DETERMINATION OF THE ELECTRIC FIELD STRENGTH IN GLOW DISCHARGES USING ARGON SPECTRAL LINES

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Abstract. The cathode sheath (CS) region is the most important part of ~~an~~ abnormal glow discharge (GD) where various processes relevant for the operation and application of GD occur. This is the region where heavy charged particles accelerate and collide with other discharge constituents generating charged and neutral particles in the ground or excited state before bombarding cathode surface. The electrons and their collision products in the CS and negative glow (NG) region are the most important discharge constituents for sustaining the GD operation. One of the most important parameters of the CS region is the electric field strength distribution, which depends on current density, pressure, cathode material, geometry of the discharge etc. This distribution determines the acceleration of the charged particles, influencing their path and kinetic energy and consequently all processes relevant for the operation of GD and numerous GD applications in the field of spectroscopic analysis, plasma etching, thin film deposition and depth profiling of cathode material. In order to establish new methods for the electric field strength determination the profiles of seven argon lines and two Balmer hydrogen lines were studied. All profiles were experimentally observed side-on to the axis of our Grimm GD source operating at low pressure in argon, argon-hydrogen and neon-argon mixtures, with three different cathode materials. The side-on spectra show simultaneous Stark shifting and splitting of two Ar I lines (Ar I 518.75 nm i Ar I 522,17 nm), as well as ~~an~~ excessively broadened profiles of five Ar II lines (Ar II 434,81 nm; 458,99 nm; 460,96 nm; 484,78 nm; 487,98 nm) ~~of~~ in the cathode sheath region of the glow discharge. A study of argon glow discharge shows that the measured wavenumber DC Stark shifts $\Delta\nu$ of two neutral argon lines can be used for reliable determination of the electric field strength F distribution in the CS. In order to experimentally determine the coefficient c in quadratic correlation $\Delta\nu = cF^2$, manifested in a low field range (up to 15 kV/cm), the values of F are measured via Stark polarization spectroscopy of hydrogen Balmer beta line. Measurements in low electric field strength range showed that the Stark shifts, although rather small, can be determined with the aid of a suitable numerical procedure. Consequently, the simple and inexpensive tool for determination of the CS electric field strength distribution of ~~an~~ argon glow discharges has been developed. During the spectroscopic observation of CS region, the excessively broadened profiles of singly ionized argon spectral lines have been detected. It has been shown that at least two groups of excited ions of argon with significantly different energies participate in the formation of the overall profile of singly ionized argon lines. The influence that cathode material has on the Ar II line shape has been demonstrated, and a simple formula for determination of the electric field strength from the width of broadened wings of the side-on recorded Ar II spectral lines has been presented.