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ECXX = ECLi, ECL, ECM, ECN, CS
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PhD Proposal 2017

School: CentraleSupelec	
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Title: Flexible and wearable energy storage devices based on carbon nanomaterials
Scientific field: Material Sciences
Key words: flexible，wearable，energy storage device，supercapacitor，carbon nanomaterial，carbon nanotube array，graphene，conducting polymer

Details for the subject:

(Maximal length of 2 pages, including images, list of reference, é The pdf file should not exceed 1Mo)

Background, Context:

With the development of electronic industry, the wearable and portable electronics become an indispensable part for our daily life and they have been widely used in medical equipments, monitoring devices, etc. In order to realize the function of these electronic devices, flexible, lightweight and high-performance energy storage devices are greatly needed. Supercapacitors (SCs) are regarded as one of the most suitable candidate for this kind of application.

Generally a supercapacitor is mainly composed of electrodes, current collectors and electrolyte. It is a kind of smart device which can be quickly charged and discharged, it possesses outstanding power performance and very long cycling life. However, most of supercapacitors (SCs) are difficult to be bended because of the utilization of rigid and heavy metal current collectors or electrodes, which limits their applications in the flexible electronics.

The purpose of this project is to prepare the flexible and wearable SCs with high performance. It is well known that the ideal SCs should not only own favorable flexibility but also considerable mechanical strength, so that its performance will not be degraded when the SCs suffer from the repeated bending. Therefore, itôs vital to maintain the flexibility and practical performance of SCs.

Research subject, work plan:

Up to now, the gel electrolytes (such as PVA/H_3PO_4) is widely used as solid electrolytes and the current collector is limited to the specified metal substrate or carbon materials. Therefore, the most accessible way is to prepare the high-performance flexible SCs by designing the novel flexible electrode.

Carbon nanomaterials, such as carbon nanotube (CNTs), graphene and their hybrids, have excellent mechanical and electrical properties. Moreover, itôs relatively easy to obtain high quality products by chemical vapor deposition (CVD) method. The carbon nanomaterials could be served as an ideal candidate in active electrode materials, which provide a potential solution to fabricate the high-performance flexible SCs.

Two approaches are proposed in this project.

1. Preparation of the aligned carbon nanomaterials by CVD method and transfering the resultant products to the soft polymer substrates, like PDMS or PU. To further compensate the performance of the SCs, the electrochemical polymerization will be utilized to deposit an uniform layer of conducting polymers on the carbon nanomaterials. The flexible electrode is obtained and used to assemble the SCs. Because the energy storage process of this supercapacitor involves two different mechanism (electrical double layer capacitor and pseudo-capacitor), it may possess a high energy density and long cycle life simultaneously.
2. The non-woven fabrics or conductive cloths will be chosen as the substrates and loaded with the carbon nanomaterials uniformly. The fabrics or cloths are considered as an appropriate electrode materials to prepare the flexible SCs. This kind of SCs is easy to split into fibers. In other words, itôs accessible to integrate with normal clothes.

For the characterizations of the microstructure of carbon hybrids based nanomaterials, the scanning electron microscope (SEM) and transmission electron microscopy (TEM) will be carried out. The intrinsic chemical structures will be analyzed by Fourier transform infrared spectrum (FTIR) and Raman spectrum. The electrochemical performances of SCs will be

evaluated by cyclic voltammetry (CV), AC impedence test, leakage current test and galvanostatic charge-discharge test.

Besides, the more advanced devices will be designed by integrating the flexible SCs with other electronics, like solar cells or dielectric elastomers, which is also another important part of this project.

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