Simulation **of Atmospheric Pressure Plasma Jet** using **Finite Element Method**

ABSTRACT: Atmospheric-pressure plasma jets (APPJ) generate chemically reactive species that 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 or UV photons. This plasma cocktail not only triggers a variety of cell responses (cell detachment, apoptosis) but is at a temperature that does not damage tissue/skin. Plasma medical applications or plasma medicine examples include the killing of cancer cells, wound healing, and sterilisation. The plasma jet set up at Queen's University Belfast has shown to be effective in bacteria inactivation. Our experiment 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. 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. 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.

BACKGROUND:

- Atmospheric Pressure Plasma jet (APPJ) is a gas discharge, operated in an open dielectric tube, projected outside the electrode arrangement into the environment as in fig. 1
- Plasma medicine as an alternative treatment for cancer, wound healing, sterilisation

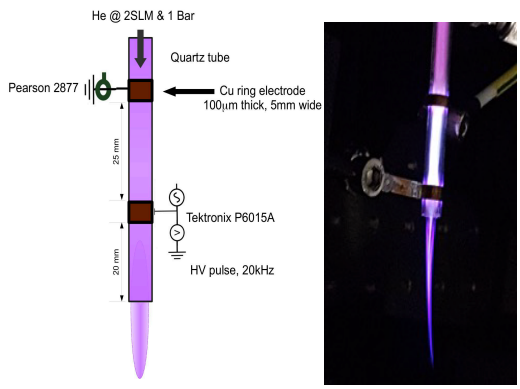

Figure 1: Schematic of QUB APPJ (C. McDonnell)

METHOD:

- Our model is a fully coupled He plasma, turbulent fluid flow, and heat transfer in fluid analysis of the plasma jet created using COMSOL Multiphysics®.

PRELIMINARY RESULTS

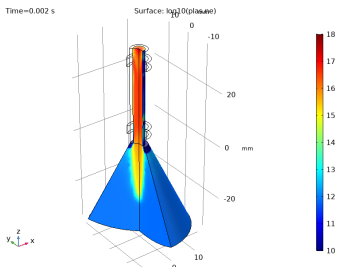

Figure 2: Snapshot of electron density

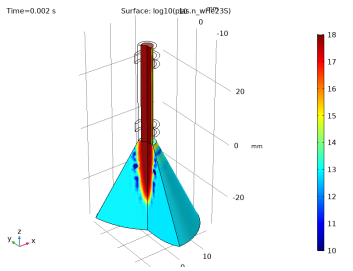

Figure 3: Snapshot of helium metastable 2 $^3S_1$

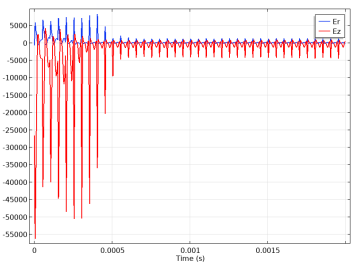

Figure 4: Electric field at tube exit

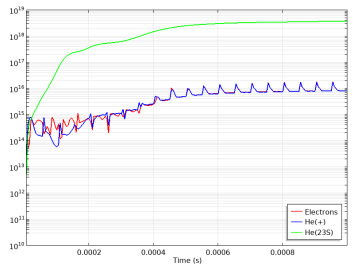

Figure 5: Number density at tube exit

Future Work: | Plans to admixtures of N2 & O2 | Try different targets e.g. copper or glass | Vary jet parameters e.g. gas mixtures, gas flow rates, power input, electrode thicknesses & distances, tube thickness |

Outstanding Problem: Influence of dielectric tube on plasma behaviour - Why does the simulation collapse when electrodes are in the pure Helium environment?

QUEEN'S UNIVERSITY BELFAST

ATOMIC AND MOLECULAR DATA NEEDS FOR PLASMA APPLICATIONS WORKSHOP

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Excerpt from the Proceedings of the 2021 Atomic & Molecular Data Needs for Plasma Applications Workshop