Modeling of rf and dc breakdown

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It is well known that studies of the non-equilibrium processes which occur in radio frequency (rf) discharges during breakdown are of interest, both for industrial applications and for a deeper understanding of fundamental plasma behavior. Capacitively coupled rf discharges are receiving an increased attention due to their wide applications in many technological processes such as plasma etching for semiconductor materials, thin film deposition and plasma cleaning. DC breakdown studies are of interest in a wide range of applications. One recent example are plasma displays. Finally studies of gas breakdown are of direct interest for development of gaseous dielectrics and circuit breakers. Most recently interest has been initiated in dc, rf and microwave breakdown at atmospheric pressures with an idea to develop micro discharges for applications for displays, nanotechnologies and light sources.

In order to optimize plasma technological processes it is often necessary to know gas breakdown conditions in a discharge device. On the other hand plasma models include numerous coefficients and some of the phenomenology that may be obtained most directly from the studies of breakdown. Therefore, it is of considerable interest to simulate and measure the breakdown curves in dc, rf or combined fields. However, as far as rf argon breakdown is concerned, agreement between the measured and predicted criteria is unsatisfactory.

The basic phenomenology of breakdown concurs with that of electron and ion swarms as space charges are negligible during the initiation of the discharge, thus a basic charged particle transport theory together with the kinetics of active species will suffice to model the breakdown. The breakdown is often epitomized in breakdown voltage (U_b) versus pressure (p) times gap (d) between the electrodes curves (Paschen curves) which basically reveal the importance of pd scaling which is valid in addition to E/N scaling.

Recently, Phelps and Petrovic [1] an analysis of the breakdown in argon. They have shown that it is possible to reconcile the data due to ion beam techniques and those from the application of Paschen law to the gas breakdown measurements which were otherwise different often by up to 2 orders of magnitude. At the same time the role of backdiffusion and nonequilibrium electron kinetics has been studied by Radmilovic and Petrovic [2,3]. Finally we should mention a large number of experiments performed at higher pressures that cover dc and high frequency breakdown data at very small gaps [4,5]. All of these studies were the basis from which we started our analysis presented here.

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