Composites graphène 3D / nanofils de Si pour micro-supercondensateurs

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Stage pouvant se poursuivre en thèse : Oui

Résumé :

Graphene is a material that is being widely explored for its potential applications notably in the field of energy (batteries, supercapacitor, fuel-cell catalyst...). Indeed it was described that graphene could be used as additive for the development of new negative electrodes for Li-ion batteries for example. In parallel, Si nanowires (SiNWs) have been developed and tested in micro-supercapacitor cells and showed a very long cyclability (millions of cycles) while the specific capacitance achieved could be improved.

The aim of this M2 internship, conducted in collaboration between INAC/SyMMES and INAC/PHELIQS, is to develop a method to grow these Si NWs inside a graphene structured matrix to increase the surface area and thereby increase the capacitive properties of the micro-supercapacitor in terms of specific capacitance, power and energy densities. The materials obtained will be characterized by various techniques. Depending on the project advances, electrochemical testing will also be attempted.

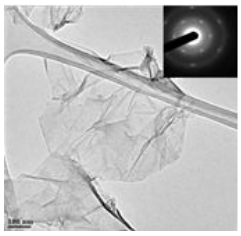
Sujet détaillé :

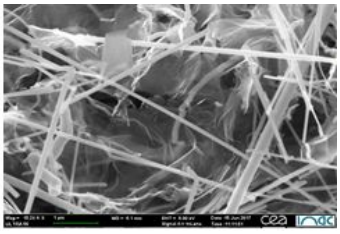
INAC showed that Si nanowires and nanotrees can be used as electrode materials for energy applications. When they are grown in contact with a substrate, these nanostructures display specific surface area adapted to microsupercapacitor applications. INAC is developing them further to carry on the enhancement of the properties already achieved.

The interest of the M2 intern is to optimize further the systems by composite formation to target such higher energy and power densities. The composite will be formed of Si nanowires directly grown inside a 3D-graphene matrix (3D-G). Combined to the Si NWs properties, the graphene-derivative scaffold will i) provide a good percolation network increasing electrode conductivity, ii) may also give access to even higher surface area and iii) will improve material robustness. The added-value to grow the Si NWs inside the graphene structure is to obtain a strong linking between both components and to move away from a simple mixing. This interaction should enhance the overall system electrical conductivity. The Si NWs/3D-G composite obtained will be used in slurry or pressed onto electrode, and tested electrochemically.

These composites development will involve chemistry steps to produce the starting material graphene oxide stock solutions, to functionalize/reduce it (Fig. left) and to decorate the graphene structure with Au NPs (Si NWs catalyst). It will also involve the study of the CVD growth conditions. So far, only few conditions (Au loading and growth T) have been tested (Fig. right) and optimizations remain to be performed. The single components and composites will be characterized after each step (SEM, TGA, XRD, TEM). And finally, the electrochemical performances of the final materials will be assessed by electrochemistry (cyclic voltammetry, galvanostatic cycling...).

This project is a collaboration between INAC/SyMMES/CAMPE (F. Duclairoir) working in the field of graphene hydrogel for supercapacitors and INAC/SYMMES/STEP and INAC/PHELIQS/SiNAPS working in the field of Si NWs for microsupercapacitors applications.





Compétences requises :

To carry out this project we are looking for students with a background in chemistry and who are now in a Nanoscience related Master Research. Surface chemistry/characterization knowledge and an interest for the energy storage field would be appreciated.