30th RD50 Workshop (Krakow)

Report of Contributions

https://indico.cern.ch/e/637212

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

Charge collection properties of irradiated CMOS detectors

Wednesday, 7 June 2017 10:00 (20 minutes)

Results of E-TCT and Sr90 measurements with CMOS detectors produced by different foundries on p-type substrates with different initial resistivities will be presented. With Edge-TCT method the thickness of depleted layer of passive CMOS detectors was estimated and studied as a function of fluence. Collected charge deposited by MIPs from Sr90 source was measured with external amplifier. Collected charge measured with Sr90 will be compared with E-TCT measurements.

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

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

Session Classification: CMOS

Contribution ID: **2** Type: **not specified**

Measurement of the acceptor removal rate in silicon pad diodes

Wednesday, 7 June 2017 14:20 (20 minutes)

Measurements were made on the depletions voltages of pad diodes of different thickness and resistivity irradiated with protons and neutrons up to 7E15 n_{eq}/cm^2.
Two sets of diodes were used.
Epitaxial diodes with a thickness of 50 μm and different resistivities (10, 50, 250 and 1000 Ohm cm).
Float zone diodes with a resistivity of more than 10 kOhm cm with different thicknesses (100, 150, 200, 285 um).
The depletion voltage is used to extract the effective doping concentration of these devices.
A fit to the data is then done to extrapolate the acceptor removal rate.

Primary authors: Mr DIAS DE ALMEIDA, Pedro Goncalo (FCT Fundacao para a Ciencia e a Tecnologia (PT)); MATEU, Isidre (Centro de Investigaciones Energéti cas Medioambientales y Tecno); FERNANDEZ GARCIA, Marcos (Universidad de Cantabria (ES)); MOLL, Michael (CERN)

Presenter: Mr DIAS DE ALMEIDA, Pedro Goncalo (FCT Fundacao para a Ciencia e a Tecnologia (PT))

Session Classification: Defect and Material Engineering

Contribution ID: **4** Type: **not specified**

Measurements of the timing resolution of Ultra-Fast Silicon Detectors vs. Temperature, Fluence, Thickness, Manufacturer.

Tuesday, 6 June 2017 11:40 (20 minutes)

We report on the performance of UFSD (Ultra-Fast Silicon Detectors) from two vendors CNM (LGAD thickness 45um) and HPK (LGAD thickness 50 and 80um).
We have measured pre-rad and after neutron fluences of 6e14 and 2e15 n/cmˆ2 the leakage current, gain, time jitter, time resolution and the value of Landau fluctuations. The pre-rad measurements were performed at three temperatures (+20C, 0C, -20C) and the post-rad measurements at -20C.
We find that LGAD with higher initial doping concentration achieve post-rad higher gain and better time resolution.
We find a clear advantage of using the thinner LGAD because of the contribution of the Landau Fluctuation to the time resolution.

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

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

Session Classification: Detectors with gain

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

TCAD simulation of silicon detectors: A validation tool for the development of LGAD

Monday, 5 June 2017 15:40 (20 minutes)

It is widely accepted that implantation profiles in the multiplication layer of Low-Gain Avalanche Detectors (LGAD) constitute a critical feature in view of keeping the gain as low as required by high-energy particle timing measurements. One of the most powerful tools we can use to predict the amount of multiplied charges and then the behavior of LGAD, both before and after irradiation, is the numerical simulation. The aim of this contribution is to present extensive results from TCAD simulations of different LGAD devices fabricated by Fondazione Bruno Kessler (FBK), Centro Nacional de Microelectrónica (CNM) and Hamamatsu Photonics K.K. (HPK) and their comparison with a wide spectrum of experimental measurements. I will also propose a robust numerical setup able to accurately reproduce current, gain and most probable charge as a function of the applied bias, temperature and fluence. This result has been achieved thanks to a fine calibration of some crucial physical parameters of the most common avalanche models, either on pin diodes and on LGAD, and also through the implementation of an empirical model accounting for the acceptor removal mechanism.

Primary author: Dr MANDURRINO, Marco (INFN Torino (IT))

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Presenters: Dr MANDURRINO, Marco (INFN Torino (IT)); Dr MANDURRINO, Marco (Universita e INFN Torino (IT))

Session Classification: Device simulation

Contribution ID: **6** Type: **not specified**

Charge collection and electric field properties of irradiated thin n-in-p planar pixel sensors

Monday, 5 June 2017 09:50 (20 minutes)

Results obtained with recent productions of thin n-in-p pixel sensors designed at MPP will be presented. Sensors of 100 and 150 um thickness have been produced at CiS and HLL and were measured before and after interconnection to FE-I4 chips. A modified FE-I4 compatible sensor with a pixel size of 50x250um2 including smaller pixel implants of 50x50um2 was designed to derive prediction on the performance of the 50x50 and 25x100 um2 pixel cells foreseen for the HL-LHC. Charge collection and electric field properties of the different sensor types were obtained by the edge Transient Current Technique (e-TCT) for not irradiated sensors and different irradiation levels up to 1e16 in the entire thickness range. The performance of the sensors in terms of charge collection (obtained by source scan measurements and beam tests) after interconnection will be compared to the e-TCT results.

Primary author: SAVIC, Natascha (Max-Planck-Institut fur Physik (DE))

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Presenter: SAVIC, Natascha (Max-Planck-Institut fur Physik (DE))

Session Classification: Pixel and strip sensors

Contribution ID: **7** Type: **not specified**

Anneal induced transforms of radiation defects in hadron and electron irradiated Si

Wednesday, 7 June 2017 13:40 (20 minutes)

The anneal induced transforms of radiation defects have been studied in n-type and p-type CZ and FZ Si. The samples were irradiated with high energy electrons (6.6 MeV), protons (26 GeV/c) and pions (300 MeV/c) by fluences up to 5×10¹⁶ cm^{−2}. In order to identify the prevailing radiation defects and to trace their evolution during thermal treatments, measurements of temperature dependent carrier trapping lifetime (TDTL) spectroscopy was combined with deep level transient spectroscopy (DLTS). The dominant radiation defects and their transform paths under isothermal and isochronal anneals have been revealed.

Primary authors: Ms MESKAUSKAITE, Dovile (Vilnius University, Institute of Applied Research); Prof. GAUBAS, Eugenijus (Vilnius University, Institute of Applied Research); Dr CEPONIS, Tomas (Vilnius University, Institute of Applied Research); Dr PAVLOV, Jevgenij (Vilnius University, Institute of Applied Research); Dr RUMBAUSKAS, Vytautas (Vilnius University, Institute of Applied Research); Prof. VAITKUS, Juozas (Vilnius University, Institute of Applied Research); Dr MOLL, Michael (CERN); Dr RAVOTTI, Federico (CERN); Dr GALLRAPP, Christian (CERN)

Presenter: Ms MESKAUSKAITE, Dovile (Vilnius University, Institute of Applied Research)

Session Classification: Defect and Material Engineering

Contribution ID: **8** Type: **not specified**

Two Photon Absorption TCT on HVCMOS, LGADs and pin diodes,

Tuesday, 6 June 2017 09:30 (20 minutes)

Edge-TPA measurements on neutron irradiated HVCMOS (CCPDv3, 7e15 neq/cm2) with improved setup and fresh LGADs and pin detectors will be presented. A first attempt to profile doping and electric field from data is envisaged.

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

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

Session Classification: Transient current technique

Contribution ID: **9** Type: **not specified**

Effect of nitrogen doping on characteristics of pad detectors irradiated with high proton fluences

Wednesday, 7 June 2017 14:00 (20 minutes)

The current-voltage characteristics of pad detectors made on high-resistivity FZ Si wafers and irradiated with 23-MeV protons are compared. The studies were performed using the detectors with the active region material of various properties: N-free, N-rich, and O-rich. The nitrogen was introduced during the growth of FZ Si crystal used for producing the substrate wafers. The oxygen was incorporated by the in-diffusion at 1150 oC for 24 h from the oxide layer deposited in the process of detectors fabrication. The detectors were irradiated with the proton fluences of 5E13, 1E14, 5E14, 1E15, and 5E15 n(eq)/cmˆ2. It is shown that after the irradiation with each of these fluences, the active region material of detectors becomes semi-insulating with nearly the intrinsic resistivity. The leakage current is dependent either on the proton fluence or on the material properties. For the lower fluences, 5E13 and 1E14 n(eq)/cmˆ2, the minimal values of the leakage current are observed for the N-rich material, while for the higher fluences, 5E14 and 1E15 n(eq)/cmˆ2, the minimal values of the leakage current are observed for the O-rich material. The results of infrared absorption measurements indicate that the concentration of N-N pairs in nitrogen-enriched FZ Si decreases with increasing the fluence above 5E14 n(eq)/cmˆ2. The properties and concentrations of radiation defect centers in the material of detectors active region have been studied by HRPITS technique. The dependences of the centers concentrations as a function of the proton fluence are demonstrated.

Primary author: Prof. KAMIŃSKI, Paweł (Institute of Electronic Materials Technology)

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Presenter: Prof. KAMIŃSKI, Paweł (Institute of Electronic Materials Technology)

Session Classification: Defect and Material Engineering

Contribution ID: **10** Type: **not specified**

Status & Challenges of Tracker Design for FCC-hh

Wednesday, 7 June 2017 09:00 (30 minutes)

A 100TeV proton collider is the central aspect of the Future Circular Collider (FCC) study. An integral part of the study is the conceptual design of individual detector systems that can exploit the luminosities reaching values of 2x10ˆ35 cmˆ-2 sˆ-1. One of the key limitations in detector design arises from an increased number of pile-up events O(1000), which makes tracking and identification of vertices extremely challenging. This talk will review the general ideas, which drive the current tracker design for the FCC-hh, like material budget, granularity in R-Φ & Z, pattern recognition & tagging capabilities, uniformity of magnetic field across large detection region, occupancy & data rates. We will also discuss the limits of current tracker technologies and requirements on their progress to meet conditions of the FCC-hh environment.

Primary author: DRASAL (ON BEHALF OF THE FCC-HH DETECTOR WORKING GROUP), Zbynek (CERN)

Presenter: DRASAL (ON BEHALF OF THE FCC-HH DETECTOR WORKING GROUP), Zbynek (CERN)

Session Classification: FCC and future developments

Contribution ID: **12** Type: **not specified**

Investigation of modified ATLAS pixel implantations

Monday, 5 June 2017 09:30 (20 minutes)

The innermost tracking detector of the ATLAS experiment consists of planar n-in-n silicon pixel sensors. Closest to the beam pipe lays the insertable b-layer (IBL). Its pixels are arranged in a pitch of $250\,\mu m \times 50\,\mu m$, with a rectangular shaped n-implant.
Based on this design six modified pixel designs have been developed in Dortmund.

The new pixel designs are arranged in structures of ten columns and have been placed besides structures with the standard design on one sensor. Because of a special guard ring design, each structure can be powered and investigated separately. Several of these sensors have been bump bonded to FE-I4 read-out chips. One of these modules has been irradiated with reactor neutrons up to a fluence of $5 \times 10^{15}\,\mathrm{n_{eq}cm^{-2}}$.

This contribution presents the results of this irradiated device, including important sensor characteristics, charge collection determined with radioactive sources and hit efficiency measurements, performed in laboratory and test beam. They are compared with the results of a non-irradiated device.

Primary author: GISEN, Andreas (Technische Universitaet Dortmund (DE))

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

Session Classification: Pixel and strip sensors

Contribution ID: **13** Type: **not specified**

Analytic expressions for time resolution of silicon pixel sensors

Tuesday, 6 June 2017 11:10 (30 minutes)

Silicon sensors with high precision timing are used in present experiments, like the NA62 Gigatracker, or planned to be used for the LHC PhaseII upgrade, like the LGAD development. Trackers with 10um position and 10ps time resolution are quoted as a long term goal for these developments. This report will discuss analytic expressions for the time resolution of silicon sensors, with focus on the key contributions to the time resolution, namely Landau fluctuations, noise and variations of the weighting field. The impact of amplifier bandwidth is discussed as well.

Primary author: RIEGLER, Werner (CERN)

Presenter: RIEGLER, Werner (CERN)

Session Classification: Detectors with gain

Contribution ID: **14** Type: **not specified**

An extenision of Ramo's theorem include resistive elements

Tuesday, 6 June 2017 09:00 (30 minutes)

With the introduction of resistive elements in the detector volumes, like for Restistive Plate Chambers or resistive MICROMEGAs, the signal induced on the readout electrodes will not only be determined by the movement of the primary charges but also by the movement of charges inside these resistive elements. This report will present an extension of Ramo's theorem to include these effects, that might have an application on solid state detectors where resistive layers are used either to evacuate charge or to introduce discharge protection.

Primary author: RIEGLER, Werner (CERN)

Presenter: RIEGLER, Werner (CERN)

Session Classification: Transient current technique

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

Depletion voltage and leakage current simulation of the ATLAS Pixel Detector according to the Hamburg model

Monday, 5 June 2017 14:30 (20 minutes)

The ATLAS Pixel detector consists of hybrid pixel modules where the sensitive elements are planar n-in-n sensors and has been operating since 2010.
In order to investigate and predict the evolution of the depletion voltage in the different layers, a fully analytical implementation of the Hamburg model was derived. The parameters of the model, describing the dependence of the depletion voltage on fluence, temperature and time were tuned with a fit to the available measurements of the depletion voltage in the last years of operation. While the temperature was monitored with on-module measurements, the 1MeV neutron equivalent fluence needs to be derived from the luminosity profile. The results of FLUKA simulations have been employed to convert the available integrated luminosity data into a neutron equivalent fluence. Since the uncertainties associated to these FLUKA based predictions prevent any precise estimate on the depletion voltage model parameters, a validation based on the comparison of leakage current data and simulation will be shown. Different numerical implementations of the available leakage current model will be compared.

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Presenter: BEYER, Julien-Christopher (Max-Planck-Institut fur Physik (DE))

Session Classification: Device simulation

Contribution ID: **16** Type: **not specified**

3D-silicon and passive CMOS pixel-detectors for the ATLAS pixel detector upgrade

Monday, 5 June 2017 10:10 (20 minutes)

A promising approach for the future ATLAS pixel detector at the HL-LHC is the usage of 3D-silicon sensors for the inner layers and the utilization of commercial CMOS technologies for the sensors of the outer layers.

3D-silicon sensors (FBK, CNM) and planar 200/250 um thick n-in-n sensors (CiS) as used for ATLAS IBL, along with passive CMOS pixel sensors in 150 nm technology (LFoundry) were characterized using the ATLAS FE-I4. Precise charge-collection efficiency (CCE) studies were carried out with ^{90}Sr at bias voltages between 20 −1500 V after irradiation with 24 MeV protons up to $7 \cdot 10^{15}$ $\mathrm{N_{eq}/cm^2}$. A GEANT4 based simulation was conducted to understand the complications arising from single pixel charge measurements with low energetic beta sources. The measured charge spectra before irradiation are compared to the GEANT4 simulation. For the description of the charge collection efficiency after irradiation a new Python based software (SCARCE) was programmed that calculates drift- and weighting fields for pixel matrices with planar and 3D electrode configurations. Despite simple assumptions (homogeneous $\mathrm{N_{eff}}$, $\tau_e = \tau_h$, 2D simulation) the measured CCE(Vbias) curves were successfully reproduced at a fluence of $1 \cdot 10^{15}$ $\mathrm{N_{eq}/cm^2}$. For the novel passive CMOS sensors key properties like breakdown behavior, depletion depth, and particle detection efficiency will be shown.

Primary author: POHL, David-Leon (University of Bonn (DE))

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Presenter: POHL, David-Leon (University of Bonn (DE))

Session Classification: Pixel and strip sensors

Contribution ID: **17** Type: **not specified**

TCAD simulations of CMOS Hi-Res MAPS detectors

Monday, 5 June 2017 14:50 (20 minutes)

I will present results of Synopsys TCAD simulations of OVERMOS, a MAPS CMOS detector based on high resistivity substrate. Following a short description of the main features of OVERMOS, I will describe experimental results of initial test structures and comparisons with TCAD simulation results, both for standard and neutron irradiated devices. I will then describe a proposed fabrication of test structures Schottky diodes to investigate radiation effects on silicon substrates of doping levels in the range 1e13 –1e17 cm-3, as typically found in CMOS technology.

Primary authors: Dr VILLANI, E.Giulio (STFC Ruthrerford Appleton Laboratory); Dr WILSON, Fergus; Dr ZHANG, Zhige; Dr DOPKE, Jens; Dr SEDGWICK, Iain; Dr FRENCH, Marcus; Dr SELLER, Paul; MCMAHON, Stephen; Dr WORM, Steve; Dr XIU, Qing Lei; Dr LIANG, Zhijun

Presenter: Dr VILLANI, E.Giulio (STFC Ruthrerford Appleton Laboratory)

Session Classification: Device simulation

Contribution ID: **18** Type: **not specified**

Measurements of Irradiated 3D Strip Sensors

Monday, 5 June 2017 11:40 (20 minutes)

The new generation of 3D pixel sensors with small pixel sizes of 50x50 μm² developed for the HL-LHC upgrade are characterized using a Sr90 radioactive source: the results are shown for non-irradiated and irradiated sensors.

Primary author: MANNA, Maria (Universitat Autònoma de Barcelona (ES))

Presenter: MANNA, Maria (Universitat Autònoma de Barcelona (ES))

Session Classification: Pixel and strip sensors

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

Radiation hardness of small-pitch 3D pixel sensors up to HL-LHC fluences

Monday, 5 June 2017 11:00 (20 minutes)

The radiation hardness of 3D pixel sensors with small pixel sizes of 50x50 and 25x100 µm² produced by CNM Barcelona is tested up to HL-LHC fluences. Since a readout chip with the desired pixel size is still under development by the RD53 collaboration, first prototype small-pitch pixel sensors were designed to be matched to the existing ATLAS IBL FE-I4 readout chip for testing. Irradiation campaigns with such pixel devices have been carried out at KIT with a uniform irradiation of 23 MeV protons to a fluence of 5×10^{15} n_{eq}/cm^2, as well as at CERN-PS with a non-uniform irradiation of 23 GeV protons to a peak fluence of 1.4×10^{16} n_{eq}/cm^2. The hit efficiency has been measured in several beam tests at the CERN-SPS in 2016. The benchmark efficiency of 97% has been reached at remarkably low bias voltages of 40 V at 5×10^{15} n_{eq}/cm^2 or 100 V at 1.4×10^{16} n_{eq}/cm^2. Thanks to the low operation voltage, the power dissipation can be kept at low levels of 1.5 mW/cm² at 5×10^{15} n_{eq}/cm^2 and 13 mW/cm² at 1.4×10^{16} n_{eq}/cm^2 for -25°C.

Primary author: LANGE, Joern (IFAE Barcelona)

Presenter: LANGE, Joern (IFAE Barcelona)

Session Classification: Pixel and strip sensors

Contribution ID: **20** Type: **not specified**

Initial studies of irradiated Ga doped LGADs

Tuesday, 6 June 2017 14:00 (20 minutes)

LGADs have been produced by CNM where Ga replaced B as a dopant in the multiplication layer in order to increase radiation hardness of LGADs. Although the devices exhibited early breakdown before irradiations they were fully functional after neutron irradiation. TCT and charge collection measurements with 90Sr were performed on devices irradiated up to the equivalent fluences of 6e15 cm-2. Initial studies indicate that Ga doped devices can be more radiation hard that the B doped ones.

Primary authors: KRAMBERGER, Gregor (Jozef Stefan Institute (SI)); Dr PELLEGRINI, Giulio (Centro Nacional de Microelectrónica (IMB-CNM-CSIC) (ES)); HIDALGO VILLENA, Salvador (Instituto de Microelectronica de Barcelona (IMB-CNM-CSIC)); CARULLA ARESTE, Maria del Mar (Instituto de Microelectronica de Barcelona IMB-CNM); SADROZINSKI, Hartmut (SCIPP, UC santa Cruz); MANDIC, Igor (Jozef Stefan Institute (SI)); CINDRO, Vladimir (Jozef Stefan Institute (SI)); MIKUZ, Marko (Jozef Stefan Institute (SI)); PETEK, Martin (Jozef Stefan Institute)

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

Session Classification: Detectors with gain

Contribution ID: **21** Type: **not specified**

Radiation damage in thin LGADs produced by HPK

Tuesday, 6 June 2017 16:10 (20 minutes)

The radiation damage effects in thin (50 and 80 microns) LGADs produced by HPK were investigated. The devices with different doping of multiplication layer were studied after neutron irradiations by TCT and charge collection measurements. The results of these measurements will be presented together with comparison with similar CNM devices.

Primary authors: KRAMBERGER, Gregor (Jozef Stefan Institute (SI)); SADROZINSKI, Hartmut (SCIPP, UC santa Cruz); SEIDEN, Abraham (University of California,Santa Cruz (US)); CARTIGLIA, Nicolo (Universita e INFN Torino (IT)); CINDRO, Vladimir (Jozef Stefan Institute (SI)); MANDIC, Igor (Jozef Stefan Institute (SI)); MIKUZ, Marko (Jozef Stefan Institute (SI)); PETEK, Martin (Jozef Stefan Institute)

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

Session Classification: Detectors with gain

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

Recent progress of the RD50 collaboration towards an R&D HV-CMOS submission in the 150 nm node from LFoundry

Wednesday, 7 June 2017 11:30 (20 minutes)

Due to their capability to integrate the readout electronics on the sensor substrate while providing fast charge collection by drift and high radiation tolerance levels of 10E15 neq/cm2, High Voltage-CMOS (HV-CMOS) detectors are being developed for their use or potential use in particle physics applications such as the Mu3e experiment, the ATLAS ITk upgrade and CLIC. Despite their fast charge collection, HV-CMOS detectors cannot supply the extremely accurate signal arrival times required by these applications as there exist charge collection time uncertainties and time-walk variations. Charge collection time uncertainties are given by the different times the charge needs to reach the collecting electrodes as a function of its generation point, whereas time-walk variations appear between the detection of small and large signals as the response time of the readout electronics is dependent on the signal strength. Charge collection time uncertainties are minimized with large sensor bias voltages. A few time-walk mitigation techniques have already been integrated in prototype HV-CMOS ASICs, such as time-walk compensating comparators, multiple threshold comparators and sampling circuits. However, these solutions often come at the expenses of needing more time for the detection or presenting limited efficiency.

This contribution describes the status of the design of an R&D HV-CMOS ASIC within the RD50 collaboration aimed mostly at improving the timing resolution of the detector using different solutions at the readout circuit level. Given its advantages in terms of isolation layers to embed CMOS electronics inside the pixel area, high number of metal layers for routing, backside biasing, stitching options and cost-efficient prototyping, the technology chosen for this ASIC is the 150 nm node from LFoundry. In this talk, I will review our current experience with LFoundry and provide details about the submission. The ASIC contains a few different matrices of HV-CMOS pixels with front-end electronics that improve the timing resolution of the detector. These electronics are based on the utilization of an analog sampling circuit, a Time-to-Digital Converter (TDC) and a super-fast amplifier. The ASIC also integrates circuits for studying new sensor cross-sections and pre-stitching options, as well as test structures. More information will be given at the workshop.

Primary authors: VILELLA FIGUERAS, Eva (University of Liverpool (GB)); ALONSO CASANOVAS, Oscar (University of Barcelona); CASANOVA MOHR, Raimon (Universitat Autònoma de Barcelona (ES)); CASSE, Gianluigi (University of Liverpool (GB)); DIEGUEZ, Angel (Universitat de Barcelona); POWELL, Sam (University of Liverpool); VOSSEBELD, Joost (University of Liverpool (GB)); ZHANG, Chenfan (University of Liverpool)

Presenter: VILELLA FIGUERAS, Eva (University of Liverpool (GB))

Session Classification: CMOS

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

Study of the onset of multiplication in proton irradiated LGADs

Tuesday, 6 June 2017 14:20 (20 minutes)

TCT and CV/IV measurements were performed on LGADs from CNM Run 7859 irradiated with protons up to 1E14 n_{eq}/cm^2. These studies were particularly focused on analysing the voltage required to fully deplete the multiplication layer of these sensors. The measurements were performed under different conditions in order to have a better understanding of the electric field inside the devices.

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

Session Classification: Detectors with gain

Contribution ID: **24** Type: **not specified**

HV-CMOS testing and design

Wednesday, 7 June 2017 11:10 (20 minutes)

The ATLAS collaboration is studying the possibility to install HV-CMOS devices in the outermost layer of the upgraded pixel detector of the ATLAS ITk for HL-HLC.
For this purpose different technologies are being investigated and different prototypes have already been produced and tested.
IFAE is participating both in design and testing of HV-CMOS devices.
Beam test results of the monolithic matrices of irradiated and non irradiated H35Demo devices will be presented. Moreover the IFAE contribution to the design of different HV-CMOS chip productions will be shown.

Primary author: CAVALLARO, Emanuele (IFAE - Barcelona (ES))

Presenter: CAVALLARO, Emanuele (IFAE - Barcelona (ES))

Session Classification: CMOS

Contribution ID: **25** Type: **not specified**

Status of LGAD productions at CNM

Tuesday, 6 June 2017 12:20 (20 minutes)

This talk will report the status of simulations and fabrications of LGAD at CNM.

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

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

Session Classification: Detectors with gain

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

Simulation and characterisation of a low gain avalanche detector for particle physics and synchrotron applications

Monday, 5 June 2017 16:00 (20 minutes)

Low Gain Avalanche detectors (LGAD) are part of family of Avalanche Photodiodes but have only small gain of an order of magnitude. LGAD's have been shown to have a very fast response time, order of picoseconds, which can make them useful in many applications, including concurrent excellent time and position resolution tracking for particle physics and synchrotron applications. Coupling of LGAD devices with single photon counting pixel detectors will allow detection of incident X-rays of energy below the noise threshold of the electronics, making them of interest to the Synchrotron community.

In this work we present results of TCAD detector simulations, fabrication and characterisation. Synopsis TCAD software was employed to perform fabrication process simulations, electrical properties modelling, detector response to incident radiation and influence of doping on gain variations. Several devices with optimised parameters and nominal no-gain sensors were fabricated at Micron Semiconductor Ltd. These were characterised using Transient Current Technique(TCT) and alpha particle TCT for charge collection, gain variation and sensitivity.

The results presented here concentrate on those obtained from devices fabricated in Run 2. Where Run 1 saw a small amount of gain. The simulation has been modified to match these results and new simulations performed to optimize the devices. Under test these devices have shown to match within error to the simulated results for both IV and gain measurements. Preliminary results show a gain factor of 3-6 is obtained for voltages in the range of 200-800V.

Further device optimization in simulation is presented, which produces higher gain and allows operation with higher bias voltages.

Primary author: Mr MOFFAT, Neil (University of Glasgow)

Co-authors: BATES, Richard (University of Glasgow (GB)); MANEUSKI, Dima (University of Glasgow); FLORES SANZ DE ACEDO, Leyre (University of Glasgow (GB)); SIMON ARGEMI, Lluis (University of Glasgow); TARTONI, Nicola; Mr MARK, Bullough (Micron Semiconductor Ltd)

Presenters: Mr MOFFAT, Neil (University of Glasgow); MOFFAT, Neil (University of Glasgow (GB))

Session Classification: Device simulation

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

Timing performance and gain analysis of heavily irradiated LGAD diodes

Tuesday, 6 June 2017 14:40 (20 minutes)

Using 120GeV pions at CERN SPS, the timing resolution and gain performance of heavily irradiated LGAD single pad diodes is evaluated. Samples were irradiated with thermal neutrons at JSI with fluences varying from 1e15 neq/cm2 to 6e15 neq/cm2. Single irradiated PIN samples were also included and presented for comparison. The voltage and temperature dependence of sample performance is presented while through use of two different amplifiers, the signal over noise ratio is evaluated for each setup. Two quartz coupled SiPMs were used as timing reference while sample leakage current was monitored for both samples and SiPMs.

Primary author: Dr GKOUGKOUSIS, Vagelis (Institut de Fisica d'Altes Energies (IFAE))

Presenter: Dr GKOUGKOUSIS, Vagelis (Institut de Fisica d'Altes Energies (IFAE))

Session Classification: Detectors with gain

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

Determination of the p-spray profile for n^+ p silicon sensors using a MOSFET

Wednesday, 7 June 2017 13:20 (20 minutes)

The standard technique to electrically isolate the n^+ implants of segmented silicon sensors fabricated on high-ohmic p-type silicon are p^+-implants.
Although the knowledge of the p^+-implant dose and of the doping profile is highly relevant for the understanding and optimisation of sensors,this information is usually not available from the vendors, and methods to obtain it are highly welcome.The paper presents methods to obtain this information from circular MOSFETs fabricated as test structures on the same wafer as the sensors. Two circular MOSFETs, one with and one without a p^+-implant under the gate, are used for this study. They were produced on Magnetic Czochralski silicon doped with $\approx 3.5\times10^{12}$cm^{-2} of boron and $\langle 100\rangle$ crystal orientation. The drain-source current as function of gate voltage for different back-side voltages is measured at a drain-source voltage of 50\,mV in the linear MOSFET region, and the values of threshold voltage and mobility extracted using the standard MOSFET formulae. To determine the bulk doping, the implantation dose and profile from the data, two methods are used, which give compatible results. The doping profile, which varies between 3.5×10^{12}cm^{-3} and 2×10^{15}cm^{-3} for the MOSFET with p^+-implant, is determined down to a distance of a fraction of a μm from the Si-SiO_2 interface. The method of extracting the doping profiles is verified using data from a TCAD simulation of the two MOSFETs. The details of the methods and of the problems encountered are discussed.

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

Co-authors: FRETWURST, Eckhart (II. Institut fuer Experimentalphysik); GARUTTI, Erika (Hamburg University (DE)); KLANNER, Robert (Hamburg University (DE)); KOPSALIS, Ioannis (University of Hamburg)

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

Session Classification: Defect and Material Engineering

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

Laboratory measurement and progress in Low-Gain Avalanche Diodes

Tuesday, 6 June 2017 12:00 (20 minutes)

In this contribution we will review the progress towards the development of a novel type of silicon detectors suited for tracking with a picosecond timing resolution, the so called Ultra-Fast Silicon Detectors.
Ultra-Fast Silicon Detectors are based on the concept of Low-Gain Avalanche Diodes, which are silicon detectors with an internal multiplication mechanism so that they generate a signal which is factor ˜ 10 larger than standard silicon detectors.

We will concentrate on the latest results from laboratory measurements, including statistics measurements on CNM 50um irradiated multi-pad sensors, determination of alpha parameters as a function of the fluence, temperature dependence of the gain, and gain measurements using red led.
Preliminary results from beam tests on 50 and 80um thick LGAD produced by Hamamatsu will be discussed.

Primary author: SOLA, Valentina (Universita e INFN Torino (IT))

Presenters: SOLA, Valentina (Universita e INFN Torino (IT)); SOLA, Valentina (Universita e INFN Torino (IT))

Session Classification: Detectors with gain

Contribution ID: **30** Type: **not specified**

Radiation hardness of a CMOS sensor process for a novel Depleted Monolithic Active Pixel Sensor

Wednesday, 7 June 2017 10:20 (20 minutes)

Depleted active pixel sensors (DMAPS) are considered for use in outer layers of the upgraded ATLAS pixel detector at HL-LHC. In my talk I will present studies of radiation hardness of a novel low capacitance DMAPS produced by TowerJazz in a 180 nm CMOS process. Charge collection takes place in a high resistivity epitaxial layer, which can be fully depleted even after irradiation. Sensors irradiated up to 1e16 neq/cm2 were characterised by Edge-TCT, Sr90 MIPs, test beam and with X-rays. An overview of results of measurements will be given.

Primary author: HITI, Bojan (Jozef Stefan Institute (SI))

Presenter: HITI, Bojan (Jozef Stefan Institute (SI))

Session Classification: CMOS

Contribution ID: **31** Type: **not specified**

Study of Deep Diffused APDs for Timing Applications

Tuesday, 6 June 2017 13:40 (20 minutes)

Deep diffused avalanche photodiodes (APD) are being studied as timing detectors for minimum ionizing particles.
In this talk, the first results and experiences in the operation of these devices are presented.

Primary authors: CENTIS VIGNALI, Matteo (CERN); DALAL, Ranjeet (University of Delhi); HARROP, Bert Gerard (Princeton University (US)); JAIN, Geetika (University of Delhi (IN)); LU, Changguo; Dr MICKEL, McClish (Radiation Monitoring Devices); MCDONALD, Kirk (Princeton University); MOLL, Michael (CERN); NEWCOMER, Mitchell Franck (University of Pennsylvania (US)); OTERO UGOBONO, Sofia (Universidade de Santiago de Compostela (ES)); Dr WHITE, Sebastian (CERN/Princeton University (US))

Presenter: CENTIS VIGNALI, Matteo (CERN)

Session Classification: Detectors with gain

Contribution ID: **32** Type: **not specified**

Thin LGADs characterization using Ion Beam Induced Charge (IBIC) and Time-resolved IBIC at the Centro Nacional de Aceleradores

Tuesday, 6 June 2017 15:30 (20 minutes)

The National Accelerator Center (CNA) is a user's facility dedicated to multidisciplinary applications of particle accelerators. In this talk, the infrastructure available at CNA for Ion Irradiation and Characterization of Materials, based on a 3 MV tandem accelerator and a compact cyclotron for 18 MeV protons will be briefly described.
In addition, a new proposal in collaboration with IFCA and IMB-CNM will be presented. The main goal of this project is to carry out an IBIC and time-resolved IBIC (TRIBIC) characterization on a set of thin (50 μm) Low Gain Avalanche Detectors (strips and pixel detectors) to study with a good lateral resolution (4μm) the gain in different zones of these devices. Of special interest will be to analyze the behavior of the detector response near the surface isolation (p-stop).

Primary author: Dr JIMENEZ RAMOS, Carmen (National Accelerator Center)

Co-authors: Dr GARCIA LOPEZ, Javier (CNA (U. Sevilla, J. Andalucia, CSIC), Sevilla, Spain); VILA ALVAREZ, Ivan (Universidad de Cantabria (ES)); HIDALGO VILLENA, Salvador (Instituto de Microelectronica de Barcelona (IMB-CNM-CSIC)); GOMEZ-CAMACHO, Joaquin (Universidad de Sevilla)

Presenter: Dr JIMENEZ RAMOS, Carmen (National Accelerator Center)

Session Classification: Detectors with gain

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

Characterization of ALD-grown aluminum oxide field insulators for silicon detectors

Monday, 5 June 2017 13:40 (20 minutes)

We present our concept of using aluminum oxide deposited by atomic layer deposition (ALD) as field insulator and coupling dielectric in segmented n-in-p silicon detectors. As opposed to the commonly used SiO2, alumina thin films exhibit a significant negative charge, which enables us to omit the critical high-temperature p-spray/p-stop implantation steps. Furthermore, the dielectric constant of alumina is higher than that of SiO2, so that a thinner layer of alumina is sufficient for insulation.
Alumina thin films with thicknesses of 50-70 nm were deposited at 200 and 300 ℃ and their properties were compared. The electrical properties of unprocessed thin films were characterized by the contactless COCOS (corona oxide characterization of semiconductor) method, which provides information on the total oxide charge, interface trap density, as well as flatband voltage and dielectric constant of the films. Similar films were used in processing of diodes and MOS capacitor structures, whose properties were then characterized by capacitance-voltage and current-voltage measurements.
The electrical characterization shows that deposition temperature has a strong effect on the properties of the films. It appears that alumina films deposited at higher temperatures are not ideal for the use in segmented detectors. Negative charge formation in the film is promoted by the annealing step required for aluminum sintering in device processing, which simultaneously improves the quality of the oxide-silicon interface. The MOS capacitor C-V measurements show a dependency on frequency. The comparability of conventional C-V measurements and the COCOS method is discussed.

Primary author: OTT, Jennifer (Helsinki Institute of Physics (FI))

Presenter: OTT, Jennifer (Helsinki Institute of Physics (FI))

Session Classification: Pixel and strip sensors

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

Light absorption and charge collection of highly irradiated silicon sensors

Tuesday, 6 June 2017 09:50 (20 minutes)

The absorption length of near-infrared light in radiation-damaged silicon has to be known to calculate the deposited charge in irradiated sensors relative to non-irradiated reference sensors.This is required in order to determine the charge collection efficiency CCE using the transient current technique TCT. The absorption length has been determined as a function of the wavelength and the
temperature for silicon irradiated with protons to fluences between 9E14-1.3E16 n_{eq}/cm^2.

Highly irradiated silicon sensors can be operated under forward bias where the electric field is expected to be to a good approximation constant. We investigate charge profiles of strip sensors obtained with edge TCT under forward bias. The charge collection lengths of electrons and holes are
extracted as a function of the particle fluence and the electric field at -20 ℃ and -30 ℃. A parameterization of the charge collection length from edge TCT measurements is compared to CCE
measurements with pad diodes for fluences between 3E15-1.3E16 n_{eq}/cm^2.

Primary authors: SCHARF, Christian (Hamburg University (DE)); Mr FEINDT, Finn (Unversity of Hamburg); GARUTTI, Erika (Hamburg University (DE)); KLANNER, Robert (Hamburg University (DE))

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

Session Classification: Transient current technique

Contribution ID: **35** Type: **not specified**

Characterization of small pitch 3D sensors from CNM

Monday, 5 June 2017 11:20 (20 minutes)

Silicon pixels of area 25x100 and 50x50 square microns, fabricated at CNM using double sided 3D technology on 230 um thick wafers, are characterized using a Sr90 radioactive source and in a pion/proton test beam at the CERN SPS. Results are shown both for non-irradiated sensors and for sensors irradiated with protons at the CERN PS.

Primary author: CURRAS RIVERA, Esteban (Universidad de Cantabria (ES))

Presenter: CURRAS RIVERA, Esteban (Universidad de Cantabria (ES))

Session Classification: Pixel and strip sensors

Contribution ID: **36** Type: **not specified**

Experimental determination of the Hardness factor for the ATLAS Irradiation Facility

Monday, 5 June 2017 13:20 (20 minutes)

The ATLAS Irradiation Facility at the University of Birmingham uses 27 MeV protons from the MC40 cyclotron to irradiate samples for the HL-LHC upgrade. The facility is also a translational access facility within AIDA-2020 and irradiates a wide variety of samples from various experiments. The fluence delivered to the sample is normalised to a 1 MeV neutron equivalent fluence for comparison with other facilities using a hardness factor from literature κ=2.2. Recent measurements at other facilities have found hardness factors which differ from those found in literature. Following guidelines set out by RD50, a preliminary value of κ = 1.6±0.07±0.2 has been evaluated using commerical BPW34F photodiodes . We will present an update on the facility and then focus on the measurements of the hardness factor.

Primary authors: PRICE, Tony (University of Birmingham (GB)); NIKOLOPOULOS, Konstantinos (University of Birmingham (GB)); Mr KNIGHTS, Patrick (University of Birmingham); Ms CANAVAN, Rhiann (University of Birmingham)

Co-authors: ALLPORT, Philip Patrick (University of Birmingham (UK)); GONELLA, Laura (University of Birmingham (UK))

Presenter: PRICE, Tony (University of Birmingham (GB))

Session Classification: Pixel and strip sensors

Contribution ID: **37** Type: **not specified**

Efficiency of the LHCb VELO sensors

Monday, 5 June 2017 12:00 (20 minutes)

The LHCb VELO detector comprises of 88 silicon sensors, with two designs, one measuring the radial distance from the beam line and the other the azimuthal angle. The necessity to bring the signals for the radial measuring sensors to the edge of the detector requires an additional metal routing line layer. After operating the detector for a couple of years at the LHC effects were seen where the second metal layer routing lines began to pick up charge from the sensor directly and causes secondary fake clusters and reduced the charge collected by the main strip. This talk will present the current understanding of the issue, how it was discovered, how it is evolving and how it is simulated.

Primary author: HUTCHCROFT, David (University of Liverpool (GB))

Presenters: HUTCHCROFT, David (University of Liverpool (GB)); HUTCHCROFT, David (U)

Session Classification: Pixel and strip sensors

Contribution ID: **38** Type: **not specified**

Beam test studies of the LGAD sensors at FNAL

Tuesday, 6 June 2017 15:50 (20 minutes)

We report the results from the latest test beam measurements of LGAD sensors performed at the Fermilab Test Beam Facility. Our studies focus on measurements of the signal efficiency, time resolution, as a function of position on the sensor, and performance of pixelated sensors. Additionally, we perform measurements of the signal efficiency and time resolution using irradiated LGAD sensors. Sensors are characterized using different readout boards.

Primary authors: APRESYAN, Artur (Fermi National Accelerator Lab. (US)); SADROZINSKI, Hartmut (SCIPP, UC santa Cruz); CARTIGLIA, Nicolo (Universita e INFN Torino (IT))

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

Session Classification: Detectors with gain

Contribution ID: **39** Type: **not specified**

LGAD Simulations with the Ga doping: an exploration

Monday, 5 June 2017 16:20 (20 minutes)

The new LGAD batch with Gallium doping is now in its first experimental stages. Using TCAD Sentaurus we explore the increase in radiation hardness that could be achieved.

Primary authors: Prof. PALOMO PINTO, Francisco Rogelio (ETSI Universidad de Sevilla); Dr HIDALGO VILLENA, Salvador (CNM-IMB)

Presenter: Prof. PALOMO PINTO, Francisco Rogelio (ETSI Universidad de Sevilla)

Session Classification: Device simulation

Contribution ID: **40** Type: **not specified**

Welcome

Monday, 5 June 2017 09:00 (15 minutes)

Welcome to the AGH University of Science and Technology

Presenter: Prof. DĄBROWSKI, Władysław (AGH University of Science and Technology)

Session Classification: Workshop opening

Contribution ID: **41** Type: **not specified**

Discussion

Monday, 5 June 2017 14:00 (30 minutes)

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

Session Classification: Pixel and strip sensors

Contribution ID: **42** Type: **not specified**

Discussion

Wednesday, 7 June 2017 09:30 (30 minutes)

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

Session Classification: FCC and future developments

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

Discussion

Monday, 5 June 2017 16:40 (30 minutes)

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

Session Classification: Device simulation

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

Discussion

Tuesday, 6 June 2017 10:10 (30 minutes)

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

Session Classification: Transient current technique

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

Discussion

Tuesday, 6 June 2017 16:30 (30 minutes)

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

Session Classification: Detectors with gain

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

Discussion

Wednesday, 7 June 2017 15:00 (30 minutes)

Presenter: MOLL, Michael (CERN)

Session Classification: Defect and Material Engineering

Contribution ID: **47** Type: **not specified**

Discussion

Wednesday, 7 June 2017 11:50 (30 minutes)

Presenter: VILELLA FIGUERAS, Eva (University of Liverpool (GB))

Session Classification: CMOS

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

Update on the RD50 project NitroStrip

Wednesday, 7 June 2017 14:40 (20 minutes)

The new NitroStrip p-on-n sensors were fabricated in CNM Barcelona within the RD50 collaboration on 4 different kinds of wafers: FZ, DOFZ, HR FZ Nitrogenated wafer and MCz. Here it will be shown electrical measurements without irradiation for some samples of those strip sensors.

Primary author: BASELGA BACARDIT, Marta (KIT - Karlsruhe Institute of Technology (DE))

Presenter: BASELGA BACARDIT, Marta (KIT - Karlsruhe Institute of Technology (DE))

Session Classification: Defect and Material Engineering