Graphene-Based Electrical Resistance Device for Neutron Dosimetry.

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Abstract: NASA's increasing focus on human exploration science necessitates further advancement of radiation shielding and detection technology. The current approach to shielding can be best described as one of mitigation and minimization, as attempts to completely stop extremely high energy ionizing particles may be infeasible. Integral to this approach is the ability to quantify astronauts' personal radiative exposure in real-time. With this in mind, our SSERVI group has proposed the use of topological and 2D material platforms in which electrical interactions with radiation can be used as a means of measuring accumulated dose [1]. These are envisioned as thin, light-weight, flexible patches capable of retro-integration onto existing spacesuit designs, which would allow for instantaneous, tissue-specific readouts and complement existing radiation monitoring systems. Specifically, this initial effort is focused on leveraging graphene's unique conductivity and ^{10}B's large neutron capture cross-section to develop a resistive sensor or graphene field effect transistor (gFET) capable of detecting and measuring neutrons produced by GCR secondary reactions. Neutron capture initiates the split of ^{10}B into ^{7}Li and alpha particles, which can create charged defects in the gFET matrix. As these local electrical fields accumulate beneath the conducting graphene layer, the subsequent increase in resistance can be correlated to neutron exposure [2]. Because capture probability is energy-dependent, and because false positives from background alpha particles can obfuscate those arising from neutron interactions, complementary radiation data will be necessary to more accurately identify the true neutron fluence. To address the possibility of non-resistivity-altering impacts wherein ^{10}B secondaries leave the gFET or bury too far away from the conducting layer to have a resistive effect, and to establish the optimal dimensions for a ^{10}B converter layer, Monte Carlo modeling of ejecta kinetics will be performed [3]. Prior to ^{10}B incorporation and neutron testing, prototypes exposed to 1.4 keV x-rays showed a corresponding resistivity increase, thus validating the proposed device's electro-mechanical architecture in agreement with literature [4,5].

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