Cryogenic Si detectors for Ultra Radiation Hardness in SLHC Environment

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Radiation hardness up to 10^{16} n_{eq}/cm^2 is required in the future HEP experiments for most inner detectors. However, 10^{16} n_{eq}/cm^2 fluence is well beyond the radiation tolerance of even the most advanced semiconductor detectors fabricated by commonly adopted technologies: the carrier trapping will limit the charge collection depth to an effective range of 20 µm to 30 µm regardless of depletion depth. Significant improvement of the radiation hardness of silicon sensors has been taken place within RD39. Fortunately the cryogenic tool we have been using provides us a convenient way to solve the detector CCE problem at SLHC radiation level (10^{16} n_{eq}/cm^2). There are two key approaches in our efforts: 1) use of the charge/current injection to manipulate the detector internal electric field in such a way that it can be depleted at a modest bias voltage at cryogenic temperature range (≤150K); and 2) freezing out of the trapping centers that affects the CCE at cryogenic temperatures lower than that of the LN_2 temperature.

In our first approach, we have developed the advanced radiation hard detectors using charge or current injection, the current injected diodes (CID). In a CID, the electric field is controlled by injected current, which is limited by the space charge, yielding a nearly uniform electric field in the detector, independent of the radiation fluence. In our second approach, we have developed models of radiation-induced trapping levels and the physics of their freezing out at cryogenic temperatures. In our second approach, we intend to study the trapping effect at temperatures below LN_2 temperature. A freeze-out of trapping can certainly help in the development of ultra-rad hard Si detectors for SLHC. A detector CCE measurement system using ultra-fast picosecond laser with a LHe cryostat has been built at CERN. This system can be used to find out the practical cryogenic temperature range that can be used to freeze out the radiation-induced trapping levels, and it is ready for measurements on extremely heavily irradiated silicon detectors. Iniial data from this system will be presented.

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