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INVESTIGATION OF THE H_β SPECTRAL LINE SHAPE IN COAXIAL DIODE DISCHARGE

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Abstract. Doppler spectroscopy of the hydrogen H_β spectral line is applied for evaluation of excited hydrogen atoms temperature in a coaxial mesh cathode diode (CMCD) glow discharge. Measurements are performed in the argon-hydrogen mixture and excited hydrogen atoms with average energy 40 eV are detected. The radial distributions of H_β and Ar II (487.9 nm) spectral lines integral intensity are also determined.

1. INTRODUCTION

A coaxial cylindrical geometry of coaxial mesh cathode diode (CMCD) allows an observation along free optical axis, perpendicular to direction of transversal excitation, and simple change of the operational mode by the exchange of electrodes polarity. In direct polarity mode inner cylindrical mesh electrode works as the cathode, while in the inverse polarity outer cylindrical hollow copper electrode is set as the cathode.

In both operating modes, the development of the far wings of H_β spectral line is detected (Šišović *et al.*, 1996). This effect is in accordance with result of theoretical and experimental studies in several different types of discharges (Baravian *et al.*, 1987; Barbeau and Jolly, 1990; Benesch and E. Li, 1984; Cappelly *et al.*, 1985; Li Ayers and Benesch, 1988; Kuraica and Konjević, 1992; Petrović *et al.*, 1992). Wings broadening of hydrogen spectral lines is related to the presence of excited hydrogen atoms with very high velocities. By exchanging of the diode polarity, in the region inside the inner mesh electrode, one can [redacted] a glass tube (Pyrex, dia 50 mm, 300 mm long). Quartz windows are mounted by Brewste: angle on both ends of the tube to allow end-on observations of the discharge.

The continuous flow of the 97%Ar+3%H_2 gas mixture is sustained at pressure in the range 20 - 150 Pa by means of a needle valve and two stage mechanical vacuum pump. To prevent oil vapors backstreaming from the vacuum pump, the zeolite trap is placed between discharge chamber and the pump. To run the discharge a current stabilized dc power supply (0-1 kV, 0-100 mA) is used. The ballast resistor of 10 kΩ is placed in series with the discharge and power supply.

For radial intensity distribution measurements the light source is translated in 1mm steps in both directions from optical by precise mechanical transporter, so the discharge image obtained through observation hole (dia 5 mm) is translated in the plane of entrance slit of 1m SPEX Czerny-Turner type scanning monochromator, see Fig. 1.With a 1200 rulings/mm grating, this instrument has a reciprocal dispersion of 0.7 nm/mm in the first order which is used throughout this experiment. All spectra recordings are performed with fixed entrance and exit slits giving gaussian instrumental profile with 0.035 nm half-width. For the radiation detection photomultiplier together with lock-in amplifier (SR510 Stanford Research) and optical chopper (SR540 Stanford Research) are used. The entire experiment is controlled by a PC.

All measurements are performed in the direct polarity mode.

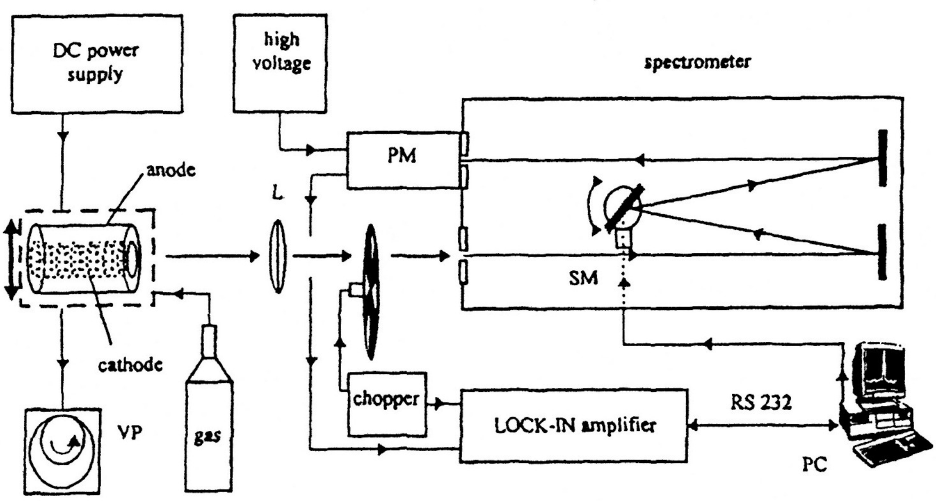

Fig. 1. Schematic diagram of the experimental setup. Symbols: VP - vacuum pump; L - lens (f=0.11m); SM - stepping motor (1 step=0.0033 nm); PM - photomultiplier EMI 9817 QB.

3. RESULTS AND DISCUSSION

The glow discharge inside the central mesh cathode is observed in five radial positions: at the optical axis of CMCD (r=0), at the distances r=1 mm and r=2 mm from the optical axis in both directions. Typical Balmer H_β line profile recorded from the discharge established in direct polarity mode is shown in Fig. 2.

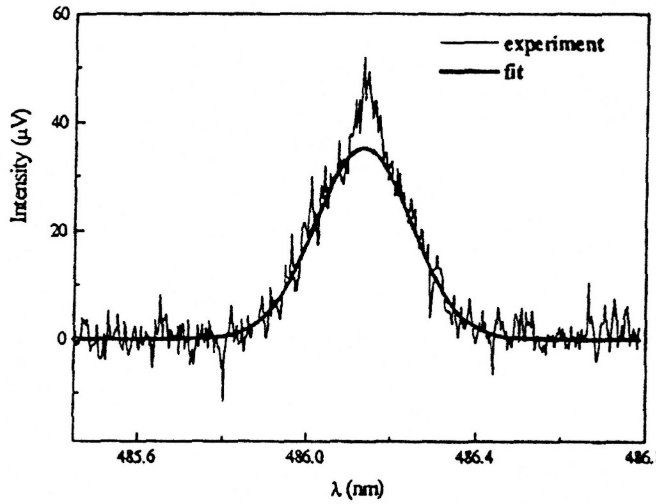

Fig. 2. The recording of H_β line profile at radial distance r=1mm from optical axis of CMCD and its best fit. Discharge conditions: Direct polarity mode; p =100 Pa; I=25 mA; U = 255V.

The overall profile consists of two parts: a narrow line core induced by Stark and Doppler broadening in plasma and intense broad wings, which are of Doppler origin. To derive the temperature of excited hydrogen atoms T_H we have assumed that lower broader part of the overall profile is a single Gaussian and performed fittings of this part of experimental profiles. By such approach, we have obtained average temperatures T_H=40 eV at all radial positions for direct polarity operational mode of CMCD.

The radial dependence of integral intensity, which is measured as an area under the H_β overall profile in the range of $\pm 5\Delta\alpha_H$, is determined and shown in the Fig. 3. As can be seen the integral intensity of the H_β line is independent of the radial distance inside central mesh cathode.

The spatial distribution of argon spectral lines integral intensities is also determined. In case of argon, integral intensities of both, neutrals and singly-ionized atoms, spectral lines rapidly decrease with the increase of radial distance from the optical axis (See Fig. 3).

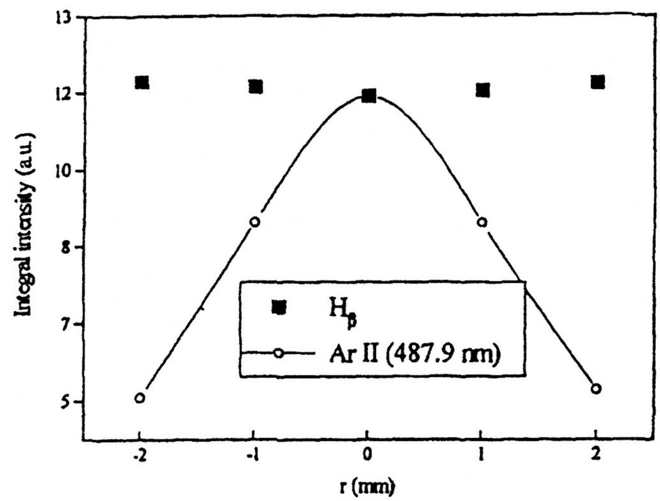

Fig 3. Radial distributions of the H_β and Ar II (479.9 nm) spectral lines integral intensity. Discharge conditions: Direct polarity mode; p =100 Pa; I=25 mA; U = 255V.

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