Graphene Foam Solid Propellant Hybrid Structure

Solid fuel loaded on reusable graphene foams significantly enhances burn rates and fuel loading for propulsion systems and energy conversion devices, while minimizing solid particles and toxic exhaust.

The control and enhancement of combustion wave propagation velocities of solid propellants are very important for the development of low cost, efficient solid rockets, solid microthrusters, and thermal-to-electrical energy conversion devices. Enhancing the burn rate of solid fuels/propellants by either adding metal/metal oxide additives or varying the fuel/oxidizer particle size is common. However, the addition of metal/metal oxide additives in the propellant mixture has several known disadvantages, including the propellant mixture is more sensitive to accidental initiation due to impact, friction, spark, flame, or heat; the condensed solid metal particles in the exhaust is detrimental to hardware because of their abrasive action; and the combustion of metals leads to toxic exhaust. There is an unmet need to develop solid fuel compositions with enhanced burn rates that may lead to improved performance in devices such as solid rocket motors. Desired solid fuel compositions should also have higher solid fuel loading. The substrate to load the solid fuel should be reusable and have little or no negative impact to the use of the solid fuels in devices such as solid rocket motors.

Purdue University researchers have developed methods of making and using compositions with solid fuel loaded on graphene foams (GFs) for enhanced burn rates for the loaded solid fuel, while minimizing the negative impact of traditional burn rate enhancement methods using metal/metal oxide additives. Since the graphene structures usually do not participate in the combustion process, there is almost no or minimum solid particles or toxic gases produced. The developed compositions provide significantly improved fuel loading, burn rate, and reusability. Researchers observed self-propagating combustion waves with average flame speed enhancements up to 8 times the bulk value. Moreover, testing the reusability of the GF structures by redepositing them with fuel after combustion resulted in similar flame speed enhancement using the fresh and the reused GF

Technology ID
2017-JAIN-67801

Category
Aerospace & Defense/Hypersonics & Propulsion Systems
Aerospace & Defense/Thermal Management & Combustion Optimization
Materials Science & Nanotechnology/Nanomaterials & Nanostructures

Authors
Shourya Jain
Li Qiao

Further information
Will Buchanan
wdbuchanan@prf.org

View online

structures.

Advantages:

-Improved fuel loading, burn rate, and reusability

-Low cost, efficient micropower systems

-Little to no solid particles or toxic gases produced

Potential Applications:

-Small-scale propulsion systems

-Microthrusters

-Thermal-to-electric conversion devices

Related Publications:

S. Jain, O. Yehia, and L. Qiao. Flame speed enhancement of solid nitrocellulose monopropellant coupled with graphite at microscales. Journal of Applied Physics 119, 094904 (2016); doi: http://dx.doi.org/10.1063/1.4943226

S. Jain, W. Park, Y. P. Chen, and L. Qiao. Flame speed enhancement of nitrocellulose monopropellant using graphene microstructures. Journal of Applied Physics120, 174902 (2016); doi: http://dx.doi.org/10.1063/1.4966933

S. Jain, G. Mo, and L. Qiao. Molecular dynamics simiulations of flame propoagation along with a monopropellant PETN coupled with multi-walled carbon nanotubes. Journal of Applied Physics 121, 054902 (2017); doi: http://dx.doi.org/10.1063/1.4975472

TRL: 3

Intellectual Property:

Provisional-Patent, 2017-03-30, United States | Utility Patent, 2018-03-23, United States

Keywords: solid propellant burn rate enhancement, graphene foam solid fuel, low cost solid rockets, solid microthrusters, thermal-to-electrical conversion, reduced toxic exhaust, improved fuel loading, reusable solid fuel substrate, combustion wave propagation, flame speed enhancement