NASA SBIR 2017 Phase I Solicitation

A1.07 Propulsion Efficiency-Propulsion Materials and Structures

Lead Center: GRC

Participating Center(s): AFRC, LaRC

Technology Area: TA15 Aeronautics

Materials and Structures research and development contributes to NASA's ability to achieve its long-term Aeronautics goals, including the development of advanced propulsion systems. Responding to this call will require a proposal describing the intent to conduct novel research in materials and structures that is linked to enhancing aircraft propulsion efficiency. Reductions in vehicle weight, fuel consumption and increased component durability/life will increase propulsion efficiency. The extreme temperature and environmental stability requirements of advanced aircraft propulsion systems demand the development of new, reliable, higher performance materials. Research in the areas of high-temperature metals/alloys and ceramics and polymers (and their composites) provides fundamental understanding of the underlying process-structure-property relationships of these materials. Study of the interactions of material systems with harsh environmental conditions and the modes of failure of these systems are of particular importance to developing more advanced materials for future aircraft propulsion systems, which will be operating at higher temperatures than today's turbine engines. Heat transport, diffusion, oxidation and corrosion, deformation, creep, fatigue and fracture are among the complex phenomena that can occur in the component materials in the extreme environment of turbine engine propulsion systems.

Many of the significant advances in aircraft propulsion have been enabled by improved materials and materials manufacturing processes. Additional advances in the performance and efficiency of jet propulsion systems will be strongly dependent on the development of lighter, more durable high-temperature materials. The specific topics of interest include:

- Advanced high temperature materials technologies including fundamental materials development/processing, testing and characterization, and modeling.
- Innovative approaches to enhance the durability, processability, performance, and reliability of advanced materials including advanced blade and disk alloys, ceramics and CMCs (ceramic matrix composites), polymers and PMCs (polymer matrix composites), nanostructured materials, hybrid materials, and coatings to improve environmental durability.

In particular, proposals are sought in:

- Disk materials and concepts such as innovative joining methodologies for bonding powder metallurgy disk material to directionally solidified/single crystal rim alloy.
- Corrosion/oxidation resistant coatings for turbine disk materials operating at temperatures in excess of 760°C (1400°F).
- High strength fibers for reinforcing ceramic matrix composites and environmental barrier coatings to enable

a CMC temperature capability of 1482°C (2700°F) or higher.

- Innovative methods for the evaluation of advanced materials and structural concepts under simulated operating conditions, including combinations of thermal loads and mechanical loads during environmental (application) exposure.
- Innovative processing methods that enhance high temperature material and coating properties and reliability, and/or lower cost.
- Development and evaluation of shape memory alloys for applications across the lower temperature range of the subsonic aircraft flight path, i.e., experiencing shape-changing phase transitions between 0 to -50°C.
- Using the unique properties of nanomaterials to tailor composite properties using nanocomposites, nano-engineered, thermally-conductive composites and micro-engineered porous structures with metals, polymer, and ceramic composites.
- Advanced structural concepts; new concepts for propulsion components incorporating new lightweight concepts as well as smart structural concepts to reduce mass and improve durability.
- 3-D additive manufacturing of complex structures/subelements demonstrating mechanical properties and environmental durability for propulsion system applications.
- Multifunctional materials and structural concepts for gas turbine engine structures, such as novel approaches to power harvesting, thermal management, self-sensing, and materials for actuation.
- Fabrication of unique structures (such as lattice block) using shape memory alloys for lightweight multifunctional/adaptive structures for engine component applications.
- Innovative approaches for use of shape memory alloys for actuation of components in gas turbine engines.
- Computational materials and multiscale modeling tools--including methods to predict properties, and/or durability of propulsion materials based upon chemistry and processing for conventional as well as functionally-graded, nanostructured, multifunctional and adaptive materials.
- Robust and efficient modeling/design methods and tools for advanced materials and structural concepts (in particular multifunctional and/or adaptive components) including variable fidelity methods, uncertainty-based design and optimization methods, multi-scale computational modeling, and multi-physics modeling tools.
- Development of physics-based models of the various failure mechanisms of the EBC (environmental barrier coatings), particularly those associated with environmental degradation (e.g., oxidation, diffusion, cracking, crack + oxygen interaction, creep, etc.).
- Multiscale design tools for aircraft engine structures that integrate novel materials, mechanism design, and structural subcomponent design into systems level designs.
- Use of multiscale modeling tools to design multifunctional and adaptive structures.
- Robust and efficient methods/tools to design advanced high temperature materials based on first principles and microstructural models that can be used in a multi-scale framework.
- Development of models to predict degradation of CMCs due to combined effect of environment and mechanical loading at high temperatures.