Topic number: 9

INFLUENCE OF THE CATHODE CONDITIONS ON *V-I* CHARACTERISTIC IN N_2 LOW-PRESSURE DISCHARGE

S. R. Gocić[(1,*)], N. Škoro[(2)], D. Marić[(2)] and Z. Lj. Petrović[(2)]

[(1)]Department of Physics, University of Niš, P.O.Box 224, 18001 Niš, Serbia

[(2)]Institute of Physics Belgrade, Pregrevica 118, 11080 Zemun, Serbia

[(*)] **gsasa@pmf.ni.ac.rs**

One of the main processes governing the dc discharges is production of secondary electrons, characterized through the effective secondary electron yield (γ_{eff}). It has been shown for argon [1] and nitrogen [2] that cathode surface conditions play an important role in γ_{eff}. Surface conditions include, not only the cleanness of the surface, but also a degree of surface conditioning [1] by exposure to the discharge. Our aim here is to illustrate possible changes in *V-I* characteristics and spatial discharge profiles, caused by cathode surface inhomogeneity. The idea for this work came from the need to explain the non-typical voltage-current characteristics (with positive slope in low-current regime) that we obtained for parallel-plate discharge in nitrogen (Fig. 1A). As we will show, the cause of this kind of behavior was in the cathode surface that was severely conditioned by the discharge that operated in constricted glow regime for a long period of time.

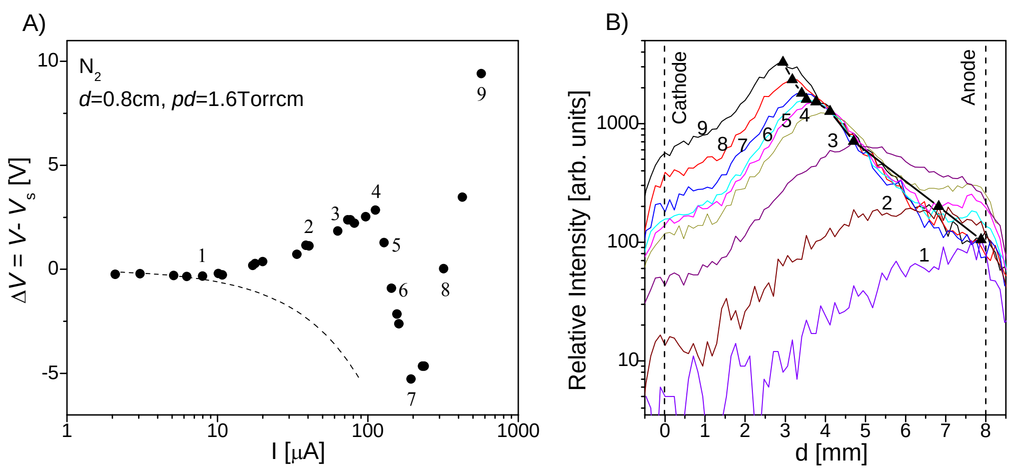

Fig. 1: A) The voltage-current characteristic of N_2 discharge. The static breakdown voltage: $U_s \approx 316$ V, pd = 1.6 Torr cm. B) Axial profiles of emission in numbered points of *V-I* characteristic (▲ - position of maximum intensity).

We have performed a new set of measurements of *V-I* characteristics, supported by side-on recording of the discharge profiles. The diameter of the electrodes was D=2.2 cm and the electrode gap d=0.8 cm. The tube was filled with research grade nitrogen at a pressure of 2 Torr. Details of experimental procedure can be found in [3]. Axial spatial discharge structure is recorded by fast ICCD camera (Andor, iStar DH720-18U-03).

Measured *V-I* characteristic is presented in Fig.1A together with axial profiles of emission (Fig.1B). The *V-I* characteristics deviates from the usual dependences [3-5] and a positive slope appears in the transition to normal glow instead of negative slope (dashed line). At the same time axial emission profiles, taken at the axes of the discharge, are in agreement with the standard behavior of low-pressure discharges [3-5], starting from low current (Townsend) mode with exponential distribution of intensity (1-2), through formation of the negative glow (3-6) with the development of the cathode fall.

2D images of the discharge spatial structure (Fig.2) clearly show that at lower currents (labels 1-4), discharge operates only within conditioned area of the cathode – limited circular area positioned close to the center of the cathode. From points 1 to 4, discharge goes from Townsend to glow-like discharge, while remaining within the same limited area. As the voltage-current characteristics gets negative slope, the discharge gradually spreads to the remaining cathode area (points 5-9). Further on, it resembles typical low-pressure glow discharge behavior, except the profile is radially distorted – curved towards the cathode. Practically, due to the conditioning of the cathode, central area has different secondary electron yield than the remaining surface. This leads to the complex behavior of the discharge – it starts in the central area where, presumably, γ is higher. The discharge will spread to the area with different γ only when current density increases enough for the charge particles, diffused outside the conditioned area, induce sufficient space charge effects to ignite the discharge at the given voltage.

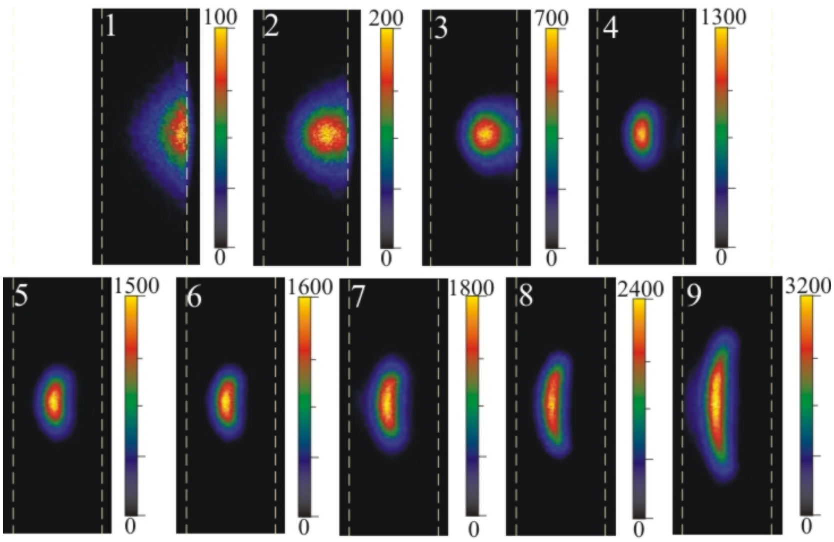

Fig. 2: 2D images of discharge spatial structure. The cathode is on the left side.

Measurements shown here indicate that one has to be careful with procedures for pre-conditioning cathode surfaces. Treatment of the cathode in glow discharge, which is often constricted, may result in inhomogeneous surfaces and misleading results. Furthermore, these results are particularly useful for studies of discharges with cathodes of different materials, which are sometimes used in applications, where the same kind of complex behavior may be expected.

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