Department of the Navy SBIR/STTR Transition Program

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Topic # N191-026
Antennas and Antenna Radomes with Extreme Thermal Shock Resistance for Missile Applications
American Technical Coatings, Inc

WHO

SYSCOM: SSP

Sponsoring Program: Strategic Systems Programs

Transition Target: Future hypersonic applications

TPOC: SSP.SBIR@ssp.navy.mil

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Other Transition Opportunities: Current hypersonic missiles in development like the Navy's offensive hypersonic strike capability, Army's Long Range Hypersonic Weapon (LRHW) dubbed "Dark Eagle," and the Hypersonic Air-Launched Offensive Anti-Surface Warfare missile, or HALO. Additional programs such as the Air Force tactical boost glide and air breathing concept, Army Operational Fires, DARPA advanced concept vehicle programs may all utilize research from this program for RF windows on board their flight vehicles.

Notes: ATC has demonstrated successful transition of SBIR technology via $12.5M sole source production contract from MDA for production of Transportation Protection System (TPS).
RIPS prototypes have been evaluated in relevant environments with funding from other programs. These include radome production for US Army DEVCO AvMC, and AFRL lens production. AFRL lenses were integrated with an RF system and tested to over 1000C in July 2022. The RIPS lenses accurately matched predicted performance and demonstrated stable RF properties throughout the temperature range. Gov. reps completed an initial Manufacturing Readiness Assessment (MRA) under ATC's OSD ManTech (FY22) program in August 2022. Initial MRA was assessed as 3 with a plan for MRA 7 or higher by 2024.

NOTE: This Navy SBIR was originally written to include a SOW focused on development of future versions of RIPS and not associated with technical maturation or prototype development. The Phase I effort was led by NAVSEA before Phase II was picked up by SSP. Efforts are in place to update SOW to point towards a specific Navy SSP program.

WHAT

Operational Need and Improvement: Evolving weapons technology is driving missiles and other flight vehicles to greater speeds and higher accelerations. The result of increased speed and acceleration is higher temperatures and thermal stresses. For instance, with vehicles traveling over Mach 4, surface temperatures can reach 1,500°C or higher. Rapid acceleration can result in extreme thermal gradients, which translate to high stresses. These increases require changes in materials to meet or exceed requirements to negate the effects on missile antennas and radomes. Flight environments include shock at launch (e.g., 30,000g for gun-launched projectiles), acceleration from zero to over Mach 5 in milliseconds to seconds, altitude of flight from sea level to 200,000 feet, and flight through adverse weather (e.g., rain, sleet). Most applications are limited by size and shape profile constraints (e.g., airframe fitting in its canister). The Navy needs new materials that package missile antennas in conformal configurations that can withstand these demanding new flight environments.

Specifications Required: There are specific material properties, namely dielectric constant and loss tangent, which need to be low (preferably below 5 and .05 respectively). Antenna and radome materials must provide for stable performance over the duration of its flight. Thermal shock is particularly difficult and can cause expansion of the outer surface during acceleration, thereby impacting both antenna electrical performance and material structural integrity. In addition, it is anticipated that future antenna applications will require frequency selective surfaces for electrical performance. These conductive patterns add requirements for surface smoothness and outer surface protection.

Technology Developed: RIPS (Reduced-density Injection-moldable Pressureless-sintered Silicon-nitride) is ATC's patented formulation and process for a silicon nitride material optimized for RF performance at extreme temperatures. The patented formulation and process are unique and create unique intrinsic properties in the finished material. RIPS is molded to net shape which reduces or eliminates the need for difficult and costly post-sinter machining. Net shape manufacture also reduces cost of complex geometries including RF windows, lenses, and radomes. RIPS's formulation and process impart finished products with controlled uniform closed-cell porosity creating a monolithic ceramic with lower density than a fully-densified silicon nitride. The resultant material has a lower dielectric constant, improved thermal shock tolerance, and maintains mechanical survivability.

Warfighter Value: Material developed as a result of this program will have opportunity for rapid deployment on board future reusable and expendable hypersonic flight vehicles in development across multiple services.

WHEN

Contract Number: N68335-21-C-0386 **Ending on:** Dec 01, 2022

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Material characterization test matrix	Low	Material characterization complete for generation of material model	3	4th QTR FY23
Survivability modeling and simulation	Low	Validated material model used to simulate RIPS relevant geometry in notional trajectory	3	1st QTR FY24

HOW

Projected Business Model: ATC will continue to develop highly-engineered materials for small markets where other large manufactures can't compete; specialty materials, high-performance, and low volume, complex shapes are key to continued success. ATC develops and manufactures materials. We plan to provide finished components (window, radome, aperture) or assemblies (bonded to frame, mounting ring, etc.) to an integrator for assembly within an RF system. Hypersonics is the driving force behind current material development and capability growth which will lead to future capacity to enter new markets.

Company Objectives: ATC would like to speak with anyone involved with the development of hypersonic weapons. Any programs utilizing radomes, RF windows, apertures, or lens are of interest to include those involved with conventional missiles, ground based radomes, satellite communication, and RF sensing in extreme environments.

Potential Commercial Applications: Potential commercial uses for high-speed antenna performance improvements are in the commercial spacecraft and satellite communications industries. The materials appropriate for this topic should have lower thermal expansion and higher erosion resistance than polymeric antenna materials, making them attractive for satellite applications where differential expansion from solar heating and erosion from micrometeorite impact are concerns. Other extreme environment sensing applications may include power generation, industrial processes, and the oil and gas industry.

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