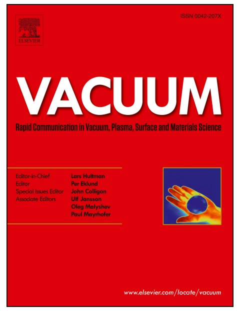

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Anode position influence on discharge modes of a LaB_6 cathode in diode configuration

George-Cristian Potrivitu[a,*], Romain Joussot[a], Stéphane Mazouffre[a,**]

[a]CNRS, ICARE, UPR3021, 1C av. Recherche Scientifique, CS 50060, F-45071, Orléans cedex 2, France

Abstract

A laboratory model of a 5 A-class cathode was experimentally studied in diode configuration with a disk anode. The core of the cathode is a flat disk lanthanum hexaboride (LaB_6) insert. Electron emission is achieved using a heating element in direct contact with the insert. The paper reports the characterization of the LaB_6 cathode operated at xenon mass flow rates between 0.4 and 1.0 mg s^{-1} with discharge currents ranging from 2 A to 12 A. Apart from the operating envelope and discharge mode (spot versus plume) differentiation, the influence of anode position on cathode discharge mode was studied. For this purpose, the cathode was operated at 4 A and 0.6 mg s^{-1} and at 10 A and 0.6 mg s^{-1}, while the cathode-anode gap was increased from 20 mm to 70 mm. Both electrical and plasma parameters were collected and analyzed in order to highlight the main changes in cathode discharge when the cathode-anode gap was increased. Particular attention was paid to the identification of the discharge mode and mode transition based on spectral analysis of discharge current waveforms. It was demonstrated that an increase in the cathode-anode gap induces the discharge mode transition from spot mode, corresponding to lower gap values, to plume mode, corresponding to higher gap values. Changes in plasma property were also noticed, the cathode-anode gap increase inducing lower plasma density and higher electron temperature in the cathode plume.

Keywords: Electron source, Cathode, Anode, Langmuir probe, Electric propulsion

1. Introduction

A Hall thruster uses a cathode as source of electrons together with an anode in order to ionize the propellant gas. During thruster operation, the cathode provides electrons towards the anode to counterbalance losses (electron-wall) and maintain the plasma discharge. A large fraction of electron current is also used for neutralization of the ion flow downstream the thruster outlet. This last fraction of the cathode electron stream typically accounts for 80% of the total cathode electron current [1]. The cathode, along with the magnetic circuit, are two of the critical components of a Hall thruster, drastically influencing the system performances and lifespan [2].

The core of a cathode is the emitting element, usually referred to as the insert, shaped as a flat disk or a hollow cylinder. The insert material can be a refractory metal, such as tungsten, tantalum or molybdenum, or more complex materials, such as lanthanum hexaboride (LaB_6), barium oxide impregnated into a porous tungsten matrix (BaO-W) or calcium aluminate, also known as electride (C12A7:e-) [3, 4]. In particular, lanthanum hexaboride is considered as a reliable material for a cathode insert, allowing for simplified handling and start-up procedures [5], longer simulated lifetimes [5] due to its lower evaporation rate, compared to BaO-W and tungsten, robustness to impurity poisoning and water vapors [3, 6]. However, a LaB_6 insert must be operated at elevated temperatures due to its relatively high work function [3]. This requires heater devices capable of delivering sufficient power to reach emission temperature at the insert which may lead to greater risk of failures [7]. This last aspect is of great importance when developing high power Hall thrusters and it is therefore under consideration by several research teams [7, 8, 9].

*Currently at NTU, Singapore
**Corresponding author
Email address: stephane.mazouffre@cnrs-orleans.fr (Stéphane Mazouffre)