GREPOW SHAPED BATTERY, SHAPE THE FUTURE

Grepow · Empowering Future Wearables

SMART RING BATTERY

(A White Paper on the Smart Ring Curved Battery Technology Industry)

SMART RING BATTERY

Abstract

As the market for miniaturized wearables expands, the smart ring has become a key focus. Its unique form factor, however, presents significant challenges for internal components, particularly battery design, performance, and safety. This creates core user issues like battery anxiety, poor comfort, and unreliable long-term performance. This white paper details how our proprietary, patented E-stacking process for curved batteries overcomes these bottlenecks. By providing industry-leading energy density, cycle life, and material innovation, our technology offers a mature power solution ready for the next generation of smart rings.

IMAGE FROM THE WEB, FOR REFERENCE ONLY.

CHAPTER 1

Market Opportunities and Core Technical Bottlenecks

1.1 Definition and Market Outlook of Smart Rings

A Smart Ring is a miniature wearable device worn on the finger, integrating sensors, processing units, and wireless communication modules. Its purpose is to deliver functions such as health monitoring (heart rate, SpO_2, temperature, sleep quality), notifications, mobile payment, and smart home control in the most seamless and convenient way. Thanks to its high portability and fashion appeal, the smart ring market is experiencing explosive growth. According to industry analysts, the global smart ring market is expected to grow from hundreds of millions of USD in 2023 to several billion USD by 2030, with a CAGR exceeding 25%. This rapid growth is driven by consumer demand for more convenient, long-lasting health-tracking solutions.

1.2 Battery Technology: The Core Bottleneck of Product Success

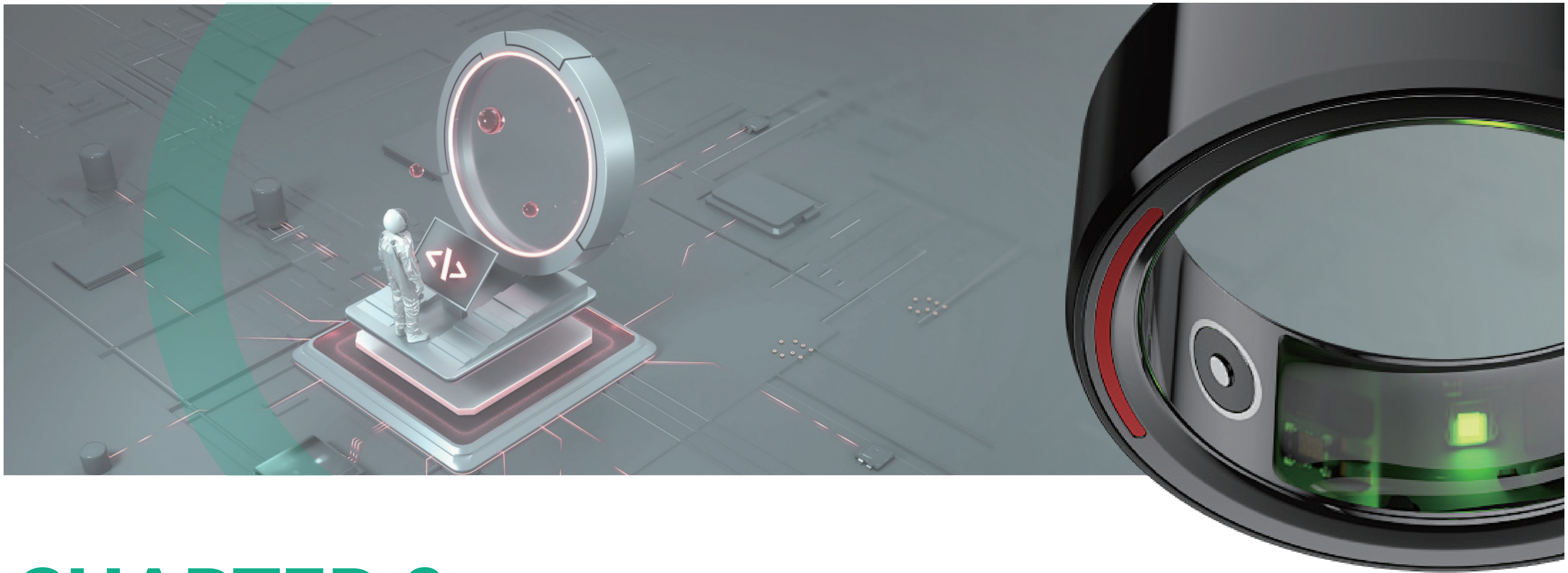
Traditional winding process batteries struggle to perfectly adapt to curved structures, often leading to wasted space, unstable performance, and even safety hazards. This is the key industry challenge to be solved.

Although the market prospects are broad, the success of a smart ring largely depends on the user experience, and battery technology is the cornerstone that determines this experience. Its main bottlenecks are:

Challenge of extreme space limitations: The ring's shape requires the battery to achieve the highest possible energy density within an extremely limited curved space.

Conflict between performance and battery life: Users expect long battery life, but the capacity of small batteries is naturally limited, while high-frequency data monitoring consumes a great deal of power.

The non-negotiable requirements for safety and reliability: As a device worn 24/7 against the skin, the battery must ensure uncompromised safety and stability in all environments.



CHAPTER 2

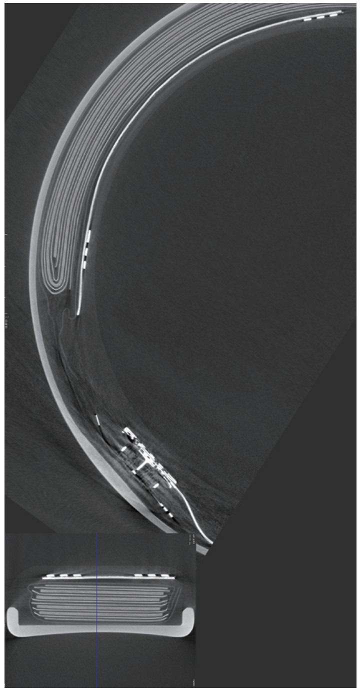
Technological Cornerstone - Three Patented Innovations Creating a Key Competitive Moat

Through systematic innovation in battery manufacturing processes, structure, and design, we have built a strong patent moat that fundamentally resolves market challenges.

2.1 Process Innovation: The Fundamental Advantages of the E-stacking Process

The curved structure of a smart ring poses a fundamental challenge to the battery manufacturing process. The traditional "winding process" commonly used in the industry has shown its inherent limitations. Our core competency stems from a disruptive innovation in the manufacturing process—the E-stacking process.

Limitations of the Winding Process VS Advantages of the E-stacking Process



Winding Curved Battery Structure Diagram

WINDING PROCESS

Similar to rolling sushi, materials like the positive/negative electrodes, and separator are layered and then wound into shape.

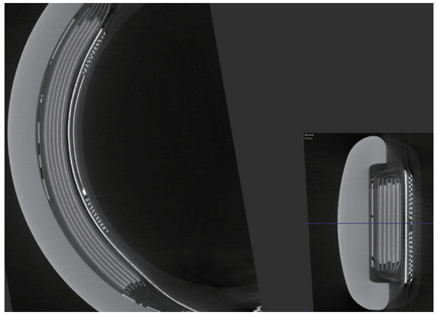
Technical Bottlenecks

- **Internal stress and deformation:**
  When forcibly bent into an arc, a winding cell experiences significant stress differences between its inner and outer sides. The inner layer is compressed, and the outer layer is stretched. This not only causes the electrode material coating to peel off but also leads to poor contact at the battery's internal interfaces, thereby increasing internal resistance and reducing cycle life. The "folding at the tail of the stacked body" phenomenon observed in competitors' products is a manifestation of this stress concentration.
- **Low space utilization:**
  The winding process inevitably creates “dead zones” at both ends of the arc, which are spaces that cannot be effectively filled with active material, leading to a reduction in energy density.
- **Poor consistency:**
  At a miniature scale, controlling the tension during winding is extremely difficult, and the alignment accuracy of the electrode plates is low. This results in significant variations in capacity and internal resistance among finished batteries, leading to poor consistency.

Limitations of the Winding Process VS Advantages of the E-stacking Process

(E-STACKING PROCESS

In this process, alternating layers of electrodes and separators are stacked—similar to a deck of cards—and then hot-pressed into a single form.)



Stacked Curved Battery Structure Diagram

Hot-Pressing Curved Battery Process

Technical Rationale and Application Value

- **Stress-free forming, more stable structure:**
  Our core invention patent (Patent No. 2013102115950) details this method. By stacking first and hot-pressing second, each electrode layer conforms naturally to the required arc. This creates a uniform internal structure with tight electrode adhesion, avoiding mechanical stress and resulting in superior electrochemical performance and extended cycle life (>500 cycles).
- **Native arc formation for higher safety:**
  Our core process involves hot-pressing the cell to form it into an integrated arc after stacking but before formation (i.e., the first activation charge). This native arc formation ensures the integrity and consistency of the internal separator and electrode structures, fundamentally eliminating the risk of internal micro-shorts that could be caused by subsequent bending, thereby greatly enhancing the product's long-term reliability and safety.
- **Optimal space utilization for higher energy density:**
  The E-stacking process enables the cell to precisely fit the curved casing of a smart ring, with minimal wasted space. Combined with high-energy silicon-carbon anode materials, this design delivers higher capacity within the same volume—for example, 21 mAh in the same size where competitors achieve only 16 mAh—directly addressing battery life concerns.
- **Higher product yield:**
  This process reduces cosmetic defect rates to below 3%, ensuring consistency and quality in large-scale production.

2.2 Structural Innovation: Enabling Ultimate Miniaturized Design

Additionally, we hold the "Battery (Curved - Dual-Tab)" design patent (Patent No.: 2023308255884). Through innovative designs like dual tabs, we further optimize the battery's spatial layout and connection reliability within the ring.

2023308255884

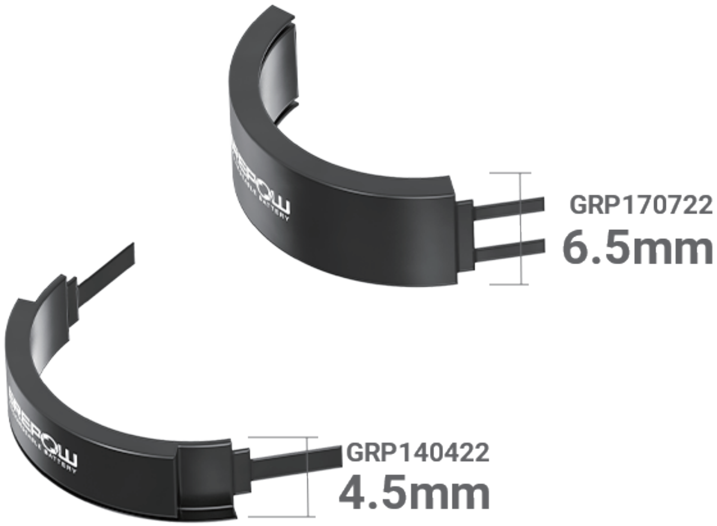
2018200140227

We have broken through the manufacturing limits of micro-batteries with our utility model patent (Patent No.: 2018200140227) ”Separator Pouch Tape for Stacked Lithium-Ion Batteries”.

Technical Rationale:

This patented technology ensures precise alignment and structural stability of the stacked electrode plates, even at extremely narrow widths.

Application Value: This technology enables greater flexibility in industrial design for smart rings. We can manufacture batteries as thin as 1.0mm (typically 2mm) and as narrow as 4.1mm (typically 6mm). This allows the end product to be thinner and more ergonomic, thereby improving wearing comfort and aesthetic appeal, and broadening the product's target audience.



2.3 Safety Innovation: Reliability by Design

For smart rings worn 24/7, battery safety is paramount. Grepow's design philosophy ensures safety through a dual approach of fundamental electrochemical principles and rigorous inspection protocols, rather than relying solely on passive protection circuits.

(The Rationale and Safety Value of Comprehensive Inspection)

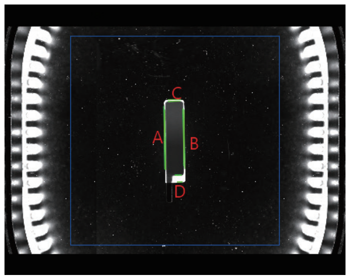
The safety of our batteries stems from stringent process controls and precise, comprehensive inspection at every stage.

100% X-Ray Inspection to Verify Internal Structure

We have integrated 100% X-Ray inspection into our design and manufacturing phases. This process examines each layer of the battery stack to ensure the precise alignment of the "Overhang" (where the anode electrode edge extends beyond the cathode). This allows us to identify and correct any stacking deviations at the source, preventing potential safety hazards. All finished cells are also X-rayed to confirm their internal structural integrity and rule out latent defects.

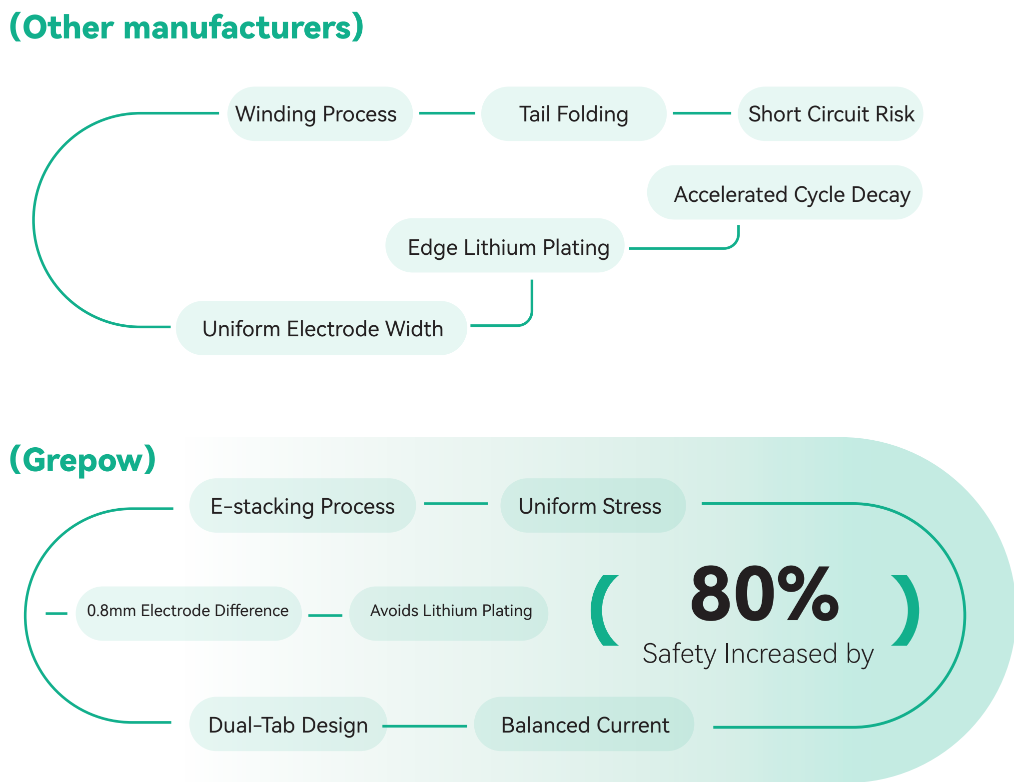
High-Precision CCD Inspection of Electrode Plates

During electrode manufacturing, we employ high-precision CCD (Charge-Coupled Device) positioning to conduct a 100% inspection of every plate's dimensions and alignment. Unlike conventional sample testing, this all-encompassing inspection method significantly enhances process stability and consistency, ensuring that each electrode plate conforms to our strict design specifications.



OK

Dimension A: 0.243
Dimension B: 0.256
Dimension C: 0.452
Dimension D: 1.839
Separator Area: 80882



Application Value:

This combination of precise Overhang control, 100% X-Ray inspection, and 100% CCD plate inspection minimizes the potential for lithium dendrite formation, ensuring stable battery performance over long-term cycling. For devices like smart rings, which are worn continuously against the skin, this translates to superior safety, a longer lifespan with stable capacity, and a significant enhancement of user trust and brand reputation.

2.4 Material Innovation: A Breakthrough in Energy Density

To meet the demands of wearables for ultra-thin designs and extended endurance, we have made significant innovations in our core material systems, focusing specifically on the application and optimization of silicon anodes.

(Core Technology: Customized Silicon-Carbon Anode Formulations)

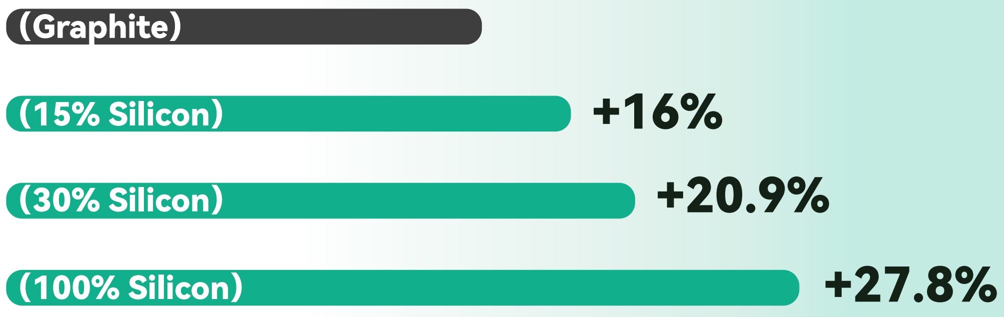
Our anode R&D has produced a range of customized formulations—including those with 15% and 30% silicon content, as well as pure silicon-carbon—to meet diverse product performance requirements. Compared to traditional graphite, our silicon-carbon systems offer superior capacity and volumetric energy density. Our innovative 100% silicon-carbon anode, in particular, has achieved breakthrough results:

Capacity: A 27.8% increase over traditional graphite anodes
Volumetric Energy Density: A 17.2% increase, a critical metric for miniaturized devices.

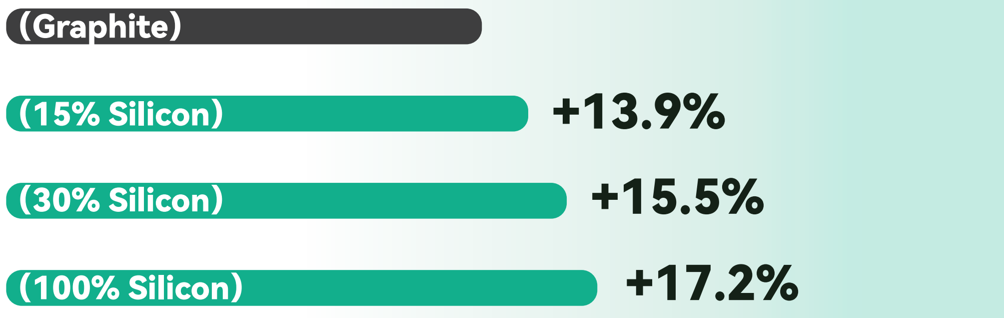
Application Value:

By incorporating silicon-carbon anodes, our batteries store more energy within the same volume, significantly extending device endurance while maintaining stable output under high-rate charging and long-term cycling. For miniature wearables like smart rings, this translates directly to longer usage times and robust performance within a constrained space, dramatically enhancing both the user experience and the product's competitive edge.

Capacity Gain by Silicon Content in Anodes



Volumetric Energy Density Gain by Silicon Content in Anodes



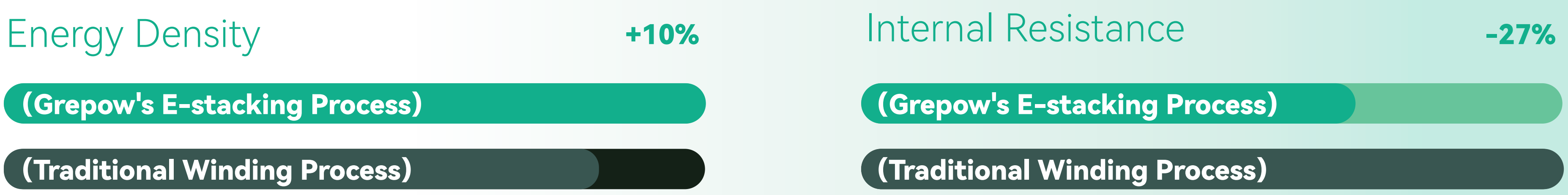
CHAPTER 3

Performance Verification – Data-Driven Comprehensive Advantages

Superior processes and designs are ultimately reflected in comprehensive leadership across key performance indicators. The comparative test data between our GRP1607026 curved battery and that of competitors intuitively proves this point.

3.1 Higher Energy Efficiency, Longer Effective Battery Life

E-stacking vs. Winding: Energy Density & Internal Resistance



Why is the E-stacking Process Superior?

Technical Rationale:

The E-stacking process results in a more uniform and tightly packed electrode stack. This minimizes inconsistencies in ion migration pathways and mitigates issues of localized current concentration. The outcome is lower internal resistance and a higher active material utilization rate, which directly translates to enhanced energy density and efficiency.

Application Value:

For devices like smart rings, which are constrained by volume and feature power-intensive functions, our E-stacking process batteries deliver a significant improvement in endurance. The higher energy density allows a battery of the same physical size to provide longer-lasting power. Furthermore, the lower internal resistance ensures stable power delivery during high-drain activities such as GPS use and continuous heart rate monitoring. As a result, users benefit from extended usage periods and reduced charging frequency, leading to a substantially improved overall experience and greater product trust.

3.2 Broader Temperature Adaptability, More Reliable All-Weather Wear

Why is our Temperature Adaptability Stronger?

Technical Rationale:

At −20℃, increased electrolyte viscosity hinders ion transport, causing battery performance to drop sharply. Our optimized electrolyte formulation and stable internal structure preserve clear ion pathways, maintaining higher discharge efficiency even in extreme cold. At 60℃, stable electrode–electrolyte interfaces suppress side reactions, likewise ensuring efficient discharge under high-temperature conditions.

Application Value:

This means that whether the user is skiing in winter or engaging in outdoor sports in summer, the smart ring can work stably, providing uninterrupted health data monitoring and interactive functions. This forms the core of the product's all-weather reliability.

+7.0%

Low-Temp Performance
(-20℃, 0.2C)

+2.3%

High-Temp Performance
(60℃, 0.5C)

Low-Temperature Performance (-20℃)

69.4% (Grepow)

62.4% (Other manufacturers)

High-Temperature Performance (60℃)

97.3% (Grepow)

95.0% (Other manufacturers)

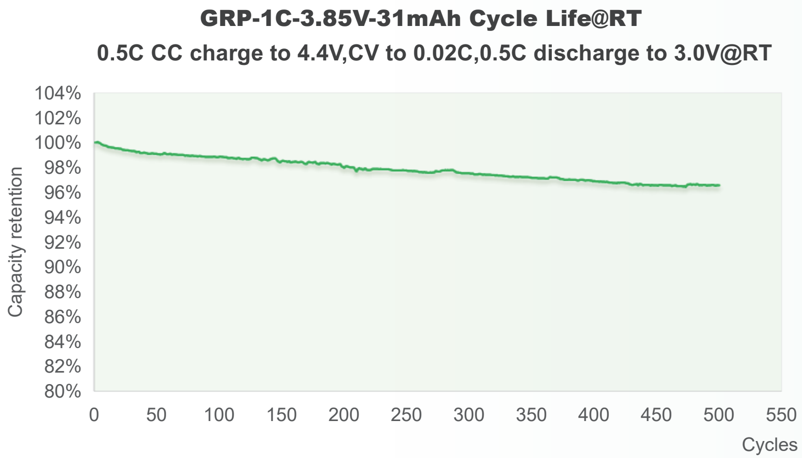
3.3 More Outstanding Cycle Life, Longer Product Lifespan

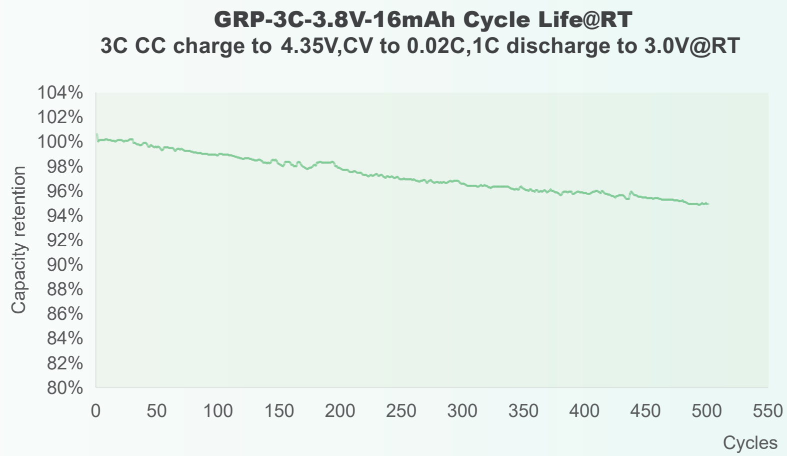
High Voltage （4.4V）：
After 500 cycles of 0.5C charge/discharge, the capacity retention rate is as high as

96%

High-Voltage Fast Charging （4.35V）：
After 500 cycles of 3C charging / 1C discharging, the capacity retention rate can still reach

95%





Technical Rationale:

Battery life decay is essentially the loss of active materials and the destruction of the internal structure. Through a stable stacking structure, a safe negative electrode Overhang design, and advanced silicon-carbon anode and high-voltage systems, we have jointly built an extremely robust electrochemical system. This allows our batteries to retain 95% to 96% of their capacity even after 500 deep charge-discharge cycles. In particular, under the stringent test of 3C charging/1C discharging, our fast-charging batteries still have a capacity retention rate as high as 94%-95% after 500 cycles.

Application Value:

500 cycles typically represent nearly two years of normal use. A high capacity retention rate promises long-term value to the end-user, meaning that even after two years of use, the smart ring's battery performance will not experience a steep decline. This is directly related to long-term user satisfaction and repeat purchase intention.

CHAPTER 4

Future Outlook – Leading the Next Generation of Smart Ring Battery Technology

As an industry leader, we are not only focused on the present but also looking to the future, committed to defining the power core of the next generation of smart rings through continuous technological breakthroughs.

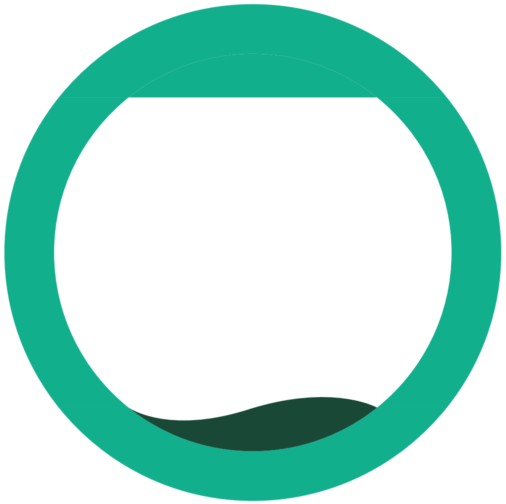
GREPOW: Defining the Power Core of Next-Generation Smart Rings

4.1 Further Breakthroughs in Energy Density

We will continue to deepen our R&D in cutting-edge fields like silicon anode materials and explore new material systems with higher specific capacity. Our goal is to increase battery capacity by another **20%-30%** within the existing size, achieving the ultimate user experience of "**charge once, use for a week**."

4.2 A Revolution in the Charging Experience

While ensuring high energy density and long life, we will focus on increasing charging speed. By optimizing electrode kinetics and electrolyte formulas, our goal is to achieve super-fast charging technology that allows for "**a day of power in five minutes**," completely eliminating users' battery anxiety.



4.3 The Ultimate Exploration of Form and Integration

Future smart wearables will be more seamlessly integrated with the human body. We are conducting preliminary research on fully flexible batteries and even biocompatible battery technologies, exploring the possibility of integrating the battery and the ring structure into a single piece to provide the ultimate **power solution** for future lighter, softer, and smarter wearable devices.

CONCLUSION

The wave of smart rings has arrived, and battery technology is the key to determining whether a brand can ride this wave in the blue ocean market. With our unique E-stacking process, systematic patent portfolio, superior product performance, and forward-looking future plans, our company has established an unshakeable leadership position in this field. Our batteries are not just components; they are core enablers for smart ring products to achieve longer battery life, more beautiful designs, higher safety, and stronger reliability. We have already gained widespread application and market validation from leading smart ring brands and look forward to collaborating with more industry pioneers to jointly define and lead the bright future of smart rings.

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