Physics And Modelling Of Tokamak Glow Discharge Cleaning

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Glow discharge cleaning (GDC) is a common technique for the conditioning of tokamak vessel walls in order to improve plasma performance and will be one of the primary conditioning techniques in ITER [1,2]. The GDC discharge is a dc low-temperature plasma discharge, operated in the absence of the toroidal magnetic field, between one or more anodes inserted into the vessel, and the entire vessel wall serving as a cathode.

This conference contribution presents a self-consistent two-dimensional model of the GDC discharge with the aim of improving fundamental understanding and predicting the wall ion current density distribution in ITER. The model combines a standard fluid model of the quasineutral plasma bulk with non-standard fluid equations for the fast electrons accelerated by the cathode sheath, based on transport coefficients and rate coefficients deduced from a Monte Carlo simulation. Examples of model results are shown in order to illustrate the general principles of the GDC discharge and the influence of the model input parameters. An important insight gained from this work is that the GDC discharge operates in a so-called hollow-cathode regime: the plasma is sustained mainly by ionization by secondary electrons emitted from the cathode, accelerated ballistically through a thin cathode sheath, penetrating the plasma as a fast electron beam, and trapped by the cathode fall surrounding the plasma on all sides. The electric field distribution inside the plasma, which determines the ion flux distribution on the vessel walls, is controlled by low-energy plasma bulk electrons. The relatively small surface area of the anode leads to the formation of an anode glow affecting the plasma uniformity. The model results have been compared with experimental data obtained on a small scale test stand as well as several large fusion devices.

This work has been funded by the IO-CEA/IRFM, contract IA #14 ref 42-586 FRW 6-49. The views expressed herein do not necessarily reflect those of ITER Organization.

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