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, the current state of alternative CMOS design detectors and how they compare to CCDs and, 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) Have 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

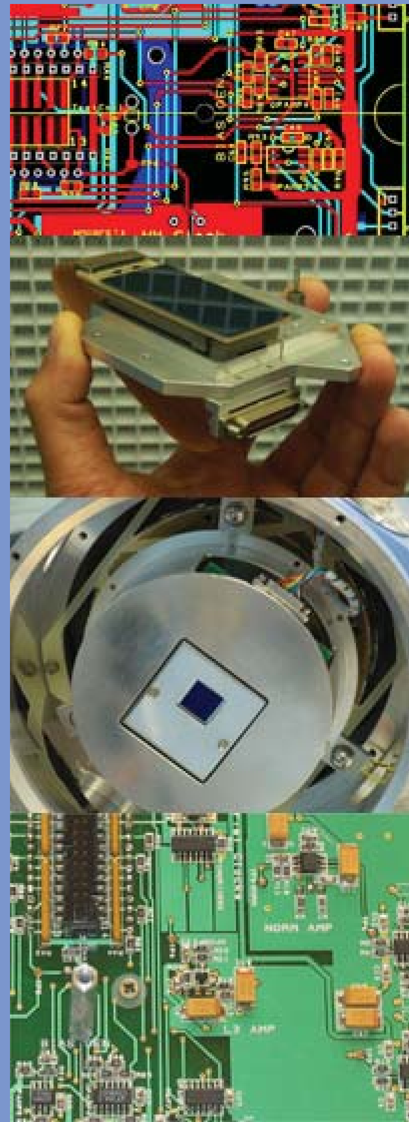
We offer ad-hoc courses, to be given at our customer's offices, adapted in dates and duration to each particular need.

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

Web: http://www.fractal-es.com
e-mail: cursos@fractal-es.com



Training

Scientific imaging in the visible and near infra-red

http://www.fractal-es.com

Introduction to solid-state detectors

1.1. Ideal vs real-world detectors

- Imaging statistics
- Noise surces
- DQE

1.2. Semiconductors physics

- Minority and majority carriers
- Periodic table, The PN junction
- Photo-electric effect & the band-gap
- The electromagnetic spectrum
- Silicon absorption depth
- Traps

1.3. The photo-diode.

- How a PN junction detects light
- How a photo-diode is used
- APDs
- Photo-diode arrays (CMOS sensors)

1.4. The charge-coupled device (CCD)

- Bucket brigade structure
- Charge transfer
- Buried channel
- Frame transfer/interline transfer/full-frame readout
- Output amplifier structure and read noise (ktC, Johnson, 1/f)
- Processing of video waveform
- Full well
- Dark current
- Cryogenic performance
- Cosmic rays/radioactive materials in camera
- Cosmetic defects
- Radiation damage in Space applications

1.5. Scientific camera systems

- Thermal design and control
- Cooling options (Peltier,LN2,CCC)
- Vacuum systems and materials
- The controller electronics

Approaching the Ideal Detector

2.1. CCDs: Boosting performance of the basic design

- Backside Illumination
- Thinning
- Fringing
- Backside passivation
- Anti-reflective coatings
- Deep Depletion CCDs
- Hi-Rho CCDs
- Anti-fringing process
- Design driver: AO (an astronomical aside)
- Low-noise amplifiers
- Hi-speed through multiple amplifiers
- Mosaicing
- Orthogonal transfer CCDs and AO
- Multiple non-destructive read (DEPFET)

2.2. The electron multiplying CCD (EMCCD)

- History
- Structure
- Multiplication noise
- Clock-induced charge
- Output signal distribution
- Modes of operation
- Photon-counting
- Application: AO (ESO CCD219)
- Application: Astronomical spectroscopy

2.3. CMOS and Hybrid devices

- Hybridised detectors
- 4T and 5T designs
- Use of microlenses
- Back-thinned CMOS

2.4. Ultimate-performance future detectors

- Silicon APD arrays for photon counting in the visible
- HgCdTe APD arrays for photon counting in the NIR
- CMIOS vs CCD

Detector Characterisation

3.1. Characterisation and Optimisation

- Photon transfer method
- QE measurement in diode mode
- Precautions when measuring dark current
- Defect mapping using flat fields
- CTE using Fe55 X-rays
- Video amplifier bandwidth using X-rays
- Gain and noise
- Linearity and full-well
- Channel cross-talk