27th RD50 Workshop (CERN)

Report of Contributions

https://indico.cern.ch/e/456679

Contribution ID: **0** Type: **Standard (20 min including discussion)**

Characterization of sensors from US vendor Tezzaron/Novati

Friday 4 December 2015 11:30 (20 minutes)

The US CMS Outer Tracker group received a first set of wafers from Tezzaron/Novati, which had been fabricated as part of an innovation grant from the US Department of Energy. A preliminary characterization has been carried out by three US institutes and aside from an anomaly with the guard ring structure the results are promising. The wafers contain a number of test structures, some of which are relevant for the Phase II Outer Tracker replacement and some for the High Granularity Calorimeter. Results from measurements of diode and strip structures are presented.

Primary author: SPIEGEL, Lenny (Fermi National Accelerator Lab. (US))

Presenter: SPIEGEL, Lenny (Fermi National Accelerator Lab. (US))

Session Classification: 3D and Pixel detectors

Contribution ID: **1** Type: **not specified**

PSI-ROC4SENS: a pixel-ROC for sensor studies [Thu/Fr 10:00-12:00]

Friday 4 December 2015 11:50 (20 minutes)

The PSI chip design team has submitted the ROC4SENS, an analogue pixel chip in $0.25\,\mu$m technology which is dedicated for sensor studies. It has a size of $7.8 \times 9.8\,\mathrm{mm}^2$ covered by 155×160 pixels with a pitch of $50 \times 50\,\mu\mathrm{m}^2$.

The pixel cell does not contain a discriminator and therefore does not apply a threshold on the signal. However this means the data will not be zero suppressed and a sequential read out of all (connected) pixels is necessary.

The ROC was submitted parasitically to the P-ROC 600 for the inner pixel layer of the CMS phase1 upgrade. A small number of samples for a test of its functionality will be available in January 2016.

The talk will describe the design of the ROC4SENS and its mode of operation.

Primary author: WIEDERKEHR, Stephan (Paul Scherrer Institut (CH))

Co-authors: MEIER, Beat (Paul Scherrer Institut (CH)); KAESTLI, Hans-Christian (Paul Scherrer Institut (CH)); HORISBERGER, Roland (Paul Scherrer Institut (CH)); ROHE, Tilman (Paul Scherrer Institut (CH))

Presenter: WIEDERKEHR, Stephan (Paul Scherrer Institut (CH))

Session Classification: 3D and Pixel detectors

Contribution ID: **2** Type: **Standard (20 min including discussion)**

TCAD simulations of LGAD devices [Wednesday!]

Wednesday 2 December 2015 15:50 (20 minutes)

I will present preliminary results from simulated LGAD devices, before and after irradiation.
Electrical properties and response to MIPs and alpha particles will be discussed,
as a function of irradiation fluences, polarization voltage and device temperature.

Summary

I will present preliminary results from simulated LGAD devices, before and after irradiation.

Primary author: BOMBEN, Marco (Centre National de la Recherche Scientifique (FR))

Co-author: SADROZINSKI, Hartmut (SCIPP, UC santa Cruz)

Presenter: BOMBEN, Marco (Centre National de la Recherche Scientifique (FR))

Session Classification: CMOS sensors and Sensor Producers

Contribution ID: **3** Type: **Standard (20 min including discussion)**

High resistivity, nitrogen-enriched FZ Si wafers for particle detectors

Friday 4 December 2015 10:00 (20 minutes)

We present the properties of the first high-resistivity, nitrogen enriched FZ Si wafers produced within the framework of the NitroSil project. The n-type wafers of 100 mm in diameter were prepared from the high-purity FZ Si crystals grown in <100> direction. The nitrogen doping was performed during the crystals growth and the doping with phosphorus was made by the neutron transmutation process (NTD) that is a unique technique enabling
a strictly controlled and uniform distribution of phosphorus in Si single crystals to be achieved. In order to remove the radiation damage and to obtain the target resistivity, after the NTD processes the crystals were subjected to a heat treatment. The nitrogen rich wafers are characterized by: ρ ≈ 2000 Ωcm, [N] ≈ 1.5E15 cmˆ-3, [O] < 1E16 cmˆ-3, and [C] < 5E15 cmˆ-3. The radial resistivity distributions of N-free and N-rich wafers are compared. The availability of the N-rich wafers on the market of semiconductor materials for particle detectors is discussed.

Primary author: Mr KWESTARZ, Michal (Topsil Semiconductor Materials SA, 133 Wolczynska St., 01-919 Warszawa, Poland)

Co-authors: Mrs SURMA, Barbara (Institute of Electronic Materials Technology, 133 Wolczynska St.,01-919 Warszawa, Poland); Dr HINDRICHSEN, Christian (Topsil Semiconductor Materials A/S, Siliciumvej 1, DK-3600 Frederikssund, Denmark); Dr JABLONSKI, Jaroslaw (Topsil Semiconductor Materials SA, 133 Wolczynska St., 01-919 Warszawa, Poland); Mr JENSEN, Leif (Topsil Semiconductor Materials A/S, Siliciumvej 1, DK-3600 Frederikssund, Denmark); Mr WODZYNSKI, Maciej (Institute of Electronic Materials Technology, 133 Wolczynska St., 01-919 Warszawa, Poland); Prof. KAMINSKI, Pawel (Institute of Electronic Materials Technology, 133 Wolczynska St., 01-919 Warszawa, Poland); Dr SVEIGAARD, Theis (Topsil Semiconductor Materials A/S, Siliciumvej 1, DK-3600 Frederikssund,Denmark)

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Session Classification: 3D and Pixel detectors

Contribution ID: **4** Type: **Standard (20 min including discussion)**

Effect of proton fluence on radiation defect structure of high-purity silicon for particle detectors

Wednesday 2 December 2015 12:20 (20 minutes)

High-resolution photoinduced transient spectroscopy (HRPITS), infrared absorption (FTIR) and photoluminescence (PL) measurements have been applied to determining the properties and concentrations of radiation defect centers formed in high-purity FZ silicon due to the irradiation with 23-MeV protons. The selected four proton fluences were equivalent to 1E14, 5E14, 1E15, and 5E15 cmˆ-2 of 1-MeV neutrons. Before the proton irradiation, the material resistivity had been of ˜ 2000 Ωcm. The irradiation with each fluence resulted in obtaining the material with semi-insulating properties, indicated by the resistivity above 2×10ˆ5 Ωcm. The HRPITS results revealed that the increase in the resistivity is due to the formation of shallow, deep, and midgap radiation defect centers that are likely to be responsible for the charge compensation in the irradiated material. The FTIR results revealed the presence of both VO and V2O centers, as well as of the divacancies in V2 (0) and V2 (-) charge states. In the low-temperature PL spectra, a number of lines attributed to the excitons bound to the defect centers were observed. The C, G, and T lines are related to the complexes involving carbon atoms and the W line is probably related to Si interstitials. The dependences of the radiation defect centers concentrations as a function of the proton fluence were determined.

Primary author: Prof. KAMINSKI, Pawel (Institute of Electronic Materials Technology, 133 Wolczynska St., 01-919 Warszawa, Poland)

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Presenter: Prof. KAMINSKI, Pawel (Institute of Electronic Materials Technology, 133 Wolczynska St., 01-919 Warszawa, Poland)

Session Classification: Defect Characterization

Contribution ID: **5** Type: **not specified**

Drift Mobility and Electric Field in Silicon Detectors Irradiated with Neutrons and Protons up to 1E17 n_eq/cmˆ2 [Thu/Friday]

Thursday 3 December 2015 09:40 (20 minutes)

Electric field in silicon irradiated with neutrons up to 1e17 n_eq/cmˆ2 and PS protons up to 3e16 p/cmˆ2 was investigated by edge-TCT. Methods for absolute determination of electric field were developed and electric field profiles in the silicon bulk obtained. From the v(E) dependence mobility degradation with fluence was extracted. A 1/sqrt(Phi) dependence of mobility on fluence was obseved for both irradiations with protons provoking ˜20 % more degradation at equal NIEL. The observed mobility degradation and the values of electric field indicate substantial reduction of trapping from linear extrapolation of low fluence values.

Primary author: MIKUZ, Marko (Jozef Stefan Institute (SI))

Co-authors: KRAMBERGER, Gregor (Jozef Stefan Institute (SI)); MANDIC, Igor (Jozef Stefan Institute (SI)); ZAVRTANIK, Marko (Jozef Stefan Institute (SI)); CINDRO, Vladimir (Jozef Stefan Institute (SI))

Presenter: MIKUZ, Marko (Jozef Stefan Institute (SI))

Session Classification: Sensors with intrinsic gain

Contribution ID: **6** Type: **Standard (20 min including discussion)**

Carrier lifetime variations in pion irradiated and annealed Si

Wednesday 2 December 2015 12:40 (20 minutes)

Results on research of fluence dependent carrier lifetime variations in pion irradiated and annealed Si will be reported. Profiles of carrier lifetime lateral variation in the as–irradiated p- and n-Si wafer fragments are to be illustrated. The obtained carrier lifetime variations are discussed.

Primary author: GAUBAS, Eugenijus (Vilnius university)

Co-authors: GKOTSE, Blerina (Université Européenne de Bretagne UEB (FR)); GALLRAPP, Christian (CERN); RAVOTTI, Federico (CERN); Mr PAVLOV, Jevgenij (Vilnius University); VAITKUS, Juozas (Vilnius University); GLASER, Maurice (CERN); MOLL, Michael (CERN); Dr CEPONIS, Tomas (Vilnius University)

Presenter: GAUBAS, Eugenijus (Vilnius university)

Session Classification: Defect Characterization

Contribution ID: **7** Type: **Standard (20 min including discussion)**

Ongoing activities at CiS

Friday 4 December 2015 10:20 (20 minutes)

The CiS research institute is engaged in developments of radiation detector technologies on several different fields. Current projects are dealing e.g. with large area thinned sensors, active edge sensors, sensor-chip packaging technologies and defect engineering.
For large area sensors, the need for smaller thicknesses can be approached by etching cavities to the sensors back side while guaranteeing stability on wafer level by thick frames at the edges. A first n-in-p pixel run with membranes up to 4x4cm² is finished and shows promising results. An active edge sensor run is currently ongoing. The status of the production, especially results of the challenging ICP trench etching step will be shown.

Primary author: WITTIG, Tobias (CIS Institut fuer Mikrosensorik GmbH (DE))

Co-authors: LAUER, Kevin (CIS Institut fuer Mikrosensorik GmbH (DE)); RODER, Ralf Mario (CIS Institut fuer Mikrosensorik GmbH (DE))

Presenter: WITTIG, Tobias (CIS Institut fuer Mikrosensorik GmbH (DE))

Session Classification: 3D and Pixel detectors

Contribution ID: **8** Type: **Standard (20 min including discussion)**

TSC measurements on 200 µm pad diodes, irradiated with 23 MeV protons [Wednesday]

Wednesday 2 December 2015 11:40 (20 minutes)

Future HEP experiments will have to face neutron equivalent fluences up to $2{\cdot}10^{16}$ neq/cm^2 and an ionizing dose in the order of a few MGy. Thin n+p Si sensors are potential candidates for coping with such radiation environment, but more experimental data are essential in order to: firstly, get a deeper understanding of the properties of hadron induced defects, and secondly develop a radiation damage model based on microscopic measurements such as the Thermally Stimulated Current (TSC) measurements.

In view of this and as a first step, TSC measurements were performend on 200 µm thick Float-Zone (FZ) p- and n-type pad diodes, irradiated with 23 MeV protons. The samples were irradiated in the fluence range $(0.3\text{-}1){\cdot}10^{14}$ neq/cm^2 , so that the maximal temperature at which the TSC signal is still sharply distinguishable from the background is 200 K.
During the talk special focus will be given on the newly developed analysis tool for TSC spectra, in order to e.g. calculate defect introduction rates and investigate their annealing behaviour.

Primary author: DONEGANI, Elena (University of Hamburg)

Co-authors: JUNKES, Alexandra (Hamburg University (DE)); FRETWURST, Eckhart (II. Institut fuer Experimentalphysik); GARUTTI, Erika (DESY)

Presenter: DONEGANI, Elena (University of Hamburg)

Session Classification: Defect Characterization

Contribution ID: **9** Type: **Standard (20 min including discussion)**

KDetSim - a ROOT based detector simulation package

Thursday 3 December 2015 15:10 (20 minutes)

A full 3D package for charge collection simulations in semiconductor detectors has been developed within the ROOT framework. It solves Poisson and Laplace equations for a given space charge in different materials. The simulation of induced current takes into account all relevant physics processes such as drift, diffusion and impact ionization and trapping.The basics/fundamentals of the package will be described and several examples shown.

Primary author: KRAMBERGER, Gregor (Jozef Stefan Institute (SI))

Presenter: KRAMBERGER, Gregor (Jozef Stefan Institute (SI))

Session Classification: Simulations

Contribution ID: **10** Type: **Standard (20 min including discussion)**

Comparisson of different non-commercial detector simulation packages

Thursday 3 December 2015 15:30 (20 minutes)

Simulation tools designed for charge collection studies were developed by different groups within rd50. These tools solve Poisson equation for a given space charge (rather than calculating it from microscopic defects). Unlike commercial packages they allow for fast simulation of drift and diffusion of generated charges allowing Monte Carlo approach on studies of detector performance. They are also ideal for simulations of TCT measurements. In order to assure reliable comparison of simulations with measurements different simulations packages were cross-calibrated by comparison of induced currents in simple well known structures. A reasonable agreement has been found with small differences usually arising from different mobility parameterizations.

Primary authors: KRAMBERGER, Gregor (Jozef Stefan Institute (SI)); FERNANDEZ GARCIA, Marcos (Universidad de Cantabria (ES)); CARTIGLIA, Nicolo (Universita e INFN Torino (IT))

Co-authors: JANSEN, Hendrik (Deutsches Elektronen-Synchrotron Hamburg and Zeuthen (DE)); KUEHN, Susanne (Albert-Ludwigs-Universitaet Freiburg (DE)); WONSAK, Sven (University of Liverpool (GB))

Presenter: KRAMBERGER, Gregor (Jozef Stefan Institute (SI))

Session Classification: Simulations

Contribution ID: **11** Type: **Standard (20 min including discussion)**

TCAD 2D SIMULATIONS FOR PHASE II PIXEL SENSOR DESIGN

Thursday 3 December 2015 17:20 (20 minutes)

The pixel sensors of the CMS silicon tracker are required to be upgraded to sustain the harsh radiation environment that will be generated during the High Luminosity Large Hadron Collider (HL-LHC) era. To overcome the problem of radiation damage in Si sensors, an R&D effort is being carried out by the Si sensor Device Simulation Group on different designs of pixel sensors through TCAD simulations. The Si pixel are n-on-p types having two different values of strip-pitch, i.e. 50 um and 25 um. In these two configurations, geometries with different isolation techniques (pspray & pstop) and design parameters like the detector thickness, the pspray/pstop peak doping concentration and the depth of the doping, metal overhang, etc have been studied. Various critical parameters like the critical electrical field regions, breakdown voltage, and the charge collection efficiency have been compared as a function of fluence for all these geometries.

Primary author: JAIN, Geetika (University of Delhi (IN))

Co-authors: BHARDWAJ, Ashutosh (University of Delhi (IN)); RANJAN, Kirti (University of Delhi (IN)); RANJEET, Ranjeet (University of Delhi (IN))

Presenter: JAIN, Geetika (University of Delhi (IN))

Session Classification: Simulations

Contribution ID: **12** Type: **Standard (20 min including discussion)**

Remarks on the thermally stimulated current measurement

Wednesday 2 December 2015 12:00 (20 minutes)

The measurement of thermally stimulated current was performed in the irradiated silicon pad detectors excited by light and by forward current. The TSC measurement was performed in the reverse bias regime. The differences in the spectrum are explained by a contribution of the non-equilibrium holes on the modulation of the microinhomogeneities related to the clusters and recombination in the case of light excitation.

Primary author: VAITKUS, Juozas (Vilnius University)

Co-authors: Mr BRAZDZIUNAS, Gytis (Vilnius University); Mr RUMBAUSKAS, Vytautas (Vilnius University)

Presenter: VAITKUS, Juozas (Vilnius University)

Session Classification: Defect Characterization

Contribution ID: **13** Type: **Standard (20 min including discussion)**

Power Dissipation Studies on n-in-n Pixel Sensors

Friday 4 December 2015 12:10 (20 minutes)

The innermost tracking detector of the ATLAS experiment consists of planar n-in-n pixel sensors. Also the newly installed insertable b-layer (IBL) consists of pixel sensors but with a revised design layout and an improved front-end electronics. The envisaged radiation dose in the run II data taking period of the innermost sensors will be a few $10^{15}\mathrm{n_{eq}cm^{-2}}$. Irradiation doses well above $10^{16}\mathrm{n_{eq}cm^{-2}}$ are considered for innermost pixel detector layers in future collider and detector upgrades like the high luminosity LHC (HL-LHC).

This contribution presents the results of a systematic study of power dissipation, which has been performed on several n-in-n single chip sensors, irradiated to fluences up to $2 \times 10^{16}\mathrm{n_{eq}cm^{-2}}$ as well as on all main structures of a non-irradiated IBL prototype wafer. Measurement parameters include variations of sensor bias voltages, operation temperatures, bulk thicknesses and irradiation fluences.

Primary authors: GISEN, Andreas (Technische Universitaet Dortmund (DE)); KLINGENBERG, Reiner (Technische Universitaet Dortmund (DE))

Presenter: GISEN, Andreas (Technische Universitaet Dortmund (DE))

Session Classification: 3D and Pixel detectors

Contribution ID: **14** Type: **Standard (20 min including discussion)**

Status of E-TCT measurements with HV-CMOS test structures

Wednesday 2 December 2015 14:40 (20 minutes)

TCT measurements with focused laser beam were recently made with test structures from different producers of HV-CMOS detectors. The test structures are processed on substrate with different resistivities. In this contribution we will compare TCT measurements with these structures before and after irradiation.

Primary author: MANDIC, Igor (Jozef Stefan Institute (SI))

Presenter: MANDIC, Igor (Jozef Stefan Institute (SI))

Session Classification: CMOS sensors and Sensor Producers

Contribution ID: **15** Type: **not specified**

IV-characterization of silicon sensors irradiated up to 2E16neq/cmˆ2

Thursday 3 December 2015 09:00 (20 minutes)

Miniature silicon strip detectors (˜1x1cm) with different thicknesses (50, 100, 150 and 300 μm) from Hamamatsu K.K. and Micron Semiconductor Ltd. were irradiated at Birmingham and Ljubljana with doses up to 2E16 neq/cmˆ2. IV measurements were performed at different temperatures for the determination of the effective energy Eeff and the current related damage rate α directly after irradiation and after room temperature annealing (10 days and 30 days). The results of these measurements performed at Liverpool will be presented in this talk.

A second set of sensors of the same type and irradiation campaign have been measured in Freiburg with a different set-up. These results will be shown by Moritz Wiehe at this workshop.

Primary author: WONSAK, Sven (University of Liverpool (GB))

Co-authors: CASSE, Gianluigi (University of Liverpool (GB)); TSURIN, Ilya (University of Liverpool (GB)); WORMALD, Michael (University of Liverpool (GB)); WIEHE, Moritz (Albert-Ludwigs-Universitaet Freiburg (DE)); DERVAN, Paul (University of Liverpool (GB)); KUEHN, Susanne (Albert-Ludwigs-Universitaet Freiburg (DE)); AFFOLDER, Tony (University of Liverpool (GB)); PARZEFALL, Ulrich (Albert-Ludwigs-Universitaet Freiburg (DE))

Presenter: WONSAK, Sven (University of Liverpool (GB))

Session Classification: Sensors with intrinsic gain

Contribution ID: **16** Type: **Standard (20 min including discussion)**

Towards to a new radiation damage model for Synopsys TCAD

Thursday 3 December 2015 16:20 (20 minutes)

For the high luminosity phase of the Large Hadron Collider (HL-LHC) at the expected position of the innermost pixel detector layer of the CMS experiment the estimated equivalent fluence after 3000 fb^{-1} is $2{\cdot}10^{16}$ neq/cm^2, and the IEL (Ionizing Energy Loss) dose in the SiO_2 is 5 MGy. The optimization of the pixel sensors and the understanding of their performance as a function of fluence and dose requires implementing a realistic radiation damage model in TCAD simulation. So far the simulations cannot explain simultaneously dark current, electrical field and charge collection efficiency. In addition, they have not been validated for such high fluences.
Therefore, to judge the validity of the currently available models used in the particle physics community, a comparison of the simulation results with I-V, C-V and CCE measurements of irradiated diodes will be presented and some new ideas toward a radiation damage model which accurately describes available data will be discussed.

Primary author: SCHWANDT, Joern (Hamburg University (DE))

Presenter: SCHWANDT, Joern (Hamburg University (DE))

Session Classification: Simulations

Contribution ID: **17** Type: **Standard (20 min including discussion)**

Radiation hardness of 3D pixel detectors up to 2e16 neq/cm2

Friday 4 December 2015 09:20 (20 minutes)

A new generation of radiation-hard 3D detectors optimised for the HL-LHC with small pitches of 25 and 50 um (implying inter-electrode spacings of only about 35 μm) is under development. Until these new productions are available, radiation hardness studies of existing pixel devices from the IBL/AFP generation with about 70 μm inter-electrode spacing are on-going. This presentation will give an overview and focus on recent results obtained with FEI3 pixel detectors irradiated with neutrons in Ljbuljana up to fluences of 2e16 neq/cm2, including IV, power dissipation and charge collection measurements.

Primary authors: VÁZQUEZ FURELOS, David (IFAE - Barcelona (ES)); CAVALLARO, Emanuele (IFAE - Barcelona (ES)); LOPEZ PAZ, Ivan (Universitat Autònoma de Barcelona (ES)); LANGE, Joern (IFAE Barcelona); GRINSTEIN, Sebastian (IFAE - Barcelona (ES))

Presenter: LANGE, Joern (IFAE Barcelona)

Session Classification: 3D and Pixel detectors

Contribution ID: **18** Type: **Standard (20 min including discussion)**

Beam test of 3D pixel detectors up to fluences of 9e15 neq/cm2

Friday 4 December 2015 09:40 (20 minutes)

3D FEI4 pixel detectors from the IBL production were non-uniformly irradiated at CERN-PS with 23 GeV protons up to a maximum fluence of 9e15 neq/cm2. The devices have been studied in beam tests at CERN SPS and good efficiencies of >97% have been achieved at the highest fluence already at 170 V. Especially interesting is the option to study a vast range of fluences on a single pixel device due to the non-uniform beam profile. This presentation will give an overview on the achieved results.

Primary authors: VÁZQUEZ FURELOS, David (IFAE - Barcelona (ES)); CAVALLARO, Emanuele (IFAE - Barcelona (ES)); LOPEZ PAZ, Ivan (Universitat Autònoma de Barcelona (ES)); LANGE, Joern (IFAE Barcelona); GRINSTEIN, Sebastian (IFAE - Barcelona (ES))

Presenter: LOPEZ PAZ, Ivan (Universitat Autònoma de Barcelona (ES))

Session Classification: 3D and Pixel detectors

Contribution ID: **19** Type: **not specified**

Tests of the Signal from Minimum Ionising Particles of 50µm Thick Silicon Micro-Strip Sensors after Extreme Fluences above 3E16 Neq cmˆ2

Thursday 3 December 2015 10:20 (20 minutes)

The development of silicon detectors tolerant to extreme fluences for future high energy and high luminosity hadron colliders (like the upgrade of the present Large Hadron Collider to high luminosity at CERN) is demanded not only for instrumenting the innermost layers (where pixel sensors will be deployed) but also for particle flow calorimetry. The anticipated fluence levels range from 2E16 neq/cmˆ2 in the inner pixel layers to possibly 1E17 neq/cmˆ2 in the forward calorimeter region. The challenge is daunting, because of the large increase of the reverse current and the severe decrease of the signal recorder by the irradiated devices. The use of thin silicon detectors in charge multiplication regime could take the tolerance of silicon detectors further towards satisfying this requirement. We show here the experimental result obtained with silicon micro-strip sensors with a thickness of 50 µm irradiated with neutrons to various fluences up to 3E16 neq/cmˆ2. After irradiation the signal is studied with fast electrons from a radioactive source, to mimic the signal of minimum ionising particles. The sensors are readout with LHC speed electronics (the ALIBAVA system, 40MHz clock speed).

Primary author: CASSE, Gianluigi (University of Liverpool (GB))

Co-authors: MILOVANOVIC, Marko (University of Liverpool (GB)); DERVAN, Paul (University of Liverpool (GB)); WONSAK, Sven (University of Liverpool (GB))

Presenter: CASSE, Gianluigi (University of Liverpool (GB))

Session Classification: Sensors with intrinsic gain

Contribution ID: **20** Type: **Standard (20 min including discussion)**

Simulation of LGAD characteristics taking into account negative feedback in detectors with carrier multiplication

Thursday 3 December 2015 16:40 (20 minutes)

The LGAD characteristics are calculated basing on the model of carrier impact ionization in the p+ built-in layer. It is shown that characteristics of the diodes are controlled by negative feedback via trapping of holes arisen due to impact ionization, which reduces the electric field and the signal gain. The dependences of collected charge vs. bias voltage and fluence are obtained and their correlation with experimental data is shown.

Primary author: Dr VERBITSKAYA, Elena (Ioffe Institute, St. Petersburg)

Co-authors: SHEPELEV, Artem (Ioffe Institute, St. Petersburg); MITINA, Darya (Ioffe Institute, St. Petersburg); Dr EREMIN, Vladimir (Ioffe Institute, St. Petersburg)

Presenter: Dr VERBITSKAYA, Elena (Ioffe Institute, St. Petersburg)

Session Classification: Simulations

Contribution ID: **21** Type: **Standard (20 min including discussion)**

Negative feedback in Si detectors with avalanche multiplication

Thursday 3 December 2015 12:20 (20 minutes)

The negative feedback in silicon heavily irradiated detectors is a basic mechanism which governs the detector performance [V. Eremin, et al., NIM A 658 (2011) 145]. The talk presents a comparative study of the mechanism in P+-I-N+ and Low Gain Avalanche Diodes (LGAD) utilizing the classic structure of avalanche photodiodes performed in the fluence range up to 1x10ˆ15 neq/cm2. The analytical evaluations are applied to express the major trends of the voltage and fluence dependences of the detector parameters.

Primary author: Dr EREMIN, Vladimir (Ioffe Institute, St. Petersburg)

Co-author: VERBITSKAYA, Elena (Ioffe Institute, St. Petersburg)

Presenter: Dr EREMIN, Vladimir (Ioffe Institute, St. Petersburg)

Session Classification: Sensors with intrinsic gain

Contribution ID: **22** Type: **not specified**

Analysis of TCT measurements of highly irradiated silicon pad diodes under forward bias

Thursday 3 December 2015 10:00 (20 minutes)

For highly irradiated silicon sensors the electric field under reverse bias takes the shape of a double junction with high field strength near the implants and a region of low field strength in between. For this condition it is not trivial to disentangle the electric field, (de-)trapping of charge carriers, and the drift velocity all of which are a function of the irradiation and the position in the sensor. However, to a good approximation the electric field is independent of position for forward bias and it can be assumed that also the trapping rates are independent of position. We started to analyze transient current technique (TCT) measurements of forward biased HPK campaign silicon pad diodes irradiated with doses above 10^{15} GeV protons/cm² to obtain information on the trapping and detrapping rates as a function of the electric field and the dose. The analysis and first results will be presented.

Primary author: SCHARF, Christian (Hamburg University (DE))

Co-authors: GARUTTI, Erika (Hamburg University (DE)); KLANNER, Robert (Hamburg University (DE))

Presenter: SCHARF, Christian (Hamburg University (DE))

Session Classification: Sensors with intrinsic gain

Contribution ID: **23** Type: **not specified**

The effective bandgap and current related damage rate of highly irradiated silicon sensors

Thursday 3 December 2015 09:20 (20 minutes)

The reverse current of irradiated silicon sensors has a strong influence on the signal-to-noise-ratio of a detector and leads to significant heat dissipation within the detector. Thus knowledge of the expected reverse current is crucial for detector design and operation.
The dependence of the reverse current on temperature and irradiation fluence is parameterized by the effective bandgap Eeff and the current related damage rate α.
These two quantities were obtained by measurements of the reverse current at temperatures of -32℃, -27℃ and -23℃ in a cold setup using a freezer and peltier. For this study planar n-in-p silicon strip detectors manufactured by Hamamatsu Photonics and Micron Technology irradiated with fluences ranging from 2x1014 to 2x1016 neq/cm2 were used.

Primary author: WIEHE, Moritz (Albert-Luwdigs-University Freiburg)

Co-authors: CASSE, Gianluigi (University of Liverpool (GB)); TSUKERMAN, Ilya (Institute for Theoretical and Experimental Physics (ITEP)); DERVAN, Paul (University of Liverpool (GB)); MORI, Riccardo (Albert-Ludwigs-Universitaet Freiburg (DE)); KUEHN, Susanne (Albert-Ludwigs-Universitaet Freiburg (DE)); WONSAK, Sven (University of Liverpool (GB)); AFFOLDER, Tony (University of Liverpool (GB)); PARZEFALL, Ulrich (Albert-Ludwigs-Universitaet Freiburg (DE))

Presenter: WIEHE, Moritz (Albert-Luwdigs-University Freiburg)

Session Classification: Sensors with intrinsic gain

Contribution ID: **26** Type: **not specified**

Welcome

Wednesday 2 December 2015 09:30 (5 minutes)

Presenter: MOLL, Michael (CERN)

Session Classification: Future Detectors & New Irrad Facilities

Contribution ID: **27** Type: **not specified**

Challenges for Particle Detectors at Future Circular Colliders

Wednesday 2 December 2015 09:35 (35 minutes)

The Future Circular Collider (FCC) is an integral conceptual design study for post - LHC particle accelerator options in a global context. It is exploring the potential of hadron and lepton circular colliders, performing an in - depth analysis of infrastructure and operation concepts and

considering the technology research and development programs that would be required to build a future circular collider. A conceptual design report will be delivered before the end of 2018, in time for the next update of the European Strategy for Particle Physics. This talk will give an

overview of the FCC studies and present specific aspects of experiments and detectors at the 100 TeV hadron collider that is a key part of this study.

Presenter: RIEGLER, Werner (CERN)

Session Classification: Future Detectors & New Irrad Facilities

Contribution ID: **28** Type: **not specified**

The new CERN proton irradiation facility

Wednesday 2 December 2015 10:10 (20 minutes)

Presenter: GLASER, Maurice (CERN)

Session Classification: Future Detectors & New Irrad Facilities

Contribution ID: **29** Type: **not specified**

Discussion on Defect Characterization

Wednesday 2 December 2015 13:00 (20 minutes)

Primary author: MOLL, Michael (CERN)

Presenter: MOLL, Michael (CERN)

Session Classification: Defect Characterization

Contribution ID: **30** Type: **Standard (20 min including discussion)**

Status of 3D detector activities at CNM

Friday 4 December 2015 09:00 (20 minutes)

I will present the last fabrication run ongoing at CNM-IMB on 3D detectors activities for the LHC upgrade and the status of the RD50 project related to 3D.

Primary author: PELLEGRINI, Giulio (Centro Nacional de Microelectrónica (IMB-CNM-CSIC) (ES))

Presenter: PELLEGRINI, Giulio (Centro Nacional de Microelectrónica (IMB-CNM-CSIC) (ES))

Session Classification: 3D and Pixel detectors

Contribution ID: **31** Type: **Standard (20 min including discussion)**

Status of CNM developments on LGAD and iLGAD detectors

Thursday 3 December 2015 11:20 (30 minutes)

We will present the last technological developments at CNM on LGAD and iLGAD detectors. The last electrical performances for pad and strip LGADs will also be presented, showing that the fabricated LGAD detectors have a voltage capability higher than 1000 V with leakage currents in the 20 nA/cm2 range, and a linear gain in the typical operating reverse voltage values (200 to 800 V) in the range of 5-10. However, red laser scanning measurements revealed a non-uniform multiplication across the strip LGAD, basically due to technological constrains.

Primary author: Dr HIDALGO, Salvador (Centro Nacional de Microelectronica (IMB-CNM-CSIC))

Co-authors: Dr MERLOS, Angel (Centro Nacional de Microelectronica (IMB-CNM-CSIC)); GALLRAPP, Christian (CERN); Dr FLORES, David (Centro Nacional de Microelectronica (IMB-CNM-CSIC)); Dr QUIRION, David (Centro Nacional de Microelectronica (IMB-CNM-CSIC)); Dr PELLEGRINI, Giulio (Centro Nacional de Microelectronica (IMB-CNM-CSIC)); SADROZINSKI, Hartmut (University of California,Santa Cruz (US)); VILA ALVAREZ, Ivan (Universidad de Cantabria (ES)); Mrs CARULLA, Mar (Centro Nacional de Microelectronica (IMB-CNM-CSIC)); FERNANDEZ GARCIA, Marcos (Universidad de Cantabria (ES)); Mrs BASELGA, Marta (Centro Nacional de Microelectronica (IMB-CNM-CSIC)); MOLL, Michael (CERN); Dr FERNANDEZ-MARTINEZ, Pablo (Centro Nacional de Microelectronica (IMB-CNM-CSIC)); FADEYEV, Vitaliy (University of California,Santa Cruz (US)); GALLOWAY, Zachary Lev; LIANG, Zhijun (University of California,Santa Cruz (US))

Presenter: Dr HIDALGO, Salvador (Centro Nacional de Microelectronica (IMB-CNM-CSIC))

Session Classification: Sensors with intrinsic gain

Contribution ID: **32** Type: **Standard (20 min including discussion)**

Radiation hardness studies of neutron and proton irradiated CMOS sensors fabricated in the ams H18 high voltage process

Wednesday 2 December 2015 14:20 (20 minutes)

High voltage CMOS detectors (HVCMOSv3), fabricated in the ams H18 high voltage process, with a substrate resistivity of $10\Omega \cdot \mathrm{cm}$ were irradiated with 24 GeV/c protons up to a fluence of 7×10^{15} n_{eq}/cm^2 and thermal neutrons up to a fluence of 2×10^{16} n_{eq}/cm^2. The detectors were characterized using edge-TCT. Both, the collected charge and the depletion depth increased after irradiation, showing a benefitial effect of irradiation on low resistivity silicon.

Primary author: FERNANDEZ GARCIA, Marcos (Universidad de Cantabria (ES))

Co-authors: GALLRAPP, Christian (CERN); MUENSTERMANN, Daniel (Lancaster University (GB)); MOLL, Michael (CERN)

Presenter: FERNANDEZ GARCIA, Marcos (Universidad de Cantabria (ES))

Session Classification: CMOS sensors and Sensor Producers

Contribution ID: **33** Type: **not specified**

Discussion (HVCMOS & Sensor Producers)

Wednesday 2 December 2015 16:10 (30 minutes)

Presenter: CASSE, Gianluigi (University of Liverpool (GB))

Session Classification: CMOS sensors and Sensor Producers

Contribution ID: **34** Type: **not specified**

Discussion Session on High Fluence Effects/Radiation

Thursday 3 December 2015 10:40 (20 minutes)

Presenter: FRETWURST, Eckhart (II. Institut fuer Experimentalphysik)

Session Classification: Sensors with intrinsic gain

Contribution ID: **35** Type: **Standard (20 min including discussion)**

TCAD simulation of Low Gain Avalanche Detectors

Thursday 3 December 2015 17:00 (20 minutes)

Recently proposed Low Gain Avalanche Detector (LGAD) designs has been subject of increasing interest within Si sensor community. The LGAD devices fabricated by CNM Barcelona have shown promising characteristics before irradiation. But, after hadron irradiation, a significant degradation of gain has been observed in these devices. These results have not been explained by earlier simulations and are attributed to the possible acceptor removal with irradiation. In University of Delhi, detailed simulation using Silvaco TCAD tool for non-irradiated and irradiated LGAD devices have been carried out. An already published effective two trap bulk damage model is used to simulate the radiation damage. The effect of different design parameters and hadron irradiation on LGAD operations will be discussed.

Primary author: DALAL, Ranjeet (University of Delhi)

Co-authors: BHARDWAJ, Ashutosh (University of Delhi (IN)); JAIN, Geetika (University of Delhi (IN)); RANJAN, Kirti (University of Delhi (IN))

Presenter: DALAL, Ranjeet (University of Delhi)

Session Classification: Simulations

Contribution ID: **36** Type: **Standard (20 min including discussion)**

Simulations of HV-CMOS

Wednesday 2 December 2015 15:00 (20 minutes)

Where we present some TCAD simulatinos on HV-CMOS 350 nm AMS, in order to assist the comparison with measurements.

Summary

Where we present some TCAD simulatinos on HV-CMOS 350 nm AMS, in order to assist the comparison with measurements.

Primary author: PALOMO PINTO, Francisco Rogelio (Universidad de Cantabria (ES))

Co-authors: FERNANDEZ GARCIA, Marcos (Universidad de Cantabria (ES)); MOLL, Michael (CERN); HIDALGO VILLENA, Salvador (Instituto de Microelectronica de Barcelona (ES))

Presenter: PALOMO PINTO, Francisco Rogelio (Universidad de Cantabria (ES))

Session Classification: CMOS sensors and Sensor Producers

Contribution ID: **37** Type: **Standard (20 min including discussion)**

Characterization of LGAD sensors from CNM Run 7859

Thursday 3 December 2015 12:00 (20 minutes)

Results from the study of LGADs from CNM Run 7859 will be presented. TCT+, CV/IV and Sr90 source measurements were performed before irradiation. Some of these sensors have been subjected to proton irradiation at CERN. The fluences to which these were exposed are 1E12, 1E13, 1E14 and 1E15 neq/cmˆ2. CV/IV curves of the irradiated samples were obtained and will be presented together with an outline of future studies to be conducted: TCT+, timing and Sr90 source measurements after irradiation; tests on strip LGADs.

Primary author: OTERO UGOBONO, Sofia (Universidade de Santiago de Compostela (ES))

Presenter: OTERO UGOBONO, Sofia (Universidade de Santiago de Compostela (ES))

Session Classification: Sensors with intrinsic gain

Contribution ID: **38** Type: **Standard (20 min including discussion)**

Van-de-Graaff Accelerator at IEAP CTU in Prague [not Friday]

Wednesday 2 December 2015 11:00 (20 minutes)

In the laboratory building of the Faculty of Mathematics and Physics, Charles University (FMP CU) in Prague Troja an electrostatic ion accelerator, Van de Graaff HV2500 (product of the HVE Europe) with maximum energy 2.5 MeV protons is currently in operation. Accelerator was commisioned in 80th of 20th century, and now is upgraded and operated by IEAP CTU staff. It is planned to maintain it in the mode "open access" minimally to 2022.

Primary author: SOLAR, Michael (Czech Technical University (CZ))

Co-authors: GRANJA, Carlos (Czech Technical University (CZ)); POSPISIL, Stanislav (Institute of Experimental and Applied Physics, Czech Technical University in Prague)

Presenter: SOLAR, Michael (Czech Technical University (CZ))

Session Classification: Future Detectors & New Irrad Facilities

Contribution ID: **39** Type: **Standard (20 min including discussion)**

Reading out thin LGADs

Thursday 3 December 2015 13:00 (20 minutes)

For the use as Ultra-Fast Silicon Detectors, we are planning to use thin (50um) LGAD.
We will report on our measurements and simulations on thin epi sensors and the issues a fast readout will bring

Primary author: SADROZINSKI, Hartmut (University of California,Santa Cruz (US))

Co-author: UFSD TEAM, UCSC Torino CNM LPNHE IJS (RD50)

Presenter: SADROZINSKI, Hartmut (University of California,Santa Cruz (US))

Session Classification: Sensors with intrinsic gain

Contribution ID: **40** Type: **Standard (20 min including discussion)**

Timing resolution of 300-micron thick LGAD sensors from CNM at testbeam and comparison with simulation.

Thursday 3 December 2015 12:40 (20 minutes)

In this contribution I will report on the the timing resolutions of 300-micron thick LGAD sensors from CNM obtained at testbeams and compare the results with prediction from simulations.
I will also illustrate the timing capabilities of future thin LGAD production and report on potential use of LGADs at LHC.

Primary author: CARTIGLIA, Nicolo (Universita e INFN Torino (IT))

Co-author: UFSD TEAM (SANTA CRUZ, TORINO), . (UCSC, INFN)

Presenter: CARTIGLIA, Nicolo (Universita e INFN Torino (IT))

Session Classification: Sensors with intrinsic gain

Contribution ID: **41** Type: **Standard (20 min including discussion)**

Effect of Al2O3 passivation layer in irradiated n-on-p strip sensors [Thursday]

Thursday 3 December 2015 17:40 (20 minutes)

The significant advantages of detectors manufactured on p-type silicon material over n-type detectors in the HEP particle tracking applications
have been well documented in the R&D community. In AC-coupled p-type position-sensitive strip detectors, however, the fixed oxide
charge in the silicon dioxide is positive and, thus, causes electron accumulation at the Si/SiO2 interface. Thus, the n-type strips
become short-circuited without additional isolation implantations. The higher processing complexity resulting from this requirement can be avoided
by the use of aluminum oxide (Al2O3, alumina) thin-film insulator, grown by Atomic Layer Deposition (ALD) method. The negative oxide
charge in ALD-oxide provides strip isolation without any additional isolation structures. Measurement and TCAD simulation study of a MOS test
structure with alumina layer show a considerable accumulation of negative oxide charge in ALD-oxide after Co-60 gamma-ray irradiations. Also
a comparative study of the simulated surface properties between alumina, p-stop and p-spray sensors will be presented. Furthermore, measurements
of 2e15 neq/cm2 proton irradiated p-type MCz-Si strip sensors with alumina thin-film insulator are compared to the simulations of corresponding
sensor design as well as with conventional isolation structures.

Summary

The effect of Al2O3 passivation layer in n-on-p strip detectors irradiated by protons up to 2e15 neq/cm2 was studied both by measurements
and TCAD simulations. The accumulation of negative oxide charge in ALD-oxide was verified by Co-60 gamma-ray irradiations.

Primary authors: HAERKOENEN, Jasu (Helsinki Institute of Physics (FI)); PELTOLA, Timo Hannu Tapani (Helsinki Institute of Physics (FI))

Presenter: PELTOLA, Timo Hannu Tapani (Helsinki Institute of Physics (FI))

Session Classification: Simulations

Contribution ID: **42** Type: **Standard (20 min including discussion)**

Status of LGAD RD50 projects

Thursday 3 December 2015 14:30 (20 minutes)

I will do a short summary on the status of the RD50 funding projects related to LGAD detectors.

Primary author: PELLEGRINI, Giulio (Centro Nacional de Microelectrónica (IMB-CNM-CSIC) (ES))

Presenter: PELLEGRINI, Giulio (Centro Nacional de Microelectrónica (IMB-CNM-CSIC) (ES))

Session Classification: Simulations

Contribution ID: **43** Type: **not specified**

Discussion Session on TCAD Simulations

Thursday 3 December 2015 18:00 (30 minutes)

Presenters: KRAMBERGER, Gregor (Jozef Stefan Institute (SI)); EREMIN, Vladimir (Ioffe Physical Technical Institute of Russian Academy of Scienc)

Session Classification: Simulations

Contribution ID: **44** Type: **not specified**

Development of the space oriented vacancy – interstitial cluster model

Wednesday 2 December 2015 11:20 (20 minutes)

We report about the progress of study of the model of vacancy-interstitial defect cluster presented earlier at 26th Cern RD50 workshop. According to this model the defect cluster is realized as a confined inclusion of disordered vacancy and interstitial defects where the subregion of interstitials is shifed from the subregion of vacancies along the trajectory of incident high energy particle. Such a structure gives rise to the two regions of acceptor and donor states separated in space. As a consequence of free carriers localization in these states the defect cluster turns into a dipol like space charged object which affects the transport and recombination of the rest of the free carriers.

Presenter: ZASINAS, Ernestas (Vilnius University)

Session Classification: Defect Characterization

Contribution ID: **45** Type: **not specified**

Discussion on LGAD

Thursday 3 December 2015 14:50 (20 minutes)

Presenter: PELLEGRINI, Giulio (Universidad de Valencia (ES))

Session Classification: Simulations

Contribution ID: **46** Type: **not specified**

Discussion: 3D and Planar Detectors

Friday 4 December 2015 12:50 (30 minutes)

Presenters: CASSE, Gianluigi (University of Liverpool (GB)); PELLEGRINI, Giulio (Universidad de Valencia (ES))

Session Classification: 3D and Pixel detectors

Contribution ID: **47** Type: **Standard (20 min including discussion)**

Thin n-in-p planar pixel sensor productions at MPP

Friday 4 December 2015 11:10 (20 minutes)

New productions of thin n-in-p pixel sensors designed at MPP will be presented.
Sensors in the thickness range between 50 and 150 um have been produced at ADVACAM on SOI wafers with slim or active edges. Evaluation assemblies have been measured by means of radioactive source scans and beam tests.
The performance after irradiation in terms of hit efficiency of different pixel cell designs will be discussed.
The main focus is the optimization of the punch-through and bias rails to limit the loss of efficiency caused by these structures at high levels of irradiation.
The results have been used in the design of the sensors for the new RD53 read-out chips implemented in the coming productions at MPG-HLL and CIS.
Measurements of charge collection at different depths in the pixel sensor bulk have been obtained with the grazing angle technique for n-in-p pixel sensors.
This analysis also allows for the determination of hit efficiency with small pixel pitches in the high pseudo-rapidity range of the new pixel systems at HL-LHC.

Primary author: SAVIC, Natascha (Max-Planck-Institut fuer Physik (Werner-Heisenberg-Institut) (D)

Presenter: SAVIC, Natascha (Max-Planck-Institut fuer Physik (Werner-Heisenberg-Institut) (D)

Session Classification: 3D and Pixel detectors

Contribution ID: **48** Type: **not specified**

Characterization of LGAD sensors from CNM Run 7062

Thursday 3 December 2015 11:50 (10 minutes)

Presenter: MATEU SUAU, Isidro (Centro de Investigaciones Energ. Medioambientales y Tecn. - (ES)

Session Classification: Sensors with intrinsic gain

Contribution ID: **49** Type: **not specified**

Spokesperson Report

Presenter: MOLL, Michael (CERN)

Contribution ID: **50** Type: **Standard (20 min including discussion)**

LGAD and irradiated doping profiles

Friday 4 December 2015 12:30 (20 minutes)

In the context of the latest CNM LGAD production run, SiMS measurements and simulations are presented for the and nntypr implants. An additional study on irradiated p-implanted doping profiles is performed with fuences of 10ˆ15neq/cmˆ2

Primary author: GKOUGKOUSIS, Vagelis (Laboratoire de l'Accelerateur Lineaire (FR))

Co-authors: LOUNIS, Abdenour (Laboratoire de l'Accelerateur Lineaire (FR)); NELLIST, Clara (LAL-Orsay (FR))

Presenter: GKOUGKOUSIS, Vagelis (Laboratoire de l'Accelerateur Lineaire (FR))

Session Classification: 3D and Pixel detectors