AXIC APPLICATION REPORT

ELECTRICAL CHARACTERISTICS OF DISCHARGES IN VACUUM

12

*by **Jozef Brcka**, AXIC, Santa Clara, California*

WHEN AN ELECTRIC FIELD is applied to electrodes a discharge between them is produced. Two typical regions can be distinquished: a region where $n_i \approx n_e$, e.g. ***plasma region***, and a region where $n_i >> n_e$ - ***space charge (or sheath) region*** - (close to the electrode surface), Fig. 1.

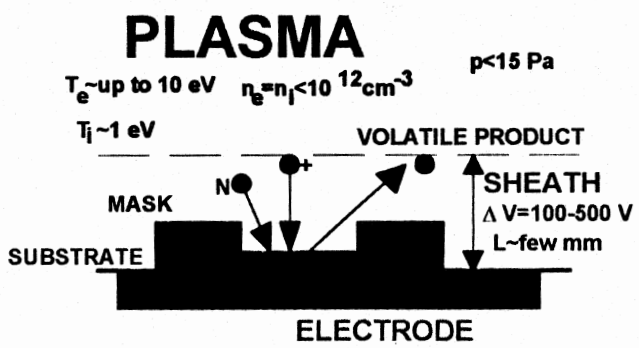
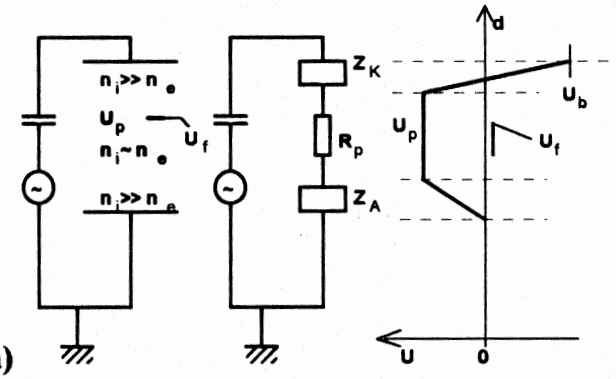


FIG. 1
Schematic representation of the reactive ion etching process.



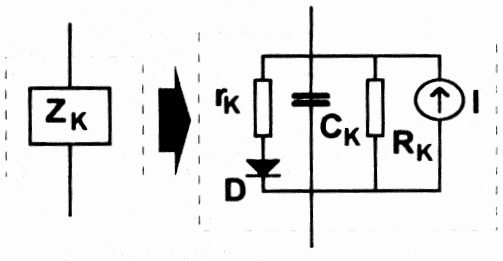


FIG. 2
Equivalent scheme of discharge and potential distribution between electrodes (a), and an equivalent scheme of space charge region (b). PLASMA is represented by ohmic component R_p, - loses of electrons in collisions with molecules. SHEATH is represented by impedance Z_K and Z_A, they have a capacitive character and depend on area, ion current and average potential in sheath. U_f is floating potential, U_p - plasma potential, U_b - dc bias of powered electrode.

The sheath of space charge (dark space) separates the plasma from electrodes and reactor walls. It is produced due to electron loses (because of high mobility of electrons) from the plasma near the surfaces. General equivalent scheme of discharge is given in Fig. 2.

Near the electrodes, electrons flow only in a direction from the plasma volume towards the surfaces (see diode in Fig. 2-b). The consequence of that is a potential difference between the plasma and electrodes is produced. Ions can not follow an oscillating electric field, thus they are accelerated towards the electrodes (represented by ion source in an equivalent scheme).

Resistor r_k limits the electron current - it has a low value. Resistor R_k takes into account a dissipation of power in the sheath due to collisions of ions with neutral particles. Potential distribution in RIE and PE systems (13,56 MHz and 380 kHz) is given in Fig. 3.

Advantages of the RIE configuration are:

- low energy ion bombardment at anode - no contamination due to resputtering of anode,
- small area of cathode - low contamination by target sputtering,
- bias - control of ion energy.

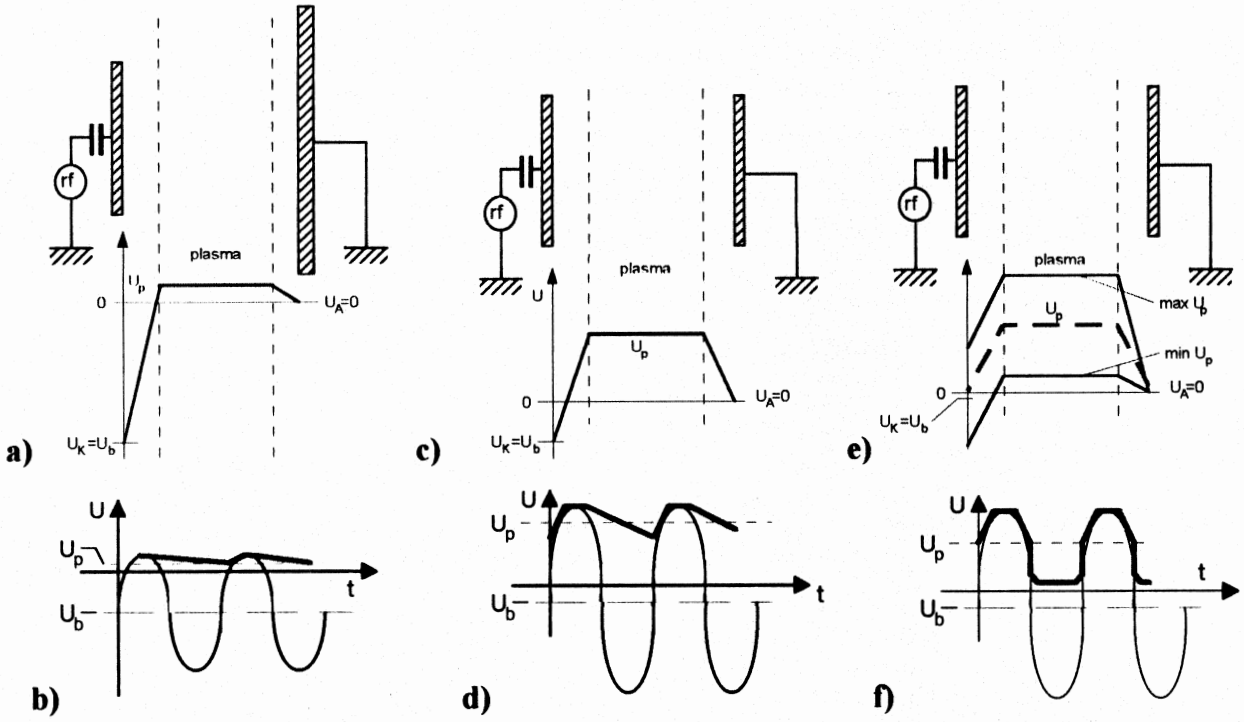


FIG. 3

Distribution of the potential between electrodes in a reactive ion etching system at 13.56 MHz: (a) and plasma etching planar diode system (c) (U_p - plasma potential, U_A - anode potential, $U_K = U_b$ - potential of cathode). Potential of rf electrode U(t) and plasma potential in RIE system (b) and in PE (d). Plasma potential is usually about 10 - 20 V higher than anode potential. Distribution of potential between electrodes in low frequency system 40 or 380 kHz (e), and potential of powered electrode U(t) and respective plasma potential (f), [for more details see, for example, ref. 1 - 3].

Axic, Inc.
493 Gianni Street
Santa Clara, CA 95054-2414
Tel. (408) 980-0240 Fax (408) 980-0524
E-mail: postmaster@axic.com

REFERENCES

[1] Gill, M.D.: Vacuum 34 (1984) 357.

[2] Rossnagel, S.M., Cuomo, J.J. and Westwood, W.D.: Handbook of Plasma Processing Technology. Noyes Publications, Park Ridge, NJ (1990).

[3] Vossen, J.L. and Kern W.: Thin film processes, Academic Press, New York (1978).