Defect and Materials Characterisation – RD50
Summary of research activities

Research line mainly devoted to the analysis of radiation-induced defects in irradiated Si materials used for manufacturing microstrip and pixel Si detectors.

Within this research line WODEAN project was started in view to specifically concentrate on detailed relation between the radiation-induced microscopic disorder and the macroscopic consequences for detector performance.

Experimental techniques used are: DLTS, TSC, Hall-effect measurements, Photoconductivity decay, TCT, EPR, FTIR, PL.

Theoretical methods in order to identify chemical nature of defects: DFT and SRIM

Status Report 2009

Contributions received from:
- I. Pintilie for WODEAN Project
- A. Junkes from Hamburg,
- R. Mori from University of Florence

Comparative studies of the defects induced by irradiation with ^{60}Co- γ rays, 6 and 15 MeV electrons, 23 GeV protons and 1 MeV equivalent reactor neutrons. Measurements revealed the existence of point defects and cluster related centers having a strong impact on damage properties of Si diodes. Several extended defects, previously detected by electrical methods (DLTS, TSC, HRPITS) and characterized from the point of view of their electrical properties, have been investigated in more detail and also with other complementary experimental (EPR, FTIR, PL) and theoretical methods (DFT and SRIM) in order to identify their chemical nature.

It was possible to distinguish between point defects: as Ip, BD (Bistable Defect) and extended defects as E30K, E4, E5, H116K, H140K and H152K. Zero bias TSC measurements have also been performed as an additional tool to study defects and defect-induced residual electric field in the detector bulk. Experimental results of ZBTSC gives evidence of a significant electrical polarization of heavily irradiated Si detectors (10^{14}-10^{16}neq/cm^2) when they are reverse biased and kept at low temperature, operative condition of microstrip and pixel Si detectors in high energy physics experiments.

Main new achievements of the WODEAN project

- Assignment of E4, E5-defect (the main leakage current generator) to tri-vacancy (V_3) and its transformation in tri-vacancy-oxygen complex (V_3O) at temperatures above 250C (DLTS and FTIR).

- Possible identification of E30K (shallow donor with enhanced generation rate after irradiation with electrons and protons) with the tri-interstitial (I3) (TSC and PL).

-Based on the experimental evidence (e.g. TEM) energetic (hadron) bombardment results in not only clusters of defects but even amorphous inclusions.

-Theoretical calculations have shown that these kind of amorphous defect clusters introduce acceptors in the lower part of the band-gap of Silicon. Good candidates to be associated with amorphous inclusions in Silicon are the previously detected H116K, H140K and H152K defects (responsible for the reverse annealing in hadron irradiated silicon).

Publications (2009-2010)

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Topics of research Year 2011 (Discussion)

- Further defect analysis at high fluences 10^{15} – 10^{16} cm^{-3}
- Investigate defects in p-type as well as n-type Si materials
- Differences in radiation induced defects in Fz vs MCz materials
- Microscopic phenomena driving charge multiplication
-Radiation induced defects in mixed irradiation fields
-Create a list of defects and properties relevant for macroscopic performances – good for simulation
-Cluster simulation : comparison of existing tools and development;
-Increase studies with TEM and HRTEM to analyse cluster
-nitrogen doped Si : can link to oxygen check availability in market