CEA Saclay –Service de Physique de l'Etat Condensé (SPEC) (page web)
Laboratoire *SPHYNX* (page web)

PROPOSITION DE STAGE 2019/2020

THERMALLY CHARGING IONIC SUPERCAPACITOR WITH VERTICALLY ALIGNED CARBON NANOTUBE ELECTRODES

Supercapacitors store electrical charge via electrical double-layer (EDL) formation at the electrolyte/electrode interface. They are characterized by their faster charging/discharging times compared to batteries, but suffer from lower energy (charge) density. Therefore, supercapacitors are used in quick power delivery and low-voltage applications such as in volatile memory backups. While conventional supercapacitors are charged using an external voltage source, Thermally Charged Ionic Supercapacitors (TISC) take advantage of the thermoelectric effects inside the electrolyte (thermos-electro diffusion) and at the electrolyte/electrode interface (EDL) to charge itself using 'heat.' As such TISC made with highly thermoelectric ionic liquids is considered as an alternative technology for waste-heat recovery applications. The performance of TISC's depends on key parameters; notably, the induced thermoelectric voltage and the specific capacitance of the electrodes. One possibility to improve the latter is to increase the electrode surface area by nanostructuration. For example, vertically aligned carbon nanotubes (VACNT) based materials are a promising candidate to build an efficient supercapacitor. However, the precise electrochemical and physical processes in TISCs are still unclear; and it is yet to be determined if TISC can become competitive against other thermos-electrochemical energy storage technologies.

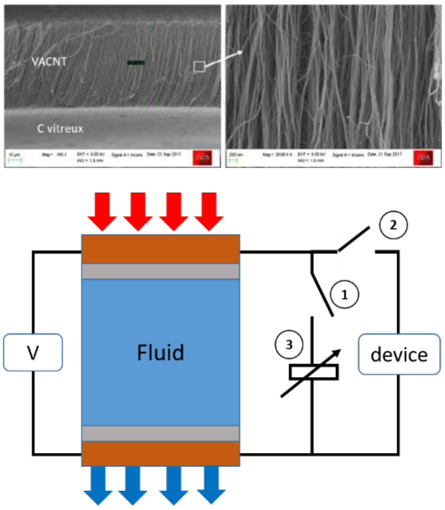

Figure 1 (Top) SEM images of vertically aligned carbon nanotubes grown on glassy carbon surface (courtesy of LEDNA/NIMBE/IRAMIS/CEA). (Bottom) A schematic illustration of a thermally chargeable ionic supercapacitor. ① Switch connecting a (charging) resistance ③ to the TISC cell. ② Switch connecting the electronic device to the TISC.

The proposed internship at SPHYNX/SPEC/IRAMIS (UMR 3680 CEA-CNRS) and LEDNA/NIMBE/IRAMIS mainly experimental: the characterization of thermoelectric properties (thermoelectric voltage and capacitance) of TISC devices using VACNT electrodes in combination with the mixtures of ionic liquids and organic solvents. The student will also participate in the electrode elaboration. More specifically, he/she will perform thermoelectrical and capacitance measurements, implementation of automated data acquisition techniques and analysis of the resulting data obtained. The student will also acquire hands-on experience in basic electrochemical characterization techniques (cyclic voltammetry and impedance measurements). The electrode synthesis will be conducted at LEDNA, using their 1-step process developed for the direct and controlled growth of vertically aligned and dense carbon nanotubes. In addition to these principal responsibilities, the student will also have the opportunity to learn materials characterization techniques such as Scanning Electron Microscopy, X-ray Photoelectron Spectroscopy and Transmission Electron Microscopy (at LEDNA). For a motivated candidate, participation in the numerical investigation of ionic liquid – electrode interactions through Monte Carlo simulation technique can also be envisaged. A successful internship may be converted to a PhD research in where a systematic comparison of thermoelectric data to the morphology (nanotube arrangements, lengths, diameter/density distribution etc.) will be investigated in order to understand the physical and electrochemical mechanisms of the thermoelectric energy conversion in complex liquids in ionic supercapacitors.

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