Wigner 121 Scientific Symposium

Wigner Research Centre for Physics
Institute for Solid State Physics and Optics
Department of Complex Fluids
Electrical Gas Discharges Research Group

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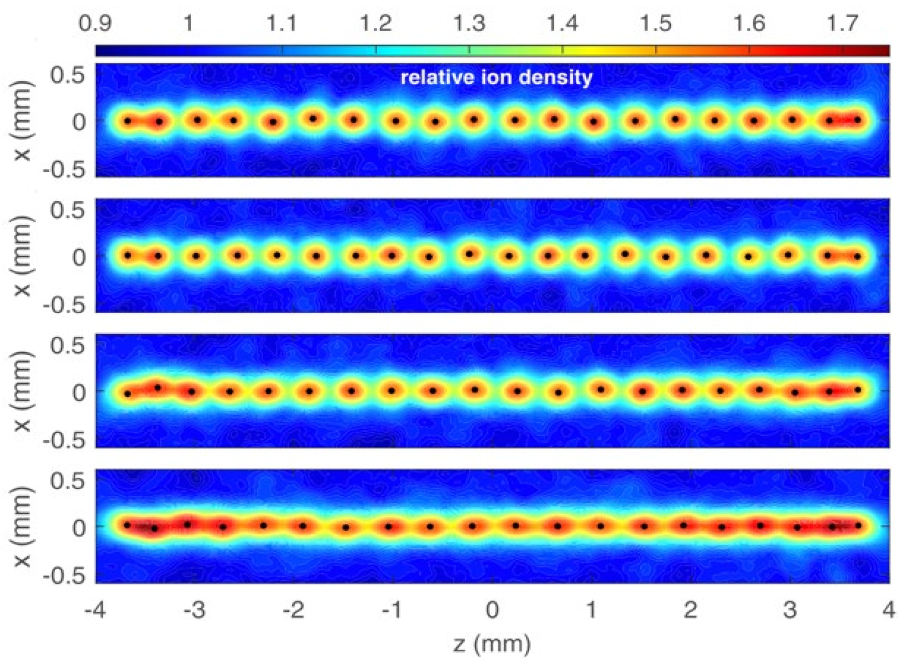
Introduction

The Electrical Gas Discharges Research Group focuses on experimental investigations and numerical simulation studies of various types of electrical gas discharges. During the past few years, we have addressed several aspects of charged particle kinetics and transport in low-temperature plasmas, structure formation in strongly coupled plasmas, technological application of high-frequency discharge systems, etc.

Complex plasmas

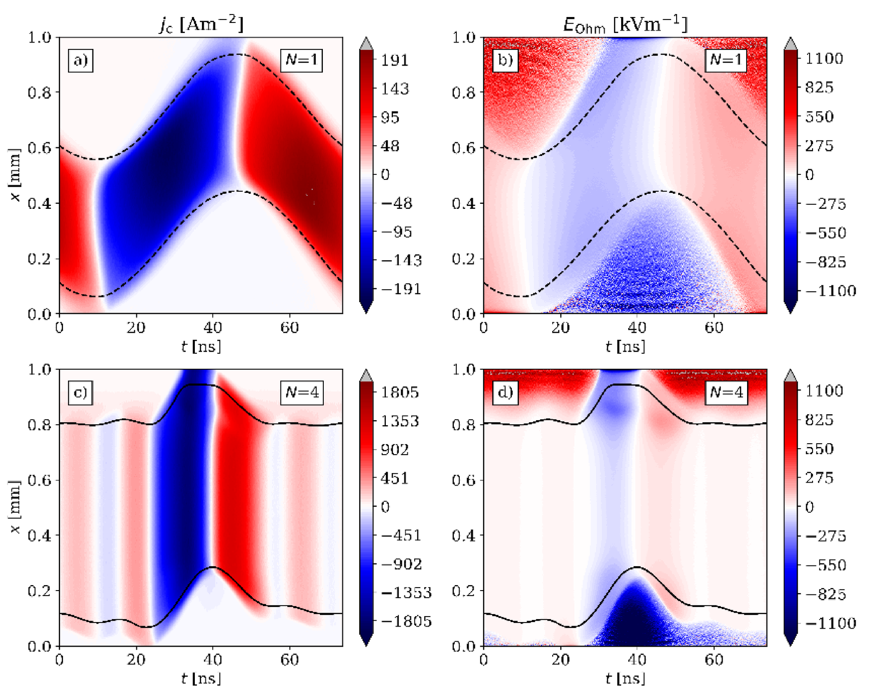


The self-organization of dust grains in a flowing plasma offers insight into the interplay among charged species in a complex plasma environment, relevant to astrophysical and technological systems.

Neon ion density distribution around the dust particles for different periods of the oscillating plasma environment during the crossing of ionization waves.

Theoretical insights into low-temperature plasmas

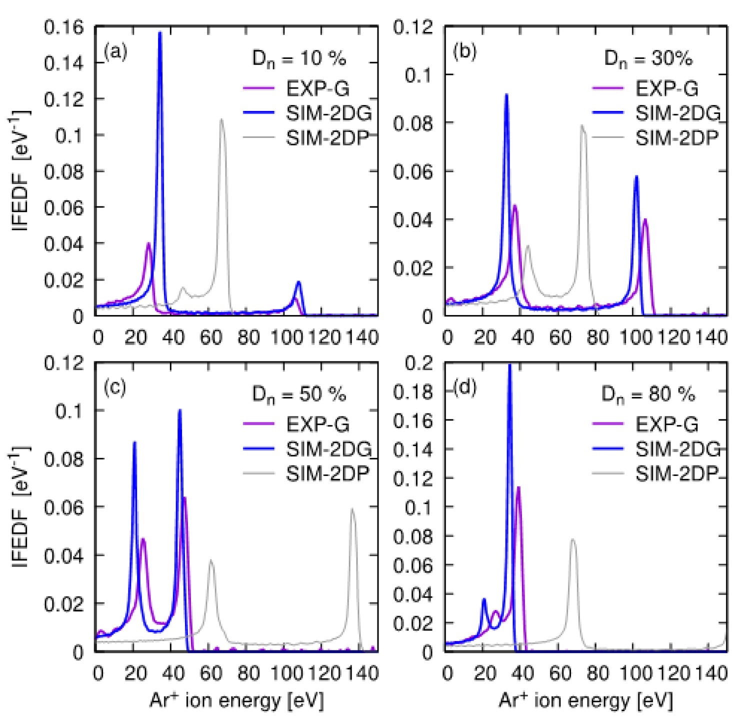
A complete, self-consistent description of the electron power absorption dynamics can be gained in low temperature plasmas by the Boltzmann term analysis, a method based on the momentum balance equation, assisted by Particle-In-Cell/Monte-Carlo-Collisions simulations.



Spatio-temporal distributions of the conduction current density and the ohmic electric field for a single harmonic waveform (a,b) and a valleys type waveform of four harmonics (c,d).

Control of ion properties in plasma treatment applications

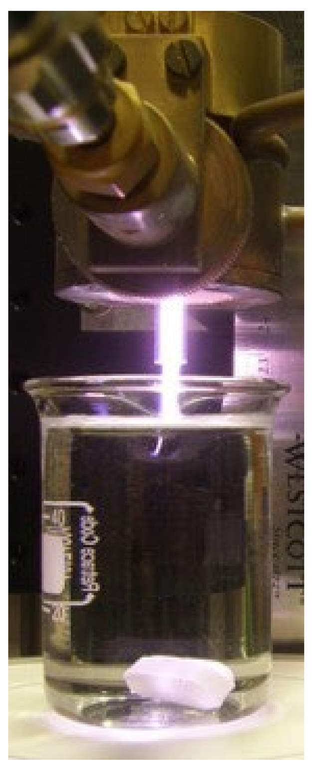
By applying tailored voltage waveforms, composed of low frequency (LF, ~100 kHz) pulsed and high-frequency (HF, >10 MHz) components, it is possible to efficiently decouple plasma generation from the shaping of the ion flux-energy distribution at the electrodes.



Experimental (EXP) and computed (SIM-2D) Ar$^+$ ion flux-energy distribution functions at the grounded (G) and powered (P) electrodes as functions of the LF pulse duty cycle.

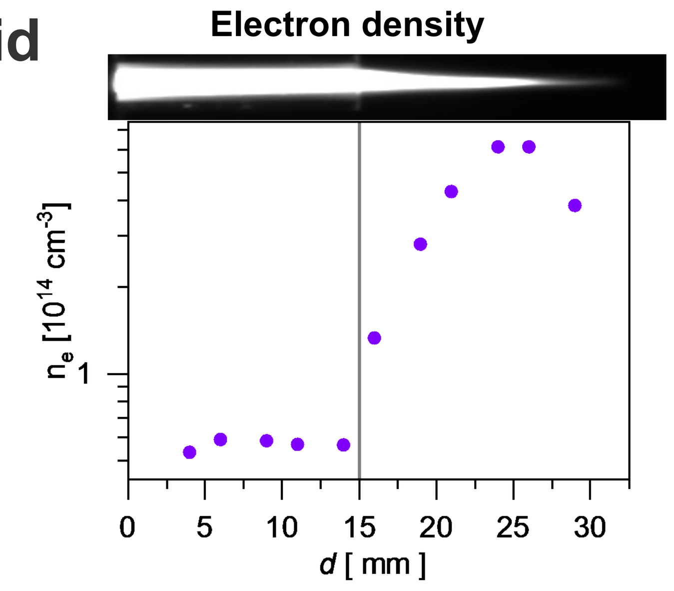
Research Highlights

Plasma – liquid interaction



Liquid in contact with a surface-wave microwave discharge

Electron density



$$e^- + H_2O \rightarrow OH + H + e^-$$

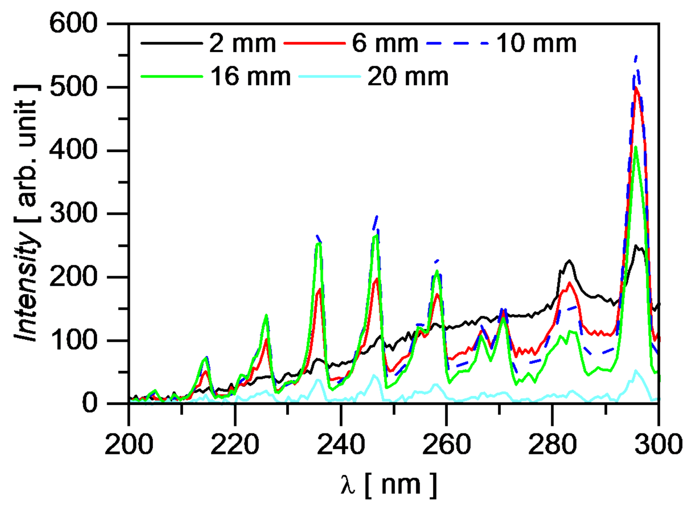
$$OH + OH \rightarrow H_2O_2$$

Ageing of deposited reactive species

10 min

5 min

NO emission



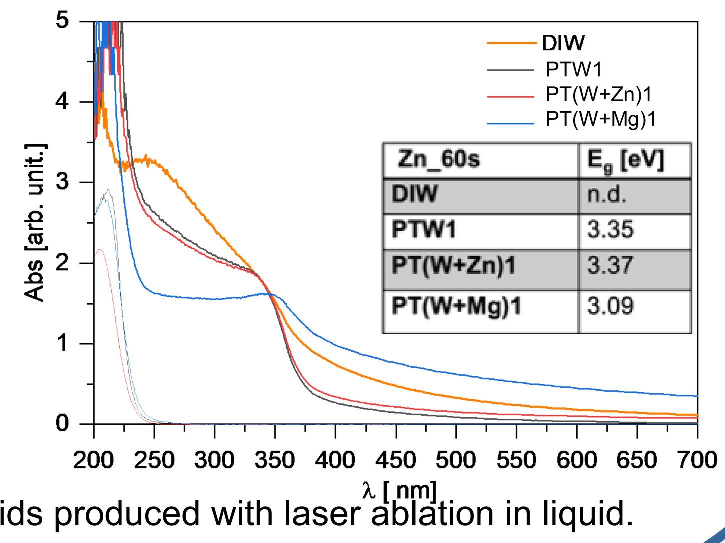
$$NO_{2(aq)} + NO_{2(aq)} + H_2O_l \rightarrow NO_2^- + NO_3^- + 2H^+$$

$$NO_{(aq)} + NO_{2(aq)} + H_2O_l \rightarrow 2NO_2^- + 2H^+$$

$$NO_{(aq)} + OH_{(aq)} \rightarrow NO_2^- + H^+$$

$$NO_{2(aq)} + OH_{(aq)} \rightarrow NO_3^- + H^+$$

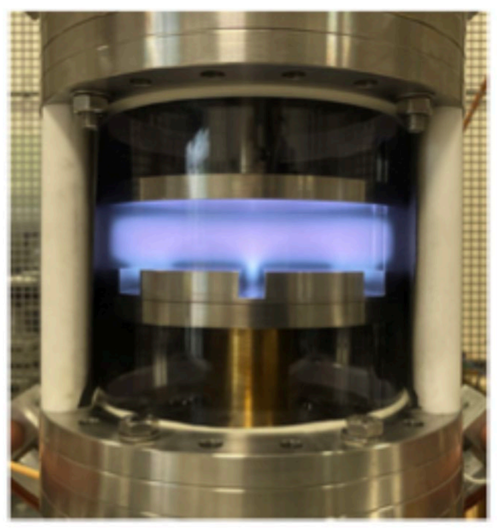
Plasma assisted modification of ZnNPs



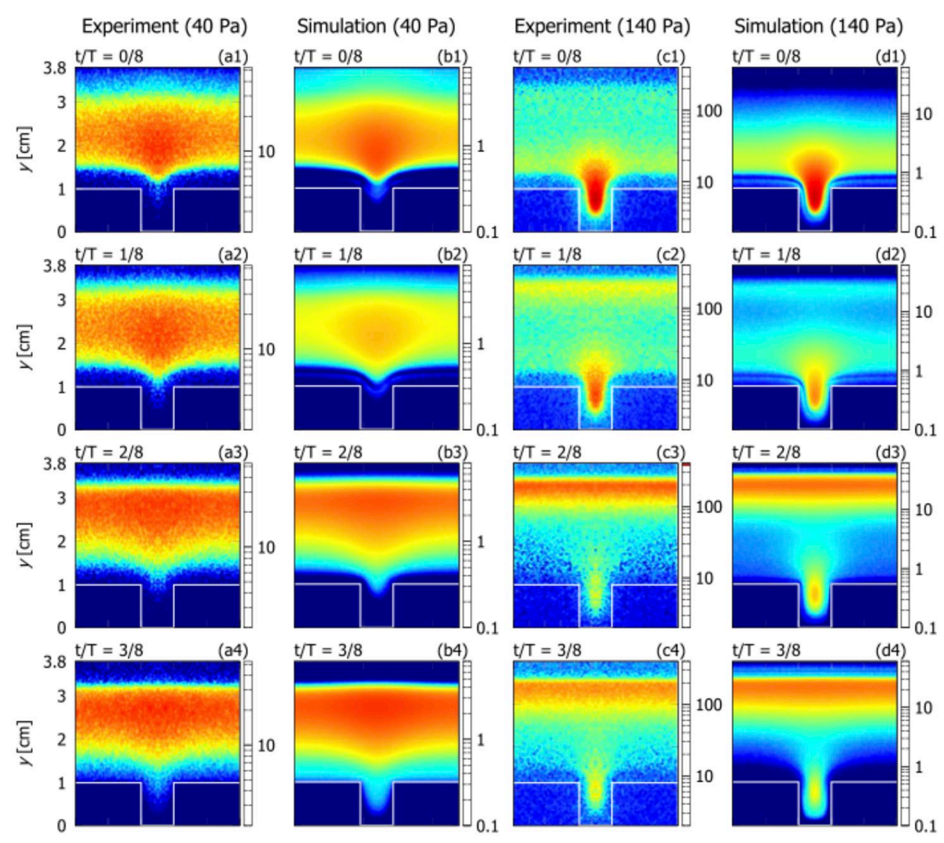
Zn_60s	E_g [eV]
DIW	n.d.
PTW1	3.35
PT(W+Zn)1	3.37
PT(W+Mg)1	3.09

Colloids produced with laser ablation in liquid.

Radio frequency discharges with structured electrodes



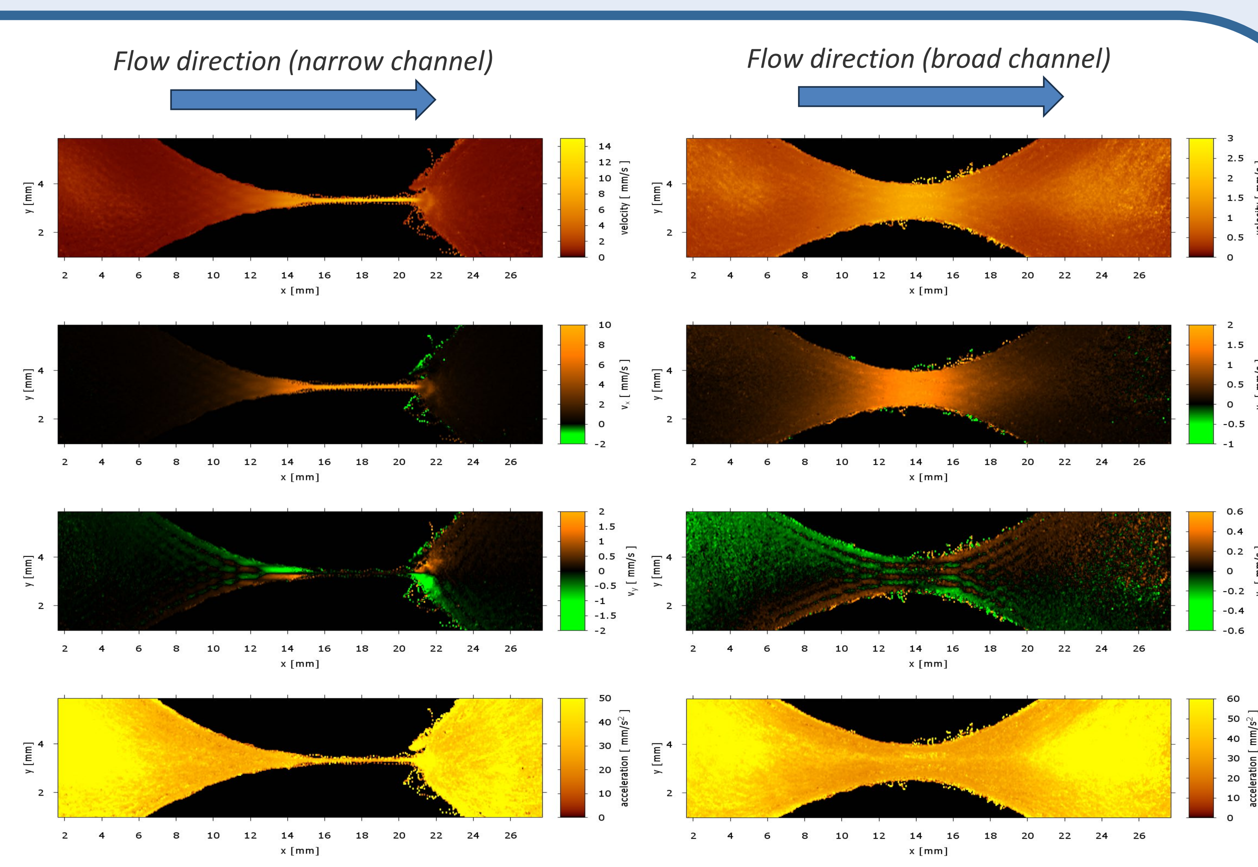
Plasma source with structured electrode in operation in He gas.



Time evolution of the He 3s 706 nm excitation rate obtained from experiments and corresponding simulation results at different pressures.

Microfluid flow in single-layer dusty plasmas

In recent years microfluids became a hot topic. The flow in straight channels is usually assumed to be laminar and the dynamics over-damped. So far the behavior of tracer particles were used to analyze flow particles. Dusty plasmas provide new possibilities to understand the elementary dynamics of microfluid flows.



Velocity and acceleration distribution for single- and triple-lane cases.

Publications of the group

[1] M Vass, S Wilczek, J Schulze and Z Donkó, 2021 *Plasma Sources Sci. Technol.* **30** 105010
[2] J Ďurian, P Hartmann, Š Matejčík[1], A R Gibson and Z Donkó, 2022 *Plasma Sources Sci. Technol.* **31** 095001
[3] P Hartmann, I Korolov, J Escandón-López, W van Gennip, K Buskes and J Schulze, 2022 *Plasma Sources Sci. Technol.* **31** 055017
[4] K Kutasi, L Bencs, Z Tóth, S Milošević, 2023 *Plasma Processes Polym.* 20:e2200143
[5] L Matthews, K Vermillion, P Hartmann, M Rosenberg, S Rostami, E Kostadinova,… O Novitskiy, 2021 *Journal of Plasma Physics, 87*(6), 905870618

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