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DEFENSE AND SPACE SYSTEMS GROUP

ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

MASTER

TITLE

QUARTERLY TECHNICAL PROGRESS REPORT
MICROWAVE PLASMA SOURCE

FOR

NEUTRAL-BEAM INJECTION SYSTEMS

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TECHNICAL PROGRESS

The cusp field RF ion source has been selected as the baseline approach for the conceptual Phase II design. Reasons for this choice include the following:

- Extensive operational experience and demonstrated feasibility with argon and helium
- Low frequency excitation compared to ECRH allows use of simpler, more conventional, power sources.
- Cusp field configuration similar to other magnetic bucket sources minimizes probability of unwanted magnetic field leakage into neutralizer region.
- Low magnetic field in plasma interior allows greater diffusion mobility, hence greater plasma uniformity than may be achievable with ECRH solenoidal field.

Figure 1 diagrams a presently existing 30 cm diameter RF ion source developed under NASA contract¹ for relatively low current density electric propulsion applications. This diagram illustrates the basic simplicity of this source. Similar sources have been operated with argon and xenon at plasma densities up to $\sim 10^{13}/\text{cm}^3$.

Conceptual design feature, for the present NBIS application are being derived in coordination with an ongoing in-house experimental investigation of the characteristics of RF excited hydrogen plasma sources in the 0.3 to 1 MHz frequency range. Nominal design parameters for these investigations are:

Plasma density $\sim 2 \times 10^{12}/\text{cm}^3$

Energy cost $< 500 \text{ ev/ion}$

Peak field strength in cusp region $\sim 1500 \text{ gauss}$.

The results of these hydrogen source investigations will also provide data for the Task 9 systems analyses and comparisons.

¹DiVergilio, W. F., Goede, H.; Komatsu, G. K.; and Christensen, T., "High Frequency Plasma Generators for Ion Thruster Applications", AIAA-81-0680, 15th International Electric Propulsion Conference, Las Vegas, Nevada (1981)

Figure 1 Schematic of the RFI Thruster

Although the baseline approach has been selected, we will continue parallel evaluation of the ECRH solenoidal and cusp field concepts as the potential of this type of source is high. Lack of ECRH performance data is currently the limiting factor. The ECRH source position will be reviewed again later in the program. As an adjunct to this effort, our in-house program will include hydrogen operation with a multi-cusp ECRH source.

As part of the task to maximize the H^+/H_2^+ , H_3^+ ratio for the RF source, empirical electron energy distributions measured in the RF hydrogen plasma will be combined with hydrogen cross section data to model the plasma. Hydrogen reaction rates will be computed for the appropriate electron temperature baths, and equations relating sources and sinks for e , H , H_2 , H^+ , H_2^+ , H_3^+ , H^- will be numerically solved for the steady-state concentrations during ion extraction. The expected ratio H^+/H_2^+ , H_3^+ , will be determined as a function of extraction rate and the electron energy distributions measured in the actual RF hydrogen plasma.

We are currently trying to contact LBL and ORNL to obtain firm interface data for the Phase II conceptual source design. Similarly, Phase II demonstration goals are now being defined to allow conceptual design of the experimental facility.

Distribution:

B. Fredricks
N. Uttinger
B. DeVergilio
A. Cole
P. Kidd
G. Inouye
D. Arnush
M. Huberman
H. Goede