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ICCD Camera Imaging of Microdischarges in Porous Ceramics

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Imaging of microdischarges inside porous ceramics generated by ac high voltage by means of intensified CCD camera at various time scales and sensitivity was performed. The images of discharge light emission were synchronized with the signal of the applied voltage. The light emission of both microdischarges inside the ceramics and a barrier discharge on the surface was recorded. The difference between the microdischarges in 10 and 80 μm pore size ceramics was described.

1. Introduction

Plasmas generated by electrical discharges at atmospheric pressure are typical with thin filamentary microdischarges. The microdischarge plasmas are widely used for various environmental applications due to its high chemical potentials. The efficiency and selectivity of the plasma chemical process can be improved when the plasma is combined with a catalyst (typically pellets or honeycomb). A small volume of the generated plasma in the pellet bed plasma reactors leads to a more perspective use of porous materials, such as honeycomb monoliths or porous ceramics. The generation of microdischarges in narrow cavities and capillaries of various porous materials, their physical properties and potential for exhaust gases removal has been recently investigated [1-3]. In the previous works we investigated the physical properties of the microdischarges generated inside porous ceramics by either DC [4-5] or AC [6] high voltages. The methods of the investigations consisted of electrical and optical measurements used to evaluate the effects of pore size, discharge power, gas mixture composition, and gas flow rate on the stable discharge development. The optical investigations included standard photographic documentation and optical emission spectroscopy. In this paper we present the photographic images recorded by intensified CCD camera system, which was implemented to visualize the discharge emission development synchronized with the applied ac voltage at various time scales.

2. Experimental Setup

The experimental setup is depicted in Fig. 1. The discharge reactor consisted of a porous ceramics placed between two stainless steel mesh electrodes inside the quartz cylinder. The ceramics were made of Al_2O_3/SiO_2, and their diameter and thickness were 31 and 7 mm,

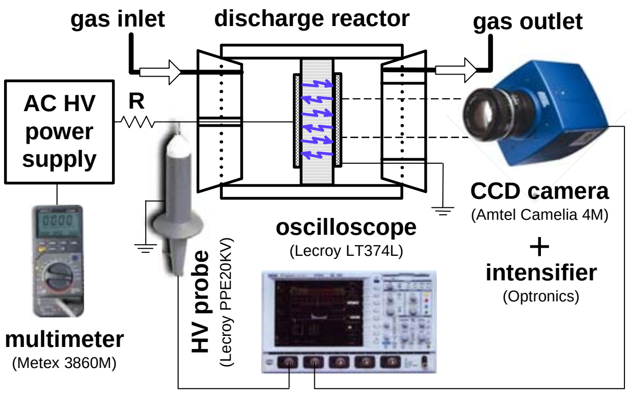

Fig.1. Simplified sketch of the experimental setup.

respectively. The pore size of the used ceramics was 10 and 80 μm. AC regulated high voltage power supply (50 Hz) was used to generate the discharge. The discharge voltage was measured by a high voltage probe Lecroy PPE20KV linked to the digitizing oscilloscope Lecroy LT374L (500 MHz, 4 GS/s). The total power was measured by the digital wattmeter Metex 3860M. Optical system consisted of a digital camera Atmel Camelia 4M (b/w, sensitivity full frame CCD sensor, resolution 2048 x 2048, square pixels 14 μm, exposure time 1 ms - 2 s) equipped with intensifier fragment Optronis (exposure time 3 ns - 110 ms, spectral sensitivity 400 - 700 nm). The camera system was synchronized with the applied high voltage. The camera images of the discharge were taken perpendicularly to the surface of the ceramics. The experiments were carried out in nitrogen at atmospheric pressure and at room temperature. The total gas flow rate was 1 l/min.

3. Results and Discussion

The paper shows various images of discharge light emission as recorded ICCD camera system at various time scales (camera and intensifier gates) and sensitivity.

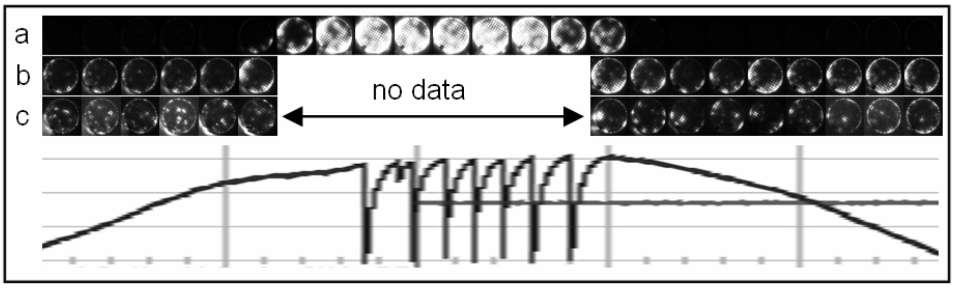

Fig.2. Light emission of the discharges synchronized with the AC high voltage signal. Parameters: pore size 80µm, nitrogen, applied voltage 15.7 kV, intensifier gate 500 µs. Series: a) intensifier sensitivity 500, integration 100x, b) intensifier sensitivity 600, integration 100x, c) intensifier sensitivity 760.

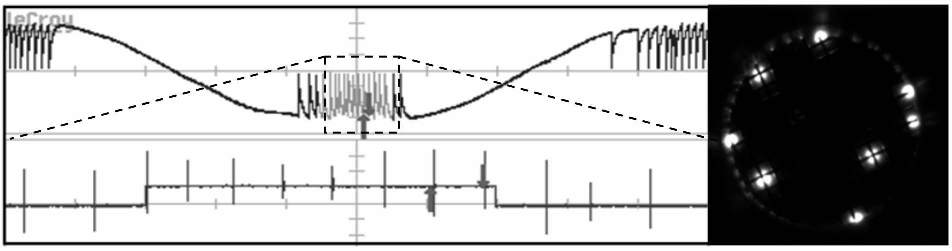

Fig.3. Light emission of the microdischarges. Parameters: pore size 10µm, nitrogen, applied voltage 16 kV, intensifier gate 1ms, intensifier sensitivity 470.

Fig.2. shows the emission of the microdischarges along the half of the AC high voltage waveform. The images in (a, b, c) are synchronized with the voltage and correspond to the region of the waveform below. Sequences a) and b) represents the light integrated in 100 exposition cycles, while sequence c) is light recorded in one cycle only. As the sequence (a) shows the most intense light emission was observed during the maximal amplitude of the applied voltage, when microdischarge breakdowns appeared. In the regions beyond the microdischarge breakdown (b, c) the discharge light emission was much smaller. The light here corresponded mainly to the emission of the barrier discharge.

Fig.3. shows the image of microdischarges taken at the maximum voltage with the camera gate of 1 ms. The number of voltage drops on the waveform (associated with microdischarges formation) corresponds to the number of the emission spots recorded by the camera. The images reveal that the microdischarges are randomly distributed inside the ceramics and consequent breakdowns appear at different places, not the same one. However, by increasing the pore size the probability that the following microdischarge appear at the same place as the previous increases. In general, the microdischarges appear closer to the edge of the electrode, where the electric field is enhanced, rather than in its central part.

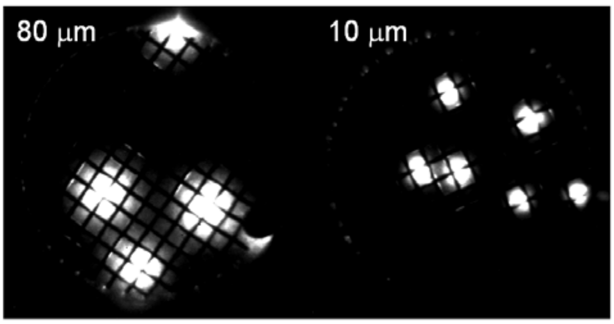

Fig.4. Comparison of the microdischarges in various ceramics. Parameters: nitrogen, applied voltage ~ 16 kV, intensifier gate 1ms, intensifier sensitivity 420.

Fig.4. shows the microdischarges in the ceramics of two different pore size at the same voltage and camera conditions. As can be seen, the light intensity of the individual microdischarge increased with the pore size as the consequence of the bigger discharge current. In the previous studies we found the amplitude of the microdischarge current pulse and the mean current increased with the pore size.

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