Annealing of effective trapping times in irradiated silicon detectors

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Charge collection efficiency of position sensitive silicon detectors degrades after irradiation due to charge trapped on defects in the lattice leading to degradation of the signal to noise ratio. The probability of drifting charges to get trapped is inversely proportional to the effective trapping times ($1/\tau_{eff,e,h}$). They have large impact on the choice of detector type (p^+,n^+ readout) and geometry. The effective trapping times change after irradiation and consequently also the observed charge collection efficiency. In order to predict the evolution of charge collection efficiency of detectors at LHC and at possible LHC upgrade (SLHC), effective trapping times were measured during annealing on a set of float zone silicon pad detectors. Detectors fabricated on the n-type bulk material were irradiated with reactor neutrons and charged hadrons up to 2×10^{14} cm^{-2} 1 MeV neutron NIEL equivalent fluence. The effective trapping times were measured using the charge correction method. It was found that $1/\tau_{eff}$ increases for holes and decreases for electrons during annealing by around 30%. The rate of these changes, which reveal underlying first order dynamics, depends on temperature and is of order of 10 h at 60°C. This behavior was found universal for any irradiation particle type or silicon material. In order to determine the temperature dependence, annealing was performed at three different temperatures $40^\circ, 60^\circ, 80^\circ$C and the activation energy extracted from the Arrhenius plot.