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DISCHARGE PROPAGATION IN CAPILLARY TUBES ASSISTED BY BIAS ELECTRIC FIELD

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***Abstract**. The paper presents experimental results on the discharge generated in capillary tubes by pulsed power assisted by additional bias electric field. The electric field applied in addition to the pulsed voltage affected the discharge propagation inside the capillaries. The results on discharge development and velocity as functions of capillary tube diameter and amplitude of the bias field as analyzed by fast imaging camera are presented.*

Keywords: pulsed discharge, capillary tubes, streamer velocity, fast camera imaging

Introduction

Automotive catalytic converters have been developed and used for the abatement of exhaust gases for almost forty years. Despite their high efficiency, legislation limits for automobile emissions require new technologies in order to meet the current emission standards. The major problems of the automotive catalysts are their low activity at low temperatures and weak performance in non-stiochiometric conditions. Several techniques have been applied to overcome these problems, e.g. hydrocarbon adsorbing traps, closely coupled catalysts, as well as efforts to develop new catalysts. Another potential solution is to generate non-thermal plasma inside the automobile catalytic converters. The plasma contains various charged and neutral reactive species which may effectively activate the catalyst and initiate various heterogeneous chemical reactions even at room temperature. Atmospheric plasmas are often used in various applications, including environmental and biomedical treatment and surface modifications. The plasma can be generated by various types of electric discharges either in large volumes but also in small constricted spaces, pores and cavities alike those in automotive catalytic converters.

The present study is focused on the discharge generation in glass capillary tubes which simulate the long capillaries of honeycomb shaped automotive catalytic converter. In past we have performed several tests and generated stable plasma inside bunch of capillary tubes by using combination of AC and DC power supplies. We addressed the effects of the amplitude of the applied voltages; length, diameter and number of capillary tubes as well as gas used mixtures on the discharge properties and stability [1,2].

The paper presents experimental results on discharge generated in a single capillary tube generated by pulsed power supply and assisted by bias electric field. The electric field applied in addition to the pulsed voltage affected the discharge propagation inside the glass capillary tubes. The results on propagation and velocity of the discharge front as affected by the amplitude of the bias field diameter of capillary tubes are presented.

Experimental setup

The experimental set-up is roughly depicted in Figure 1. The reactor consisted of 30 mm long glass capillary tube with inner diameter of 0.2 mum or 1 mm. Tungsten wire of 50 µm diameter was plugged into the tube from a bottom. The top end of the capillary tube was set inside packed bed reactor (a quartz tube wrapped by aluminium tape with a rod in centre) filled with TiO_2 pellets. The tungsten wire was powered by a pulsed power, while packed pellet bed was operated by AC power. The packed pellet reactor was used to generate auxiliary discharge that by the application of the pulsed power to the rod may spread though the capillary tube [2]. The imaging system consisted of high speed ICCD camera (4-Picos Stanford Computer Optics cameras) synchronized with the voltage pulse was used to record a single event in capillary tube. By changing of the camera delay and gate opening we were able to follow the dynamics of the discharge and measure discharge propagation velocity inside the tube.

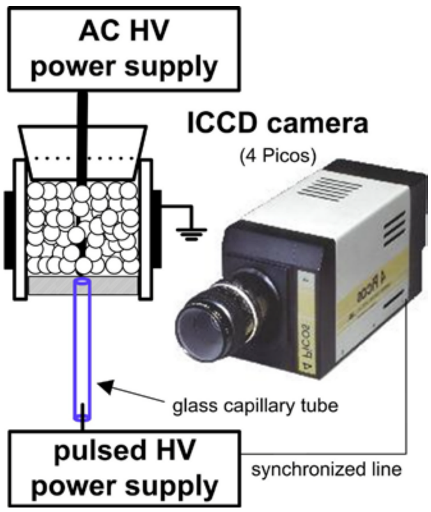

Fig.1. Schematic of the experimental set-up.

Experimental results

The propagation of the discharge generated inside the capillary tube has been monitored along 20 mm (visible part) of the capillary tube. The positive pulse (amplitude +15 kV, duration 20 ns) has been applied to the tip of tungsten wire (anode). Figure 2 shows the propagation of the discharge front as a distance from the anode in time for tube of 1 mm diameter.

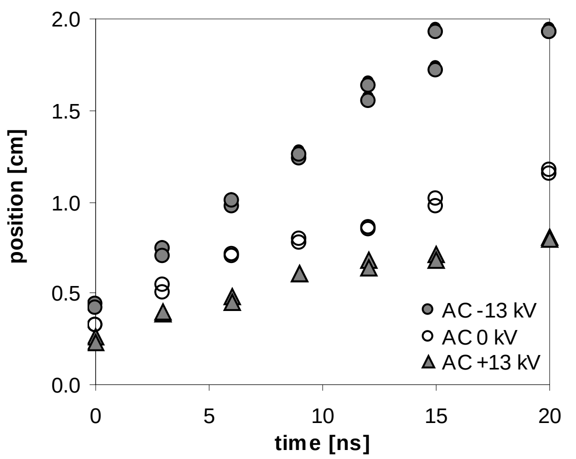

Fig.2. Distance of the discharge front from anode as function of time and bias electric field [1 mm diameter, pulsed voltage +15 kV].

Without auxiliary discharge (AC 0 kV) the discharge front moved almost linearly with time. The instant velocity of the front was found approximately constant, however slightly decreasing from 7.5*10^7 cm/s (measured during 1^{st} ns) to 3.4*10^7 cm/s (during 20^{th} ns). Application of the negative bias electric field (-13 kV) to the rod of the pellet bed reactor resulted gave an increase to the average velocity of the discharge front. Compared to previous case, the instant velocity increased to 10^8 cm/s (the 1st ns), and 7.5*10^7 cm/s (in 20th ns). On the other hand the discharge front propagation slowed down if positive bias was applied to the rod. Comparison of the results obtained for 1 mm and 0.2 mm diameter capillary tubes showed that discharge instant and average velocities increased with the decreasing tube diameter. In the present study, the average velocities were found 4.3 and 9.97*10^7 cm/s for 1 and 0.2 mm diameter tube, respectively. These results are in agreement with those of Jánský et al. [3]. More data addressing the effect of the bias field and capillary tube diameter including high speed camera images will be presented during the symposium.

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