The influence of air impurities on the evolution of plasma species in a capillary helium plasma jet

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The main aim of this paper is to numerically investigate the evolution of the different species in a capillary helium plasma jet, during the plasma bullet propagation. This study is performed for a wide range of air concentrations in the helium jet core (up to 16000 ppm). The simulation results showed that the helium species are only produced and propagated in the helium jet core (along the axis of symmetry of the tube). On the other hand, the nitrogen and oxygen species (for up to 7000 ppm air in the jet core) were produced and propagated at the side of the jet core. For air concentration levels (in the jet core) higher than 7000 ppm, the production and propagation of the nitrogen and oxygen species converges towards the helium jet core. In order to interpret the results, the mean reaction pathways behind the production of each species are examined. This analysis provides useful insight into the physics behind the evolution and characteristics of the plasma jet.

In recent years, the atmospheric pressure plasma jet (APPJ) has gained much attention due to its low production costs and the wide range of applications. Although significant progress in the understanding of the basic principles of the APPJ has been made, certain areas, such as the evolution and creation of the plasma species, need further research.

With this in mind, a two dimensional axisymmetric model was developed [1], for the study of the helium plasma jet. The configuration and the operational parameters of the helium plasma jet used in the simulation model are the same as for the experimental setup [2]. In Figure 1, the spatial profile of the level of air concentration used as input in the plasma fluid model is shown.

The simulation results showed that the plasma bullet propagated along the axis of symmetry of the tube. The high energetic electrons that promote the reactions pathways for the plasma bullet propagation, has its peak on the plasma bullet head and a crescent like shape centred on the axis of symmetry of the tube. The helium species concentration peaks along the axis of symmetry where the helium ground state atoms are at their maximum.

For levels of air below 7000 ppm in the jet core (~ 0.22 cm from the tube exit) the nitrogen and oxygen ground state molecule concentrations are higher towards the edges of the helium jet whilst their species are generated towards the centre due to the higher electron energy there. As the distance from the tube exit increases, so does the air concentration in the jet core. Once it increases beyond 7000 ppm, the reaction pathways for the production of the nitrogen and oxygen species move towards the axis of symmetry. These results provide good insight into the physics behind the plasma jet evolution and the experimentally observed emitted light.

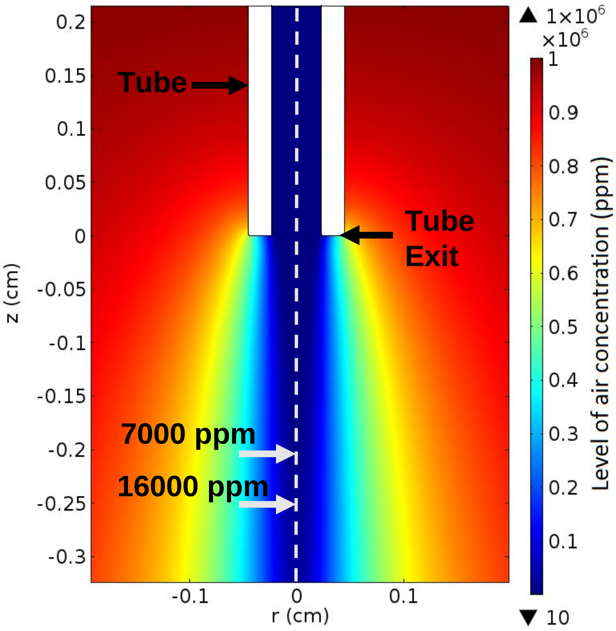

Figure 1: Plasma jet and the distribution of air concentration (ppm) in the domain.

References

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