POST-DOCTORAL POSITION

Ultra-high sensitivity CMOS imagers: prospective study of innovating solutions for the development of pixels with extreme conversion gain.

Recent progress in CMOS imaging technologies, involving performance improvements in photo-detection and in noise reduction, allow now to consider these technologies rather than CCD for very high demanding applications, such as the low light imaging. Indeed, in the past recent years [1], a new kind of pixel combining a classical pinned photodiode (PPD) and a very high conversion gain has appeared, enabling the count of one or several electrons per pixel and by a usual readout circuit. This kind of pixel is notably used in the so called « Quanta Image Sensors » (QIS) which are known as photon-counting devices and actively developed nowadays [2]. These devices are the next generation of innovative CMOS Image Sensors (CIS), and are promised to a wide field of application in low light conditions such as astronomy, security, quantum cryptography, biology (as illustrated by the next figure) …

Real image by CIS, avg of 8 frames, 0.5 photons per pixel (ppp)

Real image by QIS, avg of 8 frames, 0.5 ppp

The images above are the real captures by a CMOS Image Sensor (CIS) and a QIS prototype at the same photon level of 0.5 photons per pixel (ppp) per frame, from [1]

Actually, photon counting devices are the components the Defence domain want, for the dismounted combatant, but also for space surveillance from the ground and space. In addition, a strong demand of very low flux detection is rising for the detection of stealth satellites (see the following illustration).

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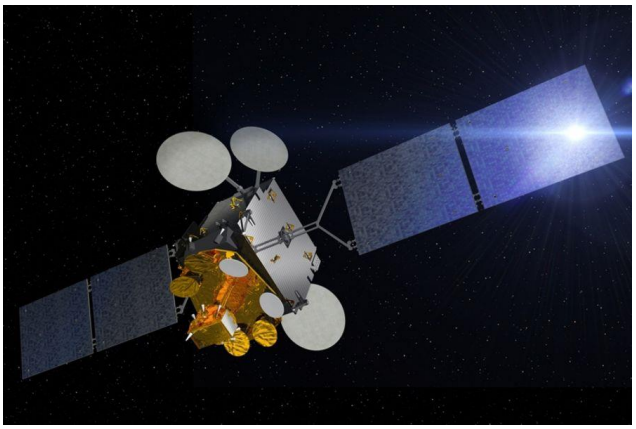
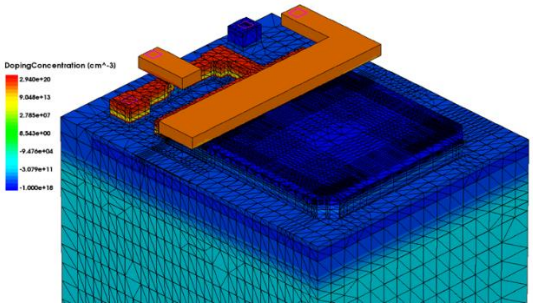


In 2007, the Athena-Fidus French-Italian military satellite has been approached by a Russian satellite in an unfriendly way. According to the French Ministry of the Armed Forces, it is an espionage act.

The objective of this project is to study various possibilities leading to very high conversion gain on a pixel including a pinned photodiode, by reducing the sense node capacitance, and in a way that the proposed solution can adapted to any fabs and technologies. The final goal is to produce a test vehicle, demonstrating the expected performances and especially the high sensitivity at very low optical flux. The innovating aspects of this project consist in the study and the development of innovating solutions of minimizing the sense node capacitance, and also on the possibility to develop strategies which can be adapted to any processes without modification. The work will rely on TCAD simulations (physical simulations for semi-conductor devices) and on measurements performed on elementary structures until a full characterization of a CMOS imager.



3D TCAD simulation of a pixel including a pinned photodiode.

MISSION: As a part of the CIMI research team, inside the ISAE-Supaero Department of Electronics, Optronics and Signal processing, the main tasks of the candidate are to:

- Realize a bibliography review of studies dealing with high conversion gain pixel applied to photon counting
- Analyse and simulate with the help of TCAD tools solutions to obtain a very high conversion gain. Study the influence of proposed modifications on pixel key parameters.
- Be involved in the design of the test vehicle, with the aim to demonstrate the key performances.
- Be involved in the characterization campaign of the test vehicle, and write articles / participate in conferences.

DURATION: 12 months

CANDIDAT'S PROFILE: The candidate must have a strong knowledge and skills in semiconductor physics, electronics and micro/nanoelectronics. The candidate will have to be familiar with semiconductor characterization devices. The candidate may be familiar with Sentaurus simulation tool, but it is not mandatory.
Good autonomy, work in a small team, for organization and communication skills are essentials.
The candidate must be an EU citizen.

Candidates should send a resume (cover letter, CV and a publication list and/or their PhD) via email to the contact persons.

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[1]. Yiheng Chi, Abhiram Gnanasambandam, Vladlen Koltun, and Stanley H. Chan, « Dynamic Low-light Imaging with Quanta Image Sensors», vol 12366. Springer, Computer Vision – ECCV 2020, 2020
[2]. P. Seitz and A. Theuwissen, Single-Photon Imaging, New York, NY, USA: Springer-Verlag, 2011
[3]. E. R. Fossum, J. Ma et a. S. Masoodian, «Quanta Image Sensor: Concepts and Progress,» chez *SPIE International Society for Optics and Photonics*, 2016