Master research internship

"Evaluation of performances and limitations of a power converter integrated on a PCB substrate for low environmental impact and favoring the circularity of components."

Research environment

SATIE, an applied sciences research laboratory focusing on information and energy technology systems and applications, is offering a research master internship. It will be supervised by Laurent Dupont (Researcher at Gustave Eiffel University), in collaboration with Morgan Almanza (associate professor at ENS Paris-Saclay) and Mickaël Petit (associate professor at CNAM). The project involves assessing the performance and limitations of a more sustainable power electronic (PE) converter designed for a domestic application such as a laptop charger. The definition of the converter will have to meet performance requirements and be compatible with a low environmental impact Printed Circuit Board (PCB) technology substrate selected to help the circularity of the valorization of materials and components for an improved end-of-life.

Challenges

The challenges facing power electronics include efficiency, high functional integration, disponibility and reliability, standardization of technological building blocks that comply with standards for a just cost. The issue of technological sustainability hinges on better control of the use of resources by promoting the circularity of technological building blocks. These levers are essential for driving the energy transition while respecting economic, environmental, and social issues. The choice of the substrate as a vector for circularity in power electronics is relevant because of its function as a technological adapter between electrical links, active and passive devices, control command interfaces and the heat exchanger. In addition, the decision to reduce the constraints on disassembly means making better use of the components through a more selective process (Figure 1).

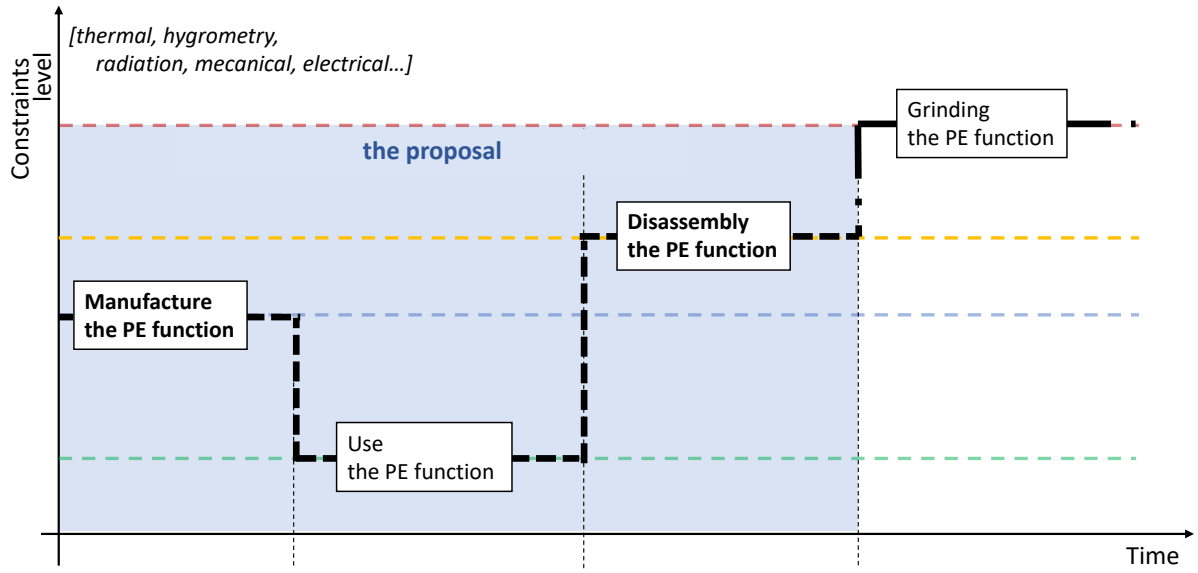

Figure 1: Stages of stress imposed on a PE assembly during its life cycle.

The prerequisite for achieving this objective is to reduce the glass transition temperature of the material making up the substrate. Even if the degradation limits are more or less those of thermoplastic substrates, this new technological definition of power electronic imposes new constraints on the efficient integration of active components, but also offers new degrees of freedom.

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Objectives

The aim of this stage is to define, develop and evaluate an electronic power converter, typically for a laptop power supply, which will be suitable for integration on a bio-based substrate characterized by a low glass transition temperature. This study will lead to the experimental evaluation of the power electronics function on this type of substrate. The subject leads to propose the best performance for the function, on a profile representative of its use, while considering the limitations imposed by the substrate technology used to facilitate the disassembly of the components.

It will be necessary to consider the performance of the active parts (power and current density, switching speed, etc.) by comparing them with the opportunities and constraints imposed by the technological choices and those of use. The converter will be developed and characterized using the technological environment of the SATIE. The technological demonstrator, designed by conventional modeling approach, will validate or invalidate the electrical and thermal performance expectations of the function over representative cycles of use. Finally, defining the method and means of characterizing the performance of the disassembly will be one of the challenges of this internship to evaluate the prospects offered in terms of circularity.

The work plan

Definition of the specifications (CdC) of the converter as the study demonstrator

- State of the art: Constraints and limitations of PCB substrates in EP
    - State of the art achievements, their performance and their technological limitations
    - State of the art of the architectures of the CdC conversion function
- - Definition of converter technology and architecture
    - Choice of technology and topology,
    - Electrical and thermal modelling and simulation.
- - Development of the demonstrator
    - Design of the converter on PCB
        - Substrates + Copper foils
        - Reference epoxy composite + glass fibre
    - Performance assessments
        - Characterization of components
        - Function characterization
        - Characterization of disassembly

Conditions and environment

The laboratory benefits from a rich scientific environment combining teaching and research. Research is supported by both simulation and experimentation, with numerous numerical tools (MATLAB, SIMULINK, ALTIUM, COMSOL, etc.) and original test facilities for characterizing the electrical and thermal performance of power components and measuring the physical properties of materials.

As part of a laboratory project to build up expertise in the targeted subject,
this internship offers good prospects of continuing to a thesis.

Place of work placement: SATIE ENS Paris-Saclay in Gif-sur-Yvette.
Duration: 4 to 8 months
Contact email: laurent.dupont@univ-eiffel.fr
Internship remuneration: flat-rate