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Keys parameters for highly-efficient silicon nanowires micro-supercapacitor

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Develop supercapacitors easily integrables in micro-electronic circuit is one of the key challenge to improve micro-electronic devices performances [1]. Elaborate silicon based micro-supercapacitors should facilitate it. Non-doped porous silicon nanowires based electrodes show promising results to reach this goal [2].

This work concerns the elaboration and the electrochemical characterization of silicon nanowires (SiNWs) based electrodes for micro-supercapacitors.

SiNWs based electrodes are elaborated by Chemical Vapor Deposition (CVD) on highly doped silicon substrate via localized gold catalysis. Their parameters (length, diameter, density and doping level) can be monitored by the Vapor Liquid Solid (VLS) method and checked after the growth by SEM [3]. Electrochemical performances of theses electrodes are characterized evaluated in an organic electrolyte (NEt_4BF_4, PC, 1M) and an ionic liquid (EMI-TFSI) by Electrochemical Impedance Spectroscopy and dynamic electrochemistry (cyclic voltametry and galvanostatic charge/discharge).

This work focuses mainly on the influence of SiNWs parameters and electrolyte on the nanostructured electrodes electrochemical performances and charge discharge stability. SiNWs length, density and doping level have been identified as key parameters to improve electrode capacity [4]. An increase of the SiNWs doping level enables to obtain electrodes with a quasi-ideal supercapacitor behavior. Pure capacitive storage of these highly doped electrodes has also been underlined [5].

A 440 $\mu F.cm^{-2}$ capacity, i.e. about 75 fold bulk silicon capacity, has been reached by using dense, highly doped, 50 µm long silicon nanowires. All devices built with two nanostructured silicon electrode show highly stable cycle efficiency (99 %) and capacity over at least 100 000 cycles for current density ranging from 5 $\mu A.cm^{-2}$ to 1 $mA.cm^{-2}$. The use of ionic liquid as electrolyte enables to enlarge the potential window and thus improve devices performances.

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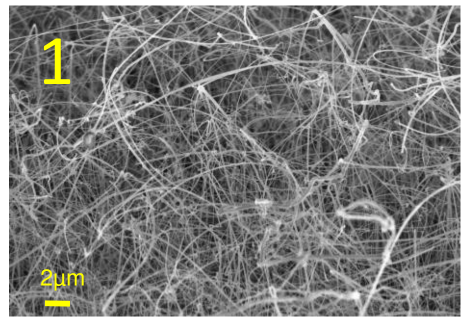

Fig. 1 : SEM image of 50µm-SiNWs micro-supercapacitor based electrode

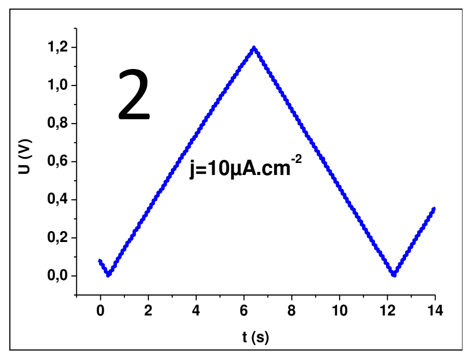

Fig. 2 : Galvanostatic charge/discharge of 50µm-SiNWs/50µm-SiNWs micro-supercapacitor with 1M, NEt_4BF_4, PC as electrolyte

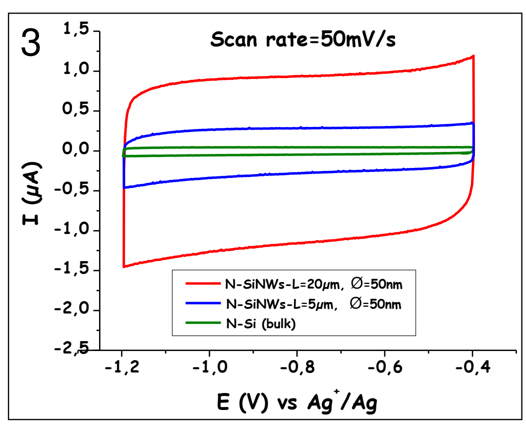

Fig. 3 : Cyclic voltametry curves of bulk silicon electrode and (5-10-20µm) SiNWs electrodes with 1M, NEt_4BF_4, PC as electrolyte