International Journal of Advance Research in Science and Engineering
Volume No. 14, Issue No. 05, May 2025
www.ijarse.com
IJARSE
ISSN 2319 - 8354

Bendable lithium-ion battery

Mr. Ritesh Pawar[1], Mr. Aditya Kharat[2], Mr. Mujjakir Attar[3],
Mr. Ajinkya Patil[4]

[1,2]Student Electrical Department, NMCOE Peth, India
[3]Assistant Professor Electrical Department, NMCOE Peth, India

ABSTRACT

The need for equally flexible energy storage systems has increased due to the quick development of flexible electronics. A bendable lithium-ion battery (LIB) built with flexible substrates and innovative electrode materials is developed and characterized in this work. Flexible current collectors and thin-film architecture are features of the battery design that allow for mechanical flexibility without sacrificing electrochemical performance. In order to preserve conductivity under stress, carbon-based materials and flexible binders were used to manufacture electrodes. Under repeated bending tests, the battery showed consistent cycle performance with little capacity reduction. This study offers a significant advancement in the development of fully flexible energy storage technologies by demonstrating the potential of bendable LIBs for incorporation into folding screens, wearable technology, and other flexible electronic systems of the future.

Key Words: *flexible electronic devices, flexible Li-ion batteries, nondestructive probe*

1. INTRODUCTION

The continuous miniaturization and evolution of electronic devices have caused a significant shift towards flexible, wearable, and portable technologies. Various applications, such as foldable smartphones, wearable health monitors, electronic skin, and implantable medical devices, necessitate flexible circuits and sensors, as well as adaptable power sources. Lithium-ion batteries, renowned for their high energy density, long cycle life, and low self-discharge rates, continue to dominate the energy storage market. Unfortunately, the traditional shapes of these devices—rigid and bulky—are not suitable for the dynamic movements required by advanced electronics. To address these limitations, scientists have created bendable lithium-ion batteries that offer both excellent electrochemical performance and structural flexibility. These batteries employ flexible substrates, flexible current collectors, and innovative electrode materials like carbon nanotubes, graphene, and flexible polymers. Cutting-edge manufacturing methods, such as 3D printing, laser patterning, and roll-to-roll processing, enable the production of batteries that can flex, contort, and stretch without compromising their energy delivery capabilities. The creation of bendable libs presents various obstacles, such as preserving ionic conductivity while the material is deformed, preventing capacity fade, and ensuring the material can withstand repeated bending and flexing without breaking.

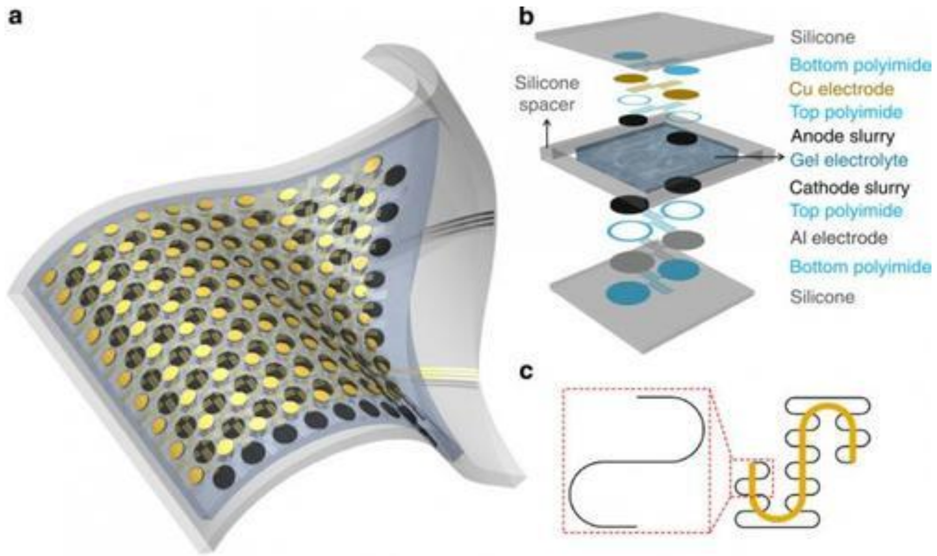
2. RELATED WORK

One of the main difficulties in building bendable libraries is the creation of adaptable electrodes. Traditional

International Journal of Advance Research in Science and Engineering
Volume No. 14, Issue No. 05, May 2025
www.ijarse.com
IJARSE
ISSN 2319 - 8354

electrode materials are usually rigid, and when they are bent or stretched, they can break or deteriorate. Scientists are investigating the potential of flexible conductive materials like carbon nanotubes, graphene, and conductive polymers as alternatives to conventional metal foils. These materials possess excellent conductivity and can flex or elongate without affecting their electrochemical capabilities [1]. Serpentine and origami designs enable battery components to bend without sustaining any harm. Fiber-shaped batteries: batteries that are formed into fibers can be incorporated into fabrics. Thin-film batteries: ultra-thin layers allow for flexibility and lightweight design, making them perfect for incorporating into compact devices.[2], Smart watches, fitness trackers, and medical patches are all examples of wearable devices. Smart textiles: garments equipped with embedded electronics, powered by integrated batteries. Flexible screens: mobile devices, e-ink, and roll able OLEDs.[3], Endurance of Mechanical Components: Preserving Functionality through Repeated Bending. Power density: reconciling adaptability with storage and voltage. Developing cost-effective, scalable manufacturing methods. [4], Samsung's advanced institute of technology successfully created flexible batteries that can be used in wearable devices. Stanford University conducted research on stretchable lithium-ion batteries by utilizing wavy electrode structures. Tsinghua University announced the development of high-performance fiber-shaped lithium-ion batteries using carbon nanotube yarn. [5]

3. METHODOLOGY



3.1. BENDABLE LITHIUM ION BATTERY

3.2. CONSTRUCTION (COMPONENTS)

1. Cathode: Coated with active materials such as lithium cobalt oxide ($LiCoO_2$) or lithium iron phosphate ($LiFePO_4$).
2. Anode: Made with materials like graphite or silicon nanowires, also coated on a flexible substrate. Battery - Stores electrical energy and supplies it to the motors via the motor controller. Used for long-term energy supply.
3. Electrolyte: Uses a solid-state or gel polymer electrolyte for flexibility and safety..
4. Separator: Thin, porous, and flexible polymer film placed between cathode and anode to prevent short-

circuits.

5. Encapsulation: Entire battery is sealed with a flexible, waterproof, and insulating polymer layer.
6. Assembly Method: Layered through vacuum filtration, screen printing, or roll-to-roll processing for scalability.
7. Current Collectors: Often made from flexible metals (like copper or aluminum foils) or conductive nanomaterial films.

3.3. WORKING

Bendable lithium-ion battery paper is a flexible, lightweight energy storage device that functions similarly to conventional lithium-ion batteries but is engineered to withstand mechanical deformation such as bending, folding, or rolling. The core structure of this battery includes a flexible substrate, typically made from Nan cellulose paper, carbon nanotube films, or graphene-coated polymers. These materials are selected for their durability, weight, and ability to conduct electricity. This flexible base serves as the foundation for the battery's electrodes, which are made using cutting-edge nanomaterials. The anode, which stores lithium ions during charging, may be made from graphene, carbon nanotubes, or silicon-carbon composites, while the cathode, which releases lithium ions, often uses materials like lithium cobalt oxide ($licoo_2$) or lithium iron phosphate ($lifepo_4$), both coated onto flexible conductors.

To facilitate the movement of ions between the electrodes while preserving flexibility, a gel polymer or solid-state electrolyte is employed instead of conventional liquid electrolytes. These electrolytes possess the unique ability to flex without rupturing or leaking, and they are commonly incorporated into a polymer matrix to create a durable and conductive gel. Flexible current collectors, constructed from materials like silver nanowires or copper-coated polymers, are incorporated into the battery to ensure efficient electron transport even when the battery bends. During the charging process, lithium ions move from the cathode to the anode via the electrolyte, while electrons travel through an external circuit, accumulating energy in the process. During the discharge phase, the lithium ions migrate back to the cathode, while electrons flow through the circuit to provide power to a connected device. The entire system is engineered to maintain its electrochemical functionality even when subjected to bending or deformation, making it suitable for various applications in wearable electronics, smart textiles, flexible displays, and medical sensors. This breakthrough allows for the development of highly adaptable and mobile power sources for future devices**.**

4. FUTURE SCOPE

1 Wearable electronics are particularly suitable for smart watches, fitness bands, and health monitoring devices because of their flexibility and lightweight design.

2: Flexible smartphones and tablets: can be seamlessly integrated into foldable or roll able screens, revolutionizing the design and portability of future mobile devices.

3: Smart textiles: allow for the storage of energy directly in clothing, enabling the operation of embedded sensors or electronics without the need for rigid components.

4: Medical devices: highly beneficial for implantable or skin-mounted devices where flexibility and biocompatibility are of utmost importance.

5: Iot devices: provide support for adaptable and compact power sources in sensors and nodes deployed in diverse environments.
6: Robotics: the incorporation of soft robots or flexible actuators to deliver localized power without the need for rigid structures.
7: Aerospace and military applications: compact and wearable power solutions for lightweight equipment.
8: Sustainable and compact energy storage has the potential to enhance recycling efforts, decrease the amount of materials required, and develop thinner, more efficient energy systems.
9: Innovative packaging and industrial design: enables the creation of new industrial designs that are not constrained by traditional battery form factors.
10: Integration with renewable energy systems: can be seamlessly integrated into unconventional surfaces such as solar fabrics or flexible panels.

5. CONCLUSION

Banded lithium-ion batteries signify a major breakthrough in battery technology, providing improved safety, efficiency, and durability. By implementing structural reinforcements or layered configurations (known as "banding"), these batteries can effectively handle thermal conditions, minimize the chances of swelling or short-circuiting, and preserve their structural integrity even after multiple charging cycles. As the need for energy storage increases in various sectors, such as consumer electronics and electric vehicles, banded lithium-ion batteries offer a promising solution to meet performance and safety requirements. Ongoing research and development are crucialenhance their design, affordability, and scalability for widespread adoption.

REFERANCES

[1] Arwa t .kutbee1 , Mohaned t. ghoneim2 , “Free from flexible lithium ion microbattery”(2015).
[2] Arwa T. Kutbee1 , Mohamed T. Ghoneim2 , “Flexible lithium ion planer thin film battery”(2015).
[3] Giegerich M. Akdere1 , C. Freund2 , “ Open , flexible and extensible battery management system for lithium ion batteries in mobile and stationary applications” (2016).
[4] Yifan Zhao1 , Juchen Guo2 , “Development of flexible lithium iom batteries for flexible electronics”(2020).