Characterization results of a large format 4k x 4k EMCCD

nüvü camēras #Booth715

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Abstract

Scientific EMCCD cameras have demonstrated excellent imaging performance under extreme low light conditions. Photon counting capability combined with a very low dark current offered by the CCD technology have made EMCCDs the detector of choice for high-performance applications such as time resolved spectroscopy and low light imaging. However, future astronomical instrumentation requires high spatial resolution while commercially available EMCCD devices are limited by a relatively modest area format of (1k x 1k). To address this requirement Université de Montréal and e2v Technologies have jointly developed a 4k x 4k EMCCD, the CCD282. This paper presents the results of cryogenic characterization of CCD282 operated with Nüvü Camēras' CCD Controller for Counting Photons version 3. Advantages of a novel large format EMCCD over existing technology are discussed with focus on demanding applications such as high resolution spectroscopy, wide field photometry and hyperspectral imaging.

Introduction

Since the advent of the first commercial EMCCD in early 2000, users have been requesting a large format EMCCD that would enable sub-electron read-out noise as well as Photon Counting. Very high resolution spectroscopy (R>30000) can't be efficiently accomplished on a 1k x 1k device. Wide field surveys looking for transient phenomenon also require large format detectors. In these fields, the CCD282 aims at being the first device to provide Photon Counting capabilities with a multi-megapixel focal plane.

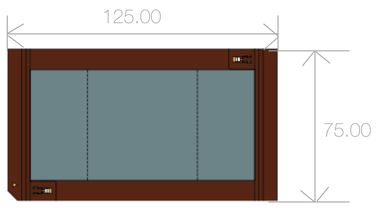

Figure 1 : Full-scale image of CCD282

The CCD282 is a standard silicon split-frame transfer EMCCD. A full-scale image of the device is presented in Figure 1. The image and store sections are designed to operate in 2-phase mode, each phase being clocked in pair. As compared to the CCD201-20 and CCD97, the CCD282 does not provide non-multiplied (conventional) output. Conventional (non-EM) read-out of the device will be possible by using an high voltage clock amplitude that is low enough to prevent Electron Multiplication. In this mode, no Excess Noise Factor will be generated.

CCD282 global specifications:	
Imaging area	4096 x 4096 pixels
Pixel size	12um x 12um
Parallel EM outputs	8
Maximum frame rate	4 to 5 fps
Controllers	2 CCCPv3

This work presents the experimental set-up developed at Nüvü Camēras to characterize this novel device.

CCD282 experimental set-up

Electronics

Nüvü's CCCPv3 EMCCD controller is used to clock the CCD282. CCCPv3 natively support a total of 4 CCD video inputs, 14 low voltage clocks and 2 high voltage clocks, while the CCD282 has 8 video outputs, 16 vertical clocks, 20 horizontal clocks and 4 high voltage clocks. The CCCPv3 firmware has been modified to make it stackable using a master/slave architecture. The modified design can support up to 8 synchronized controllers, with 7 slaves that are precisely phase aligned to the master. Communication to the synchronized controllers is done through a single serial data link to the master controller. The master controller has its own serial interface to all of the slaves. This allows the user to consider the controllers as a single entity with multiplied ressources. Phase alignment between controllers is critical for image consistency. It is achieved by locking the primary clocks of the slaves to the primary clock of the master. The resulting clocks are aligned within a window of 78 ps through all of the controllers.

The CCD282 is clocked by using two CCCPv3 in such an architecture. Each CCCPv3 is responsible for clocking half of the split-frame CCD. A flex-rigid circuit board links the controllers to the EMCCD (Figure 2). The architecture of the circuit allows for a very short signal path between the controller and the imaging device.

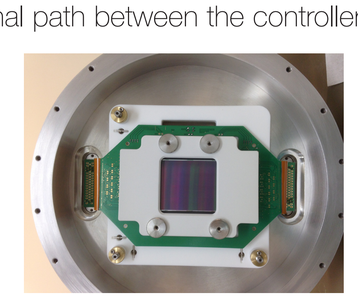

Figure 2 : Set-up of a mechanical CCD282 in cryostat used for thermal cycling

Mechanics

In order to test the CCD282, a custom cryostat has been developed (Figure 2 and 3), based on the Nüvü EMN2 system. A cryogenic support has been designed to allow for precise tip-tilt alignment of the device without having to break the vacuum.

Mechanics:	
Cryostat	Custom LN_2-cooled system
Interface	M95x1
Temperature monitoring and control	PT1000 Platinum resistance thermometers ± 0.01°C

Temperature monitoring of the CCD282 is made by using the two on-chip PT1000 platinum resistance thermometers. The sensors are located very near the EM registers, which should provide a good read-out of the temperature for the EM gain temperature compensation.

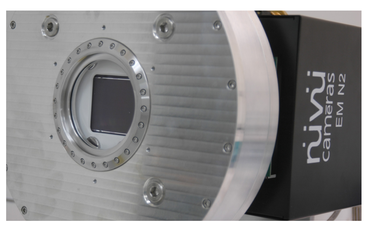

Figure 3 : CCD282 integrated with Nüvü Camēras' electronics.

Characterization conditions

Characterization conditions:	
Horizontal frequency	10MHz
Operating temperatures	-75°C to -105°C
Synchronised controllers	2
Operating mode	NIMO and IMO

This work aims at characterizing the CCD282. The read-out noise, linearity and full well will be measured. The EM gain will also be characterized and its Photon Counting performance will be assessed.

Since the CCD282 has been developed to be driven in NIMO in order to minimize vertical CIC, it will first be characterized in this mode. As this mode favours a lower CIC at the price of a higher dark current, further work will involve clocking the device in IMO to yield a lower dark current and use the arbitrary clocking capabilities of CCCPv3 to reduce the CIC.

The characterization results will be presented in the proceedings of this conference, which will be made available at http:// www.nuvucameras.com/publications.

Figure 4 : Mock-up of the commercial camera integrating the CCD282

Conclusions

The experimental set-up to characterize the CCD282 at Nüvü has been presented. The system allows for reading-out the full device at 10MHz of pixel rate per output using two CCCPv3 controllers linked in a master/slave architecture.

The 4k x 4k EMCCD device being developed over the last few years will open-up new possibilities in astronomical instrumentation. Providing the community with rigorous characterization data of this device will allow realistic simulations to be developed to better understand the potential for foreseen applications.

This novel EMCCD is being integrated into a commercial camera by Nüvü (Figure 4). Various cooling solutions, such as LN_2 and closed-loop cryocoolers will be available. A thermoelectrically cooled version is also being studied.

Acknowledgments

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