Plasma sheath and pre-sheath in front of a ceramic wall: experimental and theoretical study

V. Pigeon, N. Claire, C. Arnas, L. Couedel

Aix Marseille Univ, CNRS, PIIM, Marseille, France

The sheath and pre-sheath in front of a ceramic wall (BNSi02), immersed in a low temperature plasma, are studied both theoretically and experimentally. Measurements were performed in a multipolar device using emissive probes and the laser induced fluorescence (LIF) diagnostic which shows an unexpected and significant flow of ions directed away from the wall toward the bulk plasma. The secondary electron emission (SEE) from the ceramic is assumed to be the cause of this phenomenon, since $BNSiO_2$ is known to be a strong emitter [1]. In order to explain experimental observations of the ceramic sheath, a kinetic model accounting for SEE, energetic electrons, thermal electrons and ions is being developed.

Plasma-wall interaction is a fundamental field of research in plasma physics for numerous applications. We are presently focused on a ceramic wall used in Hall thrusters ($BNSi0_2$), in which plasma-wall interactions are important in the combustion chamber sustaining issues and in the particle transport problematic.

The study presented in this poster aims to better understand the sheath and pre-sheath physics in the vicinity of a BNSiO2 wall sample**.** The sheath and pre-sheath are studied experimentally, while a kinetic model is developed to describe the sheath.

Experimental measurements are performed in the quiescent argon plasma of a multipolar device. Both the LIF and emissive probes are used to explore the ceramic sheath, measuring ion velocity distribution functions (IVDF) and the plasma potential, respectively. The results highlight an unexpected ion flow directed toward the plasma in addition to the wall-directed one as shown in Figure 1. It appears that these flows are slightly asymmetric regarding velocities, densities and consequently fluxes. These features cannot be explained by a monotonic sheath potential drop. Moreover, previous measurements performed in similar conditions in front of metals reported monotonic potential drop [2]. It indicates that metals and $BNSiO_2$ do not behave the same way when embedded in a plasma.

We have developed a kinetic model which takes into account the $BNSi0_2$ SEE characteristic coefficient, energetic electrons, thermal electrons and ions with finite temperature. It allows to calculate the variations of the potential and the densities along the sheath as a function of the energies and temperatures of the plasma species. The results are in good agreement with previous theoretical results describing sheaths in the presence of the previously cited species [3] (Figure 2). Furthermore, the model shows that a backward ion flow is incompatible with a monotonic sheath. Further improvements of the model will aim to verify the experimental results. Moreover, emissive probe measurements will be performed in the sheath, in order to avoid the strong laser light scattering at the ceramic surface.

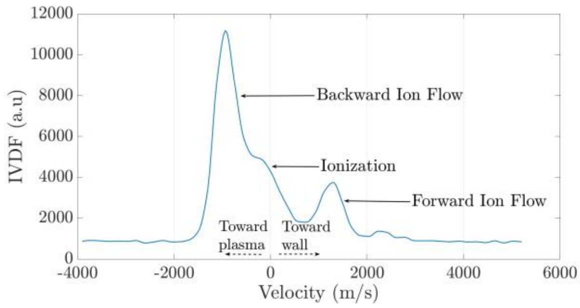

Fig. 1: IVDF at 1.5 cm from the ceramic wall sample

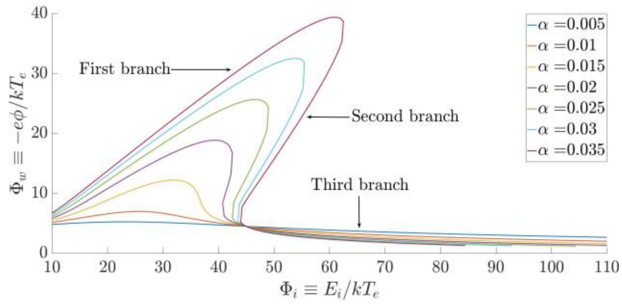

Fig 2: Wall potential variation vs impinging electron energy; α: relative energetic electrons concentration.

References

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