TOPIC #1	**Engineered Surfaces**
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DATE	**March 19, 2007**

RESEARCH OPPORTUNITY
Industry partners are interested in solutions such as processing techniques, material systems, or combinations that can modify the surface of ceramic, metallic and/or polymeric materials for a variety of aerospace application to resist erosion damage, reduce or eliminate ice adhesion, increase hardness or create a functionally gradient surfaces, reduce wear, optimize friction, resist oxidation and corrosion, or improve the microtoughness of the surface. **Solution approaches must be environmentally compliant and can not include nor introduce restricted and banned materials.**
CURRENT STATE-OF-THE-ART
Specific Solution Needs: **Improved erosion resistance for polymeric composites** **Reduced adherence of ice formation on polymeric composites or metallic structural components** **Reduced wear of carbon composites for friction applications and metallic or ceramic materials for rolling, sliding, bending, and other contact applications** **Improved oxidation resistance of carbon, polymeric and ceramic composites especially improved fiber/matrix interfaces** **Replace restricted and banned materials and coatings or processes**
RELEVANCE
The significance of this work is to improve the overall performance of the device or system of interest. Performance enhancements will help to reduce life cycle costs by eliminating overhaul cycles, reducing maintenance costs, or expanding operating conditions.
SPECIALIZED FACILITIES OR SKILLS
Depending on the system selected and subsequent application, specialized facilities exist at the industry and government partner locations including simulated service test rigs and analysis capabilities to characterization facilities availability to assess failure modes and direct future work needed to meet project objectives.

EXAMPLE METRICS AND ANTICIPATED PARTNER(S) ROLE
To support a business case, CCRP Team will need to pass a series of feasibility studies, simulation trials, sub-scale test results, characterization results, material formulations, prototyping, scale ability trial results, and projections on technology availability. A property improvement target of at least 25% is expected. **Sponsors will provide CCRP Team with consultation, candidate material substrates for modification trials, design guidance, material characterization, screening tests, etc.**

OTHER SUGGESTED PARTNERS	
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Individual	**Doug Moseley**
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TOPIC #2	**Nano Composites**
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RESEARCH OPPORTUNITY

Weight is a key driver for many aerospace applications, and a viable solution to many weight issues is the use of polymeric composites.

CURRENT STATE-OF-THE-ART

Although composites have demonstrated important weight savings and performance improvements, weak resin characteristics still exist that limit weight savings and performance benefits. Recent developments in the area of nano-enriched composites appear to significantly improve interlaminar shear strength, reduce microcracking and minimize crack propagation.

Highest interest at GE is in carbon reinforced composites with carbon nanofibers, functionalized carbon nanofibers, and nano clays as enrichments to polymeric composites. Research must be restricted to various types of high temperature polyimide resins. Forms of the carbon laminate material may include tape, woven fabric, braid and molding compound.

In addition to identifying physical property improvements, inspection of nano composite materials for fiber volume fraction, voids and nano content is also required using conventional inspection methods.

Ceramic Matrix Composite Interest at Parker

High temperature combustion technology in the gas turbine engine market has begun to demand exposure of materials within regimes metals cannot withstand for long periods. Many advanced superalloys are limited in life as temperatures exceed useful application in long term engine conditions.
In concepts today, extensions of current material designs are envisioned that ultimately bear resilient cyclic stability. Integration concepts including mechanical, diffusional or combination of both are needed to meet the rigorous environments. Through TBC's or CMC to metal joining, nano-composite enhancements may provide longer coating life or better metal to ceramic joining technologies

RELEVANCE

In some cases the addition of nano-enriched particles may offer multi-functional improvements. Advantages could provide improved impact resistance, improved

erosion resistance, reduced acoustic transmission, increased thermal conductivity, reduced thermal expansion and improved shear strength. Improvements may also exist in improved wear resistance, fire resistance, surface hardness and reduced crack propagation. Highest interest is in carbon-reinforced composites with carbon nanofibers, functionalized carbon nanofibers, aramid nanofibers and nano clays as enrichments to polymeric composites. Polymeric resins can cover epoxies, phenolics, bismaleimides and polyimides. Forms of the carbon laminate material may include tape, woven fabric, braid and molding compound. In addition to identifying physical property improvements, characterization of material properties is required for proper FEM analysis. Inspection of nano composite materials for fiber volume fraction, voids and nano content is also required using conventional inspection methods.
SPECIALIZED FACILITIES OR SKILLS
Pre and posttest quality inspection is required of all specimens. Characteristics such as fiber volume fraction, voids and nano particle content are required for all specimens. Conventional inspections methods can be used for the analysis.

EXAMPLE METRICS AND ANTICIPATED PARTNER(S) ROLE
▪ Ability to provide high quality nano-enriched resins **▪ Ability to fabricate composite components** **▪ Adequate material property testing capabilities** **▪ Adequate structural test facilities**

OTHER SUGGESTED PARTNERS	
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OTHER SUGGESTED PARTNERS	
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TOPIC #3	**Enhance properties of carbon-based materials**
NOMINATING ORGANIZATION	**GrafTech International**
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RESEARCH OPPORTUNITY
Carbon-Based Materials are available in many forms, such as carbon-carbon composite, foam, synthetic or natural graphite artifacts or powders, and find use in numerous applications. In many of these applications there are strong market needs for improved properties. The industrial partners are interested in processing techniques and/or materials to significantly enhance the following properties. **Resistance to oxidation** **Toughness** **Wear resistance (especially in friction applications)** **Friction coefficient control and modification** **Strength** **Density (especially rapid densification)** **Hydrophobicity** **Solution approaches must be environmentally compliant and can not include nor introduce restricted and banned materials.**
CURRENT STATE-OF-THE-ART
Techniques already exist to enhance all of these properties and it is probable that the industrial partners are aware of and already use those that are industrially practicable. The partners are looking for innovative methods, materials or combinations, perhaps using Ohio's collective capabilities in the areas of fiber reinforcement, nanomaterials, and polymers, to make significant improvements in these properties with industrial processes.
RELEVANCE
Many Ohio and national companies are involved in the manufacture or use of carbon/graphite, and there appears to be an upsurge in interest in and use of the material. Improving the materials further and making them more fit for use could have significant commercial and economic impact. **One example is that oxidation of graphite electrodes during the steel making process accounts for up to 10% of the consumption of graphite..** **The U.S. EAF (Electric Arc Furnace) steel industry currently produces ~32 million tons of steel, which is approximately 50% of U.S. steel production.** **Ohio currently provides over 20% of the U.S. EAF steel capacity (9.5**

million tons) and employs ~ 30,000 workers. Reducing or eliminating the oxidation loss would be of significant benefit to our economy **Other examples are carbon/graphite materials used in aerospace in brakes, as tooling for making carbon-carbon composites, and as structural components. In all of these applications improved strength-to-weight ratios, toughness and wear resistance are highly desirable.**
SPECIALIZED FACILITIES OR SKILLS
Depending on the materials and processing selected, and subsequent applications, specialized facilities exist at the industry and government partner locations including bench and pilot plant-scale prototype manufacturing capabilities, simulated service test rigs, and analysis capabilities to characterize the materials.
EXAMPLE METRICS AND ANTICIPATED PARTNER(S) ROLE
Metrics: **Early stage Business Case and Feasibility assessments to rate likelihood of technical and commercial success, Definition of Project with defined and prioritized needs. Project Plan with Critical Path identified.** **Sponsor Roles:** **Guide researchers and provide background on the applications of interest, provide guidance on component and system level requirements, coordinate testing or other company activities with the researchers.**

OTHER SUGGESTED PARTNERS	
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TOPIC #4	**Electromechanical Actuation and Control**
NOMINATING ORGANIZATION	**Aircraft Braking Systems**
TECHNICAL CONTACT	**Doug Moseley, Director R&T, ABSC**
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DATE	**March 19, 2007**

RESEARCH OPPORTUNITY

Industry partners are interested in novel approaches for dramatic reductions in the size, weight, and/or power demands for high output electromechanical actuators suitable for aerospace and automotive applications. Innovative approaches including piezoelectric actuators are encouraged.

Similarly, we seek advancements in high precision control of the force and/or position of these actuators with minimal reliance on independent and expensive feedback sensors.

CURRENT STATE-OF-THE-ART

Electromechanically actuated braking is now being introduced on aircraft and has been in development for automotive applications for years. While these systems offer substantial improvements in diagnostics, serviceability and control accuracy they are considerably larger, heavier, and more costly than their hydraulic counterparts. Most current electro-mechanical systems consist of a brushless electric motor, a gear set and a device to change rotational to linear movement such as a ball screw. The design space of each component is extremely limited to be packaged within the same wheel envelope as the present hydraulic systems. High peak power demands on the host vehicle's electrical system are also a major issue.

Along with these issues, the control problem for braking is very complex to accommodate smooth application, adjustment for wear, high cycle rates for anti-skid braking, fail-safe operation and the like. Current systems generally use position or force feedback sensors to augment the actuator control. However, these sensors are expensive and can be unreliable. Novel approaches are desired that have little to no reliance on independent feedback sensors. Alternatively, highly reliable and cost effective sensors are an option.

RELEVANCE

A break through to reduce size, weight, and/or power demands would greatly accelerate the adoption of the technology in the aerospace and automotive braking fields. The actuator technology may be equally applicable to a number of space critical actuators used throughout these vehicles.
Similarly, control algorithms or configurations that eliminate reliance on expensive and independent feedback sensors will lead to higher reliability and less costly systems.

SPECIALIZED FACILITIES OR SKILLS

The industrial partners can provide bench test facilities, environmental test facilities, and full scale dynamometer testing capability as applicable to the scope of the program.

EXAMPLE METRICS AND ANTICIPATED PARTNER(S) ROLE

Metrics:

- **Demonstrate the feasibility of reducing the weight and volume of the electromechanical actuator by a minimum of 25% and ideally 50% compared to existing technology.**
- **Demonstrate the feasibility of reducing the peak power requirements by a minimum of 25% and ideally 50%.**
- **Provide a control scheme that achieves high precision and high reliability control and eliminates dependence on expensive independent feedback sensors.**

Sponsor Roles:
Guide researchers and provide background on the applications of interest, establish benchmarks for comparison against the current state of the art, provide guidance on component and system level requirements to end users, coordinate testing or other company activities with the researchers.

OTHER SUGGESTED PARTNERS

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TOPIC #5	**High Temperature Sensors**
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RESEARCH OPPORTUNITY

There is a significant need for high temperature sensor devices for use in a variety of applications such as pressure, load, torque, speed, temperature, and position sensing within a gas turbine engine or other high temp, high noise actuation structures. In addition, other aerospace and industrial structural components and surfaces where thermal extremes are involved would also benefit from this enabling high temperature sensing technology effort.

CURRENT STATE-OF-THE-ART

Current sensor materials and systems are inadequate for the harsh environment in the hot zones of gas turbine engines. Advanced sensor materials are required which possess the necessary thermal (600-1200 F and higher) capabilities, chemical/physical/mechanical durability, electrical output, functional stability and reliability. Appropriate packaging systems as well as wireless telemetry systems/capabilities are needed for survival in these environments.

RELEVANCE

All manufacturers of gas turbine engines, especially for aerospace applications, have a desire to be able to sense a variety of operation variables in real time. These capabilities will in turn assist /permit the utilization of advanced mechanical and material systems in multiple engine applications, especially bearings, gears and shafting. Such sensor materials and designs would also be of interest for structural applications where thermal capabilities are an issue. In addition, high temperature sensing capabilities are desirable in many other applications beyond gas turbine engine, such as, diesel or gas engines, fuel systems, motor driven actuation systems, electrohydraulic actuation systems, as well as other industrial applications.

SPECIALIZED FACILITIES OR SKILLS

Expertise in engine components and systems, fuel systems, aircraft actuation systems, industrial hydraulic and automation systems, instrumentation, chemical and materials sciences, and energy systems.

EXAMPLE METRICS AND ANTICIPATED PARTNER(S) ROLE	
Metrics: **Business case to identify the market value. Plus project plan and timeline to achieve a proof of concept/feasiblity gate review. The review will include simulations, designs, as well as initial prototype and testing.** **Sponsor Roles:** **Guide researchers and provide background on the applications of interest, provide guidance on component and system level requirements, coordinate testing or other company activities with the researchers.**	
OTHER SUGGESTED PARTNERS	
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