# Study of the plasma near the plasma electrode by probes and photodetachment.

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Contemporary negative ion sources operate with a magnetic filter field extending up to the plasma electrode (PE), containing the extraction aperture [1]. It is generally accepted that a positive PE bias (Vb) reduces the extracted electron current. In some experiments an optimum Vb for negative ion extraction was found [2-4]. A possible cause of these effects was suggested in [3]: electrons are trapped in the weak magnetic field and lost along the field lines, whereas positive and negative ions are not trapped because of their large Larmor radius. More negative ions arrive from the bulk plasma to ensure plasma neutrality. However, a definite explanation of the $H^-$ ion peak vs Vb is still not available

The electrostatic particle simulation [1,5] without applied plasma electrode bias showed that the presence of the weak magnetic field produces important modifications in the positive ion flow and as a result in the structure of the plasma potential. A characteristic peak in the plasma potential (Vp) dependence versus distance to the PE (D) is predicted, in which many negative ions are localized.

The purpose of this work is to study experimentally the spatial distribution of the plasma parameters in the vicinity of the PE, using electrostatic probes and laser photodetachment. The hydrogen plasma is generated by microwaves (2.45 Ghz) in the magnetic multicusp chamber Camembert III, as described in [4, 7]. The effect of Vb on the various plasma parameters (electron density and temperature, negative ion density, plasma potential) was investigated. The magnetic field, parallel to the plasma electrode, attained a maximum value of 22 Gauss, at a distance of 3.3 cm from the PE.

The results indicate that the electron density is reduced when approaching the PE and the effect increases with the positive bias Vb. This shows that the electrons are efficiently swept away from the PE neighbourhood due to the applied positive bias. The spatial variation of the electron temperature indicates that for Vb < Vp the electron temperature is low (0.3-0.5 eV) at all the distances studied, but goes up abruptly near the PE when Vb > Vp.

The variation of the negative ion density versus D clearly indicates its enhancement when approaching the plasma electrode, at the distances D where the electron density is reduced. The optimum value is Vb = 5.5 V. An indication of a small plasma potential maximum versus D exists for Vb > 4 V.

In conclusion, the plasma in front of the plasma electrode has a complex structure and a detailed experimental study is required for its characterization.

[1] M. Bacal, A. Hatayama, J. Peters, 2005, *IEEE Trans Plasma Science,* **33**, N° 6, 1845
[2] K.N. Leung, K.W. E.hlers, M. Bacal, 1983, *Rev. Sci. Instrum.*, **54**, 56
[3] M. Bacal, J. Bruneteau, P. Devynck, 1988, *Rev. Sci. Instrum.*, **59**, 2152
[4] P. Svarnas, J. Breton, M. Bacal, R. Faulkner, 2007, *IEEE Trans. Plasma Sci.*, 35, N°4, 1156
[5] T. Sakurabayashi, A. Hatayama, M. Bacal, 2005*, A.I.P. Conference Proceedings 763,* Editors J.D. Sherman, Y.I. Belchenko, p.96
[7] A. Lacoste, T. Lagarde, S. Béchu, Y. Arnal, J. Pelletier, 2002, *Plasma Sources Sci.&Technol.*, **11**, 407