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# Electric field measurements in surface discharges in atmospheric air over solid and liquid dielectrics

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Time-resolved and spatially resolved electric field is measured in ns pulse dielectric barrier discharges sustained in ambient air over solid and liquid dielectric surfaces. The measurements are done using ps four-wave mixing diagnostics. The results indicate significant electric field reduction following ns pulse breakdown, followed by electric field reversal as the applied voltage is reduced. After the discharge pulse, the electric field decays on microsecond time scale, due to surface charge neutralization. The present results yield quantitative insight into kinetics of ns pulse surface ionization wave discharges and provide detailed experimental data for validation of kinetic models of ns pulse surface discharges.

This work presents the results of temporally and spatially resolved electric field measurements in a nanosecond pulse discharge in atmospheric air, sustained between a razor edge high-voltage electrode and a plane grounded electrode covered by a thin dielectric plate or a by a layer of distilled water. The electric field is measured by picosecond four-wave mixing in a collinear phase-matching geometry, with time resolution of approximately 2 ns, using an absolute calibration provided by measurements of a known electrostatic electric field. In discharges over quartz plate and over liquid surface, the results demonstrate electric field offset on the discharge center plane before the discharge pulse due to surface charge accumulation on the dielectric from the weaker, opposite polarity pre-pulse. During the discharge pulse, the electric field follows the applied voltage until "forward" breakdown occurs, after which the field in the plasma is significantly reduced due to charge separation. When the applied voltage is reduced, the field in the plasma reverses direction and increases again, until the weak "reverse" breakdown occurs, producing a secondary transient reduction in the electric field. After the pulse, the field is gradually reduced on a microsecond time scale, likely due to residual surface charge neutralization by transport of opposite polarity charges from the plasma. Spatially resolved electric field measurements show that the discharge develops as a surface ionization wave. Significant surface charge accumulation on the dielectric surface is detected near the end of the discharge pulse. Spatially resolved measurements of electric field vector components demonstrate that the vertical electric field in the surface ionization wave peaks ahead of the horizontal electric field. Behind the wave, the vertical field remains low, near the detection limit, while the horizontal field is gradually reduced to near the detection limit at the discharge center plane. These results are consistent with time-resolved measurements of electric field components, which also indicate that vertical electric field reverses direction after the ionization wave.

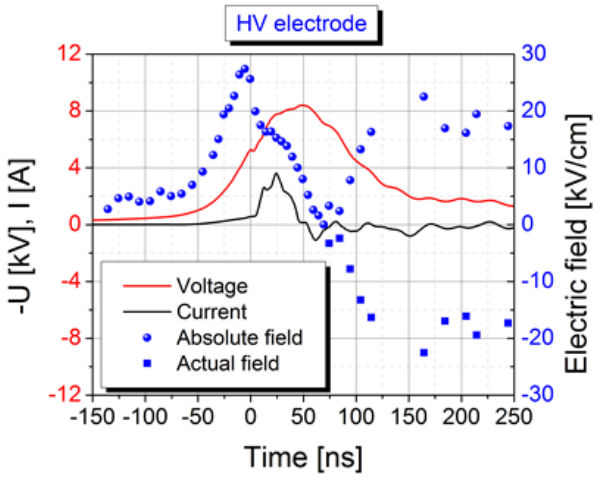


Figure 1. Time-resolved electric field measured in the negative polarity ns pulse discharge pulse over liquid water, on the discharge center plane ~ 100 μm below the high-voltage electrode.