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DC BREAKDOWN IN WATER VAPOUR AT LOW PRESSURES

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Development of miniaturized non-equilibrium plasma sources which have many specialized applications in nanotechnologies [1], treatment of materials [2,3], lighting [4] and biomedical applications [5] that typically operate in atmospheric conditions inevitably entail presence of water vapour in the discharge. Moreover, recent studies of discharges involving water (or electrolyte) electrode(s) [6] or discharges in heterogeneous water-air bubbles systems [7] call for measurements of new data for water vapour. In this paper we investigate dc breakdown in low-pressure water vapour in order to establish gas breakdown conditions, discharge formation and regimes of discharge operation. We present measurements of Paschen curves, i.e. dependence of breakdown voltage (V_b) on the pressure times electrode gap (*pd*), for several distances between electrodes (*d*). The goal of our work is to provide basic data on breakdown in water vapour, such as breakdown voltages, ionization coefficients, secondary electron yields. We also show comparison of breakdown voltages for vapour obtained from water samples with different degrees of dissolved oxygen.

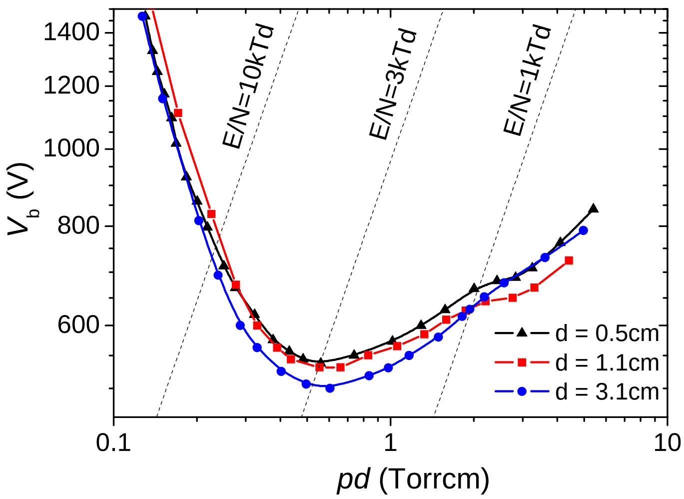

Fig. 1: Paschen curves of water vapour for three different interelectrode distances.

Discharge chamber consists of two parallel plate electrodes with adjustable gap. Copper cathode and quartz anode with transparent and conductive platinum film are placed inside a tightly fitting quartz cylinder, which prevents the long-path breakdown [8]. The chamber is connected to a water container through a valve which provides pressure regulation. Vapour is introduced into the vacuum system at a slow flow rate. Following the initial period of boiling, water in the tube becomes still and devoid of dissolved oxygen and other volatile constituents. Then, water vapour remains in the chamber for several hours in order to achieve saturation of all surfaces of the chamber. During measurements, the ambient temperature in the vicinity of the discharge chamber remained constant at around 300K.

In Fig. 1 we show results for breakdown voltages for 0.5 cm, 1.1 cm and 3.1 cm gaps. In the left-hand branch and around the minimum, three Paschen curves agree well. Curves for 0.5 cm and 1.1 cm manifest an inflection point around 2 Torr cm, which is not present at larger gaps. The origin of the inflection point is not yet clear, but it indicates the presence of a process that occurs at higher water vapour pressures (close to the critical point) and yet it satisfies the pd scaling law.

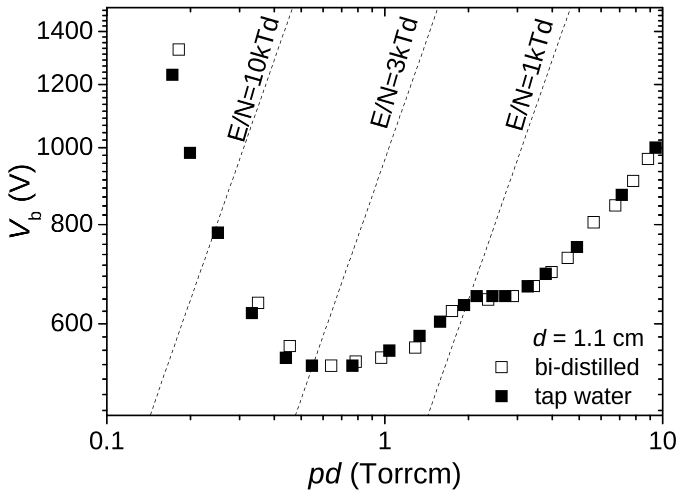

Fig. 2: Paschen curves of water vapour for different water samples. Electrode gap d=1.1 cm.

Comparison of Paschen curves taken with different water samples is shown in Fig. 2. One curve is obtained with water vapour from bi-distilled water sample and the other was acquired with regular tap water sample. Surprisingly, results show no discrepancies and breakdown voltages agree well within experimental error. Existing results entice interesting ideas for discharge applications without special water sample preparation, although further spectrally resolved measurements are planned to clarify further the influence of certain impurities contained in water samples to the discharge behaviour.

References

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