Investigation of Characteristics of Dielectric Barrier Discharge Using a Numerical Model

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***Abstract*—A numerical model for simulation of dielectric barrier discharge (DBD) is presented in this paper. Generated by a high AC voltage, DBD eventually evolves into a quasi-stationary state phenomenon with the same frequency as the applied voltage. The nature of DBD requires a time-dependent simulation which brings a large amount of calculation, and, therefore, some problem simplification must be adopted. In our model, only positive ions and negative ions, with all ionic reactions neglected, are taken into consideration. After neglecting the ionization layer, these two species are injected from the discharge electrode surface and their densities can be determined by applying Kaptzov's hypothesis. Ions' movement causes drift current and their deposition on the dielectric surface accounts for the surface charge accumulation. None of these mechanisms are independent of the others. The total behavior of DBD can be significantly influenced by the applied voltage level, frequency and geometrical settings.**

Fig. 1 shows the waveforms of applied voltage and discharge current. Differently from the experimental results published in literature, the simulated current waveform has no spikes, which are caused by either a streamer discharge or a Trichel pulse formation, because ionic reactions are completely neglected in the numerical model. The current waveform shows a noticeable phase shift with respect to the applied voltage. This can be explained as a capacitive effect created by ions drifted in the space and accumulated on the dielectric surface. Fig. 2 is the time-dependent plot of the surface charge density on the dielectric, where x-axis stands for the arc length of the dielectric boundary, y-axis represents time, and the color range demonstrates the density of surface charge. It shows that the polarity of surface charge reverses twice every voltage cycle. A pattern inclination towards the right-upper corner can be observed since injected ions need some time to move away from the discharge electrode. Moreover, the distribution of space charge is examined in simulation. This offers a detailed view of the generation and movement of ions, and, therefore, enhances the understanding of the discharge process. DBD generated under different conditions are also inspected in order to analyze the influence of voltage level and frequency on the discharge characteristics.

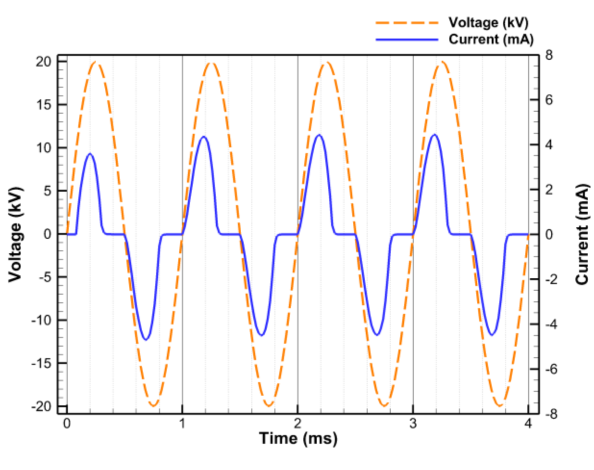

Fig. 1. Discharge current and applied voltage to the electrode as a function of time.

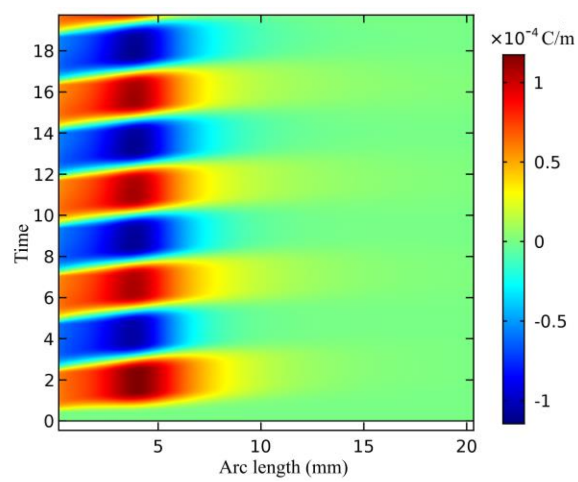

Fig. 2. Time-dependent plot of the surface charge density.