Using a Pelletron to Simulate Space Radiation for Small Space Vehicles

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Overview

Recently, luminescent materials have been proposed for use to measure incident radiation fluence. Research has shown that proton bombardment in the keV to MeV range, like that occurring in space, reduces the intensity of non-burning luminescence. Beams from small accelerators, such as the tandem Pelletron at the Louisiana Accelerator Center (LAC) in Lafayette, Louisiana, can easily be used to simulate proton exposure in space. The half brightness fluence ($N_{1/2}$) is a useful figure of merit to evaluate the degradation of luminescence and is defined as the amount needed to reduce the luminescent intensity to half of its original value.

LAC Description

The LAC has been in existence since the mid 1970's at the University of Louisiana at Lafayette (UL Lafayette). In 1991, a National Electrostatic Corporation 1.7 MV 5SDH-2 tandem Pelletron® accelerator system became operational. For the most part, research at LAC has focused on a variety of topics, including the development of high-energy ion beam microscopy systems and techniques, irradiating samples, measuring trace element concentrations, and other similar related topics. Currently, there are three high-energy transport beamlines: 1) Micro-beamline, 2) Ultra-low flux beamline, and 3) Implantation beamline. The micro-beamline uses an Oxford Microbeams (OM) system to provide micron-sized beams of protons to irradiate samples. The ultra-low flux beamline allows for the irradiation of samples in a glove box at space radiation relevant doses. The implant beamline is used for high-energy ion implantation and high-flux irradiation. In 2021, efforts were initiated to computerize the control system for the 5SDH-2 Pelletron using NEC AccelNET. This upgrade was a result of a successful $475,000 grant from the State of Louisiana. At the present time, the control components for this upgrade are being manufactured by NEC. Installation and testing for this upgrade will take place in the summer of 2023.

Example Material: Europium Tetrakis

Over the last few years, a new material, Europium tetrakis dibenzoylmethide triethylammonium (EuD_4TEA) also known as europium tetrakis, has shown some promise as the active element as a space-based radiation sensor. EuD4TEA emits the characteristic 611 nm red luminescence when excited. A sample was exposed to 3 MeV protons using the LAC Pelletron accelerator. It was mounted to an electrically isolated translational holder with a cylindrical Faraday cup. The beam current was kept small to minimize sample charging and heating. The average 3 MeV proton $N_{1/2}$ for the EuD_4TEA sample was measured to be 2.83×10^{10} mm^{-2}. This measured $N_{1/2}$ is almost a thousand times smaller than was found for other measured materials, which is reasonable since EuD_4TEA is an organic compound. Organics are often fragile and thus more susceptible to radiation damage. According to Tribble, a spacecraft at 1 AU from the sun will receive a 1 MeV proton fluence of less than about 10^{11} mm^{-2} from a large solar event. Likewise, 1 MeV proton fluences in the Earth's radiation belts and the Earth-Moon-Sun Lagrange points will be even less than the 10^{11} mm^{-2} value from large solar events. For that reason, EuD_4TEA should be a good candidate for use as a proton fluence sensor for spacecraft. This presentation will present an overview into LAC and how it can be used to test small satellites before launch into space. Emphasis will be placed on the testing and materials analysis of payload components using the LAC Pelletron accelerator.