CHARACTERIZING THE CCDS OF THE OMEGACAM WIDE-ANGLE CAMERA

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Abstract: OmegaCAM will cover the 1deg x 1deg field of view of the ESO VLT Survey Telescope with thirty two 2K x 4K pixels CCDs. Since the replacement of a unit detector or a re-arrangement of the mosaic after commissioning is not an option, every detector needs to be fully characterized in advance. These chips need to be tested under astronomical operating conditions, which differ from average CCD manufacturer procedures. The changes realized in the testbench and the results of the measurements are described below.

Key words: CCDs, CCD testing, CCD characterization.

1. OMEGACAM CCD CAMERA

OmegaCAM is a consortium composed of NOVA, Kapteyn Instituut, Leiden, Universitäts-Sternwarte München, Göttingen, Osservatori Astronomici di Padova e Capodimonte and the European Southern Observatory and is in charge of developing the OmegaCAM instrument.

This instrument is a mosaic of 32 Marconi chips (CCD44-82 1-A57). It covers a field of view of 1 deg. x 1 deg. (mosaic filling factor: 93%) with a sampling of 0.23"/pixel. Forty science grade and sixteen engineering grade CCDs have been ordered and are tested by the Optical Detector Team (ODT) with the ESO test bench.

The CCD44-82 1-A57 is a thinned back-side illuminated device with 2K x 4K pixels of 15_m. Two serial read-out registers are available. A Pt100 temperature sensor is provided on the chip. A single-layer HfO_2 antireflective coating ensures optimal sensitivity in the blue and the near UV. The invar package provides a high flatness level of ± 10µm.

2. THE TEST BENCH

In 1996, Amico & Böhm[1] designed the new ESO test bench. Several improvements were realized to optimize the turn-around time and the precision of individual CCD characterization. Two new detector heads accommodating two CCDs each have been manufactured and put into use. Scripts for a largely autonomous acquisition and data reduction have been written. Measurements of quantum efficiency (QE), photon response non uniformity (PRNU), dark current (short and long exposures), bias, readout noise, conversion factor, linearity, charge transfer efficiency (CTE) and cosmetic defects (hot pixels, very bright pixels, dark pixels, traps, very large traps bad columns and coating blemishes) are routinely performed.

The primary capabilities of the test bench are long dark exposure time (up to several hours), configurable modes and readout speeds supported by the FIERA CCD controller, uniform illumination up to a field of 20cm diameter provided by the integrating sphere, large wavelength coverage (300-1100nm), good spectral sampling (1nm) and remote control of all functions by software.

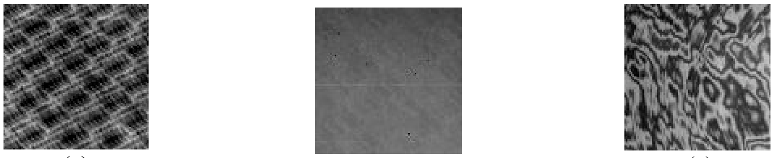
3. QUANTUM EFFICIENCY (QE) AND PHOTON-RESPONSE NON-UNIFORMITY (PRNU)

Quantum efficiency and photon-response non-uniformity are measured at an operating temperature of -120°C. The repeatability is very good (error: ± 0.2% max). The QE dispersion from device to device is increasing towards shorter wavelengths. The QE figures in the range of 300- 400 nm are higher than the minimum specification (see Table 3-1 for mean values).

Table 3.1. Mean and standard deviation of the quantum efficiency (QE) for 19 science grade devices.

Wav. nm	350	400	500	600	700	850	1000
QE %	62.5	82.9	83.7	79.1	69.9	39.9	4.5
rms %	8.7	4	3.8	3.7	3	1.9	0.2

PRNU is increasing at near-IR wavelength due to fringing effects (see Figure 3-1 (c)), and at near UV wavelength due to the backside laser annealing (“diamond pattern”), see Figure 3-1 (a).



(a) (b) (c)

Figure 3-1. Example of flat field patterns at 350nm (a), 600nm (b) and 900nm (c).

Between 420 and 870 nm the PRNU is photon noise limited (see Table 3-2 for mean values).

Table 3.2. Mean and standard deviation of the photon response non uniformity (PRNU) of 19 science grade devices.

Wav. nm	350	400	500	600	700	850	1000
PRNU%	3.5	1.6	1.2	1.2	1.3	2	8.3
rms %	0.8	0.3	0.3	0.3	0.4	0.8	2

4. COSMETICS AND COSMETIC DEFECTS

The general appearance of the images is inspected to search for anomalies (bright spot, patterns, 512x1K block stitching, scratches, parasitic light injected by on-chip ESD protection diodes [Figure 4-1.] and inky pattern [Figure 4-2.]), six specific kinds of cosmetic defects are checked: hot and dark pixels (mean per CCD: 66, rms: 72), very bright pixels (mean per CCD: 5, rms: 4), traps (mean per CCD: 3, rms: 3), very large traps (mean per CCD: 1, rms: 2) and bad columns (mean per CCD: 2, rms: 2). The overall cosmetic quality of the OmegaCAM devices is very well within specifications.

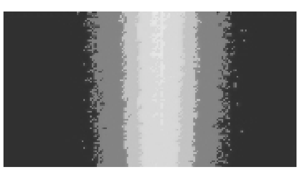


Figure 4-1. Part of a bias at 50kpix/s, binning 15x15, 6ADU of difference between the center and the sides, gain= 0.55e-/ADU

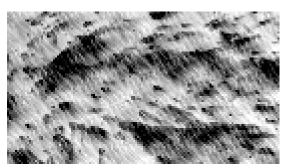


Figure 4-2. Part of a flat at 350nm, 50kpix/s, binning 15x15.

5. LINEARITY

The method consists of reading the CCD while it is illuminated with a light source (assumed to be constant on such short time scales). After flat fielding (the test is performed at 600nm where PRNU effects are the lowest), the columns are averaged, applying a median filter. The residuals from a linear least-squares fit to the signal as a function of row number represents the non-linearity. Non-linearity's are typically less than ±0.3%.

6. ELECTRICAL PARAMETERS

Conversion Factor (Gain): derived from the measurement of the mean signal on a flat field exposure and its variance (for 17 CCDs at -120°C: 0.53 ± 0.03e-/ADU at 50kpix/s).

Read Out Noise: spatial rms of the bias measured (for 19 CCDs at 50kpix/s: 2.9 ± 0.4 e^-, at 225kpix/s: 4.4 ± 0.7 e^-.

Conversion factor and read-out noise are measured for both ports and at two speeds (50 and 225 kpixels/s). The test bench is not read-out noise optimized because the main objective is to measure relative differences only.

Dark Current: A median-filtered stack of five 1-hour dark frames is used (temperature: -120°C, read out speed: 50kpix/s, high gain mode: ~0.55 e-/ADU) is computed. The horizontal and vertical over scan pixels are used to determine the dark current. It is mostly less than 1 e-/pixel/hour (for 17 CCDs at -120°C: 0.7 ± 0.6 e-/pixel/h).

Charge Transfer Efficiency: Two methods are used: one is based on the extended pixel response through the image over scan area (EPER), the other uses the standard Fe55 method (for 17 CCDs at -120°C: horizontal CTE: $0.999997 \pm 3.\ 10^{-6}$, vertical CTE: 0.9999995 ± 2.10^{-7}).

SUMMARY

For the OmegaCAM project 88 CCDs have been ordered (40 science grade, 16 engineering grade and 32 mechanical sample CCDs). Twenty nine science grade and the entire engineering and mechanical sample have been delivered. All CCDs have been characterized according to the function of their group. To realise these tests, the CCD evaluation procedure was streamlined, the reliability improved and the accuracies were assessed. The results are generally satisfactory.

REFERENCES

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