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CMOS detectors at Rome "Tor Vergata" University

F.Berrilli, S.Cantarano, A.Egidi, S.Giordano

Dipartimento di Fisica, Università di Roma "Tor Vergata", I-00133 Roma, Italy

Abstract. The new class of CMOS panoramic detectors represents an innovative tool for the experimental astronomy of the forthcoming years. While current charge-coupled device (CCD) technology can produce nearly ideal detectors for astronomical use, the scientific quality CMOS detectors made today have characteristics similar to those of CCD devices but a simpler electronics and a reduced cost. Moreover, the high frame rate capability and the amplification of each pixel - active pixel - in a CMOS detector, allows the implementation of a specific data management. So, it is possible to design cameras with very high dynamic range suitable for the imaging of solar active regions. In fact, in such regions, the onset of a flare can produce problems of saturation in a CCD-based camera.
In this work we present the preliminary result obtained with the *Tor Vergata* C-Cam APS camera used at the University Solar Station.

Key words. Sun: chromosphere - Techniques: images acquisition

1. Introduction

The Solar Physics group at Rome-Tor Vergata University, which has been involved in designing and building CCD cameras for several years up to now, is following the continuous and rapid evolution of CMOS APS technology applied to image sensors; the high frame rate capability of CMOS based cameras, combined with the ability to integrate data processing on the same chip, can be used for new applications and to improve the performance of existing ones. Our intent is to develop systems aimed at solar imaging on board of satellites, or solar telescopes in space. A first development system based on CMOS-APS has been implemented at the University Solar Station, while a new project based on CMOS-DPS (CMOS Digital Pixel Sensors) is planned, possibly using a sensor with pixel-level ADC.

Send offprint requests to: berrilli@roma2.infn.it
Correspondence to: berrilli@roma2.infn.it

2. General properties of CMOS detectors

The CMOS technology applied to image sensors is becoming very important and widespread in industrial and commercial applications, due to the integration in the same chip of all the functions of signal handling, which on the contrary, in CCD cameras, require a complex and power consuming electronics. In addition,

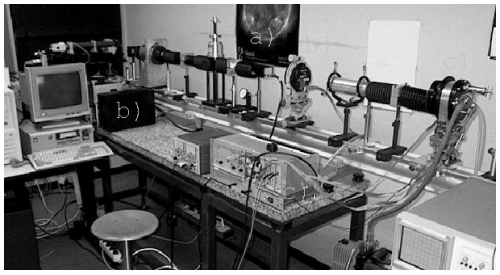

Fig. 1. The development system at the solar station. a) the APS detector, the acqusition PCI card is inside the PC; b) CCD-PI camera, similar to the present THEMIS-IPM cameras, and control electronic; c) CCD camera, former THEMIS-IPM camera, and control electronic.

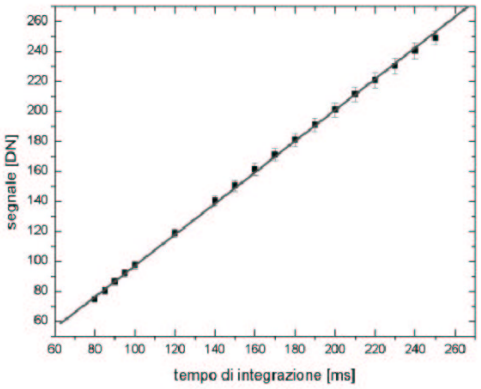

Fig. 2. Linearity of the APS camera.

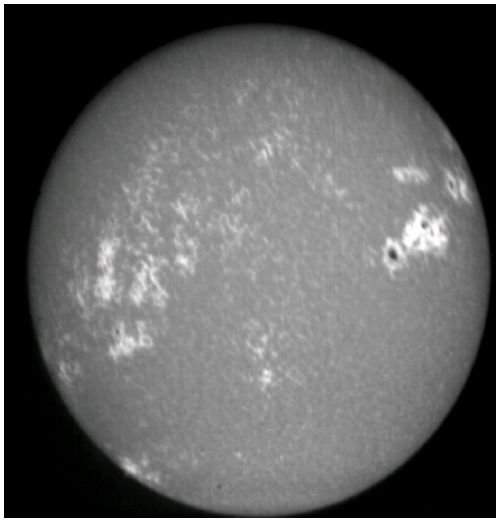

Fig. 3. The sun as acquired at the Solar Station.

the recently available devices have the function of "on-chip shutter", by which the charge accumulated in the pixel is locally converted in voltage, amplified and memorized. It is then available what is called a "camera on a chip", with great economy in weight, power and cost of the final product. The implementation inside the chip of ADC's working in parallel, at the column level or even at the pixel level, permits to reach unexpected acquisition speed, order of magnitude faster then that of CCD devices. In addition the capability of random access to pixels makes it possible to achieve extremely high frame rates in the Window Of Interest (WOI) mode, that makes it an ideal camera for spot tracking applications. The amplification and storage at the pixel level, and the correlated double sampling, has also obtained a reduction of the noise, that is approaching that of the CCD devices.

Operation in subtreshold mode of the MOS amplifier has made possible to implement devices with logarithmic response, obtaining dynamic ranges as high as 120 dB; with DPS devices the increase of dynamic range can be obtained by the technique of multiple-time sampling. The CMOS-DPS devices have then become very interesting for application in space instrumentation, where they also offer a much higher radiation resistance compared with that of CCD devices. To summarize, the following characteristics make the CMOS-DPS very attractive in applications to space instrumentation:

- very small size and weight, with all functions on a chip;
- very low power consumption;
- high radiation resistance;
- very high speed, that reach thousands of frames per second;

– low noise in medium to high light intensity applications.

3. CCD and CMOS development at Tor Vergata University

The first APS device that we have tested is based on the Ibis4 CMOS sensor from Fill Factory in Belgium, the most active company in Europe on the development and production of CMOS sensors; the camera is built by C-Cam Technology, Division of Vector International, Belgium. In fig. 1 we report the development system where we can explore all characteristics of cameras. The APS system is mounted at the Ca K II telescope of the Tor Vergata Solar Station. In fig. 2 we report the linearity of the camera, while in fig. 3 the image of the sun acquired at our Solar Station.

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