Ni-Fe 二次微电池 3D 打印构筑及电化学性能

摘要

便携式、可穿戴、高集成度电子设备是信息化时代的大势所趋，其高速发展极大的促进了拥有高能量密度，重量轻，低成本以及超薄和灵活特征的高性能电源日益增长的需求。传统的电池电极制备方法如：磁控溅射法，溶胶凝胶涂敷法，金属有机化学气相沉积法等方法技术成熟应用广泛。但是这些方法多成本较高，制备繁琐，操作复杂，难以制作高精度电极。而近些年来 3D 打印技术的迅猛发展使得微尺寸维度内快速低成本大批量制造微电池成为可能。

为了与微器件相适应，电池也要实现微型化，微电池应运而生。常见的微电池有：Ni-Zn 微电池、燃料微电池、Ni-Cd 微电池、铅酸微电池、Ni-Fe 微电池等。铅酸电池虽然技术成熟运行可靠，但是能量密度较低，循环寿命偏短，而且可能带来铅污染。Ni-Cd 电池记忆效应较强，含有有毒物质对环境有害。而 Ni-Fe 微电池成本较低，循环寿命长，原料来源广泛，对环境非常友好，是一种较为理想的材料。

本文选用水热法，分别在 180 ℃，12 h 和 120 ℃，24 h 的条件下制备了纳米花状 $Ni(OH)_2$、纳米球状 Fe_2O_3 样品。使用 XRD、SEM 作为分析手段。选用碳纳米管作为活性材料的载体，PVDF 作为粘结剂，NMP 作为 PVDF 的溶剂。用研钵研磨，再用混料机混合均匀制好浆料并测试其流变性能。3D 打印了具有三维立体结构的电极然后利用循环伏安法，恒流充放电法测试了电极的电化学性能，实验结果表明浆料性能良好，具备可充电放电性，最高比电容可达 132.55 $mF \cdot cm^{-2}$。可以作为二次电池的材料。

关键词：Ni-Fe 微电池，碳纳米管，3D 打印，水热反应法

Abstract

Portable, wearable, and highly integrated electronic devices are the trend of the information age. Its rapid development has greatly promoted the growing demand for high-performance power supplies with high energy density, light weight, low cost, and ultra-thin and flexible features. Conventional battery electrode preparation methods such as magnetron sputtering, sol-gel coating, metal organic chemical vapor deposition and other methods are widely used. However, these methods are costly, complicated to prepare, complicated in operation, and difficult to produce high-precision electrodes. In recent years, the rapid development of 3D printing technology has made it possible to rapidly and low-cost mass production of micro-batteries in the micro-dimensional dimension.

In order to adapt to the micro device, the battery should also be miniaturized, and the micro battery came into being. Common micro-batteries include: Ni-Zn micro-batteries, fuel micro-batteries, Ni-Cd micro-batteries, lead-acid micro-batteries, and Ni-Fe micro-batteries. Although the lead-acid battery is technically mature and reliable, the energy density is low, the cycle life is short, and lead pollution may be caused. Ni-Cd batteries have a strong memory effect and contain toxic substances that are harmful to the environment. Ni-Fe micro-batteries are low-cost, long cycle life, wide source of raw materials, and very friendly to the environment.

In this paper, hydrothermal method was used to prepare nano-flowered $Ni(OH)_2$ and nano-spherical Fe_2O_3 samples at 180 °C, 12 h and 120 °C for 24 h. XRD and SEM were used as analytical means. Carbon nanotubes were selected as the carrier of the active material, PVDF was used as the binder, and NMP was used as the solvent for PVDF. Grind with a mortar, mix with a mixer to make a slurry and test its rheological properties. The electrode with three-dimensional structure was printed in 3D and then the electrochemical performance of the electrode was tested by cyclic voltammetry and constant current charge-discharge method. The experimental results show that the slurry has good performance and can be charged and discharged. The highest specific capacitance can reach 132.55 $mF \cdot cm^{-2}$. It can be used as a material for secondary batteries.

Keyword: Nickel-iron micro-battery, Carbon nanotube, 3D printing, hydrothermal reaction