CHARACTERIZATION OF HYBRID NS PULSE/RF PLASMAS AND ATMOSPHERIC PRESSURE PLASMA JETS

CALEB RICHARDS, ELIJAH R JANS, DIRK VAN DEN BEKEROM, DAVID MIGNOGNA, IGOR V. ADAMOVICH, *Department of Mechanical and Aerospace Engineering, The Ohio State University, Columbus, OH, USA*.

Strong vibrational nonequilibrium is sustained in nitrogen and nitrogen/carbon dioxide "hybrid" plasmas, generated by a ns pulse train overlapping with a sub-breakdown RF waveform. N_2 vibrational level populations in the plasma are measured by broadband Coherent Anti-Stokes Raman Spectroscopy (CARS). Vibrationally excited CO_2 and CO in the plasma are detected by Quantum Cascade Laser Absorption Spectroscopy (QCLAS). The plasma is generated using a custom-designed external circuit which overlaps a ns pulse train and a sine-wave RF waveform, generated by two different power supplies, in plane-to-plane, double dielectric barrier discharge configuration. The results show that the sub-breakdown RF waveform, which does not produce ionization but heats the electrons generated by the ns pulses, has a strong effect on vibrational excitation of molecules in the plasma. This enables isolating and quantifying the contribution of reactions of vibrationally excited molecules in plasmachemical and plasma-catalytic processes. Specifically, the effect of the excitation of CO_2 asymmetric stretch vibrational mode on the dissociation of carbon dioxide is studied by QCLAS measurements of CO_2 vibrational level populations and CO product. In a closely related study, a quasi-two-dimensional atmospheric pressure plasma jet in a noble gas/nitrogen mixture, impinging on a dielectric plate (glass or quartz), is interrogated by Coherent Anti-Stokes Raman Spectroscopy (CARS). The experiments are made in N_2/Ar, N_2/He, and N_2/Ne plasma jets powered by a ns pulse train or an RF waveform. Strong N_2 vibrational nonequilibrium is measured in the jet, and found to increase as the mole fraction of nitrogen in the mixture is reduced. This suggests that N_2 vibrational excitation is produced by the energy transfer from metastable electronically excited atoms to the nitrogen vibrational mode, possibly via the metastable excited electronic state, $N_2(A^3\Sigma_u^+)$. To quantify the role of electronically excited nitrogen in this energy transfer processes, the number density of $N_2(A^3\Sigma_u^+)$ molecules in the plasma is measured by Tunable Diode Laser Absorption Spectroscopy.