SOME CONSIDERATION ON THE POTENTIALITY OF THE RELAXATION DISCHARGES USE FOR PLASMA TECHNOLOGICAL PROCESSING

I.Mustata, A.M.Lungu, G.Bajeu, C.P.Lungu,
Institute of Physics & Technology of Radiation Devices
P.O. Box MG-06 Magurele, Bucharest, Romania
C.Biloiu
Faculty of Physics, Bucharest University

Introduction

The relaxation discharges[1], here considered, comprise a capacity mounted in parallel with a discharge tube that, charged trough a resistance by a potential furnished by a source discharges very rapidly once the discharge avalanche is started. The local potential applied on both capacity and discharge decreases rapidly until plasma extinguishes and the process repeats. The rapid changing high currents can generate complete different rates of radical generation in plasma that can improve the efficiency of plasma processing.

We generated relaxation discharges in different gases using both dc and ac (50 Hz) supplying sources. We followed spectroscopically the plasma behavior in dc discharges, ac discharges and combinations of these discharges with the relaxation ones in CCl_2F_2 and CF_4 gases, mostly used in plasma etching technologies, at pressures of around 10^{-1} torr.

Experiment, results and discussions

Before presenting some of our results, we would like to make some general considerations concerning the cathode phenomena. We will restrict our considerations to the following approximations:

- the electrons are generated only by γ processes,
- due to the high electric field value E_0, the ionic and electronic currents j_{e0} and j_{p0} have only drift components,
- the fluid approximation equations are applicable,
- the ionization coefficient α (E) works at the cathode also,
- the ion and electron mobility are constant,
- $$\frac{d}{dx}(n_e-n_p) \approx 0 \qquad (1)$$

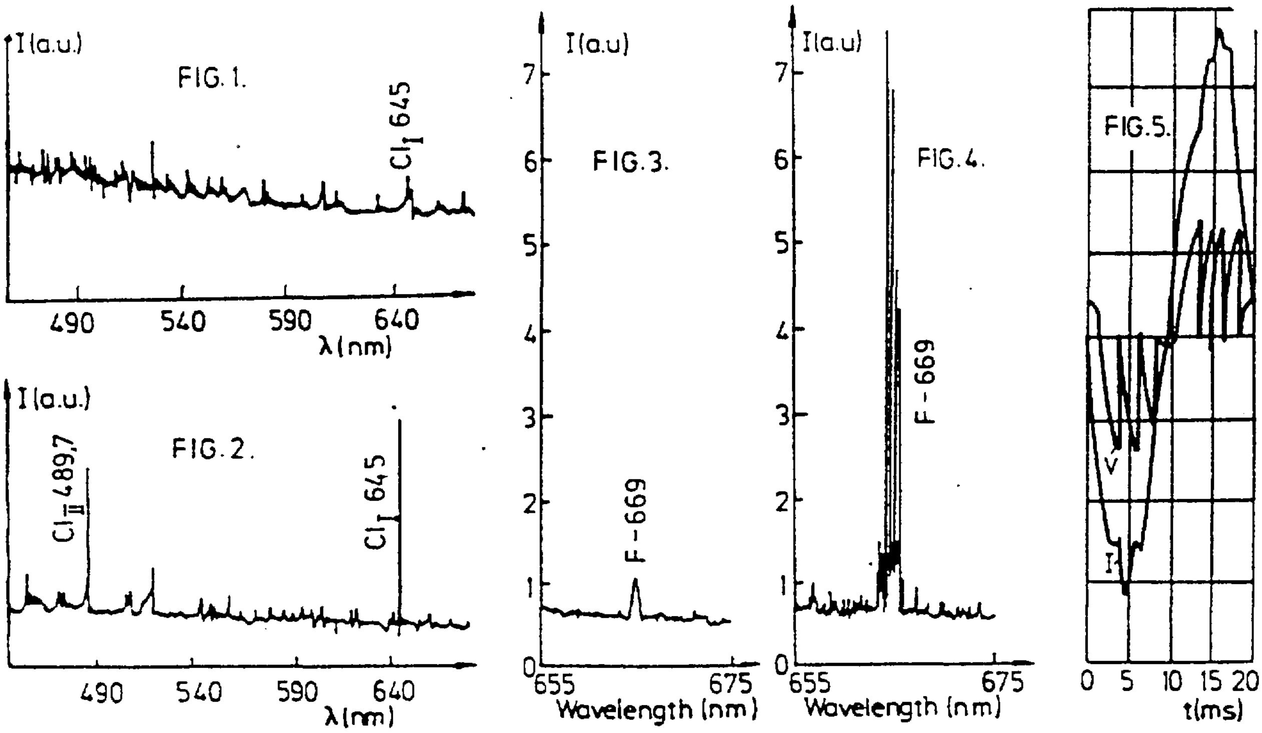
This equation considers the electric field as being linear near the cathode [2]. As we know, $\mu_e \gg \mu_p$ and finally we find out:

$$E_0^2\ \alpha\ (E_0) = \frac{eI}{\varepsilon_0 \mu_p \gamma (1+\gamma)} \quad (2) \qquad\qquad \frac{dE_0}{dx} = -\alpha\ (E_0)\ E_0\ \gamma \quad (3)$$

The eq. (2) shows that E_0 increases with total current density I increase, and from eq. (3) one can see that E_0 increase leads to an increased absolute value of dE_0/dx. So, when discharge current increases, the electric field near cathode increases together with the ionic density n_{p0} , and this allows to a more energetic action of the discharge over the cathode surface (where the probes are mounted).

When using the relaxation discharges, high picks of current are expected, together with higher degree interaction between plasma and probe carrying electrode.

Also, in the gap, the electron distribution function is expected to be very far from equilibrium and for certain conditions it can produce with a greater efficiency the necessary active radicals in the technological gases.



We recorded some spectra of dc and relaxation discharge pulses in CCl_2F_2 at pressures of 10^{-1} torr and correlated them with the etching rates of aluminum in the two cases. In Fig.1 and Fig.2 we present the recorded spectra for dc and relaxation pulses discharges respectively. Measuring the etching rate of aluminum we found out that the etching rate of relaxation pulses was by a factor of 30 greater than that of dc discharge. The explanation can be seen by comparing the two spectra, the high radical emission intensities appearing in case of relaxation discharge. In Fig.3 we present the emission spectrum (F-669 nm line) recorded in ac discharge in CF_4 at 10^{-1} torr pressure, while in Fig.4 the one obtained maintaining the same discharge conditions, excepting of a 2 μF parallel capacity. This capacity generates relaxation pulses given in Fig.5. The high intensity increasing of F-669 nm emission line in presence of the capacity can be readily appreciated.

Conclusions

Both visually and on the spectra, one can see a greater concentration of the active radicals present in the relaxation discharge. The corresponding etch rates increased by at least one order of magnitude in these cases. Further works on these discharges are necessary in order to improve their performance in surface processing.

We think these pulse discharges as being very promising for plasma etching, plasma anodisation, plasma assisted CVD, technological processes. The 50 Hz, AC discharges were used for plasma CVD in [3] and [4], but without relaxation pulses.

References

[1]. G.Y.Yan, K.I.Fuji, A.I.Schawlow, Optics Letters, **15**, No.2, (1990)
[2]. R.P.Stein, Phys Rev.,**89**, 134, (1953)
[3]. G.Tochitani, M.Shimozuma, H.Tagashira, J.Appl.Phys.**72**, No.1, (1992)
[4]. T.Hashizume, M.Yoshino, M.Shimozuma, J.Appl.Phys.,**76**, (10), 5955, (1994)