Numerical and experimental investigation of the effect of N_2 and O_2 admixtures in a helium dielectric barrier discharge

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Low temperature atmospheric pressure plasma sources have received much attention in the last decades, due to low production cost, easy implementation and applications ranging from surface modification, sterilization, plasma medicine etc. Such plasma sources usually operate with inert gases such as argon, neon or helium, and their electrodes are covered with dielectric layers in order to avoid the transition to arcing. The inert gases are preferred because they create the conditions for lower power requirements and they can produce a wide range of reactive species. However, in several applications, extra admixtures of nitrogen or oxygen species are added in the gases, in order to enhance the production of the reactive species. In the literature, there is a very limited number of studies regarding the effect of these admixtures on the evolution of helium discharge over a wide range. Consequently, understanding the effect of these admixtures (nitrogen and oxygen) on the discharge evolution is very crucial for the utilization of helium atmospheric pressure plasma devices.

With this in mind, a one dimensional plasma fluid model is developed, in order to study the effect of nitrogen and oxygen admixtures in a helium parallel plate DBD [1]. The model takes into account the analytical chemistry of helium with nitrogen, oxygen and water species and it was verified with experimental results [2] (pure He, He + N_2 and He + O_2) in order to ensure its validity. In the plasma chemistry, 52 species and 445 reactions channels are considered.

The simulation and experiment results show that the nitrogen and oxygen admixtures highly affect the discharge characteristics and evolution. In particular, for the case of pure helium discharge, it has been observed that the discharge has homogeneous characteristics with a single current peak per half period. By adding nitrogen in the helium, extra current pulses have been observed per half voltage cycle, and after a certain level of nitrogen admixtures the discharge loses the homogeneous characteristics. On the other hand, when oxygen is added in the helium gas, it is observed that the discharge continues to have one current pulse per half cycle, but loses the homogeneous characteristics at very low level of oxygen admixture. In order to interpret the results, the most important reactions pathways for the production of ions are examined from the simulation model. This methodology provides very useful information's in order to understand the plasma behaviour.

[1] Lazarou C, Belmonte T, Chiper A S and Georghiou G E 2016 *Plasma Sources Sci. Technol.* **25** 055023
[2] Chiper A S, Cazan R and Popa G 2008 *IEEE Trans. Plasma Sci.* **36** 2824–30