Modelling of streamer propagation in dielectric liquids using a dense gas model

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Ultrafast electrical breakdown in dielectric liquids is of considerable interest for applications in high-voltage insulation. For liquids with high mobility of charged particles, the breakdown takes place on a nanosecond time scale, and its mechanism is similar to the streamer breakdown of gases which is caused by the electron impact ionization of particles, with a distinction that the electron–ion recombination in the streamer channel plays a significant role compared to streamers in gases. Also very high-voltage pulses of sub-ns duration provide an extremely high electrical field in the plasma formation region in the liquid and allow ionization directly in the condensed phase by direct electron impact. Thanks to the sub-nanosecond time scale, the fluid lacks time to expand, and so the discharge is formed directly in the liquid phase [1, 2]. In this contribution we present a study positive streamer dynamics in dielectric liquid using a dense gas model [3]. The electric discharge propagation in liquid is described by the set of convection-diffusion equations with source terms for charged particles coupled with the Poisson equation for the electric potential. The equations are discretized by finite volume method (FVM) on 2D unstructured triangular grid. The convective terms are computed by upwind scheme and the accuracy of the scheme is increased by linear reconstruction restricted by the Barth-Jespersen limiter. The dissipative terms are discretized by the diamond scheme and central approximation. The second order in time is guaranted by three steps Runge-Kutta method. The Poisson equation is discretized analogously as dissipative terms in convection-diffusion equations, and the system of linear equations is afterwards solved by LU decomposition. Implemented multi-level dynamic grid adaptation algorithm allows to capture sharp peaks and steep gradients of unknowns occurring in moving region of the streamer head.

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References

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