Environmental assessment of the benefits of Bio-Based Insulated Metallic Substrate (B^2IMS) as a more sustainable power converter for domestic electrical application

SATIE and LEPMI laboratories, renowned research centers specializing in fundamental and applied sciences, are collaborating on an internship project aimed at evaluating the environmental benefits of a more sustainable power electronics converter built on a bio-based substrate.

Objectives

The internship's objective is to describe a rigorous technological inventory that considers the process assembly developed in the SATIE lab to design a simplified bio-based insulated metallic substrate in comparison with standard composite of epoxy and fiber glass.

Context and project description

Electricity is a fundamental energy vector driving mobility, healthcare, and communication in modern society. Power electronics, as a critical enabler of the ongoing energy transition, plays a key role in managing electrical energy safely and efficiently. To meet the goals outlined in the Net Zero Emissions by 2050 Scenario (NZE Scenario), over 70% of fossil energy must be replaced with electricity [1,2]. However, power electronic devices—using significant quantities of noble and less diluted materials compared to microelectronics—contribute to the mounting challenge of electronic waste (e-waste). In 2022, global e-waste generation reached 62 million metric tons, yet only 20% of it was effectively collected and recycled, resulting in significant environmental and economic costs [3].
Approximately 8% of this e-waste comes from printed circuit board substrates (PCBs), which are integral to the functionality of power electronic devices [4]. These substrates, composed of complex structures with various non-recyclable elements, are traditionally designed with a focus on process compatibility and functional efficiency rather than sustainability or ease of disassembly [2,5]. Moreover, the epoxy resins commonly used as insulating materials are primarily petroleum-based, and PCBs contain metals of varying purities, including critical, scarce, and expensive ones [6,7]. These factors underline the urgent need to develop more sustainable PCB production methods with a greater emphasis on circularity. Currently, electronic substrates, which enable technological adaptation between different components, present challenges in terms of reusability and component recovery. Existing recycling processes lack sufficient selectivity, limiting recovery options for various components [6,8,9].
To address these challenges, recent research has explored alternative materials for PCB design. While some alternatives are limited to niche applications, bio-based thermoplastics such as polylactic acid (PLA) have emerged as promising candidates for broader industrial adoption [10]. PLA is widely used in industries such as food packaging, 3D printing, and medical devices due to its biocompatibility and sustainability [11].
Compared to conventional epoxy-based substrates, bio-based substrates offer a pathway toward improved sustainability. However, they have a lower glass transition temperature, which presents challenges for integrating electronic components with greater design flexibility. The SATIE laboratory has recently developed a prototype power electronic converter using a PLA substrate to demonstrate the feasibility of designing a standard power electronic function for domestic applications, such as cellphone or laptop chargers. While this prototype confirms the technical feasibility, achieving true technological sustainability requires not only reducing environmental impact and optimizing resource efficiency, but also rigorously evaluating the benefits of this innovation. Life cycle analysis (LCA) methodology will be used to assess the environmental benefits of the tested prototype, in comparison with a standard reference PCB.
This internship is supervised by Maria Lupsea (Associate Professor at Grenoble INP-Phelma) from the LEPMI laboratory, Pierre-Xavier Thivel (Professor at Grenoble INP-Polytech) from the LRP laboratory and Laurent Dupont (Researcher at Gustave Eiffel University), with Morgan Almanza (Associate Professor at ENS Paris-Saclay) and Denis Labrosse (Associate Professor at CNAM) from the SATIE laboratory.

Plan of identified exploring subjects

- Define the elementary functional unit for the comparison the polymer characteristics and variations due to both manufacturing processes and aging.
- Identify the technological inventory of both technological substrates (bio-based and epoxy).
- Synthesis a comparison of both solutions at mid-impact level.
- Proposal for a first version of a scientific article.

Working conditions and environment

Both laboratories provide a robust scientific environment that integrates research and education. Supported by extensive technical, bibliographic, and experimental resources, this project will use various tools and specialized test facilities to thoroughly evaluate the bio-based material's electrical properties and performance stability.
The intern will be hosted by the LEPMI laboratory in Grenoble (Saint Martin d'Hères).

Candidate profile

The candidate should have a general engineering training. Modelling skills in LCA would be appreciated.

Contacts: Please send you CV and motivation letter at the internship supervisors:
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