COMPARISON OF THREE EXCITATION SCHEMES FOR CYLINDRICAL DIELECTRIC BARRIER DISCHARGES

Brockhaus A.[a] , Sauerbier, R. and Engemann J.

Forschungszentrum für Mikrostrukturtechnik – fmt
University of Wuppertal, Rainer-Gruenter-Str. 21, D-42119 Wuppertal, Germany

Abstract. Three dielectric barrier discharge jets have been analyzed mainly by spectroscopic methods. Power densities, electron concentrations, and heavy particle temperatures are in the same range for the jets. High speed imaging proves that for quite different excitation schemes the jet plasma consists of isolated, fast moving, light-emitting structures.

1. INTRODUCTION

Non-thermal atmospheric pressure plasmas (APPs) are attractive both to industry and to science. Companies seek for cost reduction by replacing traditional low-pressure plasma applications based on vacuum technology with inexpensive APPs. In the scientific world these plasmas – although being known for more than 100 years – still present considerable challenges concerning modelling and diagnostics. This study is restricted to dielectric barrier discharges (DBDs) which offer an experimentally simple way to limit the discharge current and to keep the gas temperature low. However, the self-interrupting nature of DBDs, combined with difficulties due to the high collision frequencies, severely complicates diagnostic investigations.

We have compared three different types of cylindrical DBDs which are all excited by sinusoidal voltages in the kilohertz range. All three plasma sources can produce plasma jets, i.e. light emitting plasma zones extending at least to some centimeters from the source. This feature is of course essential for all kind of non-thermal plasma processing applications.

From very early measurements of current-voltage characteristics it became obvious that the plasma jets are non-stationary – in contrast to their visual appearance. With the aid of a fast intensified CCD camera we could prove that the jet consists of so-called plasma bullets, i.e. small light emitting structures which are emitted from the DBD source at a certain phase of the sinusoidal excitation voltage [1]. The bullets move with velocities of several kilometers per second. It was not clear if this phenomenon was a speciality of our cylindrical plasma source #1 or was of general importance. Therefore a number of experiments was set up to improve the understanding of plasma formation, its properties and plasma transport.

2. EXPERIMENTAL SET-UP

The set-up for all three jets is displayed in Figure 1. DBD jet #1 is a very simple device. It just consists of a glass tube of 15 cm length, inner diameter 4 mm, with two ring electrodes (silver or aluminium foil, 5 cm in length) attached to the outside surface. The distance between the two electrodes is 3.5 cm. This discharge always requires a high helium concentration. In source #2 one of the outer ring electrodes is replaced by a concentric metallic needle electrode within the tube. In contrast to source #1 this excitation scheme enables jet production in a variety of gases including air [2]. It could be thought of as a combination between a DBD and a corona-type discharge. Finally, APP jet #3 is based on a piezo transformer principle. The operation principle is displayed in Figure 1 on the right side.

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[a] Electronic address: brockh@uni-wuppertal.de