Low-pressure small-radius hydrogen discharge as a volume-production-based source of negative ions

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Recent one-dimensional (1D) model [1] of a free-fall regime maintained hydrogen discharge showing strong accumulation of volume-produced negative ions in the on-axis region of the discharge when its radius is small (2-3 cm) is extended towards two-dimensional (2D) description of the discharge structure. RF inductively driven discharges are considered within the fluid-plasma theory. The results present detailed description of the discharge behaviour, stressing on the spatial distribution not only of the plasma parameters but also of the fluxes in the discharge: the charged-particle fluxes and the electron energy flux.

The model presents numerical solutions of a set of equations involving the balance equations of the charged particles (electrons, the three types of positive H^+-, H_2^+- and H_3^+- ions and negative ions) and of the neutral species (hydrogen atoms and vibrationally excited molecules, i.e. of the fourteen vibrationally excited states of the ground electronic state of the hydrogen molecule), the momentum equations of the positive ions, the electron energy balance equation and the Poisson equation.

The analysis of the results show that the transport processes control the discharge behaviour. In particular, the flux towards the discharge center of the negative ions produced all over the discharge volume determines their strong accumulation in the discharge center. The main conclusion is that the active part of a small radius discharge – the region of the rf power deposition – is an effective source of negative hydrogen ions. Such a result shows that conclusions for the discharge structure and, in particular, for the efficiency of the sources of negative hydrogen ions should be based on a self-consistent description of the entire discharge, including both elementary and transport processes.

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