Department of the Navy SBIR/STTR Transition Program

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NAVAIR 2016-934

Topic # N13A-T008
Innovative Interlaminar Mode I and Mode II Fracture Toughness Test Methods for Ceramic Matrix Composites
Materials Research & Design

WHO

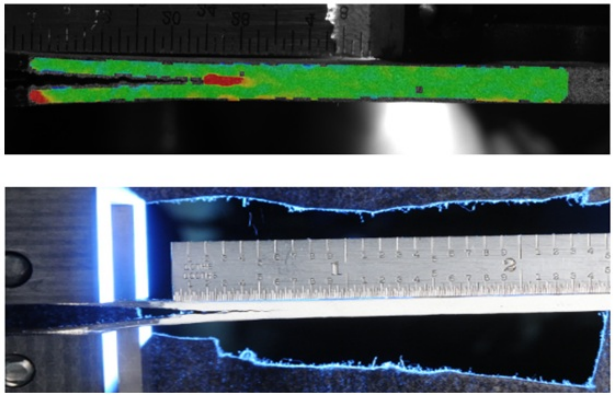
SYSCOM: NAVAIR

Sponsoring Program: Air Platform, Materials/Processes

Transition Target: The development would serve as an industry approved test standard MIL, ASTM, and related communities.

TPOC:
(301)342-8075

Other transition opportunities: Civilian aeroengine applications could significantly benefit from the development of CMCs propulsion components.



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Notes: -Top image shows strain visualization (Digital Image Correlation) snapshot taken during room temperature Mode I test.
-Bottom image shows propagated crack in a ceramic matrix composite double cantilever beam specimen during room temperature Mode I test.

WHAT

Operational Need and Improvement: As the specific power demands of advanced aeroengines increase, so too does the need for new materials that are capable of higher operating temperatures, such as ceramic matrix composites. However, thus far ceramic matrix composites (CMCs) have achieved only limited use in these applications due to concerns regarding material degradation, variability, maturation and environmental durability. Also, the typically inferior interlaminar properties of CMCs can sometimes serve as a driving factor in the design of some components, such as airfoils. In spite of their obvious importance, certain interlaminar properties, such as fracture toughness, are difficult to measure in testing. Therefore, there exists an immediate need for innovative test methods to obtain these properties.

Specifications Required: Standardized fracture toughness test methods would facilitate the measurement of reliable material databases which could be used to evaluate CMC materials which are designed to have a specific damage tolerance.

Technology Developed: MR&D is executing a combined analytical, fabrication, and experimental program to develop innovative approaches to develop standardized tests for the measurement of Mode I and Mode II fracture toughness. As a material property which quantifies resistance to crack propagation initiating from a defect, the need for a corresponding test standard is very high because it will enable confident quantitative evaluation of crack propagation and the criticality of defects for a given component. In laminated composites, such flaws have the potential to cause delaminations between plies, thus significantly degrading material strength and component performance.

Warfighter Value: The value proposition for developing Mode I and Mode II fracture toughness test standards lies in giving confidence in the quantitative evaluation of crack propagation and the criticality of defects for a given component. The alternative may result in the unnecessary replacement of expensive composite parts due to the presence of a flaw or defect which may or may not be critical.

WHEN

Contract Number: N68335-15-C-0081 **Ending on:** July 1, 2018

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Room Temperature Mode I Test Standard	Low	Test results correlate with expected behavior with 2-dimensional crack growth	4	July 2016
Elevated Temperature Mode I Test Standard	Low	Test results correlate with expected behavior with 2-dimensional crack growth	4	July 2017
Room & Elevated Temperature Mode II Test Standard	Low	Test results correlate with expected behavior with 2-dimensional crack growth	4	July 2018

HOW

Projected Business Model: Standardized Mode I and Mode II fracture toughness test methods can be used to evaluate CMC materials which are designed with a particular toughness requirement.

Company Objectives: MR&D is seeking CMCs manufacturers and aeroengine suppliers whereby this technology can be customized and further developed for other CMC materials.

Potential Commercial Applications: The primary beneficiary of these test standards will be the military and the public; as a result, it is our belief that support from CMC manufacturers and the fabricators of components using CMC materials may not be a strong basis for the continued financial support required to develop these standards. Rather, such resources, as necessary to implement the test standards, will most likely need to come from government organizations, although not necessarily entirely from the Navy. Since other government organizations, including the Air Force, NASA and the Department of Energy, all utilize and benefit from CMC materials, support from these organizations will be pursued to accomplish the end goals of this effort. Also, as mentioned above, after the current program has been completed, MR&D will use internal company funds for the activities involved with direct interactions with the ASTM C28 and ASTM D30 Committees in order to transition the work performed here to the adoption of the test standards.

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