10-22-2018

UM Scientists Further NASA's Mission to Mars

Edwin B. Smith

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ME professor Shan Jiang leads faculty-student research team in advancing space exploration

OCTOBER 22, 2018 BY EDWIN B. SMITH

Shan Jiang (third from right) discusses his interdisciplinary NASA research project with (from left) Ronald Smith, Abigail Hughes, Makena Tisor, Jungmin Jeon and Katelyn Franklin. Photo by Kevin Bain/Ole Miss Digital Imaging Services

As NASA continues preparations for missions to Mars and beyond, a team of **University of Mississippi** scientists is conducting research that may advance deep-space exploration for decades to come.

Shan Jiang, UM assistant professor of **mechanical engineering**, is the principal investigator for "An Integrated Computational Framework for Atomic-level Investigation of the Sintering Mechanisms during In-Space Additive Manufacturing of Metals and Alloys," a project funded by the Mississippi NASA EPSCoR Research Infrastructure Development, or RID, Program (No. NNX15AK39A) and directed by Nathan Murray, UM research assistant professor of chemical engineering.

The project is composed of synergistic, integrated, high-performance computing activities, including modeling, simulation, prediction and optimization of pure metal and alloy nanoparticle sintering, which is a process to make a powdered material coalesce into a solid or porous mass by heating it (and usually also compressing it) without liquefaction.

"One of the key areas of NASA mission-supportive research is 'in-space additive manufacturing' (known as AM) during Earth-independent missions on Mars," Jiang said. "In the next two decades, NASA will push three fronts in realizing the 'Journey to Mars' mission: Earth-reliant exploration aboard the International Space Station (ISS) and in low Earth orbit; proving-ground exploration with planned missions near the moon and on a redirected asteroid; and Earth-independent exploration with missions planned for low Mars orbit to explore the entry, descent, landing and in situ resource utilization on Mars."

Currently, a major area of focus on the ISS is to develop integrated AM facilities to rapidly manufacture items such as consumables and equipment replacement parts using materials such as metals, plastics, composites and ceramics.

"AM plays a key role in the NASA In-Space Manufacturing Vision for Extraterrestrial Environments, especially for 3D printing in zero gravity and for in-space additive repair," Jiang said. "Powder metal sintering and the relevant atomic-level mechanisms associated with this process govern the AM of various types of metals and alloys."

However, many fundamental aspects concerning the sintering phenomena (as well as associated melting and solidification behaviors) of various metal powders, especially at the atomic level, nanoscale and microscale, still remain largely unknown.

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Students Learn 'Real Politics' in Washington, D.C., Winter Session

OXFORD, Miss. – Eleven University of Mississippi students spent their winter break learning about the people who work behind the scenes of the American government in Washington, D.C. Lead by Jonathan Klingler, assistant professor of political science, the students of Pol 391: Applied Politics met not with candidates, but with the people who make candidates'

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OXFORD, Miss. – Stephanie Jennings Teague, of Chicago, sees her commitment of $100,000 to the Patterson School of Accountancy's new building at the University of Mississippi as a means of saying "thank you." "It is a way to show a small token of my appreciation to Ole Miss, the faculty and staff, and the accounting

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Reuters: Keep an Eye on the Money Supply

U.S. inflation roller coaster prompts fresh look at long-ignored money supply By Michael S. Derby NEW YORK – The amount of money sloshing around the U.S. economy shrank last year for the first time on record, a development that some economists believe bolsters the case for U.S. inflation pressures continuing to abate. The Federal Reserve's

“In this project, we are aiming to develop an integrated modeling-computation-optimization framework for gaining fundamental insights into the atomic-level sintering behavior of various types of metals and alloys, with the ultimate purpose of predicting and optimizing the final additively manufactured parts and in part supporting the NASA In-Space Manufacturing and Repair Platform,” he said.

Using the research expertise of fellow junior faculty members within the School of Engineering, as well as the research groups at NASA’s Marshall Space Flight Center, the program aims to build the necessary research infrastructure for NASA-related modeling and computational research in a top-notch national field, i.e., additive manufacturing for metal printing and additive repair.

“The research will provide theoretical and technical support to both ground & ISS demos of the additive manufacturing of metals and alloys,” Jiang said. “In addition, fundamental computational studies to understand the sintering mechanisms of metal/alloy powders under extreme extraterrestrial environments will fill one of the knowledge gaps in the current state of the art of the in-space AM, as contained in the NASA In-space Manufacturing Exploration Technology Development Roadmap.”

Other UM faculty members collaborating with Jiang are Hunain Alkhateb, associate professor of civil engineering; and Alex Lopez and Sasan Nouranian, both assistant professors of chemical engineering. The four have been working successfully together for more than two years.

“As we realized the importance and stipulation for the outreach and the research-activities integration, we have established an Additive Manufacturing for Research and Education Cluster, or AMREC, with one of the major goals being to foster research and educational collaboration between four faculty members within the said departments,” Jiang said. “So far, we as an interdisciplinary team have obtained three seed grants (one from NASA Mississippi Space Grant and two from Mississippi NASA EPSCoR) related to additive manufacturing.”

A membrane scientist by training, Lopez’s work is focused on the treatment of wastewaters through electrodialysis and electrodeionization using material modification of ion exchange membranes.

“The majority of my work is centered around ionic liquid-based composites materials,” he said. “The AMREC, an interdepartmental collaboration aimed at the pursuit of novel materials with application in additive manufacturing, seeks to develop new insights into the possibilities of additive manufacturing and grow the field in a transdisciplinary way.”

The team also has involved some of its students in the research. Students include Jungmin Jeon of Korea, a master’s degree candidate in mechanical engineering; Katelyn Franklin of Ocean Springs, Abigail Hughes of Elgin, Illinois, and Makena Tisor of Madison, junior mechanical engineering majors; and Ronald Smith, a junior civil engineering major from Meridian.

“Jungmin is performing the modeling of nanopowders and nanoparticles, as well as the molecular dynamics (or MD) simulations of (the) laser sintering process,” Jiang said. “She is also assisting me in training other undergraduates to learn how to use MD package and submit parallel computational jobs on supercomputers at the Mississippi Center for Supercomputing Research.”

Franklin runs bimetallic nanoparticles simulations to mimic the heating and cooling process of nanoparticles considering different heating rates, as well as performing data analysis for the simulation data. Smith is running simulations on Ti/Al core-shell particles to understand the melting behavior during the formation process of nanorods, as well as performing data analysis for the simulation data. He also helps Jeon do data analysis of single-crystal titanium nanoparticle simulations.

Hughes is learning how to use an open-source code (LAMMPS) to realize parallel MD simulations and is expected to complete some large-scale parallel MD simulations of alloy particles soon. New to learning numerical techniques in molecular dynamics, Tisor is also performing a comparative study on how the mixture of simulated Martian (as well as lunar) regolith and resin will 3D print compared to the standard photopolymer resin under Lopez’s supervision.

For more about the Department of Mechanical Engineering at the University of Mississippi, visit **https://engineering.olemiss.edu/mechanical/**. For more about NASA’s “Journey to Mars” program, go to **https://www.nasa.gov/content/nasas-journey-to-mars**. The NASA Mississippi Space Grant program, **http://msspacegrant.org/**, and Mississippi NASA EPSCoR program, **http://msnasaepscor.org/**, are funded by training grants from the NASA Office of STEM Engagement.

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