ISAE-SUPAERO PhD thesis position

Emerging radiation effects in advanced CMOS technologies for the exploration of Jupiter's moons and for nuclear fusion

Thesis directors: Vincent Goiffon (ISAE-SUPAERO), Philippe Paillet (CEA DAM DIF)

Contact: vincent.goiffon@isae-supaero.fr

Scientific Domain: Nano/Microelectronics, Solid State Physics, Semiconductor Physics, Particle/matter Interactions, Radiation Effects on Electronic Integrated Circuits

Keywords: CMOS, MOSFETs, radiation effects, ionizing radiation effects, space exploration, nuclear fusion, Europa, Jupiter, Laser MegaJoule, ITER

Context: The extremely fast-paced evolution of micro and nano-electronic technologies, associated to applications requiring higher radiation tolerance, lead to the emergence of new degradation mechanisms in modern CMOS circuits.

The effects induced by energetic particles in these advanced technologies are thus difficult to anticipate and the techniques to allow and guarantee their good resistance to extreme radiation environments are still to be established.

Major scientific projects, such as mastering nuclear fusion as a source of energy (ITER and Laser MegaJoule projects) and the exploration of Jupiter and its sattelites (Europa, Io…), scheduled in the NASA mission Europa Clipper (Figure 1) or in ESA mission JUICE, rely on the use of these technologies in intense radiation environments for which solutions do not exist today.

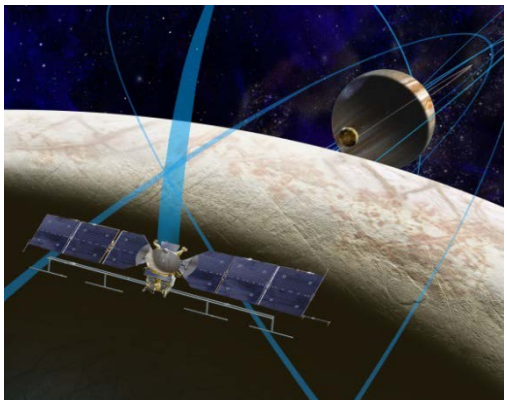

Figure 1 : Illustration of satellite Europa Clipper during one of the flight over Europa scheduled for the mission

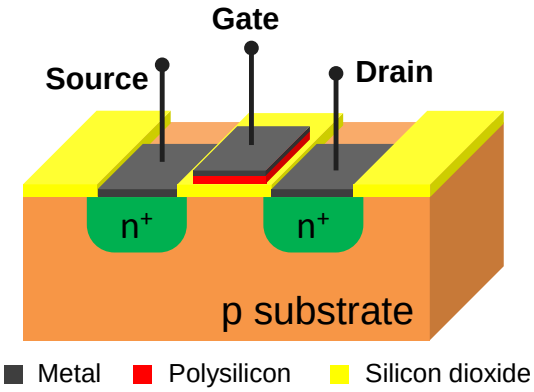

Figure 2 : Schematic of a N channel MOSFET structure

Thesis Objectives: The main objective of this thesis is to perform a study on the effect of radiations at high level of total ionizing dose (>> kGy)) and high flux of particles on advanced CMOS technologies. This evaluation is necessary to clarify the physical mechanisms involved in the loss of

performance occurring in these irradiated components, in order to develop failure analysis and prediction methods based on semiconductor physics. To achieve this study, a good understanding of the physics at different scales (from material to system) will be required. Therefore several technologies and device designs will be considered, as well as several types and sources of radiation, representative of the severe radiation environments encountered by the aimed applications (space exploration and nuclear fusion).

This systematic study will allow a better estimation of the efficiency of hardening solutions (i. e. improvement of radiation resistance) at these unusual and rarely investigated high levels, in order to efficiently select the best solutions to develop radiation hard complex systems (such as image sensors).

Schedule: The thesis work will organized as follows:

- Bibliography study
- Selection of MOSFETs structures (an example is given in Figure 2) to study (several technologies and several designs will be considered). A part of these test structures will be designed and fabricated during the thesis.
- Evaluation and characterization of the selected structures before and after irradiation (several sources and irradiation conditions will be used to represent the targeted environments).
- Identification/analysis of original degradation mechanisms and attempt to model them.
- Identification of possible hardening strategies.

Depending on the breakthroughs reached at this point of the thesis, the development and test under radiation of the new transistor designs will be envisaged. Their integration in a complex integrated circuit, like an image sensor, will also be considered.

The thesis work will be realized in collaboration with several teams from the involved research laboratories (CEA et ISAE-SUPAERO) and with other external research groups. Other interactions are to be expected with actors more directly concerned by these studies (such as NASA-JPL and ITER).

Required competences: Master Degree addressing one or several of the following themes :

- Solid State Physics / Semiconductor Physics / Semiconductor Device Physics
- Nano-Microelectronics / Optoelectronics
- Aerospace Engineering
- Particle/matter interactions / Radiation Effects on materials or electronic circuits
- Nuclear Physics

How to apply?

Please send an email to vincent.goiffon@isae-supaero.fr with a CV and a cover letter presenting the motivations for this position.

The targeted period to start this PhD project is: September 2018 to April 2019.