POSTDOC SUBJECT

Developments in **energy transport and storage technologies** (fast charge technologies, high energy density batteries, electric vehicles) are leading to a considerable **increase in heat generation in these systems during operation**. The emergence of high energy density batteries and fast charging technologies (particularly for electric vehicles) generally results **in high heat generation rates during charging and discharging cycles**. This can lead to thermal runaway, compromising the integrity of the battery pack and causing serious safety problems for users**. Improving the performance of batteries**, which is the focus of this study, is therefore highly dependent on the **effectiveness of the thermal management** applied to them. What's more, the ever-increasing drive **to miniaturise embedded systems is constantly reducing the space allocated to cooling them**, leading to the obsolescence of forced convection cooling systems (active systems) and **inevitably affecting their performance, lifespan and reliability**. These various factors inevitably **lead to the need to develop a new class of materials that dissipate heat via their own structure.**

In addition to the good thermal conductivity needed to facilitate heat dissipation, the new materials under development must also have **very good electrical resistance** in order to avoid other problems such as **short circuits or over-consumption of energy** due to lower efficiency at higher temperatures.

The original strategy proposed in this project consists of **manufacturing thermally conductive and electrically insulating nanocomposites** loaded with intrinsically thermally conductive **1D and 2D nanoparticles** with a rheology suitable for the 3D additive manufacturing process (FDM, Fused Deposition Modeling). The advantage of building **innovative passive systems** of original shape **by 3D printing** with these new nanomaterials lies in the innovation of the design, particularly in terms of the organisation of the module in space and the anisotropy of the thermal conductivity.

The development **of an insulating coating on the surface of conductive nanofillers** will be carried out by the sol-gel process. **The influence of the various synthesis parameters** (T, pH, coupling agent, precursor rate, etc.) on the homogeneity and thickness of the shell will be studied and optimised. In addition, **surface functionalization** will be evaluated in order to reduce phonon diffraction at the nanofiller/matrix interface.

The nanofillers will be introduced into the polymer matrix of interest (biosourced matrix) and the optimisation of the synthesis and processing of the nanocomposites will be based on the **characterisation tools** available in the department, such as analysis by microscopy (**TEM**), spectroscopy (**FTIR**), measurement of **electrical resistivity, indirect thermal conductivity**, mechanical properties (**DMA, traction**), SEC/GPC, etc. The breakdown voltage and losses of the nanocomposites will also be studied. Breakdown voltage and dielectric losses will/should be measured at the Ingénierie des Matériaux Polymères (IMP) in Lyon or at the Université de Grenoble Alpes (UGA).

Finally, **the development of the nanocomposite**, the **manufacture of the printable filaments** and the **shaping by fused deposition modeling 3D** printing (FDM) will be studied in order to optimise the thermal management of the battery casing. **The anisotropy of the nanocomposite** resulting from the morphology of the nanoparticles, combined with the printing process and the innovative design of the passive system, will **optimise the thermal management of the entire module**.

The constraints linked to the battery application, with the production of the **material specifications and the 3D model of the case using modelling/simulation**, will also be handled by the post-doctoral researcher on models with the support of experts in this field.

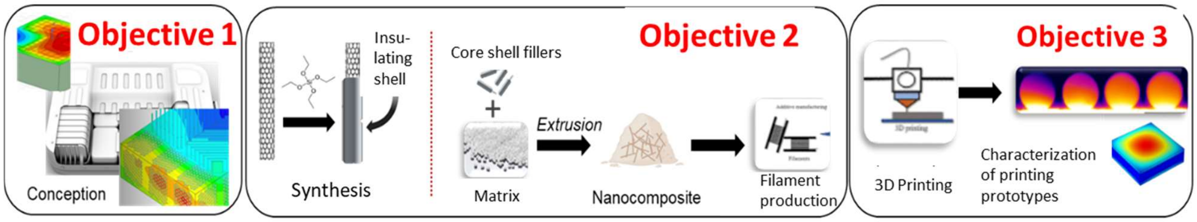

Figure 1. Schematic diagram of the proposed concept

- **Publications associated**

Pietri et al. - 2021 - Boron-Nitride-Nanotubes-for-Heat-Dissipation-in-Polycaprolactone-CompositesACS-Applied-Nano-Materials - https://doi.org/10.1021/acsanm.1c00365

Bodin et al. - 2023 - Mild air oxidation of boron nitride nanotubes. App - DOI: 10.1088/1361-6528/acae2b

- **Patents associated**

DD20409 : Nanocomposite with polymer matrix and boron nitride nanotubes

DD22296 : Process for the oxidation of boron nitride nanotubes

DD19964 : Composite material for 3D printing and 3D printing process

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