NASA SBIR 2014 Phase I Solicitation

H5.01 Additive Manufacturing of Lightweight Metallic Structures

Lead Center: LaRC

Participating Center(s): GRC, JSC, MSFC

The objective of this subtopic is to advance technology readiness levels of lightweight metals and manufacturing techniques for launch vehicles and in-space applications resulting in structures having affordable, reliable, predictable performance with reduced costs. Technologies developed under this subtopic are of interest to NASA programs such as Space Launch System (SLS), Multi-Purpose Crew Vehicle (MPCV), Orion, and commercial launch providers.

Metallic additive manufacturing (AM) technology builds near-net shape components one layer at a time using metal powder bed or wire fed processes and data from 3-D CAD models. Metallic AM technologies like Selective Laser Melting (SLM), Direct Metal Laser Sintering (DMLS), Electron Beam Freeform Fabrication (EBF3), and Laser Engineered Net Shaping (LENS) are of interest to NASA for fabrication of advanced metallic aerospace components and in-space fabrication and repair. These technologies enable the direct fabrication of net or near-net shape components without the need for tooling and with minimal or no machining thereby reducing component lead time, manufacturing cost, and material waste. Metallic AM also has the potential to enable novel product designs that could not be fabricated using conventional subtractive machining processes and extends the life of in-service parts through innovative repair methodologies. Currently, some metallic AM systems use sensors for process control but not for in-situ quality assurance (QA) or flaw detection.

The purpose of this subtopic is to invest in mid- and long-term research to establish rigorous, systematic, and scalable verification and validation methods for metallic AM. Beam tracking errors, part distortion, feedstock nozzle stand-off distance variability, excessive heat build-up in the deposit, stuck or unmelted feedstock, etc. can contribute to build deposit geometric anomalies and discontinuities. The objective would be to achieve a capability to have in-situ assessment during the deposition process to provide immediate feedback to the operator or a closed loop control system to enable real-time process correction or remedial actions to correct for defects. Although the technologies developed may be specific to one metallic AM system, it is desired that they have cross cutting capabilities to other metallic AM technologies. Proposals are invited that:

- Explore new and improved sensors and sensor systems for monitoring of the metallic AM build deposit.
- Offer technologies to use the signals generated by the energy beam (either electron beam or laser) or beam / substrate emissions for in-situ process monitoring and quality assurance.
- Propose additional devices to support real-time geometric part inspection and identification of flaws (voids, cracks, lack of fusion defects or other discontinuities).

Technologies should enable determination of the boundaries of the molten pool within 0.001” (in order to define the size and shape), measurement of temperature over the range from 700 °F to 3000 °F (representative of the molten pool and surrounding regions) to within 25 °F, measurement of geometric features to within +0.005”, detect flaws in the range of 0.010 - 0.001”, and determine chemical composition within 1 weight percent. Technologies should be compatible with standard high speed computer communication protocols and sensors should be able to update at frequencies on the order of 10 Hz. Highly desirable attributes are that technologies enable non-contact sensing and measurement, are vacuum compatible, and are relatively insensitive to contamination. Desirable attributes include that technologies are non-hazardous, do not require the use of additional consumables, and do not introduce contaminants into the process.

Research should be conducted to demonstrate technical feasibility in Phase I and show a path toward demonstration in Phase II of in-situ process monitoring and quality assurance. Phase II proposals should include delivery of a prototype system for test and evaluation in environments representative of NASA's metallic AM systems. Expected Technology Readiness Levels (TRL) at the completion of Phase I projects are 2-3 and 4-5 at the end of Phase II projects.

Links to information about NASA's additive manufacturing development projects can be found at:

- Selective Laser Melting (SLM) and Direct Metal Laser Sintering (DMLS).
    - (http://www.nasa.gov/exploration/systems/sls/3dprinting.html).
- Electron Beam Freeform Fabrication (EBF3)
    - (http://www.sciencedaily.com/releases/2009/11/091110071535.htm).
    - (http://www.nmc.ctc.com/useruploads/file/events/PA_Karen_Taminger.pdf).
- Laser Engineered Net Shaping (LENS).
    - (http://www.sandia.gov/mst/pdf/LENS.pdf).