

MASS-SPECTROMETRY INVESTIGATIONS OF HYDROGEN POSITIVE IONS IN Ar-H₂ AND H₂ RADIO-FREQUENCY DISCHARGES

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1. Introduction

Radio-frequency glow discharges are widely used in thin film and surface technology. They allow a homogeneous treatment of surface areas at rather low temperatures. Sputtering, anisotropic etching of semiconductor surfaces and the deposition of the thin films are typical applications [1]. The fluxes of particles created in plasma or at its edge drive the interactions between plasma and surfaces [2]. Mass spectrometry yields first the nature of ions created inside the plasma and second the corresponding ion energy distribution function.

2. Experimental setup

The investigated rf plasma was confined in a plasma chamber of an asymmetrical industrial OTP Plasmalab 100 capacitively coupled system [1-3] (Fig. 1). The mass-resolved ion energy distribution was measured at the grounded electrode (included the chamber walls) which was much larger than the driven electrode. The top electrode diameter was 295 mm, inter-electrode spacing 50 mm and the driven electrode diameter was 205 mm. The pressure values

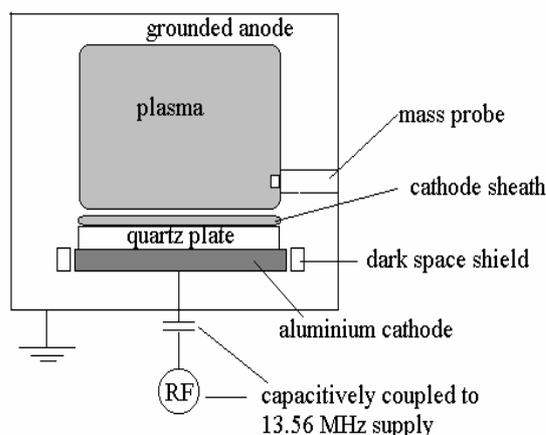


Fig 1: A schematic diagram of the capacitively coupled discharge

were 50, 70 and 90 mTorr and the range of powers was 10 – 150 W. Ion and neutrals kinetic energy distributions were measured with a Hiden EQP Plasma probe which uses an electrostatic ion-energy analyser followed by a triple section quadrupole mass spectrometer for mass analysis.

Experimental results and discussion

In figures 2 and 3 the ion energy distributions for studied hydrogen ions are presented. Figure 2 corresponds to ions resulting from argon-hydrogen mixture and figure 3 corresponds to the ions resulted from pure hydrogen discharge.

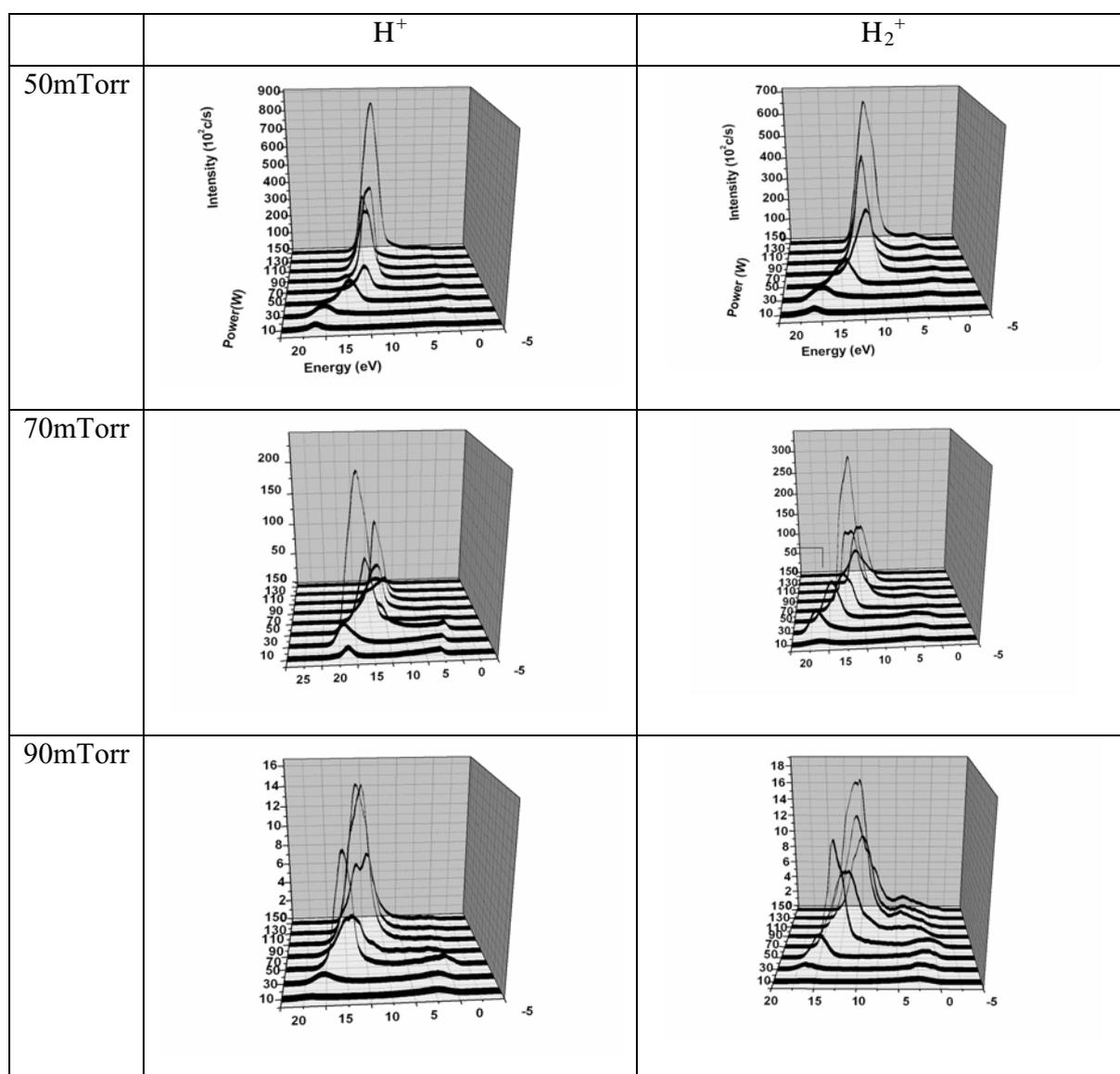


Fig. 2: Ion energy distributions for studied ions in argon-hydrogen mixture

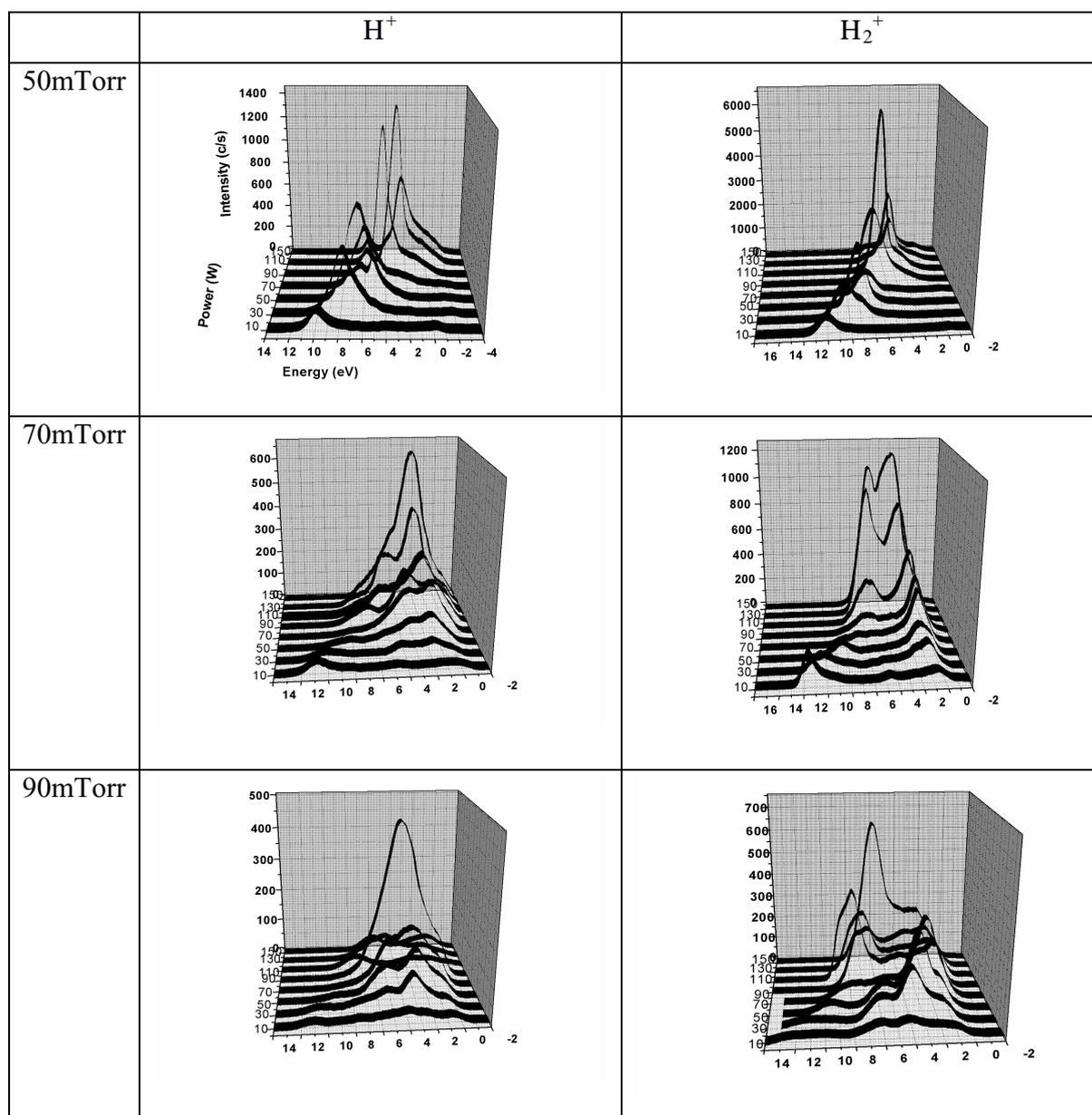


Fig. 3: Ion energy distributions for studied ions in pure hydrogen discharge

The ions energy distribution functions were determined for the positive ions H^+ and H_2^+ , for different values of the pressure and powers. It was observed that the hydrogen positive ions energy distributions obtained from argon-hydrogen mixture discharge are peaked at higher energies compared with those ones obtained in pure hydrogen discharge. Also, the intensities of the hydrogen positive ion energy distribution functions in argon-hydrogen mixture discharge are higher than in the case of pure hydrogen discharge, for all values of the pressure and power. The intensities of the hydrogen positive ions energy

distribution functions decrease with the increasing of the pressure and increase with the increasing of the rf power.

To explain these results, we must take into account the ion-neutral mean free path, given by:

$$\frac{1}{\lambda_i} = \sum_{j=1}^{N_i} n_{g,j} \sigma_{ij} \quad (1)$$

where $n_{g,i}$ refers to neutral species of the j -th ion and $\sigma_{i,j}$ is the ion-neutral scattering cross section for the j -th neutral. Under higher values of the pressure, the elastic collisions of ions with neutral gas dominate and form the low energetic part of the ion energy distribution. The mean free path given by (1) is increasing when both $n_{g,i}$ and $\sigma_{i,j}$ decreasing. As pressure is increased, the ion-neutral species mean free path decreases and becomes of the order of the sheath thickness and the ion energy distributions for both ions present multiple peaks due to ion-neutral species collisions in the sheath. These multiple peaks appear in the ion energy distribution for plasma at 90 mTorr, as shown in Figs. 2 and 3.

Conclusion

The energy distributions of the positive ions inside an rf argon-hydrogen and hydrogen discharge plasma, at the grounded electrode of an asymmetrical capacitively-coupled device were investigated. The intensities of the ion energy distribution functions are decreasing by increasing of the pressure and are increasing by increasing of the powers. The intensities of the ion energy distributions for the argon-hydrogen mixture discharge are higher compared with pure hydrogen discharge for all values of the power and pressure.

Acknowledgements

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