PHD THESIS

Funding : CNES (Department : Detection Chain and Quality Assurance), STMicroelectronics, ISAE-SUPAERO

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Duration : 3 years
Start Date : October 2020 – February 2021

Location : ISAE-SUPAERO, (Toulouse, France) and STM (Crolles, France)

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DESCRIPTION

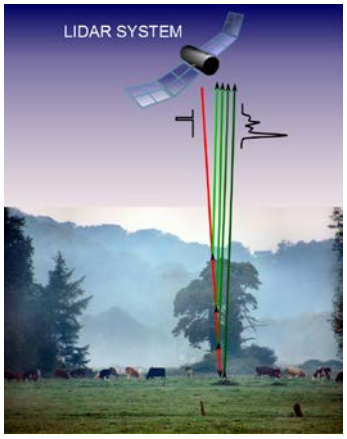
Réf : 2020-146

Domaine : Single Photon Imaging, SPAD, microelectronics, nanoelectronics, semiconductor device physics, CMOS integrated circuits, space radiation environment and effects, particle radiation, ionizing dose, displacement damage.

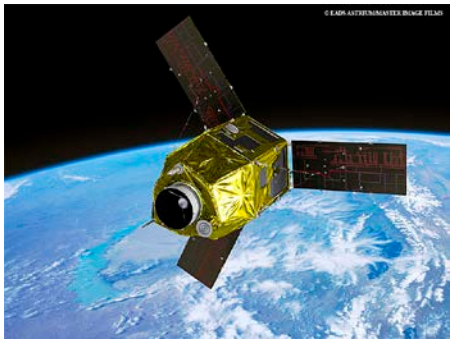
Titre :

SPACE RADIATION EFFECTS ON CMOS AVALANCHE BASED DETECTORS

Silicon Photodetectors based on CMOS microelectronics processes are nowadays widely used in various applications ranging from mobile phones to automotive. Such technology plays also a key role in space instruments in general, especially within the framework of the high temporal resolution imagery as distance matrix imagery (3D imagery, LIDAR / LADAR), flash detector, laser ecartometers ... etc.
The considerable progress of CMOS imaging technologies obtained in recent years, in terms of both improved performance in photo-detection and reduction of noise, augurs well for the possibility of considering these technologies for very low light level applications by means of further improvement in sensitivity with the ultimate target being the ability to detect the single photon and the ability to operate in counting mode.



LIDAR System


PLEIADES Satellite

The solutions currently used, excluding the electrostatic amplification requiring a vacuum tube, are based on the multiplication of carriers by impact or avalanche ionization in the silicon detector material through avalanche photodiodes in linear mode (APD) and in Geiger mode (SPAD) directly associated with the photo-detectors.
The main goal of this PhD thesis subject is to study the behavior of promising avalanche

based CMOS technologies when they face the space radiation environment. Using state-of-the-art CMOS microelectronic process optimized for avalanche detectors, the candidate will conduct a detailed analysis of the behavior of the device in response to the effects of particle radiation (ionizing and non-ionizing dose) present in space. Radiation environment encountered in medical imaging, nuclear and particle physics applications will also be considered during this project. The aim will be to model the behavior of the component and to find mitigation technique in order to improve the performance of avalanche based detectors in radiation environments.

In detail, the PhD candidate will:

- Carry out a literature survey of the state of the art concerning:
    - the use of impact ionization/avalanche in photodetectors
    - CMOS technologies optimized for imaging.
    - event reading devices allowing the reading of signals from the bipolar avalanche transistor
    - the effects of particle radiation in semiconductor materials
- Model and simulate the key phenomena related to impact ionization and the effects of radiation, in particular in mesh physical simulation of the TCAD type.
- Research and develop solutions to contain parasitic effects.
- Design and manufacture test structures of the envisaged devices (reading nodes with avalanche junction, bipolar avalanche transistors) to evaluate their static and dynamic characteristics.
- Study and propose signal reading solutions adapted to the direct quantification carried of the avalanche signal in order to design a reduced-scale prototype (realistic test structures) to evaluate and validate the proposed concepts
- Measure, irradiate and analyze the structures designed to evaluate the radiation hardness.
- Synthesize the work developed during the thesis.

Applicant Profile

Master of Science (or equivalent) specialized in at least one of the following major: Electrical Engineering/ nano or microelectronics (design, manufacturing processes, etc.) / optoelectronics / electronic imaging, sensors, detectors / semiconductor device physics / solid state physics / analog and digital electronics / radiation effects on electronic devices/ microelectronic reliability.