Fluid Modeling of Low Temperature Atmospheric Pressure Plasmas: What can and cannot be done with Commercial Software

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Low temperature atmospheric pressure plasmas have received considerable attention in recent years for a variety of applications, including biomedicine, aerodynamics, combustion, and material processing. In these applications, low temperature plasmas interact with non-isothermal, multicomponent fluid flows, including plasma and neutral chemistry, and plasma-organic/inorganic materials interactions. These systems are truly complex and are inherently coupled, multiphysics problems.

At this point, the fundamental mechanisms of the plasma and its related plasma-materials interaction are poorly understood and experiments are often difficult to interpret consistently. Experimental advances generally outpace numerical modeling of these fields, partly because of the complex nature of the system and partly because simulation tools are not easily accessible for the full community. Developing reliable numerical models based on commercial software would be helpful to broaden our modeling community. This would advance the general understand of fundamental mechanisms of plasma-materials systems. For instance, if simulation results could be easily obtained with minimum knowledge of the coding and numerical algorithms, a much greater fraction of the research community could use them. This would be especially beneficial for experimentalists without their own 'home-made' codes. Also, equation-based commercial software would be a powerful tool when solving multiphysics problems involving various coupled physical, chemical and biological phenomena (e.g. when including cells and tissues). Of course, commercial software is sometimes suffering from limited computational speed and the lack of full control of the solver algorithms. This is especially problematical for highly non-linear problems with a wide range of length and time scales, as is the case for many low temperature plasma problems. Nevertheless, we have found that significant progress can be made in spite of these serious challenges.

In this presentation, we will briefly summarize our recent modeling efforts on low temperature atmospheric pressure plasmas and the interaction with biomaterials, including the RF 'plasma needle' and surface air dielectric barrier discharge (DBD) using commercial software (COMSOL Multiphysics coupled with MATLAB). Then we will discuss advantages and disadvantages of the use of commercial software for modeling low temperature plasmas used for materials interactions.