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Numerical simulation of helical wave plasma source discharge in linear plasma device MPS-LD

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To achieve high performance and stable operation in the tokamak, it is particularly important to reduce the sputtering and erosion of the plasma-facing material. Therefore, understanding the plasma-material interactions (PSI) is a critical issue. Linear plasma device (LPD) has been widely used to study PSI in laboratory. The MPS-LD is a LPD built in Dalian University of Technology with the aim to investigate the plasma transport and PSI.[1] To this end, the plasma source is required to generate high density and high temperature steady-state plasma. The helical wave plasma (HWP) source is a potential option, which can generate axially high density magnetized plasma (up to 10^{18}-10^{19} m^{-3}). A Shoji-type antenna is chosen for the HWP source of MPS-LD. The discharge cavity is a cylindrical cavity with a length of 260mm and a diameter of 60mm. The maximum power can reach 6 kW, and the magnetic field strength range is 0-3000 Gs. In this work, HPW discharge in MPS-LD is numerical simulated and the predicted plasma parameters are presented. The HWP discharge is modeled using the three-dimensional two-fluid equation under the drift-diffusion approximation. The electrochemical reaction of argon are considered in detail.[2] Under the weak ionization assumption, Maxwell's equations coupled with plasma parameters are directly solved in the entire computational domain. All partial differential equations are solved by the finite element solver in COMSOL.[3] Since power coupling is crucial for generating high-density plasma, the key parameters affecting plasma power absorption, such as magnetic field, air pressure, RF power, and RF frequency, and the power coupling mechanism in helical wave plasma are studied in this work for the discharge optimization. The predicted HPW source parameters of the MPS-LD device will be presented to understand the power coupling mechanism. By the modeling, the range of optimal parameter for the experiment will be given, which can help to achieve the required parameters for the device.

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