South Dakota NASA EPSCoR FY2021 Major Research Grant
(Approved for a three-year project)

South Dakota investigator(s) and affiliation	Project title	Funding summary	NASA Collaborators
• Admin. PI at SDSM&T: **Edward F. Duke**, Director SD NASA EPSCoR • Science-I at SDSMT: **Nickolaus Bruno** • Co-I's at SDSMT: **Tula Paudel, Bharat Jasthi, Karim Muci, Grant Crawford, Carter Kerk** • Co-I's at SDSU: **Parashu Kharel, Todd Letcher**	Advanced Soft-Magnetic Materials for Electrified Propulsion Systems	**$750,000** (NASA) **$375,000** (Match)	• NASA Glenn Research Center: **Ronald Noebe, Alex Leary** • NASA Jet Propulsion Laboratory: **Punnathat Bordeenithikasem, Scott Roberts**

Project Summary
Advanced Soft-Magnetic Materials for Electrified Propulsion Systems

The performance of high-efficiency (HE) electronics, including those targeted in *TX01: Propulsion Systems*, is controlled through the electromagnetic behaviors of magnetically soft metal-amorphous nanocomposites (MANCs) that operate as filter inductors and transformers. These devices are integral to all-electric propulsion (*TX01.3.8*) systems and influence the cost, size, and weight of electronic filters and controller boards. The development of lightweight, high-power and HE filter inductors from tape-wound MANCs is the central goal of the proposed work, which is key to advancing the National Aeronautics and Space Administration's (NASA's) missions and fostering strategic plans. In our project, titled *Advanced Soft-Magnetic Materials for Electrified Propulsion Systems* (ASM-EPS), South Dakota (SD) NASA EPSCoR proposes to improve the mechanical and magnetic behaviors of low-cost Fe-based MANCs. Outcomes, including new stress-annealable compositions, thermomechanical processing conditions, materials properties data, and thermally efficient packaging will be directly relevant to NASA's Aeronautics Research Mission Directorate (*ARMD*) through the Advanced Air Transport Technology project given its current focus in *Strategic Thrust 4: Transition to Low-Carbon Propulsion*. The work will also increase research capacity and economic growth in SD, particularly with respect to two key research thrusts [*Energy and Environment* and *Materials and Advanced Manufacturing*] in SD's 2020 Science and Technology Plan. ASM-EPS will establish a program that stimulates competitive research and strong partnerships between SD and NASA, particularly with regard to *TX01.2 Electric Space Propulsion*. ASM-EPS is poised to improve the current implementation of brittle MANCs and develop unprecedented manufacturing capabilities with subsequent benefits for the general U.S. population (i.e., improved efficiency of power transformers, electric cars, and spreading of high-voltage over large power grids). In particular, ASM-EPS, which includes the development of the necessary human capital in STEM, is expected to have a significant impact on the electronics industry valued over $1.5 trillion.

ASM-EPS is organized into four intertwined initiatives that coordinate activities to achieve our central goal, i.e., manufacture HE high-power inductor cores from Fe-based MANCs. The proposed initiatives include (1) alloy synthesis to develop novel MANCs, (2) stress-annealing and processing to tune their magnetic and mechanical behaviors, (3) materials and core characterization to understand MANC behaviors, and (4) packaging to improve thermal transfer between energized cores and their surroundings. HE high-power inductor cores will be manufactured from "ground-up" technology through the synergy between initiatives (1)-(4).

Supporting ASM-EPS are 8 faculty from South Dakota School of Mines and Technology (SDSM&T) and South Dakota State University (SDSU) and 4 NASA researchers at Glenn Research Center (GRC) and Jet Propulsion Laboratory (JPL). A minimum of 5 graduate students and 1 undergraduate will also be supported. ASM-EPS presents a well-defined plan that fosters close partnership between institutions and utilizes current NASA assets, including a commercial planar-casting system, custom core-loss measurement instrumentation, and expert personnel. Moreover, the project will develop research infrastructure in SD through the acquisition and implementation of a planar-casting system for synthesizing MANCs for the first time in the state. Progress in SD's education infrastructure will be made through collaborative efforts between faculty members, the Tiospaye Scholar Program (STEM retention for Native Americans at SDSM&T), and the implementation of findings in undergraduate and graduate curricula. Finally, in developing HE inductor cores, SD will be positioned for economic growth with CBMM, a niobium mining company, through the development of commercial electronics.

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This Project Summary updated in terms of PI's and Co-I's on 5/18/22