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MODELING OF PREBREAKDOWN PHENOMENA IN THE CATHODE MICROPROTRUSION, TAKING INTO ACCOUNT THE MELT MOVEMENT

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The explosion of the cathode microprotrusions due to heating by emission current is considered to be the basic mechanism of the vacuum DC [1,2] and RF [3-6] breakdown. However, in these approaches, the consideration of prebreakdown processes did not take into account the dynamics of the microprotrusion shape after melting. In this work the development of hydrodynamic and thermal instabilities after melting has been self-consistent simulated in a copper cathode microprotrusion exposed to RF electromagnetic field within the two-dimensional axisymmetric model. The model includes a self-consistent calculation of the electric field strength and emission characteristics on the “emission” half-wave of the RF field within the PIC method, calculation of current density and temperature distributions in the microprotrusion. From the moment the melt appears in the top part of the microprotrusion, the model describes the movement of the liquid phase under the action of forces from the electric field (Maxvell stress) and surface tension forces. Within the framework of this model, modeling of the development of hydrodynamic and thermal instabilities for a microprotrusion with an initial electric field enhancement factor $\beta \sim 86$ in a microwave wave with a strength amplitude of 250 MV/m and a frequency of 10 GHz was carried out. The dynamics of microprotrusion heating and the change in the microprotrusion shape after melting are shown in Fig. 1 and Fig. 2, respectively.

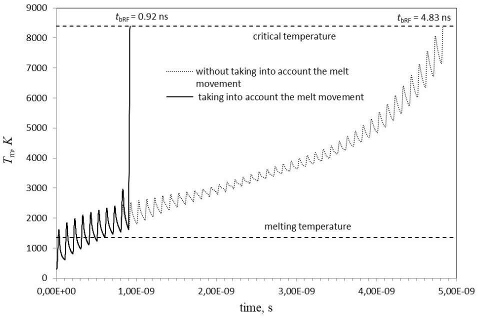

Fig. 1. Dynamics of the heating of microprotrusion with $\beta \sim 86$ to the critical temperature in an RF field of amplitude 250 MV/m and frequency 10 GHz.

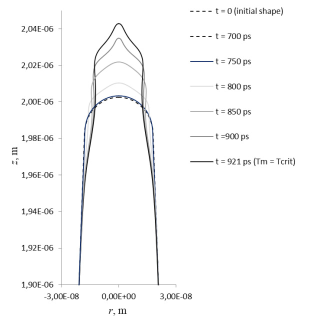

Fig. 2. Dynamics of the microprotrusion shape after melting.

Based on the results obtained (see Fig. 1), it is shown that the time for the development of thermal instability (explosion delay time) during stretching and sharpening of a microprotrusion in the molten state is significantly lower than in the case of an unchanged microprotrusion shape. This is due to the fact that after melting, the top of the microprotrusion in the electric field begins to stretch and become sharp. This leads to an increase in the electric field strength and electron emission current density.

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