Hollow Cathode Discharges: Volt-Ampere Characteristics and Space-Time Resolved Structure of the Discharge

D. Marić[1], N. Škoro[1], G. Malović[1], Z. Lj. Petrović[1],
V. Mihailov[2] and R. Djulgerova[2]

[1]*Institute of Physics Belgrade, Pregrevica 118, 11080 Zemun, Belgrade, Serbia*
[2]*Institute of Solid State Physics of Bulgarian Academy of Sciences, 1784 Sofia, Bulgaria*

draganam@phy.bg.ac.yu

Hollow cathode discharges were studied almost as long as gas discharges. In addition to applications in spectrometry and ion gas lasers [1,2], plasma processing applications such as ion etching, thin film deposition, surface treatment [3] and analysis of nanostructured surfaces [4] have been recently introduced.

Compared to parallel plate glow discharges with similar dimensions and gas pressure, hollow cathode discharges have lower breakdown voltages and operate at lower voltages for the same current density [5,6]. Enhanced discharge efficiency is due to the fast electrons and ions, which are confined inside the cathode hole [7]. When a negative glow regions facing the opposite cathode surfaces overlap, "hollow cathode effect" appears. Hollow cathode effect is the most specific feature of these devices. It is manifested as a large increase in the current density and discharge light intensity followed by a drop of a sustaining voltage. Appearance of this effect depends on both geometry and properties of the discharge.

Our aim was to establish a relationship of the discharge structure to the electrical properties in a wide range of discharge currents for steady state conditions, but also in transient stages during formation of the discharge. We were particularly interested in formation of the hollow cathode effect. Analysis of formation and maintenance of the hollow cathode discharges is based on comparisons with more simple parallel-plate discharges (e.g. [8]).

We use a commercial hollow cathode lamp which is normally applied as a spectral source. The lamp is a sealed glass tube filled with Ne (p=3.5 Torr) containing a Mn cylindrical hollow cathode open at one end and a ring shaped anode. Cathode hole is 3 mm in diameter and 15 mm long. Our measurements include ICCD imaging of the discharge emission, supported by voltage and current measurements. It was possible to identify and explain several critical points in the Volt-Ampere characteristics where the shape of the

discharge changes.

We believe that such measurements may be of interest for micro discharges where hollow cathode geometry is often applied albeit the conditions for the hollow cathode effect are not always met. Thus, one may perhaps check the regime of operation from the Volt-Ampere characteristics.

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