10th International Conference on Radiation Effects on Semiconductor Materials, Detectors and Devices

Report of Contributions

Contribution ID: **0** Type: **not specified**

Study on the Total Ionizing Dose Effects of SiGe HBTs Irradiated with 60Co γ Rays

Thursday 9 October 2014 14:30 (10 minutes)

The characteristic of the dc current gain degradation with dose and current injection level for SiGe HBT during 60Co gamma irradiation are measured and analyzed. Additionally, the typical dc and ac parameters degradation mechanisms are discussed. The experimental results of the dc and ac electronic parameters before and after irradiation are shown to result in the base current Ib, the collector current IC, the dc current gain and the maximum oscillation frequency fmax exhibiting degradation after irradiation. While other electronic parameters including the cutoff frequency fT, the ac current gain |H21| and output capacitance CCBO do not exhibit any significant change compared with those of pre-irradiation.

Summary

The dynamic change of dc current gain of the npn type SiGe HBT during 60Co γ irradiation have been investigated at different injection current levels and the damage constant of dc current gain is affected by the collector current levels. The higher the collector current is, the smaller the damage constant of dc current gain, this phenomenon indicated that improving the device current injection level or bias voltage appropriately may effectively reduce ionizing damage effects. The experimental results of typical dc and ac electronic parameters before and after irradiation showed that the base current Ib, the collector current IC, the dc current gain and the maximum oscillation frequency fmax are degraded after irradiation. While other electronic parameters including the cutoff frequency fT, the ac current gain |H21| and output capacitance CCBO did not exhibit any significant change compared with those of pre-irradiation. The surface effects induced by total ionizing dose of 60Co γ irradiation on SiGe HBT are mainly responsible for the above parameters degradation according to the low energy gamma radiation damage mechanisms.

Primary author: Dr LIU, Shuhuan (School of Nuclear Engineering and Technology of Xi'an Jiaotong University, Xi'an, China, 710049)

Co-authors: Dr XIONG, Chen (Xi'an Jiaotong University); Dr LI, Da (Northwest Institute of Nuclear Technology, Xi'an, China, 710613); DRABO, Mebougna (Alabama A&M University, Mechanical Engineering department, Huntsville, Alabama, USA.); Prof. CHEN, Wei (Northwest Institute of Nuclear Technology, Xi'an, China, 710613.); Prof. LI, Zheng (Xiangtan University, Xiangtan, Hunan ,411105, China)

Presenter: Prof. LI, Zheng (Xiangtan University, Xiangtan, Hunan ,411105, China)

Session Classification: Poster Session

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

Modeling and simulation of charge collection properties for 3D-Trench electrode detector

Thursday 9 October 2014 10:00 (20 minutes)

3D-trench electrode detector with square geometry was simulated in this paper. Charge collection of 3D-trench electrode detector was simulated using the full 3D device simulation. The induced current and collected charge caused by drifting carriers, generated by a minimum ionizing particle (MIP) incident through the detector, have been modeled and calculated. The results indicate that the total collected charge in irradiated detector change with various particle incident positions and radiation fluence. In addition, we have estimated the average total collected charge generated by the MIP at a random incident position of a 3D-trench electrode detector.

Summary

In this paper, the effect of charge collection of a square shape 3D-trench electrode detector (Fig.1a) was investigated. For a non-irradiated detector, the total collected charge is independent of the particle incident position (Fig. 2a). However, as shown in Fig. 2b, for an irradiated detector, the total collected charge changes with various incident position (at r = ri in Fig.1b). This is due to the fact that the probability of hole trapping and electron trapping will change with the particle incident position, which affects the composition of electron and hole contributions to the induced current and therefore the total collected charge. The collected charge will also be affected by the weighting field profile and electric field profile. The induced current and total collected charge reduce with increasing fluence, as the trapping probability increases linearly with radiation fluence. Fig.3a shows the collected charge caused by a MIP incident at the middle point between two electrodes, with a bias voltage of 100 V. Fig.3b is the average collected charge by a MIP at a random incident position of a 3D-trench electrode detector, at various bias voltages over full depletion voltage. We note that the collected charge increases slightly with bias voltage, and for the detector with same radiation fluence and bias voltage, the average collected charge is usually not equal to the collected charge caused by a MIP incident at the middle point between two electrodes.

Indico rendering error

Could not include image: Cannot understand URL 'http://C:\%5CUsers\%5CAdministrator\%5CDesktop

Indico rendering error

Could not include image: Cannot understand URL 'http://C:\%5CUsers\%5CAdministrator\%5CDesktop

a) b)

Indico rendering error

Could not include image: Cannot understand URL 'http://C:\%5CUsers\%5CAdministrator\%5CDesktop

Indico rendering error

```
Could not include image: Cannot understand URL 'http://C:\%5CUsers\%5CAdministrator\%5CDesktop
```

Indico rendering error

```
Could not include image: Cannot understand URL 'http://C:\%5CUsers\%5CAdministrator\%5CDesktop
```

Indico rendering error

```
Could not include image: Cannot understand URL 'http://C:\%5CUsers\%5CAdministrator\%5CDesktop
```

Primary author: Dr DING, Hao (Xiangtan University)

Co-authors: Dr CHEN, Jianwei (Xiangtan University); Dr YAN, Shaoan (Xiangtan University); LI, Zheng (Xiangtan University)

Presenter: LI, Zheng (Xiangtan University)

Session Classification: 3D Detectors

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

3D simulations of device electrical characteristics of 3D-Trench electrode detector

Thursday 9 October 2014 09:40 (20 minutes)

The square 3D-Trench electrode Si detector structure is simulated using a 3D Silvaco TCAD tool. Electrical characteristics including electrostatic potential, electric field, leakage current, and capacitance have been simulated in detail. It has been found in simulations that both leakage current and the voltage to reach the geometry capacitance (full depletion voltage, Vfd) increase with radiation fluence. The leakage current and full depletion voltage at 1x1016 neq/cm2 are 41.3 μA (volume is 2x106 μm3) and 90 V, respectively. The geometry capacitance is 99 fF for the structure in our study. The full depletion voltage calculated by CV characteristics at different radiation fluences give similar results to those analyzed by the potential and holes concentration profile simulations. In this optimal configuration the full depletion voltage can be up to 7 times less than that of a conventional 3D detector with all column electrodes.

Summary

The square 3D-Trench electrode Si detector structure is simulated using a 3D Silvaco TCAD tool. Electrical characteristics including electrostatic potential, electric field, leakage current, and capacitance have been simulated in detail. It has been found in simulations that both leakage current and the voltage to reach the geometry capacitance (full depletion voltage, Vfd) increase with radiation fluence. The leakage current and full depletion voltage at 1x1016 neq/cm2 are 41.3 μA (volume is 2x106 μm3) and 90 V, respectively. The geometry capacitance is 99 fF for the structure in our study. The full depletion voltage calculated by CV characteristics at different radiation fluences give similar results to those analyzed by the potential and holes concentration profile simulations. In this optimal configuration the full depletion voltage can be up to 7 times less than that of a conventional 3D detector with all column electrodes.
The square 3D-Trench electrode Si detector cell structure is shown in Fig.1. As can be seen from Fig.2 that leakage current increases with radiation fluence. Dotted vertical lines in the figure denote the full depletion voltages as extracted from the corresponding CV simulations (see Fig.3). The voltage to reach the saturation of leakage current also increases with fluence. For fluence of 1x1014, 1x1015 and 1x1016 neq/cm2, the saturation leakage current are 6.37x10-9, 3.33x10-8 and 4.13x10-7 A, respectively. The capacitance curves in Fig. 3 shows that the geometry capacitance is independent of radiation fluences, which is 99 fF in our case. Fig. 4 shows that the full depletion voltage determined by CV characteristics is almost proportion to fluence, and it is only 90 V for a fluence of 1x1016 neq/cm2. The magnitudes of the leakage current, capacitance and full depletion voltage obtained from simulations are in agreement with those in literature.
Fig. 1 Structure of the square 3D-Trench electrode detector
Fig. 2 Simulated detector I-V characteristics at three different fluences
Fig. 3 Simulated detector C-V characteristics at three different fluences
Fig. 4 Simulated detector full depletion voltage determined by simulated CV characteristics at different fluences

Primary author: Dr CHEN, Jianwei (Xiangtan University)

Co-authors: Dr DING, Hao (Xiangtan University); Dr YAN, Shaoan (Xiangtan University); Prof. LI, Zheng (Xiangtan University)

Presenter: Prof. LI, Zheng (Xiangtan University)

Session Classification: 3D Detectors

Contribution ID: **3** Type: **not specified**

The Pixel Detector of the ATLAS experiment for the Run2 at the Large Hadron Collider

Friday 10 October 2014 09:40 (20 minutes)

The Pixel Detector of the ATLAS experiment has shown excellent performance during the whole Run-1 of LHC. Taking advantage of the long showdown, the detector was extracted from the experiment and brought to surface, to equip it with new service quarter panels, to repair modules and to ease installation of the Insertable B-Layer (IBL). IBL is a fourth layer of pixel detectors, and has been installed in May 2014 between the existing Pixel Detector and a new smaller radius beam-pipe at a radial distance of 3.3 cm from the beam axis.

The realization of the IBL required the development of several new technologies and solutions in order to overcome the challenges introduced by the extreme environment and working conditions, such as the high radiation levels, the high pixel occupancy and the need of an exceptionally low material budget.

Two silicon sensor technologies have been adopted for the IBL modules: planar n-in-n and 3D. Both of these are connected via bump bonding to the new generation 130 nm IBM CMOS FE-I4 front-end read-out chip.

Furthermore, the physics performance will be improved through the reduction of pixel size while, targeting for a low material budget, a new mechanical support using lightweight staves and a CO2 based cooling system have been adopted.

An overview of the refurbishing of the Pixel Detector and of the IBL project as well as the experience in its construction will be presented, focusing on adopted technologies, module and staves production, qualification of assembly procedure, integration of staves around the beam pipe and commissioning of the detector.

Primary author: GUESCINI, Francesco (University of Geneva)

Presenter: GUESCINI, Francesco (Universite de Geneve (CH))

Session Classification: Upgrading LHC Experiments

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

LHC Phase 2 upgrade of the ATLAS Pixel Detector

Friday 10 October 2014 10:00 (20 minutes)

From 2024, the HL-LHC will provide unprecedented pp luminosities to ATLAS, resulting in an additional integrated luminosity of around 2500 fb-1 over ten years. This will present a unique opportunity to substantially extend the mass reach in searches for many signatures of new physics, in several cases well into the multi-TeV region, and to significantly extend the study of the properties of the Higgs boson. The increased luminosity and the accumulated radiation damage will render the current Inner Tracker no longer suitable for long term operations. It will need to be replaced with a new all silicon tracker to maintain tracking performance in the high occupancy environment and to cope with the increase of approximately a factor of ten in the total radiation fluence. New technologies are used to ensure that the system can survive this harsh radiation environment and to optimise the material distribution. Present ideas and solutions for the pixel detector will be discussed in this talk.

Primary authors: TRONCON, Clara (Milano Universita e INFN (IT)); MORETTINI, Paolo

Presenter: MORETTINI, Paolo (INFN Genova)

Session Classification: Upgrading LHC Experiments

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

Operational Experience with the ATLAS Pixel Detector

Friday 10 October 2014 09:20 (20 minutes)

The ATLAS Pixel Detector is the innermost detector of the ATLAS experiment at the Large Hadron Collider at CERN. During Run-I, the detector provided hermetic coverage with three cylindrical layers and two endcaps with three disk layers each. It consisted of 1744 n+-in-n silicon modules with a total of about 80 million pixels that were individually read out via chips bump-bonded to the silicon substrate. The ATLAS Pixel Detector started to record data since the first LHC collisions and since the beginning of its operation it performed very well. The operational challenges included the maximization of data taking efficiency, dealing with single event upsets, and the recovery of lost modules. The data acquisition techniques also had to adapt to the rapidly changing LHC beam conditions. In order to maximize the physics potential and the quality of the data, online and offline calibrations were performed on a regular basis. The calibrations ensured maximal hit and charge collection efficiency. The position resolution was improved by pixel charge thresholds, gain and various other online calibrations. With increased luminosity delivered by the LHC, radiation damage effects have been observed in the silicon sensors: an increase in leakage current and change of the depletion voltage, in agreement to the predictions. By the end of Run I, 5% of the modules were not operational, most of which have been already recovered during the current shutdown. In this talk the operational challenges of the silicon pixel detector in Run I are presented, and the expectations for the next LHC data taking period in 2015 are discussed.

Primary author: JEANTY, Laura (LBL, USA)

Presenters: JEANTY, Laura (LBL, USA); JEANTY, Laura (Lawrence Berkeley National Lab. (US))

Session Classification: Upgrading LHC Experiments

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

ATLAS Pixel IBL modules construction experience and developments for future upgrade

Thursday 9 October 2014 15:00 (10 minutes)

The first upgrade of the ATLAS Pixel Detector is the Insertable B-Layer (IBL), just installed in May 2014 in the core of ATLAS. Two different silicon sensor technologies, planar n-in-n and 3D, were used, connected with the new generation 130nm IBM CMOS FE-I4 readout chip via solder bump-bonds.
Production quality control tests were set up to verify and rate the performance of the modules before integration into staves. An overview of module design and construction, the quality control results and production yield will be discussed, as well as future developments foreseen for future detector upgrades.

Primary author: GAUDIELLO, Andrea (University of Genova and INFN, Italy)

Presenter: GAUDIELLO, Andrea (Univerisyt of Genova and INFN)

Session Classification: Poster Session

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

Upgrade to the Birmingham Irradiation Facility

Thursday 9 October 2014 10:20 (20 minutes)

In
approximately 2024,the Large Hadron Collider (LHC) will be upgraded to the High Luminosity LHC (HL--LHC). The upgrade is foreseen to increase the LHC design integrated luminosity by a factor ten. This planned increase in luminosity results in significantly
higher levels of radiation inside the planned ATLAS Upgrade detector. This means existing detector technologies together with new components and materials need to be re examined to evaluate their performance and durability within this enhanced radiation field. Of particular interest is the effect of radiation on the upgraded ATLAS tracker. To study these effects an ATLAS irradiation scanning facility using the Medical Physics Cyclotron at the University of Birmingham was built in 2013. The intense cyclotron beam allows irradiated samples to receive in minutes, fluences corresponding to years of operation at the HL--LHC. Since commissioning in early 2013 this facility has been used to irradiate silicon sensors, optical components and carbon fibre sandwiches for the ATLAS upgrade programme. Irradiations of silicon sensors and passive materials can be carried out in a temperature controlled cold box which moves continuously through the homogenous beamspot. This movement is provided by a pre--configured XY--axis cartesian robot system (scanning system). In 2014 the cooling and the cold box was upgraded from a recirculating glycol chiller system to a liquid nitrogen evaporative system. This paper reviews the design, development, commissioning and performance results of the new cooling system.

Primary author: Ms PARKER, Kerry (University of Sheffield)

Co-authors: Dr PARKER, David (University of Birmingham); DERVAN, Paul (University of Liverpool (GB)); FRENCH, Richard (The University of Sheffield)

Presenter: Ms PARKER, Kerry (University of Sheffield)

Session Classification: 3D Detectors

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

Invited Talk: Silicon Sensors for Trackers at High-Luminosity Environment - RD50 Collaboration Status Report

Wednesday 8 October 2014 16:10 (30 minutes)

Position sensitive silicon detectors are largely employed in the tracking systems of High Energy Physics experiments due to their outstanding performance. They are currently installed in the vertex and tracking part of the ALICE, ATLAS, CMS and LHCb experiments at LHC, the world's largest particle physics accelerator at Centre for European Nuclear Research (CERN), Geneva.

An upgrade of LHC accelerator is already planned, namely the high luminosity (HL) phase of the LHC (HL-LHC foreseen for 2023). This will enable the use of maximal physics potential of the machine. At the high integrated luminosity of 3000 fb^{-1} the tracking system at HL-LHC will face more intense radiation environment than the present system was designed for. This requires the upgrade of the all-silicon central trackers that will be equipped with higher granularity as well as radiation hard sensors, which can withstand higher radiation levels and higher occupancies also in the innermost layers closest to the interaction point. In order to address the problems caused by intense radiation environment, extensive measurements and simulations studies requirements have been initiated within the RD50 Collaboration, with an open cooperation across experimental boundaries, for investigating different designs and materials options for silicon sensors with sufficient radiation tolerance. Research topics include studies of sensors with n-electrode readout (mainly sensors with p-bulk), which offer the advantage of collecting electrons instead of holes resulting in an improvement of radiation tolerance. Also a further enhancement of performance is
investigated in thinned bulk sensors (reduced trapping probability) and in active edge technology (maximized sensitive area). Another line of activity is the development of advanced sensor types like 3D detectors and Low Gain Amplification Detectors (LGAD) designed for the extreme radiation environment at the inner layers. TCAD simulations of silicon strip sensors have expanded to cover both bulk and surface properties after irradiation at HL-LHC levels, producing results that are converging with measurements.

Summary

Our results from both measurements and simulations of several detector technologies and silicon materials at radiation levels expected for HL-LHC will be presented. Based on our results, latest developments in finding the most suitable silicon detectors to be used for LHC detector upgrades will be reported.

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

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

Session Classification: Irradiated Silicon Detectors

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

Leakage Current Measurements of highly irradiated Silicon Strip Sensors

Wednesday 8 October 2014 16:40 (20 minutes)

The leakage current of irradiated silicon sensors depends, among others, on sensor temperature and irradiation fluence. The temperature dependence is parameterized with the activation energy E_g and the fluence dependence with the current related damage rate α. The literature values for E_g and α are obtained from previous measurements, but α is only measured directly to a dose up to 1e15 1MeV neq/cm^2 (neq/cm^2).

Miniature micro-strip sensors ($\sim 1 \times 1$cm^2) were irradiated with protons to fluences from 1e12 to 1e15 neq/cm^2 and with neutrons from 5e15 to 2e16 neq/cm^2 to investigate the reverse current at higher fluence. Precise temperature and current measurements of the sensors from Hamamatsu Photonics K.K. (300μm thick) and Micron Semiconductor Ltd. (143μm and 108μm thick) allow the determination of E_g and α. The sensors were measured shortly after irradiation and after room temperature annealing. For the devices irradiated to higher fluences the obtained values differ from the literature value of E_g and the expected value from the linear extrapolation of α.

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

Co-authors: CASSE, Gianluigi (University of Liverpool (GB)); WORMALD, Michael (University of Liverpool (GB)); DERVAN, Paul (University of Liverpool (GB)); Dr AFFOLDER, Tony (University of Liverpool (GB))

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

Session Classification: Irradiated Silicon Detectors

Contribution ID: **11** Type: **not specified**

Simulation of Single Event Upset in SRAMs Induced by low Energy Proton With Geant4

Thursday 9 October 2014 15:40 (10 minutes)

The architecture of SRAM and single event upset cross section computation approach are presented. Deposited energy and single event upset cross section are analyzed by the simulation of single event upset in different characteristic dimensions SRAMs induced by low energy proton using Monte-Carlo code Geant4. The simulating result shows that the deposited energy will decrease with the increase of incident proton energy, but it will increase with the increase of characteristic dimensions in the 1-5MeV energy range. And the SEU cross section will decrease with the increase of incident proton energy, but it will increase with the decrease of critical charge in the 1-5MeV energy range.

Primary author: Mr LI, yonghong (xi'an jiaotong university)

Co-author: Mr DU, shu (xi'an jiaotong university)

Presenter: Mr LI, yonghong (xi'an jiaotong university)

Session Classification: Poster Session

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

Diamond detector time resolution for large angle tracks

Wednesday 8 October 2014 11:20 (20 minutes)

The physicists working at CERN, in particularly with the LHC high-luminosity upgrade plans, showed great interest in the diamond detector technology in recent years. The applications which have stimulated greater interest are the ones connected to the use of the detector close to particle beams, therefore in an environment with high radiation level (beam monitor, luminosity measurement, detection of primary and secondary-interaction vertices).

Our aims is to extend the studies performed so far by developing the technical advances which are needed to prove the competitiveness of this technology in terms of time resolution, with respect to more usual ones, such as Cherenkov radiator coupled to a MultiChannelPlate, which does not guarantee the required performances and working stability in the presence of high integrated radiation doses.

Summary

Measurements of diamond detector time resolution with tracks incident at different angles are discussed. In particularly,preliminary testbeam results obtained with 5 GeV electrons and polycrystalline diamond strip detectors are shown.

Primary author: CHIODINI, Gabriele (INFN Lecce)

Presenter: CHIODINI, Gabriele (INFN Lecce)

Session Classification: Diamond Detectors

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

Primary Design and Numerical Simulation Studies on 3D Si SOI Microdosimeter

Thursday 9 October 2014 15:50 (20 minutes)

For evaluating and measuring the absorbed irradiation microdosimetry in radiobiology and other research areas, a primary 3D pixel structure of Si SOI microdosimeter was given in the paper. For optimizing the detector structure in order to reducing detector insensitive area and improving its charge collection efficiency, a primary optimized mircodosimeter with hexagon pixel structure was offered by numerical simulating , comparing and analyzing its electronic characteristics changed with different technology parameters, such as sensitive area, electrode doping depth, electrode width, guard ring doping profile, etc. Besides, the microdosimeter responses to different irradiation alpha particle energies(0.5MeV, 1MeV, 3MeV, 5MeV), particle incident angle, detector bias voltage, irradiation damage including surface state and displacement damage were also simulated and analyzed. The simulation results may offer some valuable reference data for optimized 3D pixel microdosimeter fabrication and applications.

Summary

The primary optimized 3D pixel Si SOI mircodosimeter designed hexagon structure profile was obtained. The thickness of buried oxide SiO2 embedded in the n-type bulk silicon substrate was 2μm. The thickness of the surface silicon bulk above the buried SiO2 layer was 10um. The doping density of the n-type bulk silicon was 7×1011cm-3. The p+ -type hexagon electrode width with constant doping density ˜1e20 cm-3 was 3˜4μm, the inner long radius of the hexagon electrode was ˜10μm. The constant doping density and doping depth of the cylinder n+-type electrode in the center hexagon pixel were the same as those of p+-type electrode. The radius of n+-type electrode was 3˜4μm. The peak doping density of the p+-type guard ring with Gauss doping profile was about 1e17cm3.The detector charge sharing, CCE, energy response ,I-V characteristics affected by the different conditions described above were compared and analyzed.

Primary author: Dr LIU, Shuhuan (School of Nuclear Science and Technology, Xi'an Jiaotong University, Xi'an, 710049, China)

Co-author: Prof. LI, Zheng (Xiangtan University, Hunan, China)

Presenter: Dr LIU, Shuhuan (School of Nuclear Science and Technology, Xi'an Jiaotong University, Xi'an, 710049, China)

Session Classification: Poster Session

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

Wireless ultra-wide band transmission of bio signals

Friday 10 October 2014 12:10 (20 minutes)

The main objective of this proposal is to design a system for transmission and reception of signals and biological parameters through dedicated radio circuits using a purely digital approach (asynchronous events). Each source of biomedical parameters will be translated into temporal events that can be transmitted and received without further processing. The system, in fact, thanks to its intrinsic use of events, allows controlling in an extremely efficient release of energy for the transmission of information, and therefore exploit an approach completely on-demand to minimize the consumption of power. The events are generated occurrence of particular patterns in the input signal (and then it is extracted the information content of the signal of interest) and efficiently (with respect to energy consumption, complexity, integration and flexibility) synthesized via a digital system asynchronously. The information is transmitted only when required, allowing for a longer battery life than traditional wireless processes. From the technological point of view it will be exploited the wireless transmission techniques that employs the Impulse Radio Ultra-Wide-Band, localized around 3-5 GHz, for transmitting and receiving signals by very reduced temporal pulses, resulting in very wide spectral occupation. As a consequence of that, we gain limited power consumption at the transmitter side.
This wireless system can find various applications in the field of medicine, allowing accurate measurements of various biological parameters detected from time to time by a single receiver (collector). The latter will have the task of reworking the received signals to identify the correct sequence and the source of information.

Summary

The device must have reduced final dimensions to be integrated on a single microchip, which, after having amplified and processed the information of external sensors, must be able to transmit it at distances of the order of meters, possibly using an integrated antenna. The miniaturization of the system to use more sensors, perfectly compatible with low-consumption electronics, can meet the needs of medical applications such as the remote control of biological parameters or the construction of robotic equipment (exoskeletons). The proposed mechanism will be developed in a prototype phase to discrete components in order to validate an initial feasibility study, and will then be integrated microchip in a final stage.
We have been able to mount in a preliminary data acquisition chain an amplifier for instrumentation, which we use to interface and read out the bio signals, a voltage controlled oscillator (VCO) to digitize the information and a wireless transmitter.
The transmission tests were carried out exploiting a specific digital modulation, namely Synchronized On/Off Keying (S-OOK) digital modulation. Moreover, for these tests the carrier was used nominally at 3.5 GHz. The S-OOK modulation is devoted to "translate"bit transmission requests into transmission trigger events for the following UWB transmitter. Standard OOK maps each 1 into an impulse trigger, and each 0 into a "space"that is a no impulse trigger, or just a delay. S-OOK adds a synchronizing impulse "S"before the data bit "D", thus allowing the receiver to know whenever a data bit is being effectively transmitted and hence not requiring to recover any timing information regarding the data stream. Despite using a synchronizing impulse, this solution allows to design a fully asynchronous event-based receiver, more robust with respect to undesired delays

due to the transmission channel. Here we have used an external S-OOK modulator together with the on-chip transmitter. Indeed, this S-OOK modulation was easily implemented in one prototype ASIC. In more detail, any digital series of 0s and 1s, i.e. the modulation sequence of bits, enables or disables the RF transmitter. Hence, the effective transmitted bits were formed by a series of RF bursts centered at a carrier frequency of 3.5 GHz.
The proposed approach using standard CMOS process suggests the use of this technology for monolithic implementations of generic sensors along with microelectronic readout circuits. In addition, the prototype that we have described allows an Ultra-Wide-Band, low-power digital modulation. The range of transmission via the integrated antenna is of the order of 1 m and the total power consumption was measured as low as a few hundreds of μW. Future improvements of the microelectronic design are oriented to include an additional on-chip remote powering system, using state-of-the-art deep submicron architectures. In this way the chip will be able to work without any in-system battery and this also fits medical applications.

Primary author: GABRIELLI, Alessandro (Universita e INFN (IT))

Presenter: GABRIELLI, Alessandro (Universita e INFN (IT))

Session Classification: Bio-Medical Applications

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

Primary Experimental Radiation Effects Results of 28 Nanometer Configuration System-on-Chip(Xilinx Zynq-7010 SoC)

Thursday 9 October 2014 15:30 (10 minutes)

The experimental system we established for evaluating the single event effects (SEE) and total ionizing dose effects (TID) of Xilinx MicroZed Zynq-7010 SoC was introduced in the paper. The variation of the output current of the test SoC during 60Co gamma irradiation was measured. The irradiation dose rate was 0.04Gy(Si).s-1. The test SoC output current changing characteristics under the condition of high temperature (70oC) and room temperature annealing after total gamma irradiation dose 1.69kGy(Si) were surveyed and analyzed. Meanwhile, the SEE sensitive electronic circuit elements including (D-Cache, programmable logic(PL),memory, and registers,etc. embedded in the SoC) and several typical external ports, such as DMA, QSPI and GIC, were tested with 239Pu alpha irradiation on SoC. The single event effects of DDRAM was tested by 1060nm laser irradiation on the bakside. The phenomena of SEU, SEFI and MBU happened in different parts induced by alpha or laser irradiation in the test system were observed.

Summary

The experimental results showed that the test 28nm SoC were sensitive to SEE and ionizing irradiation. The gamma irradiation total dose evaluation threshold value for the test system was about 1.26kGy(Si).

Primary author: Dr LIU, Shuhuan (School of Nuclear Science and Technology, Xi'an Jiaotong University, Xi'an, Shaanxi, 710049,P.R. China)

Co-authors: Prof. HE, Chaohui (School of Nuclear Science and Technology, Xi'an Jiaotong University, Xi'an, Shaanxi, 710049,P.R. China); Dr ZANG, Hang (School of Nuclear Science and Technology, Xi'an Jiaotong University, Xi'an, Shaanxi, 710049,P.R. China); Prof. ZHOU, Hui (Northwest Institute of Nuclear Technology,Xi'an, Shaanxi, 710613 P.R.China); Prof. CHEN, Wei (Northwest Institute of Nuclear Technology,Xi'an, Shaanxi, 710613 P.R.China); Prof. DU, Xiaozhi (Xi'an Jiaotong University, Xi'an, Shaanxi, 710049,P.R. China); Dr DU, Xuecheng (School of Nuclear Science and Technology, Xi'an Jiaotong University, Xi'an, Shaanxi, 710049,P.R. China); Dr ZHANG, Yao (School of Nuclear Science and Technology, Xi'an Jiaotong University, Xi'an, Shaanxi, 710049,P.R. China); Dr ZHAO, Yaolin (School of Nuclear Science and Technology, Xi'an Jiaotong University, Xi'an, Shaanxi, 710049,P.R. China); Dr LI, Yonghong (School of Nuclear Science and Technology, Xi'an Jiaotong University, Xi'an, Shaanxi, 710049,P.R. China)

Presenter: Dr LIU, Shuhuan (School of Nuclear Science and Technology, Xi'an Jiaotong University, Xi'an, Shaanxi, 710049,P.R. China)

Session Classification: Poster Session

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

Charge collection in Si detectors irradiated in-situ at superfluid helium temperature

Wednesday 8 October 2014 17:20 (20 minutes)

The subject of the investigation arises from the intention to upgrade the beam loss monitoring system of the Large Hadron Collider by installation of semiconductor detectors located as close as possible to the superconducting coils of the triplet magnets and immersed in superfluid helium. For this, in-situ irradiation test of Si p-on-n detectors was carried out at 1.9K at CERN PS. The results on the collected charge and the current pulse response of Si detectors irradiated to the maximum radiation fluence of 1x10ˆ16 p/cm2, which corresponds to a dose of about 2 MGy, are described. In the measurements the collected charge Qc was determined by integrating the detector output current over the sequence of proton spills. The current pulse was generated by a laser with the 630 nm wavelength and 45 ps width and measured using Transient Current Technique. The results exhibit degradation of the collected charge with accumulated fluence at both polarities of the bias voltage and the Qc(F) dependences are well approximated using the Hecht function. It is shown that: a) detectors maintain operation at 1.9K being irradiated up to 1x10ˆ16 p/cm2; b) the rate of the collected charge degradation is smaller at forward bias with respect to that at reverse bias; c) the charge collected in detectors irradiated up to the maximum fluence is insensitive to bias polarity; d) space charge sign inversion in the electric field region occurs at relatively low fluence ˜4x10ˆ13 p/cm2 as is for RT irradiation. The results are analyzed taking into account specific of radiation-induced defect formation at low temperature.

Primary author: Dr VERBITSKAYA, Elena (Ioffe Physical-Technical Institute, St. Petersburg, Russian Federation)

Co-authors: Dr DEHNING, Bernd (CERN, Geneva, Switzerland); Dr KURFÜRST, Christoph (CERN); Dr JAAKKO, Härkönen (Helsinki Institute of Physics); BARTOSIK, Marcin Ryszard (CERN); Dr SAPINSKI, Mariusz (CERN); EGOROV, Nicolai (Research Institute of Material Science and Technology); Dr EREMIN, Vladimir (Ioffe Physical-Technical Institute, St. Petersburg, Russian Federation)

Presenter: Dr VERBITSKAYA, Elena (Ioffe Physical-Technical Institute, St. Petersburg, Russian Federation)

Session Classification: Irradiated Silicon Detectors

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

Performance studies for the new CMS outer tracker module concept at HL-LHC based on measurements of charge collection properties in irradiated silicon sensors

Friday 10 October 2014 09:00 (20 minutes)

In order to increase the discovery potential of the experiments at the Large Hadron Collider, the high-luminosity phase of the LHC (HL-LHC) is expected to deliver a total of 3000 fb^{-1}. The instantaneous luminosity will be increased by a factor of 5 compared to the LHC design luminosity. This results in an intensified radiation level and track density especially in the tracking systems, requiring new radiation hard sensors for the CMS outer tracker. The CMS tracker collaboration initiated a large campaign to evaluate several different silicon base materials and sensor layouts in order to cope with the increasing demands to radiation hardness and track density. The measurements performed on the sensors include electrical characterization and measurements of the charge collection process in the sensor using a beta source, laser and in testbeams. Additionally, the influence of the strong magnetic field present in the CMS tracker volume has been studied. To cope with the increased track density and trigger rates, a new module concept based on the coincidence of hits in two closely stacked sensors is pursued for the new tracker, allowing the use of tracking and transverse momentum information already at the first trigger level. This is needed to keep the overall readout bandwidth at a manageable level. For further data reduction, the next readout chip will implement a binary readout, comparing the signal height to a threshold value directly in the detector. The performance of the new trigger module concept has been studied using a parametrization of the charge drift in the electric and magnetic field in the sensor. From that, the phase-space of efficient operation of the module concept and the binary readout in terms of collected charge and noise has been explored.

Primary author: NURNBERG, Andreas Matthias (KIT - Karlsruhe Institute of Technology (DE))

Presenter: NURNBERG, Andreas Matthias (KIT - Karlsruhe Institute of Technology (DE))

Session Classification: Upgrading LHC Experiments

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

Measurements Results on a 180nm SOI Monolithic Active Pixel Sensor

Thursday 9 October 2014 11:40 (20 minutes)

Silicon-on-insulator (SOI) technologies have been developed for applications which require radiation hardness since many years. However, for its use as particle detector the total ionizing dose response of SOI devices is more complex than bulk silicon devices due to the buried oxide (BOX). A significant influence of radiation damage in the BOX on the transistor characteristics due to the so-called back gate effect has been observed and published in SOI technologies.
We have fabricated and tested a new 0.18 um SOI CMOS monolithic pixel sensor using the XFAB process. In contrast to most SOI technologies, this particular technology provides a double well structure, which shields the thin gate oxide transistors from the Buried Oxide (BOX). This in addition with the particular geometry between transistors and BOX makes the technology promising against back gate effects mentioned before. The process further allows the use of high voltages (up to 200V), which are used to partially deplete the substrate. Thus the newly fabricated device in the XFAB process is especially interesting for applications in extremely high radiation environments, such as LHC experiments.
We have carried out a validation program of the technology and the fabricated monolithic pixel sensor in a two stages approach. The first targets the characterization of the charge collection in the silicon bulk below the BOX, the second investigates the radiation hardness of the transistor characteristics, with focus on possible influences of the BOX.
The mentioned prototype has been irradiated with X-rays up to 700MRad under two different bias conditions. This presentation summarizes the promising results of the total ionizing dose hardness after this extreme dose of various transistor types - both, standard transistors with different geometries and enclosed transistors. The radiation performance is characterized by transistor threshold voltage shifts, leakage current shifts and transconductance shifts. Results obtained under different bias conditions are compared. Leakage current measurements on the monolithic pixel sensors at different temperatures are used to characterize the silicon bulk behavior and will be presented. To verify the function as pixel sensor we have also tested the device using 55Fe source.

Primary author: FERNANDEZ PEREZ, Sonia (CERN)

Presenter: FERNANDEZ PEREZ, Sonia (CERN)

Session Classification: Electronics

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

Picosecond timing of high-energy heavy ions with semiconductor detectors

Friday 10 October 2014 16:40 (20 minutes)

Construction of new accelerating facilities for the investigation of heavy ions requires upgrading of the time-of-flight (TOF) spectrometers for on-line monitoring of the characteristics of ions delivered to experiments. The requested time resolution of the TOF system is in the range of tens of picoseconds, which will cover characterization of ions up to uranium. The TOF systems built on scintillators and microchannel photomultipliers do not satisfy this requirement and, additionally, are not enough radiation hard to withstand the expected fluence of the detected ions and harsh radiation environment outside the beam. Semiconductor detectors and, in particular, silicon detectors whose technology allows device mass-production are now considered as a real candidate for TOF heavy ion spectroscopy. The expected restriction for fast timing of heavy ions with Si detectors is the so-called "plasma"effect related to the dense ion track. This effect creates significant delay in the signal formation, which value can reach several nanoseconds for short-range particles. Obviously, this prevents reaching the picosecond time resolution. Recent results on the timing of high-energy Au ions with Si planar detectors demonstrated the time jitter which is even better than 20 ps. In this presentation the mechanism of charge collection in tracks of heavy ions is examined to explain the observed high time resolution, and the results are projected to the performance of irradiated detectors.

Primary author: Dr EREMIN, Vladimir (Ioffe Physical-Technical Institute)

Co-authors: Dr VERBITSKAYA, Elena (Ioffe Physical-Technical Institute); Dr EREMIN, Igor (Ioffe Physical-Technical Institute); EGOROV, Nikolai (Research Institute of Material Science and Technoligy); Dr KISELEV, Oleg (GSI); Dr TUBOLTSEV, Yuri (Ioffe Physical-Technical Institute)

Presenter: Dr EREMIN, Vladimir (Ioffe Physical-Technical Institute)

Session Classification: Low Gain Avalanche Detectors II

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

Characterization of 3D and planar Si diodes with different neutron converter materials

Thursday 9 October 2014 09:20 (20 minutes)

In the past few years, considering the shortage of ^3He, many interesting developments in solid-state thermal neutron detectors have been made (see e.g. 1 and references therein). These devices normally consist in PN junctions with high aspect-ratio cavities filled with neutron converter materials. The size of the cavities and the gap in between them are designed as a trade-off between neutron absorption within the converter material and detection of the reaction products within the silicon sensor, so as to maximize the neutron detection efficiency, for which very good values up to ˜50% have been reported.
Based on our experience with 3D sensors for High Energy Physics experiments, we have started the INFN HYDE (Hybrid Detectors of neutrons) project. As a first step in this activity, we have developed a new 3D sensor structure aimed at easing the deposition of converter materials while ensuring full compatibility with a pixelated read-out chip for neutron imaging applications. A first batch of 3D sensors, fabricated at FBK in 2012, has been extensively characterized. In order to ease the testing without need for bump-bonding, arrays of cavities have been shorted to obtain diode-like devices with only two electrodes. Electrical and functional tests of bare silicon sensors with alpha particles and laser beams have been carried out to gain deep insight into their characteristics. Moreover, functional tests of 3D sensors with coupled with different converter materials have been performed with fast and thermal neutrons. In spite of the non-optimized sensor geometries, encouraging results have been obtained 2. However, given the device complexity, both in terms of topography and non-uniform charge collection behavior 2, the interpretation of experimental results was not straightforward, making it difficult to estimate the neutron detection efficiency and also to compare the measured data with Geant4 simulations. For this reason, we decided to perform additional tests using planar diodes covered with different converter materials (e.g., ^{10}B, ^6LiF, and polysiloxane 2). Test devices are PIN diodes of 1.71x1.71mm^2 active area and 300 μm thickness, with leakage currents of ˜10pA and depletion voltage of ˜50V.
Experimental results have been collected and compared with simulations carried on Geant4 platform. Although the number of impinging neutrons in the experiments was not known exactly, thus preventing to extract the detection efficiency, the agreement between the measured and simulated spectra was good, thus validating the simulation approach that was later used for device optimization. The new sensor geometries to be implemented in the next fabrication batch and selected simulation results will also be presented.

References

1 D. McGregor, et al., Journal of Crystal Growth, 379, 99 (2013).

2 R. Mendicino, et al., JINST, 9, C05001 (2014).

Primary author: Mr MENDICINO, Roberto (University of Trento, Department of Industrial Engineering, Trento, Italy and INFN, TIFPA, Trento, Italy)

Co-authors: Prof. QUARANTA, Alberto (University of Trento, Department of Industrial Engineering, Trento, Italy and INFN, LNL, Legnaro, Italy); DALLA BETTA, Gian-Franco (University of Trento, Department of Industrial Engineering, Trento, Italy and INFN, TIFPA, Trento, Italy); Mr DALLA PALMA, Matteo (University of Trento, Department of Industrial Engineering, Trento, Italy and INFN, LNL, Legnaro, Italy); BOSCARDIN, Maurizio (FBK Trento); Mr RONCHIN, Sabina (FBK Trento)

Presenter: Mr MENDICINO, Roberto (University of Trento, Department of Industrial Engineering, Trento, Italy and INFN, TIFPA, Trento, Italy)

Session Classification: 3D Detectors

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

Weightfield: Ultra Fast Silicon Detectors simulator

Friday 10 October 2014 15:20 (20 minutes)

This presentation reports on the development of *Weightfield*, a simulation program with the aim to evaluate the performance of silicon detectors. The program is controlled by a graphical interface that allows the user to select the type of silicon detector (n-in-n, n-in-p, microstrip, pads), the running conditions (depletion voltage, applied voltage, temperature, magnetic field), the type of incident particle (alpha, ideal MIP, real MIP) and the electronics used to measure the signal.

Weightfield can also be configured to study the performance of Low Gain Avalanche Detector, as it has a user-configurable gain mechanism. The program predictions have been also validated by laboratory measurements.

Primary author: Mrs CENNA, Francesca (Università di Torino e INFN)

Co-authors: SOLANO, Ada (Università di Torino e INFN); PICERNO, Antonella (Università di Torino); RAVERA, Fabio (Università di Torino e INFN); CARTIGLIA, Nicolò (INFN Torino)

Presenter: Mrs CENNA, Francesca (Università di Torino e INFN)

Session Classification: Low Gain Avalanche Detectors

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

LASER IRRADIATION OF MONOCRYSTALLINE CVD DIAMOND: A QUANTUM-KINETIC MODEL BASED ON BOLTZMANN EQUATION

Wednesday 8 October 2014 12:00 (20 minutes)

3D diamond detectors are at present investigated as they offer a superior radiation hardness with respect to planar detectors, promising to be the radiation hardest detector ever. Conductive channels are fabricated in the material by means of induced pulsed laser graphitization. The best characteristics are obtained by employing pulse durations as short as tens of femtoseconds. However a number of issues still remains open at the actual state of the art. The composition of the conductive phase is not well assessed as well as the optimal process parameters necessary to obtain low resistivity material, comparable to that of amorphous graphite, without damaging the diamond lattice. A thorough understanding of the graphitization process is still lacking. A better insight of the physics involved could greatly help to tune the parameters, e.g. pulse width, wavelength, field intensity, etc. to achieve an optimal device.
In this work we report on a theoretical simulation of the processes involved in laser irradiation under the experimental condition used to obtain high efficiency 3D detectors on monocrystalline diamond material.
A quantum kinetic approach based on the Boltzmann equation is employed to describe the response of diamond material to high excitation laser irradiation during and after the pulse duration. The different processes of excitation and rapid thermalization through electron-electron scattering to the final heat up by electron-phonon coupling are taken into account. The energy exchange between the electrons and phonons are given by a separate equation for the lattice temperature where the rate of energy transfer per unit volume from the electrons to the lattice is defined quantum mechanically.
As a result of our calculations the electron energy distribution function, average kinetic energy of the electron system and electron density are obtained as a function of laser intensity, laser photon energy (wavelength) and laser pulse duration. Furthermore we obtain the change of lattice temperature caused by irradiation..
Our calculations are intended as the first step of studying the response of diamond to laser excitation below the laser graphitization threshold, with theoretical predictions that can be validated experimentally with charge collection measurements at different laser intensities.

Summary

A quantum kinetic approach based on the Boltzmann equation is employed to describe the response of diamond material to high excitation laser irradiation during and after the pulse duration. The input parameters are derived from the experimental condition used to fabricate 3D diamond detectors on monocrystalline CVD diamond: pulse width of the order of tens of femtometers, wavelength peaked at 800 nm, different field inetnsityaround the graphitization threshold.
The different processes of excitation and rapid thermalization through electron-electron scattering to the final heat up by electron-phonon coupling are taken into account. The energy exchange between the electrons and phonons are given by a separate equation for the lattice temperature where the rate of energy transfer per unit volume from the electrons to the lattice are defined quantum mechanically.

As a result of our calculations the electron energy distribution function, average kinetic energy of the electron system and electron density are obtained as a function of laser intensity, laser photon energy (wavelength) and laser pulse duration. Furthermore we obtain the change of lattice temperature.

Primary author: APOSTOLOVA, Tzveta (Institute for Nuclear Research and Nuclear Energy (INRNE))

Co-authors: SCIORTINO, Silvio (Universita e INFN (IT)); Dr LAGOMARSINO, Stefano (INFN and Department of Physics of Florence)

Presenter: APOSTOLOVA, Tzveta (Institute for Nuclear Research and Nuclear Energy (INRNE))

Session Classification: Diamond Detectors

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

3D Pixels for the AFP Experiment

Thursday 9 October 2014 09:00 (20 minutes)

Silicon tracking detectors for forward physics experiments at the LHC will be located 210m away from the proton-proton interaction point, but only a few millimeters from the proton beam. The proximity to the beam is essential for the physics programs of these experiments (for example, AFP) as it directly increases the sensitivity of the experiment. Thus, there are two critical requirements for silicon pixel detectors. First, the dead region of the sensor has to be minimized. Second, the tracker has to be able to cope with a very inhomogeneous radiation distribution. Results of the characterization and beam test studies of inhomogeneously irradiated and slim-edged 3D pixel sensors produced at CNM-Barcelona and read out by the ATLAS front-end electronics will be presented.

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

Co-authors: CAVALLARO, Emanuele (Universitat Autònoma de Barcelona (ES)); LANGE, Joern (IFAE Barcelona); GRINSTEIN, Sebastian (IFAE/ICREA Barcelona)

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

Session Classification: 3D Detectors

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

Design of Ultra-Fast Silicon Detectors

Friday 10 October 2014 15:40 (20 minutes)

In this contribution I will review how Low Gain Avalanche Detectors can be designed and optimized for timing measurements.

Specifically I will show how the interplay of gain, signal amplitude, signal rise and collection time, detector capacitance, and read-out electronics determines the UFSDs design and their performances.

First results on timing performances of LGAD prototypes manufactured by CNM obtained at test beams at CERN and Frascati will be presented.

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

Co-authors: SEIDEN, Abraham (University of California,Santa Cruz (US)); Dr PICERNO, Antonella (Universtita' di Torino); RAVERA, Fabio (Universita e INFN (IT)); CENNA, Francesca (Universita e INFN (IT)); SADROZINSKI, Hartmut (SCIPP, UC santa Cruz); PAOLOZZI, Lorenzo (Universita e INFN Roma Tor Vergata (IT)); SPENCER, Ned (University of California,Santa Cruz (US)); MINAFRA, Nicola (Universita e INFN (IT)); ARCIDIACONO, Roberta (Universita e INFN (IT)); CARDARELLI, Roberto (Universita e INFN Roma Tor Vergata (IT)); MONACO, Vincenzo (Universita e INFN (IT))

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

Session Classification: Low Gain Avalanche Detectors

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

Charge collection efficiency of three-dimensional polycrystalline diamond detectors

Wednesday 8 October 2014 11:40 (20 minutes)

Three-dimensional (3D) diamond detectors fabricated on high quality single-crystal CVD (scCVD) material show remarkable properties as 100% charge collection efficiency at electric fields as low as 0.04 V/μm. However polycrystalline CVD diamond (pCVD) is much more easily available with lower cost and larger areas. Hence the implementation of the 3D detector concept with pCVD diamond is highly desirable. The short inter-electrode distance of 3D detectors should improve the intrinsically lower collection efficiency of polycrystalline material, thus allowing to exploit its relative lower degradation to high radiation fluences with respect to the scCVD one. In this work we report on the fabrication and test of 3D pCVD diamond detectors, with different inter-electrode distances, and we prove that their collection efficiency is equal or higher, depending on geometry, than that obtained with conventional planar detectors fabricated with the same material. Preliminary results are also presented on the irradiation and test of these detectors with 1MeV equivalent neutrons.

Primary author: Dr LAGOMARSINO, Stefano (DDepartment of Physics and INFN of Florence)

Co-authors: MOROZZI, Arianna (INFN and University of Perugia, Italy); CORSI, Chiara (LENS, Florence, Italy); PASSERI, Daniele (Universita e INFN (IT)); KANXHERI, Keida (INFN and University of Perugia, Italy); SERVOLI, Leonello (INFN, Sezione di Perugia-Universita & INFN, Perugia-Unknown); BELLINI, Marco (INO-CNR, Florence, Italy); BRIANZI, Mirko (Universita e INFN (IT)); SCIORTINO, Silvio (Universita e INFN (IT)); CINDRO, Vladimir (Jozef Stefan Institute (SI))

Presenter: Dr LAGOMARSINO, Stefano (DDepartment of Physics and INFN of Florence)

Session Classification: Diamond Detectors

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

Simulation of Synergistic Effects on Lateral PNP Bipolar Transistors induced by Neutron and Gamma Irradiation

Thursday 9 October 2014 14:40 (10 minutes)

The numerical simulation methods of neutron displacement effects, total dose effects and ionizing/displacement synergistic effects are established in this work. By the use of semiconductor devices simulation software TCAD, numerical simulation of ionizing/displacement synergistic effects on lateral PNP bipolar transistors induced by neutron and gamma irradiation is carried out with the method of changing minority carrier lifetimes, surface recombination velocity and adding charge traps to SiO2 layer. The results indicate that in the lateral PNP bipolar transistors irradiated with gamma rays up to 50 krad(Si) and with neutrons up to 3.0e13 cm^(-2), the total ionizing dose effects can enhance the neutron displacement damages and lead to larger gain degradation.

Summary

The simulation results indicate that in the base region of lateral PNP bipolar transistors irradiated with gamma rays and neutrons simultaneously, total recombination rate is larger than the sum of those in the base region of lateral PNP bipolar transistors irradiated with gamma rays and neutrons individually, the total ionizing does effects can enhance the neutron displacement damages and lead to larger excess base current and gain degradation. Therefore, ionizing/displacement synergistic effects on lateral PNP bipolar transistors are not a simply combination of total ionizing does effects and displacement effects, and enough attention should be paid to this phenomenon.

Primary authors: Ms WANG, Chenhui (Northwest Institute of Nuclear Technology of China,Xi'an 710024,China); Prof. CHEN, Wei (Northwest Institute of Nuclear Technology of China,Xi'an 710024,China)

Co-authors: Mr YANG, Shanchao (Northwest Institute of Nuclear Technology of China,Xi'an 710024,China); Mr JIN, Xiaoming (Northwest Institute of Nuclear Technology of China,Xi'an 710024,China); Ms BAI, Xiaoyan (Northwest Institute of Nuclear Technology of China,Xi'an 710024,China); Mr LIU, Yan (Northwest Institute of Nuclear Technology of China,Xi'an 710024,China)

Presenter: Ms WANG, Chenhui (Northwest Institute of Nuclear Technology of China,Xi'an 710024,China)

Session Classification: Poster Session

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

Measurements of LGAD Segmented Devices for high energy physics

Friday 10 October 2014 17:00 (10 minutes)

The High Luminosity LHC upgrade, foreseen for the third long shutdown of LHC, is pushing the challenge for detectors able to sustain up to a fluence of $2 \cdot 10^{16}$ $1\mathrm{MeV}\ \mathrm{n_e q/cm^2}$.

One of the new technologies under development is called Low Gain Avalanche Detectors (LGAD), whose concept is to generate a high electric field region inside the semiconductor material. Charge careers crossing this region may acquire high enough energy to generate secondary ionization initializing a multiplication chain.

The higher charge collected by LGAD devices is expected to neutralize the radiation induced signal degradation, moreover it allows to reduce the sensor thickness, and therefore the detector material budget, preserving a good charge to noise ratio.

Results of recent production of LGAD sensors from CNM (Centro Nacional de Microelectrónica, Barcelona) will be presented. Both diode TCT studies and electrical characterization of pixel devices will be discussed.

Primary author: CAVALLARO, Emanuele (Universitat Autònoma de Barcelona (ES))

Co-authors: LOPEZ PAZ, Ivan (Universitat Autònoma de Barcelona (ES)); LANGE, Joern (IFAE Barcelona); GRINSTEIN, Sebastian (IFAE/ICREA Barcelona)

Presenter: CAVALLARO, Emanuele (Universitat Autònoma de Barcelona (ES))

Session Classification: Low Gain Avalanche Detectors II

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

Invited Lecture: The PixFEL project: developing a fine pitch, fast 2D X-ray imager for the next generation X-FELs

Wednesday 8 October 2014 09:30 (45 minutes)

The work will provide a detailed description of the PixFEL project, aiming at the development of advanced instrumentation for 2D X-ray imaging at the next generation X-ray free electron laser facilities.

Summary

The PixFEL project represents the first stage toward the development of advanced X-ray imaging instrumentation for experiments at the next generation X-ray free electron lasers (X-FELs). The project aims at substantially advancing the state-of-the-art in the field of 2D X-ray imaging detectors by taking advantage of some key technology options. For this purpose, the collaboration is working on the design of the fundamental building blocks and investigating and implementing the enabling technologies for assembling a three-layer (one for the detector and two for the readout chip), four-side buttable chip. The ambitious goal of the research program, in the long term, is the fabrication of an X-ray camera with single photon resolution, 1 to 10^4 photons @ 1 keV to 10 keV input dynamic range, 1 kevent in pixel memory, 100 μm pitch and the capability to be operated at the fast (1 MHz or larger) rates foreseen for the future X-FEL machines. Active edge pixel technology is an interesting solution to reduce the gap between the active area and the edge of the sensor and minimize the dead area in the sensor layer. Process optimization is required for improved quantum efficiency at 10 keV. Also, a careful study of plasma effects and radiation damage is needed for a full assessment of the device operation in the environment of X-FEL experiments.
The building blocks of the readout chip are being designed in a 65 nm CMOS technology. The front-end electronics has to cover the wide input dynamic range while preserving single photon resolution at small signals. In the PixFEL project, this is achieved by means of a charge preamplifier with non-linear charge sensitivity, based on the voltage dependent impedance of a MOS capacitor in the feedback network. A time-variant shaper is used to process the signal at the preamplifier output. In-pixel A-to-D conversion is performed with a 10 bit successive approximation register (SAR) ADC, with up to 5 Msample/s sampling rate. The analog chain and the ADC will be located in one layer of the front-end chip. In order to store 1000 events, high density memory cells will be packed in the second layer. A through silicon via (TSV) technology, with a via diameter in the order of a few micrometers, may be exploited to enable inter-layer communication. Lower density, larger diameter TSVs can be used to access the input/output pads of the chip through the substrate of the second layer, in order to avoid wire bonding and carry out side-by-side placement of the elementary tiles. The activity of the project in its present stage is mainly focused on the design of the microelectronic building blocks and on the simulation of the slim edge pixel sensor. Submission of the first test structures is planned for the last quarter of 2014.

Primary author: RATTI, Lodovico (Universita e INFN (IT))

Presenter: RATTI, Lodovico (University of Pavia)

Session Classification: Opening Session

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

Invited talk: Low Gain Avalanche Detectors (LGAD) for High Energy Physics experiments

Friday 10 October 2014 14:30 (30 minutes)

Low Gain Avalanche Detectors (LGAD) represent a remarkable advance in high energy particle detection, since they provide a moderate multiplication (gain ~ 20) on the collected charge, thus leading to a notable improvement of the signal to noise ratio, which largely extends the possibilities of application of silicon detectors beyond their present working field.

LGAD detectors are based on the standard Avalanche Photo Diodes (APD), normally used for optical and X-ray detection applications. The main differences to them are the low gain requested to detect high energy charged particles, and the possibility to have fine segmentation pitches, thus allowing the fabrication of microstrip and pixel devices which do not suffer from crosstalk in their readouts, which is one of the most common limitations usually found in avalanche detectors. As the LGAD gain remains low, the signal amplitudes are prevented for exceeding the dynamic range of readout electronics. Besides, it also results in reductions of the detector noise, as well as in increased stability.

Signal multiplication in LGAD detectors allows obtaining very low mass sensors, with thickness reduced down to ~50 μm, while retaining a large output signal. At the same time, they can exhibit good performance even when the Charge Collection Efficiency (CCE) is reduced, for instance as a consequence of their operation under high irradiation conditions. In this sense, LGAD detectors are foreseen as good candidates for their implementation in radiation-hard demanded systems, since the gain implemented in the non-irradiated devices is expected to retain some effect also after irradiation. In addition, the signal enhancement, together with the possibility of thinning the detectors, is expected to provide a remarkable improvement of the timing capabilities.

This work compiles the main aspects of the first LGAD prototype productions fabricated at the IMB-CNM. The most relevant features concerning the LGAD design and the fabrication technology will be disclosed throughout the work, highlighting some of the critical issues addressed during the sample processing. LGAD prototypes have been evaluated in several institutions connected within the framework of the CERN RD-50 collaboration. The main results of their characterizations are gathered here, as well, in order to show the LGAD performance under several operation conditions.

Primary author: FERNANDEZ MARTINEZ, Pablo (Instituto de Microelectronica de Barcelona)

Co-authors: FLORES GUAL, David (Instituto de Microelectronica de Barcelona); QUIRION, David (Instituto de Microelectronica de Barcelona); PELLEGRINI, Giulio (Instituto de Microelectronica de Barcelona); KRAMBERGER, Gregor (Jozef Stefan Institute); SADROZINSKI, Hartmut (SCIPP, UC santa Cruz); VILA ALVAREZ, Ivan (Universidad de Cantabria); FERNANDEZ GARCIA, Marcos (Universidad de Cantabria); BASELGA BACARDIT, Marta (Instituto de Microelectronica de Barcelona); HIDALGO VILLENA, Salvador (Instituto de Microelectronica de Barcelona); GRECO, Virginia (Instituto de Microelectronica de Barcelona)

Presenter: FERNANDEZ MARTINEZ, Pablo (Instituto de Microelectronica de Barcelona)

Session Classification: Low Gain Avalanche Detectors

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

Design and Fabrication of an Optimal Peripheral Region for the LGAD

Friday 10 October 2014 17:10 (20 minutes)

An optimal design of the peripheral region prevents the Low Gain Avalanche Detectors (LGAD) from undesirable malfunctions, which may compromise the accomplishment of their outstanding possibilities as charge particle detectors for High Energy Physics experiments. Without a proper design, LGAD detectors may suffer from premature breakdown or high leakage current levels, which hinder the signal production, as well as enlarging the noise.

This work deals with the technological aspects of a suitable LGAD design. The impact of different design strategies for the device periphery is evaluated through simulation. As a result of the conclusions extracted from this work, a new optimized LGAD process has been devise at the IMB-CNM. Details of the new LGAD production are included in this presentation.

This work is performed in the framework of the CERN RD-50 collaboration.

Primary author: FERNANDEZ MARTINEZ, Pablo (Instituto de Microelectronica de Barcelona)

Co-authors: MERLOS DOMINGO, Angel (Instituto de Microelectronica de Barcelona); FLORES GUAL, David (Instituto de Microelectronica de Barcelona); QUIRION, David (Instituto de Microelectronica de Barcelona); PELLEGRINI, Giulio (Instituto de Microelectronica de Barcelona); BASELGA BACARDIT, Marta (Instituto de Microelectronica de Barcelona); HIDALGO VILLENA, Salvador (Instituto de Microelectronica de Barcelona); GRECO, Virginia (Instituto de Microelectronica de Barcelona)

Presenters: FLORES GUAL, David (Instituto de Microelectronica de Barcelona); FERNANDEZ MARTINEZ, Pablo (Instituto de Microelectronica de Barcelona)

Session Classification: Low Gain Avalanche Detectors II

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

High Intensity Irradiation Influence on Gain, Noise nad Offset Univormity of a Pixel Detector Readout designed in 130nm CMOS

Thursday 9 October 2014 12:20 (20 minutes)

We present the measurements of offset, noise and gain uniformity of a prototype pixel detector readout ASIC designed in CMOS 130nm. The chip works in a single photon counting mode, consists of 23552 pixels of 75 um pitch and forms a matrix of 184 x 128. A single pixel consists of a charge sensitive preamplifier with a feedback discharge circuit, shaper, trimming DACs and threshold setting blocks, two discriminators and two 14-bit ripple counters. All these elements fit into pixel area of 75 um×75 um. When a multi-thousand pixel matrix is designed, the mismatch between readout channels is one of the design top priorities. Here, the shaper and the threshold trim blocks play critical roles and they are discussed in more detail. We propose several levels of offsets trimming in each pixel individually namely:

- trim DAC controlled by 7 bits to tune the IDAC current,
- control of tuning range in two different ways: by multiplying the current IDAC by factor n and/or by changing base current in the source followers,
- by adding an extra offset at the input.

The ASIC was measured for offset, noise and gain uniformity and trimming capability, which will be presented. In order to be used in an experiment or a final X-Ray detector device it was tested for radiation hardness. Two ASICs were placed in the high intensity X-Ray generator for 27 hours and 237 hours respectively. The distance between the X-ray source to the ASIC was 250mm. The X-ray generator with Mo rotating anode target was running at 60kV-300mA. Each chip received of about 3.7k rad each minute per pixel. The offset, noise and gain uniformity was measured each hour.

Summary

The measured offset spread from pixel to pixel of the IC can be reduced from the level of about σ = 16.8 mV rms down to σ = 0.74 mV rms which is less than 12 e- rms. taking into account the gain. The equivalent noise charge measured is of 89 e- rms. To distinguish between the input pulses of different amplitudes (generated in the detectors by the X-ray photons of different energies), then the spread of the gain dominates. In our solution the mean gain is trimmed to the value of 63 μV/e- with the spread of 3% rms. The summarized performance of the IC together with comparison to other world's top designs will be presented.
The results of offset, gain and noise uniformity before, during (every hour) and after high intensity irradiation (3.7k Rad per pixel each minute) of the ASIC with the energy of mainly 17.5keV and continuous X-ray, or Bremsstrahlung, up to 60kV will be presented. Preliminary data analysis proves radiation hardness of our solution with minor changes of the analog parameters and no digital blocks damage is visible.

Primary author: MAJ, Piotr (AGH UST)

Co-authors: Mr SATLAWA, Tadeusz (AGH UST); TAGUCHI, Takeyoshi (Rigaku Corporation)

Presenter: SATŁAWA, Tadeusz

Session Classification: Electronics

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

On polarization in compensated semiconductors

Wednesday 8 October 2014 14:50 (20 minutes)

It is well known that in some detectors the performances deteriorate with the operation time or increasing flux (e.g. CdTe and CdZnTe detectors). This phenomenon is often described by the general term "polarization". The exact mechanism is usually unclear, but it is generally agreed that the effects are caused by a buildup of a space charge in the device. Such space charge decreases the electric field causing a decrease in charge collection efficiency. It may also increase the charge collection time which requires longer shaping times in the electronic circuitry, leading to increased electronic noise (mainly 1/f).
The nature of the space charge and the formation mechanisms remain vague. It is well documented that the effect is influenced by the semiconductor properties as well as by contacts. Namely, the polarization can be very pronounced with one metallization, and practically disappear with another (for the same semiconductor sample).
In this study finite element calculations were used to assess the impact of imperfect ohmic contacts, and compensating trap properties on the space charge formation and on the macroscopic device behavior. It is shown that low recombination velocity of otherwise ohmic contacts leads to a formation of space charge inside the device, but the space charge density is insufficient to affect the electric field distribution significantly without the presence of compensating levels.

Primary author: RUZIN, Arie (Tel Aviv University (IL))

Presenter: RUZIN, Arie (Tel Aviv University (IL))

Session Classification: Materials and Defects Characterisation

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

Processing and characterization of epitaxial grown GaAs radiation detectors

Wednesday 8 October 2014 15:10 (20 minutes)

Radiation detectors made of epitaxial GaAs are an alternative for silicon devices for spectroscopy and radiography applications requiring moderate photon energies more than 10 keV. Being basic starting material of optoelectronics industry, the processing technology of GaAs devices is well established. Atomic numbers (Z=31, 33) of GaAs extends the X-ray absorption edge beyond Si (Z=14) detectors. In this contribution we report processing of 130μm thick epitaxial GaAs pixel detectors fabricated on heavily n-type doped GaAs substrates. An undoped epi layer was grown in a horizontal CVPE reactor. In the final phase of epitaxy, a thin p+ layer doped with zinc was grown to complete the p-i-n structure. The detectors and test structures were characterized by Capacitance Voltage (CV)/ Current Voltage (IV), Transient Current Technique (TCT) and Deep Level Transient Spectroscopy (DLTS) measurements. Full depletion voltage (Vfd) of detectors is about 15V and leakage current at Vfd below 10 nA/cm2 . Signal transit time determined by TCT is about 8ns at bias voltage less than electron drift velocity saturation, which occurs at >30V bias. DLTS measurements revealed deep levels in epitaxial layers. TCAD simulations were carried out with appropriate defect model in order to verify the experimental results.

Co-authors: Mrs GÄDDA, Akiko (VTT Microsystem and Nanoelectronics); Dr JUNKES, Alexandra (Hamburg University (DE)); KARADZHINOVA, Aneliya (University of Sofia (BG)); Dr TUOMINEN, Eija (Helsinki Institute of Physics (FI)); Dr TUOVINEN, Esa Veikko (Helsinki Institute of Physics (FI)); Dr HÄRKÖNEN, Jaakko (Helsinki Institute of Physics); Dr LUUKKA, Panja (Helsinki Institute of Physics (FI)); Dr KOSTAMO, Pasi (Oxford Instruments Analytical Oy); Dr NENONEN, Seppo (Oxford Instruments Analytical Oy); PELTOLA, Timo Hannu Tapani (Helsinki Institute of Physics (FI)); Dr RIEKKINEN, Tommi (VTT, Microsystem and Nanoelectronics)

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

Session Classification: Materials and Defects Characterisation

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

Design and TCAD simulation of double-sided pixelated low gain amplification detectors

Friday 10 October 2014 15:00 (20 minutes)

A double-sided variant of low gain amplification detector is introduced, suitable for pixel arrays without dead-area in between the different read-out elements. Design options and selected results from TCAD simulations are discussed, along with the proposed fabrication process.

Summary

Low Gain Amplification Detectors (LGAD) are attracting wide interest within the HEP community. The first prototypes developed by CNM Barcelona have been characterized by several groups, showing very promising performance. These devices are potentially able to provide very good position and timing resolution at the same time, a fact that could open new opportunities in particle tracking detectors as well as in other application fields. Some studies have highlighted a severe gain reduction in LGADs after irradiation, so radiation tolerance should be thoroughly addressed in new device developments. In addition, alternative design and fabrication approaches are necessary to pass from pad detectors to strips and pixels. In fact, existing LGADs are built with a single-sided fabrication process, and feature a blank ohmic contact on the back side and read-out junctions on the front side, embedding an additional doping layer to control the avalanche multiplication mechanism and properly designed terminations to prevent from early breakdown at the edge. This works well for pads, but in case of patterned detectors it would lead to large spatial non uniformities in the signal amplitudes since charge carriers collected at the junction edges would experience no multiplication.
In this work, we propose a modified, double-sided LGAD structure, having a large multiplication region (n/p junction) on the back side and ohmic read-out pixels on the front side. The device concept has been validated with the aid of TCAD simulations, showing multiplication gains from a few units up to about 30 depending on the dose of the multiplication layer and on the operational conditions. The design options and selected simulation results will be presented, along with the proposed fabrication process to be implemented at FBK.

Primary author: Prof. DALLA BETTA, Gian-Franco (INFN and University of Trento)

Co-authors: PIEMONTE, Claudio (FBK); CENNA, Francesca (INFN Torino); PANCHERI, Lucio (U); Prof. BRUZZI, Mara (Universita e INFN (IT)); BOSCARDIN, Maurizio (FBK Trento); CARTIGLIA, Nicolo (Universita e INFN (IT)); PATERNOSTER, giovanni (FBK)

Presenter: Prof. DALLA BETTA, Gian-Franco (INFN and University of Trento)

Session Classification: Low Gain Avalanche Detectors

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

Investigation of total ionizing dose effect and displacement damage in 65 nm CMOS transistors exposed to 3 MeV proton

Thursday 9 October 2014 12:40 (20 minutes)

Abstract: The paper reports the 65 nm CMOS transistors exposed to 3 MeV proton to study the total ionizing dose (TID) effect and displacement damage (DD) together. The proton fluence of 7×1014 p/cm2 is equivalent with 1 Grad(SiO2) total dose and 1016 n/cm2 1 MeV neutron. Under this unprecedented hostile environment, the degradation of 65 nm CMOS transistors was mainly due to TID effect. Referring to the results from 10-keV X-ray irradiation, no visible DD-induced degradation could be observed even for this extremely high proton fluence.

Keyword: 3 MeV proton; total ionizing dose effect; displacement damage; 65 nm CMOS

I. Introduction:
Investigation of radiation damage in harsh environment continues to be essential, since the increasing radiation dose and particle fluence to which semiconductor detectors are intended to be exposed. In the High Energy Physics (HEP) field, there are not only low energy electrons and photons, but also protons, neutrons and other particles which own the ability to induce displacement damage. To evaluate the radiation damage under the mixed environment, 3 MeV proton can be a good candidate as the radiation source. With the fluence of 7×1014 p/cm2, combining with the LET in SiO2 of 9.3×10-2 MeV.cm2/mg and the NIEL in Si of 5.2×10-5 MeV.cm2/mg, the deposited dose is calculated to be 1 Grad(SiO2), whereas the 1 MeV neutron equivalent fluence is about 1016 n/cm2. Thus, this radiation source can be used to evaluate the radiation damage under hostile radiation environment.

II. Irradiation setup:
The irradiation was performed in room temperature and in vacuum chamber. The proton beam was produced by the CN accelerator at INFN Laboratori Nazionali di Legnaro (Padova), with the kinetic energy of 3 MeV and a maximum proton current of 1 μA.
Before irradiation, the beam uniformity was checked by a Gafchromic radiology film which was exposed to the beam for few seconds. Then the beam was carefully aligned to make sure that the sample could be placed in the region of uniform beam. The beam intensity was measured with a Faraday cup before and after each exposure. During irradiation, the relative fluence was continuously monitored and adjusted by the current on the sample.
The irradiated samples were designed by CERN, fabricated by TSMC, wire-bonded and tested in Padova. The samples were CMOS transistors in a commercially available 65 nm CMOS technology, with 1.8 nm gate oxide and 1.2 V supply voltage.
The irradiation was performed at a flux of 4×1010 p/cm2/s for the first region when the fluence is lower than 7×1013 p/cm2, then 4×1011 p/cm2/s when the fluence is between 7×1013 p/cm2 and 7×1014 p/cm2. During irradiation and the following annealing, the transistors were kept under "worst case"bias: for nMOS, the gate was kept at 1.2 V whereas all other terminals grounded; for pMOS, all the terminals were grounded.

III. Results and discussion:
From the results in Fig. 1., along with the increase of the proton fluence, the evolution of Vth shift is consistent with the radiation damage due to the total ionizing dose (TID) effect. For nMOS transistors, the competition between the positive trapped charge and the negative interface traps could be observed. Considering the thin gate oxide (1.8 nm), the trapped charge and interface traps should be mainly built up in the STI oxide. This is proved by the radiation-induced narrow channel (RINC) effect, where the narrowest transistor (120/60 nm) performing the biggest negative shift. After annealing, due to the progressive accumulation of interface traps, for most of the transistors,

Vth keeps increasing. For pMOS transistors, due to the buildup of the positive trapped charge and the positive interface traps during irradiation, the absolute value of Vth keeps increasing. Meanwhile, although the Vth shift of transistors with geometries from 240/60 nm to 1 μm/60 nm almost overlap, it still could be observed that the biggest shift is according to the narrowest transistor (120/60 nm).

Fig. 1. Evolution of the shift of Vth along with the increase of the proton fluence for 65-nm nMOS (a) and pMOS transistors (b), when the proton fluence arrives at 7×1014 p/cm2, the deposited dose is of 1 Grad(SiO2) and the 1 MeV neutron equivalent fluence is about 1016 n/cm2.

From the historical point of view, CMOS transistors are not very sensitive to displacement damage (DD) due to its nature as a "majority carrier device". However, since this is an unprecedented hostile environment, it is necessary to evaluate the comparative sensitivity of CMOS transistors to DD.
If only from Fig. 1., it is difficult to evaluate the degradation level of the transistors due to DD independently. Referring to the structure of the samples, there are ESD protection diodes connected with the gate contact of every transistor. Therefore, the evolution of the gate leakage can be used as an indicator of DD in diodes. In addition, 10-keV X-ray irradiation was performed for comparison due to the negligible NIEL of the photon. The ratio variations of gate leakage and on-state drain current of 360/60 nm nMOS transistors together with the accumulation of X-ray dose or the increase in proton fluence are presented in Fig. 2. Under the X-ray environment, the increase of gate leakage was negligible, whereas this increase was quite big under the 3-MeV proton environment, suggesting the evident damage related with DD. However, under both the two environments, the on-state currents of the nMOS transistors did not behave big difference, considering that there are also the differences in radiation source and dose rate, no visible DD-induced degradation could be observed even for this extremely high proton fluence (7×1014 p/cm2 ,with the 1 MeV neutron equivalent fluence of 1016 n/cm2).

Fig. 2. Ratio variation of gate leakage IG (with VG=1.2 V) (a) and drain current (with VG=VD=1.2 V) (b) of 360/60 nm nMOS transistors under 3-MeV proton and 10-keV X-ray irradiation environment.

IV. Conclusion:
TID effect and DD in 65 nm CMOS transistors were investigated together by 3 MeV proton. The fluence of proton beam was up to 7×1014 p/cm2, which was equivalent with 1 Grad(SiO2) total dose and 1016 n/cm2 1 MeV neutron. Therefore, 3 MeV proton is a good candidate to evaluate the radiation damage under the mixed environment. Under this unprecedented hostile environment, the 65 nm CMOS transistors behaved visible degradation which was consistent with the TID-induced degradation. To study the DD-induced degradation, 10-keV X ray irradiation was performed for comparison, the results suggests that no visible DD could be observed even for this extremely high proton fluence.

Summary

TID effect and DD in 65 nm CMOS transistors were investigated together by 3 MeV proton. The fluence of proton beam was up to 7×1014 p/cm2, which was equivalent with 1 Grad(SiO2) total dose and 1016 n/cm2 1 MeV neutron. Therefore, 3 MeV proton is a good candidate to evaluate the radiation damage under the mixed environment. Under this unprecedented hostile environment, the 65 nm CMOS transistors behaved visible degradation which was consistent with the TID-induced degradation. To study the DD-induced degradation, 10-keV X ray irradiation was performed for comparison, the results suggests that no visible DD could be observed even for this extremely high proton fluence.

Primary author: Dr DING, LILI (INFN, Padova; Department of Information Engineering, Padova

University, Italy)

Co-authors: PACCAGNELLA, Alessandro (U); BISELLO, Dario (Universita e INFN (IT)); Dr BAGATIN, Marta (Department of Information Engineering, Padova University, Italy); Dr MATTIAZZO, Serena (Department of Physics and Astronomy, Padova University, Italy); Mr GERARDIN, Simone (Padova University)

Presenters: BISELLO, Dario (Universita e INFN (IT)); Dr DING, LILI (INFN, Padova; Department of Information Engineering, Padova University, Italy); Dr BAGATIN, Marta (Department of Information Engineering, Padova University, Italy)

Session Classification: Electronics

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

Invited Lecture: Lessons learned in constructing diamond-based pixel systems

Wednesday 8 October 2014 10:15 (45 minutes)

With the first three years of the LHC running complete, ATLAS and CMS are planning to upgrade their innermost tracking layers with more radiation hard technologies. Chemical Vapor Deposition (CVD) diamond is one such technology. CVD diamond has been used extensively in beam condition monitors as the innermost detectors in the highest radiation areas of BaBar, Belle, CDF and all LHC experiments. More recently the first diamond-based hybrid pixel detector system using polycrystalline CVD diamond with state-of-art front-end electronics, the ATLAS FE-I4 pixel chip, was built and installed into ATLAS. This talk will describe the lessons learned in constructing diamond-based pixel systems in high energy physics, specifically the ATLAS Diamond Beam Monitor (DBM).

Presenter: KAGAN, Harris (Ohio State University)

Session Classification: Opening Session

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

Results from the pilot runs and beam tests of diamond pixel detectors

Wednesday 8 October 2014 12:20 (20 minutes)

H. Kagan on behalf of the RD42 collaboration

Progress in experimental particle physics in the coming decade depends crucially upon the ability to carry out experiments at high energies and high luminosities. These two conditions imply that future experiments will take place in very high radiation areas. In order to perform these complex and perhaps expensive experiments new radiation hard technologies will have to be developed. Chemical Vapor Deposition (CVD) diamond has been developed as a radiation tolerant material for use very close to the interaction region where detectors must operate in extreme radiation conditions. During the past few years many CVD diamond devices have been manufactured and tested. As a detector for high radiation environments, CVD diamond benefits substantially from its radiation hardness, very low leakage current, low dielectric constant, fast signal collection and ability to operate at room temperature. As a result CVD diamond has now been used extensively in beam condition monitors at every experiment in the LHC. In addition, CVD diamond is now being considered as a sensor material for particle tracking detectors, closest to the interaction region where the most extreme radiation conditions exist. We will present the state of the art results of diamond radiation hardness. We will also summarize the results from the pilot run of the CMS Pixel Luminosity Telescope (PLT), a luminosity monitor based on single-crystal CVD diamond pixel sensors. During the pilot run the PLT sensors experienced high fluences of incoming particles, at which time the sensors showed a deviation from the results of the expected diamond radiation hardness. In order to understand this deviation, a series of beam tests with pixel and pad detectors have been performed. The results of these beam tests will be presented and will shed the light on the anomalous behavior of the PLT single-crystal CVD sensors.

Primary author: KAGAN, Harris (Ohio State University on behalf of the RD42 Collaboration)

Presenter: KAGAN, Harris (Ohio-State University, USA)

Session Classification: Diamond Detectors

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

First Results on biased CMOS MAPS-On-DIAMOND devices

Wednesday 8 October 2014 12:40 (20 minutes)

K. Kanxheri, A. Morozzi, D. Passeri, Stefano Lagomarsino, Silvio Sciortino, L. Servoli

A new type of device, the MAPS-on-Diamond, obtained bonding a thinned Monolithic Active Pixel Sensor (a RAPS03 thinned to 25 micrometers) to a standard 500 micrometer pCVD diamond substrate has been fabricated, allowing a highly segmented readout (10x10 micrometer pixel size) of the signal produced in the diamond substrate. A biasing scheme has been adopted for the device to allow the charge transport inside the diamond without disrupting the CMOS functionalities of the Active Pixel Sensor.
The device has then been calibrated with monochromatic X-rays, and tested with charged particles to verify the collection of the signal produced in the diamond substrate as a function of the device bias.

Primary author: SERVOLI, Leonello (INFN Perugia (IT))

Presenters: PASSERI, Daniele (INFN Perugia); KANXHERI, Keida (INFN Perugia); SERVOLI, Leonello (INFN Perugia, Italy)

Session Classification: Diamond Detectors

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

Electronic stimulation of interstitial defect reactions in irradiated p-type silicon

Wednesday 8 October 2014 14:30 (20 minutes)

L.F. Makarenko*, S.B. Lastovski, M. Moll*, **I. Pintilie*Belarusian State University, Minsk, Belarus**
***Scientific-Practical Materials Research Centre of NAS of Belarus, Minsk, Belarus*CERN, Geneva, Switzerland
**** National Institute of Materials Physics, Magurele, Romania

In silicon, the recombination enhancement of migration has been investigated in detail for aluminum interstitial (Ali) 1 and boron interstitial (Bi) 2. Much less data are available on carbon interstitial (Ci) 3.
We found that electronic excitation by charge injection influences not only the behavior of single interstitial impurity atoms but also the formation and stability of their complexes with interstitial oxygen. Using forward current injection at room temperature with densities in the range of 15-30 A/cm2 the radiation induced boron-oxygen complex, which is the main compensating center in irradiated Si solar cells, can effectively be eliminated. Additionally, evidence has been obtained on the negative-U properties of the boron-oxygen complex. Forward current injection does not influence on the stability of the carbon-oxygen complex but enhances the transformation from its metastable to its stable atomic configuration during the association of mobile Ci with Oi.
Characteristics of these processes have been determined and their effects on radiation damage of silicon diodes are discussed.

1. J. R. Troxell et al., Phys. Rev. B, 19, 5336 (1979).
2. J. R. Troxell, G. D. Watkins Phys. Rev. B. 22, 921 (1980).
3. A. R. Frederickson, et al., J. Appl. Phys., 65, 3272 (1989).

Primary author: MAKARENKO, Leonid (Belarusian University, Minsk)

Presenter: MAKARENKO, Leonid (Belarusian University, Minsk)

Session Classification: Materials and Defects Characterisation

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

An evidence of strong electron-phonon interaction in the neutron irradiation induced defects in silicon

Wednesday 8 October 2014 15:30 (20 minutes)

J.Vaitkus, V.Rumbauskas, G.Mockevicius, E.Zasinas, A.Mekys

Dept. of New Materials Research and Measurement Technology, Institute of Applied Research Vilnius University, Sauletekio al. 9-III, Vilnius LT-10222, Lithuania

It is known an investigation of photoconductivity dependence on excitation photon energy can be used for the deep level spectrum analyze, but an accurracy depends on model that is chosen for the analyze.
In this work the temperature dependence of photoresponse spectrum was investigated in the silicon single crystal samples irradiated by neutrons to fluence up to 3e16 cm-2. Due to a rather long photoresponse time constant a new differential photoresponse spectrum analyze method was used for the deep levels near to the valence band energy measurement.
The slow transient dependence of photoresponse during the excitation and during decay, and it dependence on additional excitation permitted to propose the deep level competition processes and a role of cascade type excitation of free carriers.
Slow relaxation processes also were observed during measurement of galvanomagnetic effects that was analyzed in terms of modulation of conductivity band bottom by clusters.
The modeling of bias voltage influence on the contribution of the cluter related potential modulation demonstrated a possibility to avoid this effect at high bias.

Summary

The photoresponse spectral dependence at different temperature permitted to analyze the proprties of deep level related to the radiation induced cluster, and by the data observed in transient behavior of photoresponse to propose the nature of slow relaxation observed in Hall and magnetoresistance effects.

Presenter: RUMBAUSKAS, Vytautas (Vilnius University, Lithuania)

Session Classification: Materials and Defects Characterisation

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

Long term charge collection performance of silicon sensors: an investigation on the causes of the recently observed

Wednesday 8 October 2014 17:00 (20 minutes)

Presenter: MORI, Riccardo (Albert-Ludwigs Universität Freiburg, Freiburg im Breisgau, Germany)

Session Classification: Irradiated Silicon Detectors

Contribution ID: **50** Type: **not specified**

Monolithic active pixel sensor for ionizing radiation using 180nm HV-SOI process

Thursday 9 October 2014 11:20 (20 minutes)

A new type of sensor for ionizing radiation based on Partially Depleted High Voltage SOI technology (PD-SOI) has been developed.
Similar to exisiting SOI based monolithic active pixel sensors (MAPS) a buried silicon oxide interdielectric (BOX) layer is used to separate the CMOS electronics from the handle wafer which is used as a depleted charge collection layer. However, compared with these SOI MAPS that suffer from radiation damage in the buried oxide (back gate effect) and parasitic coupling through the BOX layer, this technology offers an additional isolation by an non depleted implant between BOX and the active circuitry. This is a special feature of the PD-SOI process. Therefore we see a high potential with this technology to implement fast and radiation hard MAPS. The concept and measurement results from a first prototype are presented.

Presenter: HEMPEREK, Thomas (Physikalisches Institut, University of Bonn, Germany)

Session Classification: Electronics

Contribution ID: **51** Type: **not specified**

Test-beam results on a monolithic pixel sensor in the 0.18um Tower-Jazz technology with high res istivity epitaxial layer

Thursday 9 October 2014 12:00 (20 minutes)

The ALICE experiment at CERN will undergo a major upgrade in the second Long LHC Shutdown in the years 2018-2019; this upgrade includes the full replacement of the Inner Tracking System (ITS), deploying seven layers of Monolithic Active Pixel Sensors (MAPS). For the development of the new ALICE ITS, the Tower-Jazz 180 nm CMOS imaging sensor process has been chosen as it is possible to use full CMOS in the pixel and different starting materials (including high resistivity epitaxial layers). A large test campaign has been carried out on several small prototype chips, designed to optimize the pixel sensor layout and the front-end electronics. Results match the target requirements both in terms of performances and of radiation hardness. Following this development, the first full scale chips have been designed, submitted and are currently under test, with promising results.
A telescope composed of 4 planes of Mimosa-28 and 2 planes of Mimosa-18 chips (monolithic pixel sensors both developed in the 0.35 .m AMS process) is under development at the DAFNE Beam Test Facility (BTF) at the INFN Laboratori Nazionali di Frascati (LNF) in Italy. The elescope has been recently used to test a Mimosa-22 chip (a monolithic pixel sensor built in the 0.18 .m TowerJazz process) and we foresee to perform tests on the full scale chips for the ALICE ITS upgrade by the end of this year.
In this contribution we will describe the TowerJazz process and show some first measurements of spatial resolution, fake hit rate and detection efficiency of the Mimosa-22 chip obtained at the BTF facility in June with an electron beam of 500 MeV.

Presenter: MATTIAZZO, Serena (Università di Padova, Italy on behalf of the ALICE Collaboration)

Session Classification: Electronics

Contribution ID: **52** Type: **not specified**

Deterioration of detection and charge collection efficiencies for CMOS imagers in a 15 MeV proton beam

L. Bissi, G. M. Bilei, M. Menichelli, D. Passeri, A. Saha, M. Salvatore, L. Servoli

INFN Perugia

Standard CMOS imagers are suitable for charged particle detection with high efficiency, thanks to the very high S/N ratio for MIPs, and being fabricated using advanced technological nodes (130 nm or less) are intrinsically resistent to radiation damage, at least in medium-high particle fluence environments.
The study of their behaviour is then useful to understand the current limitations of the use of such cheap devices for beam monitoring or single particle detection.
In this work, carried on within the AIDA project, we present the results on the variation of the detection and charge collection efficiencies of such detectors, damaged using the 14 MeV proton beam at INFN Laboratori Nazionali del Sud to a fluence up to 10ˆ14 15 MeV protons/cmˆ2, for Minimum Ionizing Particles.

Presenter: SERVOLI, Leonello (INFN Perugia (IT))

Contribution ID: **54** Type: **not specified**

Development of a bidimensional dosimeter for IMRT based on polycrystalline diamond

Thursday 9 October 2014 15:10 (10 minutes)

A bidimensional dosimeter consisting of 12x12 pixels on a 2.5x2.5cm2-wide polycrystalline Chemical Vapour Deposited diamond (pCVD) has been manufactured. The prototype has been tested under Intensity Modulated Radiation Therapy (IMRT) fields for a possible application in pre-treatment verifications of cancer treatments.

Tests have been performed under a 6 MVRX beam with an IMRT field for breast cancer. Measurements have been taken by shifting the device along the x/y axes to span a total map of 10x8 cmˆ2. Main results, shown and discussed in this paper, evidence that absorbed doses measured by our pCVD device along IMRT profiles are consistent with both those acquired with a commercial device based on silicon diodes and calculated by the Treatment Planning System (TPS).

Co-authors: BALDI, Andrea (Universita' di Firenze); DE SIO, Antonio (Universita' di Firenze); BUCCIOLINI, Marta (Universita' di Firenze)

Presenters: ZANI, Margherita (Universita' di Firenze); SCARINGELLA, Monica (University of Firenze, Italy)

Session Classification: Poster Session

Contribution ID: **55** Type: **not specified**

Belarusian HPHT diamonds. Material properties and detector characteristics

Thursday 9 October 2014 15:20 (10 minutes)

N.M. Kazuchits, L.F. Makarenko, M.S. Rusetsky, Ya. I. Latushko
Belarusian State University, Independence Ave. 4, 220030, Minsk

Synthetic diamond crystals grown by the HPHT (High Pressure High Temperature) technique have impurities, such as nitrogen and metallic catalysts, as well as inclusion and structural defects, which result in variations of optical and electrical properties for crystals obtained by different producers.
In Belarus, synthetic diamonds (trademarked as STM Almazot) are manufactured at the Science and Technology Center "Adamas"1. The diamond single crystals, conventionally synthesized by the high pressure (4.5–5.0 GPa) and high temperature (1350–1450 °C) gradient technology using the Ni–Fe–C liquid solvent/catalyst carbon metallurgy system, were investigated. Growth was carried out of about 65–70 h. The solvent/catalyst system comprised the 70% Fe and 30% Ni metals in crystal growth cell, respectively.
To characterize the diamond crystal, it was sliced to form diamond plates. The sizes of individual diamond plates vary between 4–20 mm2 (area) and 0.2–0.4 mm (thickness). The plates were investigated by different experimental techniques: optical absorption, photo- and cathodoluminescence and ESR methods 2. It has been found that STM Almazot crystals have strongly nonuniform impurity and defect distributions.
To select plates for detector structures, photoconductivity measurements have been used. Electrical contacts have been formed using boron implantation followed by activation annealing in vacuum. Spectrometric, dosimetric and pulse characteristics of test detector structures were studied, as well as the spectral characteristics of photoconductivity in the UV range. It is shown that the dosimeters, pulse radiation detectors and photodetectors for the UV range have high performance characteristics which are comparable with those of the detectors made of natural type IIa diamond. Small local regions with extremely high sensitivity to radiation have been found in the STM Almazot crystals. These regions can be used to fabricate devices for small field dosimetry.

1. www.adamas.by
2. E. Gaubas, et al.. Diamond and Related Materials, 47 (2014): 15-26

Presenter: MAKARENKO, Leonid (Belarusian University, Minsk)

Session Classification: Poster Session

Contribution ID: **56** Type: **not specified**

Beam Test Characterization of CMS Silicon Pixel Detectors for the Phase-1 Upgrade

Friday 10 October 2014 10:40 (20 minutes)

The Silicon Pixel Detector forms the innermost part of the CMS tracking system and is critical to track and vertex reconstruction. Being in close proximity to the beam interaction point, it is exposed to the highest radiation damage in the silicon tracker.
In order to preserve the tracking performance with the LHC luminosity increase which is foreseen for the next years, the CMS experiment has planned to build a new pixel detector with four barrel layers mounted around a reduced diameter beam pipe, as compared to the present three layer pixel detector in the central region. A new digital version of the front-end readout chip has been designed and tested; it has increased data buffering and readout link speed to maintain high efficiency at increasing occupancy. In addition, it offers lower charge thresholds that will improve the tracking efficiency and position resolution. Single chip modules have been evaluated in the DESY electron test beam in terms of charge collection, noise, tracking efficiency and position resolution before and after irradiation with 26 GeV protons from the CERN Proton Synchroton equivalent to the fluence expected after 500 inverse femtobarn of integrated luminosity in the fourth layer of the pixel tracker. High efficiency and an excellent position resolution have been
observed which are well maintained even after the proton irradiation. The results are well described by the CMS pixel detector simulation.

Presenter: KOROL, Ievgen (Deutsches Elektronen-Synchrotron (DE))

Session Classification: Upgrading LHC Experiments

Contribution ID: **57** Type: **not specified**

Radiation Damage in the LHCb VELO and its Impact on Operations in LHC Run 2

Friday 10 October 2014 10:20 (20 minutes)

LHCb is a dedicated experiment to study New Physics in the decays of heavy hadrons at the Large Hadron Collider (LHC) at CERN. Heavy hadrons are identified through their flight distance in the Vertex Locator (VELO), which consists of two retractable silicon strip detectors surrounding the interaction point.

The VELO comprises 42 modules made of two n+-on-n 300 um thick half-disc silicon sensors with R-measuring and Phi-measuring micro-strips. One upstream module is manufactured with n+-on-p technology, which allows a direct comparison of the two technologies in real operational conditions. In order to allow retracting the detector, the VELO is installed as two movable halves containing 21 modules each. The detectors are operated in a secondary vacuum and are cooled by a bi-phase CO2 cooling system. Analogue front-end chips are reading out the sensors and feed the signal into DAQ boards where it is converted to digital and processed in FPGAs.

During data taking in 2011 and 2012 the VELO sensors have received a large and non-uniform radiation dose of up to 1.2 x 1014 1 MeV neutron equivalent /cm2.
Type-inversion has already been observed in the innermost regions close to the interaction point. The analysis of the radiation damage has been refined during the LHC shutdown. It is expected that the VELO can no longer be operated efficiently with uniform bias voltages across all sensors in Run 2 of the LHC. Results of of the radiation damage analysis will be presented based on measurements of reverse currents versus voltage and temperature, charge collection efficiency versus voltage and cluster finding efficiency. In addition, the new Run 2 operational procedures addressing the non-uniform radiation damage will be discussed.

Presenter: RINNERT, Kurt (University of Liverpool (GB))

Session Classification: Upgrading LHC Experiments

Contribution ID: **58** Type: **not specified**

Invited talk: Status of the RDH project

Friday 10 October 2014 11:20 (30 minutes)

RDH (Research and Development in Hadrontherapy) is the INFN project which aims to coordinate together different research groups which are involved in the field of charged particle oncological therapy, i.e. radiotherapy based on the use of charged hadron beams (protons or light nuclei). This technique is the result of fruitful collaboration of medicine, physics and biology. It exploits the properties of energy deposition in matter by massive charged particles, with many advantages with respect to conventional radiotherapy based on X-rays. Charged particle therapy has indeed a high potential in terms of precision and selectivity. However, there exist uncertainties mostly connected to physics and biology (range uncertainties, radiobiological effects) which at present still represent significant limitations. Furthermore, as in the case of normal radiotherapy, there are requests to implement quality control and in-vivo monitoring techniques, which stimulate the development of applications deriving from the experimental techniques of nuclear and particle physics. In addition, since hadron accelerators have higher costs with respect to standard medical electron LINACs, the development of new and more efficient acceleration systems is another topic in which the expertise of physics community can be fundamental. The program of RDH, similarly to that of other several institutes in the world, includes several of the mentioned chapters: specific radiobiological investigations, development of software tools (in particular for treatment planning), design of new accelerator sources and the development of particle detection techniques. These find different applications, ranging from the monitoring of therapeutic beams to medical imaging techniques. In particular the concern is focused on two different aspects: in vivo monitoring, exploiting the production of secondary particles and radioisotopes induced by the primary beam, and imaging aimed to achieve a more precise range assessment, and therefore a more precise planning of the treatment. One of the most promising approaches in this respect is proton tomography (pCT). All these experimental developments benefit from the knowhow in particle detectors and nuclear electronics deriving from basic research.
The status of the different parts of RDH project will be reviewed, highlighting the most recent results and the general perspectives of these researches.

Presenter: BATTISTONI, Giuseppe (INFN Milano (IT))

Session Classification: Bio-Medical Applications

Contribution ID: **59** Type: **not specified**

Development of silicon monolithic arrays for dosimetry in external beam radiotherapy

Friday 10 October 2014 12:30 (20 minutes)

Francesca Bisello4,5, Marta Bucciolini1,2, Mara Bruzzi1,3, David Menichelli4, Monica Scaringella1,3, Cinzia Talamonti1,2, Margherita Zani1,2

1 University of Florence
2 Azienda Ospedaliera Unversitaria Careggi, Firenze
3 INFN- Florence Division
4 IBA Dosimetry GmbH, Schwarzenbruck, Germany
5 Friedrich-Alexander Universität Erlange-Nürnberg

This presentation is a review of the activity of our collaboration, aimed to develop new tools with high spatial resolution and high performances for dosimetry in external beam radiotherapy.
The first step (in2007) was the introduction in dosimetry of detector solutions mutated from high energy physics, namely epitaxial silicon as base material, and a guard ring in the diode design. This allowed obtaining state of the art radiation hardness, in term of sensitivity dependence on accumulated dose, with a robust geometry particularly suitable to monolithic arrays and modular design.
Following this study a 2D monolithic array has been developed, featuring a detector based on 6.3x6.3cm2 modules with 3mm pixel pitch. This prototype has been widely investigated and turned out to provide good performances in the measure of dose distributions of small and IMRT fields.
A further linear array prototype has been recently design to investigate increased spatial resolution (1mm pitch) and technical solutions to further improve radiation hardness. This 24cm long device is based on a modular assembly of 64cm long modules. It features low sensitivity changes versus dose (0.2%/kGy) and dose per pulse (⊠1% in the range 0.1-2.3mGy/pulse, covering applications with flattened and unflattened fields). It has been tested with very satisfactory results in quality assurance of linear accelerators, with special regards to small fields, as well as profiling of proton pencil beams.

Presenter: BISELLO, Francesca (, IBA Dosimetry, Schwarzenbruck, Germany)

Session Classification: Bio-Medical Applications

Contribution ID: **60** Type: **not specified**

MULTIDISCIPLINARY APPLICATIONS OF LASER-DRIVEN IONS: RATIONALE AND PRELIMINARY RESULTS OF THE ELIMED NETWORK

Friday 10 October 2014 11:50 (20 minutes)

GA Pablo Cirrone1, Giacomo Cuttone1, Georg Korn2, Daniele Margarone2,
Francesco Romano1, Valentina Scuderi1,2,
Marco Borghesi3, Giacomo Candiano1, Domenico Doria3, Dario Giove4, Tiziana Licciardello1, Mario Maggiore5, Lorenzo Manti6,7, Valentina Marchese1, Giuliana Milluzzo1, Agatino Musumarra8, Francesca Perozziello6,7, Francesco Schillaci1, Antonella Tramontana1

1 Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali del Sud, Via Santa Sofia 62, Catania, Italy, pablo.cirrone@lns.infn.it
2 Institute of Physics of the ASCR, v.v.i. (FZU), ELI-Beamlines project, Na Slovance 2, Prague, Czech Republic
3 Centre for Plasma Physics, Queen's University Belfast, BT7 1NN, UK
5 Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Legnaro, Viale dell'Università 2, Legnaro (Pd), Italy
6 INFN Sezione di Napoli, Complesso Universitario M. S. Angelo, Via Cintia - 80133 Napoli, Italy
7 University of Naples Federico II, Complesso Universitario M. S. Angelo, Via Cintia - 80133 Napoli, Italy
8 Università di Catania, Dipartimento di Fisica e Astronomia, Via S. Sofia 64, Catania, Italy

Introduction: Nowadays, laser-accelerated ions represent a fascinating alternative in the field of non-conventional acceleration techniques. The ELIMED project aims to demonstrate the potential medical applicability of optically accelerated proton beams. Design, development and characterization of beam transport, selection and dosimetric devices for high-energy laser-driven proton beams will be presented.
Summary: Over the last decades, charged particle acceleration using ultra-intense and ultra-short laser pulses has been one of the most attractive topics in the relativistic laser-plasma interaction research. One of the most challenging ideas driving recent activities consists on using high power lasersto generate high-energy ions for medical applications. The high interest of the scientific community in laser driven ion schemes stems from the fact that conventional ion accelerators, beam transport lines and gantry systems are complex and expensive. More compact laser-based accelerators could significantly increase the future availability of high-energy ion beams in hospitals, thus providing particle therapy to a broader range of patients.
In this framework, the purpose of the ELIMED 1 network consists in demonstrating that laser-driven high-energy proton beams can be used for multidisciplinary applications and in particular in the hadron-therapy field. Indeed, the kick-off for medical applications and for radiobiological investigations will be given once the laser-accelerated proton beam transport, selection and dosimetry system is tested and fully operational. We started to design and develop a beam transport line prototype able to deliver laser-generated proton beams with optimized properties and adequate repetition rates. A focusing device consisting of four magnetic quadrupoles is currently under construction. The scope of this device will be to reduce the initial angular divergence of the particle beam accelerated from the target improving the transmission efficiency of the entire transport system. A prototype of the key component of the whole beam line, the Energy Selector System (ESS), able to control and select the laser-driven proton beams, has already been developed and experimentally characterized with mono-energetic proton beams at the LNS-INFN, Catania and LNL-INFN Legnaro, Italy, as well as laser-driven proton beams available at the TARANIS laser facility, Queen's University of Belfast (UK). Moreover, a Faraday cup prototype optimized for absolute dosimetry with high dose rates and intense ion beams has been designed and tests are

ongoing. In this contribution, a description of the solution studied for the beam transport selection and dosimetry, as well as preliminary results obtained with the ESS along with the Geant4 Monte Carlo simulation of such device, will be presented and discussed.

References:
1.D. Margarone, G.A.P. Cirrone, G.Cuttone and G. Korn AIP Conf. Proc. 1546, pp. 1-1 doi:http://dx.doi.org/10.1063/1.4816599

Presenter: CIRRONE, Pablo (Laboratori Nazionali del Sud (INFN))

Session Classification: Bio-Medical Applications

Contribution ID: **61** Type: **not specified**

aSi Electronic Portal Imaging Device for the Radiotherapy In Vivo Dosimetry

Friday 10 October 2014 12:50 (20 minutes)

Introduction. Following the EURATOM 97/43 recommendation, since 2000 is operative in Italy the D.L.vo 187/00 about the radioprotection of the patients undergone at medical radio exposition. In radiotherapy the number of Quality Controls increases as function of the treatment complexity and the workload is sometime responsible of their partial absence, that increases the dosimetric errors. Moreover in this field severe incidents have been recently reported by the international media. Opinion of many physicists is that a control during the treatment using a dedicated software for the in-vivo dosimetry (IVD) could strongly reduce the presence of dosimetric errors. This mean a major presence of physicists during the radiotherapy execution, where actually there is a general absence of this professional component. Moreover the IVD is one of the best ways to gain experience to prevent errors when introducing new radiotherapy techniques.
Methods. Actually amorphous Silicon Electronic Portal Devices (aSi EPIDs) associated at the linacs are used for imaging visual inspections and someone use them for the IVD that however supply estimations of the real delivered doses in patient. Indeed even the more complex (and time consuming) clinical IVD 3D-procedure, use the initial reference CT scans (used for the plan) to reconstruct the x-ray fluence to use in a second step for the re-computation of the dose in the same reference CT scans. Then if the patient's shape or setup are changed, the reconstructed fluence is not accurate and so the reconstructed doses. Only a wide-spread use of image guided radiation therapy could assure more accurate daily dose distributions, but also higher doses at normal tissues and time consuming. For these reasons the IVD must supply in real time useful warnings to activate quality controls to remove the causes of errors. The DISO Project, supported by INFN and the Università Cattolica S.C. developed software for the IVD using the aSi EPIDs of the linacs Varian, Elekta and Siemens, interfaced with the Record and Verify System of the Centre. An original calibration procedure of the aSi EPIDs was developed to use a generalized procedure based on a set of experimental data by different linacs.
Results In the recent years 20.000 IVD tests for 3D CRT, IMRT and VMAT treatments have been obtained in 8 Italian Centres participating at the DISO Project with software prototypes. On the basis of these results recently the BEST Medical Italy developed the SOFTDISO, a dedicated software for 3DCRT, IMRT and VMAT techniques. SOFTDISO supplies two tests (i) the ratio between the reconstructed dose at the isocenter point, and that planned for the patient by TPS with a tolerance level of 5%, (ii) a γ-analysis between a reference and a current EPID images acquired during the successive fractions, with $P\gamma < 1 \geq 90\%$ agreement (and acceptance criteria of 5% and 3 mm). The major causes of discrepancies were in general due to inadequate quality controls as : -patient setup, -occasional morphological changes, -systematic morphological changes, -attenuators on the beams (patient supports), -TPS implementation, - CT number implementation, -laser misalignment, -output dose variations, -partial missing of beam delivery during IMRT.
Conclusions: The SOFTDISO is able to supply in quasi real time the IVD tests based on the use of aSi EPID and the results confirm that even if about 15% of tests resulted out-tolerance levels, once removed the causes of the dose discrepancies, the mean values of the IVD indexes for each patient were within the tolerance levels. Moreover for the tests off-tolerance levels due to patient morphological changes, SOFTDISO is a useful tool for the adaptive radiotherapy strategy.

Presenter: PIERMATTEI, Angelo (Istituto di Fisica e UOC Fisica Sanitaria Università Cattolica S.C. Roma, Italy)

Session Classification: Bio-Medical Applications

Contribution ID: **64** Type: **not specified**

Radiation tests of pixel readout chip designed in 40nm CMOS technology

Thursday 9 October 2014 14:50 (10 minutes)

The tests with gamma rays were performed on the pixel detector readout chip designed in TSMC 40nm CMOS technology. The ASIC works in single photon counting mode, consists of both analog and digital blocks including charge sensitive amplifier, two shapers, two discriminators, two separate counters and more supporting blocks. For the purpose of radiation hardness tests different radiation doses were applied from 140 Mrad to 2540 Mrad. The biasing tranzistors'characteristics, both for p-mos and n-mos types, were measured for the following radiation doses: 140 Mrad, 240 Mrad, 440 Mrad, 880 Mrad and 2540 Mrad. The characterization of the ASIC, including DC offset correction and gain measurements, was performed before and after radiation for the dose equal to 140Mrad.

Summary

Certain changes of the biasing transistors'characteristics are observed after the irradiation. The behavior of the transistor varies depending on its type (p-mos or n-mos). The irradiation also changes the gain (decrease) and the DC offsets in each pixel, however the channel architecture allows for effective correction and returning the nominal conditions without noticeable change.

Primary authors: DROZD, Alexandra; MAJ, Piotr

Presenter: SATŁAWA, Tadeusz

Session Classification: Poster Session

Contribution ID: **65** Type: **not specified**

Radiation effects in RMD Deep-Depleted APDs used as charged particle detectors

Friday 10 October 2014 16:20 (20 minutes)

Sebastian White, The Rockefeller University, NYC
Richard Farrel, RMD/DYNASIL
Kirk McDonald and Changuo Lu, Princeton University, NJ
Thomas Tsang, BNL Instrumentation Division
Mitch Newcomer, U. Pennsylvania

Since 2007 we have been developing a high timing precision charged particle detector based on the RMD technology. Our primary focus has been on a solution for high rate applications and hence radiation damage effects have been part of our R&D.
The RMD devices have been irradiated in a beam of 72 MeV protons (up to a fluence of 0.5*10ˆ13 n/cmˆ2. Although QE was degraded and there was an increase in leakage current, as predicted by CMS APD rad dam. scaling laws, performance as a timing detector could be restored to the un-irradiated level by cooling. Recently we have resumed testing at higher fluence in the CERN PS and planning further measurements at FNAL and MGH.
We will report on past results and current plans.

Primary author: Prof. WHITE, Sebastian (Rockefeller University (US))

Presenter: Prof. WHITE, Sebastian (Rockefeller University (US))

Session Classification: Low Gain Avalanche Detectors II