Type of presentation: Poster

IT-4-P-2793 Monte Carlo simulations of electron trajectories for the study of betavoltaic battery configurations

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Battery development goals are to produce small, light, safe, high power and very long lasting batteries. Betavoltaics batteries use semiconductors to convert beta particles (electrons) emitted from a radioactive source, much like photovoltaic panels convert sunlight to electricity. For betavoltaic devices the source can be within the devices themselves, while the radiant sun energy comes from outside the photovoltaic devices. A further difference is that betavoltaic cells can be stacked up.
The simplest structure for a betavoltaic battery consists of the beta layer on top of a pn junction producing electron-hole pairs, which are collected on both sides of the junction. Beta emission in the layer is isotropic within the layer, with randomization of the emission location and the emission characteristics. Each electron emission is isotropic in a sphere, calculated using direction cosines from the random localized emission point.
The Monte Carlo simulation program used is called MC–SET and deals with deposited beam energy calculations and with multi-layers. The simulation tracks each electron in its trajectory inside the specimen, and at each step calculates the energy lost by the electron. The energy deposited from all the electrons in the simulation is stored in a 3-D energy matrix. Other parts of the electrons energy, such as backscattered, transmitted and out to the device electrons are also recorded during the simulation.
The purpose of this investigation is to describe a methodology for simulating beta voltaic batteries, with different geometric configurations. The relationship between the nuclear radiation emission and the energy obtainable is evaluated.
Figure 1 presents the electron depth dose for a bulk Ni specimen, with a normal beam direction. The two selected energies correspond to the average beta emission energy and the maximum beta energy for the Ni-63 isotope. For the high value absorption in the Ni layer occurs at depths of up to about 10 um, while the curve for 17 keV indicates that all the average beta particle energy is absorbed within 1 um of Ni-63. Figure 1 inset shows the depth dose for a layered structure of Si-Ni-63-Si, for 2 um Ni-63 layer. This curve shows the relative amounts of energy deposited in the Ni-63 and the Si layers, the latter being the effective maximum energy available for conversion.
Figure 2 gives the energy deposited in one Si layer, for increasing values of Ni-63 thickness. The left hand curve corresponds to same activity for all layers, i.e. same number of beta emissions, while the right hand curve corresponds to all layers having the same specific activity (beta emissions per gram), corresponding to a typical Ni-63 isotope specific activity of 15 Ci/gr.

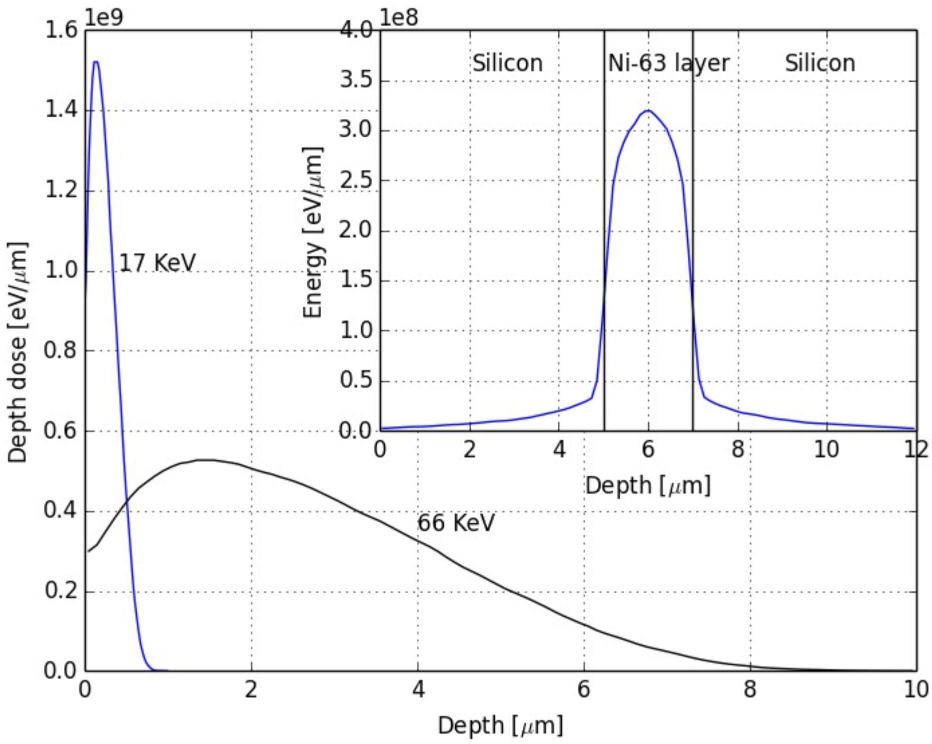

Fig. 1: Ni electron depth dose for 2 energies based on Ni-63 emission data and (inset) electron depth dose for Si-Ni-63-Si device

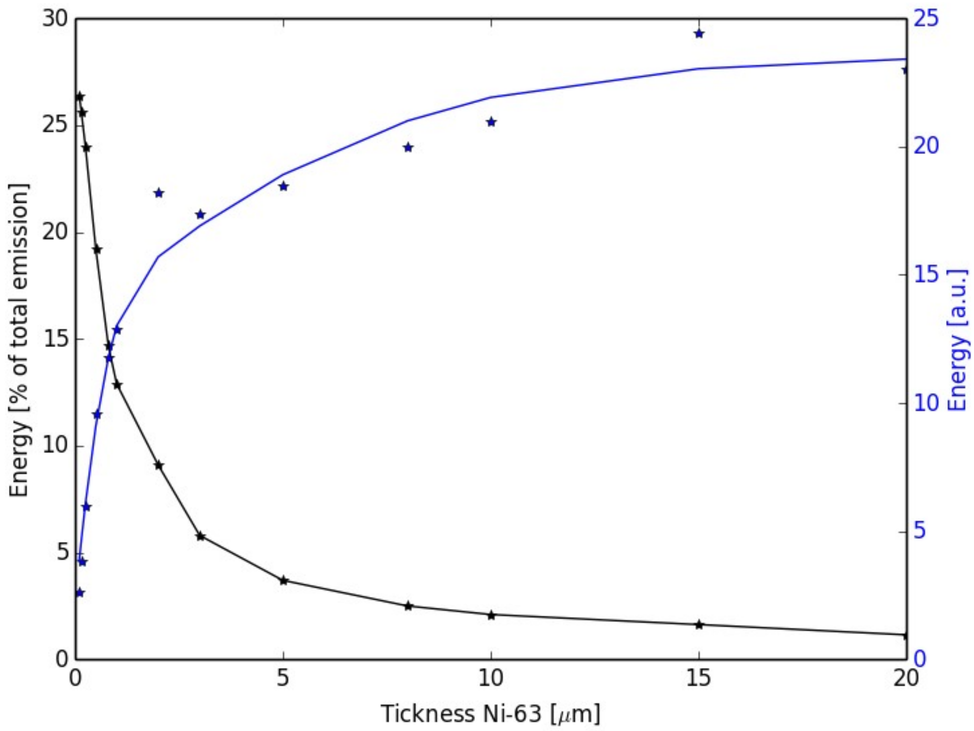

Fig. 2: Relative amount of beta energy emission from Ni-63 layer deposited in Si layer