Self-consistent modelling of spot patterns on anodes of DC glow discharges

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Self-organized patterns of spots on a flat metallic anode in a cylindrical glow discharge tube are computed. A standard model of glow discharges is used, which comprises conservation and transport equations of ion and electron species, written with the use of the drift-diffusion and local-field approximation, and the Poisson equation. The computation domain is the near-anode region, separating the anode and the cylindrical discharge column. Multiple solutions, existing for the same value of discharge current and describing modes with different configurations of anode spots, and none at all, are computed in a wide range of currents by means of a stationary solver. At low currents the spots exhibit unusual forms with localized field and anode current density reversal.

1. Introduction

Beautiful regular patterns of bright spots on anodes of DC glow discharges have been observed for many decades; see references in [1]. Recently, such patterns were shown to be potentially useful for the treatment of cancer [2]. 2D spot patterns on glow anodes have been computed in [3], although not for a wide range of currents and apparently without a proper description of the discharge column.

Recently, self-organized spots and patterns on cathodes of arc and DC glow discharges have been described and systematically computed in terms of multiple steady-state solutions, which exist for the same values of the discharge current and describe modes associated with different spot patterns [1]. In this work, multiple solutions describing different modes have been for the first time computed for the case of an anode of a DC glow discharge.

2. Model and numerics

The reported results refer to a helium discharge under the pressure of 5 Torr, in a 1 mm-diameter cylindrical tube. The numerical model was the same as in [4]. Boundary conditions used for a metallic anode and a dielectric lateral wall were conventional ones. The height of the computation domain was 5 mm, which proved to be sufficient for an axially uniform column to be formed in a wide range of currents. The boundary conditions on the column side are zero normal derivatives of the charged particles densities and a constant value of axial electric field, related to the discharge current (a specified parameter). Axially symmetric and 3D solutions were computed by means of the Plasma module of COMSOL Multiphysics, employed in a nonstandard way permitting the use of a stationary solver.

3. Results

As an example, Figure 1 shows electron densty distribution on the anode. A regualr ring of spots is formed, similar to what was observed in the experiments (references in [1]).

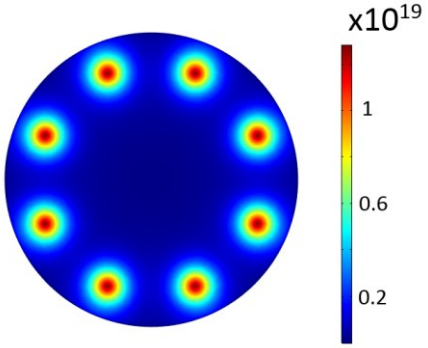

Fig. 1. Electron density on the anode. 0.01 A.

The modelling results differ from what is known from the theory and modelling of multiple modes on cathodes of arc and dc discharges: no pronounced N-shaped current voltage characteristic and no bifurcations have been observed; the spots assume a "mini-cathode" structure at low currents.

3. Acknowledgements

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4. References

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