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CONDUCTION CURRENT IN LOW-DENSITY PLASMA OPENING SWITCHES*

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Recently [1], a new concept of conduction has been proposed for low-density plasma opening switches. The concept suggests that a unipolar ion layer is formed near the cathode as electrons leave it under the action of an electric field induced by magnetic field penetration into the plasma. The main aspects of this concept, being an alternative to that on the formation of a bipolar near-cathode space charge layer subject to unlimited cathode emissivity [2], are reduced to the following.

For a collisionless plasma, the magnetization time of electrons in a rising magnetic field is given by $\tau = (3mc / e\dot{B})^{1/2}$, where $\dot{B}$ is the field rise rate, m and e are the electron mass and charge, c is the velocity of light. The transport of current across a strong magnetic field is provided by electron drift in crossed magnetic and polarization electric fields. The polarization field results from charge separation during the motion of electrons in the current channel. As a result, the velocity of field penetration into a plasma of density n is given by $u = (\dot{B}c / 6\pi en)^{1/2}$, and the switch conduction current for this velocity by $I_c = (3\pi encr_c^2 \dot{B} l^2 / 2)^{1/2}$.

The paper presents a comparison of the derived relations with experimental data [3], showing that the conduction current behaves strictly as $I_c \propto n^{1/2}$ at a plasma density of about 10^{11} – 10^{14} cm^{-3} and field rise rate of about 0.3 – 4 kA/ns and that this behavior holds for any plasma bridge length. Attaining the same conduction current at different bridge lengths requires that nl^2 be constant. As the magnetic field rise rate varies, the conduction current behaves as $I_c \propto \dot{B}^{1/2}$. These results differ radically from what is predicted by the bipolar model [2]. Additionally, the paper presents arguments of why the axial current channel width varies nonmonotonically during a pulse and gives estimates of the electron temperature in plasma opening switches at different plasma densities and field rise rates.

REFERENCES

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