

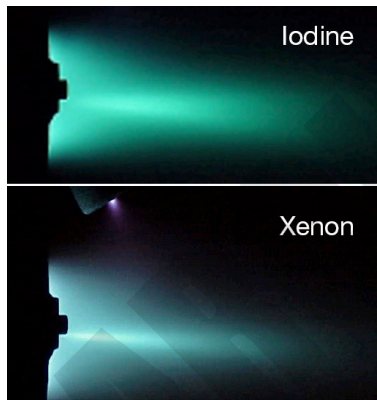


Iodine Hall Thrusters

NASA's Space Technology Mission Directorate

Solar electric propulsion (SEP) is expanding the capabilities of spacecraft ranging from satellites that are less than 300 kilograms (kg) through large exploration-class spacecraft. The number of missions that could use SEP continue to grow.

Hall effect thrusters are one of the primary propulsion systems for SEP missions. These thrusters use the electricity from solar arrays to make the thruster's cathode give off electrons. As the electrons bombard an inert propellant gas, they strip additional electrons from atoms and molecules to produce positively charged ions. An electric field then accelerates the ions into an exhaust plume of plasma that races out the back of the thruster, pushing the spacecraft forward. Current state-of-the-art Hall thrusters use xenon propellant, but iodine has emerged as a promising alternative for improving overall system performance.



Busek BHT-200 thruster operating on iodine and on xenon. (Copyright Busek Co. Inc.; used with permission.)

Mission Benefits

Iodine Hall systems promise to make SmallSats (less than 180 kg) much more versatile and to vastly improve the performance of higher power Hall systems. Typical SmallSats (including CubeSats) are launched into their prescribed low Earth orbits with no or limited onboard propulsion. This greatly limits their ability to make orbital maneuvers like long-duration stationkeeping, orbit altitude changes, plane changes, and safe deorbiting. Iodine Hall electric thrusters (iHETs) are the best near-term option to provide these capabilities because of their low-volume, high-delta-velocity (ΔV) performance, and unpressurized, safe form prior to launch. NASA's future small-satellite missions will safely achieve greater technical objectives because of iodine Hall thrusters.

Propulsion System Advantages

Conventional high-power Hall thrusters use xenon propellant. Because iodine propellant is stored and launched as a solid, its density is about 3 times greater than that of high-pressure xenon and the spacecraft's propellant tanks can be smaller. In addition, the density specific impulse, a rating that combines storage efficiency with propulsive performance, is much higher for iodine than for xenon. This advantage could lead to smaller spacecraft or could provide volume for additional scientific instruments.

Solid iodine does not need to be contained in a high-pressure tank, so the operating pressure will decrease from 2500 pounds per square inch (psi) with xenon to less than 2 psi. The change will cause a system-level ripple effect of smaller, low-mass tanks and support structure, resulting in lower cost spacecraft. It also will enable additive manufacturing to be used for the spacecraft components. Finally, testing with a condensable propellant like iodine will reduce facility requirements and enable high-power testing in low-cost ground facilities.

NASAfacts

Table 1.—iHET Phase I performance objectives

Performance Parameter	Xenon BHT-200 TacSat-2	Threshold Iodine Thruster	Iodine Thruster Goal
Specific impulse (Isp), seconds	1,375	1,300	1,600
Density Isp, g-sec/cm ³	2,200	6,370	7,840
System life at 200 W, hours	1,840	2,000	15,000

Current Work

The highest risk elements of an iodine system include long-life cathode operation, integrated feed system performance, thruster material changes needed for iodine compatibility, and high-efficiency, compact power-processing units (PPUs). These elements will be addressed under an existing NASA Glenn Research Center Phase III Small Business Innovation Research (SBIR) contract with Busek Co. Inc. to develop 600-watt (W) iodine Hall thruster technologies based on Busek's BHT-600.

The 600-W PPU will be made of modules derived from a compact 200-W PPU. The effort will reduce the mass and volume of the PPU by almost 80% and 90%, respectively.



Busek BHT-600 thruster. (Copyright Busek Co. Inc.; used with permission.)

Demonstration Mission

The 600-W iodine system will be developed at the same time as the iodine satellite (iSAT) mission, which is led by the NASA Marshall Space Flight Center and is funded under the Small Spacecraft Technology Program.



Conceptual design of the 12U iSAT spacecraft.

The iSAT spacecraft will demonstrate a high ΔV change from the primary iodine propulsion system. The mission will use Busek's 200-W iodine Hall thruster technology to demonstrate CubeSat maneuverability, including plane change, altitude change, and lower perigee to ensure atmospheric entry in less than 90 days. The 200-W technology is being developed under an Air-Force-sponsored Phase II SBIR contract, including the 200-W PPU module that will be used in the 600-W PPU.

Program Details

The iodine Hall thruster task is let by the NASA Glenn Research Center (GRC). Performance and long duration testing the propulsion system and its individual components will be conducted in vacuum facility 7 (VF-7) at NASA GRC.

The iodine Hall thruster task is under the Advanced In-Space Propulsion (AISP) Project. Information on other AISP tasks and other Game Changing Development (GCD) efforts can be followed at:

<http://gcd.larc.nasa.gov/projects/microfluidic-electropropulsion/>

NASA's GCD program investigates ideas and approaches that could solve significant technological problems and revolutionize future space endeavors. GCD projects develop technologies through component and subsystem testing on Earth to prepare them for future use in space. GCD is part of NASA's Space Technology Mission Directorate.