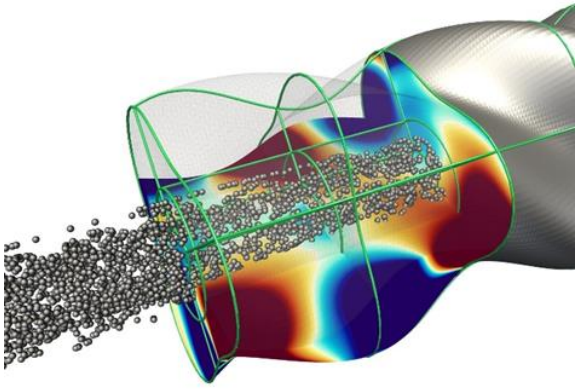
Category: Services

Reference: TD-DE-1019

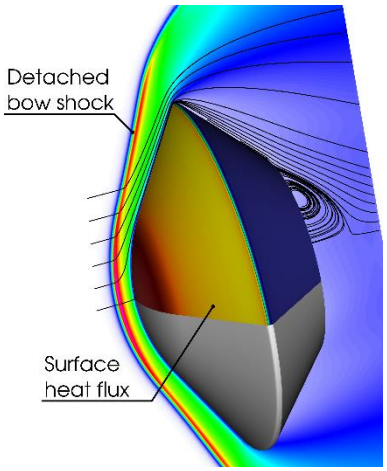
Simulation of plasma dynamics and electromagnetics

The offered service is based on the simulation software PICLas and the expertise of the founders in the field of numerical simulation of plasma dynamics. The developed three-dimensional software PICLas, uses particle-based numerical methods and a high-order field solver to enable the simulation of dilute gas and plasma flows under the influence of electromagnetic forces. The software has been successfully used in the simulation of atmospheric entry maneuvers, electric propulsion systems, and satellite communications components (traveling wave tubes).

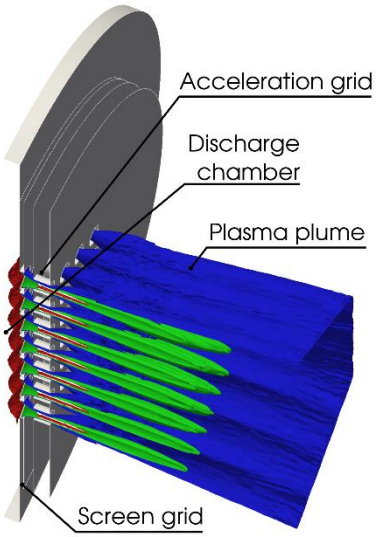
Many high-tech terrestrial processes that use vacuum conditions, plasma, and laser-plasma interactions are not well understood. The numerical simulations offered by the company are intended to provide vacuum coating companies and semiconductor manufacturers using these processes with insight into the physical details to improve product development and optimize the working parameters of their equipment. The services are thus expected to provide time and cost savings by reducing the number of test campaigns and prototypes required.



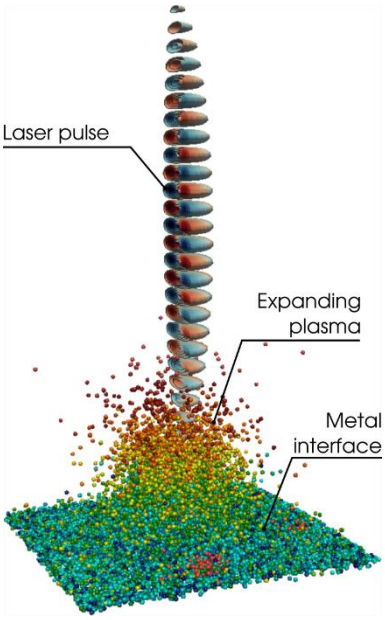
The three company founders were instrumental in the development of PICLas and have gained extensive experience in noble gas and plasma dynamics. This enables them to use PICLas efficiently and to make necessary extensions for applications outside the space sector.



Atmospheric entry at Saturn's Titan



Plasma plume expansion of an electric thruster



Laser-plasma interaction

Innovative Aspects:

Conventional computational fluid dynamics have difficulties to simulate rarefied gas and plasma flows under strong thermal and chemical non-equilibrium, especially under the influence of electromagnetic forces. The innovative approach of PICLas is the coupling of two well-established particle methods, Particle-in-Cell and Direct Simulation Monte Carlo. While the former is used to simulate the interaction between charged particles and electromagnetic forces in free molecular flow, the latter is used to model rarefied gas flows including the exchange of internal energies and chemical reactions. Both methods have been verified and validated for a multitude of applications such as atmospheric entry, electric propulsion systems, gyrotrons, and travelling wave tubes. The advantages over other computational tools have been demonstrated, based on e.g. simulations of a 140 GHz gyrotron, where PICLas was able to reproduce the expected operating frequency, while a commercially available tool failed to do so.

With the increasing affordability of computational resources, an additional advantage is the strong focus on the optimization of PICLas for high-performance computing with a parallel efficiency of over 90% on up to 12 000 cores for certain cases. This allows the code to be utilized for complex, three-dimensional problems (e.g. the interaction of several thrusters of an electric propulsion system or the complete vacuum coating facility) with a reasonable computational demand.

Finally, the service of the technology owner allows other companies to focus on their main business and benefit from modern numerical simulation technologies without large upfront investments. Detailed physical insight provided by numerical simulations can support development of innovative products, help find optimal working parameters to reduce the downtime of production facilities, and limit the number of prototypes and test runs to a few.

Application Areas:

Current: Atmospheric entry manoeuvres, electric propulsion systems, travelling wave tubes, gyrotrons, laser-plasma interaction.

Potential: Vacuum surface coating, semiconductor manufacturing, high-frequency engineering, nano- and microsystems.

Cooperation:

- Industrial companies, whose processes include vacuum, plasma dynamics or laser-plasma interaction
- These could be semiconductor manufacturers and companies that are developing and/or utilizing vacuum surface coating technologies, high-frequency components such as gyrotrons and travelling wave tubes, and nano- and microsystems
- The technology owner would perform numerical simulations of the respective processes to enable the partner to optimize working parameters, improve the development of novel products and gather detailed insight in the physics