Phase I Project Summary

Firm: Tech-X Corporation
Contract Number: NNX10CF60P
Project Title: Next Generation Ion Thruster Design Tool to Support Future Space Missions
Identification and Significance of Innovation:

- Ion thrusters are being planned for high-power and high-power-to-thruster operating conditions.
- Computational modeling will significantly reduce the expenses for NASA in performing Long Duration Tests and Wear Tests to study all operating conditions
- Self-consistent, fully kinetic ion thruster discharge chamber model, which solves for plasma potentials without simplifying approximations, is desired.
- Detailed electric field calculations will improve the understanding of the chamber plasma processes.

Technical Objectives and Work Plan:
Objectives:

- Include electric field effects into ion engine modeling in a physically precise manner. This will be the first time that this has been done.
- Demonstrate the ability of this computer tool to support ion thruster development for future space missions.

Work Plan:

- Integrate and enhance particle tracking capabilities in discharge chamber model with OOPIC Pro.
- Demonstrate the dynamic electric field model for the NASA's Evolutionary Xenon Thruster (NEXT) discharge chamber.
- Measure the ion impingement effects on the discharge chamber components and performance parameters.
- Demonstrate the kinetic model for studying the NEXT high power and high-thrust-to-power operating conditions.

Technical Accomplishments:
The most important success of this work was using a PIC-MCC model with a detailed electric field solver that utilized no approximations to model the performance of the plasma in the discharge chamber of an ion engine. This detailed and accurate of a calculation of the discharge chamber has never been performed before. This is a significant improvement over the state-of-the-art in discharge chamber modeling. The results from Phase-I indicate that this model is working properly and producing results that compare well to experimental measurements. In addition to the electrical potentials presented, many other results are presented. The particle current plots are information that has not been presented anywhere else to the best of the authors' knowledge. These results indicate that the computer model we have developed as part of this Phase I project can be a very useful tool in the design and understanding of ion engines. Other accomplishments are:

- ✓ Our numerical plasma potential, and number density distribution results are in good agreement with the experimental measurements.
- ✓ We also demonstrated modeling of ion induced sputtering of molybdenum material surface via self-consistent kinetic PIC-MCC simulations.

NASA Application(s): The off-the-shelf ion thruster discharge chamber computational tools should reduce the time spent by NASA employees developing these tools for electric propulsion systems. Easy-to-use OOPIC Pro software can be used by NASA personnel for performing plasma simulation of the ion thruster discharge chambers. Also these tools can be applied to modeling other electric thrusters such as the HiVHAC Hall thruster, and electrodynamic bare tethers. The fully electromagnetic capabilities in this code make them an ideal tool for modeling cathodeless RF ionization schemes as well.
Non-NASA Commercial Application(s): Accurate plasma modeling and sputter erosion tools have applications in other government organizations as well as the aerospace, satellite, ion source and plasma processing industries.
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