SIMULATION OF ATMOSPHERIC-PRESSURE PLASMA JETS USING FINITE ELEMENT METHOD

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Atmospheric-pressure plasma jets (APPJ) are devices that generate chemically reactive species and operate at atmospheric pressure and ambient temperature for a wide range of applications. Plasmas jets produce charged particles (electrons and ions), neutral metastable species, radicals, electric fields, and VUV and UV photons. This plasma cocktail not only triggers a variety of cell responses (cell detachment, apoptosis), but is also at a temperature that does not damage tissue/skin. APPJs are used routinely in material processing and biomedical applications. Material processing examples include surface modification, etching, and thin film deposition [1]. Plasma medical applications or plasma medicine examples include the killing of cancer cells, wound healing, and sterilisation [2]. The plasma jet at Queen’s University Belfast has shown to be effective in bacteria inactivation [3].

The plasma jet consists of helium gas flowing through an open dielectric tube into air at atmospheric pressure and room temperature. Gas flowing through the quartz tube excited by the pulsed voltage given by the copper electrodes creates the plasma. Adding a small impurity to the noble gas produces the chemically active species. The flow rate of the working gas or the electrical field geometry determines the length of the plasma plume. APPJ can be 1000s K in the tube, but the plasma jet itself can have temperatures of a few 100 K making it ideal for biomedical applications.

A plasma fluid simulation with 2D finite element method is being used to model our APPJ. The model created in COMSOL Multiphysics® includes coupled calculations of the plasma, turbulent fluid flow, and heat transfer. The simulation results include the electrical and plasma properties of the jet, including fluid velocity, number density, electron density, reaction rates, plasma potential, and electric fields.

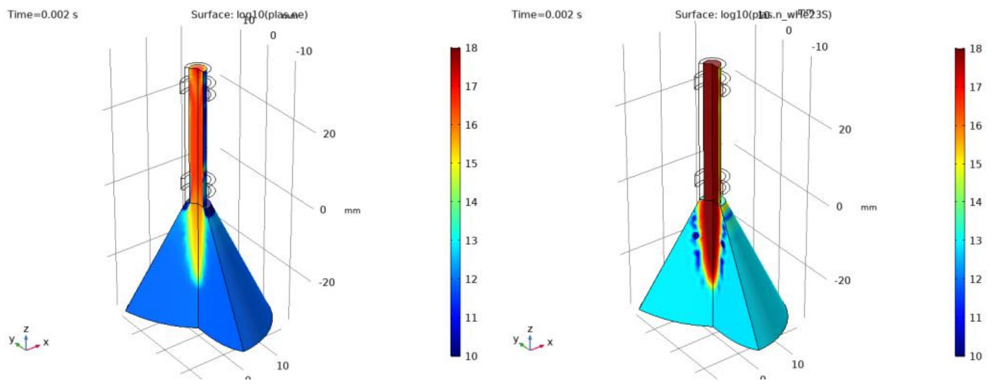

Fig 1. Left) Snapshot of electron density | Right) Snapshot of metastable helium 2 $^3S_1$ state density

Currently, the model only includes He, but a model with reactive species derived from N_2 and O_2 is being developed. The aim is to compare experimental emission observations with predictions from the simulation. A key test of the correlation between the experiment and the model will be to investigate the effect of, for example, input power variation. It will also be interesting to vary the gas composition in the plasma jet.

References

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