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Characterisation of a volume dielectric barrier discharge in N_2/O_2 mixture using absolutely calibrated optical emission spectroscopy

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Non-thermal atmospheric-pressure plasmas such as the employed dielectric barrier discharge (DBD) are advantageous for various biomedical applications since they make a contact- and painless therapy possible [1][2]. However, in order to avoid adverse health effect for patients, it is important to understand the impact of such discharges on biological tissue as well as the principle of operation and parameters. Gaining knowledge of properties and effects of plasma sources used for biomedical applications makes it possible to configure plasmas free of risk for humans. Therefore, the investigation of the electrical properties and plasma parameters of the used volumetric plasma source is fundamental regarding its future application.

Varying the atmosphere in which the discharge is ignited introduces the possibility to further study the biomedical impact of the discharge chemistry. Resulting oxidative and nitrogen-biased effects on biological tissue as a function of the gas admixture can be studied in this way. This is why the employed discharge is mounted to a suitable vessel in order to exclude any influence of the surrounding air. The setup of the DBD is presented in figure 1. The driven electrode consists of a copper electrode which is covered with a dielectric barrier made of Al_2O_3. The repetition frequency can be adjusted between 75 Hz and 5000 Hz and the amplitude of the applied voltage pulse can be varied between 6 kV_{pp} and 30 kV_{pp}. The distance between the driven and the grounded electrode is kept constant at 1 mm. The discharge is ignited in various gas admixtures of molecular nitrogen (N_2) and molecular oxygen (O_2). The gas flow and pressure within the vessel is controlled via mass flow controllers combined with a rotary vane pump.

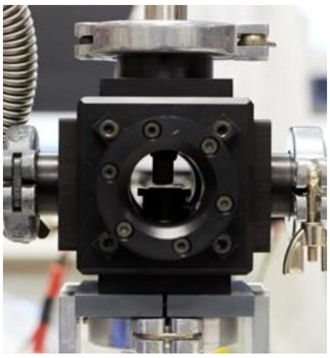

Figure 1: Picture of the experimental setup.

The energy density is determined by current and voltage measurements and the discharge is analysed by optical emission spectroscopy (OES). The discharge is characterized using absolutely calibrated optical emission spectroscopy in combination with numerical simulation to analyse the impact of different N_2/O_2 admixtures on the fundamental plasma parameters (electron velocity distribution function, reduced electric field, electron density and gas temperature).

The results indicate that an increase in the oxygen fraction leads to an increase in the electron density. It is possible to interpret this effect based on the kinetics of nitrogen and oxygen molecular ions by a variation of the atmosphere in which the discharge is ignited.

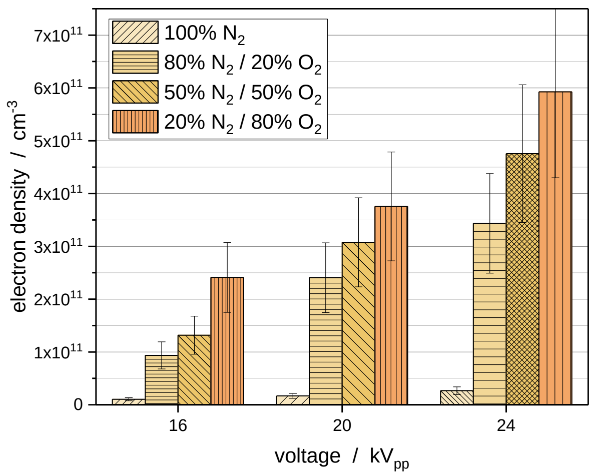

Figure 2: Electron densities determined for varied voltage amplitudes and a pulse frequency of 1000 Hz in different gas mixtures.

References:
[1] S. Emmert *et al.*, Clinical Plasma Medicine, **1**, 1 (2013)
[2] J. Hauser *et al.*, Biomedical Engineering, **54**, 2 (2009)
[3] B. Offerhaus *et. al.*, Plasma Processes and Polymers, **14**, 10 (2017)

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