IIT MADRAS
Indian Institute of Technology Madras
Technology Transfer Office
TTO – IPM Cell
Industrial Consultancy & Sponsored Research (IC&SR)

AN ELECTRODE ACTIVE MATERIAL FOR IMPROVING ELECTROCHEMICAL PERFORMANCE OF LITHIUM-ION BATTERIES

IITM Technology Available for Licensing

Problem Statement

- Existing LIBs face challenges in meeting the energy and power density requirements for advanced applications such as portable augmented reality systems and smart mobile robots, hindering the full utilization of microprocessors in these devices.
- **Sb2S3 is a promising next-generation anode material for LIBs** due to its high theoretical capacity, but it suffers from low rate capability and serious capacity loss during extended high current cycling.
- The invention aims to address the **performance limitations of Sb2S3 anodes by introducing aluminum substitution (Sb1.9Al0.1S3)** and specifically focusing on the alloying regime (1 V to 10 mV vs. Li/Li+) to achieve enhanced rate capability and cycling stability, making it a potential alternative anode for next-generation LIBs.

Intellectual Property

- IITM IDF Ref. **2380**
- **IN 202241039060**

Technology Category/ Market

Category- Advanced Lithium-Ion Battery Anodes with Aluminum Substitution
Applications - Smart Mobile Robots, Electric Vehicles, Energy Storage
Industry - Automotive and Electric Vehicles (EVs)

Market- India's lithium-ion battery size is estimated at USD 2.48 billion in 2023 and is expected to reach **USD 5.49 billion** by 2028, registering a **CAGR of 17.21%.**

Research Lab

Prof. Sudakar chandran
Dept. of Physics

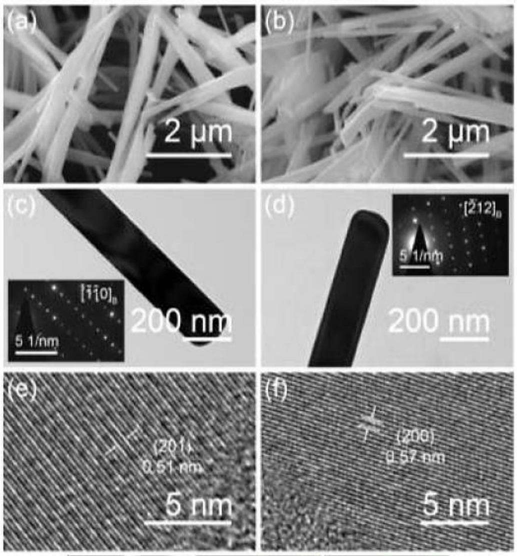

FIG.1. Depicts Scanning electron micrographs of (a) Sb2S3 and (b) Sb1.9Al0.1S3 revealing nanorod morphology of the anodes. Bright field transmission electron micrographs of (c) Sb2S3 and (d) Sb1.9Al0.1S3. Insets in (c) and (d) show the diffraction patterns acquired from the respective nanorods. High resolution transmission electron micrographs of representative Sb2S3 and Sb1.9Al0.1S3 nanorods are shown in panels (e) and (f), respectively.

Technology

Synthesis Methodology:

- The invention describes a hydrothermal synthesis method for producing nanorod-shaped antimony sulfide (Sb2S3) and its aluminum-substituted variant (Sb1.9Al0.1S3).
- The process involves dissolving SbCl3 and 3-MPA in ethanol, subjecting the solution to hydrothermal treatment at 180 °C, followed by annealing at 330 °C in argon ambient to obtain the desired nanorod structures.

Aluminum Substitution Strategy:

- The invention introduces an aluminum substitution strategy in which 5 at% aluminum is substituted for antimony in Sb2S3 to create Sb1.9Al0.1S3.
- This strategy enhances electrochemical performance, including high-rate capability (471.9 mAh/g at 10C) compared to pristine Sb2S3 (89.2 mAh/g at 10C), without altering the crystal structure or morphology.

CONTACT US
Dr. Dara Ajay, Head
Technology Transfer Office,
IPM Cell- IC&SR, IIT Madras

IITM TTO Website:
https://ipm.icsr.in/ipm/

Email: smipm-icsr@icsrpis.iitm.ac.in
sm-marketing@imail.iitm.ac.in
Phone: +91-44-2257 9756/ 9719

Technology Contd.

Optimized Cycling Regime:

- The invention emphasizes improved performance by cycling the aluminum-substituted Sb2S3 anode exclusively within the alloying regime.
- This strategy results in significantly better performance, with enhanced rate capability and cycling stability observed over 1000 cycles at 5C (4.7 A/g), addressing key challenges in the utilization of antimony trisulfide as an **anode material for lithium-ion batteries**.

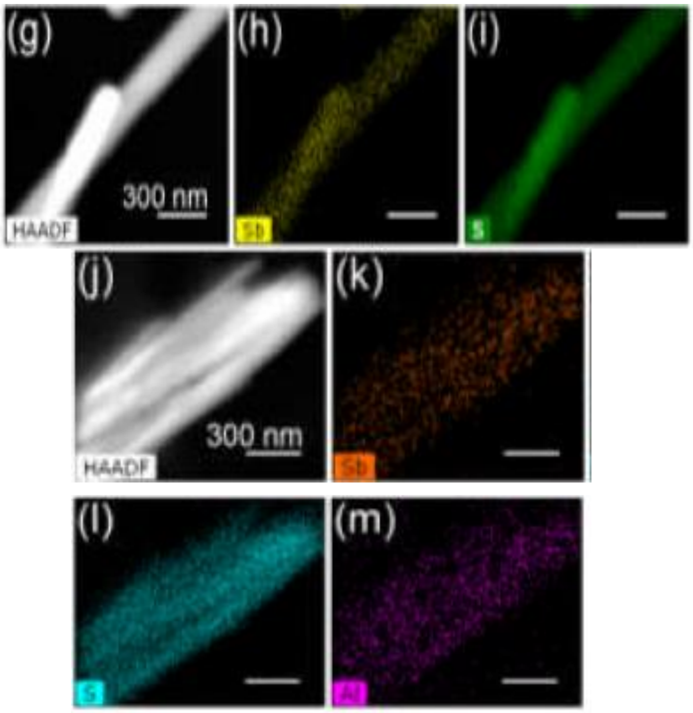

FIG.2. Depicts High angle annular dark field image of Sb2S3 is shown in (g) and element maps of Sb and S are shown in panels (h) and (k), respectively. High angle annular dark field image of Sb1.9Al0.1S3 is shown in (j) and element maps of Sb, S and Al are shown in panels (k), (l) and (m), respectively.

TRL (Technology Readiness Level)

TRL - 4: Technology validated in lab scale.

Key Features / Value Proposition

1. Performance Enhancement:
Aluminum-substituted Sb2S3 nanorods offer improved electrochemical performance, with high-rate capability and cycling stability, addressing key limitations in current lithium-ion battery anodes.

2. Synthesis Efficiency:
The hydrothermal synthesis method ensures the efficient production of nanorod-shaped Sb1.9Al0.1S3, providing a scalable and cost-effective manufacturing process.

3. Alloying Regime Optimization:
The innovation introduces a strategy focusing on cycling only within the alloying regime, enhancing the anode's performance and extending its lifespan over 1000 cycles at 5C.

4. Crystal Structure Integrity:
The aluminum substitution strategy maintains the crystal structure integrity of Sb2S3 nanorods, ensuring a stable and reliable electrode material for lithium-ion batteries.

5. High-Rate Capability:
Sb1.9Al0.1S3 exhibits a remarkable rate capability of 471.9 mAh/g at 10C, surpassing the performance of pristine Sb2S3, making it a compelling choice for high-power applications.

CONTACT US
Dr. Dara Ajay, Head
Technology Transfer Office,
IPM Cell- IC&SR, IIT Madras

IITM TTO Website: https://ipm.icsr.in/ipm/

Email: smipm-icsr@icsrpis.iitm.ac.in
sm-marketing@imail.iitm.ac.in
Phone: +91-44-2257 9756/ 9719