Spectroscopic method for nitrogen impurity estimation in helium atmospheric discharge

Nikola Cvetanović[1], Saša S. Ivković[2] and Bratislav M. Obradović[2]

[1]*Faculty of Transport and Traffic Engineering, 11010 Belgrade, Serbia*
E-mail: nikola@ff.bg.ac.rs
[2]*University of Belgrade, Faculty of Physics, 11001 Belgrade, Serbia*

Nonthermal atmospheric pressure discharges have recently emerged as the most investigated and most promising laboratory plasma sources. In the last two decades they have been extensively studied both theoretically and experimentally (see e.g. Brandenburg, 2019). These discharges are predominantly dielectric barrier discharges operating in noble gases. It was shown in several articles that presence of gas impurities within the working gas can be crucial for barrier discharge operation, in some cases even for providing its sustenance. Numerous models have shown the influence of gas impurity level on discharge parameters (see e,g. Martens et al. 2010, Wang and Wang 2005, Zhanf et al. 2019). Therefore, the knowledge of impurity level is required both in experimental work and for designing facilities. Non-invasive methods for gas impurity measurement are preferable. However, measurement of gas impurity using optical spectroscopy is a difficult task, due to the complex processes of production and excitation of emitters.

Here we will present a novel spectroscopic method for estimating the nitrogen molecular impurity in discharge operating in helium. This is a typical working gas/impurity combination - due to low cost of helium on the one hand, and air leakage into the chamber and gas supply system. Furthermore, a certain amount of air impurities is always present in the gas supply cylinder. The method is based on the intensity ratio of prominent nitrogen molecular band and strong helium line. Namely the N_2 ($C^3\Pi u$–$B^3\Pi g$, 0-0) at 337 nm, and the HeI (3^3S-2^3P) at 706 nm were chosen. A collisional-radiative model was developed, and a functional dependance of intensity ratio on impurity at a given reduced electric field was numerically obtained.

In connection, an experimental study was performed to investigate the influence of gas flow rate on a helium dielectric barrier discharge (Ivković et al. 2022). The experiment was concentrated on the presumed connection between the gas flow rate and the impurity level, and consequential change of the discharge operation. A closed-chamber barrier discharge with plane electrodes was examined for a set of gas flow rates. Using the abovementioned spectroscopic method, a strongly non-linear decrease of impurities concentration with increasing flow rate of the working gas was observed.

References

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