Seminar Talk

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Tuesday, October 17, 2017
3:00 p.m. KH 224

Title: Spatially Resolved Measurements of N2 Concentration within an Atmospheric Pressure, Non-Thermal Helium Plasma Jet Using Planar Laser Rayleigh Scattering

Abstract:
An atmospheric, non-thermal (or, non-equilibrium) plasma jet device operates, in general, by generating a weakly ionized plasma using either helium or argon flowing inside a dielectric tube (I.D. 2 mm), and ignited by power sources ranging from AC to nanosecond high-voltage pulsed excitation. The mean electron temperature (~20,000 K) is much greater than the heavy neutral and ion species (T < 400 K), and, with careful addition of O2, N2, or other processing gases, electron-impact ionization, dissociation, and excitation can proceed via plasma-chemically efficient (or even impossible) pathways compared to thermal means. Reactive species can be tailored for low gas temperature material processing such as nanomaterial synthesis, etching, and surface functionalization. Control over the plasma properties is paramount, and non-thermal plasma jet technology has the drawback that optimization involves tuning nonlinearly coupled parameters such as the excitation power source, device geometry, gas flow rates, etc. This talk focuses on only one key aspect of a helium gas guided plasma jet operating in streamer mode: the diffusion of externally co-flowing neutral N2 gas into the buoyant, laminar helium jet flow field and its dependence on helium gas flow rate. This is especially troublesome for microplasmas in which the diameter is much less than 1 mm. We have developed a relatively simple technique for measuring the spatially resolved absolute concentration of N2 and He within the steady state flow field using Planar Laser Rayleigh scattering. This diagnostic utilizes the fact that the total Rayleigh scattering cross for helium is ~100x smaller than that of N2 (as well as O2 and argon, for example). Results will be presented for cases in which the laminar He flow momentum flux is insufficient to overcome both the diffusional and buoyancy effects, thereby rendering the plasma jet streamer propagation to be so spatio-temporally unstable that it is impractical for application. The opposite case is presented in which the jet remains laminar, the core flow is practically 100% He, and the streamer remains spatio-temporally stable.

Bio:
Bob Leiweke received the B.S. (1991) and M.S. (1994) degrees in Aeronautical & Astronautical Engineering, and Ph.D. (2004) in Mechanical Engineering at The Ohio State University, Columbus, Ohio. His M.S. work focused on theoretical fluid mechanics; weak vortex interactions with shallow terrain in a rotating reference frame. Bob earned his Ph.D. by developing a laser-based gas temperature diagnostic for highly vibrationally-excited carbon monoxide that was generated by a weakly ionized, optically-

pumped plasma. Bob was an NRC Postdoctoral Fellow at The Air Force Research Laboratory from 2004 – 2007 where he studied the effect of high voltage pulse shaping on the gas temperature, electrical and plasma-chemical efficiencies of dielectric barrier discharges. Since then, Bob has performed basic research on the plasma dynamics and plasma-chemical kinetics of atmospheric pressure, non-equilibrium helium plasma jets. Since 2007, he has been an adjunct faculty at Wright State University, Department of Mechanical Engineering. At AFRL, he is currently working with plasma-generated shock waves to enhance the fuel-air mixing in supersonic combustion flame holder cavities.