S5-P-000702

THE DYNAMICS OF A STREAMER IN A SHARPLY INHOMOGENEOUS ELECTRIC FIELD AND ITS INFLUENCE ON THE AMPLITUDE-TIME CHARACTERISTICS OF VOLTAGE AND CURRENT*

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Due to wide range of applications, nanosecond discharges in gases in sharply inhomogeneous electric fields have attracted the attention of researchers all over the world [1–2]. Therefore, it is extremely important to know what physical processes occur at the breakdown stage. The purpose was to find experimentally and study the relationship between the dynamics of the discharge formation and the amplitude-time characteristics of current and voltage.

The formation of a nanosecond discharge with the use of a Hamamatsu streak-camera and with simultaneously wideband (10 GHz) measurement of voltage and displacement current caused by a streamer in one pulse was studied (Fig. 1). Nanosecond voltage pulses of various amplitudes (16–27 kV) were applied across a point-to-plane gap (8.5 mm) filled with air at various pressures (13–200 kPa). It was found that as soon as a streamer appears in the vicinity of the pointed electrode the voltage across the gap drops. At the same time, a pre-breakdown current begins to flow. The magnitude of the pre-breakdown current, as well as the voltage drop, is determined by the rate of formation of dense plasma and, accordingly, by the rate of redistribution of the electric field in the gap. The streamer velocity determines the rise time and amplitude of the current. The higher the streamer velocity, the shorter the rise time and the higher the amplitude of the pre-breakdown current. The propagation of a backward and third ionization waves was observed both with the streak camera and by measuring the displacement current. As they propagate, the discharge current increases to its amplitude value.

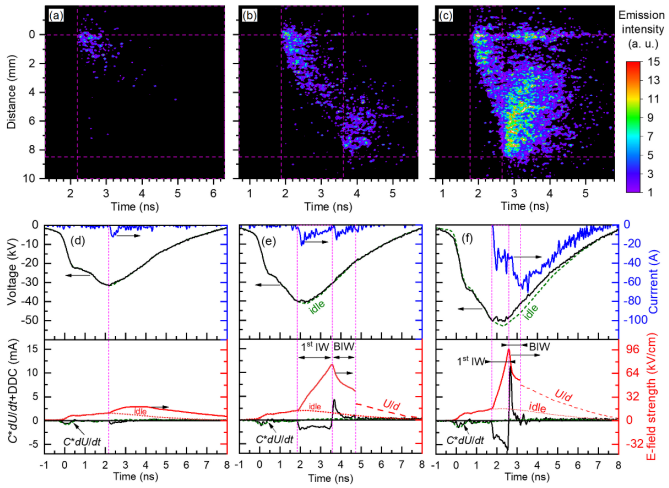

Fig.1. (a–c) Streak-images and (d–f) corresponding waveforms of voltage, current, displacement current ($C_{gap}dU/dt$ + Dynamic Displacement Current) measured with the collector placed behind the grounded grid electrode, and the electric field strength near the surface of the grounded electrode at various voltages across the gap. 1st IW – first ionization wave (streamer), BIW – backward ionization wave. Air at a pressure of 200 kPa.

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* This research was supported by the MSHE of the Russian Federation within Agreement No. 075-15-2021-1026.