Facile and High-Throughput Fabrication of CNT Carpet-PDMS Structures toward Flexible Supercapacitors

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Flexible electronics have a wide range of applications in wearable and multifunctional electronics,[1] including flexible displays, electronic skins, and implantable medical devices. Consequently, technologies for flexible energy storage need to be developed for flexible electronic devices. The fabrication process for flexible supercapacitors is time-consuming, which is not practical for high-throughput production.[2,3] Furthermore, the volumetric energy densities still need to be improved significantly.[4] Carbon nanotubes are a promising electrode material for flexible supercapacitors owing to their excellent properties.[5] Here, we develop a facile fabrication technique utilizing vertically aligned carbon nanotube (VACNT) carpets, which enables high-throughput fabrication of flexible supercapacitors. Our unique technique ensures a strong adhesion between VACNT carpets and Polydimethylsiloxane (PDMS), which facilitates a stable charge-discharge under varied strain conditions. Such performance characteristics are critical to determine their practicality as flexible supercapacitors.[6]

To fabricate flexible substrates with embedded VACNTs, we synthesized VACNTs using low-pressure chemical vapor deposition (LPCVD) into carpet-like structures and transferred them onto a PDMS substrate before fully cured, enhancing the adhesion between VACNTs and PMDS attributed to the viscoelastic property of PDMS. The entire fabrication process allows a rapid and facile fabrication and integration of VACNT/PDMS substrate. The VACNT structures possess a very high surface area, which is a key for flexible supercapacitors with a high capacitance. The electrochemical property of VACNTs on PDMS was measured in 30% KOH using cyclic voltammetry. The measured capacitance, which has an area of $0.54cm^2$, was approximately 170 μF/cm^2 at a high scan rate of 1V/s. In addition, the strong adhesion between VACNTs and PDMS enables the structure to sustain various bending strains. The structure can be bent up to 180 degree and the capacitance under such strains was found to be consistent under the bending angle varying from 0 to 180 degree.

As next steps, the performance of this flexible supercapacitor will be fully characterized at various applied strain values (stretching, bending and twisting in different durations under different temperatures and humidity). The cyclic behavior of supercapacitor will also be investigated under such applied strains. Our goal is to make an all-solid-state flexible supercapacitor with the solid electrolyte, toward, for example, the energy storage for flexible mobile phones.

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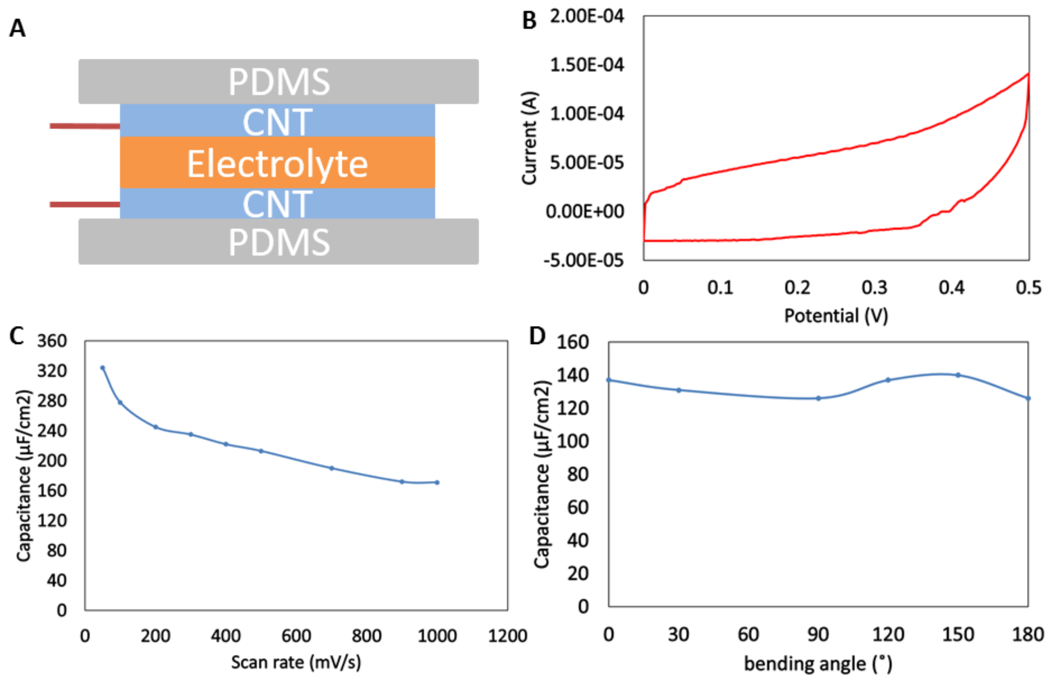

Figure 1. a) Schematic of CNT-PDMS structures. b) Cyclic voltammetry result. c) Capacitance at a scan rate of 50-1000mV/s. d) Variations of capacitance under different bending angles.