Magnetohydrodynamic and knudsen flow simulation of low pressure plasma phenomena using a cloud-based numerical simulation platform

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In the past decades, low pressure plasmas have established their key role in the field of material processing and surface modification. They have proven indespensable in deposition of super hard and wear resistant coatings and recently in preparation of nanocomposite coatings. These applications often require deep understanding of the underlying processes, in which validated numerical simulation can be instrumental.

This contribution illustrates how industrial-scale challenges encountered when using low-pressure plasmas can be addressed by means of a computer model. Firstly, it presents a magnetohydrodynamic model of low pressure arc plasma. The model solves the compressible Euler equation for the plasma ions coupled to the external magnetic field and the electrical potential obtained from the Poisson equation. The charge density in the Poisson equation is calculated assuming Boltzmann equilibrium for electrons.

Secondly, a numerical model of gas flow at low pressure is presented. Since the Navier-Stokes equations fail to describe flows at the Knudsen number approaching and lager than one, we use the so-called DSMC (direct-simulation Monte Carlo) method. It is illustrated that obstacles, proximity of the walls or the orientation of the gas inlet act very differently in Knudsen flow regime than they do in high-pressure viscous regime.

All the numerical models presented in this work have been implemented using the *PlasmaSolve Simulation Suite* created by integrating several open-source libraries with Amazon EC2 cloud. This solution enables use of realistic 3D geometries and effective parallelization of parametric studies.

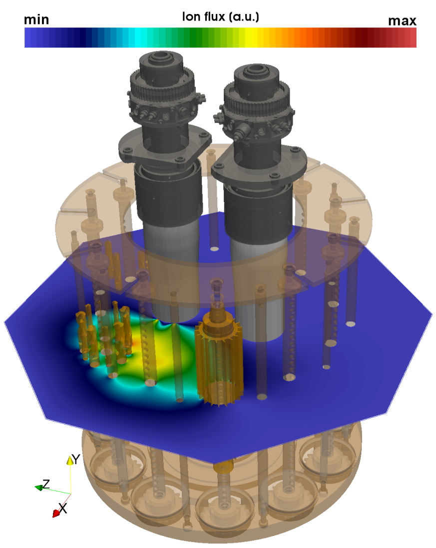

Figure 1: *Ion flux obtained from the magnetohydrodynamic simulation projected into the industrial deposition chamber.*