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Flexible, Fabric-integrated Supercapacitors based on Nanosized MnO_2 and Polypyrrole - Carbon Nanotube/Graphene Composite

A flexible, fabric–integrated supercapasitor has been designed and fabricated using carbon nanostructured materials. Carbon Nanotube (CNT) sheet was surface-modified by laser milling using a solid-state laser to create nano-sized defect sites. The latter have been identified in a previous study predominately as amorphous carbon particles [1]. MnO_2 nanoparticles were selectively precipitated onto the defect carbon particles when the sheet was exposed to $KMnO_4$ and ethanol. Polypyrrole was introduced by exposing the Laser Milled (LM)-CNT sheet to $KMnO_4$ and pyrrole in an acidic pH, where the MnO_2 particles acted as an oxidizing agent. The LM-CNT composite displayed energy densities that were an order higher as compared to the non – LM – CNT composite. It also revealed a higher cyclic stability, retaining 96% capacitance after 5000 cycles at 4A/g current density. The asymmetrical full device utilizing MnO_2 and PPy showed a peak energy density of over 55 - 60 Wh/kg at 1kW/kg power density . The porous nature of the 3D graphene was utilized for fabric integration [2]. A sandwich structure was created with fabric as a base, graphene as a highly conductive paste (150 S/cm), and CNT composite sheet as electrode, to assemble a flexible super capacitor. Details are presented in Fig. 1.This devise is easy to fabricate in a scalable manner, which makes it a promising candidate for wearable electronic applications.

References

[1] S. Gbordzoe, S. Kanakaraj, R. Wolf, M. Haase, N. Alvarez, V. Shanov, “Effects of Laser Cutting on the Mechanical and Structural Properties of Carbon Nanotubes”, Materials Science and Engineering-B, 223(2017): 143-152.
[2] Zhang, Lu, Derek DeArmond, Noe T. Alvarez, Daoli Zhao, Tingting Wang, Guangfeng Hou, Rachit Malik, William R. Heineman, and Vesselin Shanov. "Beyond graphene foam, a new form of three-dimensional graphene for supercapacitor electrodes." Journal of Materials Chemistry A 4, no. 5 (2016): 1876-1886.

Figures

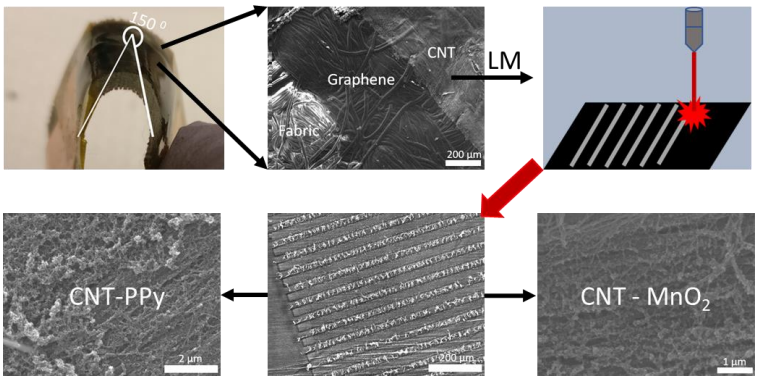

Figure 1: Figures on first row show (left to right) fabric integrated CNT composite supercapacitor, SEM image of fabric/graphene/CNT interface and schematic of the Laser Milling (LM) process. Second row figures display (middle) LM-CNT sheet, (left) CNT – Ppy composite and (right) CNT – MnO_2 composite.