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On the High-Voltage Regime of the Discharge in Hollow-Cathode Tube

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Abstract. A comparison of the operating characteristics of the high-voltage regime of the discharge in a hollow-cathode tube, the hollow-cathode discharge (HCD) and the discharge to a plane cathode are presented. The disappearance of the hollow-cathode effect and the transition to a high-voltage discharge after inserting several anode rods into the cathode cylinder is exhibited. The similarity between the operating characteristics of such a high-voltage discharge and of a plane cathode discharge is shown. The loss of ions at the anode rods, as well at insulators or floating conductors is believed to be the reason behind the increase of the operating voltage and the disappearance of HCD characteristics. Practical means of increasing the operating voltage are mentioned.

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In recent years HCD has been widely used to exite noble gas and noble gas-metal vapour mixtures [1–3]. However, research is needed to improve the degree of excitation of high-lying atomic and ionic levels in such discharges. One possibility is to increase the operating voltage, which in turn produces faster electrons needed for effective excitation of these high-lying levels.

Rozsa [4] has developed a structure with an internal anode system in which the operating voltage is 3–4 times higher than that in a conventional HCD. The discharge in such a structure has proved to be efficient both in noble gas [5, 6] and in metal-vapour/noble-gas mixtures [7–9].

Recently, Iijima [10] found that covering part of the inner wall of a hollow-cathode by insulators raises the operating voltage compared to the conventional HCD. This has been shown to yield improved operation of the $He–Zn^+$ laser.

These examples in the existing literature indicate that the high-voltage regime of discharges is of considerable practical importance. On the other hand, some important properties of such a discharge are still not fully understood.

It is aim of this work to compare the operating characteristics of the high-voltage discharge in a hollow-cathode tube with those of the conventional HCD and of the discharge to a plane cathode. In the opinion of the authors, this comparison allows much better understanding of the high-voltage discharge.

1. The Experimental Set-Up

Three discharge tubes were used to compare the electrical operating characteristics of the high-voltage discharge in the hollow-cathode tube, the conventional HCD, and the discharge to a slightly curved open cathode, containing only the negative zones of the glow discharge (cathode dark space, negative glow and eventually Faraday dark space).

The hollow cathode in which a high-voltage discharge was realized is a 10 mm-I.D., 10 cm-long stainless steel cylinder. Six tungsten rods of 1.5 mm diameter are placed along the cylinder and form the anode structure. The distance between the surfaces of anodes and cathode is 0.5 mm. A schematic diagram of the geometry of the electrodes is shown in Fig. 1a.

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