RF discharge particle-in-cell simulation for ITER diagnostic first mirrors cleaning [[1]](#footnote-1)\*)

DOI: 10.34854/ICPAF.2023.50.2023.1.1.260

1Varshavchik L.A., 1Kogakov S.I., 1Lyullin Z.G., 1Starovoitov E.A., 1,2Mukhin Е.Е.

1Ioffe Institute, St.-Petersburg, Russia 2Faculty of Physics of St. Petersburg State University, St Petersburg, 198504, Uliannovskaya  
 str 3, [physics@spbu.ru](mailto:physics@spbu.ru)

ITER diagnostic first mirrors will be subjected to contamination by materials sputtered from the reactor first wall and other surfaces during ITER operation, that may lead to suppression of diagnostics performance. To protect the mirrors, RF capacitively coupled discharge is considered [1], where the diagnostic mirror itself is the powered electrode. RF discharge numerical modeling in the first mirror unit geometry can help to optimize the cleaning system design.

RF discharge simulation in complex 3D geometries is a challenge, due to the necessity to perform 3D simulations and the use of non-regular numerical mesh to provide the correct description of boundaries. Also, there is an important requirement of the current continuity at both electrodes that leads to non-standard formulation of the problem. Particle-in-cell method was chosen for the simulations.

To realize the simulations performance, the special program modules are being developed in addition to the existing Monte-Carlo code KITe [2]. This code allows us to simulate 3D transport of the atoms and ions in neutral background gas considering particle collisions (gas atoms have their own thermal velocities) and particle-surface interaction. External magnetic and electric fields may also be taken into account.

RF discharge simulation problem consist of the following blocks: 1) simulation of electrons and inelastic reactions; 2) the mathematical model development and its implementation for calculation of local electrical fields based on the space charge distribution; 3) the use of the electric circuit equation, where the discharge channel is its element with lumped parameters. Currently, development of these major issues is almost completed and the code testing / optimization are being carried out.

The most complex sub-task is the local electrical fields calculation based on the Poisson equation solved on the triangular numerical mesh. The bias current should be considered in the boundary conditions so that the problem is different from the standard Dirichlet template. The problem linearization and the following discretization produce an equation matrix with size equal to the number of nodes and, therefore, the equation number is big. Solving the equations, we will get the electric potential 3D distribution.

When the testing is completed, the RF discharge simulations in complex models of ITER diagnostic first mirror units will be performed. The current approach will help to simplify and speed up the diagnostic construction development.

This report was prepared as an account of work for the ITER Organization (Rosatom contract N◦ Н.4а.241.19.22.) and was supported by the Foundation for the Advancement of Theoretical Physics and Mathematics “BASIS” and by the activities in Ioffe Institute (Russian Federation state funding assignment 0034–2019–0001).

References

1. Shigin P. et al. RF discharge mirror cleaning system development for ITER diagnostics //Fusion Engineering and Design. – 2021. – Т. 164. – С. 112162.
2. Varshavchik L. et al. Three-dimensional simulation of neutral transport in gases and weakly ionized plasmas (2021) Plasma Physics and Controlled Fusion, 63 (2), art. no. 025005

1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/L/E/ru/KH-Varshavchik.docx) [↑](#footnote-ref-1)