THESIS PROPOSAL :

IONOGEL-BASED ALL-SOLID 3D MICRO/NANOSTRUCTURED MnO_2 MICROSUPERCAPS

In order to enhance the energy density of micro-supercapacitors (µSCs), pseudocapacitive materials such as MnO_2 or electroactive polymers can be used as µSC's electrodes. Nevertheless, these pseudocapacitive materials implemented in µSCs do not significantly boost areal energy and power densities compared to carbon based µSCs, mainly due to the limited cell voltage of pseudocapacitive material (1 V in aqueous media) regarding the carbon technology (3 V in organic electrolyte). Moreover, one attractive way to significantly improve the energy densities of µSCs when the footprint area is limited as in miniaturized devices is to improve the surface to volume ratio by developing a high specific area with a 3D scaffold. When thin films are step-conformally deposited on a 3D scaffold exhibiting high area enlargement factor (AEF), the areal capacitance of the 3D µSC is significantly enhanced at least by one order of magnitude compared to the planar one.

Based on our transdisciplinary consortium, we aim at increasing the energy density and the safety of innovative all-solid state µSCs. The strategy is to develop high surface electrodes based on pseudocapacitive materials that would be operated in severe conditions (wide temperature range, low pressure and miniaturization) thanks to specifically designed high performance solid state electrolytes, namely ionogels, providing compatibility with commonly used microelectronic fabrication processes. More specifically, interdigitated 3D electrodes will provide high areal capacitance, and further technological challenges will be addressed thanks to the solid and safe electrolytes endowed with liquid-like properties, as well as microdevice integration.

This thesis at Institut des Matériaux Jean Rouxel (IMN, Nantes) will imply close relation with partners of the consortium at IEMN Lille and ICGM Montpellier.

Main goals of the thesis:

- To prepare inorganic, organic or hybrid ionogels required to design all solid state device compatible with microelectronic process, that can sustain high temperature required for solder reflow process and that shows no leakage and can be encapsulated by standard techniques. These ionogels must be chemically and mechanically compatible with micro/nano MnO_2 electrodes or other pseudocapacitive materials;
- To study electrochemical performances of µSCap (impedance spectroscopy, evaluation of performance using standard electrochemical experiments);
- To deepen the understanding and thus to rationalize the effect of confinement onto electrochemical properties (interfaces studies by means of Raman and IR spectroscopies);
- Overall, to prepare the transfer of the scientific and technical achievements to devices of interest in energy storage, miniaturization, extreme environments (space, aircarft, etc.), and / or requiring increased safety.

Profile sought: physico-chemist, the candidate will have to manipulate simple concepts and syntheses in chemistry, perform electrochemical studies, and have the willingness to deepen understanding using various physical methods.

Starting : Fall 2017

Monthly net salary : ~1400 € (social security included) + eventually 150 € if teaching

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