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Progress and Developments in Open Source Electric Propulsion for Nanosats and Picosats at AIS

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AIS is currently the first and only open source, open development based electric propulsion (EP) effort in the field. Over the past year, significant progress has been made on a number of micro ion and plasma thruster technologies for nanosats and picosats.

First, in March 2021, the first ever fully open-source electric propulsion system, the AIS-gPPT3-1C Micro Pulsed Plasma Thruster, successfully made it to orbit aboard the Care Weather Hatchling Veery 1U Cubesat, marking the first time an open-source thruster has ever been flown. While current development on this system has been retired, the design has been released under the CERN-OHL-S V2 license.

In addition to the original pulsed plasma thruster initiative that AIS was born from, AIS has been conducting a number of tests on the development of low-cost ionic liquid ion source (ILIS) electrospray thruster technology. This past year, breakthrough performance was established with the prototype ILIS1 emitter, which was hand modified from the original linear ridge design to a single spike, achieving up to 3uN of thrust for the single spike emitter at over 4500s ISP, operated stably in bipolar mode for a period of 30 minutes. These results confirm the direction moving forward for spike emitters, and work is underway to establish a larger 2D spike array of emitters to achieve full performance. Both the V1 and V2 prototype designs of the ILIS1 have been released under the CERN OHL-S V2 license.

AIS has also been pioneering work utilizing advanced molecular fuel for the development of ultra-compact, low power Hall thrusters for Cubesats and PocketQubes. Significant progress has been made with Adamantane fuel, a solid diamandoid hydrocarbon that exhibits direct sublimation in vacuum at low temperatures. Currently AIS is the only entity in the world specifically developing Adamantane fueled micro ion thruster technology. Initial tests verified very low power and temperature requirements for sublimation, and demonstrated ionization of the fuel from less than 1W to 2W of power with HV input. In addition, glow discharge, positive and negative charge extraction, and neutralizer plume extraction was demonstrated.

Moving forward, AIS has developed an ultra-low power glow discharge hollow cathode neutralizer for Hall thrusters, requiring only 2W of power, utilizing stainless steel and Somos PerFORM 3D printed parts, operated on Adamantane fuel. This first hollow cathode, the AIS-GDN1, was successfully run in self-ignition mode, as well as with a prototype micro Hall thruster. Work is currently underway for the next iteration of the cathode.

Several tests were also successfully conducted on the first ever AIS Hall thruster, the AIS-EHT1 Micro End Hall Thruster, a 0.3U size Hall system run on sublimated Adamantane fuel. Successful ignition was demonstrated with both a tungsten filament neutralizer as well as the GDN1 hollow cathode. The current V1 design of the EHT1 has been retired, and will be released under the CERN-OHL-S V2 license.

Finally for Hall thrusters, AIS has developed the smallest full Hall thruster system ever designed, the AIS-AHT1-PQ Pico Anode Layer Hall Thruster. At only 0.1U total volume (24x42x56mm), including fuel tank, fuel management, valve, thruster, and electronics, and nominal 10W power the AHT1-PQ is the first Hall thruster compatible down to PocketQube class satellites. The Hall thruster is also run in a unique neutralizer-less configuration, eliminating conventional neutralizers used for Hall thrusters, making the system more compact. Recently, successful ignition of a stable anode layer plasma was demonstrated, and work is currently underway to achieve full system ignition and testing.

Lastly, AIS has recently started a new vacuum arc thruster (VAT) initiative, with the first prototype AIS-VAT1 thruster system. The thruster measures only 42x42x16mm in size, rated to 2.5W nominal power, and leverages off-the-shelf components, extremely simple electronics, 3D printing, and triggerless operation to make it the simplest and lowest cost thruster developed yet at AIS. The thruster was successfully demonstrated to 10k pulses from 1-10 Hz at up to 5W power using solid titanium fuel. Additional work is being done to begin preparing the first off-the-shelf flight systems.

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