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Diagnostic and modeling of fast pulsed discharges

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1. Background

Fast nanosecond (ns) pulsed discharges came into the international scientific scene in the mid 1990's [1], being later developed for high pressure applications such as plasma assisted combustion [2-4] and flow dynamics [5]. This talk will present a review of experimental and numerical methods developed during the last 10-15 years with the aim of studying ns discharges, and the results obtained for a wide range of pressures (0.1 mbar - 15 bar), mixture compositions and specific delivered energies.

2. Approaches to experiments and modeling

Electrical diagnostics allows time resolved (synchronized with an accuracy of 0.2 ns) discharge electrical current, reduced field and deposited energy. Measurements of electron density can be performed by electrical methods and by Stark broadening; H, O, N lines are typically used. Electric field in the discharge can be measured with tens of picoseconds and hundreds of microns resolution using the second harmonic generation of the ps laser emission traversing the region of the electric field.

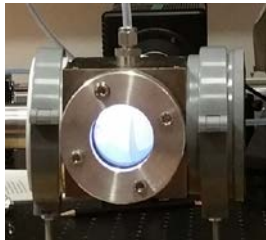


Figure 1. Uniform ns discharge in air. $P=25$ mbar, $U=5$ kV, $f=1$ kHz

ICCD imaging with spectral filtering provides information about discharge uniformity in space and typical dimensions of the plasma.

Developing, in parallel, comprehensive experimental diagnostics and numerical modeling provide insight into the physics of nanosecond discharges. During the last few years, codes describing volumetric and surface nanosecond discharges taking into account non-local effects on the discharge front, detailed chemical kinetics in the discharge/afterglow, and following fast energy release and hydrodynamic perturbations are now available.

3. Results and perspectives

At low pressures (Fig. 1), the ns plasma is uniform while with pressure increase (Fig. 2) the discharge is more concentrated in space. At moderate pressures, the dis-

charge develops uniformly in space within a wide range of specific deposited energies: from 0.001 to 1-5 eV/particle. At and above atmospheric pressure, a few modes are possible, from a low current corona discharge to a filamentary discharge with a typical current density of 10^4 - 10^5 A/cm².

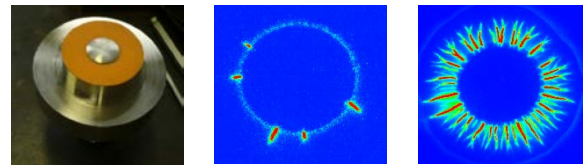


Figure 2. Electrode system (the HV electrode is a 2 cm diameter disk in the center) and nSDBD discharge. Air, $P=10$ bar; $U=+46$ kV, ICCD gate is 1 ns.

Peculiarities of kinetics of the discharges with high reduced electric fields and high delivered energy will be discussed using examples of the classical fast ionization wave (FIW) discharge at low specific delivered energy, the capillary FIW discharge at moderate pressure and the nanosecond surface dielectric barrier discharge (nSDBD) at high pressure (Fig.2).

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