Alternating Electrode Micro-Cathode Arc Thruster design and performance

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A Micro-Cathode Arc Thruster (µCAT) with a magnetically enhanced system has been proven to provide a micro-Newton level thrust capable for nanosatellite control.[1] Two particular conceptions have been investigated, namely the Ring-Electrodes Cathode Arc Thruster and the Co-Axial Cathode Arc Thruster as shown in Figure 1.[2,3] An application of an external magnetic field results in a cathode spot rotation causing an increase in thruster efficiency. The applied magnetic field also leads to an increase in ion velocity and lifetime of the thruster.[4]

It has been shown that different cathode materials with pulsed arcs can lead to different ion velocities and efficiencies. In a propulsion system, the system power can be defined using the following equation:

$$P = 2T * Isp * g_0 * \eta$$

T is shown as the thrust, g_0 is 9.81m/s^2, η is the overall efficiency of the system, and Isp is the specific impulse of the thruster. Using this equation it is seen that a lower ion efficiency will lead to a higher thrust, T.

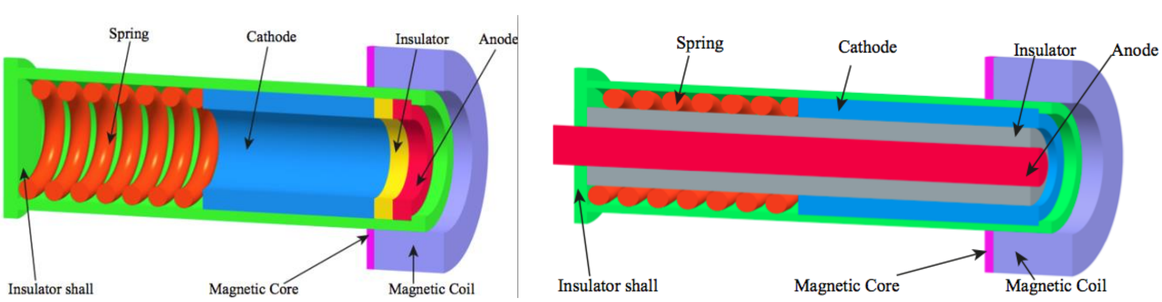

Figure 1: (a) schematic of ring electrodes micro-cathode arc thruster (re- µCAT). (b) co-axis cathode micro-cathode arc thruster (ca- µCAT

In this paper a different design concept is utilized, named the alternating electrodes micro-cathode arc thruster (ae-µCAT), using a mechanism similar to the µCAT but with two different material electrodes, as shown in Fig. 2. In this design the thruster consists of a titanium outer electrode with an outer diameter (OD) of 0.35in and a thickness of .035, a ceramic insulator with an OD of 0.327 and a thickness of 0.039, and a nickel inner electrode with and OD of 0.25in and a thickness of 0.025in. Steel springs are incorporated into the design to allow for each material to be pushed forward whilst eroding. A ceramic screw is also implemented to hold down the nickel material while an aluminum shell encases the entire thruster.

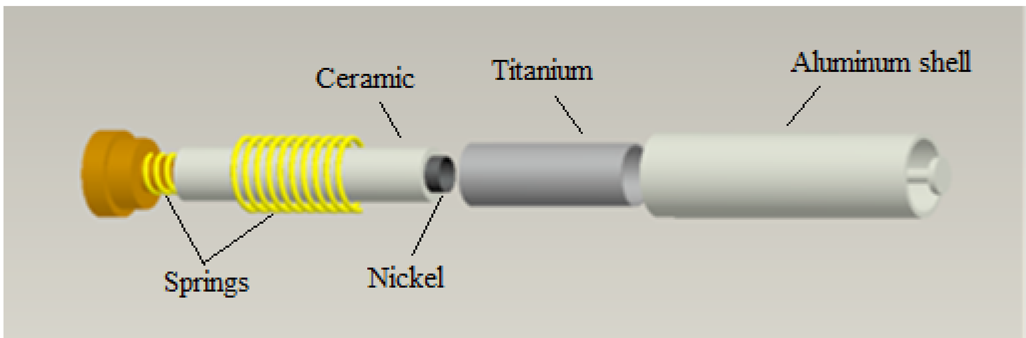

Figure 2: Schematic design of the alternating electrodes micro-cathode arc thruster (ae- µCAT)

The ion velocities, with different cathodes, in the plasma jet generated by the µCAT, were studied by means of the time-of-flight (TOF) method equipped with an enhanced ion detection system (EIDS).[5,6] Utilizing the EIDS allows us to overcome noise generation while simultaneously solving arc current perturbations which are an effect from single Langmuir probes.[5] For this setup, the ae-µCAT is placed in alignment with the EIDS grid system. The ions from the ae-µCAT discharge will then travel through a series of copper wire grids, which are powered by an alternate power supply. The EIDS voltage source is larger than the ae-µCAT in order to generate a corresponding spike in arc current.[5] As the ions pass through the EIDS, a signal is sent to an oscilloscope. Knowing the time difference between each signal and knowing the distance between each of the probes within the EIDS, we can calculate the velocity with a simple equation. The ae-µCAT thruster, utilizing two electrodes, allows us to measure the velocity of the nickel and titanium ions. Initial results show the velocity distribution of each material, Fig 3. It is easily seen that the ion velocity is greater for titanium than it is for nickel. Thus one can expect higher thrust in coming from the nickel cathode.

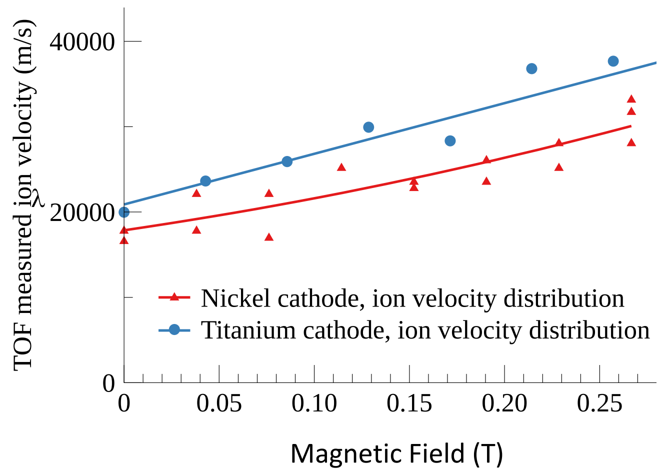

Figure 3: Preliminary results of the ae-μCAT ion velocities with the different cathode species

References

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