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SIMULATION OF CAPACITIVELY COUPLED RF DISCHARGE AT LOW-PRESSURE: THE SOLVING ISSUES *)

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Capacitively coupled RF discharge at low pressure has wide range of applications from diagnostic mirror cleaning in tokamak-reactors to technological processes such as materials modification, sterilization and polishing, films etching and deposition in microelectronics. Numerical modelling is applied to the plasma-assistant technologies development / optimization as well as for fundamental researches of operational modes and physics of RF plasma discharge.

The problem is significantly complicated by the presence of a number of conditions necessary for the practical application of the calculation results. In particular, for physical correctness it is necessary to guarantee the continuity of the current on the electrodes (i.e., taking into account displacement currents), the ability to simulate a discharge in arbitrary geometries requires 3D calculations. The precise description of surfaces having free-forms is possible only when using an irregular (triangular) computational mesh. Important requirements for carrying out calculations are the requirements for calculation speed, the presence of a user-friendly interface, and auxiliary functionality.

The requirements listed above were implemented in the KITe code we developed. Besides the simulations of low-pressure radio-frequency capacitively-coupled discharge, the code also allows for modelling impurities transport and deposition in complex geometries such as ITER diagnostic ducts. The calculations are performed on supercomputer at Ioffe Institute.

In the last code modification two special boundary conditions were added to the standard model of local electrical fields calculation (Poisson's equation and Dirichlet boundary condition) in order to include considering the displacement current. The current continuity condition is equivalent to the condition of the sum of charges at both electrodes and the volume plasma charge is equal to zero, that follows from the resulting equation system. The calculation of charge transfer through external electrical circuit allows simulation of both in DC-coupled and decoupled (where the asymmetry results in presence of the DC bias) schemes. However, additional boundary conditions produce the technical issues of the solving as the equation matrix become non-symmetrical and ill-conditioned, especially in the case of the complex geometries.

The report presents the results of discharge modeling using code KITe at some elementary geometries: the concentric spheres, plane-parallel electrodes, isolated system of charged particles. The comparison with the standard model was performed. The model convergence and stability with variations of geometries and computational mesh are investigated.

The code validation by GEC and some other mock-ups is planned.

References

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*) abstracts of this report in Russian