Symmetric micro-supercapacitors based on vertical graphene nanosheet electrodes with high power and energy density performances

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Abstract

In recent years, tremendous research efforts have been devoted to the development of high performance micro-supercapacitors (µ-SCs) due to their unique properties in terms of high power density, long cycling stability, excellent reversibility and fast high-frequency response.[1] Within this context, the synthesis of novel nanostructured material based on carbon or derivatives will play a crucial and key role on the design of advanced electrodes for micro-supercapacitor devices. Precisely, graphene has recently aroused a great deal of attention as nanostructured carbonaceous material in the field of µ-SCs owing to its peculiar characteristics such as high surface-to-volume ratio or large surface area (2630 m^2 g^{-1}), which make it a potential and prominent candidate for on-chip electrochemical energy storage into miniaturized electronic devices (e.g. micro-robots) in the near future.[2]

In this work, we report the performance of a novel 2-D planar micro-supercapacitor using vertical graphene nanosheet (VGN) electrodes grown by electron cyclotron resonance-chemical vapor deposition (ECR-CVD) on silicon substrates. The morphological and structural characterization of the electrodes was examined by scanning electron microscopy (SEM), transmission scanning electron microscopy (TEM) and RAMAN spectroscopy respectively. From an application perspective, the symmetric micro-supercapacitor was analyzed using cyclic voltammetry, galvanostatic charge-discharge cycles and electrochemical impedance spectroscopy employing an aprotic ionic liquid ($PYR_{13}TFSI$) as electrolyte. The device exhibits a quasi-ideal electrical double layer capacitive behaviour as well as a high power density value of 4 mW cm^{-2} and a specific energy of 15 mJ cm^{-2} at a wide cell voltage of 4V. In addition, an outstanding cycling stability after 300000 galvanostatic cycles at a high current density of 1 mA cm^{-2} was tested. These results reflects that the synergistic combination of both VGNs as electroactive material and $PYR_{13}TFSI$ as electrolyte pave the way towards advanced high performance micro-supercapacitors with high power and energy densities.

References

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Figures

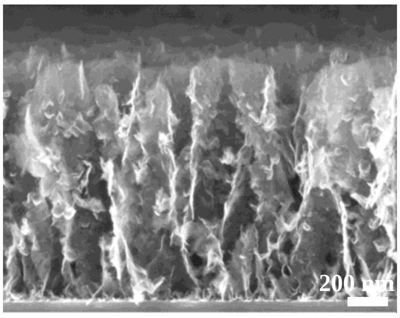

Figure. SEM micrograph of VGNs grown by ECR-CVD on highly n-doped Si (111) substrates.