Module 1: Introduction to solid-state detectors

1.1. Ideal vs real-world detectors

- Poisson Statistics
- Read-Noise and other noise sources
- Signal-to-Noise ratio (SNR)

1.2. Semiconductor physics

- Periodic table and semiconductor structure
- Photo-electric effect
- The PN junction
- The electromagnetic spectrum
- Silicon absorption depth
- Other semiconductors

1.3. The photo-diode

- Structure and standard modes of operation
- Integration mode
- Concept of Quantum Efficiency (QE)
- Avalanche photo-diodes (APDs)
- Photodiode array sensors

1.4. The charge-coupled device (CCD)

- Bucket brigade structure
- Charge collection
- The buried channel
- Charge transfer
- Frame transfer and Interline transfer
- Output amplifier
- Video processors and CDS
- Charge transfer efficiency (CTE)
- Traps
- Full well and blooming
- Dark current
- Inverted mode operation (IMO)
- Cosmetic defects
- Remnance
- Bias areas
- Binning and Windowing
- Cosmic rays
- CCDs in space

1.5. CMOS Image sensors

- Pixel Structure
- The MOSFET transistor
- Array Structure
- 3T,4T,5T Geometries
- Global versus Rolling Shutter
- Scientific CMOS
- Consumer Digital Cameras

Module 2: Approaching the Ideal Detector

2.1 CCDs

- Backside Illumination
- Thinning
- Fringing
- Backside passivation
- Anti-reflective coatings
- Deep Depletion CCDs
- Hi-Rho CCDs
- Anti-fringing structure
- Low-noise amplifiers
- Multiple outputs
- Ultra-large CCDs
- Mosaics
- Orthogonal transfer CCDs (OTCCD)
- Curved CCDs

2.2 The electron multiplying CCD (EMCCD)

- Structure
- Multiplication noise
- Clock-induced charge
- Output signal distribution
- Modes of operation
- Photon-counting
- Applications

2.3 CMOS detectors

- Microlenses
- Backside Illumination
- Hybridisation
- Silicon on Insulator technology

2.4 Ultimate-performance future detectors

- Repetitive non-destructive read (RNDR)
- Hi Speed, large format, backside illuminated CMOS
- HgCdTe avalanche photodiode arrays

Module 3: Scientific Camera Systems

3.1 Additional Camera Elements

- Thermal control and cooling options
- Vacuum materials
- Controller Electronics
- Detector Handling Precautions

3.2 Camera Testing

- Measurement of Gain
- The photon-transfer method
- Characterisation using X-rays
- The EPER method
- Measurement of Quantum Efficiency
- Tuning the output amplifier
- Flat-field illumination
- Measurement of Linearity, Dark current, Point Spread Function (PSF) and Coplanarity

3.3 Project Issues

Summary

The course includes an overview of the solid-state physics, the basic principles of photo-diodes, CMOS and CCD detectors, an explanation of how CCD detectors have been progressively improved over the last 40 years and how their performance is now closely approaching that of an ideal detector. Also, the current state of alternative CMOS design detectors and how they compare to CCDs. Finally, the optimisation, characterisation and operation of practical camera systems.

To whom this course is addressed

The course is oriented at physicists, engineers and astronomers that are working in instrumental projects that involve the use of CCDs.

Previous knowledge

A basic grounding in Physics is required.

By attending the course, you will

(a) Gain an in-depth knowledge of the physics underlying modern detectors (b) Have an appreciation of the current advanced level of detector technology and the related developments in the near future (c) Be in a position to identify a suitable detector technology for their particular engineering application and to understand the various performance parameters described in manufacturers data sheets and (d) Have knowledge of the techniques of detector characterisation.

FRACTAL training

FRACTAL offers courses in Project Management, System Engineering, Optics, Mechanics, Detectors and Software.

General courses

Our open courses are given in Madrid. The calendar is updated in our web page.

The courses last 1, 2 or 3 consecutive days.

Customized courses

We offer ad-hoc courses, to be given at our customer's offices, adapted in dates and duration to each particular need.

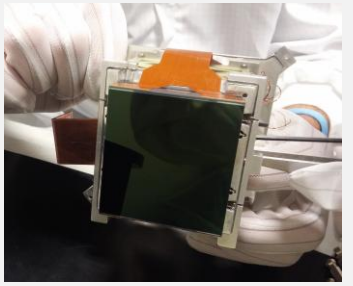
Computer based training

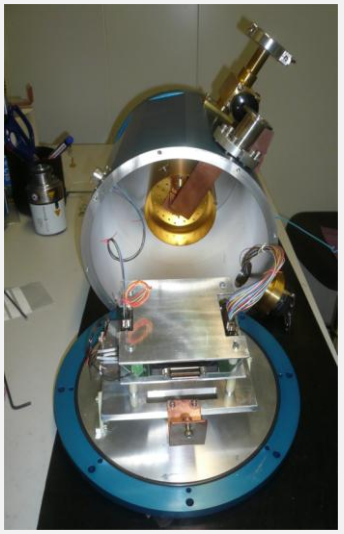
We provide consultancy services to allow our customers to implement e-learning tools with their own materials.

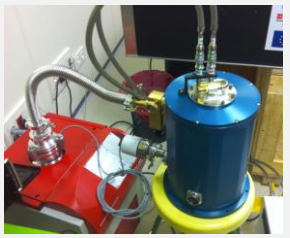
The services could include:

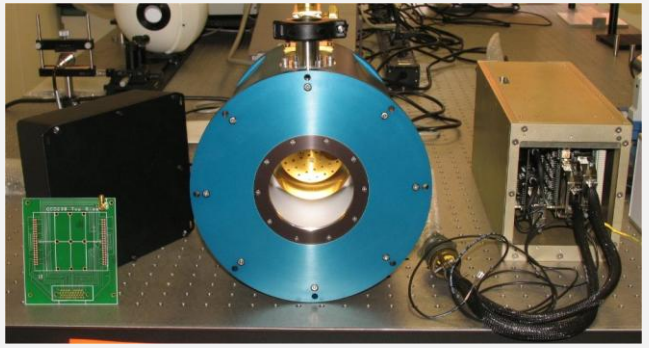
- Integration of an e-learning platform in the client web page
- Training in both, installation and use
- Organizing the e-classes

Scientific imaging in the visible and near infra-red









Fractal SLNE

Training

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