MEASUREMENTS OF ELECTRIC FIELD IN A NANOSECOND PULSE DISCHARGE BY 4-WAVE MIXING

EDMOND BARATTE, IGOR V. ADAMOVICH, MARIEN SIMENI SIMENI, KRAIG FREDERICKSON,
Department of Aerospace and Mechanical Engineering, The Ohio State University, Columbus, OH, USA.

Picosecond four-wave mixing is used to measure temporally and Picosecond four-wave mixing is used to measure temporally and spatially resolved electric field in a nanosecond pulse dielectric discharge sustained in room air and in an atmospheric pressure hydrogen diffusion flame. Measurements of the electric field, and more precisely the reduced electric field (E/N) in the plasma is critical for determination rate coefficients of electron impact processes in the plasma, as well as for quantifying energy partition in the electric discharge among different molecular energy modes. The four-wave mixing measurements are performed using a collinear phase matching geometry, with nitrogen used as the probe species, at temporal resolution of about 2 ns . Absolute calibration is performed by measurement of a known electrostatic electric field. In the present experiments, the discharge is sustained between two stainless steel plate electrodes, each placed in a quartz sleeve, which greatly improves plasma uniformity. Our previous measurements of electric field in a nanosecond pulse dielectric barrier discharge by picosecond 4-wave mixing have been done in air at room temperature, in a discharge sustained between a razor edge high-voltage electrode and a plane grounded electrode (a quartz plate or a layer of distilled water). Electric field measurements in a flame, which is a high-temperature environment, are more challenging because the four-wave mixing signal is proportional to the to square root of the difference betwen the populations of N2 ground vibrational level (v=0) and first excited vibrational level (v=1). At high temperatures, the total number density is reduced, thus reducing absolute vibrational level populations of N2. Also, the signal is reduced further due to a wider distribution of N2 molecules over multiple rotational levels at higher temperatures, while the present four-wave mixing diagnostics is using spectrally narrow output of a ps laser and a high-pressure Raman cell, providing access only to a few N2 rotational levels. Because of this, the four-wave mixing signal in the flame is lower by more than an order of magnitude compared to the signal generated in room temperature air plasma. Preliminary experiments demonstrated four-wave mixing signal generated by the electric field in the flame, following ns pulse discharge breakdown. The electric field in the flame is estimated using four-wave mixing signal calibration vs. temperature in electrostatic electric field generated in heated air. Further measurements in the flame are underway.