THREE-DIMENSIONAL MODELLING OF SELF-ORGANIZATION PHENOMENA IN CATHODE BOUNDARY LAYER DISCHARGES USING COMSOL MULTIPHYSICS

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Modelling of self-organization phenomena in cathode boundary layer discharge is presented. The model, implemented with Comsol Multiphysics software, comprises equations for conservation of electrons and a single ion species written with the drift-diffusion transport approximation, Poisson's equation, and using the local-field approximation. Processes considered are direct ionization and dissociative recombination. The gas modelled is xenon at 30 Torr. The discharge configuration is the same as shown in figure 1 of [1]. Standard boundary conditions have been used; in particular the dielectric wall absorbed charged particles. Solutions were found using a stationary solver, which decoupled physical from computational stability and is a key feature of the present modelling. The control parameter was switched from discharge voltage to discharge current, depending on the differential resistance of the discharge.
Multiple solutions have been computed. One of these solutions is 2D (axially symmetrical) which exists for all values of discharge current and is termed fundamental. Other solutions are 3D and they exist for a limited range of the discharge current. There are states where the 3D solutions become 2D, these states are called bifurcation points and belong also to the fundamental mode. The bifurcation points are points of neutral stability of the fundamental mode against 3D perturbations and were computed by means of linear stability theory [2]. Cathodic spot patterns found in new 3D modes are qualitatively the same as observed in experiments, fig. 2 of [1]. New solutions are compared to their previous counterparts and they are discussed within the framework of self-organization theory [3] and are found to fit the general pattern of self-organization.

1. W. Zhu and P. Niraula, “The missing modes of self-organization in cathode boundary layer discharge in xenon”, Plasma Sources Sci. Technol., vol. 23, no. 5, pp. 054011, 2014.
2. P G C Almeida et al, “Analysing bifurcations encountered in numerical modelling of current transfer to cathodes of dc glow and arc discharges” 2009 J. Phys. D: Appl. Phys. 42.
3. M. S. Benilov, "Multiple solutions in the theory of dc glow discharges and cathodic part of arc discharges. Application of these solutions to the modeling of cathode spots and patterns: a review", Plasma Sources Sci. Technol., vol. 23, no. 5, pp. 054019, 2014.

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