A study of magnetized plasma sheath near solids of different geometries

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We present results of a two-dimensional particle-in-cell simulation. The subject of study was an interaction of low-temperature electronegative plasma with conductive solids in the presence of magnetic field. Our self-consistent model simulated the formation of sheath layer influenced by the magnetic field, presence of heavy negative charge carriers and by geometry of the solid immersed into plasma.

The interaction of chemically active plasma mixtures with solids is a complex problem whose study is of great importance for both plasma-assisted surface treatment technologies and interpretation of Langmuir probe measurements. However, theoretical description of the interaction often contains too restrictive conditions that limit pressure, plasma composition or geometry of studied problem. Therefore, computer simulations are highly desirable to understand the physical and chemical processes involved in the interaction.

There are two main approaches to simulations of plasma-solid interactions. The fluid approach is based on solution of a system of conservation equations, Poisson’s equation, Maxwell equations, etc. Some simplifications used in the fluid models assume high pressures, Maxwell distribution function of particles or simplified composition of plasma. The information obtained by these models is not sufficient mainly on the microscopic level. The second approach – particle simulations – is more accurate and does not contain the above-mentioned assumptions. On the other hand, the computational demands of particle models are very high.

We employed the particle approach – a combination of molecular dynamics with Monte Carlo simulation of collisions. The results were compared with a hybrid particle-fluid model which coupled fluid and particle parts iteratively to achieve lower computational time and to preserve the microscopic level of results. In our contribution we discuss the form and composition of the sheath layer near a cylindrical probe and near an uneven planar substrate as well as the transport of charged species through the sheath and their fluxes to the surface. The influence of shape of the solid, magnetic field, pressure and electronegativity of the plasma are also discussed.