J. Phys. D: Appl. Phys. **20** (1987) 429–437. Printed in the UK

Axial distributions of the plasma parameters of a longitudinal discharge in helium in hollow cathodes used for lasers

J Mizeraczyk

Institute of Fluid Flow Machines, Polish Academy of Sciences, Fiszera 14, 80 952 Gdańsk-Wrzeszcz, Poland

Received 14 April 1986, in final form 17 September 1986

Abstract. This paper presents results of the measurements of distributions of the electron energy distribution function, the mean energy and concentration of electrons, and the plasma potential along the axis of a longitudinal discharge (LD) in hollow cathodes which are used for He–inert gas and He–metal lasers. The measurement technique employs the second derivative of the electric probe current–voltage characteristics. The results show that the LD in cathodes longer than about 15 mm is axially inhomogeneous. The LD consists of two zones having the properties of the negative glow (NG) and the positive column (PC) of glow discharge, respectively, and a transitional zone between them. The relative lengths of the zones depend on the helium pressure and the discharge current. At low helium pressures (~6.7 mbar) and discharge currents (~20 mA) almost the whole cathode is occupied by the PC-type plasma. As the helium pressure and discharge current increases the NG-type plasma lengthens at the expense of the PC-type zone. The LD in cathodes shorter than 15 mm has NG-type plasma along nearly all its length, as long as the helium pressure is higher than about 6.7 mbar. In this aspect it resembles a transverse discharge in a hollow cathode. The results obtained prove that the positioning of the anode outside the cylindrical hollow cathode may, under special conditions, essentially influence the properties of the discharge occurring in the cathode.

1. Introduction

Papers by Borodin *et al* (1967), Moskalev (1969), Zykova and Kutscherenko (1976) and Mizeraczyk (1983, 1985) on investigations of a longitudinal discharge (LD) in cylindrical hollow cathodes having various diameters and lengths showed that the LD may, under special conditions, be axially inhomogeneous, contrary to another kind of discharge in a hollow cathode, known as the transverse discharge (TD) (Mizeraczyk and Urbanik 1983). The reason for the non-uniformity of the plasma is the axial motion of electrons toward the anode, caused by an internal positioning of the anode with respect to the cathode (figure 1).

Axial inhomogeneity of the LD plasma results in different properties of the LD and the TD in hollow cathodes having relatively small inner diameters (3–10 mm). This fact is of a great importance since both discharges are used in producing laser radiation (Mizeraczyk *et al* 1984). However, to the best of the author's knowledge, there is no other publication on the axial properties of the LD in hollow cathodes as used in laser technology than his own (Mizeraczyk 1983), concerning measurements of the axial distributions of the cathode current density.

It is the aim of this work to measure the plasma parameters, the electron energy distribution function (EEDF), the mean energy and concentration of electrons, and the plasma potential along the axis of the LD in helium in hollow cathodes typical of He–inert gas and He–metal vapour lasers.

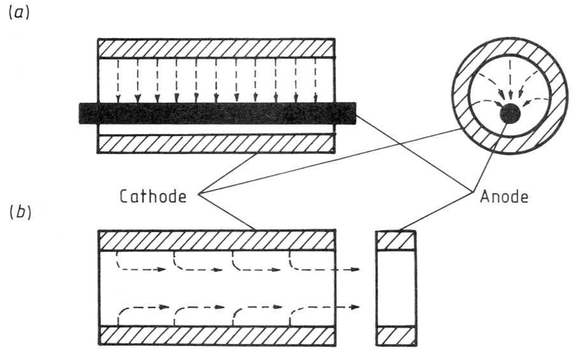

Figure 1. Schematic diagram of hollow cathodes characterised by (*a*) transverse and (*b*) longitudinal discharge direction.