THE BEENAKKER’S CAVITY FOR UNIFORM COLUMN OF NON-EQUILIBRIUM ARGON PLASMA GENERATION: EXPERIMENT AND 3D-MODELING

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Different devices like surfatrons [1] and resonators [2] can be used for generating elongated columns of non-equilibrium low temperature microwave-initiated plasma. In this paper we present results of the experimental tests and numerical modeling of elongated column of argon low temperature plasma, generated by the Beenakker’s cavity [3]. The discharge is initiated inside a quartz tube at 0.5 Torr gas pressure. The quartz tube goes through the center of the resonator as in the case of Van Dalen’s modification of Beenakker microwave cavity [4]. An adjustable quartz rod is being moved until a resonance initiation of plasma column is achieved. We used a commercial microwave generator with working frequency 2.45 GHz and output power 80 W. Optical radiation from plasma is registered by digital camera and spectrometer.

Since for our discharge system the experimental conditions are such that the relaxation path of the electron energy considerably exceeds the radius of the discharge tube, we describe the discharge by means of self-consistent model in the non-local approximation [5]. The model includes the balance equation for the electron energy, Maxwell equations, Boltzmann equation for free plasma electrons, Poisson equation and kinetic equations for the electrons, argon ions (Ar+ and Ar+2) and electronically excited argon states: coupled metastable 3P2÷3P0 level, coupled resonant 3P1÷1P1 level and 3 higher lying lumped levels [6]. The electrodynamic system is asymmetric, thus a full 3D-model is used for its description. All simulations are performed in the finite element program Comsol 3.5a [7].

The modeling revealed that a uniform plasma column appears for a certain length of adjustable rod. The density of the excited atoms in resonance state is found uniform along the tube axis outside the cavity which is linked with non-locality of the problem. The modeling gives additional information about plasma parameters inside the resonator, structure of microwave and DC fields. This work confirms experimental results with detailed modeling of argon plasma column generated inside the Beenakker’s cavity.

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