Electric field strength measurement by Stark polarization spectroscopy in diffuse helium-nitrogen barrier discharges

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Stark polarization spectroscopy is applied to a diffuse helium-nitrogen barrier discharge to measure the electric field strength. The splitting of the allowed and the forbidden line around 492.2 nm (4^1D $\rightarrow$ 2^1P°) as well as the shift of the allowed line are investigated. Both are compared to the electric field strength calculated from the ratio of the singlet lines at 667 nm (3^1D $\rightarrow$ 2^1P°) and 728 nm (3^1S $\rightarrow$ 2^1P°).

1. Introduction

Discharges in helium with molecular admixtures like nitrogen or oxygen are important for applications at atmospheric pressure because of their ability to produce radicals at low power requirements. For a better understanding of these discharges and to optimize applications, numerical simulations and their comparison with crucial discharge parameters of the experiment are necessary. One of the most important discharge parameter is the electric field strength, which can be determined by Stark polarization spectroscopy [1], and from the intensity ratio of the two singlet lines [2]. The combination of both methods allows a precise absolute calibration by Stark polarization spectroscopy, and a good spatial and temporal resolution by the intensity ratio method.

2. Experimental setup

The investigated discharge is ignited between to plane electrodes, covered by glass plates at a gap distance of 3 mm. The chamber is filled with a mixture of helium and 500 ppm nitrogen at 1 bar. A square wave voltage with a frequency of 5 kHz and an amplitude from 0.8 kV to 1.5 kV is applied. Under these conditions, a diffuse glow-like discharge develops.

The discharge emission is observed by a system consisting of a monochromator (0.75 m focal length, 1800 mm^{-1} grating) and a photomultiplier tube. The photomultiplier signal is amplified and recorded by an oscilloscope, allowing an averaging of up to 50000 signals. For low intensities, as for the Stark splitting line at 492.2 nm, a photon counting procedure is used to improve the signal-to-noise ratio.

3. Results

A typcial example of the Stark spectroscopy measurement is shown in figure 1 for three distances to the cathodic dielectric. Two characteristics are visible: Firstly, the emission maximum appears later for

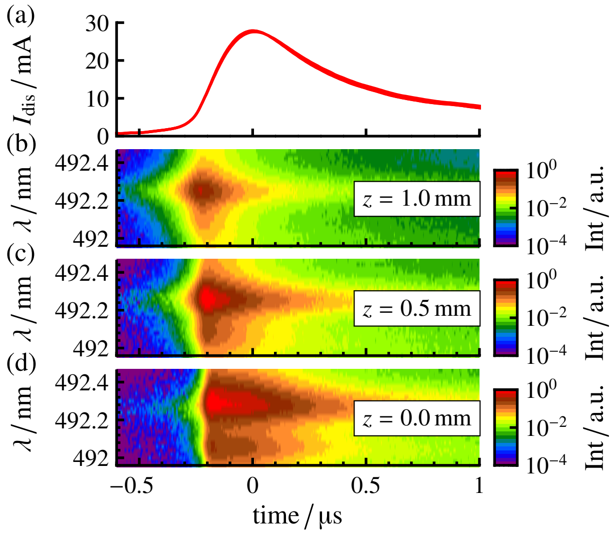

Fig. 1: (a) Discharge current and (b-d) spectrally resolved emission at 492.2 nm for three distances z from the cathodic dielectric.

decreasing distance to the cathodic dielectric, which indicates the propagation of the cathode-directed ionizing front. Secondly, the forbidden line becomes more pronounced. Hence, the electric field strength increases towards the cathode, a cathode fall region forms. The limitations of this method are visible as well. The separation of the forbidden line is weak for low electric fields and a large background emission (probably first positive system of nitrogen) exceeds the forbidden line for later times. Therefore, the shift of the allowed line and the line ratio method are used to calculate the electric field for comparison.

References

[1] N Cvetanović, M M Martinović, B M Obradović, and M M Kuraica, *J. Phys. D: Appl. Phys.* **48** (2015) p. 205201.

[2] S S Ivković, G B Sretenović, B M Obradović, N Cvetanović, and M M Kuraica, *J. Phys. D: Appl. Phys.* **47** (2014) p. 055204.