Title: Center of Research and Education for 2D Optoelectronics (CRE2DO) at Florida International University

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Summary: The Center for Research and Education in 2D Optoelectronics (CRE2DO) at Florida International University (FIU) will become a leading hub for innovative research and education in alignment with NASA's Strategic Objective 3.3: Inspire and Engage the Public in Aeronautics, Space, and Science, and resonant with NASA Science Mission Directorate (SMD) priorities. The center will develop the research infrastructure able to address some of the most important challenges of space exploration through strong partnerships with NASA Centers (Glenn, JPL) and Penn State 2D Crystal Consortium.

Recently, the class of two-dimensional (2D) materials, featuring: tensile strengths hundreds times greater than steel, high flexibility and conductivity, tremendous energy storage capacity, etc., shows the potential to advance every field, from electronics, to energy and to medicine. NASA is vested into high performing nanomaterials such as carbon nanotubes in space technologies, through its Game Changing Development which targets ultra-lightweight nanomaterials. The proposal outlines a technical and education plan that propels the 2D-functional materials to enabling NASA technical advancements while preparing the future STEM workforce.

The CRE2DO goals are:

- Goal 1. Partner with NASA in developing cutting-edge technologies that leverage the realm of 2D materials in detectors and superconducting materials, space-resilient infrastructure materials and small satellite technology.
- Goal 2. Leverage NASA resources to integrate the proposed research with education efforts that contribute to STEM workforce development.
- Goal 3. Inspire and educate the next generation of explorers through unique STEM learning opportunities that resonate with NASA mission.
- Goal 4. Develop a comprehensive understanding of the steps that foster the development of future STEM professionals and widely disseminate the acquired knowledge.
- Goal 5. Enhance research capacity at FIU by fostering faculty collaborations, cluster research and development of research infrastructure.
- Goal 6. Attain sustainability in all center activities.

CRE2DO will explore novel two-dimensional (2D) functional materials to be incorporated in sensors, integrated optics/photonics, and small satellites (CubeSats). Characterization of devices and materials in extreme space environments (temperature and radiation) will be an overarching theme. The three integrated thrusts will engage a large number of students to be trained at FIU and NASA Centers.

- Thrust # 1. Chemical transformations in 2D chalcogenide materials to enable advanced functionality in optoelectronics. The thrust will focus on synthesizing 2D nanomaterials with superior properties to their bulk counterparts, and on fabrication of devices and their testing in simulated extreme space environments.
- Thrust # 2. Mechanical Integrity of 2D TMD Materials in Polymer Composites. The outcomes will enhance space reliability of mechanical and electrical components in spaceship devices and wearable electronics. The thrust will explore mechanical properties of 2D nanocomposites.
- Thrust # 3. Thin Film In-Package High-Data Rate mm Wave Communication for Small CubeSats. The novel architectures bridge the gap between integrated circuits (ICs), which will be built at the nanoscale, and the rest of the system components that are at the millimeter scale. 2D materials, including graphene and boron nitride (BN) nanosheets, will be employed at the interface to enable reliable bump-connections while enabling improved thermal dissipation owed to their reduce dimensionality.

The STEM Transformation Institute at FIU will lead the educational program. The three-prong approach includes: NASA Centers student summer internships, yearlong internships in campus, and curricular interventions. Resources at NASA Centers will be leveraged through undergraduate and graduate student internships and testing of materials and devices in space application-relevant conditions.