JOB OFFER

Position : PhD student – Evaluation of electrothermal imbalance of SiC MOSFET components in parallel

AXES / COMPETENCES / PROJECT	Greener Technologies / High Reliability Energy / project SiCRET+

TYPE OF CONTRACT	☐ Secondment ☐ Permanent ☐ Fixed term	☒ PhD thesis ☐ Apprentice ☐ POST DOC	DURATION/DATE 36 months Oct. 2023 • Sept. 2026

% of activity for a secondment : ……

PLACE	☒ IRT Toulouse ☐ IRT Bordeaux ☐ IRT Sophia ☒ **Other : SATIE lab (Gif/Yvette, Ile de France)** **Icam lab (Toulouse)**	TECHNICAL STAFF TO MEET DURING INTERVIEW	1/ Fabio COCCETTI 2/ Bernardo COGO 3/ Franck VANGRAEFSCHEPE 4/ Stéphane LEFEVRE (Thesis supervisor) et Laurent Dupont (SATIE) et Jean-Pierre Fradin (Icam) (laboratory supervisors)

FIRM/ LABORATORY

The Saint Exupéry Technological Research Institute (IRT) is an accelerator for science, technological research and transfer to the aeronautics and space industries for the development of innovative solutions that are safe, robust, certifiable and sustainable.
We offer on our sites in Toulouse, Bordeaux, Sophia Antipolis an integrated collaborative environment made up of engineers, researchers, experts and doctoral students from industrial and academic backgrounds for research projects and R&T services backed by technological platforms around 4 areas: advanced manufacturing technologies, greener technologies, methods & tools for the development of complex systems and smart technologies.
Our developed technologies meet the needs of industry, integrating the results of academic research.
The SATIE laboratory is a CNRS Joint Research Unit (UMR 8039) under the joined supervision of Gustave Eiffel University, which is a unique and pioneering university composed of six entities covering multidisciplinary topics to respond to the continuous transformation of cities and societies. SATIE's studies focus on information technology and electrical energy systems and applications. The laboratory has about 90 people in academic staff, about twenty members in the technical and administrative staff and about 80 doctoral and postdoctoral students. The EPIC group (Integrated Power Electronics under Stress) works particularly on the challenges of energy conversion, including the integration of power electronics to assess the reliability of innovative technologies since the 1980s. In this project, SATIE will be involved in several working groups and particularly to identify methods and indicators to quantify electrothermal imbalances of SiC MOSFET components in parallel.
Icam, Toulouse site, is an EESPIG: Private Higher Education Establishment of General Interest. Its research activities are structured at the level of the Icam group around 3 axes: Production, Storage and Management of Energy, Innovative Structures and Materials, Societal and Technological Transition of Companies. This structure brings together about sixty researchers and thirty doctoral students. Each axis is structured in themes. One of the themes of axis 1 deals with heat transfer in electronics and is positioned at the interface between heat transfer in power modules based on wide band gap semiconductors and cooling technologies. As part of this activity, Icam supports and develops the DEPTH-LAB platform that will make it possible to thermally characterize components, products and systems in environments representative of their real/application environment. On this collaborative platform, Icam carries out numerous collaborative projects with industrial and academic partners (partner laboratories and institutes: IRT Saint-Exupéry, LAAS, LAPLACE, etc.). In this project, Icam will be involved in the measurement of semiconductor junction temperatures as well as in the modeling and simulation aspects.

MISSIONS

The thesis will benefit from a professional framework of excellence and very stimulating as it brings together the best industrial experts in the field of electrification for energy transition and the top laboratories working on power electronics and reliability. Indeed, the PhD will be integrated in the SiCRET+, collaborative project that gathers industries of aeronautics and space, railway, automotive, electrical network and academic laboratories in Toulouse, Paris, Lyon, Bordeaux in order to enhance knowledge about the reliability of SiC MOSFET power modules : understanding of failure modes, development of testing and ageing methodologies, ageing modelling, proposition of rules and good practice, especially for paralleling dice in a module.
The parallelization of chips in a module to increase the current gauge is a technique commonly used and well mastered in the case of Si chips whose behaviour, drifts during lifetime and failure modes are well known. In the case

of SiC chips, knowledge is much more incomplete and there is a fear of anomalous behaviour if the chips associated in parallel have too different parameters, whether at the beginning of life or following an unbalanced aging due to a too asymmetrical design of the module. The SiCRET+ project aims to explore these issues, both for the normal use (normal switching) and for abnormal but inevitable cases of life that the modules must be able to withstand (avalanche, short circuit, over-current on the body diode...).
The objectives of the proposed research work are to define, develop and validate characterization methods capable of providing information on stress levels carried over to the nearest chips integrated in parallel in a power module. This characterization method will then be applied to different modules to evaluate the field of electrothermal imbalances between chips, select cases of imbalanced modules to be subjected to aging tests and characterize modules that have undergone aging tests.
The associated tasks are:

- Build and maintain a state of the art of the performances and limits of methods for characterizing electrothermal conditions as close as possible to SiC MOSFET chips especially for the case of chips associated in parallel.
- Evaluation and qualification of thermosensitive electrical indicators (TSEP, Thermo Sensitive Electrical Parameters) with experimental campaigns to evaluate the integrity close to the active parts in parallel.
- Complete the study with numerical studies whose results will be compared with experimental results to consolidate conclusions and allow extrapolations beyond the test cases.
- Validation of the methodology on industrial modules and application on new and aged modules.
- Writing of scientific articles and thesis

DESIRED PROFILE

Bac + 5 (M2 or Engineer) in the field of electrical engineering.
Interest in correlations between experimental and numerical data in a cooperative framework between different institutions and companies.
Preferably a first experiment, internship type, carried out in the field of power electronics and experimental characterization

TECHNICAL KNOWLEDGE

- Power electronics, mechatronics, measurements.
- Mastery of 3D finite element simulation software (COMSOL).
- Appetite in the realization of electrical and thermal measurements.
- MATLAB, finite element modeling tool (COMSOL will be a plus).
- English (written and oral): level B2 to C1.
- Writing and communication skills.

SKILLS

Teamwork / Adaptability / Rigor / Reliability (keeping commitments) / Ability to analyse and synthesize / Mobility

IF INTERESTED, Please apply to :

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jean-pierre.fradin@icam.fr,

This job offer is also on our website : www.irt-saintexupery.com