Electronegative plasmas and Ion-Ion plasmas applied to the semiconductor industry, fusion and space propulsion

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Low-pressure electronegative plasmas are typically stratified plasmas with the negative ions accumulated in the centre of the discharge due to the ambipolar electric field. The negative ions can therefore not reach the surrounding boundaries and their flux to the wall is negligible. The situation change when pulsing the plasma or applying a magnetic field: in the first case the electrons are lost rapidly in the early afterglow leaving behind an ion-ion plasma that decays within the diffusion time of the ions. In the latter case, the electrons are confined in the centre of the discharge by the magnetic field, and allow under certain conditions the formation of an ion-ion plasma at the plasma periphery close to the boundaries. Due to the reduced number of electrons in the ion-ion region, the ambipolar field is weak or vanishing and both the positively and the negatively charged ions can reach the wall. This particular plasma state can therefore be used as a dual positive-negative ion source and finds applications in for example the semiconductor industry for charge-free etching [1-3], neutral beam injection for fusion [4], for treating bio-materials where electrons can cause significant damage or for space propulsion.
Within our team at LPP, ion-ion plasmas are used in a new concept for plasma propulsion where both positively and negatively charged ions are used for thrust [5-7]. This concept is called PEGASES, an acronym for Plasma propulsion with Electronegative GASES.

A review will be presented on the physics of ion-ion plasmas and the state of the art in the variety of applications using these plasmas. In particular the concept and the progress in the development of the PEGASES thruster will be discussed.

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