A magnetized RF ion source for space propulsion applications

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In the framework of an innovative double stage Hall thruster concept, a new magnetized Inductively-Coupled Plasma (ICP) source with internal coil coupling is studied. The coil, inserted in a dielectric tube, is driven by a radiofrequency power supply. An internal magnet is introduced in the coil to confine the plasma. A RF compensated Langmuir probe is used to measure plasma parameters such as ion densities, electron temperatures, and electron energy probability functions. A parametric study is conducted by varying pressure (from 0.5 mTorr to 10 mTorr) and coupled power (from 50W to 200W). A capacitive probe is designed to quantify the capacitive coupling by measuring the radiofrequency plasma potential. Then, a particular focus is placed on the effects of the power supply frequency variation.

1. Issues of Hall thrusters

Hall thrusters are plasma sources that are known to deliver high ion ejection speed, which implies a very high specific impulse. However, since the same electric field provides electron energy for ionization and controls ion acceleration, thrust and specific impulse are closely linked.

In the next generation of satellites, electric propulsion will be used not only for orbit raising but also for station keeping. Thus, an important issue is to design versatile thrusters able to operate efficiently at high thrust and moderate specific impulse or high specific impulse and lower thrust.

2. Toward a double stage Hall thruster

The double stage Hall thruster concept allows to separate control of ionization and acceleration since ionization is provided in a separate plasma source while ion acceleration is performed through a magnetic barrier, as in a standard Hall thruster.

The concept of double stage itself raises practical and fundamental questions. Putting an ion source behind a magnetic barrier may lead to ion losses at the walls or large plasma instabilities [1]. Preliminary studies show that ion losses and instabilities can be minimized if the plasmas source is magnetically confined and placed as close as possible to the acceleration region.

In view of this, we have designed a new concept of double stage thruster. The ionization stage is an **ICP** source with a coil inserted in the central cylinder of the thruster [2]. A closed magnetic circuit is included to confine the plasma and reduce wall losses. This may provide a lower electron temperature and an increase of the electron density. A laboratory prototype based on this concept, called **ID-Hall** (**I**nductive **D**ouble-Stage **Hall** thruster) has been built and is being characterized.

3. Characterization of the ion source

Before integrating all parts of the system, an overall characterization of the plasma without a closed magnetic circuit is presented. The first results were obtained working with Argon using a cylindrical coil driven by a radiofrequency power supply. An internal magnet was added to confine the plasma. We used a RF compensated Langmuir probe and a capacitive probe for the diagnostics.

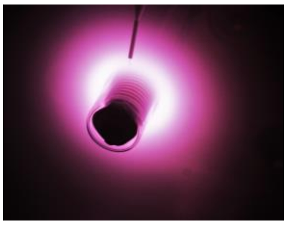

Fig.1: ICP magnetized plasma generated by the coil with internal magnet

In this presentation, we present the first results regarding the electronic densities, temperatures, energy probability functions, and efficiency of coupling. The pressure was varied from 0.5 mTorr to 10 mTorr and the coupled power from 50W to 200W. The influence of the static magnetic field intensity was studied in addition to the **impact of the power supply frequency**.

4. Acknowledgments

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5. References

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