Generation of runaway electrons during pulsed breakdown of high-pressure (tens of atmospheres) gases

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A mechanism for the initiation of explosive electron emission at the interface between the cathode and a dense gas is proposed. It is based on the accumulation of positive ions, which appear as a result of gas ionization by field-emission electrons, near natural microprotrusions. The distance at which ions appear decreases with increasing gas density, which leads to an increase in their Coulomb field on the emitting surface. As a result, for a high-pressure gas (tens of atmospheres), an explosive increase in the emission current density occurs, leading to the formation of explosive-emission centers in tens of picoseconds. They initiate the development of plasma protrusions providing conditions for the generation of runaway electrons. In turn, runaway electrons ionize the gas, leading to its subnanosecond breakdown. Such a breakdown scenario can be realized under conditions of a critically low reduced electric field (i.e., the ratio of its strength to the pressure), when, firstly, it is an order of magnitude lower than that required for the transition of thermal electrons to the runaway regime and, secondly, so low that the characteristic time of the avalanche multiplication of thermal electrons is longer than the duration of the voltage pulse.

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