



HAL
open science

Diagnostic and modeling of fast pulsed discharges

Tat Loon Chng, Inna Orel, Chenyang Ding, Georgy Pokrovskiy, Mhedine Ali Cherif, S.A. Shcherbanev, I.V. Adamovich, N.A. Popov, Svetlana Starikovskaia

► **To cite this version:**

Tat Loon Chng, Inna Orel, Chenyang Ding, Georgy Pokrovskiy, Mhedine Ali Cherif, et al.. Diagnostic and modeling of fast pulsed discharges. 13th Frontiers in Low-Temperature Plasma Diagnostics (FTLDP) and 1st Frontiers in Low-Temperature Plasma Simulations (FTLPS) Workshop, May 2019, Bad Honnef, Germany. hal-02407641

HAL Id: hal-02407641

<https://hal.science/hal-02407641>

Submitted on 6 Jan 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Diagnostic and modeling of fast pulsed discharges

T.L.Chng¹, I.S. Orel¹, Ch.Ding¹, G.V. Pokrovskiy¹, M.Alicherif¹, S.A. Shcherbanev¹,
I.V. Adamovich², N.A.Popov³, S. M.Starikovskaia¹

¹Laboratoire de Physique des Plasmas (CNRS, Ecole Polytechnique, Sorbonne University, University Paris-Sud, Observatoire de Paris, University Paris-Saclay), FR-91128Palaiseau Cedex, France

²Nonequilibrium Thermodynamics Laboratories, Department of Mechanical and Aerospace Engineering, Ohio State University, Columbus, OH 43210, USA

³Skobeltsyn Institute of Nuclear Physics, Moscow State University, Moscow, 119991, Leninsky gory, Russia

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.

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.

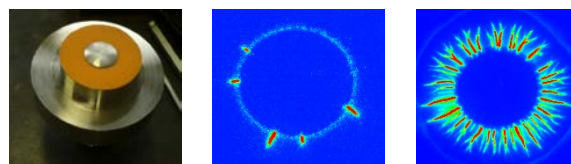


Figure 2. Electrode system (the HV electrode is a 2 cm diameter disk in the center) and nSDBD discharge. Air; $P=10$ bar; $U=+46$ kV, ICCD gate is 1 ns.

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).

Acknowledgements

This work was partially supported by LabEx Plas@Par, French National Research Agency (ASPEN Project), French-Russian international laboratory LIA KaPPA (CNRS) and RFBR 17-52-16001. The support of Prof. Adamovich by the Ecole Polytechnique Gaspard Monge Visiting Professor Program is gratefully acknowledged.

References

- [1] LM Vasilyak, SV Kostyuchenko, NN Kudryavtsev, IV Filyugin, *Phys.-Uspekhi*, 1994, 163, 263-286
- [2] A Starikovskiy, N Aleksandrov, *Prog. Energy Combust. Sci.* 2013, 39, 61-110
- [3] IV Adamovich, I Choi, N Jiang, J-H Kim, S Keshav, WR Lempert, EI Mintusov, M Nishihara, M Samimy, M Uddi PSST, 2009, 18, 034018
- [4] Y Ju, W Sun, *Prog. En. Comb. Sci.* 2015, 48, 21-83
- [5] S B Leonov, I V Adamovich, V R Soloviev PSST, 2016, 25, 063001