NASA SBIR 2017 Phase I Solicitation

Z3.02 Advanced Metallic Materials and Processes Innovation

Lead Center: MSFC

Participating Center(s): JPL, LaRC

Technology Area: TA12 Materials, Structures, Mechanical Systems and Manufacturing

This subtopic addresses specific NASA needs in the broad area of metals and metals processes with the focus for this solicitation on solid state welding, additive manufacturing, and processing of specialty materials including bulk metallic glasses and boron nitride nanotube (BNNT) reinforced metal matrix composites (MMCs). Topic areas for solid state welding revolve around joining high melting point metallic materials including combinations of these higher melting point metals—preferably using solid state welding processes such as friction stir, thermal stir, and ultrasonic stir welding. Higher melting point materials include the nickel based superalloys such as Inconel 718, Inconel 625, titanium alloys such as Ti-6Al-4V, GRCop, and Mondaloy. The technology needs for solid state welding should be focused on process improvement, structural efficiency, quality, and reliability for higher temperature propulsion and propulsion-related components and hardware.

The primary objectives of this technology area include:

- Advances in process control, temperature monitoring and control, closed loop feedback, and implementing changes to the process parameters such as temperature, power, welding speed, etc.
- Monitoring and controlling processing parameters in real time in order to make quality, defect-free weld joints with desired and optimal grain morphology, mechanical properties and minimal distortion.
- Innovations in in-situ diagnostic and non-destructive testing technologies for solid state welding
- Decoupling of the stirring, heating, and forging process elements characteristic of thermal or ultrasonic stir welding to achieve greater process control.

Several NASA programs are embracing metallic Additive Manufacturing (AM) technologies for their potential to increase the affordability of aerospace components by offering significant schedule and cost savings over traditional manufacturing methods. This technology is rapidly evolving and a deeper understanding of the process is needed to support certification and the use of AM hardware. The metallic AM topic area needs are concentrated on advancing the state of the art for powder bed fusion and/or directed energy wire deposition processes.

The primary objectives are focused on process improvements and include:

- Surface finish improvements for internal and external AM components targeting a goal of 32 RMS; approaches may include in-situ process modifications to achieve better surface finishes directly from the AM machine, or secondary finishing approaches. The impact on total cycle time and cost from CAD to final part should be assessed as part of the justification for the approach proposed.

- Linking process parameters to mechanical properties, microstructure, grain texture and grain size through empirical observations, real time process monitoring, or modeling.
- In-situ assessment or process monitoring of grain size, defect detection, build anomalies, and defect repair.
- Improved thermal monitoring and control hardware and methods to minimize build-to-build variations and microstructural anomalies.
- Development of hardware and/or process modifications to eliminate distortion and thermal residual stresses in as-built AM parts.
- Development of hardware and software tools that enable integrated CAD-to-part digital data capture, comparison, and archival for maintaining a “digital twin” correlation between parts and CAD design, slicing and tool path programming, in-process build information, secondary processing, and inspection data to document a traceable pedigree on parts for certification.

The goal of work supporting this area is to help build the knowledge needed to support certification of AM hardware. In the specialty materials processing area, the focus for this solicitation is on bulk metallic glasses (BMG) and BNNT reinforced MMCs. Specific areas of interest relate to optimized processing to fabricate these materials while retaining their unique microstructures and properties.

Of specific interest for BNNT MMCs are innovative processing methods that:

- Achieve uniform distribution and alignment of BNNTs within the metal matrix.
- Minimize the formation of brittle phases at the “reinforcing agent / metal” interface.

Product forms of interest include continuously- or discontinuously- reinforced nano-composites, and hybrid laminate materials. Improved processing may involve modifying incumbent methods such as powder metallurgy, melting/solidification, thermal spray, and electrochemical deposition or introduction of new method. The success of proposed processing improvements will be measured by increases in tensile strength achieved over existing alloys. Consequently, proposals must include characterization and testing of the fabricated materials.

Of specific interest for BMGs are innovative processing methods for rapid prototyping of net shape bulk metallic glass components. Product forms of interest are uniformly thin walled structures and structures of high dimensional accuracy and precision (from nm to cm scales). Consideration must be given to the availability of BMG feedstocks or accommodating the raw materials for in-situ alloy fabrication. Any approach should demonstrate control of contaminant elements (e.g., oxygen and carbon) or show an immunity to their presence.