Thin, Durable And High-Performance Flexible Batteries for Flexible Electronics

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Abstract

Flexible electronics have surged in the past several decades, which remarkably advance sustainability, health, security, and connectivity of humanity.[1] Meanwhile, the rapid developments of flexible electronics demand high-performance flexible batteries that can deliver large and dynamically stable energy for flexible devices. In addition, it is desirable that the flexible batteries feature thin thickness and high durability under high-level mechanical deformations. Such requirements are difficult to achieve in conventional batteries because slight flexing can cause serious delamination and damage to the components inside. Therefore, novel materials and designs are crucial to render batteries flexible.

In this presentation, we present high-performance flexible batteries based on flexible electrodes constructed by interpenetrating novel materials with carbon nanotubes. Firstly, the layered MXene is functionalized by the $KMnO_4$ and complexed with carbon nanotubes to form a parallel circuitry at nanoscale, which enables ultrahigh rate capability (50% capacity retention when the current density increases from 0.1 A/g to 10 A/g) of the aqueous zinc ion batteries (Figure 1). Meanwhile, carbon nanotubes serve as the matrix for the freestanding electrodes, thus rendering the flexibility for the batteries. The as-fabricated flexible batteries feature ultrathin thickness (0.1 mm for the entire battery) and durable output under high-level mechanical deformations.[2]

In addition to the aqueous zinc ion batteries, a flexible lithium ion battery is designed by coupling two interpenetrating assemblies: rolled-up $NiFe_2O_4$ nanomembranes and commercial $LiMn_2O_4$ nanoparticles embedded in carbon nanotube matrix. Stabilized by the PAAm/gelatin based artificial interface, the freestanding anode ($NiFe_2O_4$-carbon nanotubes) shows high capacity of 612 mAh/g based on the entire mass of the freestanding electrode. Such high performance enables high energy output of 295 Wh/kg at the power density of 14000 W/kg for the flexible lithium ion battery. In addition, excellent stability of the full flexible battery is achieved as no capacity fade is observed in 1000 charge/discharge cycles (Figure 2). Moreover, the intrinsic flexibility of the

freestanding electrodes enables the fabrication of a flexible lithium-ion battery, which shows high stability even under harsh mechanical deformations.

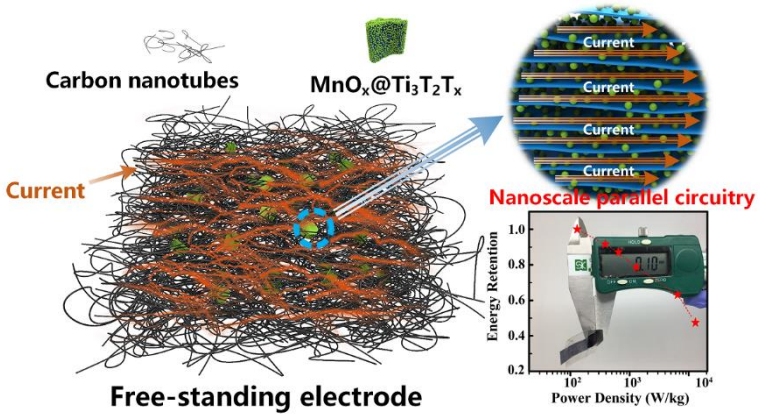

Figure 1. Thin and high rate flexible zinc ion battery

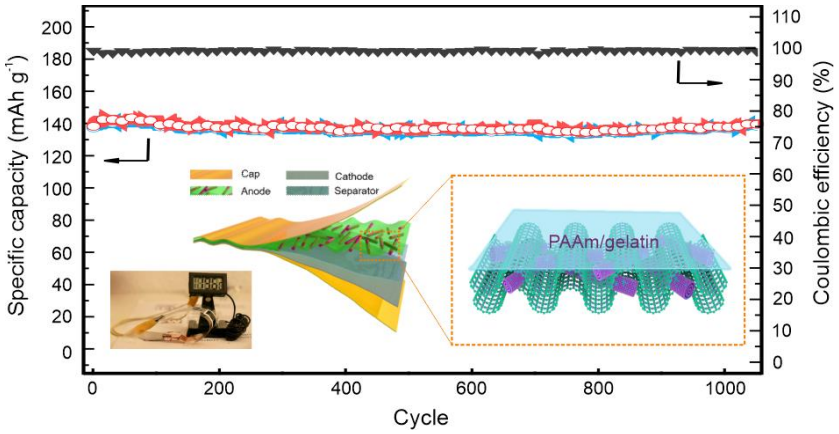

Figure 2: High performance flexible lithiun ion battery with thin thickness and high durability.

References

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