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ELECTROPLATING TECHNIQUES FOR IMPROVING ELECTROCHEMICAL RESISTANCE OF SILICON AND NICKEL MEMS ELECTROSPRAY THRUSTERS

Abstract

Ionic liquid ion source electrospray thrusters offer high specific impulse propulsion for small spacecraft performing in-orbit and de-orbiting maneuvers. Micro-Newtons of thrust are generated as ions are freed from the surface of the ionic liquid propellant by electrostatic forces. The power requirement to achieve ion discharge is lessened when the thruster surface is densely patterned with sharp structures, known as emitters. State-of-the-art emitters are on the order of 200 micrometers tall and are typically fabricated using mature microelectromechanical systems processes.

Silicon and porous nickel substrates are presently being studied—the former for its ease of manufacturing and the latter because it allows the propellant to be passively supplied, decreasing the weight and complexity of the design. One issue with non-inert substrates is the electrochemistry that occurs when particles of one charge are emitted and leave behind oppositely charged particles to interact with the propellant and structure. These interactions cause degradation of the emitting structures, resulting in a reduction of thruster lifetime and ultimately mission lifetime.

The scope of this work is to mitigate electrochemistry at the emitter tips to increase thruster lifetime by providing a benign electrochemical environment. Presently, the potential difference across the double layer formed between the emitter and propellant can be maintained below the electrochemical window by alternating the applied voltage at roughly 1 Hz. The approach presented here improves upon this method by using a seedless electrochemical plating process to coat Si and Ni emitters with a thin layer of platinum. Ideal plating conditions to achieve roughly 100 nanometers of platinum coating on the substrate are identified, and the thrusters are fired to determine the change in electrochemistry occurring at critical areas such as the emitter tips.

The plating bath is a commercially-available electrolyte, H2Pt(NO2)2SO4. Plating is performed in a temperature-controlled environment with mechanical agitation provided by the working electrode. A potentiostat is used to control the three-electrode cell. Preliminary plating experiments suggest an electric field-limited plating mechanism, with heavier deposits occurring in areas with stronger fields. Results of lifetime testing are not included at this time.

Further testing to achieve more uniform deposition is in progress, although deposition that favors sharp structures is likely acceptable because of the heightened electrochemistry at the emitter tips. In addition, the relatively high resistivity of the Si substrates contributed to the non-uniform deposition patterns observed. New methods for making electrical contact with the Si samples are being investigated.