Scientific CCD-in-CMOS imagers for astronomy

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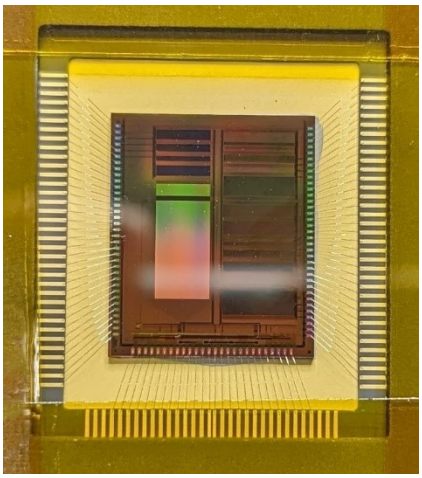

A prototype CCD-in-CMOS device manufactured by Teledyne e2v

Project highlights:

- A joint project with Teledyne e2v, a world leading UK-based manufacturer of space imagers for many missions by ESA and NASA;
- Investigate the potential of the trap pumping technique in CCD-in-CMOS imagers for the first time;
- Receive hands-on laboratory training and experience in characterising image sensors for space applications within the Centre for Electronic Imaging (CEI) at the OU;
- Travel to experimental facilities in UK and Europe, and attendance of international conferences and meetings.

Project description:

Charge Coupled Devices (CCD) are used in most cameras found in ground and space-based telescopes due to their excellent uniformity, quantum efficiency, low noise, and availability as large area devices. A new class of imagers made with Complementary Metal-Oxide Semiconductor (CMOS) technology, but using specially designed low voltage CCDs as photosensitive elements has emerged as an attractive choice for Earth observation [1]. These CCD-in-CMOS devices employ the Time Delayed Integration (TDI) technique and offer several advantages, such as orders of magnitude faster readout than CCDs, fully integrated electronics, and small pixels.

The potential of the newly developed CCD-in-CMOS devices for space-based astronomy has not yet been evaluated. In particular, the effects of space radiation on the Charge Transfer Inefficiency (CTI) could be more manageable compared to CCDs due to the much faster, column-parallel readout and the lack of serial register. The Centre for Electronic Imaging has developed the powerful technique of Trap Pumping (TP) [2] which allows the identification and characterisation of individual radiation-induced traps in CCDs with sub-pixel resolution.

TP is now being applied to the CCD camera in the Euclid space telescope, launched in 2023, and will provide unique data on the evolution of the trap population during the mission.

The most important objective of this project will be to build the experimental apparatus and apply the TP technique to CCD-in-CMOS imagers for the first time. A distinct challenge will the operation of the devices at temperatures around -100 °C, needed to eliminate the dark signal. The project will also gather data on the performance of such imagers at cryogenic temperatures with particular emphasis on the dark current and image glow.

The project's main goal will be to establish the suitability of CCD-in-CMOS image sensors for scientific and space-based imaging. A successful outcome will allow such imagers to be used in a variety of science applications and will open new opportunities for advanced instruments. Some examples include cameras with faster readout and better radiation hardness, or even combining infrared-sensitive materials with TDI for the next generation of the extremely successful Gaia star mapper telescope.

This is a joint project between the Centre for Electronic Imaging (CEI) at the OU and Teledyne e2v (Te2v), a world-leading UK-based manufacturer of scientific CCD and CMOS image sensors.

References:

1. Jérôme Pratlong et al., "High-resolution charge domain TDI-CMOS image sensor for Earth observation," Proc. SPIE 10785, 107850X (2018).
2. J. Skottfelt et al., "Trap pumping schemes for the Euclid CCD273 detector: characterisation of electrodes and defects", Journal of Instrumentation, vol. 12, article no. C12033 (2017).