First Barcelona Techno Week: Course on semiconductor radiation detectors

Report of Contributions

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

Welcome

Monday 11 July 2016 09:00 (5 minutes)

Author: Prof. HERMS, Atilà

Presenter: Prof. HERMS, Atilà

Session Classification: Introductory concepts

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

Course Introduction

Monday 11 July 2016 09:15 (15 minutes)

Authors: GASCON, David (University of Barcelona (ES)); BALLABRIGA SUNE, Rafael (CERN)

Presenters: GASCON, David (University of Barcelona (ES)); BALLABRIGA SUNE, Rafael (CERN)

Session Classification: Introductory concepts

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

70 years of semiconductor nuclear detectors, principles and overview of implementations

Monday 11 July 2016 09:30 (1 hour)

The explanation of the photo-electric effect in 1905 literally shed light on the structure of matter. Nevertheless, it still took 40 years before the first practical solid devices exploited this understanding for detection of ionizing nuclear particles. From then on, during 70 years a succession of innovations has led to widespread use of semiconductor nuclear detectors in physics, materials analysis and medical imaging. The silicon-based micro- and nano-electronics technology enabled much of these semiconductor sensor developments. (Short demo with Timepix device).

Author: HEIJNE, Erik (Czech Technical University (CZ))

Presenter: HEIJNE, Erik (Czech Technical University (CZ))

Session Classification: Introductory concepts

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

Interaction of photons and electrons with matter

Monday 11 July 2016 10:50 (50 minutes)

Introductory concepts: cross section, mean free path and attenuation coefficients. Interaction of photons with matter: photoelectric effect (Auger electrons and fluorescence photons), Compton scattering, pair production, Rayleigh scattering. Interaction of electrons with matter. Emphasis on materials commonly used as radiation detectors (Si, GaAs, CdTe, CdZnTe, Ge)

Author: Prof. SALVAT, Francesc (University of Barcelona)

Presenter: Prof. SALVAT, Francesc (University of Barcelona)

Session Classification: Introductory concepts

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

Signal formation in semiconductor detectors (I)

Monday 11 July 2016 11:40 (50 minutes)

Semiconductor properties, the p-n junction (depletion width, capacitance), fluctuations on the charge (Fano factor), signal induction, drift, diffusion and the small pixel effect. Detectors classification (for example: 1. Hybrid (1.a. hybrid, 1.b. hybrid+3d), 2. Monolithic Active Pixel Sensors (2.a CMOS with charge collection on epitaxial layer, 2.b. Depleted MAPS (HV or HR substrate), CMOS on SOI, DEPFETs).

Author: HEIJNE, Erik (Czech Technical University (CZ))

Presenter: HEIJNE, Erik (Czech Technical University (CZ))

Session Classification: Introductory concepts

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

Semiconductor detectors: practical Monte Carlo simulation

Monday 11 July 2016 14:00 (1 hour)

Author: Prof. SALVAT, Francesc (University of Barcelona)

Presenter: Prof. SALVAT, Francesc (University of Barcelona)

Session Classification: Introductory concepts

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

Introduction to CMOS

Monday 11 July 2016 15:00 (1h 30m)

CMOS transistors, Moore's law, technology roadmap, operation and characteristics (equations for strong and weak inversion), (very short description of bipolars, circuits where they are used) small signal circuit, matching, noise, passive components in CMOS technologies, radiation effects, technology scaling.

Author: Prof. SERRA-GRAELLS, Francesc (IMB-CNM)

Presenter: Prof. SERRA-GRAELLS, Francesc (IMB-CNM)

Session Classification: Introductory concepts

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

Pulse processing electronics (I)

Monday 11 July 2016 17:00 (1h 30m)

Analog CMOS circuit design: The charge sensitive amplifier (Noise mechanisms, ENC, noise sources, dimensioning the input transistor, the preamplifier reset, the shaper, baseline stabilization, discriminator, sample and hold, ADCs, TDCs, packaging and interconnects, examples.

Author: O'CONNOR, Paul (Department of Physics)

Presenter: O'CONNOR, Paul (Department of Physics)

Session Classification: Introductory concepts

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

Pulse processing electronics (II)

Tuesday 12 July 2016 09:00 (1h 30m)

Analog CMOS circuit design: The charge sensitive amplifier (Noise mechanisms, ENC, noise sources, dimensioning the input transistor, the preamplifier reset, the shaper, baseline stabilization, discriminator, sample and hold, ADCs, TDCs, packaging and interconnects, examples.

Author: O'CONNOR, Paul (Department of Physics)

Presenter: O'CONNOR, Paul (Department of Physics)

Session Classification: Introductory concepts

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

Sensor design and Interconnects

Tuesday 12 July 2016 11:00 (1h 50m)

Si and compound semiconductor sensor design (distances, implantation, interpixel capacitance), edgeless Si sensors. Interconnections: Bump bonding, TSV (types, processing steps, materials involved, etc.)

Author: VÄHÄNEN, Sami (VTT technical research centre of Finland)

Presenter: VÄHÄNEN, Sami (VTT technical research centre of Finland)

Session Classification: X-ray and charged particle detectors

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

Radiation hardness in Si detectors

Tuesday 12 July 2016 14:05 (1 hour)

Radiation hardness in semiconductor detectors. 3D detectors.

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

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

Session Classification: X-ray and charged particle detectors

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

Applications of hybrid pixel detectors (I)

Tuesday 12 July 2016 15:05 (1 hour)

Applications of hybrid pixel detectors: medical, space applications, dosimetry, material science, electron microscopy

Author: CAMPBELL, Michael (CERN)

Presenter: CAMPBELL, Michael (CERN)

Session Classification: X-ray and charged particle detectors

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

Applications of hybrid pixel detectors (II)

Tuesday 12 July 2016 16:35 (1 hour)

Applications of hybrid pixel detectors: medical, space applications, dosimetry, material science, electron microscopy.

Author: CAMPBELL, Michael (CERN)

Presenter: CAMPBELL, Michael (CERN)

Session Classification: X-ray and charged particle detectors

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

Review of hybrid pixel detector readout chips for spectroscopic X-ray imaging

Semiconductor detector readout chips with pulse processing electronics have made possible spectroscopic X-ray imaging, bringing an improvement in the overall image quality and, in the case of medical imaging, a reduction in the X-ray dose delivered to the patient. In this contribution we review the state of the art in semiconductor-detector readout ASICs for spectroscopic X-ray imaging with emphasis on hybrid pixel detector technology. We discuss how some of the key challenges of the technology (such as dealing with high fluxes, maintaining spectral fidelity, power consumption density) are addressed by the various ASICs. In order to understand the fundamental limits of the technology, the physics of the interaction of radiation with the semiconductor detector and the process of signal induction in the input electrodes of the readout circuit are described. Simulations of the process of signal induction are presented that reveal the importance of making use of the small pixel effect to minimize the impact of the slow motion of holes and hole trapping in the induced signal in high-Z sensor materials. This can contribute to preserve fidelity in the measured spectrum with relatively short values of the shaper peaking time. Simulations also show, on the other hand, the distortion in the energy spectrum due to charge sharing and fluorescence photons when the pixel pitch is decreased. However, using recent measurements from the Medipix3 ASIC, we demonstrate that the spectroscopic information contained in the incoming photon beam can be recovered by the implementation in hardware of an algorithm whereby the signal from a single photon is reconstructed and allocated to the pixel with the largest deposition.

Summary

Author: BALLABRIGA SUNE, Rafael (CERN)

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

Review of hybrid pixel detector readout chips for spectroscopic X-ray imaging

Wednesday 13 July 2016 09:00 (1h 40m)

ASICs for spectroscopic X-Ray imaging, digitization methods, count-rate, strategies for dealing with high fluxes, charge summing and hit allocation architectures, power consumption, detector tiling.

Author: BALLABRIGA SUNE, Rafael (CERN)

Presenter: BALLABRIGA SUNE, Rafael (CERN)

Session Classification: X-ray and charged particle detectors

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

Review of Monolithic pixel detectors

Wednesday 13 July 2016 11:10 (1h 40m)

Passive monolithic pixel sensors and active monolithic pixel sensors: CCDs, CMOS with charge collection on epitaxial layer, Depleted MAPS (HV or HR substrate), CMOS on SOI, DEPFETs

Author: KUGATHASAN, Thanushan (CERN)

Presenter: KUGATHASAN, Thanushan (CERN)

Session Classification: X-ray and charged particle detectors

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

Semiconductor radiation detectors for synchrotrons and XFELs".

Wednesday 13 July 2016 14:00 (2 hours)

Synchrotron radiation and XFEL experiments exploit the iteraction of X-rays with the sample under examination in order to investigate its properties.

Depending on the application, the detector should detect the X-rays transmitted, scattered, diffracted or produced by the samples or the photoelectrons emitted, providing high temporal, spatial or energy resolution.

The requirements on the dynamic range are particularly demanding due to the high fluxes provided by synchrotron beamlines and to the need to detect signals also from weakly interacting samples.

Starting from the requirement of the experiments we will review some of the detectors used at synchrotrons:
- Diffraction/scattering: hybrid detectors;
- Fluorescence emission spectroscopy: SDD, MAIA, crystal based spectrometers;
- High resolution imaging: Scintillator-coupled detectors and hybrid detectors with interpolation;
- Soft X-rays: CCDs

The requirements become even more challenging in the case of XFELs where several thousands photons per pixel should be detected in one shot and therefore special solutions for extending the dynamic range have to be found.

We will review some of the detectors used at existing XFELs (CSPAD, pnCCD, MPCCD, GOTTHARD) and developed for the future sources (AGIPD, LPD, DSRC, JUNGFRAU, PERCIVAL).

Author: BERGAMASCHI, Anna (PSI)

Presenter: BERGAMASCHI, Anna (PSI)

Session Classification: X-ray and charged particle detectors

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

Space Applications

Wednesday 13 July 2016 17:30 (1 hour)

Space applications of semiconductor detectors: pixel detectors, strip detector, Compton detectors. Examples: AMS, Astrogam, LOFT, Athena.

Author: Prof. HERNANZ, Margarida (ICE (CSIC-IEEC))

Presenter: Prof. HERNANZ, Margarida (ICE (CSIC-IEEC))

Session Classification: X-ray and charged particle detectors

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

CMOS Image and Vision Sensors for 2-D and 3-D

Thursday 14 July 2016 09:00 (1h 30m)

1. Basic Concepts

2. Milestones and Trends

3. Imaging vs Computer Vision

4. Photodiodes and Pixels

5. Readout and Sensor Architectures

6. Exemplary 2-D Sensors

Author: Prof. RODRIGUEZ-VAZQUEZ, Angel (IMSE-CNM)

Presenter: Prof. RODRIGUEZ-VAZQUEZ, Angel (IMSE-CNM)

Session Classification: Light detection

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

CMOS Image and Vision Sensors for 2-D and 3-D (II)

Thursday 14 July 2016 11:00 (1h 50m)

1. Motivations for Time-of-Flight Estimation.
2. Evolution of 3D Shape Measurement
3. ToF Estimation in CMOS Technology
4. Single-Photon Detection in CMOS
5. SPAD Arrays For 3D Imaging
6. Si-PM For PET and HEP

Author: Prof. CARMONA, Ricardo (IMSE-CNM)

Presenter: Prof. CARMONA, Ricardo (IMSE-CNM)

Session Classification: Light detection

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

Front End electronics for Photodetectors

Thursday 14 July 2016 14:00 (1h 30m)

Review of photodetectors model: APD, SPAD, SiPM. Front end electronics for photodetectors: input stage (charge amplifier, transimpedance, RF amplifiers), effect of interconnetions. Optimal processing for timing: design considerations, filtering, TDC design, etc. Examples of readout ASICs for photodetection.

Summary

Author: RIVETTI, Angelo (Universita e INFN Torino (IT))

Presenter: RIVETTI, Angelo (Universita e INFN Torino (IT))

Session Classification: Light detection

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

Digitization and time pick-up

Friday 15 July 2016 09:00 (1h 30m)

Digitizers for photodetectors: ADCs, waveform sampling, etc. Digital pulse processing with emphais on timing properties extraction.

Author: RIVETTI, Angelo (Universita e INFN Torino (IT))

Presenter: RIVETTI, Angelo (Universita e INFN Torino (IT))

Session Classification: Light detection

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

Applications: particle physics and medical imaging

Friday 15 July 2016 11:00 (1h 50m)

Applications of photodetectors in high energy physics and medical imaging. Focused on solid state (APDs, SPADs, SIPM) but in context of PMT technology.

Author: CASELLA, Chiara (Eidgenoessische Tech. Hochschule Zuerich (CH))

Presenter: CASELLA, Chiara (Eidgenoessische Tech. Hochschule Zuerich (CH))

Session Classification: Light detection

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

Applications: biology and fluorescence

Friday 15 July 2016 14:30 (1h 30m)

pplication of photodetectors in Super-resolution Microscopy, Single Molecule Spectroscopy, Time-resolved Fluorescence Spectroscopy

Author: Dr ANDILLA, Jordi (ICFO)

Presenter: Dr ANDILLA, Jordi (ICFO)

Session Classification: Light detection

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

Applications: space and astronomy

Friday 15 July 2016 16:30 (1h 30m)

Application of photodetctors in ground and space astrophsyics instruments. CD and CMOS Imaging Devices for Ground Based Telescopes and Space Missions. Cosmic ray amd VHE particle detection with solid state photo-sensors.

Summary

Authors: GASCON, David (University of Barcelona (ES));   Prof. GÓMEZ, Jose M. (ICCUB-IEEC)

Presenters: GASCON, David (University of Barcelona (ES));   Prof. GÓMEZ, Jose M. (ICCUB-IEEC)

Session Classification: Light detection

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

Demonstration: practical Monte Carlo simulation

Presenter: Prof. SALVAT, Francesc (University of Barcelona)

Session Classification: Introductory concepts

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

Introduction

Thursday 14 July 2016 16:50 (20 minutes)

Session Classification: Industrial

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

Development Process of Hybrid Photon Counting X-Ray Detectors

Thursday 14 July 2016 17:10 (20 minutes)

DECTRIS is a technology leader in hybrid photon counting X-Ray detection. The DECTRIS photon counting detectors have transformed basic research at synchrotron light sources, as well as in the laboratory and with industrial X-Ray applications. This pioneering technology is the basis of a broad range of products, all scaled to meet the needs of various applications. The focus of today's talk will be in describing the basic steps of the DECTRIS product development process. The different disciplines involved in this development process will be identified, with particular emphasis on their specific roles and on how they continuously have to interact with each other requiring precise coordination. Furthermore, the basics and the advantages of single-photon counting technology will be discussed. A brief overview of DECTRIS and of the DECTRIS product portfolio will also be presented.

Presenter: LIVI, Paolo (DECTRIS)

Session Classification: Industrial

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

The Age of Solid-State Detectors for XRF and XRD Analysis

Thursday 14 July 2016 17:30 (20 minutes)

PANalytical provides solutions for the chemical (which and how much of certain elements) and structural (in what molecular structure) analysis of a wide variety of materials. Our customers can be found in virtually all markets including building materials, metals, mining, food, pharma, cosmetics, polymers, oils, plastics, thin film metrology, nanomaterials and many more in industries and research.

Our solutions are based upon analytical X-ray technologies like X-ray diffraction (XRD) and X-ray fluorescence (XRF) spectrometry. Over the last two decades PANalytical has introduced a number of solid-state detectors in a range of instruments as an essential part for performance improvement.

Solid-state detectors are the enabling technology for the energy-dispersive XRF (EDXRF) spectrometry where instrument performance is directly linked to detector properties. One- and two-dimensionsal XRD analysis is enhanced and enabled by the use of stripped and pixelized sensors linked to the dedicated application-specific integrated circuits (ASIC) for sensor readout.

Main performance drivers for future detectors are the improvements in energy resolution such as: count-rate capability, detection area, detection efficiency and radiation hardness. Detectors used for XRD analysis have an extra demand of good spatial resolution. These requirements are universal for all X-ray detectors, but the applicable solution is determined by the underlying technology.

Presenter: JOVANOVIC, Vladimir (Panalytical)

Session Classification: Industrial

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

Spectral imaging with MARS

Thursday 14 July 2016 18:10 (20 minutes)

Presenter: ATHARIFARD, Ali (MARS Bio-imaging Ltd (MBI))

Session Classification: Industrial

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

Usage of pixel detector to attract learning of particle physics

Thursday 14 July 2016 18:30 (20 minutes)

Presenter: TOMESEK, Lubos (Jablotron)

Session Classification: Industrial

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

Exhibition

Thursday 14 July 2016 16:20 (30 minutes)

Session Classification: Industrial

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

Introduction to ICCUB

Monday 11 July 2016 09:05 (10 minutes)

Author: GARRIDO BELTRAN, Lluis (University of Barcelona (ES))

Presenter: GARRIDO BELTRAN, Lluis (University of Barcelona (ES))

Session Classification: Introductory concepts

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

Timepix demonstration

Monday 11 July 2016 12:30 (20 minutes)

Presenter: HEIJNE, Erik (Czech Technical University (CZ))

Session Classification: Introductory concepts

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

Advacam - From Sensor Fabrication to X-ray Imaging

Thursday 14 July 2016 17:50 (20 minutes)

Presenter: VÄHÄNEN, Sami (VTT technical research centre of Finland)

Session Classification: Industrial