Time development of electric field in γ-mode RF APGD in helium

Z. Navrátil[1*], R. Josepson[1], N. Cvetanović[2] and B. Obradović[3]

[1]*Department of Physical Electronics, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic*
[2]*Faculty of Transport and Traffic Eng., University of Belgrade, Vojvode Stepe 305, 11000 Belgrade, Serbia*
[3]*Faculty of Physics, University of Belgrade, Studentski trg 12, 11001 Belgrade, Serbia*
[*]*Contact e-mail:* zdenek@physics.muni.cz,raavo.josepson@ttu.ee

1. Introduction

Using bare metal planar electrodes and radio-frequency (RF) power source, a homogeneous, so-called α-mode radio-frequency atmospheric pressure glow discharge (RF APGD) is generated in helium at low RF powers [1]. The RF APGD transits at higher powers into a γ-mode, which is constricted at atmospheric pressure [1, 2]. γ-mode discharge is an efficient source of charged particles, metastables and reactive species [3]. Time-averaged electric field values in γ-mode RF APGD, obtained from simulations, reach 12 kV/cm in RF sheaths [4]. In this work, we applied a method of Stark polarization spectroscopy of helium 492 nm line [5] for time-resolved measurement of electric field in RF sheath of γ-mode RF APGD.

2. Experimental setup

RF APGD was generated between bare metal electrodes in helium (gas purity 5.0) at atmospheric pressure. The γ-mode was stabilized using hemispherical electrodes, 8 mm in diameter. The discharge gap was 2 mm. Electrical parameters were monitored by a digital storage oscilloscope (LeCroy WaveRunner 6100A). The RF power for generation of γ-mode was 15 W, the amplitudes of voltage and current were 240 V and 0.65 A. Temporally resolved optical emission spectroscopy was performed by a method of time-correlated single photon counting (TCSPC). The light coming out of the discharge by optical fibre was first monochromatized (Jobin Yvon HR-640, grating 1200 gr. mm^{-1}, instrumental FWHM 0.075 nm) and then analyzed by a single photon counter (Becker & Hickl SPC-150), with PMT (PMC-100-4) working in a photon counting mode. Arrivals of individual photons were correlated with the RF signal taken from function generator with a temporal step of 0.8 ns. The light was collected from 20 μm region close to the instantaneous cathode.

3. Results

The example of fitted time-resolved spectral profile is shown in Fig. 1. The measured spectral profiles, consisting of forbidden ($2\,^1$P – $4\,^1$F; ≈491.9 nm) and allowed ($2\,^1$P – $4\,^1$D; 492.2 nm) helium spectral lines, were fitted with a linear combination of pseudo-Voigt functions. The FWHM of the forbidden line was larger than that of the allowed line. (The latter had FWHM 0.1 nm, roughly in agreement with combined van der Waals, resonant and instrumental broadening.) This is probably due to insufficient spatial resolution or presence of non-axial electric field in the constricted γ-mode. Since the allowed line included mostly emission from field-free region, the electric field was determined from the Stark shift of the forbidden component. The instantaneous electric field reached 32 kV/cm in the RF sheath.

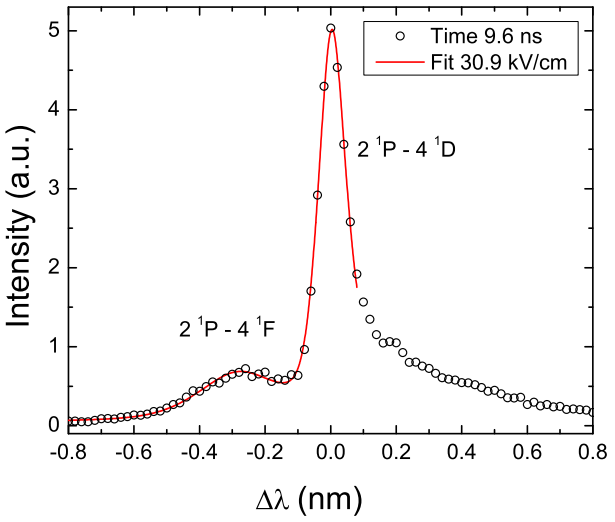

Fig. 1: *Example of fitted spectral profile of He 492 nm line measured in the RF sheath.*

Acknowledgements

The present work was supported by grant GA13-24635S of Czech Science Foundation, project CZ.1.05/2.1.00/03.0086 funded by European Regional Development Fund, project CZ.1.07/2.3.00/30.0009 co-financed from European Social Fund and the state budget of the Czech Republic and project LO1411 (NPU I) funded by Ministry of Education, Youth and Sports of the Czech Republic.

References

[1] J. Park *et al.* 2001 *J. Appl. Phys.* **89** p. 20
[2] S. Y. Moon *et al.* 2006 *Phys. Plasmas* **13** p. 033502
[3] D. Schröder *et al.* 2013 *J. Phys. D: Appl. Phys.* **46** p. 464003
[4] Shi J and Kong M G 2005 *IEEE Trans. Plasma Sci.* **33** p. 624
[5] B. M. Obradović *et al.* 2008 *Appl. Phys. Lett.* **92** p. 191501