Experimental study of ion optics with improved structural strength

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Increasing lifetime and efficiency are the most important tasks to be solved in the course of state-of-the-art ion thruster development. Those characteristics depend on the design of ion optics, which is the critical part of an ion thruster.

The task of increasing the lifetime is usually solved by lowering the current density of ions moving from the discharge chamber to the inner surface of the screen grid or by using of carbon-based materials. The first method leads to enlargement of the ion optics diameter, and, accordingly, thruster size and weight. Usage of carbon-based materials is more promising, while maintaining high values of the ion current density.

The task of improving the efficiency of the thruster is achieved by increasing the ion optics transparency for ions, which can be implemented by two ways: reducing of walls thickness between screen grid holes, and increasing of the electric field between discharge chamber plasma and accelerator grid. For this purpose, the screen grid thickness should be reduced while maintaining minimum distance between the electrodes at which electric breakdown is absent between the grids.

All of the abovementioned measures to change the geometry of the ion optics, along with increased lifetime and efficiency of the thruster, decrease the mechanical strength of the electrodes. The electrodes with small thickness (less than 0.5 mm for a thruster with diameter more than 200 mm), must survive vibration during launch. This problem can be solved by using of carbon-carbon composite with fillers based on bidirectional fabrics or unidirectional tapes as grids material. The thickness of the monolayer of such electrodes is in the range of 0.07 mm to 0.1 mm. Laser drilling of holes with classic circular geometry cause fiber cutting, which leads to further decrease in strength. In this connection, a new form of apertures to be square with rounded corners, instead of circular holes, was proposed. This geometry with orientation of monolayers 0°/90° allows placing holes so that the fibers passing along the walls between holes remain intact. This allows improvement in grids structural strength.

This paper presents the results of comparative test of ion thrusters, which were equipped with round hole geometry ion optics, and ion optics having square-shaped holes.