A considerable advance has been made recently in the development of small-sized picosecond pulsed power supplies [1]. Advantage was taken of these power supplies and techniques for diagnosing fast processes to perform a detailed experimental study of the runaway electron beams (REBs) generated during breakdowns in atmospheric-pressure gas-filled diodes [2–4]. The basic features of these REBs, such as their short duration (~ 45 ps), the current amplitude (~ 0.1–10 A), and the effect of the prepulse on the REB current, still remain unexplained. Our aim is to consider the processes of the generation and disruption of the picosecond REB with emphasis on the runaway kinetics, the increase in emission current and plasma density, and beam instabilities. It has been shown that an application of a few-nanosecond ten-kV prepulse gives rise to a streamer appearance near the cathode. Application of the main pulse (of a rate ~2 MV/ ns) results in the REB generation with the streamer electrons involved into the acceleration, and in increase of the electron emission from the cathode and the plasma density. At the high enough plasma density fast beam instability disrupts the REB.


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