Topic: N142-119

Materials Research & Design

Ultra Sharp Fiber Architectures for Ceramic Composites

Hypersonic aerodynamic efficiency and performance is currently constrained by materials capabilities. Airframes and control surfaces with sharp leading edges offer improved velocity and range by reducing drag but at the cost of higher temperatures and stresses. While ceramic composites offer thermochemical stability and strength; the diminutive scale of sharp leading edges precludes the use of traditional reinforcements. Materials Research & Design (MR&D), through our design/analysis services and partners, has developed a high-temperature ceramic composite material for erosion free leading edge applications. MR&D uses fine diameter tungsten wire reinforcements to produce a small scale composite that can be manufactured into ultra-sharp geometries. MR&D and its partners ultimately seek to demonstrate the fabrication of an ultra-sharp ceramic composite utilizing very fine tungsten wires and to prove its effectiveness in ground based arc jet testing.

Technology Category Alignment:

Air Platforms
High-Speed/Hypersonics
Materials & Manufacturing Processes
Propulsion and Extreme Environments

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SYSCOM: ONR
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Corporate Brochure: https://navystp.com/vtm/open_file?type=brochure&id=N68335-15-C-0357

Department of the Navy SBIR/STTR Transition Program

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WHO

SYSCOM: ONR

Sponsoring Program: Navy Strategic Systems Program Office; DARPA Tactical Technology Office

Transition Target: Hypervelocity Projectile

TPOC:
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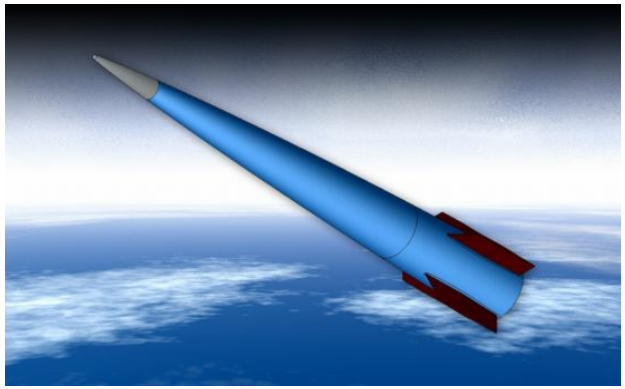
Other transition opportunities: Tactical Boost Glide, Conventional Prompt Global Strike



http://www.onr.navy.mil/~/media/Files/Fact-Sheets/35/Hypervelocity-Projectile-2012B.ashx

WHAT

Operational Need and Improvement: Future hypersonic missions require vehicles with sharp, erosion free leading edges and nose tips. State of the art ceramic matrix composite (CMC) leading edges are relatively blunt and made with large diameter tows. An improved CMC leading edge material and geometry provides increased range, higher velocities, and enhanced efficiency.

Specifications Required: Dimensionally stable leading edges capable of 30 minutes of operation at 4500°F. The leading edge radius is required to be 0.040 inches or smaller.

Technology Developed: Development and optimization of manufacturing processes needed for the design and fabrication of an ultra-sharp CMC leading edge. This includes the design of fiber architectures capable of creating a composite with fine grain unit cells, or "building blocks", in order to reinforce small geometry structures. The fiber architecture is created by braiding a preform with very fine diameter, commercially available tungsten wire. The tungsten wire preform is infiltrated with a ceramic matrix via hot isostatic pressing (HIP).

Warfighter Value: Low drag, sharp leading edges afford hypersonic vehicles and projectiles a decrease in time to target through extended range, higher speed, and precision targeting. This allows the Navy to address current and future threats in the areas of fire support, ship defense, and anti-surface warfare.

WHEN

Contract Number: N68335-15-C-0357 **Ending on:** September 1, 2019

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Initial R&D	N/A	Finite Element Model	3	March 2016
Processing Trials	Med	98% Densification	4	December 2016
Material Characterization	Low	B-Basis Allowables	4	April 2017
Arc Jet Test	High	Low Erosion, Dimensional Stability	5	April 2018
Flight Test	High	30 Minute Flight	6	September 2019

HOW

Projected Business Model: MR&D's business model is founded on research and design services. The developed technology requires analysis specific to each application to determine an optimal fiber architecture and geometry. Once a design is finalized, MR&D subcontracts preform fabrication and densification according to desired specifications. As such, MR&D benefits most from the initial design phase of each new application found for the technology.

Company Objectives: MR&D desires to transition the technology to hypersonic vehicles of interest to the Navy and other DoD services including the Hypervelocity Projectile and Tactical Boost Glide programs. Additionally, MR&D wishes to expose the technology to prime contractors and small businesses that also have a need for novel technology for hypersonic vehicles.

Potential Commercial Applications: Dimensionaly stable ceramic composites with ultra sharp fiber architectures may offer increased performance for commercial turbine engine fan blades.

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