Electrical Breakdown in Water Vapor at micrometer separations

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The DC breakdown have been measured between planar tungsten electrodes in pure H_2O at micrometer separations from (40 to 900 µm) and at the vapor presures of 19.4 and 29.7 mbar. The results are presented in the form of Paschen curves. The I-U characteristics of the DC discharges were measured and different characters of the discharge were detected depending on the *p.d* parameter.

The microdischarges attracted in last decade great attention as sources of stable and reliable non-equilibrium high pressure plasma. The applications of microdischarges have great potential in such fields as generation of UV and UV/VIS radiation, plasma sterilization in the medicine, plasma display panels, nanotechnologies, etc. [1]. One of the most important characteristics of DC discharges is the breakdown voltage, which applied over the range of pressures and discharge gap separations is known to follow Paschen Law, i.e., the dependence of the breakdown voltage V_{br} on the product *p.d* of the pressure *p* and the electrode separation *d*. Due to increased interest in electric discharges driven in water in last decade [2], the electric discharge in pure water vapors is of great interest for this community. In this work we present the experimental data on the DC breakdown voltage measured in pure water vapors and tungsten electrodes at micrometer separations.

The electrodes of the discharge system were located in a high vacuum chamber. The vacuum was generated by the turbo-molecular pump (Pfeiffer Vacuum TMU 064 70 $l.s^{-1}$) and membrane pump. The background pressure of $2x10^{-5}$ mbar has been achieved. The low pressures were measured by the ionisation gauge (Pfeiffer Vacuum, PKR 261) and the vapor pressures were measured by the capacitance gauge (Pfeiffer Vacuum, PCR 260). The discharge system for generation of the microdischarges consists of two planar tungsten electrodes with diameter of 2 mm. The electrodes were mechanically polished and chemically cleaned in ultrasonic bath. More detailed description of the system could be found in [3].

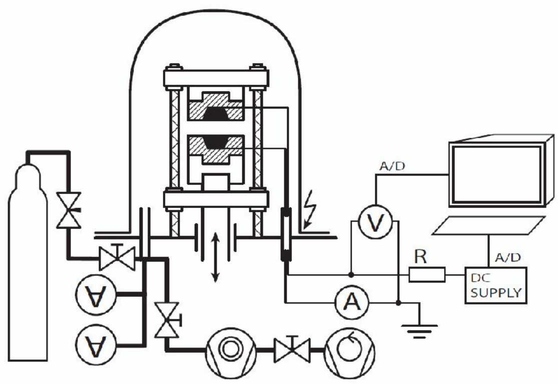

Fig. 1: Schematic view of the system for experimental studies of electrical breakdown in water wapors at micrometer separations.

One of the electrodes was fixed and the other was movable continuously with micrometer scale linear feed-through. Both electrodes were equipped with dielectric cap (glas) to prevent the ignition of the discharge at longer path at low pressures. One of the electrodes was earthed, to the second electrode we have applied DC voltage ramp. The 0 µm separation of the electrodes was established by checking the electrical contact between the electrodes and then the movable electrode was pulled away by the means of the micrometer screw. The DC breakdown voltage was identified from the I-U characteristics of the discharge. Using this method we were able to measure the breakdown voltage with high reproducibility. The electrodes gap was varied in the range from 40 to 900 µm. The water vapour was prepared from bi-distilled water, which was subjected to several pump freeze-thaw procedures.

The measured Paschen curves as well as one I-U characteristics of the discharge are presented in the Figure 2.

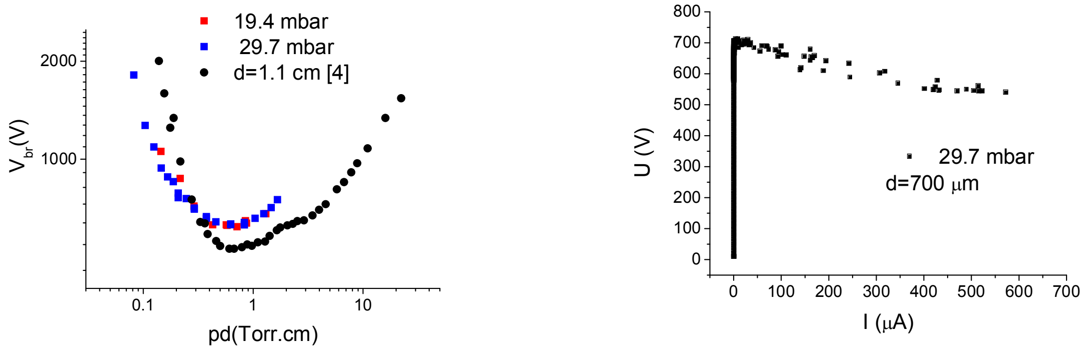

Fig. 2: Paschen curve (left panel) measured at two different H_2O pressures (19.4 and 29.7 mbar) and electrode separation *d* from 40 to 800 μm. For comparision Paschen curve as measured by Škoro et al. at d=1.1 cm and H_2O pressures from 0.03 to 20 Torr. The U-I characteristics of microdischarge as recorded for electrode separation of 700μm and water vapour pressure 29.7 mbar.

We compare present data with the recently published one by Škoro et al. [4] which were measured at different experimental conditions (d=1.1 cm, p=0.03 – 20 Torr) and with different electrode materials (Cu and Pt). The difference between the present data and those of Škoro et al. [4] may result from such factors as different electrode materials (different efective secondary emission coefficient) and different breakdown voltage estimation method. We have as well empoyed different method for the measurement of Paschen curves. In present case the experiments were carried out at fixed vapor pressure and the electrode separation was varied. The data by Škoro et al. were recorded at fixed electrode separation and by variation of the vapor pressure. According to our experience especially at the left side of the Paschen curve there exist difference between data measured at fixed electrode separation and at variable electrode separation especially in the case of micrometer separations, where the influence of field emission of the electrodes play an important role at small separation.

References

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