NASA EPSCoR Rapid Response Research – Cycle 1
Abstracts

LA - 18-EPSCoR R3-0001

Characterization of C-18150 Additively Manufactured material

PI: Prof. T. Gregory Guzik

Louisiana Board Of Regents

This team (Dr. T. Gregory Guzik of LaSPACE, Dr. Shengmin Guo of LSU, and Dr. Michael M Khonsari of LSU) will target NASA Commercial Space Capabilities Office research call CSCO-2017-01 entitled Characterization of C-18150 Additively Manufactured Material The objective of the proposed research is to evaluate the quality of copper-alloy (C-18150) parts made by a powder bed fusion additive manufacturing processselective laser melting (SLM). This Louisiana team has expertise and facilities to carry out all required tasks listed under the RFP for project CSCO-2017-01. In specific, the proposing team will characterize the SLM copper-alloy, C-18150, in the as-built condition and also optimize the heat treatment process to maximize material properties. In addition, this team will conduct thermal physical property measurements for C-18150 samples.

KY - 18-EPSCoR R3-0009

SMD Task B: Aerial Platforms For The Exploration Of Earth Volcanoes: Measuring Atmospheric Chemical And Physical Properties

PI: Dr. Suzanne Smith

University Of Kentucky, Lexington

The NASA Established Program to Stimulate Competitive Research (EPSCoR) Rapid Response Research (R3) program, in collaboration with the Science Mission Directorate (SMD) and Commercial Partnerships Office, seeks proposals that will address research issues important to NASA with a goal of researchers

working for one year to solve defined NASA technical problems. This proposal addresses problems listed in the solicitation under Appendix A, SMD Task B, Aerial Platforms for Missions to Measure Atmospheric Chemical and Physical Properties. The proposed work will (1) build the analytical payloads to measure the concentration of volcanic gases (SO_2, H_2S, CO_2, CO, NO_2, CH_4, H_2O and associated O_3) emitted in volcanic environments together with temperature, relative humidity and wind speed; (2) integrate the analytical payloads into two sUAS platforms, a fixed wing and a rotary wing, thermally shielded to sample over Earth volcanoes; and (3) to deploy and test these aerial platforms during a field mission measuring the gasses emitted from a volcanic system.

KY - 18-EPSCoR R3-0010

SMD Task A: A Fully Eulerian Simulation Approach for High-Temperature Fluid-Solid Interaction

PI: Dr. Suzanne Smith

University Of Kentucky, Lexington

The NASA Established Program to Stimulate Competitive Research (EPSCoR) Rapid Response Research (R3) program, in collaboration with the Science Mission Directorate (SMD) and Commercial Partnerships Office, seeks proposals that will address research issues important to NASA with a goal of researchers working for one year to solve defined NASA technical problems. This proposal addresses problems listed in the solicitation under Appendix A, SMD Task A, High-Temperature Subsytems and Components for Long-Duration (months) Surface Operations. The proposed work will focus on development of reliable computer simulation methods to model Venus atmospheric entry environments and interaction with future thermal protection system (TPS) flight hardware. We are proposing the development of a high-fidelity multi-physics solver which can be used to simulate problems where the material response of the TPS and the fluid mechanics are closely-coupled.

SD - 18-EPSCoR R3-0015

Characterization of GRCop-42 Additively Manufactured Material (CSCO-2017-03 rev A)

PI: Dr. Edward Duke

South Dakota School Of Mines & Technology

The overall goal of this study is to complete material property and evaluation testing on a dispersion strengthened copper-alloy, GRCop-42, a low-cost alloy developed for additive manufacturing. GRCop-42 was developed as a higher conductivity version of GRCop-84 by dividing the amount of chromium and niobium in half. This material is being developed for use as a main combustion chamber liner, which is necessary for all expander cycle engines because this component requires high thermal conductivity. Initial testing shows the conductivity of GRCop-42 is significantly higher than GRCop-84, but there is a small but statistically significant sacrifice in low cycle fatigue strength, which is the main failure mode for main combustion chamber liners. This study will increase the body of knowledge of GRCop-42 by conducting micrograph characterization (before and after heat treatment and/or HIP), SEM characterization (before and after heat treatment and/or HIP), a wide variety of mechanical property testing (both at room temperatures and several elevated temperatures up to 1300F), characterization of virgin powder, computer tomography, surface roughness, x-ray fluorescence for chemical alloy analysis, and LXRD testing for residual stress analysis.

DE - 18-EPSCoR R3-0021

Investigate potential of Mars and Lunar resources

PI: Prof. William Matthaeus

University Of Delaware

The proposed project of the University of Delaware is to develop â€œcement-likeâ€ construction materials from lunar and martian regolith using novel methods for making cement binders from geopolymers on earth. This directly addresses NASAâ€™s needs for astronaut survivability and the utilization of Mars and Lunar resources, specifically as it applies to in-situ resource utilization for building shelter structures using additive manufacturing technology, thereby minimizing the upload from Earth. The proposed work consists of: i) Testing the RegoLight 3D printing technology using the BP-1 Lunar soil simulant provided by Kennedy Space Center. ii) Developing formulations of geopolymer binder for 3D printing structural components. iii) Determining the chemical composition of the geopolymer â€œbondsâ€ by analytical methods. iv) Optimizing the curing time and temperature. The project will leverage the current experience of the investigators of the Materials Physics in Space of the German Aerospace Center of the the vacuum 3D solar printing technique together with expertise of the University of Delaware geopolymer-based binders to validate 3D printing/chemical curing with solar sintering to obtain building blocks for extraterrestrial habitats.

AR - 18-EPSCoR R3-0023

Extreme Environment Integrated Circuits Using SiC JFET Technology for Advanced NASA Venus Missions

PI: Dr. Keith Hudson

University of Arkansas

Venus presents a significant thermal management challenge for any probe or lander. Vehicle, instrument and system designs must account for its corrosive, high-pressure, high-temperature (470Â°C) environment. The recent development of a silicon carbide (SiC) JFET process at NASA Glenn Research Center (NASA-GRC) demonstrates a much higher device operating temperature compared with those using a silicon (Si) technology. The breakthrough results achieved by the SiC JFET technology should improve the whole electronic system with much higher operating temperature and much better radiation hardness. Implementation of this technology can substantially reduce the cooling elements for the electronic systems and improve the robustness of vehicles, instruments and systems used in a Venus

Mission. Working as a basic building block, SiC integrated circuits (ICs) based on the SiC JFET technology are expected to play a key role in fulfilling the needs of a variety of space exploration missions at NASA. This project aims to develop an Arkansas State research infrastructure so that the team eventually could tackle the grand technical challenge in SiC IC technology by developing transformative, cost-effective, high temperature SiC JFET devices. The research team includes two researchers from one Arkansas institution - University of Arkansas (UA) and one Arkansas local industry â€" Ozark IC (OzIC). The team will look to senior scientists, Dr. Glenn Beheim and Dr. Phil Neudeck, from NASA-GRC for guidance in the process migration.

The research goal of this project is to launch a major research direction for the State of Arkansas in the area of developing innovative high temperature SiC ICs for extreme environments based on one of the breakthrough techniques originally developed by NASA-GRC. The research team will adopt this unique device processing technology and advance the SiC JFET process using the High-Density Electronics Center (HiDEC) facility at the UA campus. The achievement of this goal will lead the team to become one of the top groups in the world in this emerging field within the next three years. As a result, it will significantly contribute to and promote the development of a research capability of the state in areas of strategic importance to the U.S. - NASA missions, energy exploration and military engines. This goal will be implemented by replicating and providing SiC ICs processing for small and medium sized markets, based on the SiC JFET technology. OzIC and NASA-GRC have recently signed a licensing agreement, in which both parties agree to collaboratively transfer the SiC JFET process by leveraging the current fabrication capabilities at HiDEC together with the strong research expertise for materials and devices at the UA. Areas of planned collaboration include process development, device design, characterization, and data analysis. These collaborative activities will be performed in both NASA and UA facilities. In addition to the research activities, this project also includes intensive interactions between Arkansas researchers and NASA experts. The project aims not only to develop long-term partnerships with NASA research centers to contribute to NASA missions but also to promote state economic growth and work-force development through a technology transfer to local industry. The project will foster the growth of the overall research infrastructure and therefore enable the team to emerge as a nationally outstanding group that should obtain substantial support from sources outside of the NASA EPSCoR RRR program. Specific research objectives for this project include:

a. SiC process module development (UA)

b. Preliminary SiC JFET device simulation and development (UA, OzIC)

c. Prototype SiC device characterization (UA, OzIC)

AL - 18-EPSCoR R3-0024

FY18 Alabama NASA EPSCoR Rapid Response: Development of Fiber-Optic High-Temperature Heat Flux Sensors for Venus Exploration

PI: Dr. Lawrence Dale Thomas

University Of Alabama, Huntsville

The following technical proposal is submitted in response to the current call by NASA SMD Planetary Division for High-Temperature Subsystems and Components for Long-Duration (months) Surface Operations on the planet Venus. The problem at hand is how to maximize the survivability of sensors, electronics and other components on future Venus surface landers under the extreme Venus ambient (~500 Â°C, 90 earth atm, highly acidic atmosphere, etc). Among the many challenges faced by potential long-duration landed missions, the most prominent one is maintaining the operation of on-board instruments with minimal or no active thermal control for extended periods [1]. These so-called mid-term missions are primarily designed to investigate geophysical properties of Venus such as heat flow, seismology, and geodesy. They require pertinent sensors and the associated subsystems to be able to withstand the severe temperature on Venus surface for weeks or even months. This sets up the context of the current proposal. The objective of the proposed research is to develop a fiber-optic heat flux sensor (HFS) that is able to operate at an ambient temperature as high as 500 Â°C with a 10-mW/m2 heat flux sensitivity. The innovation of the work is three-fold:

a) There has been very little prior research on fiber-optic HFS, so the intended work represents a new concept in heat flux sensing.

b) Unlike traditional optical fiber thermal sensors, the new design uses gold-coated high temperature fiber Bragg gratings (FBG) as the sensing elements, which can withstand temperatures above 500 Â°C.

c) To improve the survivability of the interrogation-detection system under extreme conditions, an innovative scheme based on FBG wavelength discriminators is proposed, which allows the use of broadband light sources (e.g., LED) and direct power measurement.

AL - 18-EPSCoR R3-0027

FY18 Alabama NASA EPSCoR Rapid Response: Characterization of Bi-Metallic Joints Formed by Different Processes

PI: Dr. Lawrence Dale Thomas

University Of Alabama, Huntsville

The family of Cr-Cu alloys is used as the liner in high heat flux applications. Alloying considers the addition of Zr, Nb, Co, and Ag to improve the properties. C-18150 is based on Zr additions which promote age hardening to strengthen the alloy. However, subsequent operation at elevated temperatures can result in Ostwald ripening of the precipitates thereby reducing strength. In contrast

GRCop-84 is strengthened by Cr2Nb dispersoids which form during solidification. The formation of these dispersoids leaves an almost pure Cu matrix which increases the thermal conductivity. Nickel based superalloy 625 will be evaluated along with the lower strength 300 series stainless steel alloys (SS). Inconel 625 can be operated up to 1500Â° F (816Â° C) while SS alloys are generally limited to 900Â° F (482Â° C). Although short term operation can extend the use of SS alloys upwards of 1500Â° F (816Â° C). Although Ni and Cu form a single-phase alloy, the influence and stability of the alloying elements must be evaluated for operation in a high flux environment. This project has three objectives designed to fully characterize SLM fabricated GRCop 42:

1) Baseline the interfaces of the as-fabricated material combinations by characterizing the microstructure in two orientations using optical microscopy (OM) and scanning electron microscopy (SEM).

2) Evaluate the effectiveness of various heat treatments on NASA supplied samples. Trade off in temperature between the two alloys will be evaluated due to the limitations of the lower melting temperature Cu alloys. After heat treatment, hardness profiles across the interface will be conducted. Miniature specimens will be machined and tested before and after heat treatments.

3) Evaluate stability of the interface following long term exposure to high temperatures simulating the operational environment. As diffusion is expected to occur in Ni-Cu interfaces, elevated temperature tests will be conducted and specimens characterized microscopically and in tension following exposure to evaluate potential Kirkendall effects.

NV - 18-EPSCoR R3-0035

Rock, H2O, And H2: Energy From Water-Rock Interactions On Mars

PI: Dr. Lynn Fenstermaker

Nevada System of Higher Education

Hydrogen, perchlorate, and elements such as Mg and Fe would be very valuable for extended human exploration of Mars because they could be a significant source of fuel and key raw materials for manufacturing. Extended human stays on Mars will also likely utilize the Martian regolith as plant growth medium, wetting the initially dry regolith with liquid water to form soil. This initial wetting of the Martian regolith can release very valuable materials for in situ resource utilization.

Previous work on Earth has shown that interactions of liquid water with fresh, Fe-rich mineral surfaces produces hydrogen, which could potentially be used as a fuel source on Mars. Perchlorate is widely present on Mars, and could also be isolated as part of the wetting process that would occur in soils because it is easily solubilized. In addition, many locations on Mars contain abundant metals and non-metals that could be utilized in situ, including Fe, Mg, Cl and S.

Therefore, we propose water-rock experiments to examine the interaction of minerals found in Mars regolith with liquid water, and the resources available during these reactions. These experiments will

build on water-rock experiments currently ongoing in our laboratory, and will utilize a series of Mars soil simulants including 1) JSC-Mars 1 2) Mojave Mars simulant and 3) a modified Mojave Mars simulant that is currently being developed at Johnson Space Center, as well as individual minerals. This work will be performed in collaboration with NASA scientist Dr. Elizabeth Rampe, and has been discussed with NASA contact Warren Ruemmele, and will help shed light on the potential production of both fuel sources and material resources for long-term Martian exploration.

ND - 18-EPSCoR R3-0038

Development of a High Temperature (500 C) and High Power Testbed for GaN HEMT/SiC based Switching Power Converter for Long-Duration Venus Surface Operations

PI: Dr. James Casler

University Of North Dakota, Grand Forks

A high temperature high power switching power converter testbed utilizing GaN HEMT or SiC power semiconductors will be developed. The switching power converter is the key device that is able to interface the high temperature power source, i.e. high temperature thermoelectric to the high temperature energy storage device for the long duration operation for the Venus surface operations. Existing Si based semiconductor devices will not be able to operate at such a high temperature. The newly developed GaN HEMT and SiC power semiconductor devices has the capability to operate at a such high temperature, but the whole power converter system level evaluation and study has not been done. The developed high temperature high power testbed will utilize the high temperature possible power semiconductor devices and develop the possible power converter topologies that is able to operate at the high temperature which enables the long duration Venus surface operations.