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CONDITIONS FOR ELECTRON RUNAWAY IN AN AIR GAP WITH AN INHOMOGENEOUS ELECTRIC FIELD: THEORY AND EXPERIMENT *)

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The phenomenon of electron runaway—their continuous acceleration in a gas or a plasma medium in a sufficiently strong external electric field—plays a key role in subnanosecond breakdown of gas gaps. The present report compares the conditions for the generation of runaway electrons in air gaps with different degrees of inhomogeneity of the electric field distribution provided by varying the opening angle of the conical cathode [1,2]: in the range 0^o–180^o in calculations and 40^o–120^o in experiments (a set of replaceable graphite cathodes has been used).

It is demonstrated that, in a weakly inhomogeneous electric field (according to the proposed classification, this corresponds to cones with angles greater than the Taylor angle of 98.6^o), the runaway condition has a local character. The transition of free electrons into the runaway mode is determined by the local distribution of the electric field near their starting point—the tip of the cone. The local field strength must exceed a threshold value comparable to the strength critical for runaway of electrons in a uniform field. If a free electron goes into the runaway mode in the near-cathode region, then it will continue to run away, continuously accelerating, throughout the entire gas gap.

In a strongly inhomogeneous field (cones with angles less than 98.6^o), this condition is not sufficient for electrons to run away throughout the entire gap. An electron accelerating in the near-cathode region may begin to slow down in a weak field at a distance from the cathode and turn into a thermal one. In this case, the runaway condition becomes nonlocal. It is determined by the dynamics of electrons in the entire gap, primarily in the near-anode region, and reduces to the requirement that the potential difference applied to the gap exceeds a certain threshold value, which depends on the gap width and gas parameters.

The features of electron runaway in a gas gap when using needle or tubular edge cathodes are also discussed [2,3].

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References

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