DETERMINATION OF THE SECONDARY ELECTRON EMISSION COEFFICIENTS FROM BREAKDOWN CHARACTERISTICS OF THE MICRODISCHARGES

M. Klas(*), Š. Matejčík

Department of Experimental Physics, Comenius University, Mlynska dolina F2-71,

Bratislava 84248, Slovakia

(*) **matej.klas@gmail.com**

In the past years large effort was focused in generation of stable and reliable non-equilibrium high pressure discharges [1]. One of the methods of generation of atmospheric pressure plasma is the scale down of the electrode gaps to micro-separations. The breakdown voltage is according to Paschen'Law function of the product of pressure and separation between the electrodes. The departures from the Paschen law were observed at high pressures and at micrometer separations [2,3]. There exist only few studies for electrode separations smaller than 1mm. The microdischarges, with separations in the range of 100 um are working at the boundary of the validity of the Paschen law. For that reason we decided to build new experiment to prove the Paschen law for microdischarges with electrode separations from 10 μm to 1mm. The breakdown voltage significantly depends on the secondary electron emission coefficient γ. Assuming that ion bombardment is dominant factor of the secondary emission, which is valid for reduced fields is in the range E/p≥ 100 -200 $V.cm^{-1}Torr^{-1}$ [4,5] the γ can be determinate from the breakdown voltage:

$$\gamma = \frac{1}{e^{\eta V_{br}} - 1} \qquad (1)$$

where η is *α/E* obtained from [6-10].

The electrodes of the discharge system are located in the high vacuum chamber generated by turbomolecular pump (background pressure of $2x10^{-5}$ mbar) and we used as the working gas the high purity argon (Linde 5.0). The system for the breakdown measurement of the microdischarges consists of two planar copper electrodes with diameter of 5 mm. The electrodes were mechanically polished and chemically cleaned in ultrasonic bath. One of the electrodes was fixed and the other one was movable continuously with micrometer scale linear feed-through. The electrodes were equipped with dielectric cap (dielectric breakdown strength =13,8 kV/mm) to prevent the ignition of the discharge at longer paths at low pressures. The maximum discharge current was set to 1,6 mA and then the DC voltage was applied at ramp speed of 0,05 kV/s until the point of breakdown was reached. The point of the breakdown was identified from the time dependence of the potential difference across the discharge tube. Using this method we were able to measure the breakdown voltage with high reproducibility and high accuracy.

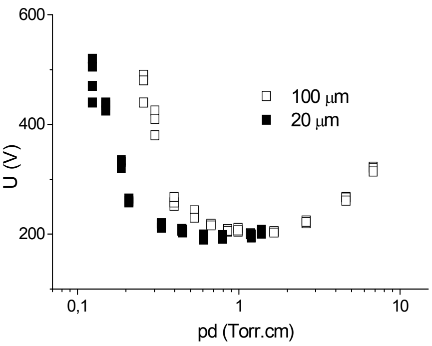

Fig. 1: Experimental paschen curves in Ar for 20μm and 100μm electrode distances

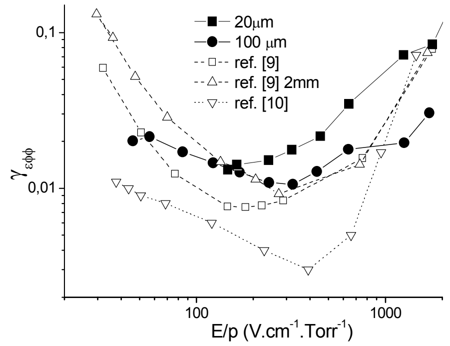

Fig. 2: Effective secondary emission coefficient in Ar compare with Ref. [9,10] and recalculated data for 2mm [9]

In the Figure 1 we present the Paschen curves for the microdischarges in Ar measured at two different separations 20 and 100 μm. The secondary electron emission coefficients γ (Figure 2) were calculated using the equation (1) and the data presented in the Figure 1. The first Townsend coefficients for calculations were taken from [6]. The Paschen curves show differences at the low pressure site. This is usually explained in terms of field emission of the electrons from the cathode. This explanation is supported also by the effective secondary emission coefficients γ_{eff} in Figure 2. The γ_{eff} show differences at high values of E/p. The γ is higher for 20μm separation, this is due to the fact that not only the ion bombardment contributes to γ_{eff}, but also the field emission, which is stronger at low separations of the electrodes.

We compare the present data with that of Auday and Guilot [9,10]. The difference between present data and that of these authors may arise from several factors i) geometry of the discharge system, ii) the quality of the Cu electrodes (purity and roughness), iii) the purity of the gas and iv) the accuracy of discharge breakdown voltage measurements.

Acknowledgement

This work has been supported by the VEGA project Nr. VEGA 1/0051/08.

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