Methods for Fabrication of Electric Propulsion Tips

Tech ID: 25092 / UC Case 2013-929-0

BRIEF DESCRIPTION

The technology is a method for fabrication of silicon microfabricated emitter tips.This process has two-step etching process which utilizes field emission electric propulsion (FEEP) and indium propellant.

FULL DESCRIPTION

This invention relates to the methodology used for the creation of silicon microtip emitter arrays to be used for electric propulsion in space applications. The proposed electrospray emitter will utilize field emission electric propulsion (FEEP).

The device consists of a heater which heats an indium propellant that covers an array of emitters aligned to an accelerating electrode. A high potential difference is applied between the emitters and the extraction grid, generating a high electric field. This electric field causes local instability of the indium propellant at the tip and results in Taylor cones produced from the propellant at the emitter tips. This propellant is ionized by the field and the ions are extracted towards the grid.

Each tip is fabricated from a two-step etching process. The first etching produces protruding columns identical to a prepared mask pattern. The second isotropic etching stage is used to sharpen the columns, resulting in a tapered tip with a base that is wider than the apex. Depending on the mask configuration, the sidewalls of the emitter tip could include grooved sidewalls with various dimensions, or porous sidewall surface. The grooves and/or porous surfaces improve propellant flow from the base to the emitter tip.

The resulting device has a longer thrust range, higher thrust density and is more easily customizable that previous emitter tips.

Space is an industry that is ideal for MEMS devices because they are small, lightweight and therefore cheaper to put into orbit. Microfabricated sharp tips are sometimes used for electric space propulsion applications, such as in field emission electric propulsion (FEEP) and colloid thrusters. Such tips are used in instances where fine control and low power thrust of spacecraft are needed.

A FEEP device, in particular, is a type of ion thruster that uses a liquid metal with a relatively low ionization energy as a propellant. The propellant is ionized and accelerated using a strong electric field between an emitter and an accelerator electrode to produce a Taylor cone with the propellant at the emitter tip. Ions are extracted from the cone tip and then accelerated to high velocities. A colloid thruster works similarly in using electrostatic acceleration to accelerate a charged liquid propellant. These devices have thrust capabilities on the order of microNewtons and offer a significant advantage over current state of the art technologies in enabling precise thrust control.

Two key problems arise with current thrusters: the lack of a capability to operate in ion and droplet mode with a single propellant and the lack of ability to produce a uniform emission with a large array of emitters. Studies have shown that FEEP thrusters are capable of producing controlled ion emissions but not droplet emissions, although it has been suggested that controlled droplet emission can be achieved with an array of emitters. In contrast, colloid thrusters have been able to produce controlled droplets but lack the ability to sustain controlled ion emissions. In addition, both colloid thrusters and FEEP thrusters have not demonstrated uniform emission using a large array of emitters. In addition, current FEEP, Colloid and liquid metal ion thrusters are plagued with low thrust density which limits their scalability.

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OTHER INFORMATION

CATEGORIZED AS

- **Energy**
  - Hydrocarbon
  - Transmission
- **Environment**
  - Remediation
  - Sensing
- **Engineering**
  - Engineering
- **Materials & Chemicals**
  - Chemicals

» **Sensors & Instrumentation**
- » Analytical
- » Physical Measurement
- » Position sensors
- » Process Control
- » Scientific/Research

» **Transportation**
- » Aerospace
- » Alternative Propulsion
- » Automotive

SUGGESTED USES

- Electrospray thrusters for electric propulsion in space applications

ADVANTAGES

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- Longer thrust range
- Higher thrust density
- Lower cost
- Less mass and volume
- More easily customizable
- Scalable

LEAD INVENTOR

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RELATED CASES

2013-929-0

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