QUADRUPOLE MASS SPECTROMETRY CHARACTERIZATION OF LOW PRESSURE MICROWAVE PLASMAS FOR ATOMIC SPECIES PRODUCTION

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Introduction

Interaction of atomic species on surfaces is of primary importance to better control surface treatments assisted by remote plasmas. However, up to now, many attempts have been done to define these phenomena qualitatively and, to a lesser extent, quantitatively. For example, by looking at the recombination coefficients of N or O atoms on silica, one can see a large amount of data which are widely spread.

We report results from our first measurements on the characterization by mass spectrometry of microwave remote plasmas used to create N and H atoms.

1. Experimental setup

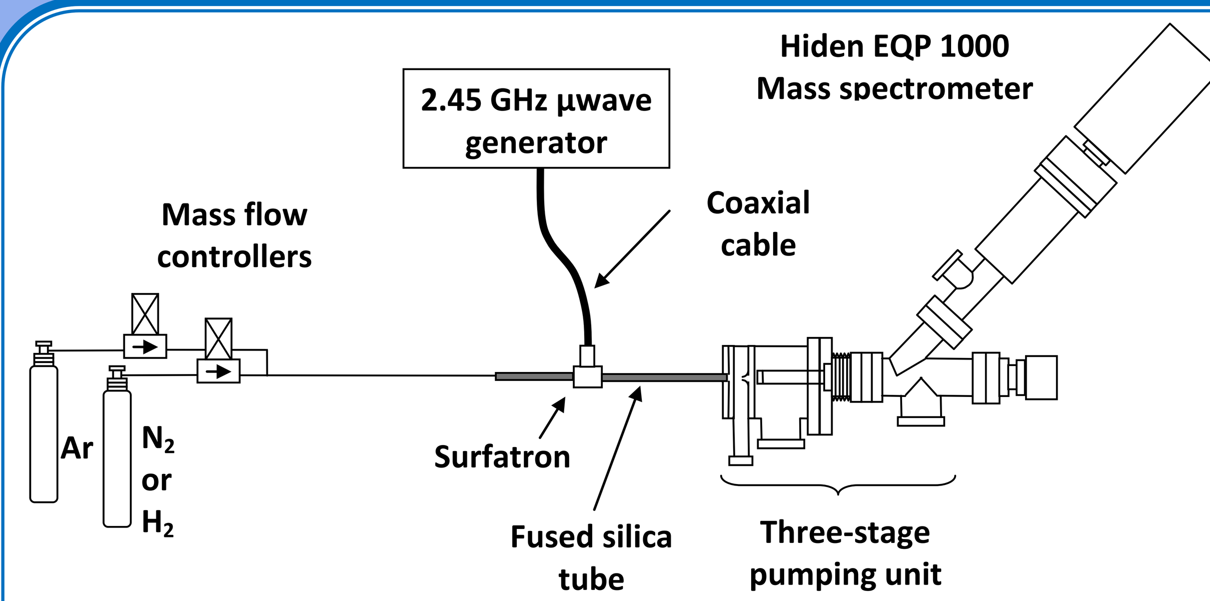

Figure 1 Experimental setup

Measurements are performed in Residual Gas Analysis mode, i.e. neutral species from the post-discharges are collected and then positively ionized by electronic impact. For a **X** species, QMS signal intensity at the respective m/z ratio depends on electron energy ε and can be written:

$$I_X(\varepsilon) = A \times T_X \times \sigma_X(\varepsilon) \times \gamma \times [X] \times j_e$$

2. Dissociation rate determination

For Ar/N_2 plasma (and respectively Ar/H_2), QMS signal intensity at m/z = 14 (or 1) is the sum of the signal coming from the ionization of N (or H) atoms (produced in the plasma) and the dissociative ionization of N_2 (or H_2) molecules (see figure 2 and 3).

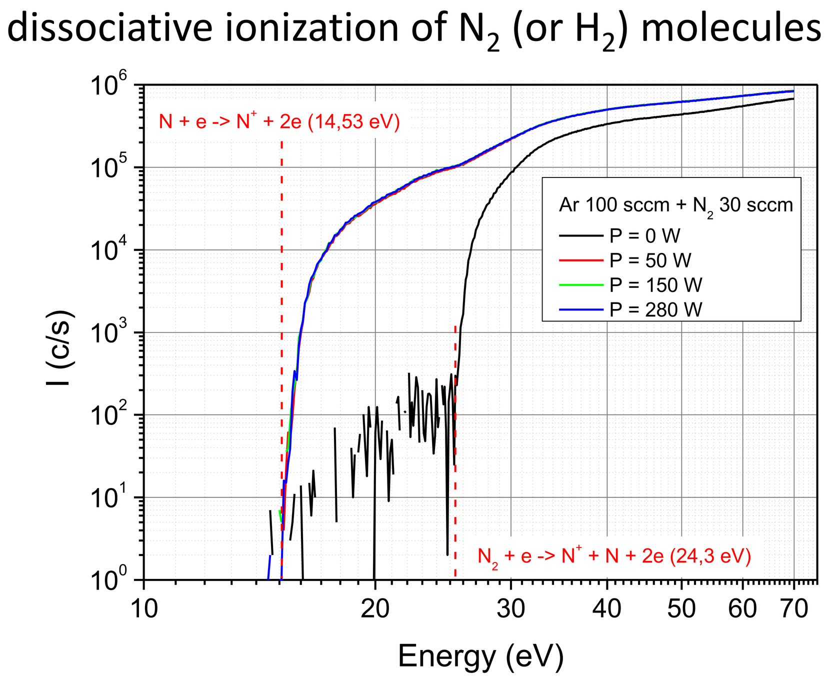

Figure 2 QMS intensity at m/z = 14 vs electron energy for a Ar/N_2 plasma (100/30 sccm)

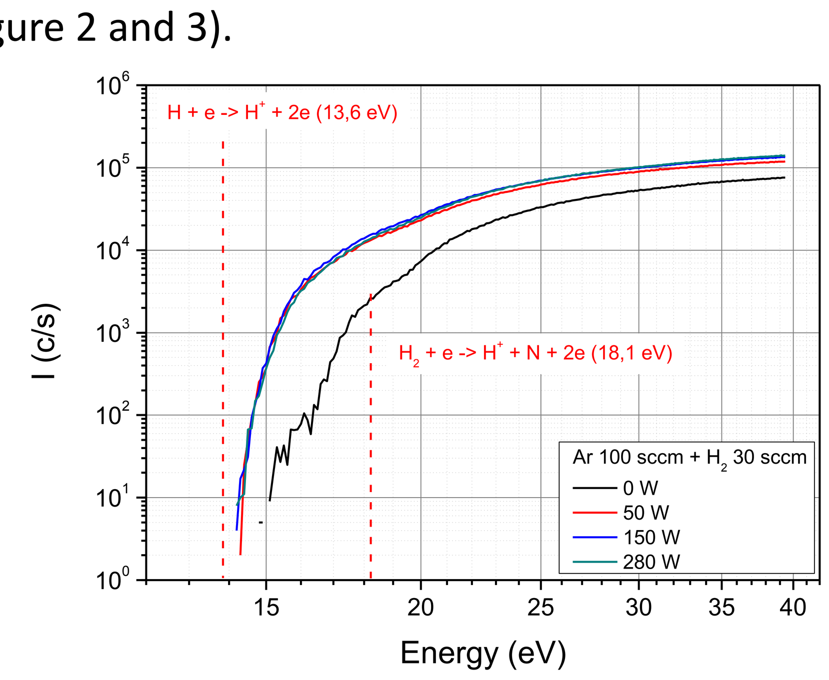

Figure 3 QMS intensity at m/z = 1 vs electron energy for a Ar/H_2 plasma (100/30 sccm)

As the threshold of these two processes are different, the signal intensity can easily be separated in the two components. This intensity can be expressed as follows:

$$Im_{/z=14}(\varepsilon = 20eV) = K \times \sigma_{N\to N^+}(\varepsilon = 20eV) \times [N]$$

$$Im_{/z=14}(\varepsilon = 60eV) = K \times \left(\sigma_{N\to N^+}(\varepsilon = 60eV) \times [N] + \sigma_{N_2\to N^+}(\varepsilon = 60eV) \times [N_2]\right)$$

Knowing the values of the cross sections of these different processes [1-3], dissociation rate can be determined :

$$\frac{[N]}{[N_2]} = \frac{\dfrac{\sigma_{N_2\to N^+}(\varepsilon = 60eV)}{\sigma_{N\to N^+}(\varepsilon = 20eV)}}{\dfrac{Im_{/z=14}(\varepsilon = 60eV)}{Im_{/z=14}(\varepsilon = 20eV)} - \dfrac{\sigma_{N\to N^+}(\varepsilon = 60eV)}{\sigma_{N\to N^+}(\varepsilon = 20eV)}}$$

Similar expressions are obtained in the case of Ar/H_2 plasmas at m/z = 1.

3. Results

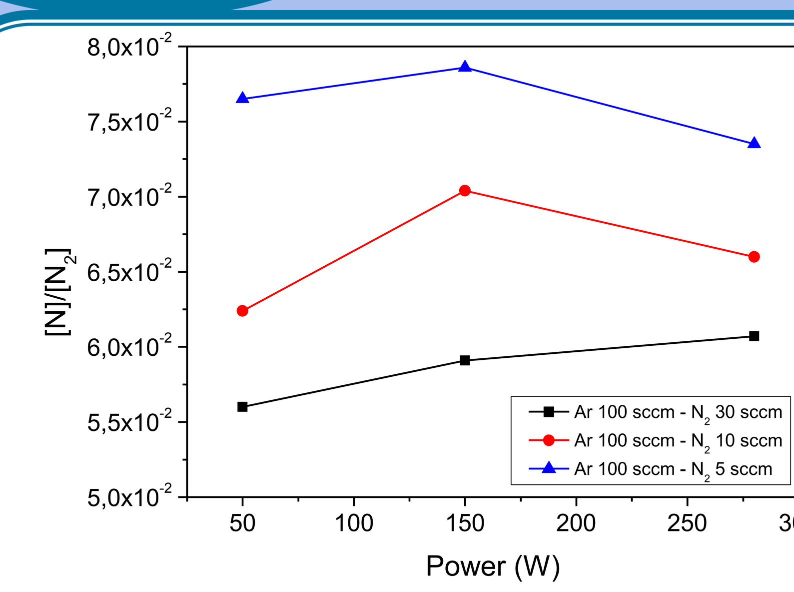

Figure 4 N_2 dissociation rate for Ar/N_2 plasmas

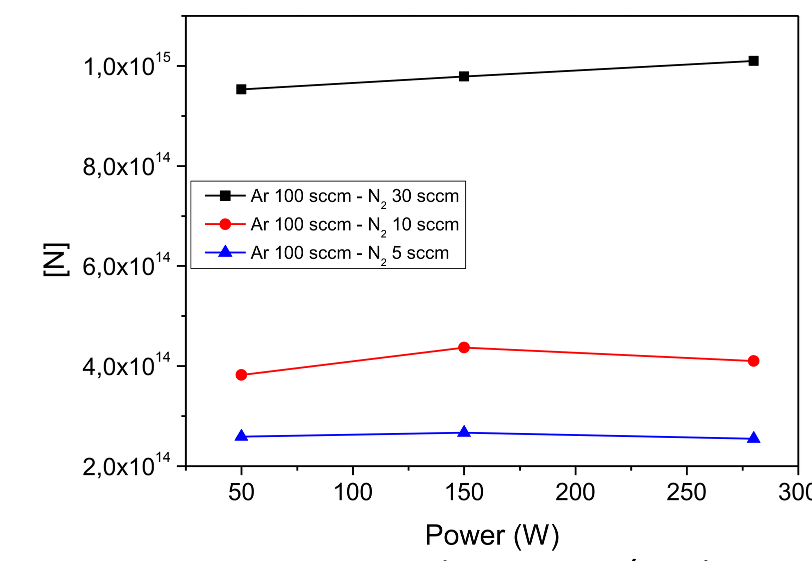

Figure 5 N atoms density in Ar/N_2 plasmas

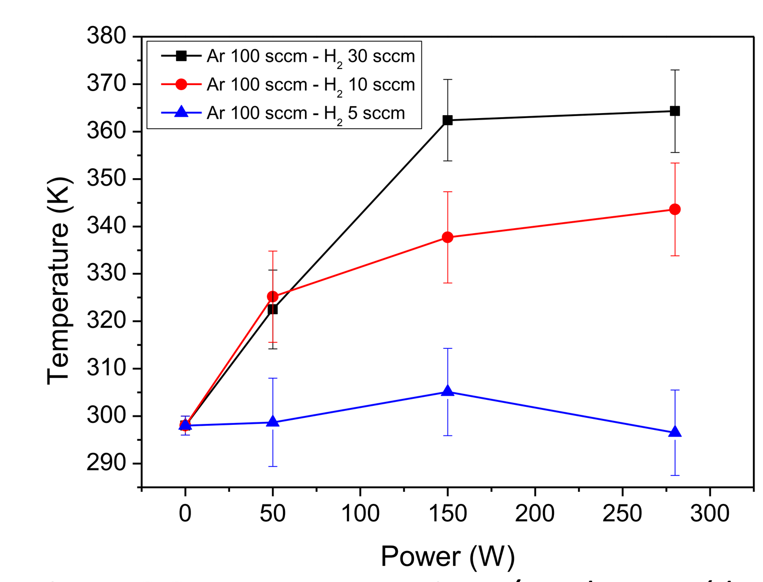

Figure 6 Gas temperature in Ar/N_2 plasmas (deduced from perfect gas law and density measurements)

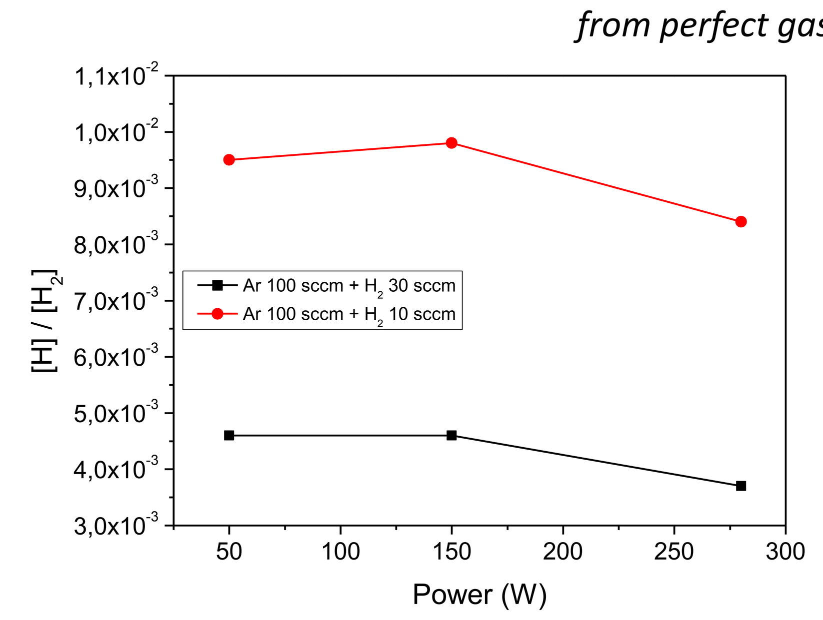

Figure 4 H_2 dissociation rate for Ar/H_2 plasmas

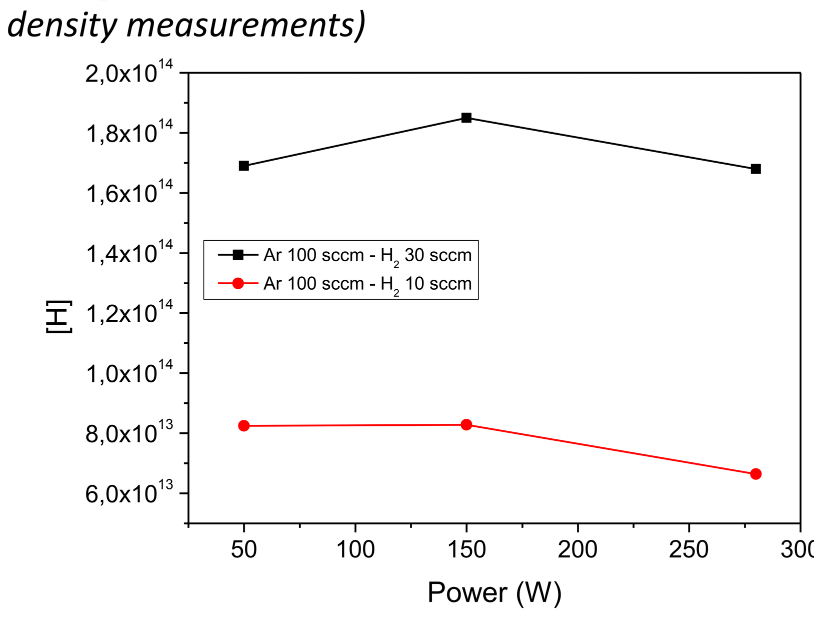

Figure 5 H atoms density Ar/H_2 plasmas

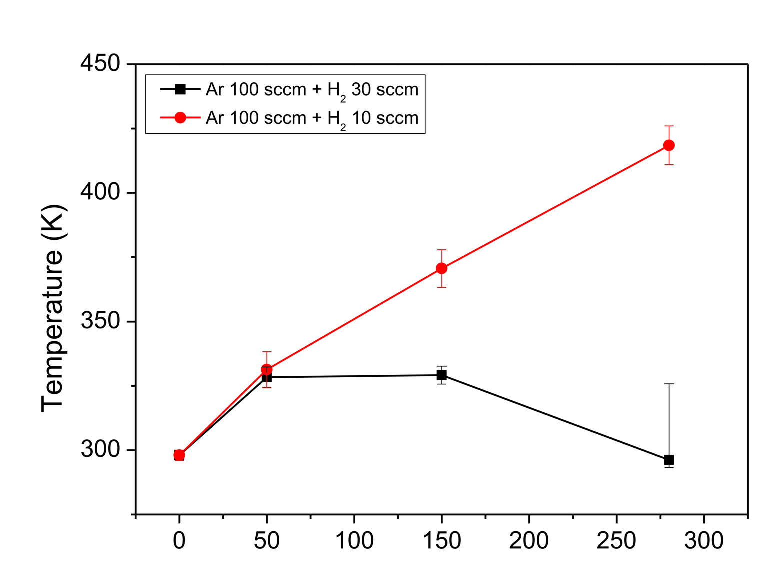

Figure 6 Gas temperature in Ar/H_2 plasmas (deduced from perfect gas law and density measurements)

Conclusions & Perspectives

- N_2 and H_2 dissociation rate and N and H densities are in agreement with literature [4-6]
- Next steps :
  - Production of O and C atoms
  - Study how atoms recombine on a surface put between the plasma source and the mass spectrometer

References

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