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SOI Thin Microdosimeter Detectors for Low Energy Ions and Radiation Damage Studies

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The aim of this work was to study the applicability of silicon microdosimeters for high LET ion measurements. The response and radiation damage of two silicon on insulator (SOI) 3D microdosimeters developed by the Centre for Medical Radiation Physics (CMRP) were investigated with a range of different low energy ions, with high linear energy transfer (LET). The two microdosimeters n-SOI and p-SOI were irradiated with a number of different ions including ^{7}Li, ^{12}C, ^{16}O and ^{48}Ti with ranges below 350 μm in silicon.

The two detectors used in this work are called the Bridge and the Mushroom. The Bridge microdosimeter is based on an array of planar 30 x 30 x 10 μm cubic SVs fabricated on a high resistivity of 3 kΩ.cm n-SOI active layer of thickness 10 μm and low resistivity supporting wafer [1]. The Mushroom microdosimeter structure used in this work is called a trenched 3D and it consists of 3D cylindrical SVs with a core columnar n+ region and each SV is surrounded with p+ trench to form a p-n junction. The Mushroom microdosimeter has a thickness of 9.1 um and diameter of 30 μm fabricated on high resistivity p-type silicon (> 10 kΩ.cm).

Using a specially generated low intensity beam (beam fluence of approximately 1200 particles/s), irradiations were conducted at The Heavy Ion Accelerator Facility (HIAF) at the Australian National University using both the Bridge and Mushroom 3D microdosimeters. Radiation damage of the Bridge and Mushroom microdosimeters was studied using the ion beam induced charge collection technique (IBIC) at the 6 MV accelerator SIRIUS, located at the Centre for Accelerator Science (CAS) facility at ANSTO. This system includes a Confocal Heavy Ion Micro-Probe (CHIMP) which is capable of delivering Carbon, Helium and Hydrogen ions with energies of 24 MeV, 5.5 MeV and 8 MeV, respectively.

Results presented will show that no plasma effects were seen in the SOI microdosimeters when irradiated with the high LET ions. A Monte Carlo simulation using Geant4 was compared to the experimental measurements, whereby some discrepancies were observed for heavier ions at lower energies. This discrepancy can be partly attributed to uncertainties in the thickness of the energy degraders and overlayers of the devices. The radiation hardness of the two devices was studied using the Ion Beam Induced Charge Collection technique (IBIC). Charge buildup was seen outside of the SV in the SiO_2 layer after irradiation, however both types of microdosimeters when biased had no essential changes in charge collection efficiency (CCE) in the SV after irradiation with low energy ions. IBIC results for both detector types will be presented in full

References:
[1] L. T. Tran, L. Chartier, D. Bolst, et al., “3D silicon microdosimetry and rbe study using ^{12}C ion of different energies,” IEEE Trans Nucl Sci, vol. 62, no. 6, pp. 3027–3033, Dec 2015.

Speakers Gender

Male

Travel Funding

No

Level of Expertise

Student

Do yo wish to take part in the poster slam

No

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