Phase 2 Project Summary

Firm:	Radiation Monitoring Devices, Inc.
Contract Number:	2-NNX11CA24C
Project Title:	Fast Neutron Dosimeter for the Space Environment

Identification and Significance of Innovation:

Model calculations and risk assessment estimates indicate that secondary neutrons make a significant contribution to the total absorbed dose received by space crews during long duration space missions. However, only a limited number of measurements of the dose contribution from secondary neutrons have been made. In part this is due to an inability to easily discriminate between the fraction of dose which results from secondary neutrons and that which results from exposure to energetic charged particles. The energy of the secondary neutrons range from 1 to >150 MeV. Scintillation materials provide the optimum volume to payload performance, but their use has been limited by the need for PMTs. A compact, lightweight, low-voltage, sensitive photodetector, such as CMOS SSPMs are an ideal candidate for this application.

This SBIR Phase-II project has designed and fabricated a compact, lightweight, energy-efficient dosimeter for secondary neutrons from space radiation using state-of-the-art scintillation materials, such as Diphenylanthracene (DPA), coupled to a high-gain, solid-state photomultiplier (SSPM), which is a high-density array of Geiger photodiodes, fabricated with CMOS (complementary metal-oxide-semiconductor) technology. Such a dosimeter would overcome many of the limitations in the current generation of neutron dosimeters and meet the dosimetry needs for future human-space-exploration missions to the moon and Mars.

Technical Objectives and Work Plan:

The goal of the program was to develop a neutron dosimeter for assessing the dose in high radiation space environments by meeting the following technical objectives:

A. Determine conditions for growing large scintillation crystals of DPA (>1 cm^3).
B. Determine scintillation information needed to assess neutron energy and dose.
C. Evaluate and optimize performance of prototype fast-neutron dosimeter.

The following work was proposed to meet the above objectives:

1. Select and purchase materials for crystal growth.
2. Refine simulation of detector.
3. Refine calculation of the dose and dose-equivalent.
4. Construct apparatus for growing large DPA crystals.
5. Grow, cut and package large, >1-cubic-cm, DPA crystals.
6. Characterize basic scintillation properties.
7. Characterize response of scintillation material to 241-AmBe neutrons.
8. Assemble SSPM-DPA detector and SSPM-based ACS.
9. Characterize performance of SSPM-DPA detector.
10. Characterize performance of SSPM-based ACS.
11. Design and fabricate readout electronics for DPA and ACS.
12. Procure Components and Assemble Prototype.
13. Develop Code for Readout Electronics.
14. Test prototype.
15. Condense and review project results and prepare for transition to Phase III.

Technical Accomplishments:

In the Phase-II, we elaborated on the design specification needed for the critical components, which included the scintillation material, DPA, the SSPM photodetector, and the anti-coincident shielding, to assess dose in a space radiation environment that exceeds the performance of existing technologies. New growth methods were used to fabricate large DPA

crystals while simulations were used to refine and validate neutron dose calculation methods. The signal and data processing readout electronics were developed for the DPA-SSPM and anti-coincident shields which enable an event-by-event analysis for determining neutron dose.

NASA Applications:

During spaceflight, both the immediate rate and total neutron exposure information can be recorded simultaneously by these high-efficiency neutron dosimeters. The lightweight, compact size and inexpensive nature of these sensors also opens the possibility of monitoring many areas for comparison of radiation exposure, including individual monitors for each crewmember with online data for the whole mission. Ground-based research and comparisons will also become easier and less expensive with the SSPM dosimeter. The CMOS environment used to fabricate the SSPM and supporting electronics enables low-cost and lightweight space radiation dosimeters and solar particle monitors for NASA satellites.

Non-NASA Commercial Applications:

Inexpensive radiation dosimeters are in general demand for commercial applications, such as personnel or waste monitoring; other applications include border monitoring for homeland security and protecting satellites and ground-based equipment from solar flares. The ability to inexpensively mass-produce these devices creates an entirely new market for arrays of distributed sensors. As high altitude commercial flights become more prevalent, active dosimeters can provide the redundant safeguards and information required to protect companies from unnecessary litigation and passengers from hazardous radiation conditions. We will also consider application of these instruments for dose monitoring both for air travel and space tourism, such as planned by Virgin Galactic. As space is opening to commercial entities, such as Space X, we will explore the potential for these instruments for their applications.

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