Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 185 (2017) 432 – 437

Procedia Engineering

www.elsevier.com/locate/procedia

6th Russian-German Conference on Electric Propulsion and Their Application

Plasma local parameters measuring in the low power radio-frequency ion thruster's discharge chamber

Vladimir Kozhevnikov[a,b,*], Sergey Khartov[a,b],
Maxim Suvorov[a,b], Ivan Cherniy[a,b]

[a]Moscow Aviation Institute (National Research University), Moscow, 125080, Russian Federation
[b]Research Institute of Applied Mechanics and Electrodynamics (RIAME), Moscow, 125080, Russian Federation

Abstract

This paper presents the results of plasma parameters probe studies in the discharge chamber of low power laboratory ion thruster. The measurement procedure based on the use of triple Langmuir probe placed into the discharge chamber's plasma. During the plasma measurements probe characteristics were collected automatically by data acquisition software created in LabVIEW development environment. In the current paper we discuss the results of the experiment: electron temperature T_e distribution and electron number density n_e distribution in the plasma in the hemispherical discharge chamber of the low power laboratory ion thruster. The distributions were obtained without applying an accelerating potential in the ion-optical system for different values of the propellant (xenon) mass flow. Results obtained are in good agreement with the similar experimental data presented in publications of other authors.

Peer-review under responsibility of the scientific committee of the 6th Russian-German Conference on Electric Propulsion and Their Application
Keywords: radio-frequency ion thruster; plasma diagnostics; Langmuir probes

1. Introduction

During the development of a low power high-frequency ion thruster for small satellites (weighing up to 500 kg) produced in the «Research Institute of Applied Mechanics and Electrodynamics (RIAME)» from 2013 the laboratory ion thruster with the output beam diameter d = 80 mm was created. While developing one of the most challenging requirements is increasing of plasma power absorption from a stimulated high-frequency inductive electric field. In a region of plasma called as a skin layer an electromagnetic wave could pass in, and there occurs a process of power absorption. With the increase of electron density n_e in the skin layer, absorption proceeds more efficiently, but thickness δ of a skin layer decreases. Therefore, to design an efficient low-power thruster one needs to know the local plasma parameters distributions.

* Corresponding author. Tel.: +7-499-158-0020.
E-mail address: k208@mai.ru

Peer-review under responsibility of the scientific committee of the 6th Russian-German Conference on Electric Propulsion and Their Application
doi:10.1016/j.proeng.2017.05.070

Some earlier experimental studies for the local plasma parameters were provided by scientists from the University of Giessen (Germany). These data were collected for mercury plasma of radio-frequency thruster's series and distinctive conclusions in this works were:

- magnitude of the azimuthal electric field ***E*** has a maximum at the wall of discharge chamber and falls to zero at the axis,
- electron temperature T_e also has a maximum at the wall of discharge chamber and falls at the axis, but not to zero,
- plasma density has a maximum on axis and a minimum at the wall of discharge chamber due to the recombination processes at the wall.

These results should be qualitatively common for other types of radio-frequency plasma, in our case it is the xenon plasma.

2. Test facility

The object of our investigation is a laboratory model of low-power RIT-8, which functions in conjunction with the automatic radio-frequency generator unit and the power supply source of the ion-extraction system. Hemispherical discharge chamber with an internal diameter d = 80 mm and the working volume height h = 38 mm was used. Discharge chamber was made of a mixture of aluminium oxide (50%) and silicon nitride (50%). Inductor wound on the chamber was made of a copper tube (external diameter d = 3 mm) and has five complete turns. Its inductance is L = 2.78 mH at the measurement device frequency of 10 kHz. For the uniform study of local plasma characteristics inside the discharge chamber, a number of holes was made for the Langmuir probe. Chamber geometry and holes disposition are shown in Figure 1.

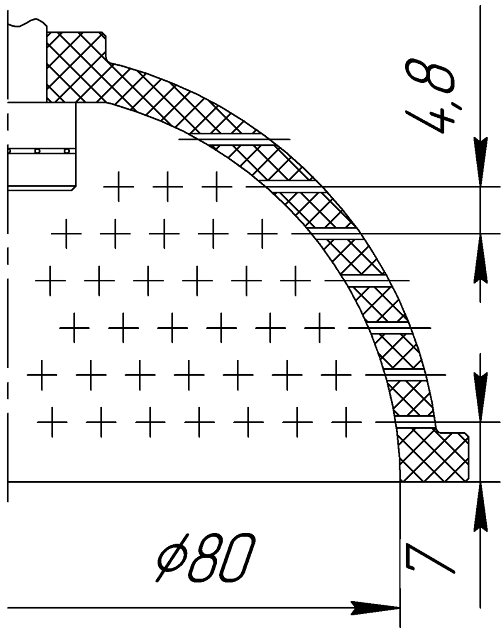

Fig. 1. Geometry of the laboratory ion thruster's discharge chamber.

Discharge chamber with the mounted Langmuir probe is shown in Figure 2. Free holes in the chamber wall were filled with a compound based on the aluminium oxide powder.