# Materials Genome Initiative

## Project Manager(s)/Lead(s)

John Vickers/EM01
(256) 544–3581

## Sponsoring Program(s)

Space Technology Mission Directorate
Game Changing Development

## Project Description

The Materials Genome Initiative (MGI) project element is a cross-Center effort that is focused on the integration of computational tools to simulate manufacturing processes and materials behavior. These computational simulations will be utilized to gain understanding of processes and materials behavior to accelerate process development and certification to more efficiently integrate new materials in existing NASA projects and to lead to the design of new materials for improved performance. This NASA effort looks to collaborate with efforts at other government agencies and universities working under the national MGI.

MGI plans to develop integrated computational/experimental/processing methodologies for accelerating discovery and insertion of materials to satisfy NASA's unique mission demands.

The challenges include validated design tools that incorporate materials properties, processes, and design requirements; and materials process control to rapidly mature emerging manufacturing methods and develop certified manufacturing processes.

The approach includes physics-based modeling to guide material design (e.g., composition, grain size, and texture); fiber layup; multiscale modeling to predict the influence of materials design on mechanical properties and durability; process modeling to determine optimal processing parameters to reliably produce as-designed material nano-/micro-structures and enable advanced manufacturing methods; and material data management to support robust material design methodology.

Capabilities provided by this technology include: (1) Develop reliable process control and certification methods for the manufacture of engine components for the Space Launch System (SLS) by selective laser manufacturing (SLM), (2) Computational tools to enable process control with a reduced reliance on trial-and-error approaches will accelerate the development cycle, (3) Simulation of the behavior of components manufactured through the SLM process will be used to inform the certification process to reduce the testing burden and the associated time and cost for future additively manufactured components, and (4) Evaluate optimal material configurations for advanced woven thermal protection systems (TPS) concepts. These highly tailorable material architectures allow for TPS to be designed for specific mission requirements. However, with this ability to tailor the material architecture creates a large design space that is impractical to explore through fabrication, as these systems are costly to build and test. Consequently, computationally assisted design is being implemented to assist the design process. Additionally, these design tools will be evaluated for use in predicting the response of these materials to operational regimes that cannot be examined in the laboratory.

### Anticipated Benefits

Synergistic efforts in multiscale modeling, information management, experimental characterization, and materials processing will accelerate design, development, and sustainment of ultra-durable material systems.

The quantitative impact includes the reduced time between discovery and technology insertion by at least half relative to current practice; shorter maturation and insertion period can translate to lower costs, greater affordability, and lower risk of failure; and integration of materials certification within a comprehensive computational approach will reduce time and cost to certify new flight hardware.

### Potential Applications

Computational materials tools will be developed in close collaboration with existing projects. These tools will be applied to improve manufacturing processes and

materials performance while also reducing the cost and time to insert new materials and processes into NASA applications. For the SLS project, computational tools will focus on reducing manufacturing variability, and part certification to reduce cost and time to infuse new parts. For the conformal TPS project, trade studies for component architecture will be developed to virtually examine multiple configurations, as manufacturing multiple configurations is not financially viable to downselect potential systems.
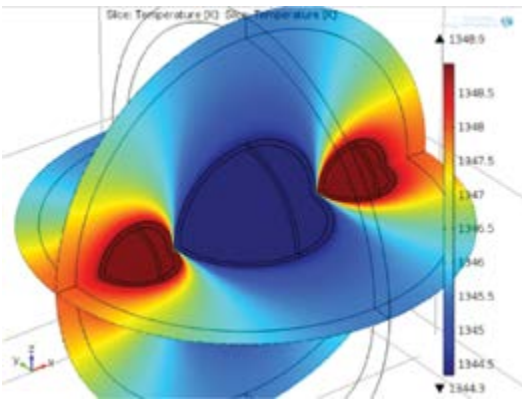


**Physics-based model of powder bed heating for selective laser melting.**
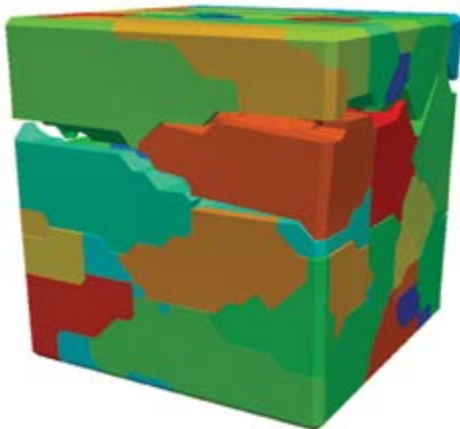


**Multiscale simulation utilizing aggregate dislocation behavior for crack growth in a material formed by additive manufacturing.**
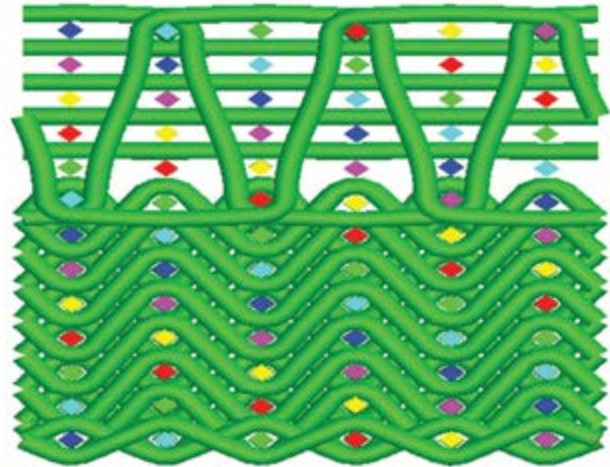


**Hybrid weave concept of a 3D conformal TPS to be analyzed for thermomechanical behavior.**

## Notable Accomplishments

A near-infrared camera system has been developed and calibrated to monitor the melt pool for metallic additive manufacturing systems. Thermal maps of the melt pool and semi-solidus areas have been analyzed to develop algorithms to track and quantify the melt pool area. These algorithms have been used to create closed loop control for an additive manufacturing system to improve manufacturing quality and to demonstrate improved process reliability.

Micromechanical simulations of 2D TPS weaves have been developed to assist in initial downselect of novel woven TPS designs.