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Author: Mr. Colum Walter
Universität der Bundeswehr München, Germany, Colum.Walter@unibw.de

Prof. Tobias Sander
Universität der Bundeswehr München, Germany, tobias.sander@unibw.de
Mr. Pavel Smirnov
Universität der Bundeswehr München, Germany, pavel.smirnov@unibw.de
Prof. Jochen Schein
Universität der Bundeswehr München, Germany, jochen.schein@unibw.de
Prof. Christian Mundt
Universität der Bundeswehr München, Germany, christian.mundt@unibw.de

LASER-INDUCED FLUORESCENCE MEASUREMENTS FOR THE CHARACTERIZATION OF THE CAPACITIVELY COUPLED RF-PLASMA THRUSTER C-STAR

Abstract

The novel electric satellite propulsion system C-STAR is being developed and investigated at the Universität der Bundeswehr München as part of the small satellite mission SeRANIS (Seamless Radio Access Networks for Internet of Space). In addition to several communication payloads and in-orbit experiments the satellite enables the demonstration of the propulsion system in its operational environment in space.

The thruster is based on capacitively coupled radiofrequency plasma generation and is equipped with a magnetic nozzle as the plasma acceleration stage. The contactless generation and acceleration of the plasma is a main advantage of this technology and should allow the adaption of the propulsion system to a wide range of propellants. For this study a demonstrator of the thruster is using argon as propellant while the use of propellants with a higher atomic mass will be investigated in the future and the use of xenon is planned for the SeRANIS mission. A further unique benefit compared to common electric satellite propulsion systems such as gridded ion thrusters or hall thrusters is the simultaneous acceleration of ions and electrons within the plume which eliminates the need for a separate neutralizer. The acceleration of ions and electrons is assured by a combination of coupled phenomena including the creation of an ambipolar field in the plume and the formation of a ring current due to a diamagnetic and an an $\overrightarrow{E} \times \overrightarrow{B}$ drift.

Preliminary to an In-orbit Demonstration (IoD) of the propulsion system the functionality and performance parameters must be verified in ground tests. This study presents a noninvasive setup for the characterization of the plume and the evaluation of the thruster's performance by laser induced fluorescence (LIF) spectroscopy. The LIF technique is used to determine the temperature of neutral argon by evaluating excitation scans. This is achieved by exciting the metastable $(^2P^0_{3/2})4s$ level to the upper level $(^2P^0_{1/2})4p$. Excitation scans are recorded by detecting the fluorescence while tuning the wavelength of a pulsed dye laser around the center wavelength of the transition of 696.7352 nm in vacuum. The temperature of the argon neutrals is determined by comparing the detected excitation scan with calculated spectra. The Doppler broadening as well as the Zeeman broadening caused by the magnetic field of the nozzle are considered within the evaluation of the results.

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