

SD NASA EPSCoR 2015 Major Research Grant
(Approved for funding Sept. 1, 2015 – Aug. 31, 2018)

South Dakota investigator(s) and affiliation	Project title	Funding summary	NASA and other partners
<ul style="list-style-type: none"> • PI at SDSM&T: Edward F. Duke, Director SD NASA EPSCoR • Co-I's at SDSMT: Grant Crawford, William Cross, Lori Groven, Jon Kellar, Keith Whites, Dimitris Anagnostou • Co-I's at SDSU: Qiquan Qiao, Robert McTaggart • Co-I's at USD: Mary Berry, Paul May • Industry Partners: Mike O'Reilly (Optomec, Inc.), Vincent Fratello (Quest Integrated) 	Development of Direct-Write Materials, and Electronic and Electromagnetic Devices for NASA Printable Spacecraft	\$750,000 (NASA) \$375,016 (Match)	<ul style="list-style-type: none"> • NASA Jet Propulsion Laboratory (Kendra Short and others) • Glenn Research Center (Dawn Emerson and others) • Optomec, Inc. • Quest Integrated, LLC

Project Summary

(Funded South Dakota NASA EPSCoR 2015 Major Research Project)

Development of Direct-Write Materials, and Electronic and Electromagnetic Devices for NASA Printable Spacecraft

The objective of this project is to develop the necessary research base that will enable printable spacecraft to become a reality. Printable spacecraft is a futuristic, potentially game-changing endeavor envisioned by NASA Jet Propulsion Laboratory (JPL) for use in future space exploration missions. The printable spacecraft vision is for the creation of thin, ultra-lightweight, and flexible substrate sheets with customized, embedded sensors and electronic modules for data gathering, communication, and micro-propulsion. Various electronic components and devices will be printed on these sheets, which, when deployed, will flutter like falling leaves to a target surface, collecting data throughout their journey. Deployment in this manner would eliminate the need for complex landing systems. Upon reaching their destination, the sheets will act as a large wireless network of sensors that transmit collected data back to the host spacecraft. A multi-disciplinary team of 10 subject experts from five disciplines (materials science, electrical engineering, chemistry, chemical engineering, and physics) and three South Dakota (SD) universities will collaborate to achieve this ambitious goal. The SD team emerges from a longstanding teaming ecosystem that has extensive research on all facets of printing technology, one that is ideally suited for support of the printed spacecraft initiative. The SD team will be joined by NASA and industry partners in this research endeavor. The research is very well aligned in three programmatic theme areas: (1) Printable Space Compatible Materials, (2) Printed Electronics and Electromagnetic Devices, and (3) Printable Power and Propulsion. The following research subtasks are distributed under these theme areas:

- Gaining a fundamental understanding of the relation between processing, microstructure, and mechanical/electrical performance of printed materials in space environments.
- Utilizing overcoatings for printed electronics use in harsh space environments.
- Developing functionally gradient flexible substrates with coefficient of thermal expansion (CTE) matched to that of printed components for use in space environments.
- Synthesizing nanoinks for accurate, direct-write printing of interconnections, sensors, and electromagnetic devices with fine features.
- Designing and direct-write printing electronics and electromagnetic devices and modules for space applications.
- Synthesizing and deploying reactive inks for chemical propulsion systems.
- Developing a printed photovoltaic power generation technology using ultra-lightweight, robust and highly efficient perovskite solar cells and luminescent solar concentrators.

In addition to the printed spacecraft initiative, the research will contribute to the strategic research and technology development priorities of NASA's Space Technology and the Human Exploration and Operations Mission Directorates. Another objective of the project is to enhance state research infrastructure. To achieve this, the project will add new critical equipment (e.g., a research-grade profilometer) that will greatly enhance the research capabilities at SD universities. Also, this project will support five PhD programs (out of which three are new) in STEM areas in SD. The research will create new knowledge providing critical content for two relevant graduate courses, as well as the printed spacecraft initiative. The research has significant state fidelity through its alignment with SD's Science and Technology Plan. Furthermore, this project will support two early-career faculty, facilitate undergraduate research, and train six graduate students, including a graduate internship where students will work side-by-side with NASA researchers at JPL and Glenn Research Center. Finally, the project will deliver NASA-relevant outreach activities to Native American high school students in SD through visits to the Pine Ridge and Rosebud Reservations.

NASA received a total of 27 proposals for this solicitation. From these, 15 were recommended for funding.

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