Flexible, Tunable, Sewable Energy Storage Device

Technology #17262

Applications

High energy/power density (micro)supercapcitors have applications in fast actuators, radio frequency transmitters (such as in cellphones), photo-flash lights, etc. Yarn-based (micro)supercapacitors are excellent for use in wearable and flexible devices.

Problem Addressed

The large ion-accessible surface area of carbon-based nanomaterials such carbon nanotubes and graphene enables miniature high-performance supercapacitors with high power and energy densities. However, metal nanowires such as niobium nanowires show higher specific capacitance and energy/power densities than that of most carbon-based EDL supercapacitors. Furthermore, niobium nanowires, in form of long yarns, are stronger and 100 times more conductive than multiwall carbon nanotube yarns and are highly chemically stable suitable for wearable technologies.

Technology

Niobium nanowires are fabricated via a mechanical drawing process as described in the published papers [1,2]. Two different designs are fabricated and tested: 1) yarn-based supercapacitors for flexible and wearable devices[1]; 2) rigid surface mount micro-supercapacitor devices for use on printed circuit boards[2].

The yarn-based supercapacitor devices showed peak power and energy densities of up to 55 $W \bullet cm^{-3}$ and 7 $mWh \bullet cm^{-3}$ which are 2 and 5 times higher than that for state-of-the-art CNT yarns, respectively[1]. Theoretical volumetric capacitance values were found to be 1.5×10^{7} $F \bullet m^{-3}$, which is 3 times higher than that of the MWCNT yarns.

The rigid surface mount micro-supercapacitor devices showed specific capacitance of up to 1 $kF \bullet m^{-2}$ (100 $mF \bullet cm^{-2}$) with peak energy and power density of 2 $kJ \bullet m^{-2}$ (6.2 $MJ \bullet m^{-3}$ or 1.7 $mWh \bullet cm^{-3}$) and 150 $kW \bullet m^{-2}$ (480 $MW \bullet m^{-3}$ or 480 $W \bullet cm^{-3}$), respectively[2]. This remarkable power density, originating from the extremely low equivalent series resistance value of 0.27 Ω (2.49 $\mu\Omega \bullet m^{2}$ or 24.9 $m\Omega \bullet cm^{2}$) and large specific capacitance, is among the highest for planar micro-supercapacitors electrodes made of nanomaterials[2].

To boost the performance the nanowires were coated with pseudo-capacitive materials such as conducting polymers (e.g., poly(3,4-ethylenedioxythiophene) or PEDOT). It was also demonstrated that gels doped with acid (e.g. polyvinyl alcohol (PVA) with sulfuric acid) can be used for making solid-state devices (i.e., liquid electrolyte free cells).

Advantages

- Increases capacitance, energy per volume, strength and conductivity.
- Niobium nanowire yarns are hypoallergenic, chemically stable, biocompatible, and bioinert.

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- Niobium nanowire yarns are flexible, tunable, and sewable.

Categories For This Invention:

Electronics & Circuits
Nanowires (Electronics & Circuits)
Energy
Energy Storage
Materials
Micro & Nanotech
Nanowires (Micro & Nanotech)
Medical Devices
Life Sciences
Biotechnology
Other (Biotechnology)

Intellectual Property:

High-performance supercapacitors based on metal nanowire yarns
Issued US Patent
9,865,404
High-performance supercapacitors based on metal nanowire yarns
Issued US Patent

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Publications:

High-Performance Supercapacitors from Niobium Nanowire Yarns
ACS Applied Materials and Interfaces
2015
Vertically Aligned Niobium Nanowire Arrays for Fast-Charging Micro-Supercapacitors
Advanced Materials
2017

External Links:

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Image Gallery:

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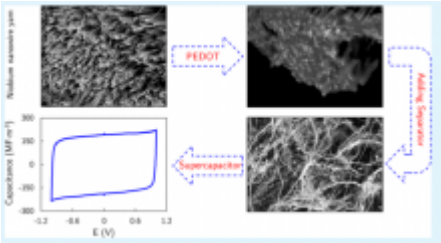

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