Hierarchical assembled nanostructured electrodes based on transition metal chalcogenides for next generation secondary batteries

M.-R. Zamfir[a,*], M. Ezzedine[a], L. Sacco[a], I. Florea[a], C. - S. Cojocaru[a]

[a]LPICM, CNRS, Ecole Polytechnique, Université Paris-Saclay, 91128, Palaiseau
* mihai-robert.zamfir@polytechnique.edu

Transition metal dichalcogenides (TMDCs) pose as potential candidates for applications in the area of energy storage due to their layered structure (with the general formula MX2, in which a layer consists of a sheet of transition metal atoms (M) bonded to two adjacent sheets of chalcogen atoms (X = S, Se or Te)), high surface area and electrochemical properties [1]. Depending on the chemical composition TMDCs can be used either as cathode or anode material exhibiting theoretical specific capacities larger than the commercially available graphite anode or transition layered metal oxides [2]. At the same time their large interlayer van der Waals gaps allow the intercalation of Li ions (or larger size Na ions) in the structure alleviating the large volume expansion presented in alloying type materials. However due to their low electronic conductivity the cycling performances are poor [3].

In this work we have developed hierarchical assembled nanostructured electrodes based on carbon nanotubes (CNTs) carpets used as current collectors decorated with TMDC nanomaterials using simple scalable techniques. The role of the CNTs is: i) increasing the specific electrode surface area ii) insuring the fast charge transfer and III) to promote good crystallinity of the deposited active material. The functionalization of vertically aligned CNT by TMDs offers an unprecedented opportunity for their use in energy storage devices. These hierarchical architecture electrodes, due to their unique combination of redox chemistry, rapid ionic-transport channels, short-distance interactions between charge carriers, as well as between carriers and ions, and their earth-abundance, will play a key role in the successful implementation in the area of next generation rechargeable batteries.

[1] L. Peng, et al. Adv Energy Mat. 6 (2016) 1600025
[2] H. Hwang, et al. Nano Lett. 11 (2011) 4826
[3] W.Y. Li, et al. J. Mater. Chem. 22 (2012) 14864

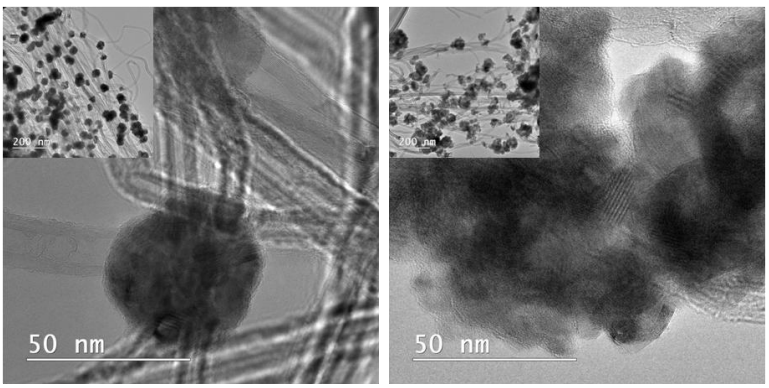

Figure 1: HR-TEM analysis of functionalized CNTs with transition metal nanoparticles and the morphological and structural changes after thermal sulfurization.