

Université de Technologie de Compiègne – Thesis proposal

Part 1: Scientific sheet	
Thesis proposal title	Heterogeneous modeling of batteries for safe operation at very-high-power
PhD grant	Doctoral work contract based on a French Ministry of Research Grant
Research laboratory	Roberval, M2EI team (Mechatronics, Energy, Electricity, Integration) web site: https://www.utc.fr/en/research/utc-research-units/mechanics-energy-and-electricity-roberval/
Thesis supervisor(s)	Nicolas DAMAY (assistant professor) Christophe FORGEZ (full professor)
Scientific domain(s)	Electrical engineering, Physics
Research work	<p>The HIPOBAT project (High-Power Batteries) aims to develop batteries, associated models and control strategies for allowing operations at very high power (full charges or discharges in a few minutes). A research program including 12 laboratories from Germany and France will work together towards these goals. The <i>Université de Technologie de Compiègne</i> (UTC) brings to the HIPOBAT project its characterization and modeling experience.</p> <p>In the case of lithium-ion or sodium-ion batteries operating at very-high-power, the assumption of a homogeneous behavior is no longer relevant. To the contrary, large concentration gradients are expected within the porous electrode, the electrolyte and the insertion material particles. This leads to significant effects upon the electrical and thermal macroscopic behaviors, making classical characterization and modeling approaches irrelevant. More particularly, a form of energy called heat of mixing, coupled to concentration gradients, can be released in large quantities after the end of a fast discharge or a fast charge, thus leading to an overheating risk.</p> <p>The goal of this PhD thesis is to challenge the homogeneous approaches and to develop a heterogeneous battery model that can predict the electrical behavior, the heat generation and the temperature evolution during very-high-power operations. The parameterization of this model will be based on non-invasive electrical and thermal measurements. This model will be used to ensure safe operation at very-high-power, particularly during very-fast-charging. Also, it will be used for the characterization and comparison of high-power batteries, either those developed in the HIPOBAT project (including all-solid-state batteries) or commercial ones, for benchmarking purposes.</p>
Key words	High-power batteries, electro-thermal modeling, heterogeneity, characterization
Requirements	We are looking for a candidate with an electrical engineering background and with modeling skills. A certain knowledge of electrochemical and thermal phenomena would be appreciated. Experimental skills will be necessary for the models characterization and validation. Also, excellent reading and writing in English are mandatory.
Starting time	October 2024
Location	Compiègne (France), with possible exchanges in France or Germany

Part 2: Job description	
Duration	36 months
Additional missions available	It will be possible to teach during the PhD thesis.
Research laboratory	The new recruit will join the M2EI (Mechatronics, Energy, Electricity, Integration) research team at UTC's Roberval laboratory. This team has extensive experience in electrical and thermal modeling of batteries for on-board electrical energy systems. These models, of the equivalent electrical circuit type, enable optimum battery sizing, diagnosis, as well as monitoring in an on-board context.
Material resources	The new recruit will have his own desk, laptop and access to our informatic and experimental platforms.
Human resources	The PhD student will be integrated into the M2EI team of the Roberval laboratory, which includes 15 teacher-researchers, 2 post-docs, 15 PhD students, 2 research engineers and an engineering assistant.
Financial resources	A grant is given by the French Ministry of Research, in the context of the HIPOBAT project. This also covers the purchase of specific scientific equipment.
Working conditions	Regular work with the PhD supervisors and with the HIPOBAT partners. Some missions or stays in Germany or other cities in France are likely.
Research project	HIPOBAT project
National collaborations	Expected collaborations with the Collège de France (Paris).
International collaborations	Expected collaborations with the ISEA (Aachen university).
International cosupervision (cotutelle)	None
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Please contact first the thesis supervisor before applying online on <https://webapplis.utc.fr/admissions/doctorants/accueil.jsf>