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Laser-based diagnostics of repetitively pulsed nanosecond discharges in atmospheric pressure air

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Atmospheric pressure air plasmas are widely used for surface treatment and activation, exhaust gas control, aerodynamic flow control, plasma assisted combustion, or destruction of toxic compounds [1]. The efficiency of these processes strongly depends on the energy requirements of the plasma sources employed. We present here a nanosecond repetitively pulsed (NRPP) discharge generated in a pin-to-pin electrode configuration in atmospheric pressure air, characterized by energy requirements of a few W/cm^3 for electron densities of about 10^{12} cm^{-3}, i.e. several orders of magnitude lower than with typical rf, mw, or dc plasma sources capable of producing the same level of electron density. Corona, diffuse and filamentary regimes of NRPP discharges have been observed depending on the applied voltage (5-8 kV), repetition frequency (2-30 KHz), gas temperature (300-1000 K), air flow rate (1-17 m/s) and gap distance (1-7 mm).

The small plasma volume (1-10 mm^3) and short lifetime of plasma species (tens of nanoseconds) limit the available diagnostic methods. Measurements of current and voltage have been made to determine the energy deposited into the discharge. Spatial and time evolution of the excited state species $N_2(B)$, $N_2(C)$, $N_2^+(B)$, NO(A) and O(3p ^{5}P) were obtained using intensity calibrated emission spectroscopy [2].

Laser diagnostic techniques are currently tested for detection of other important species. A pulsed Cavity Ring-Down Spectroscopy (CRDS) at 770 nm is planned for detection of $N_2(A)$ species. Two approaches have been considered for the detection of atomic oxygen: Cavity-Enhanced Spectroscopy by probing a forbidden transition at 636 nm [3] and Two-Photon Laser Induced Fluorescence (TALIF) at 225 nm with fluorescence at 844 nm [4,5]. We present here preliminary results and the difficulties we encountered: laser beam steering due to high temperature gradients or laser broadening effects for CRDS, and calibration and quenching problems regarding TALIF.

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