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Electrohydrodynamics of charge-injecting high-voltage electrodes

XUEWEI ZHANG, Texas A&M University Kingsville — In liquid dielectrics, initiation of electrical breakdown usually takes place at the electrode/liquid interface under a much lower electric field than that required by molecular ionization, even if the material is highly purified. One of the main causes is the fact that there exist micro-protrusions and micro-pores on the electrode surface. Smart use of charge injection to improve electrical breakdown strength has been demonstrated in previous works. The objective of this paper is to propose and numerically study a new design of charge injecting electrodes inspired by inkjet printer. In a needle-plane configuration, the needle electrode is hollow and has microchannels connecting its interior to the outside, both filled with the same dielectric liquid. The highly inhomogeneous electric field has electrostriction effect, creating a low-pressure region at the needle tip. The pressure difference across the microchannels will drive liquid flow from inside the electrode to the outside. During this, the liquid jets will be electrified and carrying the charge with the same sign as the electrode (homocharge). We build the electrohydrodynamic model and develop a numerical program to simulate this process. The steady-state simulation results confirm that the hollow electrode with microchannels can effectively inject homocharges which enhance the electrical conductivity and lower the electric field in the region near the electrode surface.

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