Benchmarking an **Atmospheric Pressure Plasma Jet** using **COMSOL Multiphysics®**

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. In collaboration with Prof Murakami of Seikei University, we have a working model that is a good match for our experiment. The simulation results include the electrical and plasma properties of the jet. COMSOL Multiphysics® enabled us to simulate our experiment's unique power supply which is a pulse decaying sinusoidal waveform. Some of our preliminary results are shown below.

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

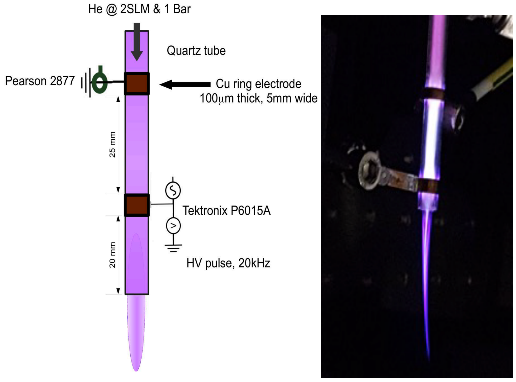

Figure 1: Schematic of QUB APPJ (C. McDonnell)

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

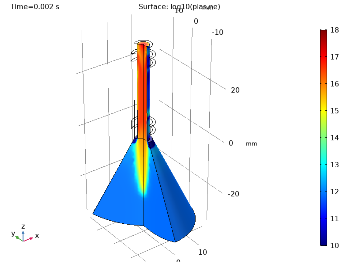

Figure 2: Snapshot of electron density

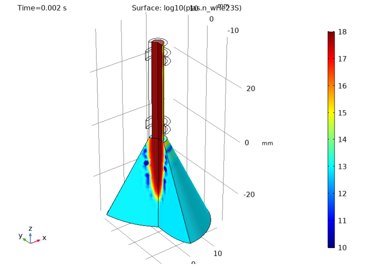

Figure 2: Snapshot of helium metastable 23S

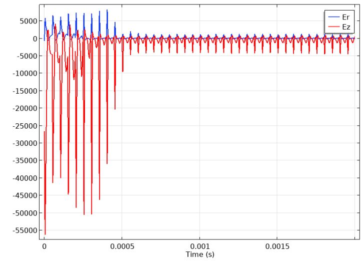

Figure 4: Electric field at tube exit

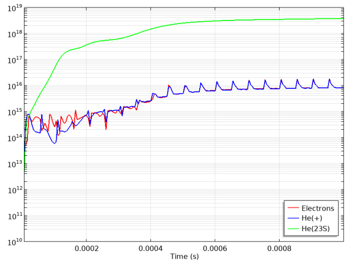

Figure 5: Number density at tube exit

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?

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