Simulation on the characteristic of plasma evolution in three electrode gas spark gaps

Ao Xu, Lin Yang, Wei Zhong, Yulong Liu, Dazhi Jin, Lei Chen

Institute of Electronic Engineering, China Academy of Engineering Physics, Mianyang, China

The performance of three electrode gas spark gaps is directly effected by the characteristic of plasma evolution while gaps are operating. However, it is difficultly to obtain all the plasma parameters only by experiments. Therefore, it is necessary to study the characteristic of plasma evolution in three electrode gas spark gaps with the help of simulation tools. This paper presents a sequence of images of plasma evolution in three electrode gas spark gap obtained by high speed camera. Then, the simulation results of this experimental geometry are present with the help of a 2D PIC-DSMC code. According to compare results between the experiment and the simulation, it could confirm the validity of the code. Finally, the temporal and spatial density distribution of electrons, ions and neutral particles are cognized, and the temperatures of particles in plasma channel are obtained. It would be helpful to further understand three electrode gas spark gaps.

1. Experiment

Experimental setup is shown in Fig.1, that the electrodes of the three electrode gas spark gap are placed in a vacuum system filled with nitrogen gas at atmospheric pressure. And the camera consists of four intensified charge-coupled device cameras using the same optical axis by means of an internal beam splitter. Then the cathode is grounded, while the anode before switching is at a constant positive voltage of 2kV. The gas spark gap is triggered by applying a 1kV negative (with respect to the cathode) voltage pulse to trigger electrode.

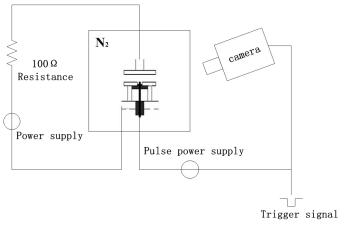

Fig.1 Experimental setup

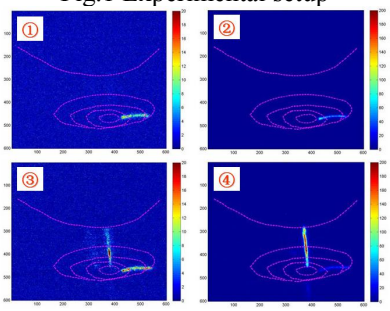

Fig.2 Sequence images of plasma evolution

Fig.2 gives a sequence of images in three electrode gas spark gap, starting abrupt change of trigger pulse. As found in the experiment, the trigger process includes two steps. First, breakdown was initiated between the trigger electrode and the cathode. Second, a streamer was launched from the trigger electrode toward the anode.

2. Simulation

According to the geometry and the voltage of the three electrode gas spark gap in above experiment, a simulation model was established with the help of a 2D axial symmetrical PIC-DSMC code. Then, the mechanisms describing the particles in the gap plasma were as follows: electrons are emitted from trigger electrode according to Fowler-Nodheim filed emission. The electrons move to the gap undergoes various kinds of collisions and produce ions. Moreover, ions and electrons can cause the emission of electrons at all the electrodes.

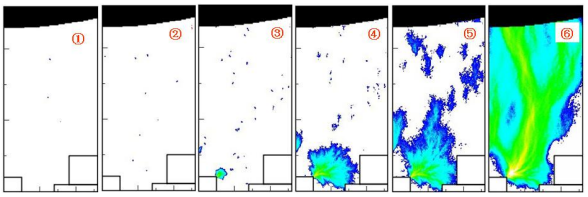

Fig.3 Simulation results of electrons distribution evolution

Fig.3 shows the 2D PIC-DSMC simulation results of the plasma evolution in the three electrode gas spark gap used in above experiment. It is found that the results between the experiment and the simulations are identical. Moreover, detailed change of plasma parameters also can be obtained with the help of PIC-DSMC simulation.

3. Conclusion

With the help of simulation tools, it is possible to obtain the detailed characteristics of plasma evolution in three electrode gas spark gaps. It would be helpful to further improve the performance of these gaps.