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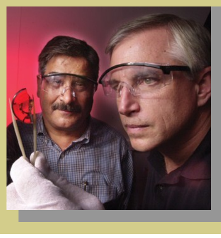
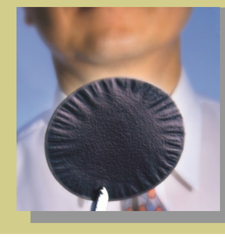
Technology Opportunity







# A Real-Time, Ubiquitous Structural Health Monitoring System for Fiber-Reinforced Composite Materials

The Florida State University invites companies to join us in commercializing a new method for monitoring the structural health of fiber-reinforced composites (FRCs). The continuous push to create faster and lighter vehicular structures has radically increased the use of fiber-reinforced composite (FRC) materials in the aerospace industry and others because these composites possess high specific strength and stiffness. Economic constraints have also contributed to the growing trend of airlines operating aircraft beyond their design lives, making their effective monitoring for structural damage an important safety feature. Increasingly, too, composite materials are used in the construction of buildings, dams, naval structures, and ground-based vehicles.

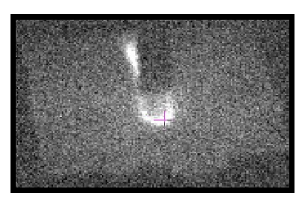
## The Problem

Multiscale, multifunctional advanced composite materials have the potential of creating a paradigm shift in how engineered structures are used. Their failure modes which enhance their ability to absorb impact energy are unlike those seen in metallic materials and have no single, similar self-propagating crack features. Metals show visible damage caused by impact mainly on the surface of structures, while damage is hidden inside composite structures especially when subjected to low velocity impact such as bird collisions or tool drops. This barely visible damage may cause serious decrease in material strength of the structure over its life-cycle.

Current inspection and monitoring techniques are based primarily on exterior examinations and/or externally mounted sensors placed at discrete locations. Since failures in composites are frequently microscopic, originate internally, and are slow to reveal themselves externally, current detection systems are limited in their effectiveness.

A cost issue also exists. In the case of airplanes, approximately 27% of their life-cycle cost is spent on inspection and repair. Thus, accurately and quickly identifying the location and severity of damage at the micro-structural levels is essential to detecting macroscopic fatigue and avoiding catastrophic failures. Future sensors for Structural Health Monitoring (SHM) of aerospace structures are envisioned to be an array of inexpensive, spatially distributed, integrated sensors supporting online/real-time acquisition of structural integrity information on the loading, environmental effects, structural characteristics and responses of these structures. The information obtained from the sensors can then be used to monitor the structural integrity of the components in real-time in order to avoid catastrophic failures.

## The Solution



With the recent advances in material research, solutions to damage monitoring will need to be based on an integrated platform. At FSU's High-Performance Materials Institute, a novel SHM system is in development, which will detect minute structural damage in FRC materials (e.g., fiberglass, carbon fiber). Essentially, this is a biomimetic solution pre-existing in nature that can act as a guide towards ubiquitous sensing by use of Triboluminescent materials. Triboluminescence is a physical phenomenon, where upon duress crystalloid materials emit copious amounts of visible light. By integrating these triboluminescent materials in fiber-reinforced composites alongside a transmission medium, failure information can be obtained.

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The novelty, resides in the fabrication of light gathering optoelectronic devices and detectors designed to transmit subsurface light emissions. These optoelectronic devices rely on classical usage of fiber optics and efficient collection through newly developed 3-dimensional photovoltaic devices, thus creating an intrinsic triboluminescent photoactive structural health monitoring (iTriP SHM) system. This new system will dramatically reduce the man-hours and machine time spent visually analyzing structures for damage because the light emissions produced by triboluminescence are automatically detected and received for health diagnosis.

## Applications

- Applications include civil, marine and aerospace for commercial and military involvement.
- The system conducts real-time, wide-area damage monitoring of entire component sections at a relatively low cost due to ubiquitous sensing.
- The system's life-cycle savings reduces the number of human hours required for monitoring by allowing structural engineers to more quickly and accurately pinpoint structural faults.
- Structures incorporating the system—bridges, airplanes, spaceships—benefit from the early detection of structural weaknesses, which can reduce the potential for catastrophic failures.

## Unique Advantages

- Tailorable structural health monitoring techniques for a variety of applications
- The system's lightweight design enables it to be incorporated into a wide variety of weight-conscious devices, such as airplanes and spacecraft.
- The system's low cost reduces the number of human hours required for monitoring by allowing structural engineers to more quickly and accurately pinpoint structural faults.
- Structures incorporating the system—bridges, airplanes, spaceships—benefit from the early detection of structural weaknesses, which can reduce the potential for catastrophic failures.
- The system conducts real-time, wide-area damage monitoring of entire component sections at a relatively low cost.

## Status

- U.S. Application No. 12/691,537: Systems, Methods, and Apparatus for Structural Health Monitoring
- Provisional Patent filed in October 2011: Triboluminescent Optical Fiber Sensor
- Proof of concept phase and manufacturing scale-up.
- Researcher has demonstrated triboluminescent response to external stimuli in laboratory scale reinforced and unreinforced composite laminates, and cementitious composite samples.

## Current Work Underway

- Construct a test-bed application for demonstration of iTriP SHM system.
- Match light detection points to damage location, characterize light intensity to damage using C-Scan, and field test the prototype.
- Derivation of detection and location learning algorithm.

## For Licensing Opportunities Contact

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