NASA SBIR 2014 Phase I Solicitation

Z2 Cross Cutting Advanced Manufacturing Processes for Large Scale Bulk Metallic Glass Systems for Aerospace Applications

Amorphous metals (also known as bulk metallic glasses) are a unique class of non-crystalline metals that possess the ability to be cast into high-tolerance hardware using similar processing techniques as plastics and yet retain mechanical properties similar (and in most cases superior to) titanium alloys Amorphous metals are a relatively new class of metal alloys that have mechanical properties and processing characteristics which set them apart from similar crystalline alloys (e.g., titanium, aluminum, or steel). Glassy metals are first designed by finding deep eutectic melting points in multi-element alloys such that when cooled at a high rate (usually >1000 K/s) crystal nucleation and growth does not occur and the amorphous liquid structure is frozen into the solid. Further work on amorphous metals has led to the development of composites consisting of an amorphous matrix phase reinforced with soft, crystalline dendrites which improve the composite's toughness and ductility. The properties of the amorphous metal can thus be tuned by the second phase. Strength, hardness, ductility, fatigue life, toughness, density, thermal expansion, thermal diffusivity, among others, can all be adjusted in these amorphous metal composites. Special emphasis is placed on new processes for fabricating large sheets (width >150 mm, uniform thickness nominally between 0.1 and 1 mm, length > 2 x width to continuous) of bulk metallic glass alloys and advanced low-density thin ply, hybrid carbon fiber/BMG unidirectional impregnated tapes at widths greater than 75 mm.

Subtopics

Z2.01 Cross Cutting Advanced Manufacturing Process for Large Scale Bulk Metallic Glass Systems for Aerospace Applications

Lead Center: JPL

Participating Center(s): LaRC, MSFC

Amorphous metals (also known as bulk metallic glasses) are a unique class of non-crystalline metals that possess the ability to be cast into high-tolerance hardware using similar processing techniques as plastics and yet retain mechanical properties similar (and in most cases superior to) titanium alloys Amorphous metals have mechanical properties and processing characteristics which set them apart from similar crystalline alloys (e.g., titanium, aluminum, or steel). They are metastable, resulting in manufacturing challenges as well as post processing and machining challenges, especially when scaling these materials. If BMGs can be scaled up to usable sheets (sizes greater than 150 mm wide), these materials see a greater infusion threshold in aerospace and defense applications. Specific applications for BMG sheets include MMOD shielding and multifunctional structures; casings and structural components on launch vehicles and habitats.

BMG alloys (to include but not limited to Al-based, Zr-, Mg-, Fe-, etc.) are desired in sheet form at a width >150 mm, a uniform thickness nominally between 0.1 and 1 mm, a length > 2 x width to continuous. In addition to BMG alloy sheets, the development of BMG composite sheets consisting of an amorphous matrix phase reinforced with soft, crystalline dendrites which improve the composite’s toughness and ductility are also desired. BMG composite sheets at a width >150 mm, a uniform thickness nominally between 0.1 and 1 mm, a length > 2 x width to continuous. The properties of the amorphous metal can thus be tuned by the second phase. Strength, hardness, ductility, fatigue life, toughness, density, thermal expansion, thermal diffusivity, among others, can all be adjusted in these amorphous metal composites.

Special emphasis is placed on new processes for fabricating large BMG alloy and BMG composite sheets (width >150 mm, uniform thickness nominally between 0.1 and 1 mm, length > 2 x width to continuous) of bulk metallic glass alloys and advanced low-density thin ply, hybrid carbon fiber/BMG unidirectional impregnated tapes at widths greater than 75 mm.

A phase I effort should demonstrate one or more manufacturing/processing approach(s) that yield a sheet with the following dimensions: width >150 mm and uniform thickness nominally between 0.1 and 1 mm, length > 2 x width to continuous) of bulk metallic glass alloys and/or advanced low-density thin ply, hybrid carbon fiber/BMG unidirectional impregnated tapes approaching widths greater than 75 mm as proof of concept. Material should be delivered to the sponsor for evaluation. Plans for meeting dimensional goals, measuring manufacturing characteristics including but not limited to thickness, width, fraction or percent crystallinity, porosity or other defects, and evaluating manufacturing capability including but not limited to capacity/lead time, yield, cost reduction and process improvement opportunities to be reported at the conclusion of phase I.

A Phase II effort should demonstrate the manufacturing capability from Phase I that produces a BMG alloy and/or BMG composite sheet with a width >150 mm, uniform thickness nominally between 0.1 and 1 mm, length > 2 x width to continuous). The sheet should then be post processed and formed into a complex structural component from either/or of the large sheets of bulk metallic glass alloys and/or advanced low-density thin ply, hybrid carbon fiber/BMG unidirectional impregnated tapes at widths greater than 75 mm. Manufacturing variability of critical characteristics, including but not limited to thickness, width, fraction or percent crystallinity, porosity or other defects, should be measured. Manufacturing capability including but not limited to capacity/lead time, yield, cost reduction and process improvement opportunities (future work) should be reported. Material should be delivered to the sponsor for evaluation.