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Silicon detectors for the sLHC

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ABSTRACT

In current particle physics experiments, silicon strip detectors are widely used as part of the inner tracking layers. A foreseeable large-scale application for such detectors consists of the luminosity upgrade of the Large Hadron Collider (LHC), the super-LHC or sLHC, where silicon detectors with extreme radiation hardness are required. The mission statement of the CERN RD50 Collaboration is the development of radiation-hard semiconductor devices for very high luminosity colliders. As a consequence, the aim of the R&D programme presented in this article is to develop silicon particle detectors able to operate at sLHC conditions. Research has progressed in different areas, such as defect characterisation, defect engineering and full detector systems. Recent results from these areas will be presented. This includes in particular an improved understanding of the macroscopic changes of the effective doping concentration based on identification of the individual microscopic defects, results from irradiation with a mix of different particle types as expected for the sLHC, and the observation of charge multiplication effects in heavily irradiated detectors at very high bias voltages.

1. Introduction

The upgrade of the LHC to sLHC envisaged for 2020 requires silicon detectors of unprecedented radiation tolerance for the central tracking detectors. Current radiation field simulations for the general-purpose experiments ATLAS [1] and CMS [2] foresee radiation levels of around $2.0\times10^{16}\ \mathrm{n_{eq}/cm^2}$ for the innermost pixel layers and $1.0\times10^{15}\ \mathrm{n_{eq}/cm^2}$ for the innermost strip layers.[1] These sLHC fluences exceed the LHC values by about an order of magnitude, and mean that with the sLHC, detectors must enter a new era of radiation hardness, requiring the development of a new generation of silicon detectors.

RD50 is an international collaboration of over 250 scientists from 47 institutes, working on semiconductor detectors to meet the challenges from high luminosity colliders and hence high radiation

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[1] Non-ionising radiation doses of different particle types and energies are normalised to the silicon crystal lattice damage from neutrons of 1 MeV energy. The unit is 1 MeV neutron-equivalent per $\mathrm{cm^2}$ or in brief $\mathrm{n_{eq}/cm^2}$ [5].