GEC12-2012-000060

Abstract for an Invited Paper
for the GEC12 Meeting of
the American Physical Society

Non-linear optical diagnostic studies of high pressure non-equilibrium plasmas[1]

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Picosecond Coherent Anti-Stokes Raman Spectroscopy (CARS) is used for study of vibrational energy loading and relaxation kinetics in high pressure nitrogen and air nsec pulsed non-equilibrium plasmas in a pin-to-pin geometry. It is found that $\sim$33% of total discharge energy in a single pulse in air at 100 torr couples directly to nitrogen vibration by electron impact, in good agreement with master equation modeling predictions. However in the afterglow the total quanta in vibrational levels $0 - 9$ is found to increase by a factor of approximately 2 and 4 in nitrogen and air, respectively, a result in direct contrast to modeling results which predict the total number of quanta to be essentially constant. More detailed comparison between experiment and model show that the VDF predicted by the model during, and directly after, the discharge pulse is in good agreement with that determined experimentally, however for time delays exceeding $\sim$10 μsec the experimental and predicted VDFs diverge rapidly, particularly for levels v = 2 and greater. Specifically modeling predicts a rapid drop in population of high levels due to net downward V-V energy transfer whereas the experiment shows an increase in population in levels 2 and 3 and approximately constant population for higher levels. It is concluded that a collisional process is feeding high vibrational levels at a rate which is comparable to the rate at which population of the high levels is lost due to net downward V-V. A likely candidate for the source of additional vibrational quanta is the quenching of metastable electronic states of nitrogen to highly excited vibrational levels of the ground electronic state. Recent progress in the development and application of psec coherent Raman electric field and spontaneous Thomson scattering diagnostics for study of high pressure nsec pulsed plasmas will also be presented.

[1]This work supported by the DOE and NSF