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STUDY OF CATHODE SHEATH IN HYDROGEN GLOW DISCHARGE

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Abstract. We present the results of an experimental and theoretical study of the cathode sheath region in a plane cathode, hollow anode, Grimm discharge of hydrogen, operated at low pressures. Stark polarization spectroscopy and deconvolution procedure are used to determine electric field distribution and energies of excited hydrogen atoms.

1. INTRODUCTION

Models of elastic, inelastic, and reactive collisions of energetic hydrogen ions, atoms, and molecules are developed recently for predicting H_α and H_2 near-UV emission, H_α Doppler profiles, and ion energy distributions for low-pressure, low-current discharges in H_2, see Ref.1 and 2 and references therein. The models are applied to low-pressure Townsend discharges in spatially uniform electric field. The aim of this study is to extend investigation of some elementary processes, including interaction with cathode, to the cathode sheath region of glow discharge.

2. EXPERIMENTAL

Our discharge source is a laboratory-made modified Grimm-type GDS, described in detail elsewhere [3]. The hollow anode, 30 mm long with inner and external diameters 8.00 and 13 mm, has a longitudinal slot (15 mm long and 1.5 mm wide) for discharge observations. The water-cooled cathode holder has an exchangeable electrode, 18 mm long and 7.60 mm in diameter. The spectra were recorded side-on in 1/8 mm steps along the discharge axis. By means of a needle valve and two separate two-stage mechanical vacuum pumps the pressure was sustained in the range 2-6 mbar. To run the discharge, a 0-2 kV and 0-100 mA current stabilized power supply was used. A ballast resistor 5 kΩ was placed in series with the discharge and power supply.

Radiation from the discharge source was polarized with a plastic polarizer and focused with unity magnification onto the entrance slit of a monochromator-CCD system with 0.74 nm/mm reciprocal linear dispersion. The measured instrumental FWHM (Gaussian form) with 20 μm slit was 0.0384 nm.

RESULTS AND DISCUSSION

Examples of experimental results with copper cathode are presented in Fig. 1. An experimental π-polarized H_β profile fitted with a model function:

$$y(\lambda) = J(\lambda) * S_E(\lambda) * \left[G_1(\lambda) + G_2(\lambda)\right] \quad (1)$$

composed of two Gaussians $G_1(\lambda)$ and $G_2(\lambda)$ convolved with instrumental profile $J(\lambda)$ and Stark shift $S_E(\lambda)$ in electric field E is presented in Fig. 1a. The distribution of measured electric field within cathode sheath is given in Fig. 1b, while energies of excited hydrogen atoms are presented in Fig. 1c. More details will be presented at the Conference.

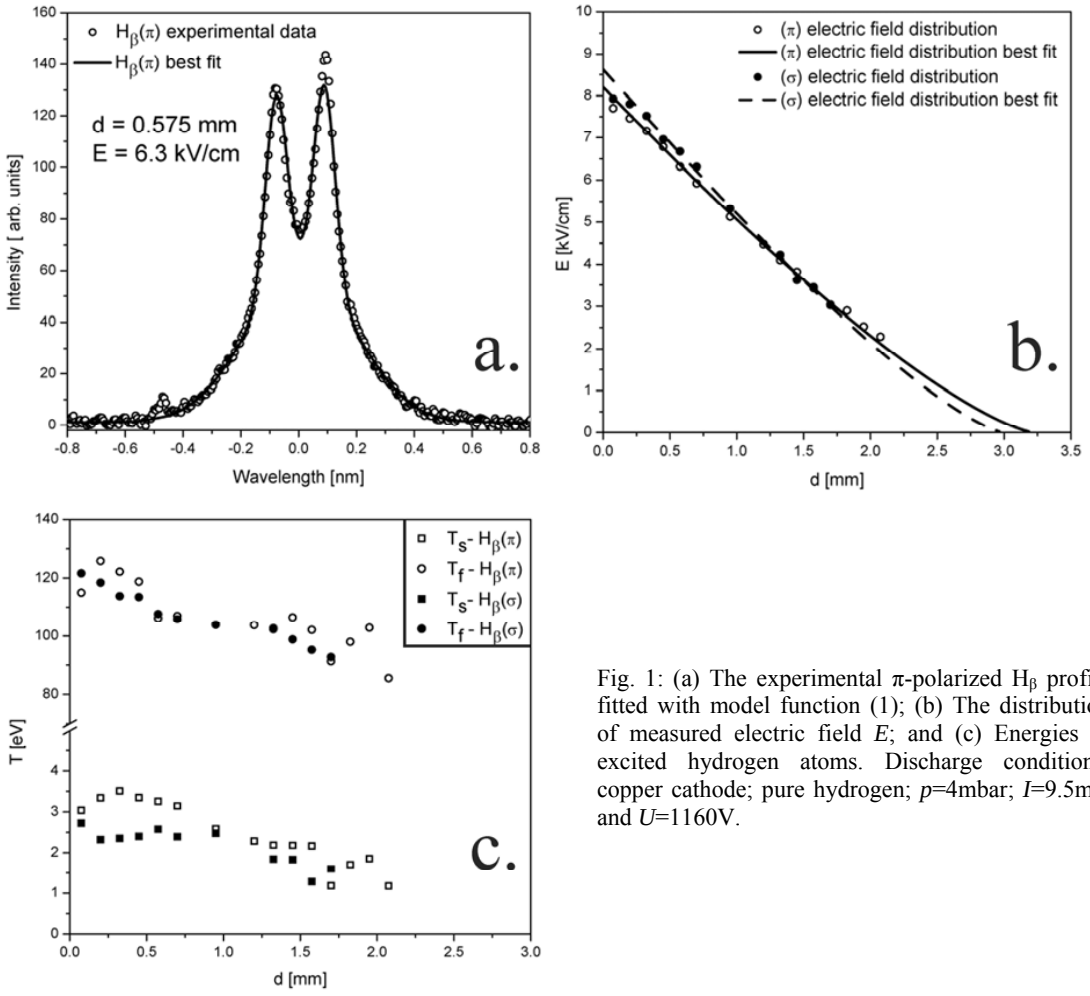

Fig. 1: (a) The experimental π-polarized H_β profile fitted with model function (1); (b) The distribution of measured electric field E; and (c) Energies of excited hydrogen atoms. Discharge conditions: copper cathode; pure hydrogen; p=4mbar; I=9.5mA and U=1160V.

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References

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