ASYMMETRIC SUPERCAPACITORS AND THEIR SYNTHESIS THEREOF

IITM Technology Available for Licensing

Problem Statement

- **Current supercapacitors face limitations** in performance due to poor electronic conductivity and low rate capability of **MnO_2, necessitating improved cathode materials.**
- There is a need for **high-conductive and high-aspect-ratio asymmetric supercapacitors** with enhanced cathode materials, **addressing the limitations of existing designs for practical applications.**

Technology Category/ Market

Category – Energy Storage Devices and Nanofiber Technology
Applications – Advanced Materials **,** Electronic system & Design Manufacturing, Renewable energy storage, Aerospace applications, Power Backup systems
Industry –Energy Storage and Renewable Technologies
Market -The global energy storage systems market size was valued at US$ 210.92 billion in 2021 and is expected to hit US$ 435.32 billion by 2030 and poised to grow at a **CAGR of 8.4%** from 2022 to 2030.

Key Features / Value Proposition

Technical Perspective:

- The invention enhances **supercapacitor performance by introducing a core-shell nanofiber structure**, addressing issues of poor **electronic conductivity in MnO_2** and achieving optimal electrode morphologies through controlled synthesis methods.

User Perspective:

- Users **benefit from improved energy storage devices** with higher efficiency and reliability, offering applications in portable electronics, electric vehicles, renewable energy, and aerospace, backed by a **cost-effective and scalable synthesis process**.

TRL (Technology Readiness Level)

TRL-4 Technology validated in Lab.

Technology

Core-Shell Nanofiber Design
- Introduces a novel core-shell structure where nanofibers of a second metal oxide (e.g., MnO_2) are coated on a Nano fibrous first metal oxide (e.g., ZnO), optimizing energy storage capabilities

Electrospinning Technology
- Utilizes electrospinning to create Nano fibrous mats, offering a high aspect ratio, large surface area, and ideal morphology for energy storage devices.

Hydrothermal Coating Process
- Implements a hydrothermal coating method to apply Nano flakes of a second metal oxide onto the first metal oxide nanofibers, enhancing the overall performance of the super capacitor electrodes.

Calcination for Morphological Optimization
- Involves controlled calcination at 500°C to optimize the granular morphologies of the metal oxide nanofibers, ensuring improved conductivity and efficient charge/discharge cycling.

Asymmetric Super capacitor Configuration
- Integrates the synthesized core-shell nanofibers as the cathode, paired with a carbonaceous active material as the anode, resulting in an asymmetric super capacitor with high conductivity and aspect ratio.

Intellectual Property

- **IITM IDF Ref. 1397**
- **IN 393748 (PATENT GRANTED)**

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Images

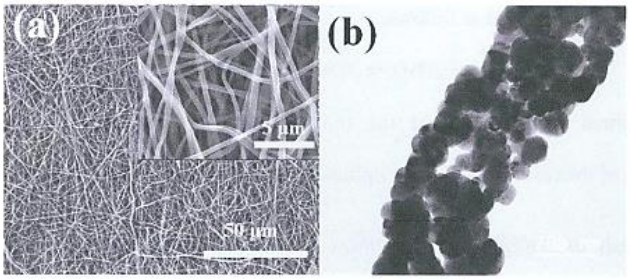

Fig. 1(a) depicts the HRSEM image of ZnO nanofibers obtained by calcining spun fibers (PVA:ZnAc = 0.5) at 500 °C for 2h, while Fig. 1(b) shows the TEM revealing a nanofiber composed of granular nanoparticles.

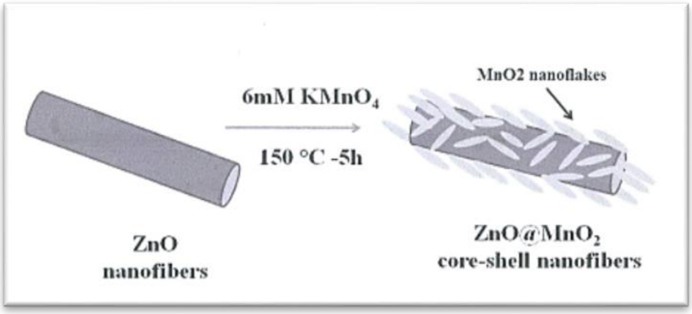

Fig. 2(a) and (b) are schematic representation of Coating of Mn02 Nano flakes on ZnO nanofibers by hydrothermal method

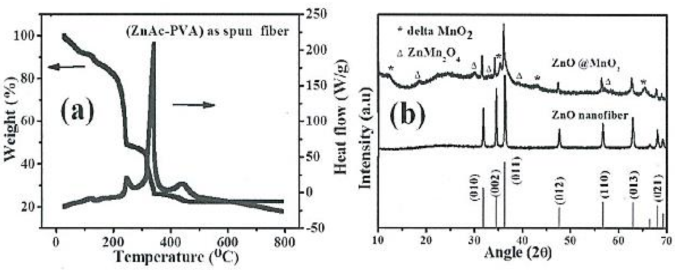

Fig. 3(a) displays X-ray diffraction patterns of ZnO nanofiber and ZnO@MnO2 core-shell nanofiber, alongside standard ZnO reference patterns. In Fig. 3(b), TGA and DSC analyses are presented for the as-spun ZnAc nanofiber.

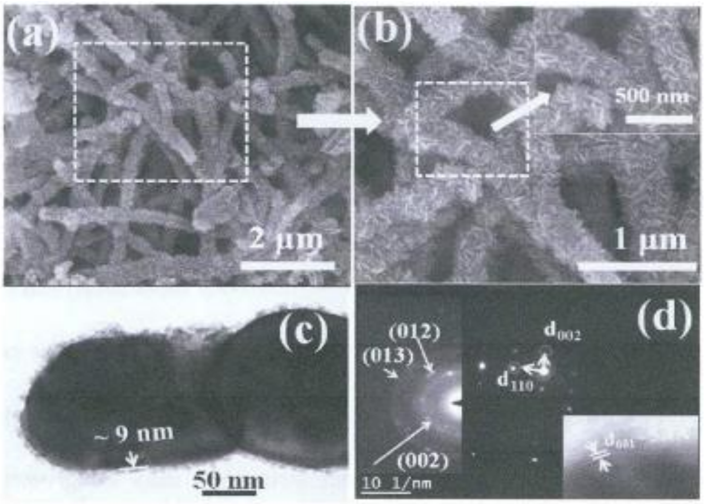

Fig. 4(a) and (b), high-resolution SEM images display ZnO@MnO2 nanofibers at three magnifications. Fig. 4(c) and (d) show TEM images, including a cross-sectional view, of ZnO/MnO2 core-shell structures.

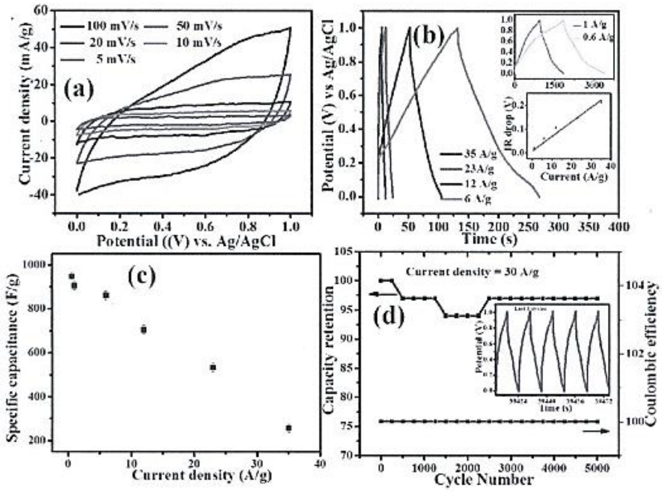

Fig. 5(a)-(d) depict cyclic voltammetry, GCD profiles, specific capacitance variation, and capacity retention with coulombic efficiency. Inset exhibits charge-discharge profiles for the penultimate five cycles.

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Images

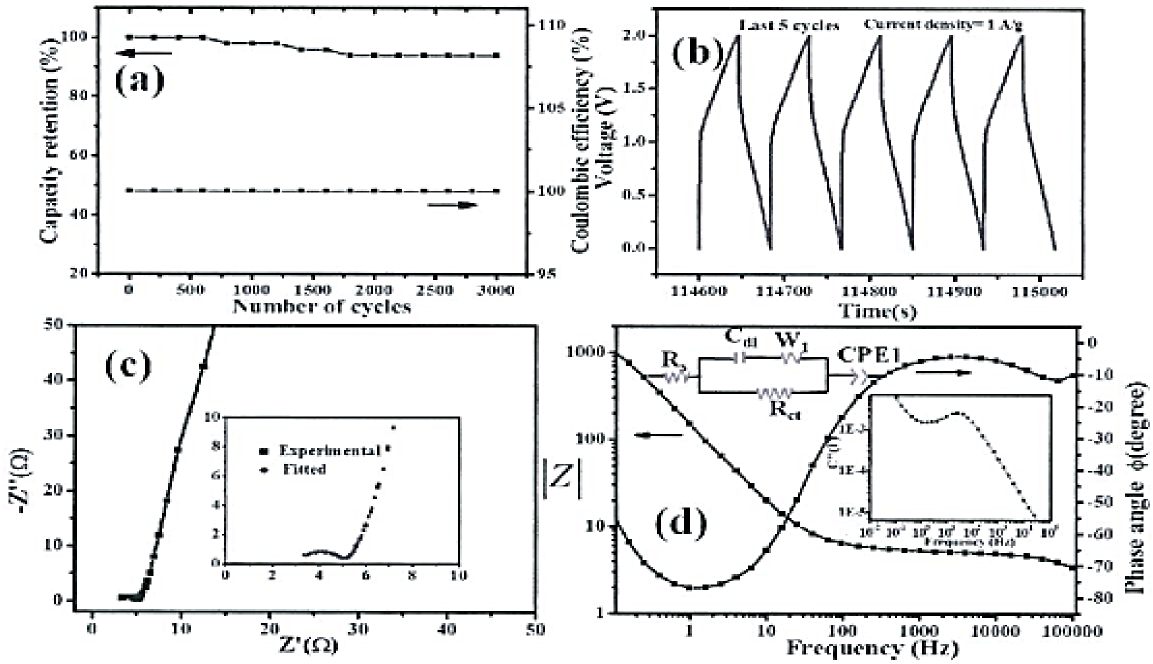

Fig. 7(a)-(b): Capacity retention and coulombic efficiency at 1 A/g. Fig. 7(c): Nyquist plot; Fig. 7(d): Bode plots for phase angle and impedance. Fig. 8(a): Schematic of the ASC prototype with a lit red LED.

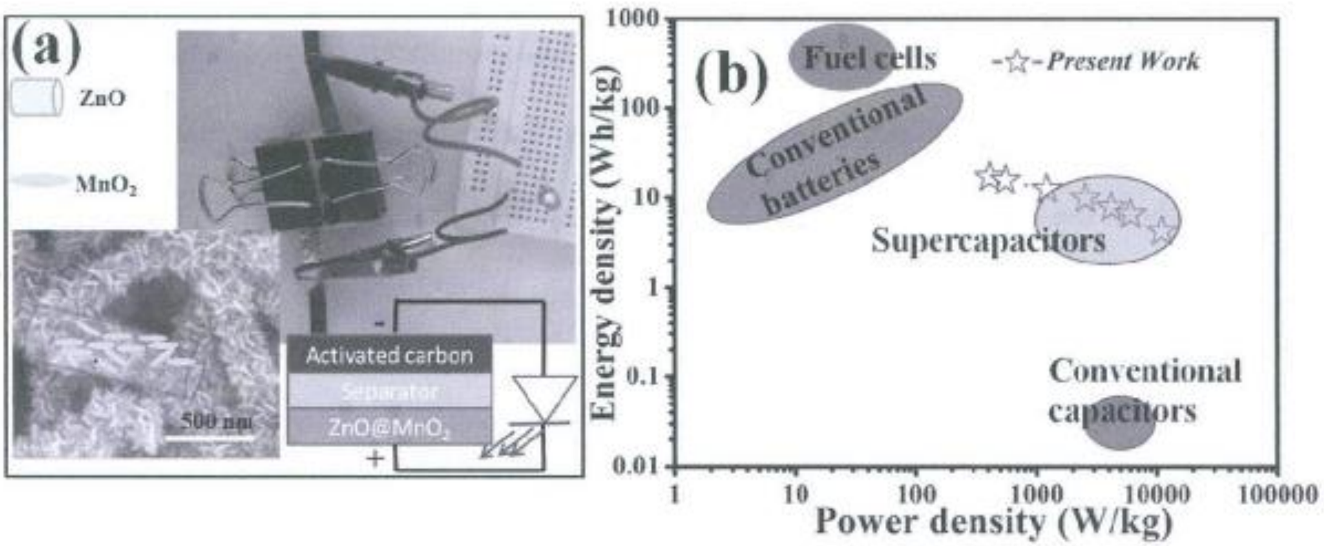

Fig. 8(b), a Ragone plot displays Power density vs. Energy density for ACIZnO@MnO2 asymmetric supercapacitor, positioning it alongside conventional capacitors, super capacitors, conventional batteries, and fuel cells.

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