Topic: N151-072

Composites Automation

Resin Infusible Carbon Fiber Unidirectional Broadgoods for Fatigue Dominated Applications

The product being developed is a unidirectional carbon fiber broadgood fabric with high permeability that holds the tows together without nonstructural stitch fibers. Components manufactured using this broadgood fabric are expected to have improved fatigue performance because stitches have been shown to be damage initiation sites under fatigue loading, reducing runout strain. Composites Automation specializes in composite technology including development of new materials and processes, analytical modeling of fabrication procedures, and design and development of damage tolerant composite structures. Initial targeted applications are large high performance Navy components. High permeability unidirectional broadgoods are being increasingly used in both military and civilian high performance composite applications. The material is lower cost than incumbent unidirectional fabrics. Phase II has produced prototype quantities of 18 ounce unidirectional T700 broadgoods with improved performance compared to incumbent material. The ultimate goal is to license the technology to existing fabric producers or produce the fabrics ourselves.

Technology Category Alignment:

Air Platforms
Engineered Resilient Systems (ERS)
Ground and Sea Platforms
Manufacturing Technology for Affordability
Manufacturing Technology for Affordability

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SYSCOM: ONR
Contract: N68335-17-C-0059

Department of the Navy SBIR/STTR Transition Program

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ONR Approval #43-3252-17

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WHO

SYSCOM: ONR

Sponsoring Program: ONR Code 33

Transition Target: NAVSEA, NAVAIR

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Other transition opportunities: Large scale Naval structures that require the use of composites for performance or weight improvements. This material is also. applicable for both aircraft applications for both the Navy and Air force.



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Fabrication setup for producing unidirectional carbon fiber broadgoods

WHAT

Operational Need and Improvement: Large scale composite Navy components are typically fabricated using dry fiber broadgoods that are placed onto tooling and subsequently infused with resin. Unidirectional broadgoods typically use stitching to hold fibers together to form a dry fabric. Composites made using these fabrics have exhibited considerably lower fatigue runout strains than autoclave cured unidirectional prepreg held together by the B-staged epoxy resin. The observed fatigue degradation initiates as microcracks at the stitches. This SBIR focuses on developing dry carbon unidirectional fabric consisting of straight fibers with no features (stitches) that can create stress concentrations, while maintaining a 55% fiber volume fraction when infused. This would allow lower cost composite fabrication processes such as infusion to be considered for manufacturing fatigue dominated structures and components.

Specifications Required: This SBIR is developing dry carbon unidirectional fabric consisting of straight fibers with no features that can create stress concentrations, while maintaining a 55% fiber volume fraction when infused. The fatigue performance goal for a quasi-isotropic laminate (layup [0/45/90/-45]ns) using this material is runout at 10 million cycles, R=-1, at 3000 microstrain, with no microcracking. This material must also demonstrate that the dry fabric can maintain its shape when handled and draped dry and have an appropriate permeability for resin infused processes.

Technology Developed: The CA developed process currently produces 4 inch wide unidirectional fabric without the use of stitch fibers. The fabric can be produced with a range of areal weights from 4 oz up to 18 oz/yd2. The equipment is being scaled up to produce fabrics with 12 inch widths. The material developed in Phase I had a permeability appropriate for resin infusion. This material exhibited improved performance compared to the incumbent broadgood material. The CA material crack development was shown to be similar to standard prepreg damage initiation and propagation, demonstrating improved damage tolerance of the CA material compared to the baseline.

Warfighter Value: The material provides improved fatigue performance with reduced cost allowing production using conventional resin infusion methods to produce reduced weight composite structures.

WHEN

Contract Number: N68335-17-C-0059 **Ending on:** December 1, 2018

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Optimize particle and veil material for improved handling and mechanical performance	Med	Demonstrate ability of veil and particles to be incorporated in a continuous fabrication of unidirectional tape	6	November 2017
Scale up broadgood process	Low	Demonstrated continuous run of 100 ft of 12 inch wide tape with an areal weight of 18 oz/yd2 with appropriate handleability	6	February 2018
Fabricate and test composite properties using the produced NCF fabric	N/A	Fabricate quasi-isotropic panels with the developed material: perform tensile test to document crack initiation and propagation; conduct fatigue testing to show required fatigue performance	6	January 2019

HOW

Projected Business Model: It is fully anticipated that at the end of the Phase II Option, that a full scale prototype solution for large-scale manufacturing of unidirectional NCF fabric with comprehensive validation and test data will be obtained. After the Phase II Option Phases, Composites Automation anticipates a complimentary one year development program or joint venture with an established fabric producer. It is anticipated that with an investment of ~$2.5M, this product will be fully qualified with initial production and sales. The next year should have our partner in full production and sales ramp-up. We anticipate that the total investment from the SBIR funding and through joint ventures with an established fabric producer would be ~$5M and generate annual licensing profit in excess of $1M. In addition, CA will evaluate potential for producing composite structural components that fit within our scope and size of our operation. The advantages of expanding versus teaming will be assessed to determine the path that benefits our company.

Company Objectives: The technical success on the proposed program would result in the creation of a relevant patent portfolio to protect the IP and is anticipated to generate at least three different commercialization opportunities, including 1) to become a new material supplier for high-performance and low-cost unidirectional broadgood and/or 2) license the technology to existing material suppliers and 3) manufacture new composite structures requiring improved fatigue performance compared to incumbent material.

Potential Commercial Applications: Applications include both Navy/DoD structures made using the VARTM process (ongoing discussion with Seemann Composites, Inc.) as well as commercial applications such as large on- and off-shore wind blade structures (discussions with TPI Composites). The potential to reduce material costs through material avoidance as well as improve fatigue life due to our novel material form will be evaluated by these companies and may provide material performance enhancements that will open other opportunities in both the military and civilian sectors.

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