WG3 - Discussion

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Summary of talks today

6 talks in the WG2-WG3 joint session

Studies on LGADs (p-type Silicon), several thickness and types of gain layers, with or without Carbon co-doping, different type of irradiations, various techniques (IBIC, Alpha Spectroscopy 1-6 MeV, SPA/TPA-TCT, CV/IV)

- *gain loss, acceptor removal rates, NIEL scaling*

12 presentations in the WG3 session

Studies on Silicon, p-on-n and n-on-p diodes, LGADs (p-type and n-type Silicon, RSD/AC-LGAD), and SiC Schottky diodes, different irradiations and investigation techniques(IV/CV, CCE, sheet resistance, FTIR, ODMR, DLTS, TSC), theoretical modeling of point defects (DFT)

- *Surface and bulk damage, gain loss, donor and acceptor removal effects, radiation induced defects, formation energies and transitions between charge states*

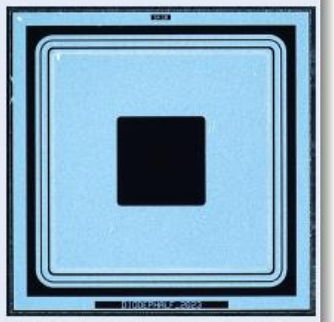
WP3-WG3 project

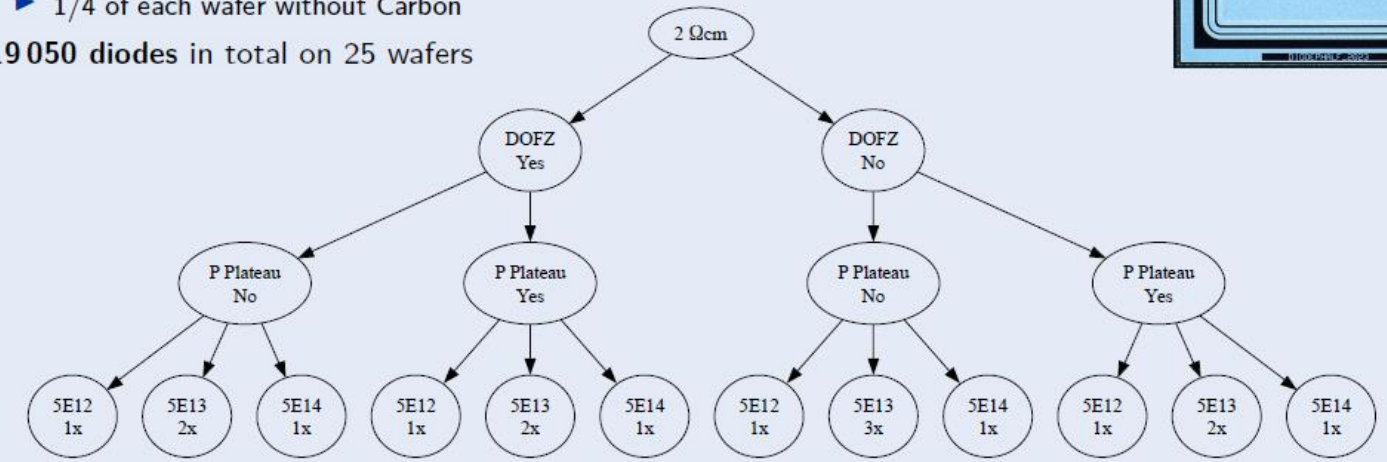
Radiation damage in Si PiN and LGAD sensors (CERN-DRD3-PROJECT-2024-005)

- Samples fabricated within RD50 – 2022 -01 project: *Defect engineering in PAD diodes mimicking the gain layer in LGADs*

PiN diodes, mimicking the gain layer in LGADs, with bulk resistivity of 2 Ωcm and 10 Ωcm are now ready for radiation damage investigations.

- *p*-type Silicon pad diodes, FZ and DOFZ wafers
- 2 Ω cm and 10 Ω cm wafers, 250 µm and 525 µm thickness respectively
- Large diodes 6.25 mm^2, small diodes 1.56 mm^2
- Phosphorus plateau co-doping for some wafers
- 3 Carbon implantation doses: $5 \cdot 10^{12}\,cm^{-2}$, $5 \cdot 10^{13}\,cm^{-2}$ and $5 \cdot 10^{14}\,cm^{-2}$
  - 1/4 of each wafer without Carbon
- **19 050 diodes** in total on 25 wafers





- ❑ Large quantity (**19050**) of diodes produced for defect spectroscopy
- ❑ Different flavours to check effects of Carbon, Boron, Oxygen and Phosphorus content
- ❑ First proton irradiation campaign completed, annealing study ongoing

see Niels "**Gain-Layer Project**" talk

Institutions involved

Country	Collaborating Institution	Town	Institution Code	Contact
Germany	CiS Forschungsinstitut für Mikrosensorik GmbH	Erfurt	CiS	Kevin Lauer
Germany	Institute for Experimental Physics, University of Hamburg	Hamburg	UHH	Jörn Schwandt
Italy	INFN Torino	Torino	Torino	Valentina Sola
Lithuania	Vilnius University	Vilnius	VU	Tomas Ceponis
Romania	National Institute of Materials Physics	Magurele	NIMP	Ioana Pintilie
Romania	Horia Hulubei National Institute for R\&D in Physics and Nuclear Engineering	Magurele	NIPNE	George Alexandru Nemnes
Romania	Institute of Space Science - INFLPR Subsidiary	Magurele	ISS	Andrea Danu
Slovenia	Jožef Stefan Institute	Ljubljana	JSI	Gregor Kramberger
Switzerland	CERN	Geneve	CERN	Michael Moll
Spain	IFCA-CSIC-UC	Santander	ICFA	Ivan Vila
China	IHEP		IEHP	Mei Zhao

Project leader: Ioana Pintilie

Deliverables and time scale, as planned in Annex 7 of MoU

Number	Title	Description	Start date	End Date	Institutions
Di.1	**Report on microscopic and macroscopic investigations in irradiated defect engineered gain layers for Si based LGADs,** fluences up to 10^{17} n_{eq}/cm^2	- SIMS, IV/CV, CCE, TCT characterization - DLTS/TSC/TSCap/FTIR/PL/Hall investigations - annealing studies - *Geant4&TRIM,* Molecular Dynamics (*MD*) simulations and *ab initio* calculations using density functional theory (*DFT*) for the relevant defect configurations	**Q2 2025**	**Q3 2027**	**NIMP**, CERN, CiS, NIPNE, INFM Torino, Vilnius, IFCA, JSI, ISS, IHEP
Di.2	**Device modeling of PiN and LGAD devices with radiation induced defects**	The changes in I-Vs/C-Vs will be investigated using customized computer programs accounting for the results of *MD* and *ab initio* simulations. The information provided by the 3D models about charging and current distribution will be further refined by including the specific technology details in TCAD. An evaluation based on fluence, irradiation type and annealing will be used for developing parametrization models based on Machine Learning (*ML)* tools. This will enable a predictive tool that will by-pass the TCAD time and resource consuming calculations.	**Q1 2026**	**Q4 2027**	**HH**, NIPNE, NIMP, CERN, JSI, INFN Torino
Di.3	**Report on microscopic and macroscopic investigations in irradiated defect engineered optimized LGADs,** fluences up to 10^{17} n_{eq}/cm^2	Based on previous experimental results and developed parametrization models the most promising in terms of radiation hardness defect engineered LGADs will be fabricated and characterized from microscopic and macroscopic point of view.	**Q1 2027**	**Q4 2028**	**CERN**, NIMP, HH, CiS, IHEP, JSI, NIPNE, ISS, Vilnius, ISS, INFN Torino

WG3 – RD50 projects

Title	Contact person
1. **RD50-2023-05: PAB – Partial Activation of Boron to enhance the radiation tolerance of the gain implant**	*Valentina Sola, INFN Torino*
2. **RD50-2023-06: Impact ionization parametrization at extreme fluences**	*Gregor Kramberger, JSI*
3. **RD50 -2023-07: PIN sensors for dosimetry & NIEL studies**	*Michael Moll, CERN*

Start regular WG3 zoom meeting for following the progress in both WG3-WP3 and RD50 projects, e.g. once at 2 months?