SIMULATION OF COLD AIR PLASMA JET

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ABSTRACT

Hot plasma jets have been used in various cutting and welding processes for many decades. In recent years, small-scale cold plasma jets have received considerable attention due to their ability to produce a reactive chemistry at low temperatures. Applications for cold plasma jets include thin film deposition, etching, surface decontamination, and sterilization of living tissue.

Plasmas are inherently multiphysics phenomena, featuring a tightly coupled system of electromagnetics, fluid flow, physical kinetics, chemical reactions, and heat transfer. In the plasma jet under consideration in this work, air is forced through a small annulus with the inner wall at high voltage and the outer wall grounded. The strong electric field across the annulus generates an air plasma, and the flowing plasma proceeds through a nozzle, forming a plasma jet into the ambient air. The small diameter of the plasma and the turbulent heat transfer in the flow facilitate a low jet temperature, while reactive species continue to exist for some distance away from the nozzle.

Analysis of the cold air plasma jet is conducted using COMSOL Multiphysics. The non-equilibrium, non-Maxwellian plasma is modelled using a fluid approximation that solves for the transport of the electron density and the mean electron energy, and the two-term Boltzmann equation is used to calculate the transport coefficients and electron impact reaction rate coefficients. The plasma chemistry includes 19 species and 183 reactions, and transport equations are solved for each species. To solve for the momentum transport of the bulk fluid, the k-ε turbulence model is used. The plasma, species transport, and fluid flow equations are coupled to one another and to a heat transfer equation that accounts for conduction and convection, including the effect of

turbulence. The analysis results show the temperature of the jet and the concentrations of reactive species within the jet.