Diagnostics in pulsed Hydrogen Plasmas

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1. Introduction

Hydrogen plasmas are widely used in the microelectronic industry with applications in the fields of deposition, etching and surface treatment. However hydrogen is a very peculiar element due to his low mass and his electronegative character, and the mechanisms in low pressure hydrogen plasma aren't well understood yet [1]. Moreover, H_2 plasmas present a great potential interest for the treatment of new materials such as graphene [2]. To modify the surface of such ultrathin layers without damaging the material, very low ion energy bombardment is required. By contrast, for other applications such as etching of several nanometer thick layers, the ion energy must be very high to get a significant etch rate. The low (<15eV) and high (>300eV) energy ranges are hard to access in a typical ICP reactor, but can be obtained by pulsing the plasma.

2. Measurements

To assist the development of innovative processes in H_2 plasmas, we have thus analyzed systematically CW and pulsed inductively-coupled plasmas (ICP) both with and without RF bias power. In particular, we carry out time-resolved ion flux and time-averaged ion energy measurements in different pulsing configurations.

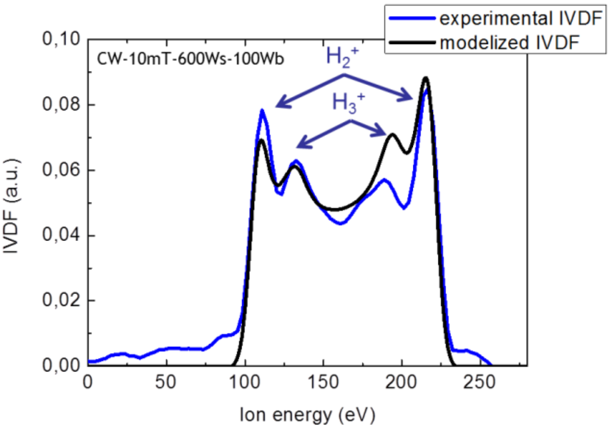

Fig. 1: *IVDF in an H_2 inductively coupled plasma. Comparison between model and experiment.*

The ion flux is measured by a pulsed capacitively-coupled planar RF probe [3-4], which is synchronized with the plasma pulses to allow time-resolved measurement of the ion flux (and of the high energy tail of the EEDF) with a 10µs resolution. This system will be discussed in details.

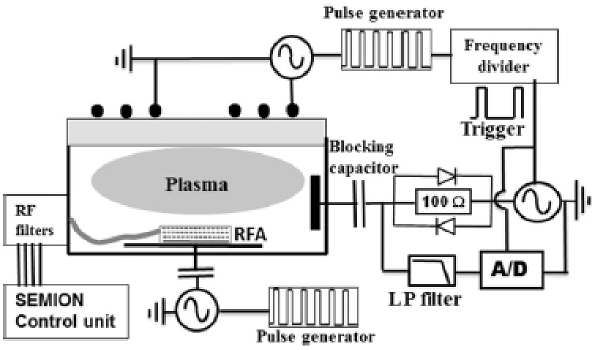

Fig. 2: *Schematic of the experimental setup showing the ICP chamber, the Semion RFA deployed on a 300mm wafer, and the ion flux probe.*

The time variations of the ion flux in pulsed plasmas present peculiar features compared to other plasma chemistries that will be discussed. These results are consistent with the low dissociation rate typically reported in H_2 plasmas [5].

A large variety of ion energies and shapes of IVDFs measured by a RFA probe are also reported. As it can be seen on figure 1, the IVDFs are typically very broad (due to the low ion transit time of low mass ion through the sheath) and either bi or tri-modal (H^+, H_2^+ and H_3^+ contributions according to simple modeling of the IVDF shape). The variation of the shape of the IVDF in pulsed plasma mode will be discussed in detail.

References

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