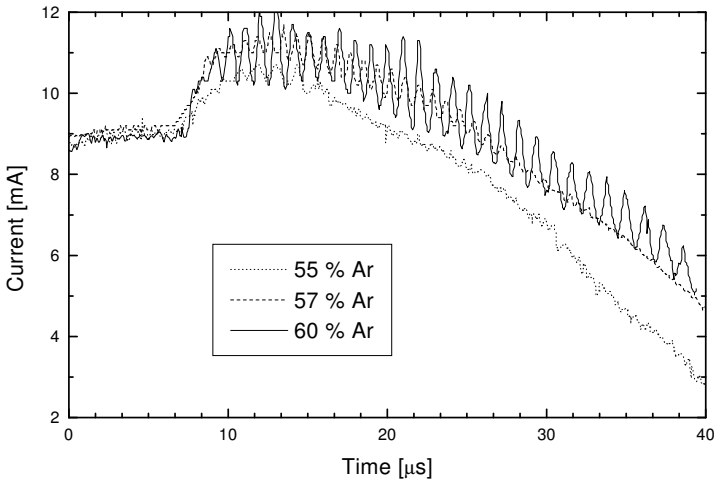

Fig. 2. Temporal evolution of the discharge current near its maximum of APGD in mixtures of nitrogen and argon.

A result of spatio-temporally resolved emission spectroscopy is shown in Fig. 3. One can see that the oscilations can also be investigated in the discharge luminosity distribution. An APGD in the mixture of nitrogen and 1,3-butadiene was generated as well. 1,3-butadiene was chosen because of its very low ionization energy (9.08 eV). As in the case of nitrogen – argon mixtures the APGD burns up to 10 % of butadiene in nitrogen. Oscilations in the discharge current were observed too. It was not possible to generate the APGD in mixtures of argon and butadiene or carbon dioxide. However, the admixture of butadiene to argon homogenized the discharge, but the electrical measurement has shown a discharge current consisting of many current peaks. These peaks are narrower and their number per one half period is larger than in pure argon. The CO_2 admixture to nitrogen has the same effect as oxygen, the APGD changes to filamentary DBD at very low concentrations of CO_2 ($\approx 0.5\%$).

To understand the different effects of various gas admixtures to the APGD stability a more profound knowledge about the decisive processes in the APGD is needed. So far Penning-ionisation due to metastable collisions and electron desorption from the dielectric surface has been discussed in literature [2, 8]. These knowledge have to be brought in agreement with the presented results or it has to be extended to explain them. This will be the aim of future investigations.

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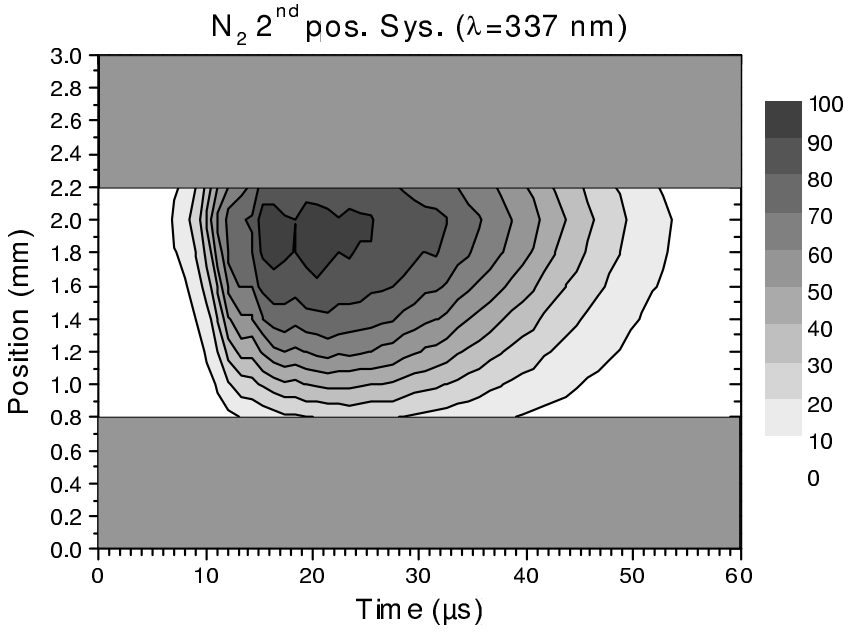

Fig. 3. Spatio-temporally resolved intensity distribution of the second positive system of N_2 of an APGD in nitrogen with 25 % of argon. The upper electrode is the anode and the intensity is grey-coded in relative values (%).

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