NOTE ON THE SELF-SUSTAINING CREEP DISCHARGES IN GAS AT THE DIELECTRIC SURFACE

J. Klobukowska, J. Brzosko

Colloque C7, supplément au n°7, Tome 40, Juillet 1979, page C7- 469

NOTE ON THE SELF-SUSTAINING CREEP DISCHARGES IN GAS AT THE DIELECTRIC SURFACE

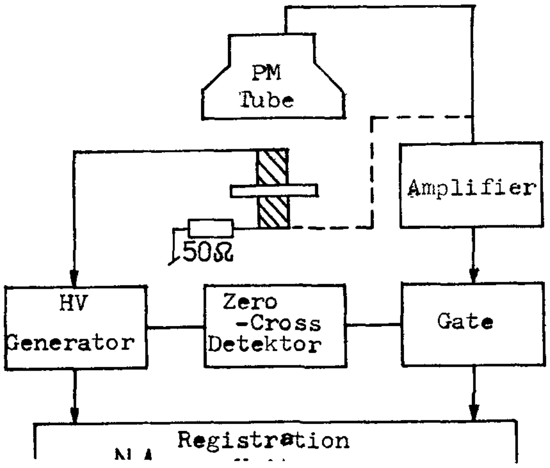
J. Kłobukowska and J.S. Brzosko.

Institute of Physics, Warsaw University Branch, Białystok, Poland.

When a thin dielectric specimen is placed between flat cylindrical electrodes of a diameter much smaller than that of the specimen and alternating voltage, ν = 50 Hz is applied, creep discharges take place in the gas phase near the surface.The discharges concentrate in narrow channels oriented radially with respect to the electrode and may be registered by means of a photomultiplier (flashes) or charge amplifier (apparent charge). Study of the conditions in the plasma channel requires investigation of the discharge self-sustain ance.

In this note the preliminary results are given which provide a basis for checking the validity of Paschen's law as the self-sustainance criterion. The electric field intensity near the electrode edge can be approximated by the quasi-uniform field up to the critical distance R_o. The calculations based on the equivalent circuit method [1],[2] reveal that R is strongly dependent on the damping parameter

which strongly depends on the effect of injection of carriers into the specimen [3]. The discharges were detected by means of a high sensitivity and low noise level photomultiplier or a charge amplifier working in the pulse regime.The electronic set-up(Fig.2) allowed us to measure the voltage characteristic of the discharge intensities and to determine the inception voltage U_o^{inc}.



$$U_o^{inc} = pR_oB\ln^{-1}\left[ApR_o\ln^{-1}\left(1+\frac{1}{\gamma}\right)\right]$$

where p is the pressure of the specimen ambient gas, R_o is equivalent distance between flat electrodes for the discharge channel fitted to best agreement with experimental data.

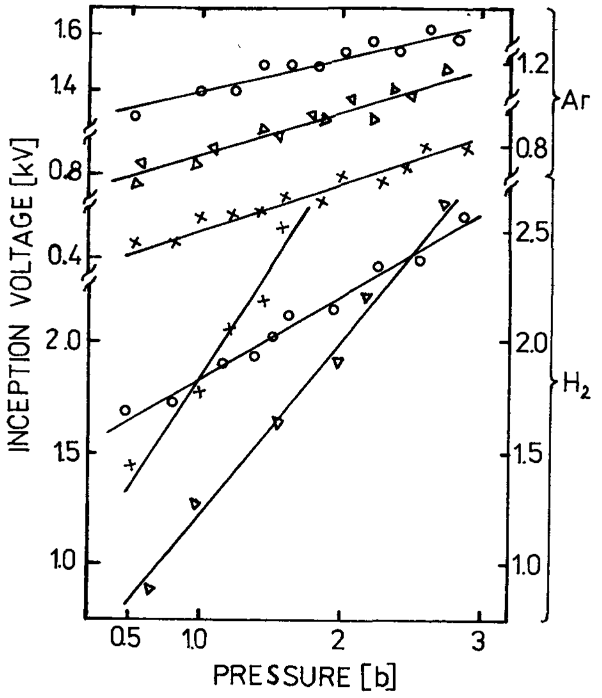


Fig.3

The coefficients A, B and γ were taken from the literature for plane geometry and the investigated gases for example from ref.[4]. The values of R_o obtained as a result are of the order of 4 x 10^{-3}cm for argon, 2 x 10^{-2}cm for air, and 5 x 10^{-2}cm for hydrogen. The values of U_o^{inc} are 1 - 3 times smaller than the measured ones. Additionally the dependence of R_o on the thickness of the sample was checked. An increase of the specimen thickness induced an increase of the range of the effective electric field, due to the lowering of the damping parameter a (see Fig.1). As a result longer sparks are allowed, what corresponds to the experimental results;

h = 0.22 mm and R = 4 x 10^{-3}cm,

h = 1.3 mm and R_o= 6 x 10^{-3}cm.

The results of our measurements allow us to draw the following conclusion:

1. Paschen's law is qualitatively fulfilled for the creep sparks for pressure as well as for spark length variation, which suggest that the discharges are self-sustaining
2. The spark length R_o is of the order of 10^{-2}cm, which corresponds to the field intensity of the order of 10^5Vcm^{-1} and damping parameter 10 - 100 cm^{-2}. As a result our quasi-uniformity assumption of the electric field is fulfilled, see Fig.1.
3. No dependence on the polarity of the electrode has been observed for the untransparent bakelite BC, see Fig.3.
4. The absolute values of U_o^{inc} are strongly dependent on the specimen material even for similar R_o magnitudes (see Fig.3).

Taking into account that the discharge time is of the order of 10^{-8}s even for sparks 1 cm in length [5] and that U_o^{inc} is independent of polarity of the electrode we can suggest that self-sustainance is based on photoionization effects as well as exchange of carriers between the plasma channel and the specimen surface.

References:

[1] Busch K., Raport Elektrot.Z., A 92,1971 604

[2] Brzosko J.S., Grudziński J., Konarzewski A., Wojewódzka A., Żukowski E., J.Phys.D:Appl.Phys. 10 1977 1583

[3] Brzosko J.S.,Żukowski E.,Grudziński J. Żukowski W.,Konarzewski A., I.E.E.E. Transactions 1979, accepted for publication

[4] Babikow M.A.,Komarow N.S.,Siergiejew A., Technika Vysokich Naprażenij, Gosenergozdat, Moskva-Leningrad 1963

[5] Kärkkäinen S., 1974 Finland Tech. Res. Centre Rep. vol.6