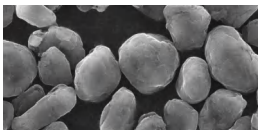
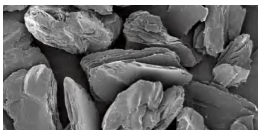
IEST®
元 能 科 技

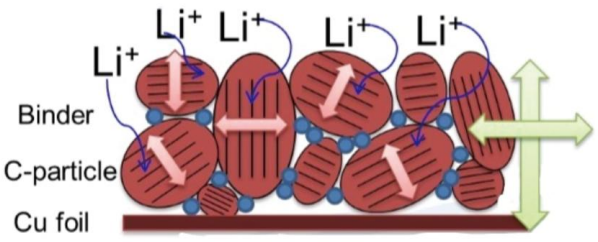
IN-SITU CELL SWELLING ANALYZER


–Dedicated to lithium-ion battery testing and development–

Swelling Behavior of The Lithium Ion Battery(LIB)

During the charging and discharging process of lithium-ion batteries(LIBs) as lithium ions are intercalated or deintercalated into the electrodes, the LIBs will expand and contract;Ideally,the intercalation and deintercalation of lithium ions are reversible,but in the actual cycle proces, there is always a part of lithium ions that cannot be extracted from the electrodes or deposits on the surface of the anode as an insoluble by-product during the cycle, resulting in irreversible swelling of



or other more serious consequences, such as the deformation of the LIBs, the fragmentation of material particles, the rupture of the solid electrolyte interphase(SEI), and the consumption of electrolyte. Thus, the swelling behavior of the LIB becoms an impotant indicator for evaluating the reliability of the battery. During the production process, the particle size, binder and must be optimized in advance.

For the next generation anode materials with higher energy density such as silicon and lithium metal the swelling ratios of these materials are much greater than that of the graphite anode. Therefore, how to accurately and effectively evaluate the swelling behavior of the LIBs made by these new anode materials becomes more important,which can guide the design of the LIB pack and improve the space utilization under the premise of safety.

On the other hand, the lithium plating also can cause the expansion of LIBs. Thus, how to identify the lithium plating window under different charging rate and temperature by the expansion behavior of LIBs is very helpful for the developments of the fast charging technology, sectional charging technology and other charging strategies.

Traditional Methods for Swelling Evaluation

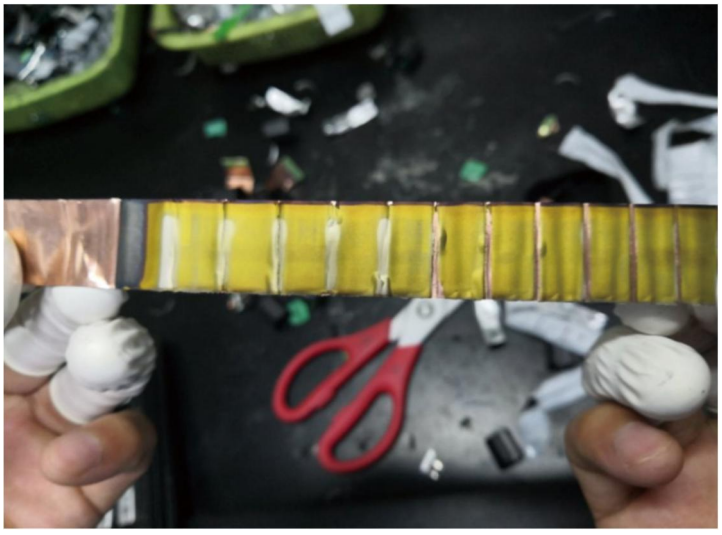
Disassemble the LIBs with different conditions and measure the thickness of the cell or the electrodes by micrometer;

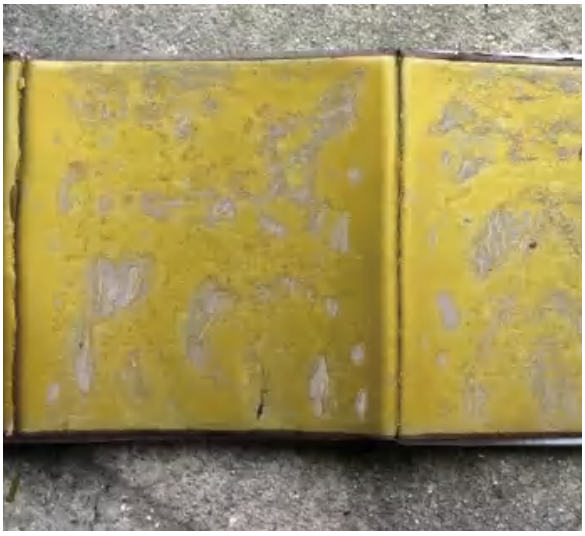
Li plating window Judgment:Disassemble the full-charged cell and judge whe1ther there exists lithium plating phenomenon on the surface of the anode electrode by visual inspection;

Destructive Test: Waste cells and exist higher safety risk and higher operation cost due to the requirements of the dry environment and professional operators;

Ex-situ Test: Only the thickness data on several specific states can be acquirted, and the swelling behavior of LIBs cannot be described systemically;

Big Deviation for Li plating window assessment: Not every lithium plating SOC and poterntial in different charing rate can be quantified.



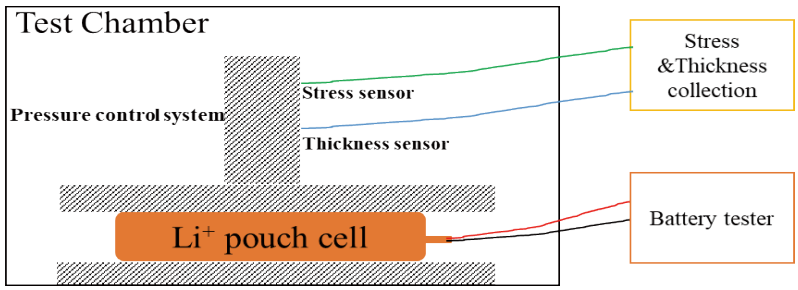


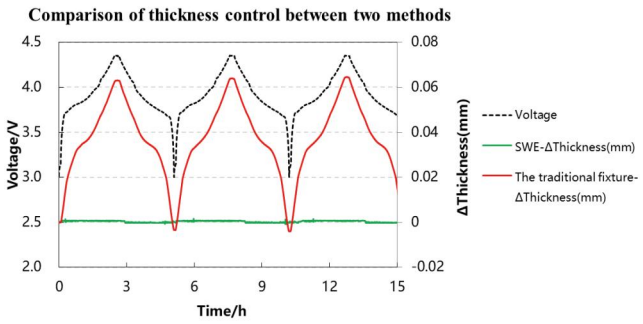
Swelling Behavior of The Lithium Ion Battery(LIB)

IN situ swelling analysis system: Combined with the highly stable automatic platform and the high-precision thickness and mechanical sensors, it can achieve long-term stability and accurately detect the expansion thickness and the expansion force under different conditions.

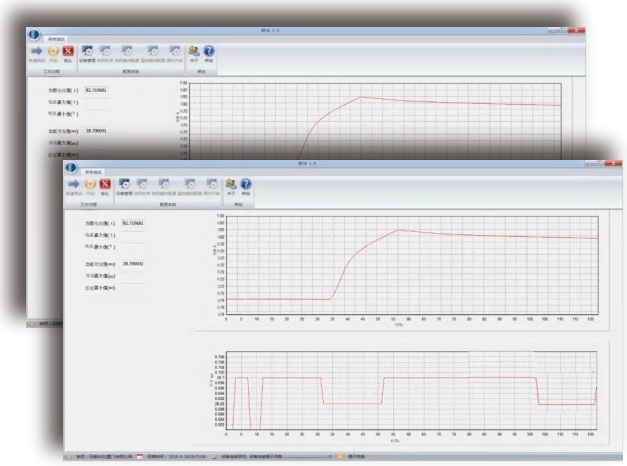
Multi-function test modes: the constant pressure and constant gap test modes can be realized for the cell, and the performance of the cell under different stress conditions can be evaluated.

High precision control : The traditional fixture will generate ~70um deformation under the constant gap testing mode, which leads to the inaccurate swelling force test. However, the in-situ SWE analysis system of IEST can control the change of the gap within ~1um by active modulation, and record the accurate swelling force during the constant gap testing mode.

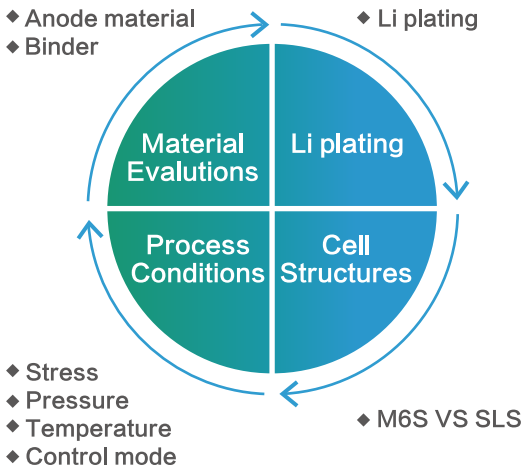




SOFTWARE



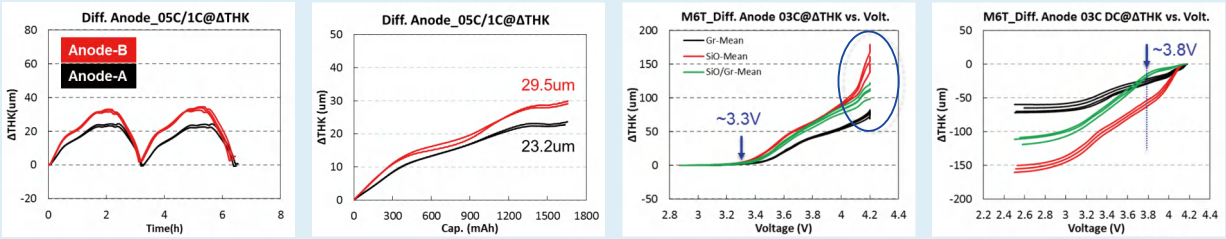
APPLICATIONS



★Developed with CATL the top power battery company and Authorized exclusively for the patent.

APPLICATION CASES– MATERIAL EVALUTIONS

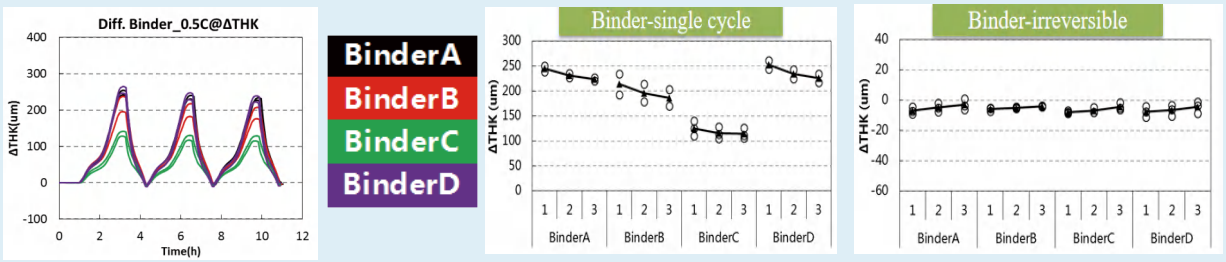
1. Swelling behavior analysis of different anode materials



Two types of anode material batteries with the same design and capacity, of which the full charge swelling and irreversible swelling thickness of B are significantly greater than that of A, which can be used to screen and evaluate battery anode materials with swelling requirements;

The swelling difference of three LIBs made by different anonde materials can be used to study the swelling mechanism of anode materials during charge and discharge.

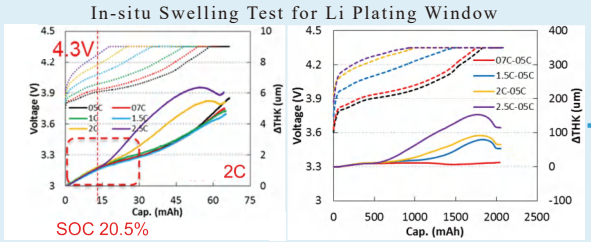
2. Swelling behavior analysis of different binder



Comparison of the swelling behaviors of four LIBs made by different binders, the level of irreversible swelling is the same,and the main difference lies in the single-cycle swelling thickness,
In which the binder-C has the best swelling suppression effect, Thus, it can be used for evaluating And screening different binder materials.

LI PLATING ANALYZE

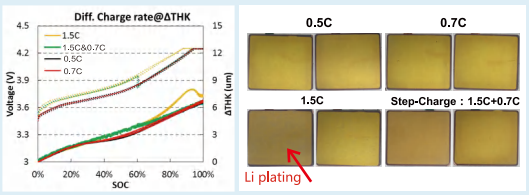
1. Non-destructive Li plating window judgment



Rate	Thickness (um)	Capacity (mAh)	Voltage (V)
07C	3061.75	/	/
1.5C	3045.86	1189.22	4.283
2C	3048.60	924.15	4.285
2.5C	3048.85	543.82	4.286

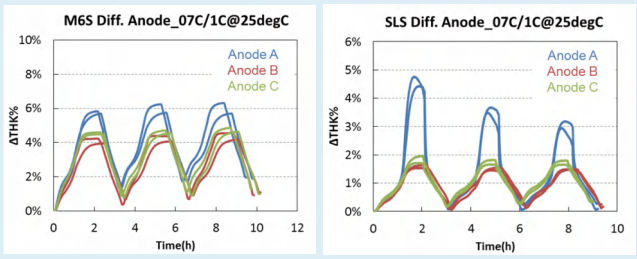
Compared with normal Li-intercalation curve, the swelling curves with Li-plating will deviate the normal curve when reaching the Li-plating voltage, accordingly the accurate Li-plating rate, voltage and SOC window will be acquired.

2. Application of step charge



Quantitate the Li-plating voltage and Li-plating SOC window under a certain Li-plating rate, guide the echelon fast charging technology effectively, and realize the safe fast charging through the moderate charging strategies.

APPLICATION OF CELL STRUCTURE

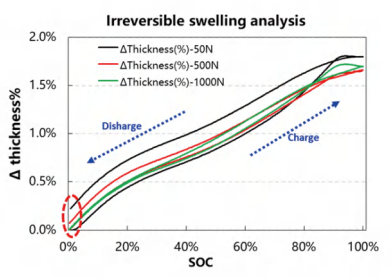


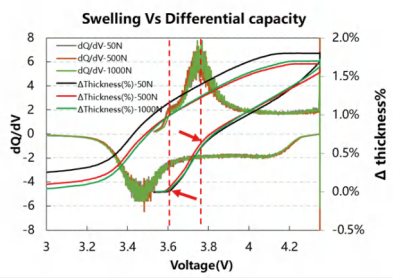
- Two models are used to evaluate the swelling of different anode cells, and the comparison result is almost the same, which is A > C > B
- Because the two sides of the rolled cell are bound, the expansion stress will accumulate to the middle of the cell, which causes the increase of the thickness during the cycling. However, the four sides of the stacked cell are not restricted, so the expansion stress could be released during the cycling (Single-sided anode).
- In-situ Swelling data can be used to deeply analyze the influence of the cell structure on stress and strain.

PROCESS CONDITIONS

1. Different pressure conditions

- NCM523/graphite battery (3446106, theoretical capacity 2400mAh)
- Different constant pressure conditions (50N/500N/1000N)

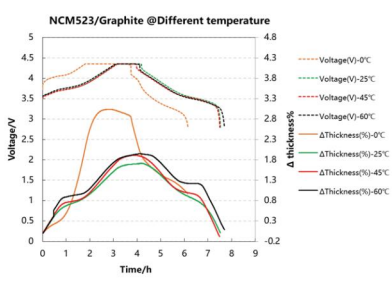


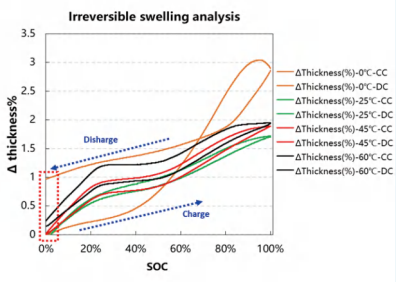


- Properly increasing the pressure can reduce the irreversible swelling ratio of the battery;
- During the charging process, the two inflection points of the swelling curve correspond to the two peaks of the differential capacity curve, indicating that the swelling of the battery is related to the phase transition of deintercalation of lithium.

2. Different temperature conditions

- NCM523/graphite battery (3446106, theoretical capacity 2400mAh)
- Different temperature conditions (0℃，25℃，45℃，60℃)

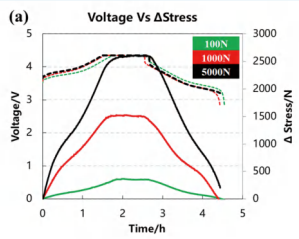


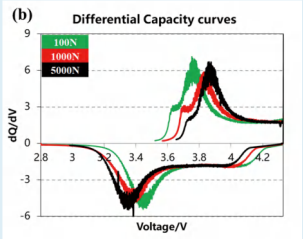


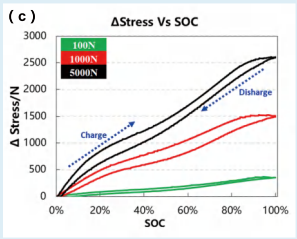
No matter the temperature rises from room temperature (25℃) up to 45℃ and 60℃, or drops to 0℃, the irreversible swelling of the cell increases. However, the causes of irreversible swelling may be different under high temperature and low temperature conditions

3. Different stress conditions

- NCM523/graphite battery (3446106, theoretical capacity 2400mAh)



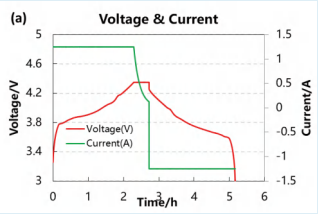


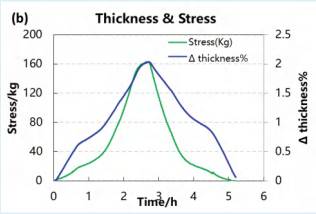


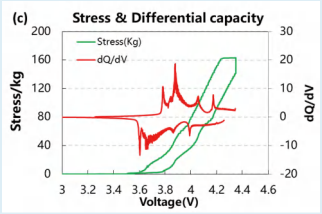
In the range of 5000N, with the increase of the pre-load, the swelling stress of the cell increases gradually, which leads to the increase of the polarization of the cell and the deterioration of the dynamic performance. Therefore, we must pay attention to the influence of the initial pressure When designing cell packing.

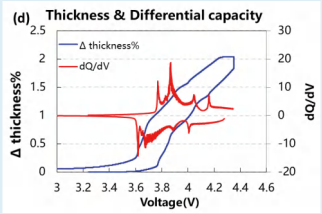
4. Thickness and stress changing during charge–discharge

- LCO/graphite battery (theoretical capacity 2500mAh)
- Test under constant pressure and constant gap mode









In-situ swelling analyzer(SWE)was used to monitor the changes of swelling thickness and swelling force of the pouch cell in constant pressure and constant gap modes. It wan found that the curves of swelling thickness and swelling force were both related to the structural phase transition during charge-discharge process. This in-situ analysis method can be used by researchers to analyze the swelling behavior of cells with different systems and production process, so as to design cells with better perfomance.

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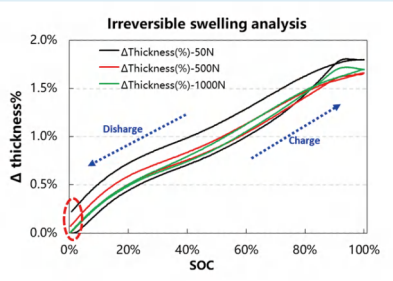

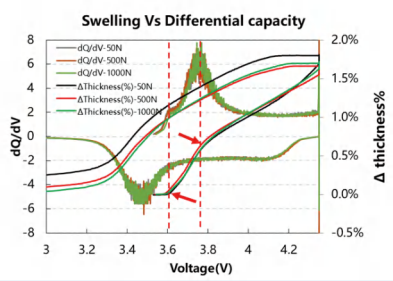

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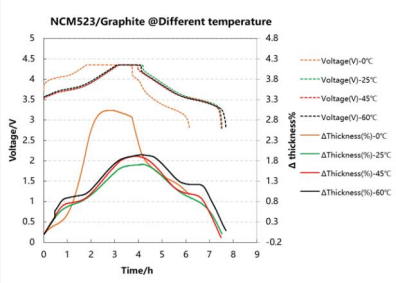

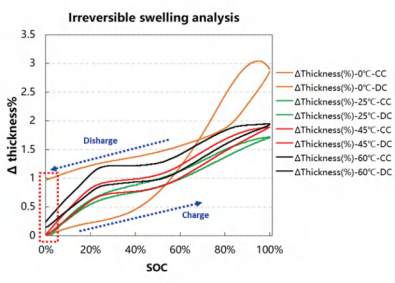

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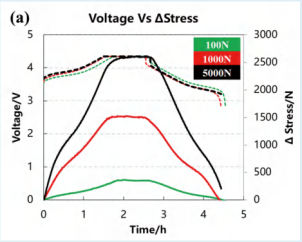

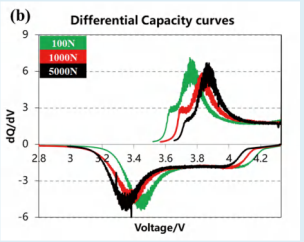

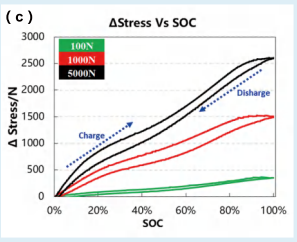

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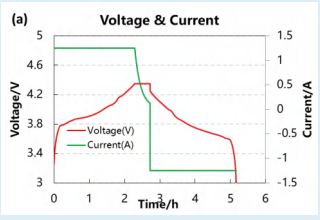

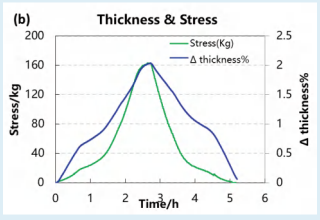

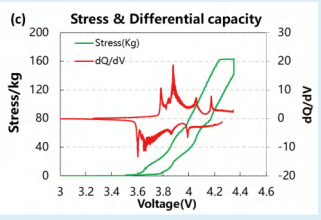

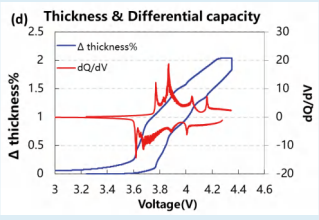

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PARAMETER AND INSTALLATION REQUIREMENT

Device Parameters	
Pressure measuring range	10~1000kg
Pressure measuring resolution ratio/ accuracy	1kg/±0.3%
Absolute thickness measuring range	100mm
Absolute thickness measuring resolution ratio/ accuracy	1μm/±10μm
Relative thickness measuring range	±5mm
Relative thickness measuring resolution ratio/ accuracy	0.1μm/±1μm
Temperature and humidity range	-20℃~ 80℃(SW2100)
Measurable max pouch cell size	220*180mm(If there is special size, it can be customized)

Installation requirements	
Voltage	220~240V/50~60Hz
Voltage variation tolerance	±10%
Power dissipation	3500W(SWE2100)、500W（SWE2110）
Environment temperature	25±5℃
Environment humidity	Humidity <95%Rh at the temperature of 40℃
Environmental magnetic field	Keep away from intense electromagnetic fields
Net weight	330KG(SWE2100)、150KG（SWE2110）
Dimenstion	600*1100*1800(SWE2100) 385*430*960(SWE2110)

Auxiliary device	
Charge-discharge device	Self-supply or provided by IEST
Computer	Self-supply or provided by IEST

Note: IEST is committed to continuous improvement of products. IEST reserves the right to alter the specifications of its products without notice.

Type	SWE 2100	SWE 2110
Temperature control	-20~80℃	None

PCD202212

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