STUDY OF CATHODE SHEATH IN HYDROGEN GLOW DISCHARGE

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Abstract. We present experimental/theoretical study of cathode sheath in a plane cathode, hollow anode, Grimm discharge in hydrogen, operated at mbar pressures and voltage ≈ 1kV. The purpose of our study is to extend recently developed methods for predicting the H_β profiles induced by Stark and Doppler effects in a micro-hollow gas discharge at larger pressures [1]. Starting from kinetic equations for distribution functions of ions, and taking into account relevant inelastic processes (charge exchange, ionization by electrons and photons), we have obtained an expression for electron current density, which enables us to find an equation for electric field distribution in a high-field approximation. We use its solution to fit measured electric field distribution, obtained by deconvolution of spectral lines recorded side-on by means of Stark polarization spectroscopy. In deconvolution we use the model profiles

$$y(\lambda) = J(\lambda) * S_E(\lambda) * [G_1(\lambda) + G_2(\lambda)]$$

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. The model profiles fit well experimental profiles and provide estimation of energies of excited hydrogen atoms. The best fit values of model free parameters (such as effective cross section for dissociation of H_2 molecules due to electron impact) agree well with tabulated values, while the temperatures T_1 and T_2, that correspond to $G_1(\lambda)$ and $G_2(\lambda)$, remain practically constant throughout the cathode sheath indicating that energetic H atoms produced by neutralization and reflection of hydrogen ions from the cathode, move almost collisionlesly through the matrix gas. These findings place the focus of our further research to a study of formation of hydrogen ion beams and their interaction with cathode.
Our plasma source is a laboratory-made modified Grimm-type GDS operated in hydrogen [2]. The hollow anode, 30 mm long with inner and outside diameters 8.00 and 13 mm, has a longitudinal slot (15 mm long and 1.5 mm wide) for discharge observations. To record line spectra Ebert type spectrometer (2 m; 0.736 nm/mm) and CCD detector (3648 pixels, 8 mm) were used. The instrumental profile was Gaussian like having full half-width of 0.016 nm.

[1] Dj. Spasojević, M. Cvejić, N. M. Šišović and N. Konjević, Appl.Phys.Lett. 96, (2010) 241501
[2] I. R. Videnovic, N. Konjevic, M. M. Kuraica, Spectrochimica Acta Part B 51 (1996) 1707.