NASA STTR 2014 Phase I Solicitation

T10 Nanotechnology

Nanotechnology, addresses four subareas: engineered materials and structures, energy generation and storage, propulsion, and sensors, electronics, and devices. Nanotechnology describes the manipulation of matter and forces at the atomic and molecular levels and includes materials or devices that possess at least one dimension within a size range of 1-100nm. At this scale, quantum mechanical forces become important in that the properties of nano-sized materials or devices can be substantially different than the properties of the same material at the macro scale. Nanotechnology can provide great enhancement in properties, and materials engineered at the nano-scale will shift the paradigm in space exploration, sensors, propulsion, and overall systems design.

Subtopics

T10.01 Lightweight Structural Nanomaterial Concepts

Lead Center: LaRC

Carbon fiber reinforced polymeric (CFRP) composites are considered state of the art (SOA) for lightweight aerospace structural materials. However, a systems study suggests that having specific mechanical properties that exceed CFRPs by 2-4x will yield significant savings in launch vehicles. Currently, SOA nanomaterials with potential to supplant CFRPs as the lightweight structural material of choice are available in formats possessing mechanical properties far below those measured at the nanoscale. These excellent nanoscale properties have to be demonstrated at scales that permit the evaluation of these materials in structural components with properties that offer mass advantage over CFRPs. Proposals are sought in the following areas:

- Innovative approaches to chemically and/or physically enhance load carrying capability of nanomaterials and influence their macroscale mechanical properties as demonstrated by structural properties on the coupon scale that are at least double the specific strength and stiffness of epoxy CFRPs.
- Manufacturing methods that permit the control of nanostructures at the molecular level to induce structural perfection of such structures as to produce articles at the coupon scale which possess mechanical properties that are at least double those measured for epoxy CFRPs.

T10.02 Smart Structural Composites for Space

Lead Center: JSC

Participating Center(s): GRC, LaRC

Advanced structural composites with the potential for enhanced damage detection are highly desired for spacecraft. Smart aspects, for example structural health monitoring or self-healing, should be introduced through utilization of advanced materials and nano-additives. Such composites could allow for the realization of the mass reduction that composite materials have promised for spacecraft but have not yet achieved.

NASA is currently evaluating composite materials for structures due to their relatively high strength, light weight, and potential low cost. There are a multitude of potential applications to primary and secondary structures, including vehicle, habitat module, and pressure vessel structures. Lighter materials with high specific strength can have drastic reduction in uptake mass, resulting in more cost effective space exploration. Smart materials such as piezoelectric, shape memory, and self-healing materials, will take structural composites to the next level.

One integral and limiting design concern for structural composites is that of damage tolerance. Upon impact, nearly imperceptible cracks may form upon impact, which, while tiny, may have drastic effects on structural integrity. To compensate, structural composites are designed to be thicker and heavier than would otherwise be required, thus negating the weight savings that these materials promise. One way to surmount this challenge and to realize the anticipated weight savings is to design smart materials. For instance, advanced materials and technologies should be developed to detect damage incidents, from tool drops during manufacturing to micrometeoroid and orbital debris impacts on orbit. Monitoring of extent of damage and the initiation of self-healing could reduce the complexity of composite maintenance and increase materials performance lifetime and reliability. Thermal/electrical/mechanical properties may be introduced or enhanced for multi-functionality such as thermal management or electrostatic discharge prevention and resultant weight savings. Overall, smart structures focused on space applications will have a significant impact on NASA's Space Exploration program.

While the subtopic description is broad, the offerer will narrowly define the composite system and intended applications. This subtopic is not intended for materials coupon-level work only; proposed systems should have a targeted demonstrator structure identified as a deliverable. Solutions may employ nanotechnology but are not required to do so. The smart structural composite should be proposed as an alternate material in this identified structure, with additional or enhanced functionality. In Phase I, composite samples will be fabricated and tested to demonstrate basic functionality. The targeted demonstrator structure will be identified, and critical test environments and associated performance predictions will be defined relative to the final operating environment. Deliverables include composite samples and the associated test data, predictions, and definitions. During Phase II, while full-scale parts are not required, scaled-up composite samples will be built in application-appropriate geometries. Samples will be tested in a simulated operational environment for demonstrate of performance in critical areas. Further scale-up requirements will be defined, and performance predictions will made for subsequent development phases. Deliverables will include composite samples and the associated test data, definitions, and predictions.