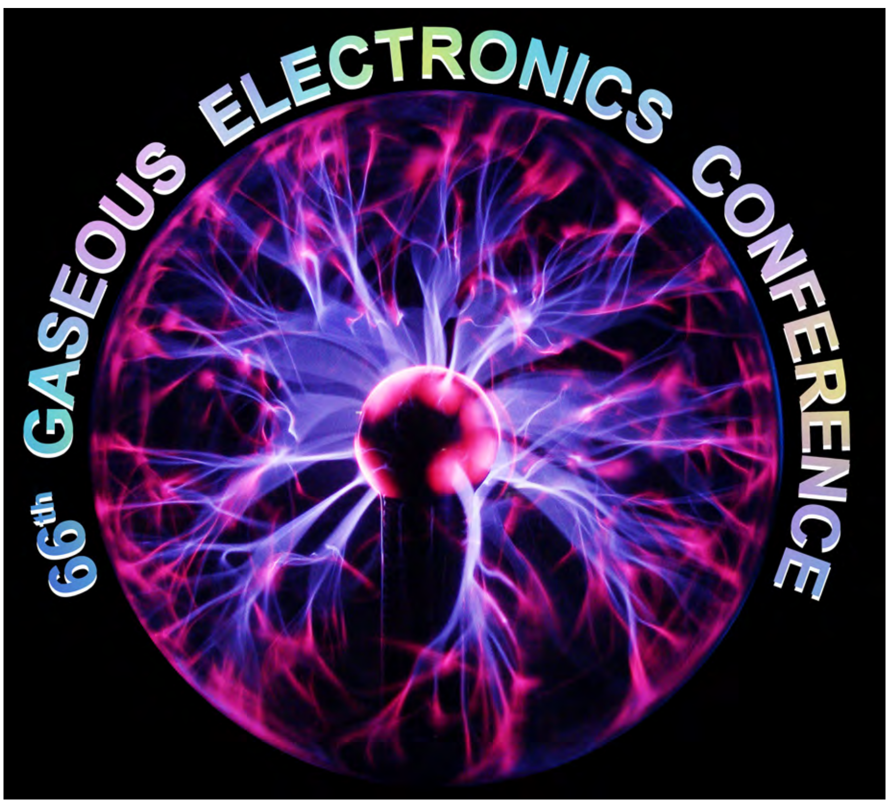
Void dynamics in low-pressure acetylene RF plasmas

BULLETIN

OF THE AMERICAN PHYSICAL SOCIETY

66th Annual
Gaseous Electronics Conference

September–October, 2013
Princeton, New Jersey



Volume 58, Number 8

APS physics

10:45

DT1 3 Experimental study of charged particle transport in a magnetized low-temperature plasma* R. BAUDE, F. GABORIAU, G.J.M. HAGELAAR, *LAPLACE, University de Toulouse, France* Magnetized low-temperature plasmas are widely used in different types of applications: materials processing, space propulsion, or neutral beam injection. However, the role of the magnetic field in these plasmas is not fully understood, in particular when the plasma chamber has no cylindrical symmetry. The magnetic drift is then bounded by the walls and can play an important role in the plasma transport. In this work, an experimental set up has been developed to study electron transport across a magnetic field barrier and obtain experimental data for the validation of magnetized plasma models, in conditions similar to those of negative ion sources for neutral beam injection. In order to experimentally characterize the electron transport, the local ion and electron current densities at the walls are measured. The diagnostic used is a wall current probe similar to a segmented planar probe designed and developed to spatially and temporally measure the ion and electron current density. The experimental current density profiles are compared with current density profiles calculated with a 2D fluid model.

*This work is supported by the French National Research Agency (project METRIS ANR-11-JS09-008).

11:00

DT1 4 Cross-field diffusion in low-temperature plasma discharges of finite length DAVIDE CURRELI, *University of Illinois at Urbana Champaign* The long-standing problem of plasma diffusion across the magnetic field is here critically reviewed, focusing on low-temperature linear devices of finite length having the magnetic field aligned mainly along one axis of symmetry. After a review of the past six decades of works on both the experimental measurements and the theoretical interpretations, we compare and discuss the results obtained from different approaches. Macroscopic fluid-based models can give a first order description of the quasi-neutral region of the plasma. Microscopic calculations of the kinetic motion of plasma particles using three dimensional Particle-in-Cells evidence the big relevance of electrons kinetics, not revealed when electrons are simply approximated as Boltzmann-like. We highlight the relevance of including into the description also the non-neutral region of the sheath boundary, where quasi-neutrality is broken and ions become supersonic, and the wall, whose electrical short-circuiting interaction with the plasma can't be neglected.

11:15

DT1 5 Void dynamics in low-pressure acetylene RF plasmas* FERDINANDUS MARTINUS JOZEF HENRICUS VAN DE WETERING, SANDER NIJDAM, JOB BECKERS, GERARDUS MARIA WILHELMUS KROESEN, *Eindhoven University of Technology, Department of Applied Physics, P.O. Box 513, 5600 MB Eindhoven, the Netherlands* In low-pressure acetylene plasmas, dust particles spontaneously form under certain conditions. This process occurs in a matter of seconds to minutes after igniting the plasma and results in a cloud of particulates up to micrometer sizes levitated in the plasma. We studied a capacitively coupled radio-frequency plasma under normal gravity conditions and constant flow of feed gas (argon and acetylene). After the dust cloud has been formed, an ellipsoid-shaped dust-free zone – called a void – develops and grows as a function of time. Concurrently, the dust particles grow in size. Peculiar dynamics of the void have been observed, where during its expansions it suddenly stops growing and even shrinks, to shortly thereafter resume its expansion. We infer this is induced by coagulation of a new batch of dust particles inside the void. The whole dust growth and void expansion/contraction is periodical and highly reproducible. Several techniques are used to gain information about the plasma dynamics. Microwave cavity resonance spectroscopy is used to determine the global electron density. Scattering of a vertical laser sheet is used to visualize the dust particle density. The electrical characteristics of the plasma are determined using a commercially available plasma impedance monitor.

*This work is supported by NanoNextNL, a micro and nanotechnology programme of the Dutch Government and 130 partners.

11:30

DT1 6 Acoustic nonlinear periodic waves in pair-ion plasmas SHAHZAD MAHMOOD, *PINSTECH, Islamabad* TAMAZ KALADZE, *Govt. College Lahore* HAFEEZ UR-REHMAN, *PINSTECH, Islamabad* Electrostatic acoustic nonlinear periodic (cnoidal) waves and solitons are investigated in unmagnetized pair-ion plasmas consisting of same mass and oppositely charged ion species with different temperatures. Using reductive perturbation method and appropriate boundary conditions, the Korteweg-de Vries (KdV) equation is derived. The analytical solutions of both cnoidal wave and soliton solutions are discussed in detail. The phase plane plots of cnoidal and soliton structures are shown. It is found that both compressive and rarefactive cnoidal wave and soliton structures are formed depending on the temperature ratio of positive and negative ions in pair-ion plasmas. In the special case, it is revealed that the amplitude of soliton may become larger than it is allowed by the nonlinear stationary wave theory which is equal to the quantum tunneling by particle through a potential barrier effect. The serious flaws in the earlier published results by Yadav *et al.*, [PRE **52**, 3045 (1995)] and Chawla and Misra [Phys. Plasmas **17**, 102315 (2010)] of studying ion acoustic nonlinear periodic waves are also pointed out.

11:45

DT1 7 Dynamic contraction of the positive column of a self-sustained glow discharge in molecular gas flow MIKHAIL MOKROV, *Institute for Problems in Mechanics, RAS, Moscow 119526, Russia* MIKHAIL SHNEIDER, *Princeton University, Princeton, New Jersey 08544, USA* GENNADY MILIKH, *University of Maryland, College Park, Maryland 20742, USA* We study dynamic contraction of a quasineutral positive column of a self-sustained glow discharge in nitrogen and air in a rectangular duct with the convection cooling. A set of time-dependent two-dimensional equations for the nonequilibrium weakly-ionized plasma is formulated, and then solved numerically. Transition from diffusive state to contracted one is analyzed. It is shown that in nitrogen the contraction occurs in the so-called "hard" or hysteresis mode while in air the character of the transition depends on pressure. Under relatively high pressure, hysteresis does not occur and the transition takes place in so called "soft" mode. When the pressure reduces and thus the role played by electron attachment diminishes, the transition in air occurs in the hysteresis mode. In such a case the inhomogeneous contraction can occur, when a high density plasma channel starting from the initial perturbation near one electrode propagates to the opposite electrode. The discharge evolution of such kind is computed for a case of self-sustained glow discharge in nitrogen. The results are in agreement with experiment.