Contribution ID: **25** Type: **Talk**

Non-Ionizing Energy Loss: Geant4 simulations towards more advanced NIEL concept for radiation damage modelling and prediction

Wednesday 17 November 2021 10:00 (20 minutes)

The Non Ionizing Energy Loss (NIEL) concept is used to compare and scale the damage impacted on semiconductor devices in different radiation fields. A particular weakness of the present NIEL concept consists in the inability to predict the different formation rates of cluster and point defects in the silicon (Si) crystal for different particles and particle energies. NIEL gives only the total energy imparted in displacements and does not separate between energy going in point defect formation and energy going into cluster formation. To be more specific, differences between radiation damage produced by neutrons and protons of the same displacement energies (i.e. damage parameters normalized to the NIEL) has been observed experimentally. In this work, we present the results of Geant4 and FLUKA simulations in order to investigate proton/neutron differences from first principles. The interactions of neutrons and protons of different energies in a 100 um thick Si target were studied and the kinematics of the Primary Knock-on Atoms (PKA) has been characterized. The dependence on NIEL on the target recoil energy is explored along with its dependence on secondary particle production from inelastic collisions.

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Session Classification: Defect and Material Characterization