Mechanism of spark channels filamentation in an atmospheric discharge

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The mechanism of spark channels filamentation, which are formed in air at atmospheric pressure on a nanosecond time scale, is discussed. The data obtained using multi-frame laser probing with an exposure time of 70 ps and a spatial resolution as high as 3–4 μm are used. It is demonstrated that at the top of a homogeneous spark channel forming from the cathode the conditions proving a means for a successive development of the ion acoustic, Buneman, and, as a special case of a two-stream, – filamentation instabilities are achieved. Estimates show that the electric field at the top of the channel is as high as the Dreiser field (~1 MV/cm), while the electron drift velocity becomes close to the thermal velocity. In this case an important role is played by the conditions for the generation of the runaway electrons, which form the space charge region in the neutral air gap between the top of the growing channel and the anode. Achievement of such extreme conditions at the top of the growing channel is essential for the generation of the highly ionized plasma filaments with the diameter of ~c/ωpe ~ 10 μm, where c is the speed of light in vacuum and ωpe is the electron plasma frequency. The findings indicate that the filamentation instability arise as a specific plasma formation process that plays an important role in the complicated mechanism of the current transmission in the different types of a gas discharge.

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