Defect and Material Characterization

Envisaged there are 3 interlinked research work packages (WPx). The corresponding milestones (Mxy) and delivery times as described below:

WP1. Analysis of electrically active defects and of the radiation induced changes in the electrical characteristics of devices built on p-type silicon (1st to 60th month).

M1.1. Detection/characterization of all the defects induced by irradiation in STFZ and defect engineered p-type silicon pad sensors. (12 month)

M1.2. Determine defect annealing behavior in STFZ and defect engineered p-type silicon pad sensors during treatment at 80 C for minimum 10.000 min.– correlation with the device performance – LC, Neff, trapping times and E-field distribution (18 month)

M1.3. Determine defect transformations and kinetics in STFZ and defect engineered p-type silicon pad sensors during treatments at high temperatures (between 150 and 350 C) – correlation with the device performance – LC, Neff, trapping times (24 month)

M1.4. Identify the role of impurities in the formation of the defects impacting on the device performance (30 month)

M1.5. Detection/characterization of radiation induced defects in LGAD and HVCMOS sensors based on STFZ and defect engineered p-type silicon, establish the annealing behavior (annealing at 80 C), correlation with electrical performance of the devices (month 36)

M1.6. Validity tests on optimized defect engineered sensors (pads, LGADs and HVCMOSs) - comparison prediction and experiment, evaluate the need for a next optimization run of experiments (month 42)

M1.7. Validity tests on finally optimized defect engineered sensors (pads, LGADs and HVCMOSs) (month 60)

WP2. Microstructural Investigations of extended and clustered defects by electron microscopy (6th to 36th month).

M2.1. Microstructural characterization of the irradiation induced clustered defects, fluences between 10^{15} and 10^{17} cm^{-2} and monitor the evolution of clusters at 80 C (month 12)

M2.2. In situ- annealing studies at 5 temperatures (between 150 C and 350 C) in order to determine the structural transformations of the extended and clustered defects (month 24)

M2.3. Microstructural characterization of the oxide-semiconductor interface in irradiated LGADs and HVCMOS devices, time evolution at 80 C (month 36)

M2.4. Microstructural characterization of the oxide-semiconductor interface in irradiated optimized LGADs and HVCMOS devices (month 48)

WP3. Theory (during the 3rd to 60th month).

M3.1. Modelling the detected defect generation/kinetics and the impact on the device performance corresponding to annealing treatments at 80 C (month 24)

M3.2. Modelling the detected defect generation/kinetics and the impact on the device performance corresponding to annealing at high temperatures (between 150 C and 350 C) and conclude about the role of the intentional added impurities (month 30)

M3.3 Identify the optimal impurities concentrations for pads, LGADs and HVCMOSs to be produced. (36 month)

M3.4 Correcting the developed models according to validity test foreseen as M1.6 and provide new optimization solutions for M 1.7. (month 48)

M3.5. Validity test for the developed theoretical models based on the results obtained on M1.7 optimized sensors (month 60)

Research for the next 5 years focusses on irradiated p-type silicon (B or Ga-doped, C co-doped) with the aim of revealing and characterizing the radiation induced defects, evaluate their impact on sensor properties and provide the input defect parameters. Detailed defect investigation could reveal mitigating solutions to acceptor removal in p-type sensors.

- standard and defect engineered p-type silicon, pads, LGADs and HVCMOS.
- different type of irradiations covering irradiation fluences from 10^{11} to 10^{17} cm^{-2}, equivalent 1 MeV neutrons.
- advanced defect analyses

⇒ – many different samples, manpower and equipment (a common RD50 project would help)