ANODIC PLASMA BALL AS A SOURCE OF NEGATIVE IONS

H.G. Lergon and K.G. Müller
University of Essen, Fed. Rep. of Germany

ABSTRACT

In front of an anodic sample a plasma ball forms which may provide an intense source of negative ions. The influence of the DC working point and a superimposed AC voltage on the fluxes of the different negative ions are investigated. Relative intensities and total negative ion current change drastically with working point and frequency.

1. INTRODUCTION

In plasma applications it is an essential problem to produce a plasma of definite properties by a suitable choice of the external parameters. For surface treatment with plasmas the fluxes and energies of the different ion components to the sample are the governing quantities. Depending on the direction of the electric current to the sample we dinstinguish three different modes of operation: the cathodic, the floating, and the anodic sample. In an AC situation the mode of operation may change within one period. For a pronounced cathodic operation secondary electrons emitted by the surface of the sample are accelerated in the sheath and ionize in front of the sample thus enhancing the original plasma. This effect can be observed in a RF plasma1). A pronounced anodic operation leads to a plasma ball which may serve as an intense source of negative ions2).

Fig. 1 describes a general experimental situation of a sample in a plasma. The DC supply may be a source of constant voltage or of constant current. The last case with vanishing DC current is applicable to an insulated sample in a RF plasma. Non-vanishing DC currents are possible only for a reference electrode in contact with the plasma. Such a double electrode system provides an additional parameter for optimizing surface treatment with RF plasmas. In most applications the AC voltage between the plasma and the sample is produced automatically by the RF plasma production device.

In this paper we investigate the influence of the DC bias and the AC frequency on the negative ion currents to an anodic sample.

2. EXPERIMENTAL

The plasma of a DC positive column in an Ar-SF_6 mixture is investigated by a combined mass spectrometer-wall probe diagnostics[3]. Here ions are extracted by an orificed wall probe, representing the sample, and analyzed in a quadrupole mass spectrometer. For different working points of the wall probe defined by the DC probe voltage we measure the DC probe current and the DC currents of the different negative ion species depending on the frequency of the superimposed AC voltage of 5 volts amplitude.

On the basis of our former investigations[2] we have chosen the discharge parameters (see fig. 2, upper part). The range of the working point of the sample includes the appearance of the anodic ball and its full developement.

3. RESULT AND DISCUSSION

Fig. 2 refers to a situation close to an insulated sample without anodic ball. For vanishing AC voltage (f=o) the results of our former investigations[2] are reproduced: Only F^--ions reach the sample possessing kinetic energies of about 5 eV. If a low frequency signal is superimposed, the DC electric current to the sample, I_p, and the DC negative ion current to the mass spectrometer, I^-, increase. This is due to rectification at the non-linear DC characteristics of the sample, $I_p(U_p)$ and of the negative ions, $I^-(U_p)$, U_p being the sample voltage. With increasing frequencies the rectification effect decreases which may be explained by capacitive shunting of the sheath.

Fig. 3 summarizes the result of an investigation of an anodic plasma ball. In comparison to fig. 2 SF_x^--ions appear and the currents I_p and $I^-(F^-)$ rise by at least an order of magnitude (see ref.[2]). The rectification effect for the sample current practically disappears whereas it still can be observed at the negative ion currents. At low frequencies all currents decrease with increasing frequency. This only partly can be attributed to the disappearance of the rectification effect. The main influence of the frequency can be seen at the SF_x^--ions which pass a minimum and increase again.

The manipulation of the total negative ion flux to a sample and the chemical composition of this flux by changing working point and frequency may be used in practical applications such as surface treatments and ion sources.

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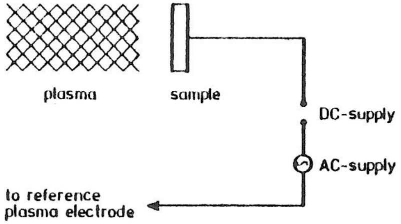

Fig. 1: Idealized situation of a sample-plasma contact

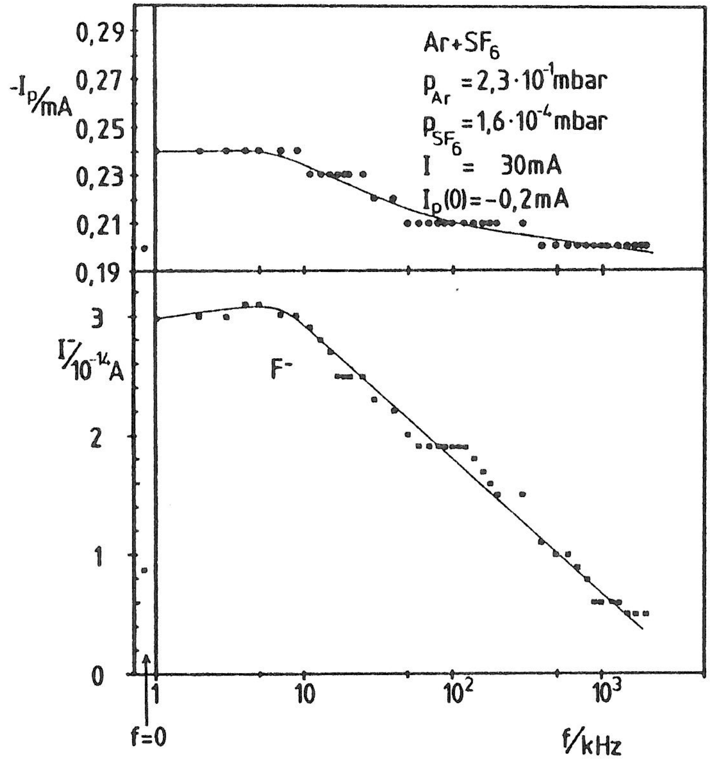

Fig. 2: DC sample current I_p (upper curve) and DC current I^- of F^--ion to mass spectrometer versus frequency of the superimposed AC voltage for the case of sample current $I_p(f=o)$ = -0,2 mA; f=o refers to vanishing AC voltage.

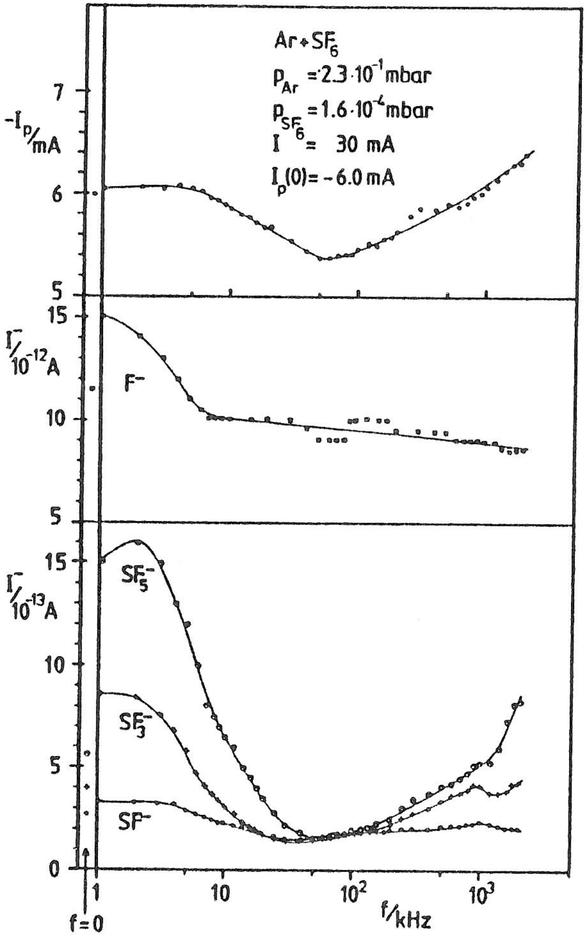

Fig. 3: DC sample current I_p (upper curve) and DC current I^- of the different negative ions to mass spectromter (medium and lower curves) versus frequency of the superimposed AC voltage for the case of sample current $I_p(f=o)$ = - 6 mA; f=o refers to vanishing AC voltage.