INNOVATIVE BATTERY TESTING SOLUTION PROVIDER

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IEST 3 Major Business

- Battery R&D Solutions
- Battery Testing Service
- Battery Testing Instruments

IEST WeChat

IEST Instruments

IEST Instruments

DEDICATED TO BATTERY TESTING AND DEVELOPMENT

IEST

PRODUCT CATALOGUE

www.iestbattery.com

Initial Energy Science&Technology(Xiamen) Co., Ltd

INTRODUCTION

Founded in 2018, Initial Energy Science & Technology Co., Ltd(IEST) is a comprehensive provider of advanced testing instruments for batteries(LIBs, SIBs, and SSBs).

IEST is committed to delivering top-tier testing instruments with following testing scope:

- **Anode & Cathode Powders**: Resistivity & Compaction Density;
- **Seperators/Electrolyte**: Tortuosity / McMullin Number / Ionic Conductivity;
- **Anode & Cathode Electrodes**: Resistance, Uniformity;
- **Cells**: In-situ Gassing & Swelling of coin cells, pouch cells, stacked cells, prismatic cells, cylindrical cells;
- **Modules**: Cyclers, CV & EIS testing.

IEST places significant emphasis on the R&D of cutting-edge technologies, and our mission is to enhance our customers' product quality, so as to contribute to the advancement of new energy technologies, and we have supplied over 2,500 instruments to more than 700 clients worldwide.

CATALOGUE

Single Particle Force Properties Test System

Scan QR code for details

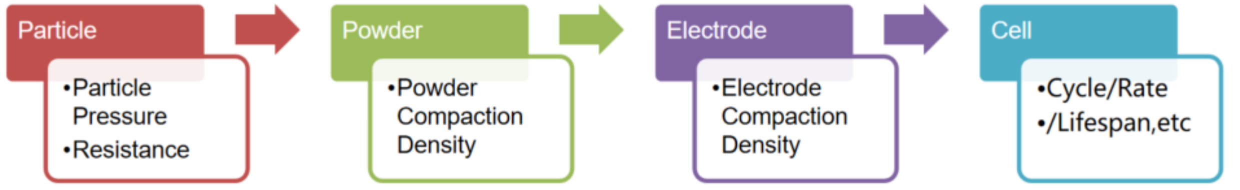
A Model Table

Item	Single Particle Force Tester	
Model	SPFT1000	SPFT2000
Applicable Samples	Particle size: 5-50μm(anode & cathode particles, solid electrolyte particles)	
Test Parameters	Force, Displacement	
Test Range	Displacement Range: 0-75μm Force Range: 0-100mN	
Test Accuracy	Microscope magnification: up to 1200 times Force Accuracy: ±0.1 mN Min. Displacement unit: 10nm Data Collection Frequency: 1000Hz	
Other Features	Stress-strain Curve Particle Image Observation Automatic Pressure Controll Fully Automatic Software	
Automatic XY-axis control	X	√

Note: IEST prioritizes continuous product updates, and our specifications are subject to change without prior notice.

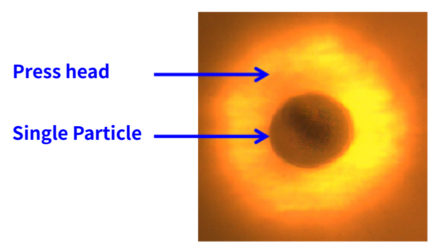
B Product Introduction

Background: Crushing strength of particles can be used to evaluate the pressure resistance of the material and guide the rolling process. Materials with higher particle mechanical strength will have better subsequent cycle stability.

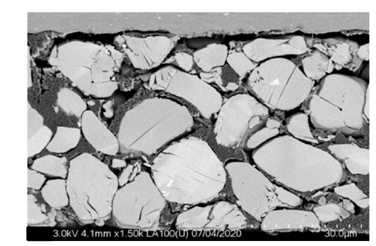


Applicable Samples

1. Cathode: NMC/LCO/LRMs
2. Anode : Silicon-based materials, Hard Carbon, etc.
3. Solid Electrolytes

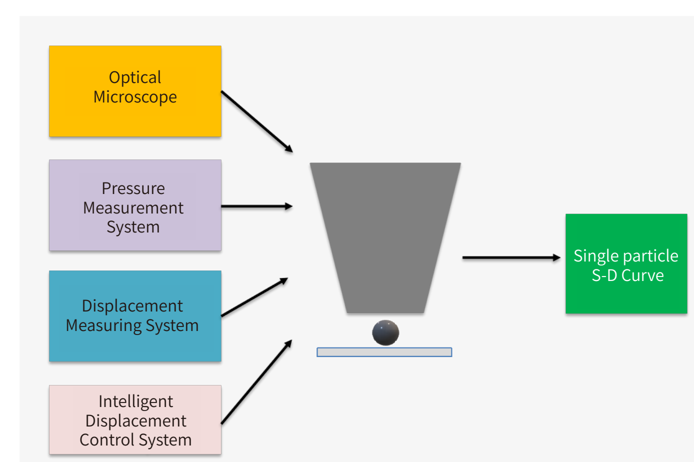


Single Particle Compression (Bottom View)



Particle cracked after cyclic compression (SEM Image)

Equipment Schematic



Basic Functions

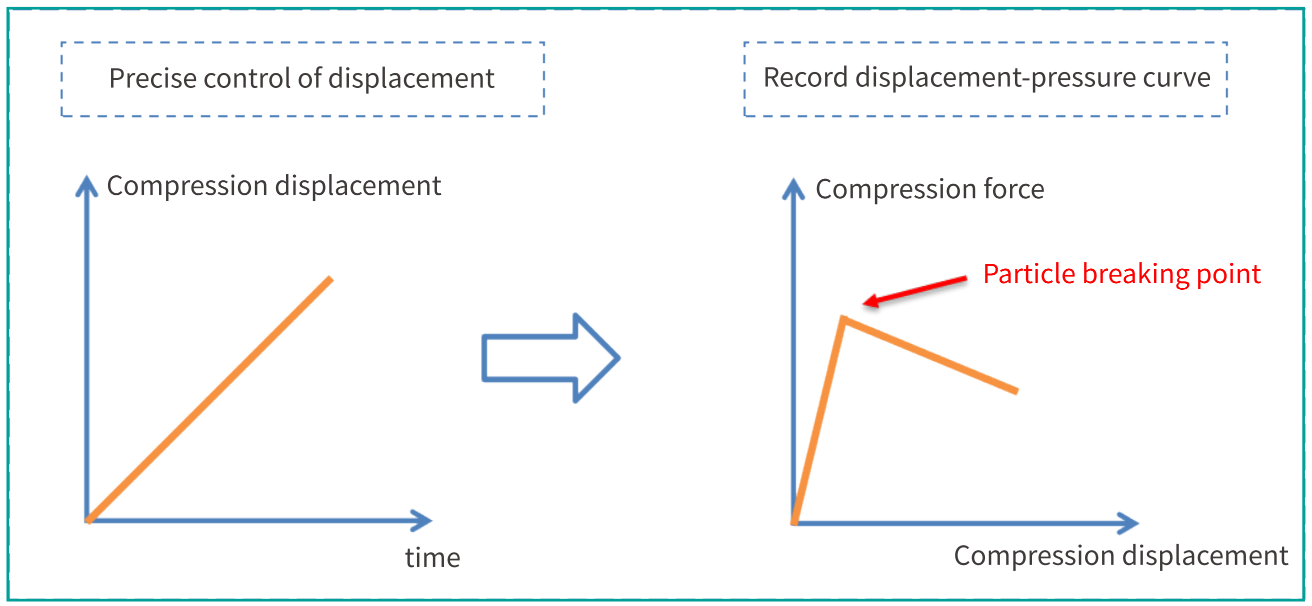
Apply compression to the particle to generate a force-displacement curve, from which the particle's failure point can be identified. This process determines the force at which the particle is crushed or fails.

Functional Modules

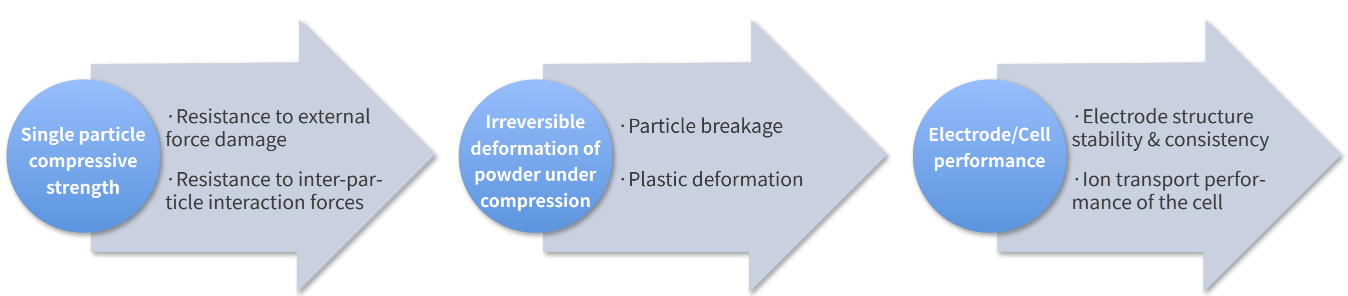
Displacement, pressure, software integrated control;
Real-time photography and video recording of particles.

C Main Test Steps

- **Sample Preparation**: Disperse the powder evenly into the anhydrous ethanol solution, and then add it dropwise to the glass slide;
- **Particle Location**: Locate the single particle with the optical microscope;
- **Particle Compression**: Compress the particle at a constant speed;
- **Data Collection**: Collect the force-displacement curves during the compression so as to find the failure point.

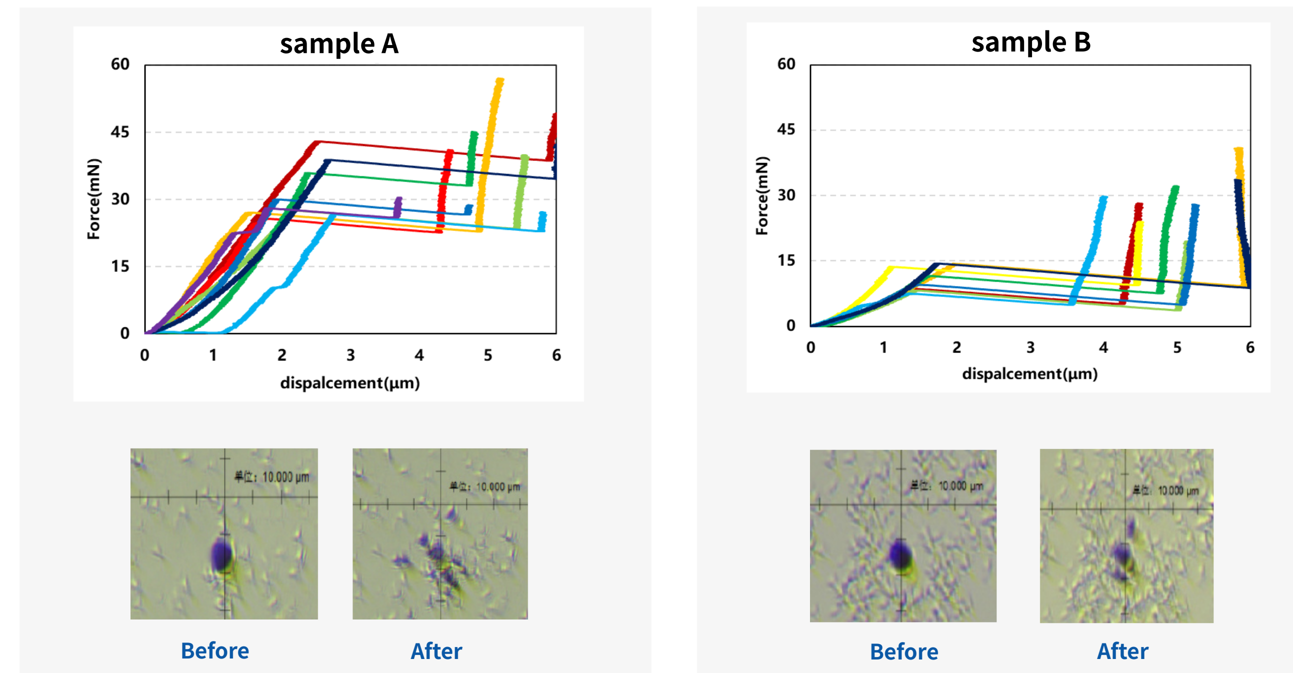


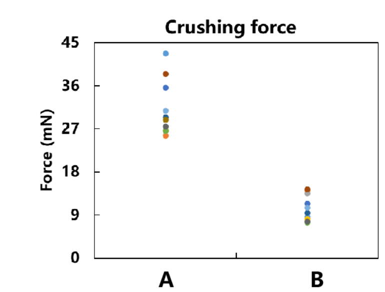
Particle Compression Property and Powder Compaction



D Application Cases

1. Application on Anode Materials ——SiC

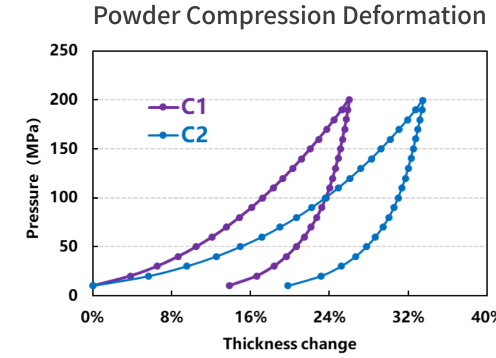




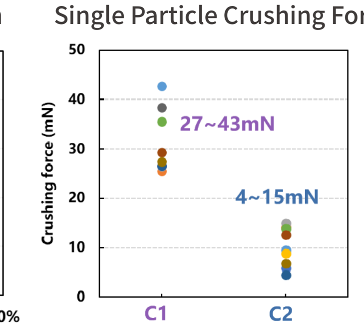
1. Comparison of crushing force distribution: A>B.
2. Analysis of stress-displacement curves: Sample A exhibits initial micro-cracking followed by complete collapse, while sample B experiences direct structural collapse and fragmentation.
3. Comparison of Disintegration States: After fracturing, all three groups disintegrate into fine granular states.

2. Application on Anode Materials ——Pure Carbon

Powder Compression Deformation



Single Particle Crushing Force

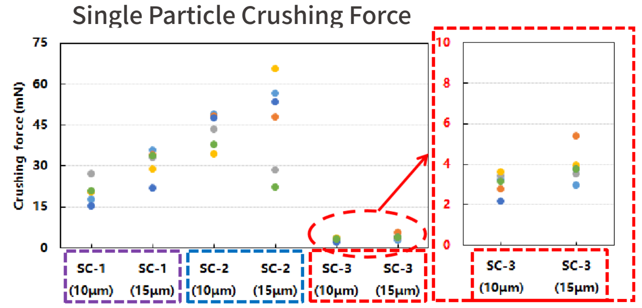


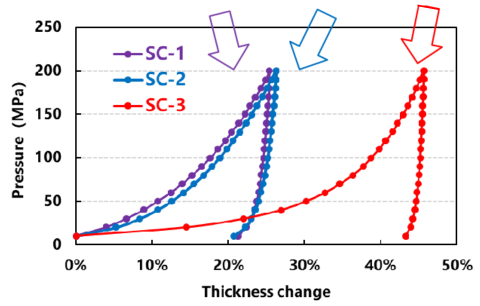
Material	Irreversible Deformation Parameter	Maximum Deformation Value
C1	13.8%	26.0%
C2	19.8%	33.5%

Conclusion: The compressive property of particle C1 is stronger. Hence, C1 powder shows a higher compression modulus than that of C2.

3. Application on Anode Materials —— SiC Composites

Single Particle Crushing Force



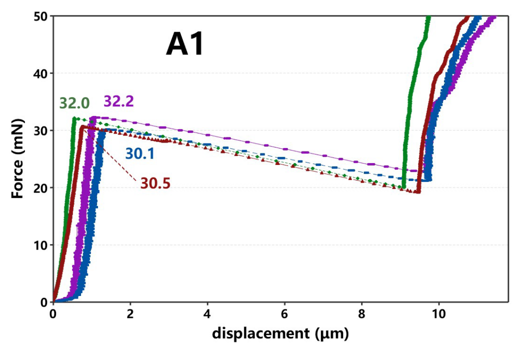


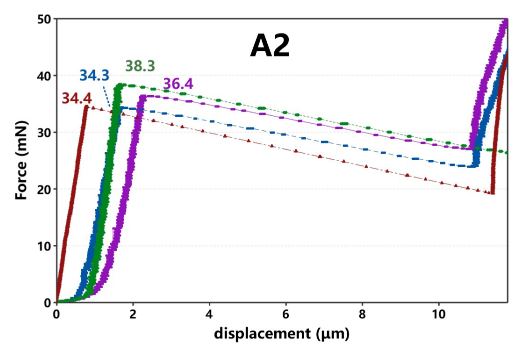
Powder Deformation

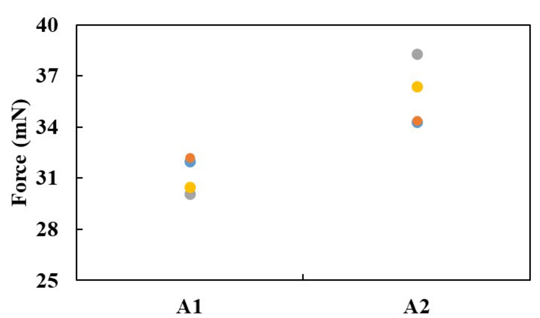
Material	Irreversible Deformation Parameter	Maximum Deformation Value
SC-1	21.3%	25.4%
SC-2	20.8%	26.3%
SC-3	43.3%	45.7%

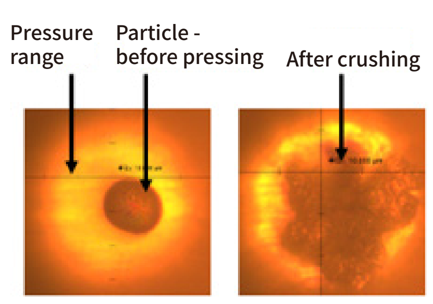
Conclusion: SC-3 particles exhibit weaker compressive strength, leading to significantly greater maximum and irreversible deformation during compression compared to the other two samples.

1. Application on Cathode Materials——NCM811







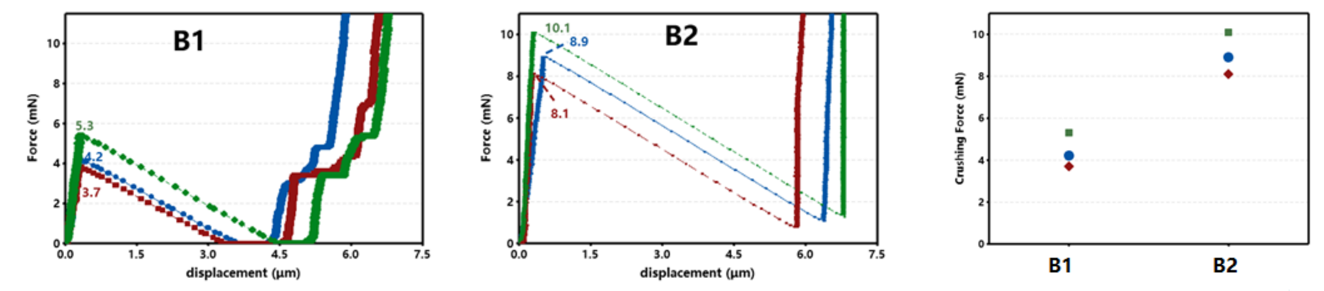


The two NMC materials A1 and A2 are sintered from the same precursor, but the sintering process is different. The particle size D50 is 18 μm.

Conclusion: The compression resistance of A2 is superior to that of A1, and modifying the sintering process can enhance the material's hardness to a certain extent. Single-particle mechanical property characterization methods offer valuable insights for optimizing the sintering process of materials.

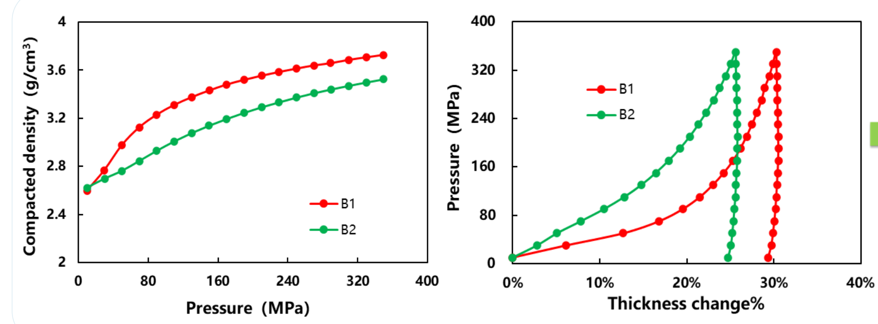
2. Application on Cathode Materials——NCM811

Single Particle Testing

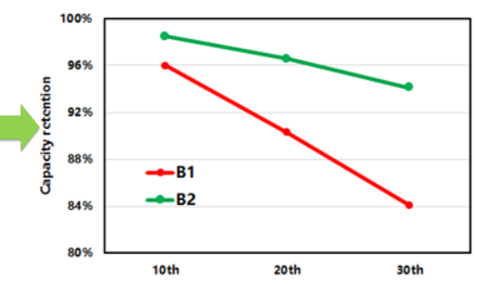


Two NMC materials, B1 and B2, are sintered from different precursors, and the particle size D50 is both 9.5 μm;

Powder Testing



Cell Testing



After assembling into half-cells following the same procedure, cycling at 3.0~4.3V, 0.5C, and 45 °C, sample B2 exhibits better cycling stability.

Conclusion: The crushing processes of the two types of particles differ, leading to variations in powder compaction density and charging cycle performance.

Powder Resistivity& Compaction Density Measurement System

Scan QR code for details

A Model Table

Model	PRCD1000	PRCD2000	PRCD3000	PRCD1100	PRCD2100	PRCD3100
Stress & Pressure	Stress up to 1T & Pressure 70 MPa			Stress up to 5T & Pressure 350 MPa		
Test Principle	2-probe	4-probe	2-probe & 4-probe	2-probe	4-probe	2-probe & 4-probe
Applicable Samples	Cathode Samples	Anode Samples	Anode & Cathode Samples	Cathode Samples	Anode Samples	Anode & Cathode Samples
Resistance Range	1 μΩ~20 MΩ			1μΩ~1200MΩ	1μΩ~200MΩ	
Sensor Resolution & Accuracy	Thickness Sensor: Resolution 0.5 μm, Accuracy±10 μm Stress Sensor: Resolution 0.1 KG, Accuracy±0.3% F.S. Resistance Sensor: Resolution 0.1 μΩ, Accuracy±0.1%F.S.					
Test Parameters	Thickness, Compaction Density Resistance, Resistivity, Conductivity Stress, Pressure Temperature & Humidity					
Other Specifications	1.Mold/Jig Diameter: 10 mm / 13 mm / 16mm 2. L*W*H: 320*400*800 (mm) 3. Instrument Power: 450W 4. Instrument Net Weight: 85KG			1.Mold/Jig Diameter: 10 mm / 13 mm / 16mm 2. L*W*H: 370*575*1140(mm) 3. Instrument Power: 2100W 4. Instrument Net Weight: 250KG		
Test Modes & Functions	Multi-pressure Test Mode: Suitable for testing of **Compaction Density & Resistance** without fixed steppings Variable Pressure Test Mode: Suitable for testing of **Compaction Density & Resistance** with fixed steppings Pressure Relief Test Mode: Suitable for testing of **Rebounced Thickness Curve** Steady-state Test Mode: Suitable for testing of **Stress-Strain Curve & Elastic Modulus**					

Note: IEST prioritizes continuous product updates, and our specifications are subject to change without prior notice.

B Instrument Principle

Test methods: Put a certain amount of powder (1~2g) into the mold and vibrate it, put the mold into the instrument box, set the pressure (⩽200MPa) and the holding time, and start testing the thickness and resistance changes of the powder during the compression process.

Test parameters: Stress, pressure, thickness, resistance, resistivity, conductivity & compaction density.

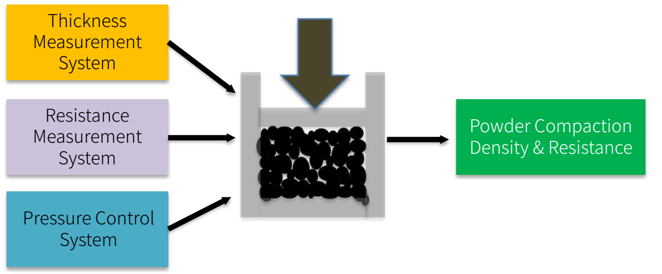
Calculation formula

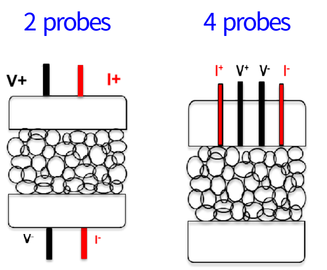
Compaction Density(g/cm³): $D = \frac{m}{S*L}$

Resistance(Ohm): $R = \rho\frac{l}{S}$

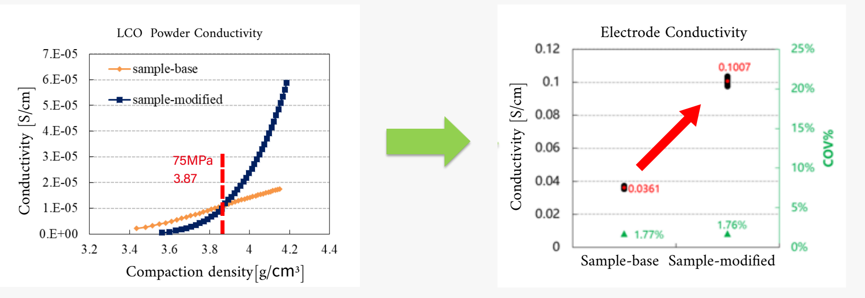
Conductivity (S/m): $\sigma_e = \frac{1}{\rho} = \frac{l}{RS}$

Resistivity(Ω*cm)-PRCD2100: $\rho = k\frac{U}{I}$ (Where k is the compensation coefficient)





C Why Compaction Density instead of Tapped Density?



LCO Powders

The compaction density of the LCO electrodes is around 3.8- 4.0g/cm³ after calender.

Result analysis:

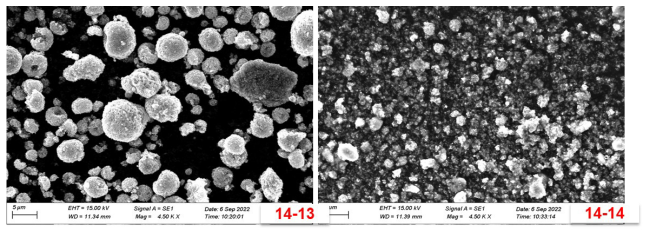
Result Analysis: Using LCO powder as an example, when the compaction density of the modified powder sample is less than 3.87g/cm³ (pressure <75MPa), its conductivity is lower than that of the unmodified powder sample.

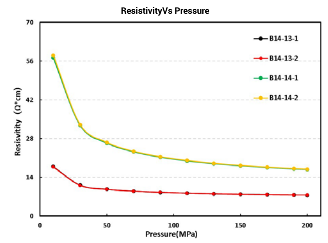
However, when the compaction density exceeds 3.87g/cm³ (pressure >75MPa), the conductivity of the modified powder begins to surpass that of the unmodified powder, and the conductivity improves significantly as the compaction increases.

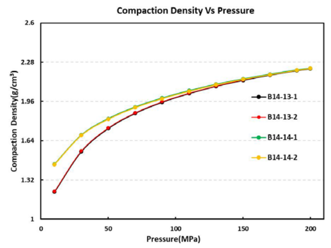
Conclusion: When testing the conductivity of powder, the compaction density should be close to the actual compaction of the powder in the electrode.

D Application Cases

(1) Cathode material-LMFP



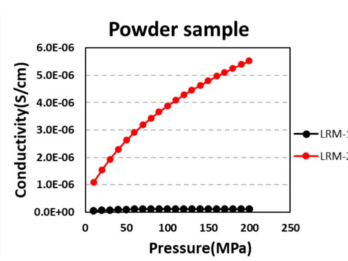


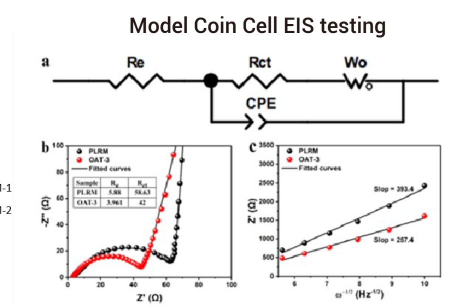


Conclusion 1: The conductivity of B14-13 is superior to that of B14-14. This is primarily due to its lower porosity, which enhances particle contact throughout the compression process, resulting in better conductivity.

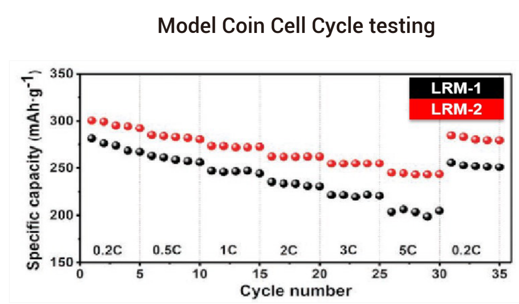
Conclusion 2: The compaction density shows minimal difference under high-pressure conditions but varies under low-pressure conditions. This is mainly because samples with a wide particle size distribution have poor flow and rearrangement characteristics, leading to higher porosity and lower compaction density under low pressure.

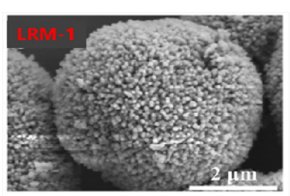
(2) Lithium-rich materials

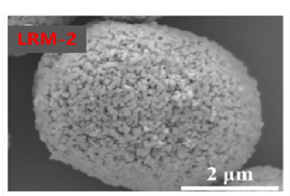




W.B. Guo et.al. Adv. Mater. 2021, 33, 2103173



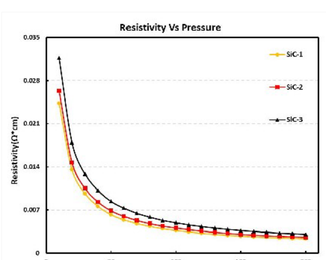


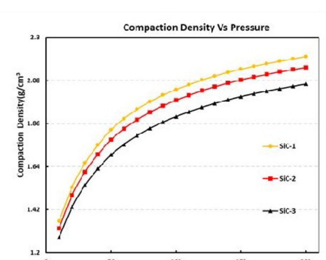


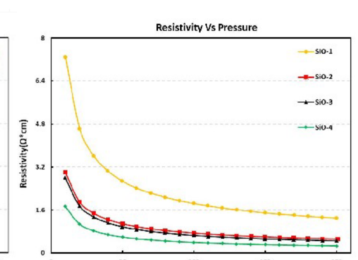
Analysis of the lithium-rich material with different modification methods.

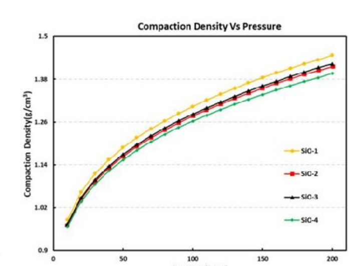
The resistivity of the lithium-rich material can be reduced effectively by adjusting its surface structure.

(3) Silicon-based materials









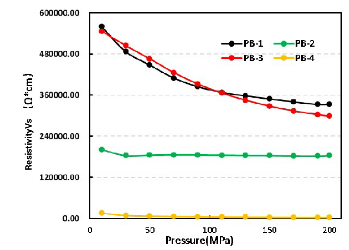
Test Condition: Si content: 3%, 6% and 10%(SiC-1/ SiC-2/ SiC-3)

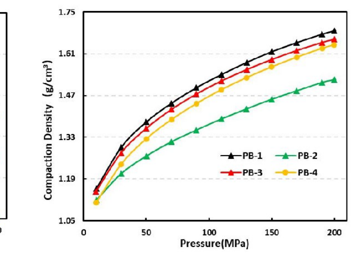
Conclusion
Resistivity: SiC-1< SiC-2< SiC-3
Compaction density: SiC-1> SiC-2> SiC-3

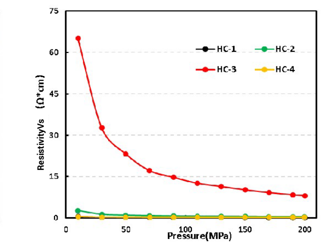
Test Condition: Sintering temperature of SiO Materials: SiO-1< SiO-2<SiO-3<SiO-4

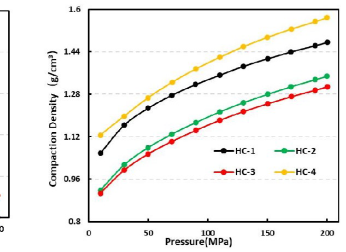
Conclusion
Resistivity: SiC-1> SiO-2> SiO-3> SiO-4
Compaction density: SiC-1> SiO-2> SiO-3> SiO-4

(4) Anode & cathode materials for sodium ion battery



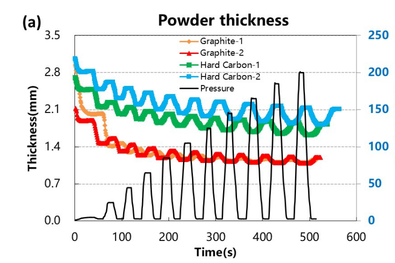


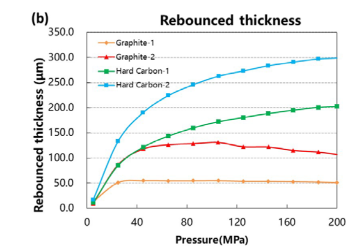


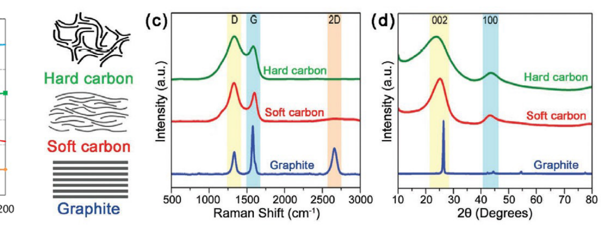


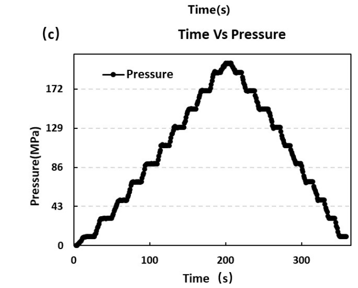
Conductivity evaluation of anode & cathode powders for sodium ion batteries : Effectively evaluate the conductivity and compaction properties of Prussian blue and hard carbon under different modification conditions.

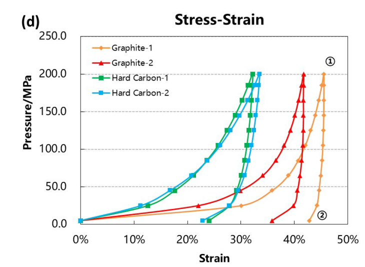
(5) Compression properties of carbon materials











Name	Reversible Deformation	Irreversible Deformation	Max Deformation
Graphite-1	2%	43%	45%
Graphite-2	6%	36%	42%
Hard Carbon-1	8%	24%	32%
Hard Carbon-2	10%	23%	33%

Conclusion: the conductivity of graphite is greater than that of hard carbon, so is its powder compressibility.

E Testing Mold

Mold for testing

Automatic demolding instrument

Mold Parameters	
Mold Material	Stainless Steel, Ceramic, PEEK
Diameter	10mm/13mm/16mm
Test Pressure	Up to 550MPa
Service Life	12000 Times

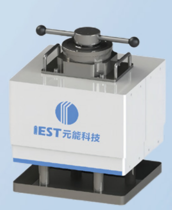
Note: IEST prioritizes continuous product updates, and our specifications are subject to change without prior notice.

Solid Electrolyte Measurement System

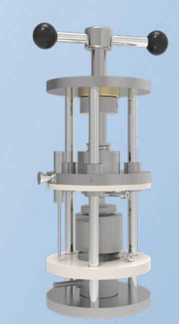
Scan QR code
for details

A Creative Solutions

This instrument is suitable for testing of various types of **solid electrolytes**, such as **oxides**, **sulfides** and **polymers**.



SEMS1300



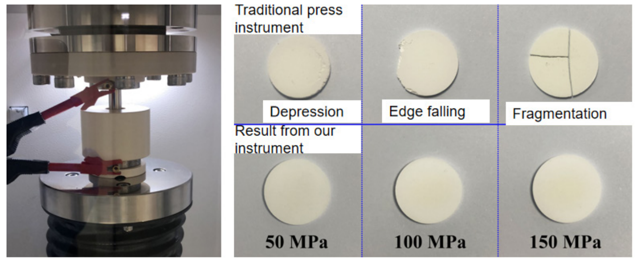
SEMS1000

SEMS1100

B Application Cases

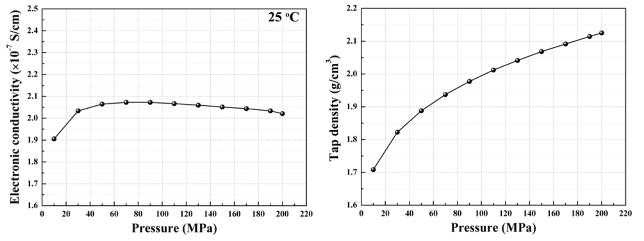
(1) Formation of green pellet

The equipment can be used to prepare the green pellet for solid-state batteries.



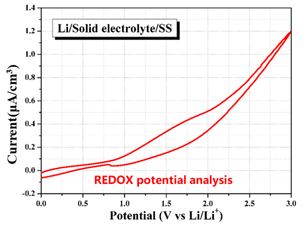
(2) Electronic conductivity & compaction density

The electronic conductivity of the solid electrolyte under varying pressures can be measured using an external electrochemical impedance spectroscopy (EIS) module.



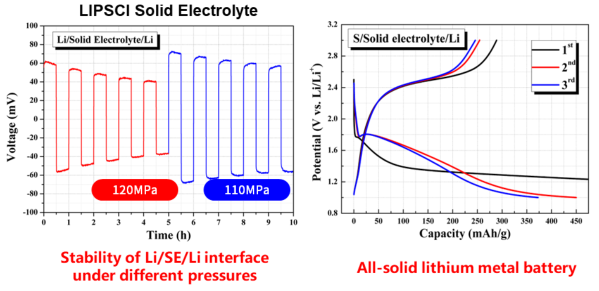
(3) Electrochemical stabilization window

Using the cyclic voltammetry (CV) module, the electrochemical stability window of solid electrolytes can be analyzed under different pressure conditions.



(4) Solid-state battery cycling performance

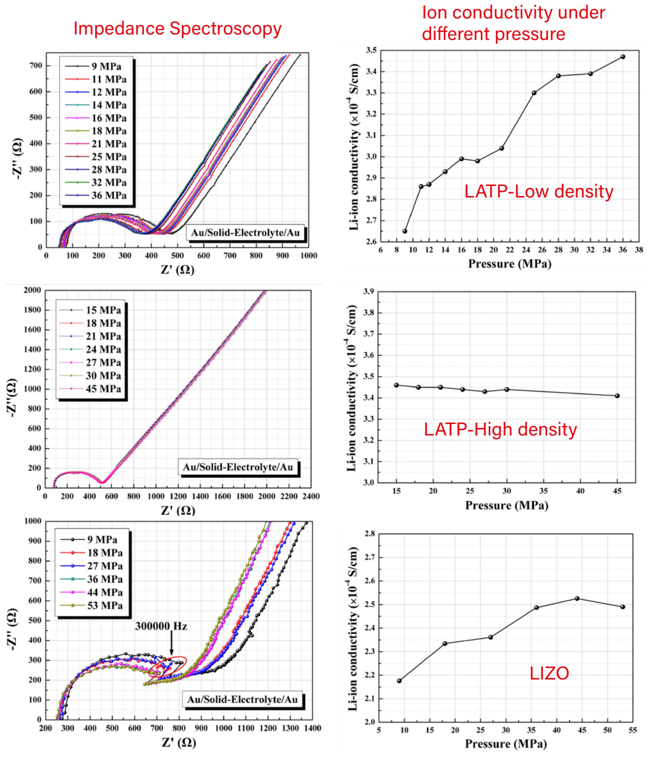
The charge-discharge (CD) module allows for the analysis of the cycling performance of solid lithium metal batteries under varying pressures and different electrochemical parameters.



(5) Ionic conductivity

Testing range: 10MHz~0.1Hz **Voltage disturbance:** 10mV

The electrochemical impedance spectroscopy (EIS) module automatically measures the ionic conductivity of solid electrolytes under varying pressures.

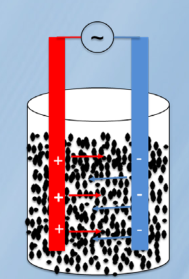


Battery Slurry Resistance Analyzer

Scan QR code for details

A Slurry Resistivity Test Principle

Test Methods: Put a certain volume of slurry (~80mL) into the measuring glass, insert a clean electrode pen, start the software, start to test the change of the slurry resistivity at the three pairs of electrodes with time and save it to the file.



Resistivity (Ω*cm): $\rho_e = \frac{U}{I} \times \frac{S}{l}$

Main features:

1. Separate the voltage and current lines, eliminate the influence of inductance on voltage measurement, and improve the accuracy of resistivity detection;
2. The disc electrode with a diameter of 10mm ensures a relatively large contact area with the sample and reduces the test error;
3. It can monitor the change of resistivity with time at three positions in the vertical direction of the slurry in real time;

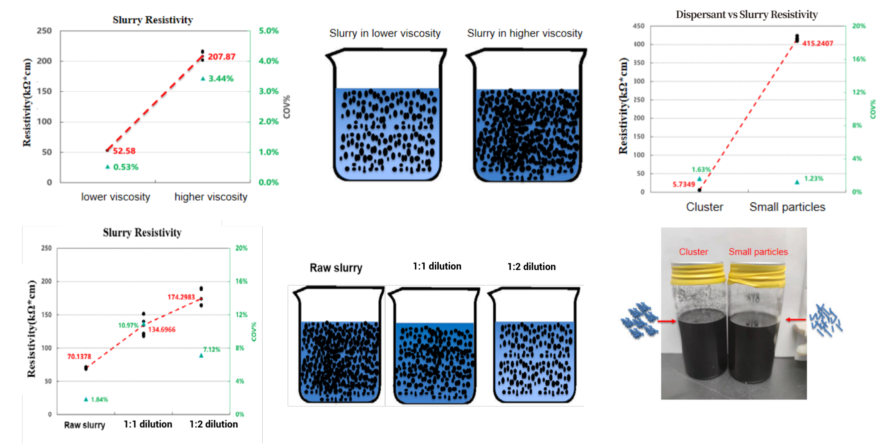
B Specifications

Product model	BSR2300		
Resistivity range	2.5Ω*cm~50MΩ*cm	Resistivity accuracy/resolution	±5%/0.01Ω*cm
Conductivity range	0.02μS/cm~400mS/cm		
Temperature range	0~40°C	Temperature accuracy/resolution	±0.5°C/0.1°C
Number of test electrodes	three pairs		

Note: IEST prioritizes continuous product updates, and our specifications are subject to change without prior notice.

C Application Cases

(1) Evaluation of conductive agent slurry with different formulations

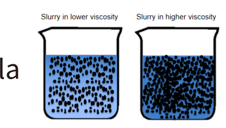


When the viscosity, concentration and dispersant type of the conductive agent are changed, the resistivity also changes!

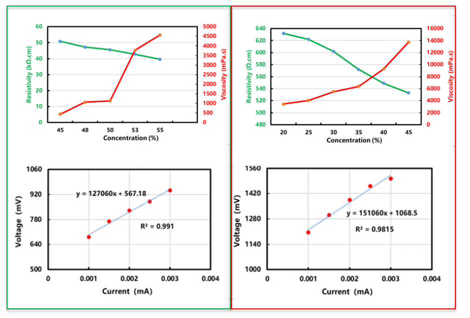
In the future, specifications can be formulated for the slurry resistivity of a certain fixed viscosity, and the stability of the slurry process can be monitored!

(2) Concentration-viscosity-resistivity correlation

Slurry formula



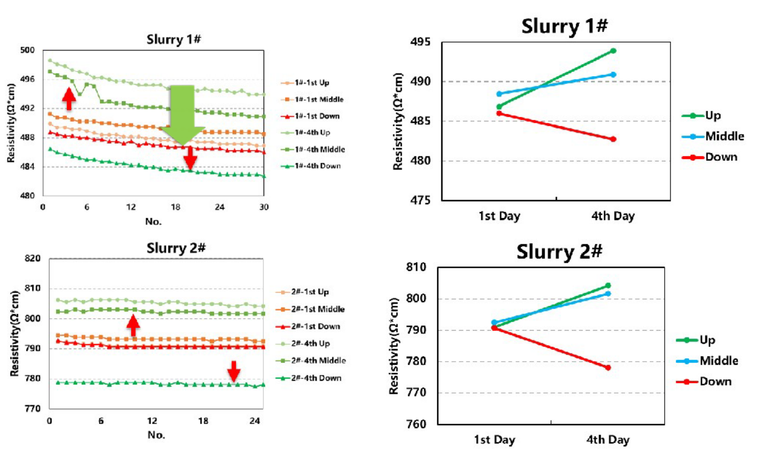
Graphite	SP	CMC	SBR
96.5	0.5	1.5	1.5
LCO	SP	CNT	PVDF
94.0	2.0	1.0	3.0

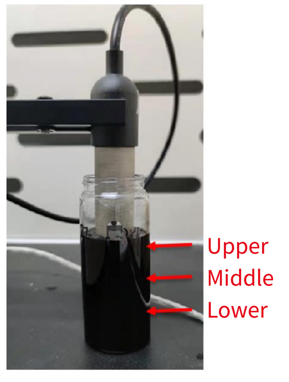


The resistivity of the slurry decreases with the increase of the concentration, and the change of the viscosity is also inversely proportional to the relationship;

The I-V curve test of these two types of slurries basically conforms to Ohm's law, and the current and voltage have a linear relationship, indicating that the slurries are mainly electronic conductors;

(3) Slurry settling performance





On the first and fourth day of testing, the resistivity of the upper and middle channels increased, while the resistivity of the lower channel decreased, indicating that after four days of shelving, the slurry shows obvious settlement.

Subsequently, a shelving period can be formulated for a certain of slurry according to the change of the resistivity to ensure the uniformity of the slurry!

Battery Electrode Resistance Analyzer

Scan QR code for details

A Model Table

Model	BER2300	BER2500
Pressure method	Servo motor	
Resistance range & accuracy	1μΩ~3.1kΩ(±0.5%F.S)	
Pressure range & accuracy	up to 1000kg——5~60Mpa(±0.3% F.S)	
Thickness range	/	0~5mm
Thickness resolution & accuracy	/	0.1μm/±1μm
Testable parameters	Resistance, resistivity, conductivity, pressure, temperature and humidity	Resistance, resistivity, conductivity, pressure, temperature and humidity, thickness, compaction density
Features	Single point test mode; Continuous test mode; Variable pressure mode	

Note: IEST prioritizes continuous product updates, and our specifications are subject to change without prior notice.

B Testing method and principle

Test parameters: The battery electrode resistance analyzer (BER series) adopts **the double-plane pressure-controllable disk electrode** to directly measure the overall resistivity of the real electrode, that is, the sum of the coating resistance, the contact resistance between the coating layer and current collector and the current collector resistance.

Feature

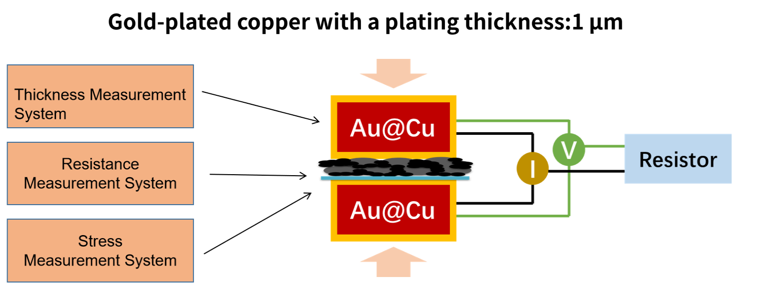
1. **Pressure Range**: 5~60MPa
2. **Test Range**: 0~5mm
3. **Test Accuracy**: ±1μm

Calculation formula

Compaction Density(g/cm³): $D = \frac{m_{\text{Area density}}}{L_{\text{Coating Thickness}}}$

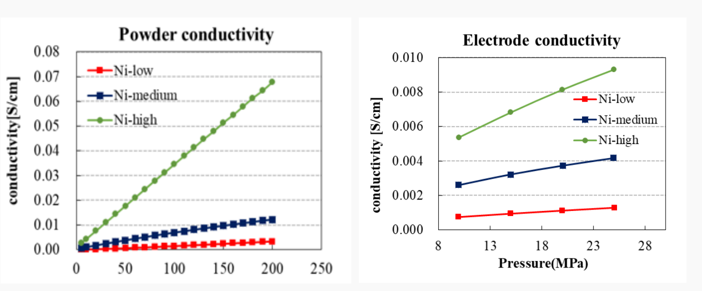
Resistance(Ohm): $R = \rho\frac{l}{S}$

Conductivity (S/m): $\sigma_e = \frac{1}{\rho} = \frac{l}{RS}$



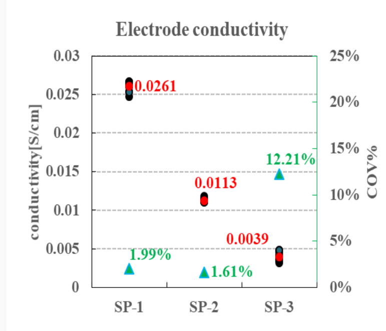
C Appliction Case - Material Evaluation

(1) Material evaluation : correlation between powder conductivity and Electrode conductivity



Conclusion: The powder conductivity and electrode conductivity have the same trend!

(2) Conductivity evaluation of conductive agents



Constant pressure test

Pressure: 25MPa

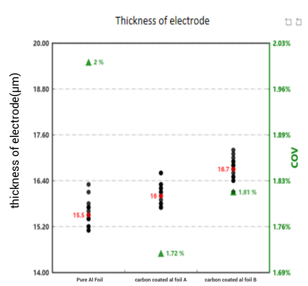
Holding time: 25s

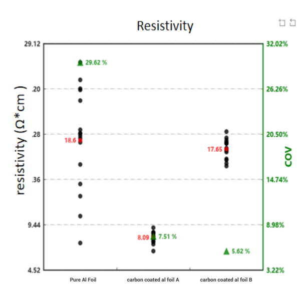
Points tested: 15points.

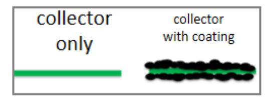
Conclusion: Electrode conductivity characterization can be used to evaluate the conductivity and dispersion performance of conductive agents!

* Coefficient of Variation COV = (Standard Deviation SD / Mean) × 100%

(3) Evaluation of primer coated aluminum foil: pure aluminum foil, carbon coated aluminum foil A, carbon coated aluminum foil B







Constant pressure test:

Pressure: 25MPa

Holding time: 15s

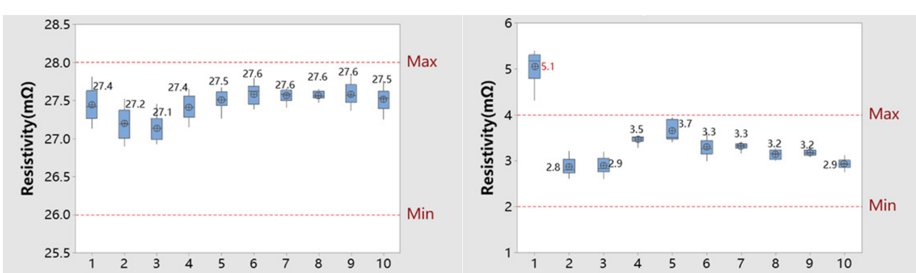
Points tested: 10 points.

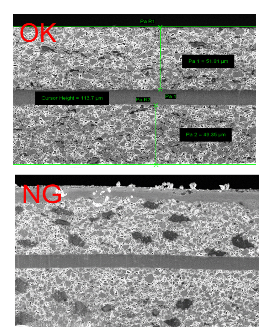
Conclusion

1. Different primer coating processes will change the conductivity of the current collector;
2. After coating 1~2μm primer material on the aluminum foil, the conductivity uniformity of the current collector is better;

D Application Case - Process Evaluation

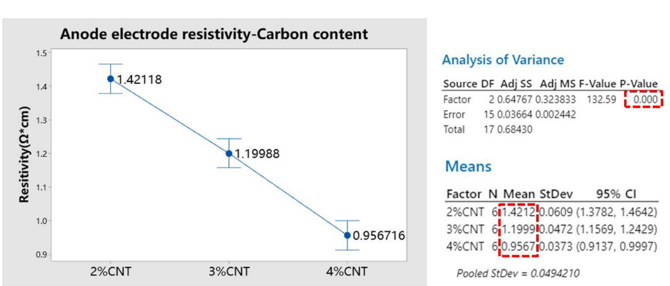
(1) Uniformity evaluation for the distribution of conductive agent

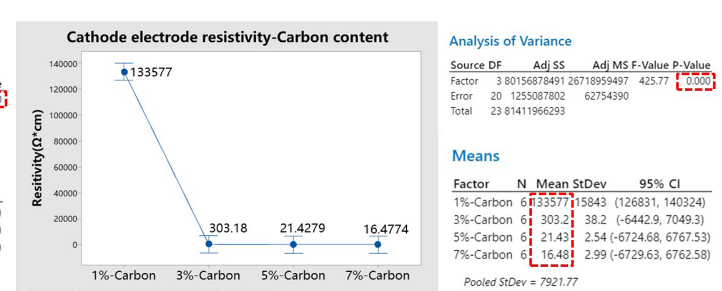




Conclusion: The quality of the first batch of the 10 anode electrodes is not acceptable as its resistivity is outside the normal range.

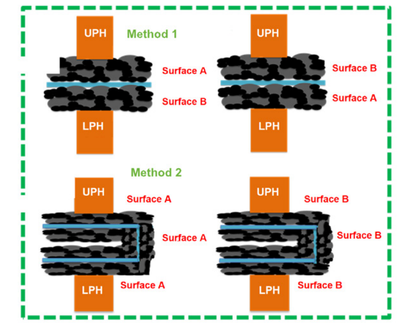
(2) Positive and negative electrodes with different conductive agents



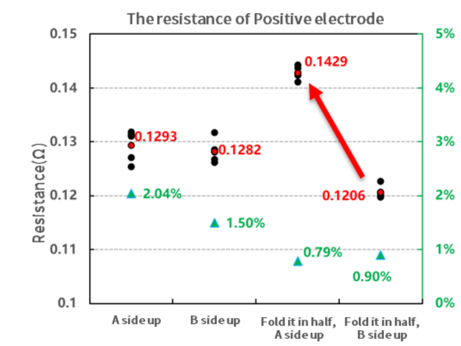


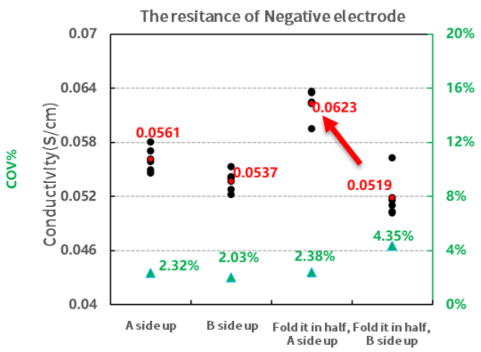
Conclusion: The resistivity of the NCM electrodes decreases with the increase of Carbon content, and when the content is greater than 5%, the resistivity decreases slightly.

(3) Separate the resistivity of the A and B coating layers for the double-coating electrode



UPH/LPH: Upper/Lower Press Head





M1: $R_{Total} = R_{UPH\text{-}A} + R_A + R_{A\text{-}foil} + R_{foil} + R_B + R_{B\text{-}foil} + R_{B\text{-}LPH}$

M2: $R_{Total} = R_{UPH\text{-}A} + 2R_A + 2R_{A\text{-}foil} + R_{foil} + R_{A\text{-}LPH}$

Constant pressure test

Pressure: 25MPa

Holding time: 15s

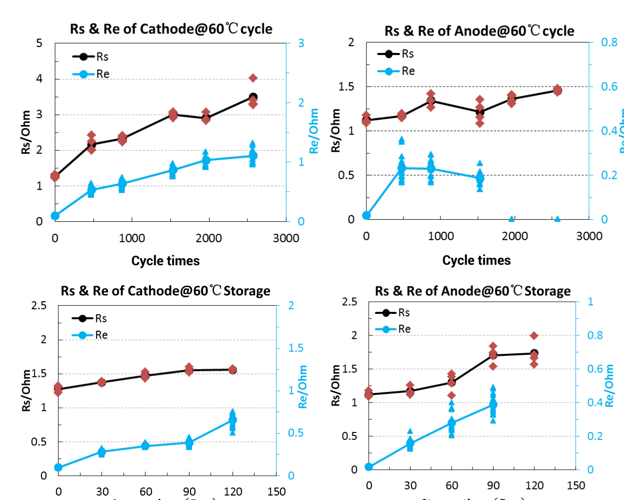
Points tested: 5 points for each group.

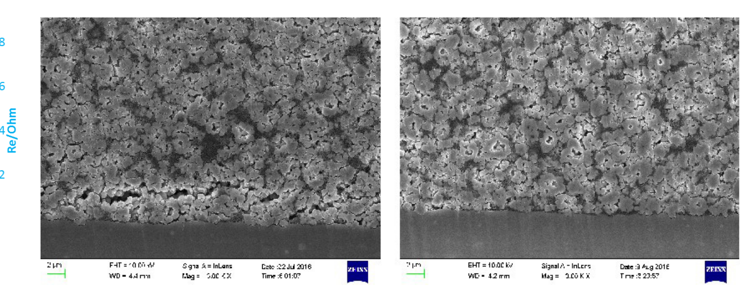
Conclusion

1. When the A side or the B side is facing up alone, the difference in the resistance and uniformity of the electrode sheet is small;
2. The difference between the A side and the B side after folding is mainly due to the difference in the coating on the two sides, so this method can be used to judge the difference in the coating on the AB side;

E Application Case - Failure Analysis

(1) Analysis of electrode resistance during high temperature cycle&storage





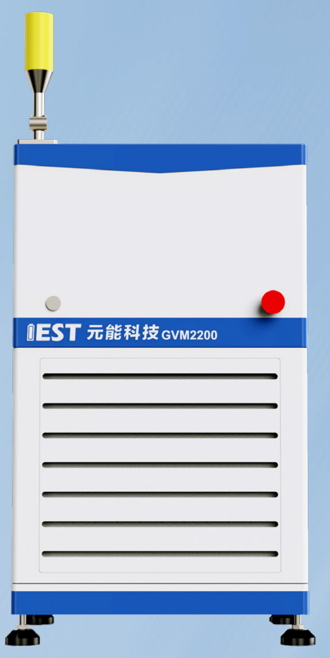
The resistance of the cathode continues to increase with the increase of the cycle numbers, indicating that a large change has taken place on the cathode side after the high temperature cycle, which may be related to the byproducts on the surface of the cathode particles or the contact between the particles;

Conclusion

1. The resistance of **cathode** electrodes increases with the number of **cycles**.
2. The resistance of **anode** electrodes increases with the **storage time**.

In-Situ Gassing Volume Analyzer

Scan QR code for details

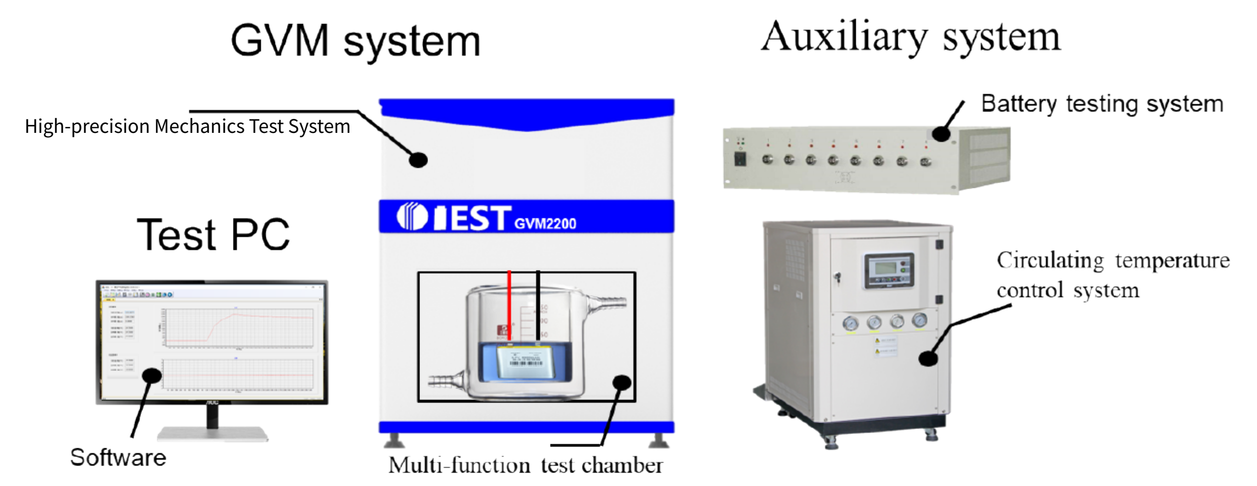


A Model Table

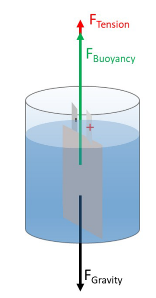
Model	GVM2100	GVM2200	GVM2150
Channel	Single Channel (1 Cell)	Dual Channel (2 Cells)	Single Channel (1 Cell)
Maximum Cell Weight (Including Fixture)	1000g	1000g	5000g
Test Temperature	RT~85℃	RT~85℃	RT~85℃
Volume Change Resolution	1μl	1μl	10μl
Volume Change Measurement Precision	±10μl	±10μl	±30μl
System Stability	≤20uL(RT,≤60min) ≤50uL(RT,60min~12h)	≤20uL(RT, ≤30min) ≤50uL(RT, 30min~12h)	≤30uL(RT, ≤30min) ≤50uL(RT, 30min~12h)
Instrument Dimensions	540*540*910mm	540*540*910mm	540*540*910mm
Instrument Weight	70kg	75kg	70kg
Maximum Dimensions (Excluding Tabs): 220 × 180 mm (Custom sizes available upon request)			

Note: IEST prioritizes continuous product updates, and our specifications are subject to change without prior notice.

B Creative solution - in-situ gassing monitor



C Instrument Principles



$F_{Tension}+F_{Buoyancy}=m_{Cell}g$ **Formula 1**

$F_{Buoyancy}=\rho_{silicone\ oil}gV_{Cell}$ **Formula 2**

$F_{Tension}=-\triangle F_{Buoyancy}=-\rho_{silicone\ oil}g\triangle V_{Cell}=\triangle m_{Sensor}g$ **Formula 3**

$\triangle V_{Cell}=-\triangle m_{Sensor}/\rho_{silicone\ oil}$ **Formula 4**

By combining Newton's law (formula 1) and Archimedes' buoyancy principle (formula 2), specialized sensors are used to measure the real-time mass changes of the cell during the charge & discharge process, and then the cell's volume changes can be further calculated(formula 3 and 4).

D Product Features

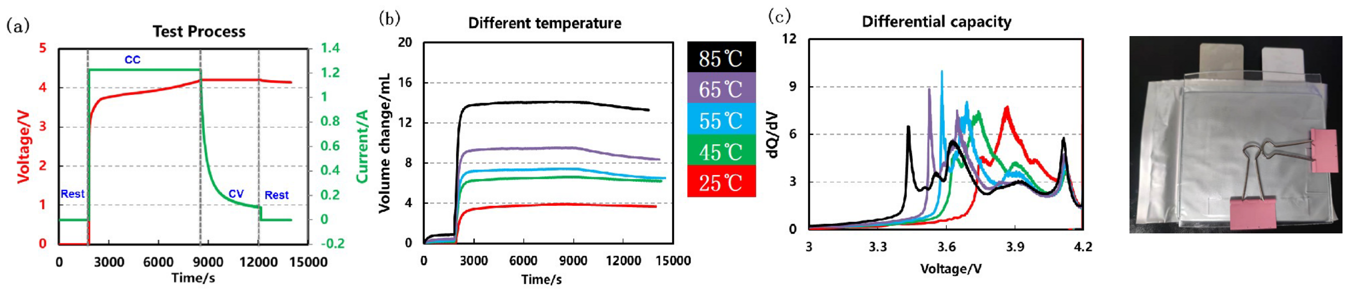
- **Multi-Level Gassing Testing**: Material Gassing → Single-Layer Stacked Cell Gassing → Small Pouch Cell Gassing → Cylindrical & Prismatic Cell Gassing
- **Multi-Channel Gassing Testing**: Single Channel → 2-Channel → 8-Channels Testing
- **Multiple Temperature Settings**: Room Temperature Testing → High and Low Temperature Testing (RT to 85°C with Water Bath Control)
- **Comprehensive Gassing Analysis**: Gassing Volume → Gassing Pressure → Gassing Composition Analysis

Applications

- Overcharge Gassing
- Cycle Gassing
- Storage Gassing
- Formation Gassing

E Application Case - Formation Gassing

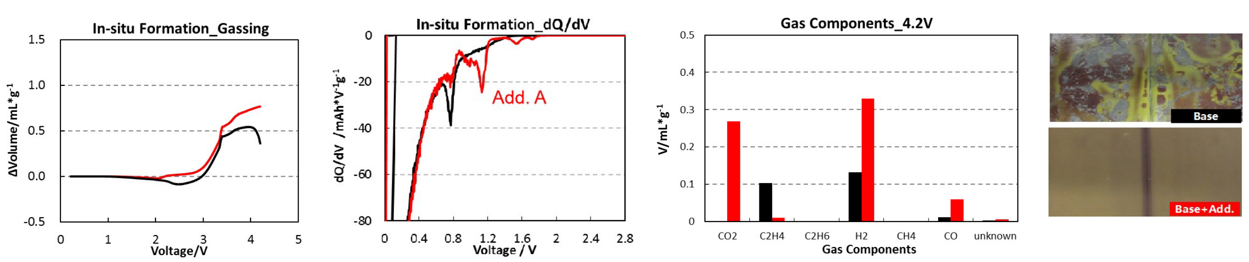
(1) Formation at different temperatures



Test Conditions: ⊘ NCM/Gr Pouch Cell ⊘ Rate: 0.5C ⊘ Charging: CC 4.2V ⊘ Capacity: 2400mAh

Conclusion: The gas production increases gradually with the increases of formation temperature, and when formation temperature is around 55°C, the first phase transition reaction peak will be more acute.
In addition, from the differential capacity curve, as the formation temperature increases, the polarization decreases.

(2) Formation with different electrolyte additives

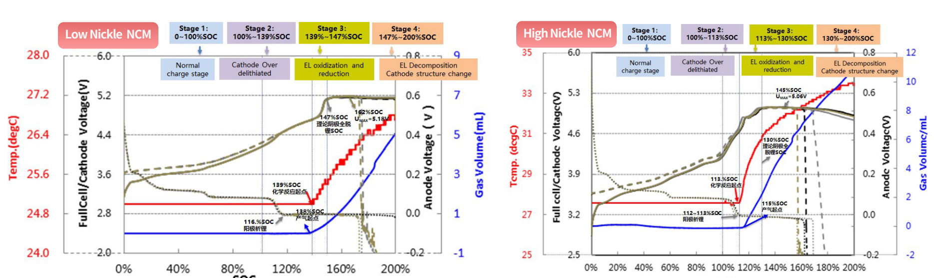


Test Conditions: ⊘ Temp: 25°C ⊘ Rate: 0.02C

Conclusion: The gas production & gas production rate of the cells with additive A(red) are greater than those without the additive, which means this additive enables a more complete **SEI formation** in the cells.

F Application Case - Overcharge Gassing

(1) NCM cells with different Ni contents



Note: EL is the abbreviation for electrolytes.

Test Conditions

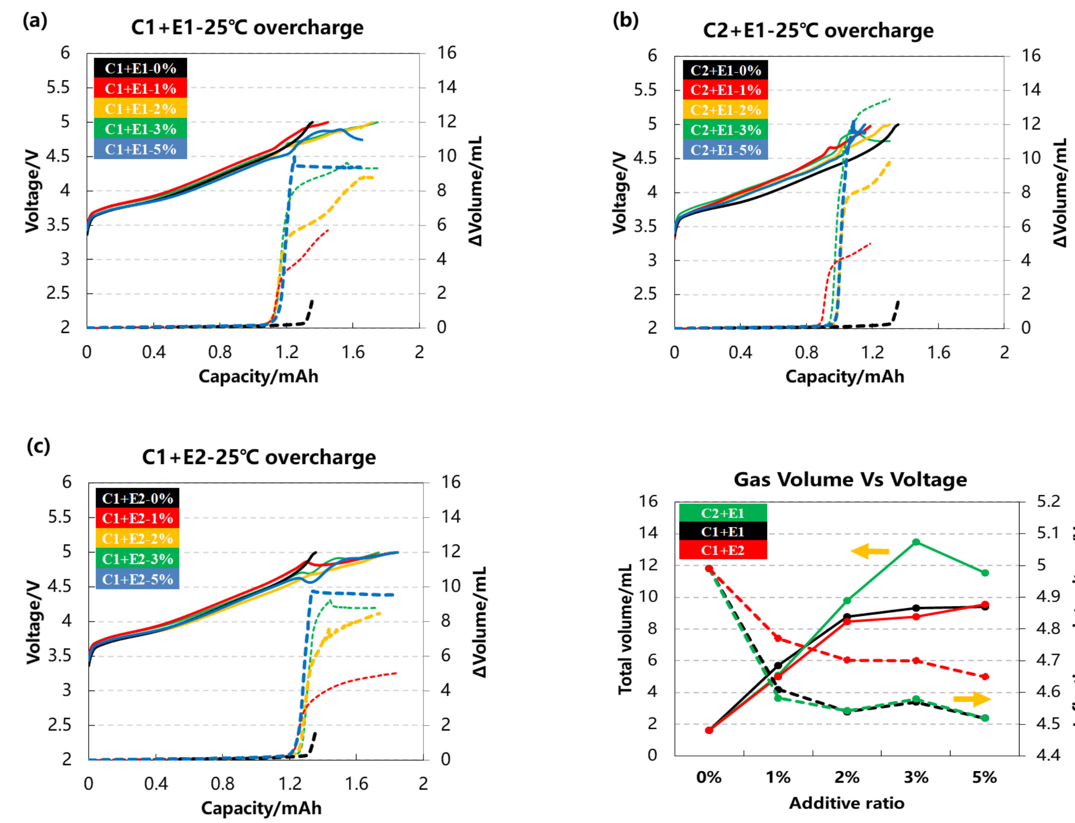
⊘ Temperature: 25°C

⊘ Rate: 0.5C

Conclusion

1. The slope of the volume change curve suddenly increases when overcharged to a certain potential, then the surface temperature of the cell increases sharply, and gas generation starts instantly from there;
2. As the nickel content increases, the state of charge (SOC) at the onset of gas generation shifts from 138% to 115%.

(2) Cells with different cathodes and contents of electrolyte additives

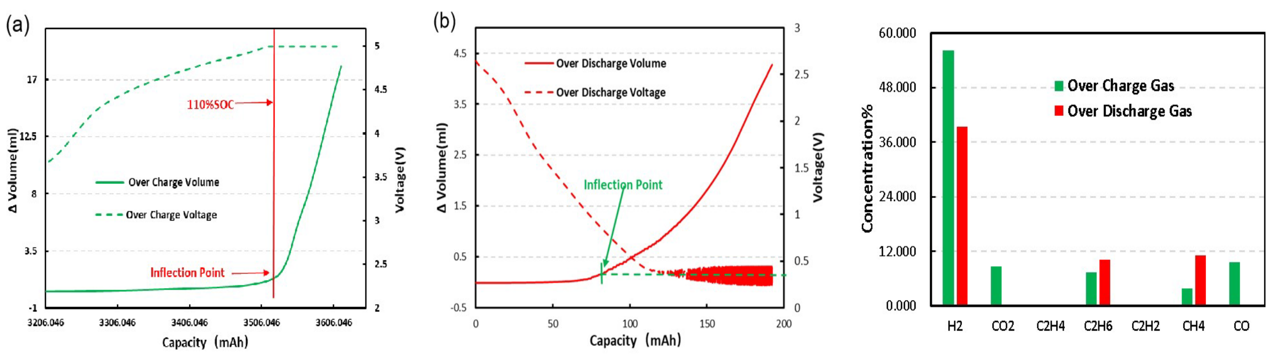


Note: C: Cathode electrodes E: Electrolyte additives

Additives contents	Gassing volume after overcharge to 5V(mL)			Voltage in gassing curve inflection point		
	C1+E1	C2+E1	C1+E2	C1+E1	C2+E1	C1+E2
0%	1.625	1.625	1.625	4.99	4.99	4.99
1%	5.708	5.068	5.005	4.61	4.583	4.77
2%	8.786	9.783	8.457	4.54	4.543	4.70
3%	9.335	13.479	8.785	4.57	4.58	4.70
5%	9.391	11.522	9.549	4.52	4.52	4.65

Conclusion: Both cathode electrodes and the contents of electrolyte additives affect gas production, while the type of additives mainly affects the potential of gas production.

(3) Overcharge and overdischarge of LFP batteries



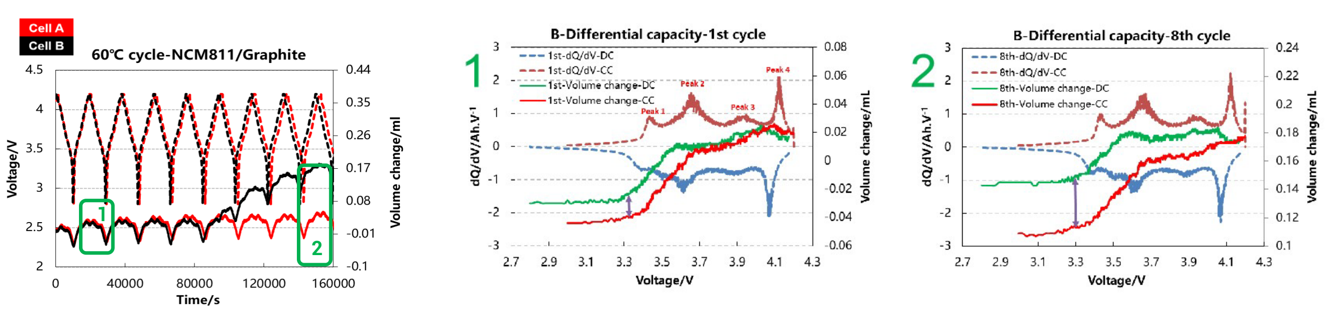
Test Conditions: ⊘ LFP/Graphite Cells ⊘ 0.5C CCCV to 5V ⊘ 0.5C DC to 0V

Conclusion

1. As the cell is overcharged or overdischarged, the starting point of gas production can be detected in real time;
2. Gas chromatography analyzes the gas composition under these two working conditions. In addition to the same gas type as the over-discharge cell, a relatively high content of CO and CO_2 gas is also detected.

E Application Case - Cycling Gassing

(1) Cycle performance of different NCM cells

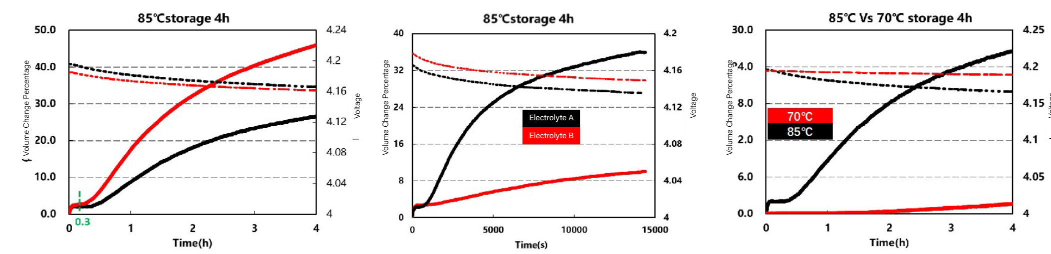


Test Conditions: ⊘ NCM/Gr Pouch Cell ⊘ Temperature: 60°CRate: 0.5C ⊘ Voltage: 3-4.2V

Conclusion: The volume change of cell B is greater than that of cell A, and the gap of volume change deepens with the increase of cycles, which indicates the irreversible volume swelling increases as well.

E Application Case - Storage Gassing

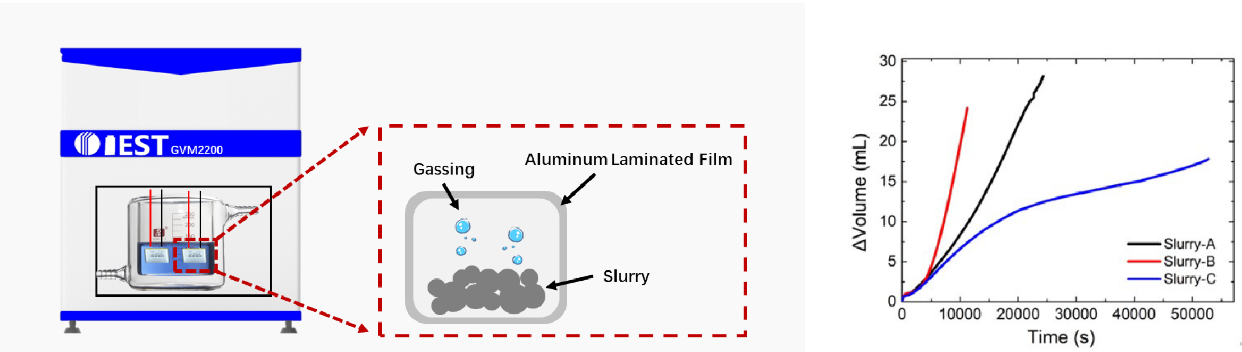
(1) Storage performance under 3 different conditions



Test Conditions: ⊘ 4.2V fullly charged ⊘ storage at 85°C for 4h

Conclusion: Different cathode materials, electrolytes, and storage temperatures all affect the volume change of the cells.

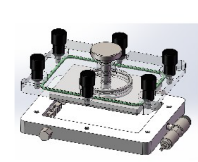
E Gassing from silicon-based slurries



Conclusion

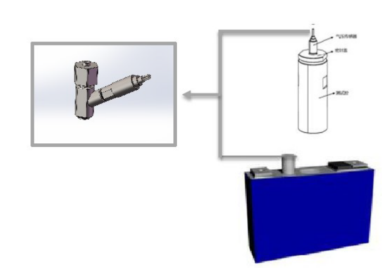
1. Pre-magnesium or pre-lithiation treatment of silicon monoxide results in gas generation in the slurry.
2. Lithium compensation additives in the cathode tend to decompose and generate gas during the actual slurry and lithium compensation process.

E Comprehensive gassing solutions

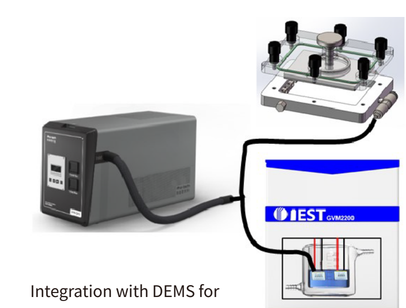


Stacked Cell Molds

Multi-Channel Gassing Testing

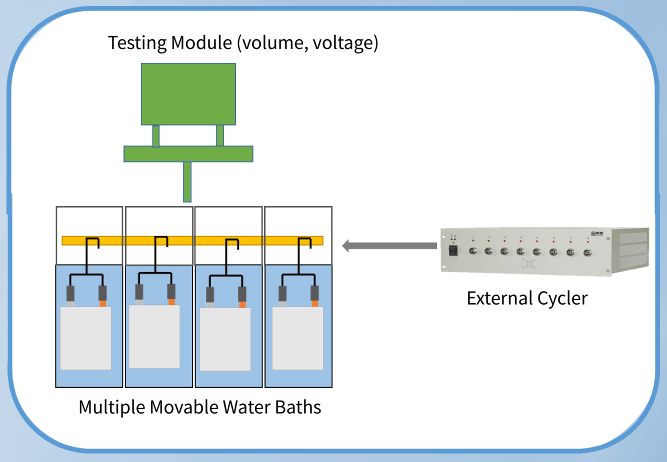


High-Precision Pressure Sensors



Integration with DEMS for Gas Analysis

In-situ Multi-channel Storage Gassing Test System



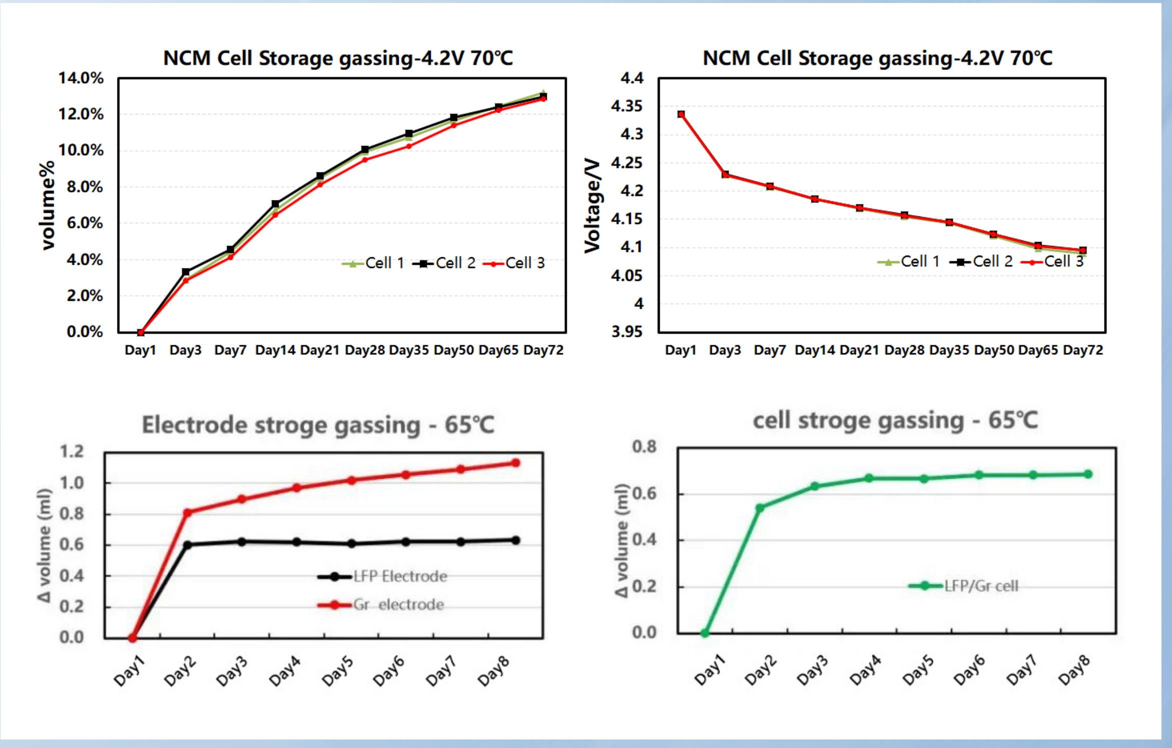
Features

In-situ Storage Gassing testing for **pouch cells**

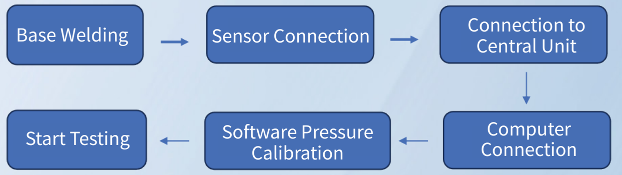
Multi-channel Testing (up to **64 channels**)

Automatical Data Recording(volume, voltage and internal resistance)

Access to External Cyclers



Square & Cylinder Cell Internal Pressure Testing System



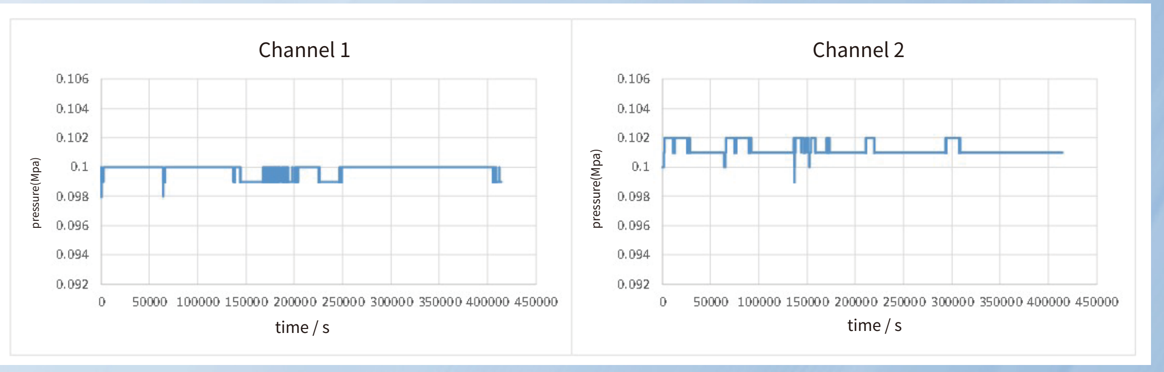
Applicable Samples: Cells with the **diameter of liquid injection port >7mm**

Measure Range: 0.5MPa, 1MPa, 1.5MPa, 2MPa

Test Duration: up to 6 months

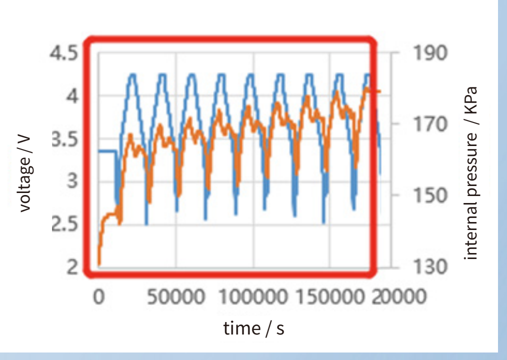
Sensor Accuracy: 0.3% F.S.

Number of Channels: 8



Test conditions: 60°C atmospheric pressure test

Test results: 115 hours, 0.003MPa fluctuation



Conclusion: As the cycle count increases, the pressure value rises, and after reaching a certain level, it stabilizes for a period of time.

In-Situ Cell Swelling Solutions

Scan QR code for details

- Model Coin-cell Swelling Analyzer (MCS Series)
- In-Situ Rapid Swelling Screening For Silicon-Based Anode(RSS Series)
- In-situ Swelling Analyzer for Consumer Battery/Cells (CBS Series)
- In-situ Swelling Analyzer for Power and Energy Storage Cells(SWE Series)
- Battery Pressure Distribution Film(BPD Series)

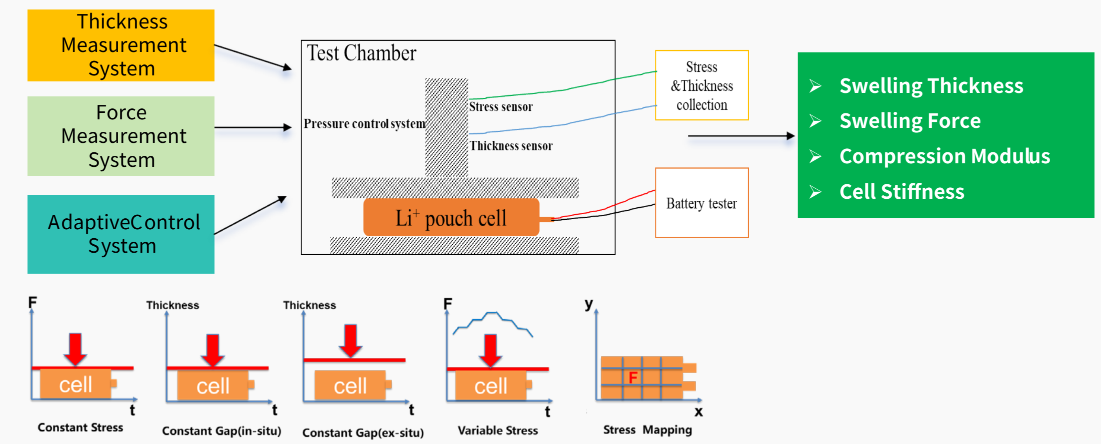
A Complete Solution for Cell Expansion

Model Coin Cell | Silicon-Based Anode | Consumer Battery | Consumer Battery & Power Battery & Energy Storage Battery | Battery Pressure Distribution Measurement System

MCS series | RSS series | CBS series | CBS series & SWE series

Model coin cell | Stacked Cell | Pouch Cell | Square Cell | Short-blade Cell (<700*400*100 mm) | Solid-state Batteries

B Instrument Principle



Test Range & Accuracy

- Force: 1kg~10T(Accuracy: 0.3% F.S)
- Displacement: 0.1mm~100mm Accuracy: ±1μm
- Number of channels: 1-4 channels
- Temperature: -20°C~80°C

C Specifications

Model Number		MCS1400	RSS1400	CBS1400
Test Mode	Constant Gap	×	×	√
	Constant Pressure	√	√	√
	Steady-State Compression	×	√	√
Compatible Battery Cell	Battery Cell Type	Coin Cell	Coin Cell / Small Pouch Cell	Coin Cell / Small Pouch Cell
	Maximum Cell Size	/	60*90mm	100*100mm
	Channel Quantity	1/2/3/4	1/2/3/4	1/2/3/4
Pressure Control	Pressure Adjustment Range	5kg	1-100kg	1-300kg
	Pressure Measurement Range	/	0-100kg	0-300kg
	Resolution	/	±1kg	±1kg
Pressure Measurement	Accuracy	/	±0.3%F.S	±0.3%F.S
Thickness Control	Accuracy	/	±1μm	±1μm
Battery Cell Thickness Measurement	Measurement Range	×	0~5mm	0~6mm
	Resolution	×	0.01μm	0.1μm
	Accuracy	×	±1μm	±1μm
Expansion Thickness Measurement	Measurement Range	±5mm	±5mm	±6mm
	Resolution	0.01μm	0.01μm	0.01μm
	System thickness measurement accuracy	±1μm	±1μm	±1μm
	Thickness sensor measurement accuracy	±0.1μm	±0.1μm	±0.1μm
Dimension		600*315*380mm	1200*700*1700mm	1300*700*1700mm
Weight		53kg	600kg	830kg

Note: IEST prioritizes continuous product updates, and our specifications are subject to change without prior notice.

C Equipment Specifications

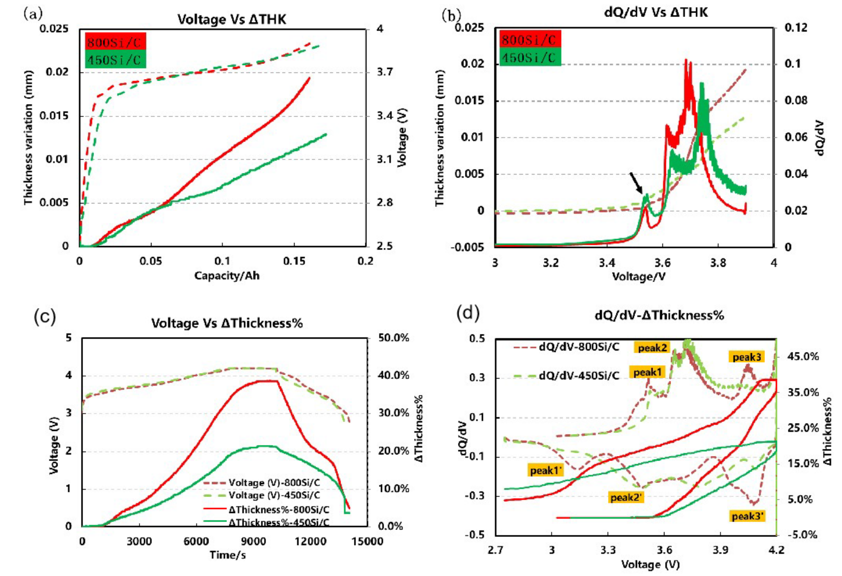
Model		SWE2100	SWE2110	SWE2500	SWE2510
Test Mode	Constant Gap	√	√	√	√
	Constant Pressure	√	√	√	√
	Steady-state Compression	√	√	√	√
Applicable Cell	Cell Type	Pouch Cell Prismatic Cell	Pouch Cell Prismatic Cell	Pouch Cell Prismatic Cell	Pouch Cell Prismatic Cell
	Maximum Cell Size	220*180mm	220*180mm	400*300mm	400*300mm
	Number of Channel	1	1	1	1
Pressure Control	Pressure Method	Servo Motor	Servo Motor	Servo Motor	Servo Motor
	Pressure Adjustment Range	20-1000kg	20-1000kg	50-5000kg	50-5000kg
Thickness Control	Accuracy	±1μm	±1μm	±2μm	±2μm
Cell Thickness Measurement	Measurement Range	0~80mm	0~80mm	0~100mm	0~100mm
Swelling Thickness Measurement	Measurement Range	±5mm	±5mm	±5mm	±5mm
	Resolution	0.1μm	0.1μm	0.1μm	0.1μm
	Accuracy	±1μm	±1μm	±1μm	±1μm
Temperature Control	Temperature Control	√	×	√	×
	Temperature Control Range	-20~80℃	×	-20~80℃	×
	Accuracy	±2℃	×	±2℃	×
Dimension		700*1220*1850mm	410*455*980mm	1100*1600*2000mm	820*750*1650mm
Weight		490kg	150kg	1100kg	850kg

D Product Features

1. **Multi-Level Expansion Testing**: Electrodes, Pouch Cell, Prismatic cell, Short-blade Cell
2. **Multi-Channel Expansion Testing**: Single-channel → Dual-channel → Four-channel
3. **Temperature Control**: -20℃—80℃
4. **Wide Force Ranges**: 5kg → 100kg → 300kg → 1000kg → 5000kg → 10000kg

E Application Case - Materials Evaluations

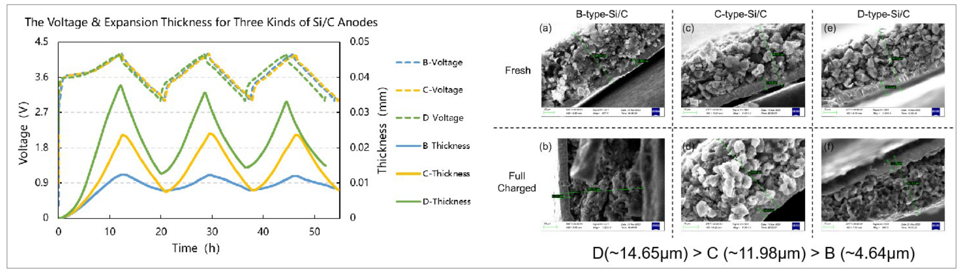
(1) Formation & charge-discharge swelling of cells with different Si/C contents

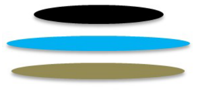


Test Conditions: ✓ Pouch Cell(stacking) ✓ 200 mAh (1 cycle) ✓ Cathode: NCM811
✓ Anode: 450Si/C (450 mAh/g) 800Si/C (800 mAh/g)

Conclusion: The higher the **silicon content** in the anode, the greater the swelling is(Max thickness change is around 40%), and the silicon-lithium alloy formed will affect graphite' s **phase transition potential** of lithium intercalation.

(2) Anode: NCM-Si/C cells with different modifications

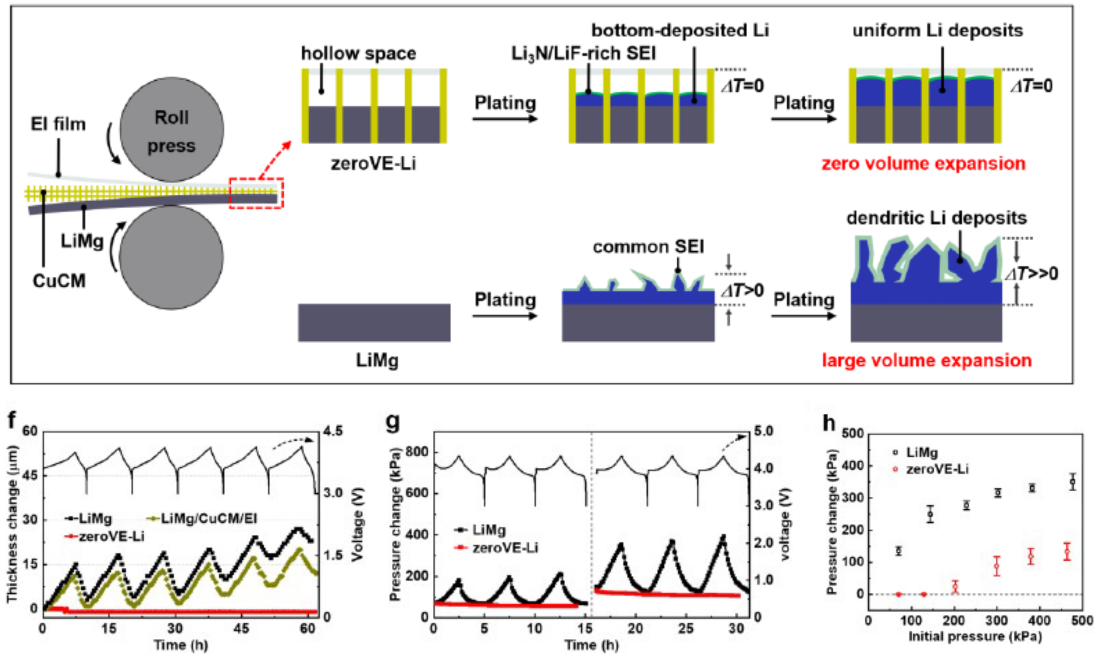




Test Conditions: ✓NCM/Si/C Coin Cells ✓ Si/C#D(~14.65um) ✓ Si/C#C (~11.98um) ✓ Si/C#B(~4.64um)

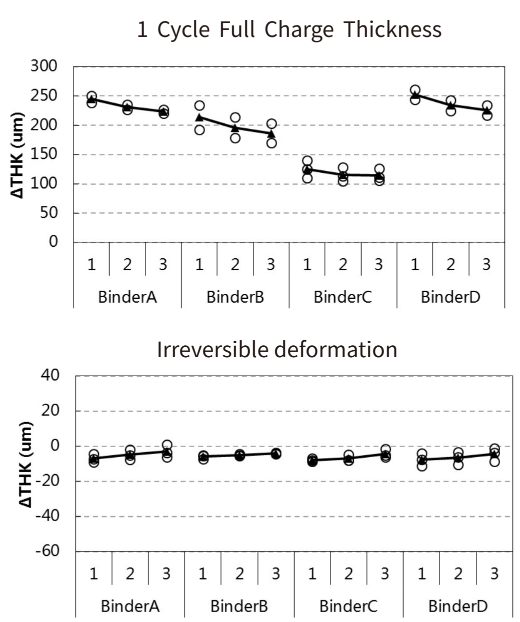
Conclusion: SiC#B shows the minimum swelling volume, and the swelling performance of the 3 anode materials share the same trend observed with the SEMs.

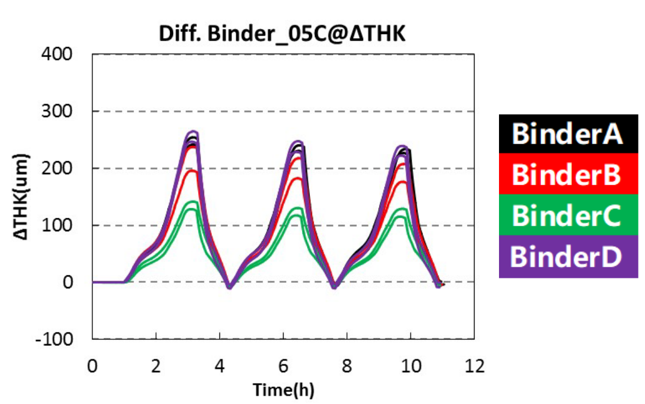
(3) Cycle swelling of cells with different Li metal



Conclusion: The modified lithium metal anode can significantly reduce the volume expansion of the cycle process.

(4) Cycle swelling of cells with different binders

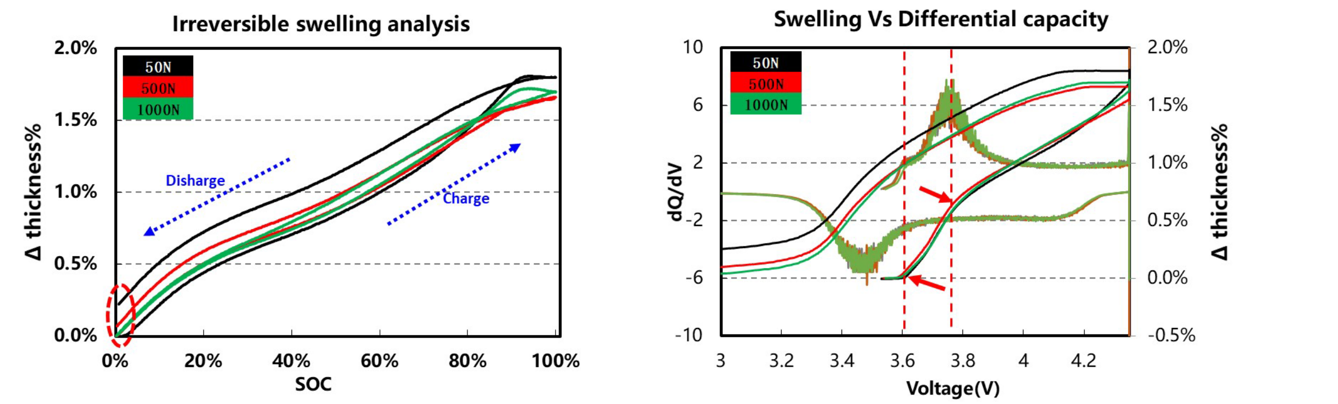




Conclusion: The irreversible swelling of the 4 tested cells is similar, and the main difference lies in the **swelling thickness after one cycle of full charge**, that cells with **binder C** outperformed the others.

E Application Case - Process Conditions

(1) Swelling of prismatic cells under different pre-stress

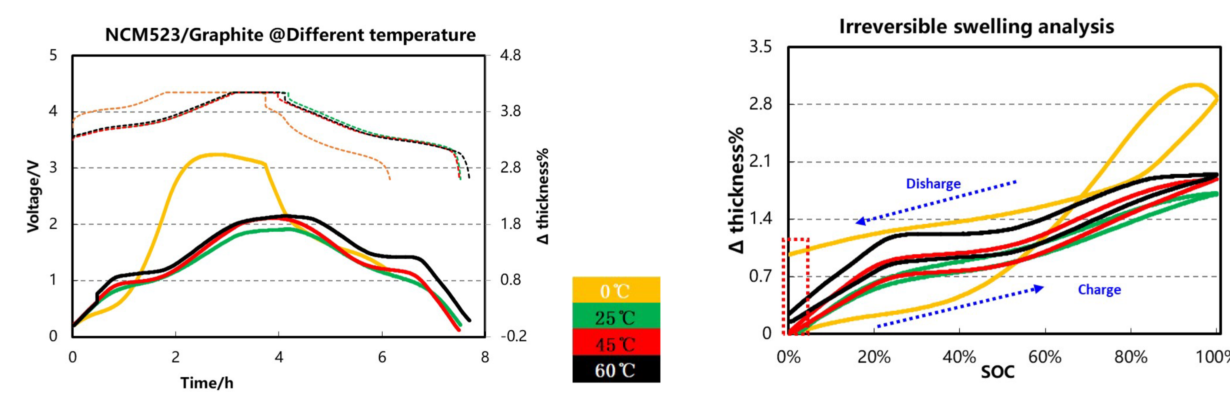


Test Conditions: ⊘NCM523/Gr Prismatic Cells(2400 mAh) ⊘34cm*46cm*106cm(T*W*L) ⊘Pre-stress: 50N/500N/1000N

Conclusion

1. The proportion of irreversible swelling of the cells can be reduced by increasing the pre-stress.
2. During the charge process, the 2 inflection points of the swelling curve correspond to the 2 peaks of the differential capacity curve, indicating that the swelling of the cell is related to the phase transition of lithium intercalation & deintercalation.

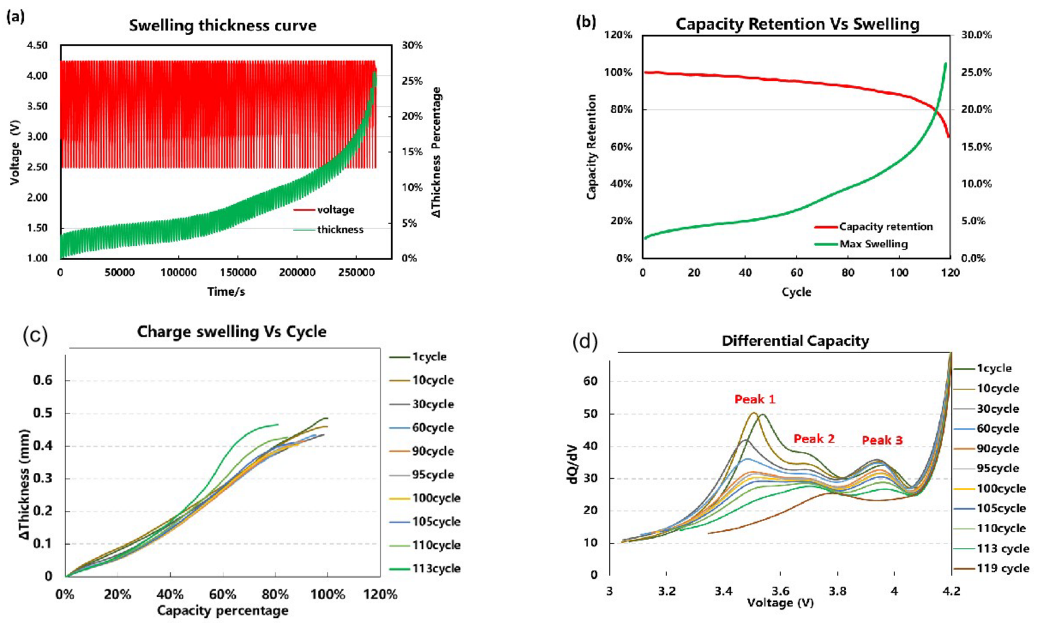
(2) Swelling of prismatic cells under different temperature



Test Conditions: ⊘NCM523/Gr Prismatic Cells(2400 mAh) ⊘34cm*46cm*106cm(T*W*L)
⊘Temperature: 0°C/25°C/45°C/60°C

Conclusion: The **irreversible swelling of the cells increases** in both cases when the temperature increases from 25°C to 60°C, as well as decreases from 25°C to 0°C. However, the causes of such swelling under high-temperature and low-temperature conditions may differ.

(3) Swelling of prismatic cells under different cycles



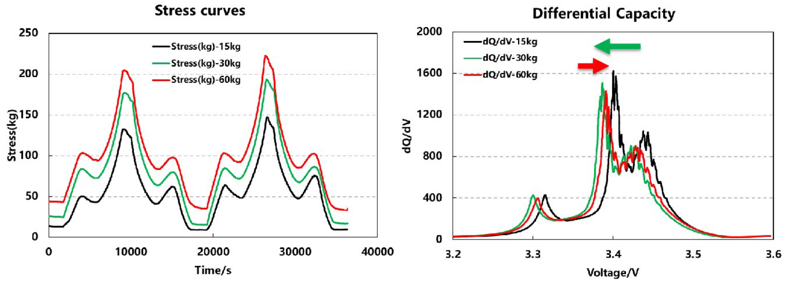
Test Conditions: NCM811-Gr Prismatic Cell (50 Ah) Voltage: 3V ~ 4.2V Rate: 1C

Conclusion

1. The **swelling curve** of the cell corresponds to its **capacity attenuation curve**. Generally, when there is a sudden drop in capacity (the intersection point of the 2 curves), it is either due to gas generation or side reactions.
2. Lithium plating may occur after 115th cycle.

(4) Swelling of prismatic cells under different pre-stress

Pre-stress(kg)	Pre-stress(kPa)	Max Stress(kg)-1st cycle	Max Stress(kPa)-1st cycle
15	5	130	51
30	10	170	67
60	20	200	79



Test Conditions

- LFP/Gr Prismatic Cells(100 Ah)
- Pre-stress: 15kg/30kg/60kg

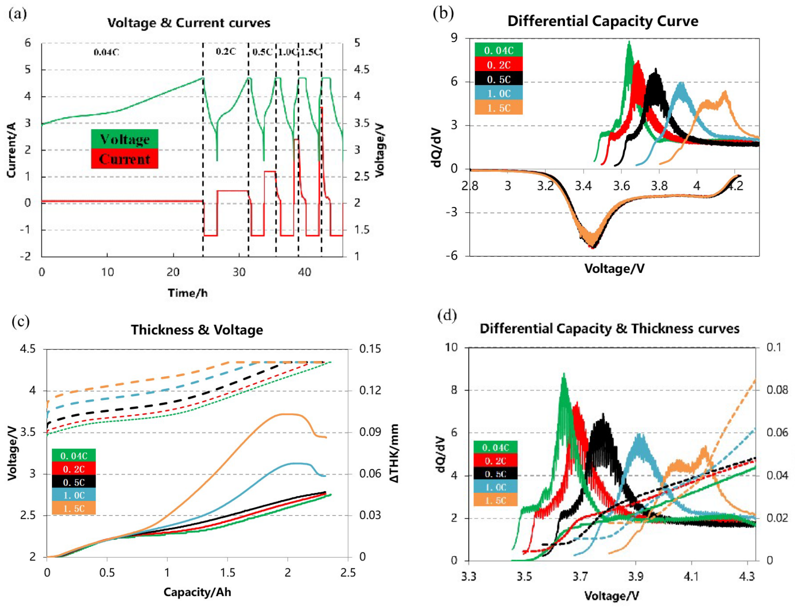
Conclusion

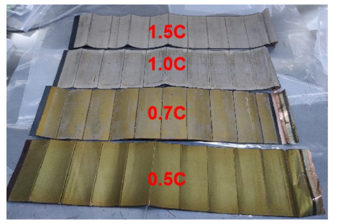
1. The **initial gap** of the cells gradually **decreases** with the increase of pre-stress, and the **variation in swelling force** becomes more significant during the charge and discharge process.

2. The **charge polarization** of the cells first decreases and then increases with the increase of pre-stress, indicating that a pre-stress of around **30kg** is beneficial for improving **the rate performance of prismatic cells**.

E Non-destructive lithium plating analysis

(1) Lithium plating under different rate



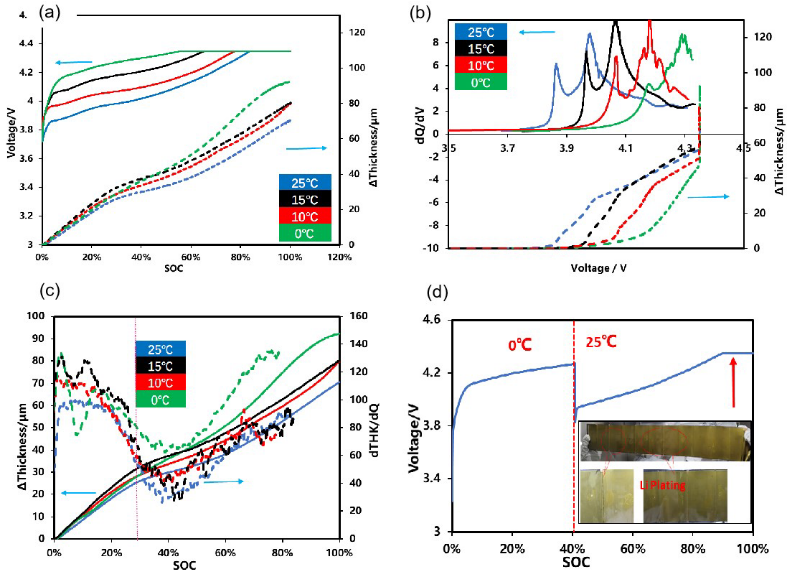


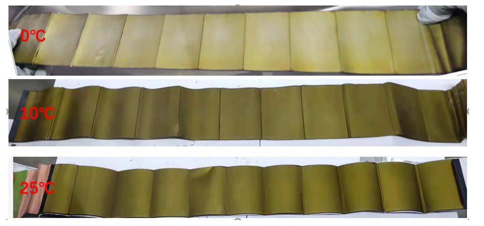
Test method: Charge the cells at different rates and discharge them at the same rate to analyze the differences in their voltage curves and swelling thickness curves.

Conclusion

1. The slope of the cell' s thickness curve increase with the increase of rate.(c)
2. Lithium plating gets more and more serious with increase of rate.

(2) Lithium plating under different temperature





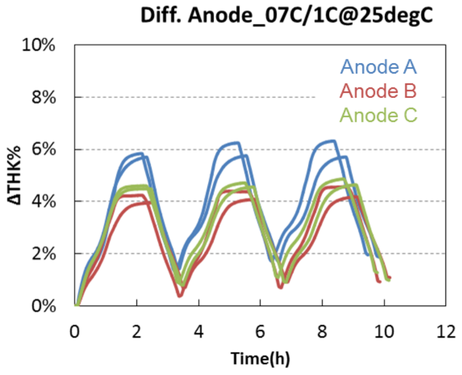
Test method: In situ detect the thickness curves of batteries with different temperatures.

Conclusion: The position where the thickness curve at a certain temperature bifurcates compared with the thickness curve under high temperature which is without lithium plating is the temperature window of the lithium plating.

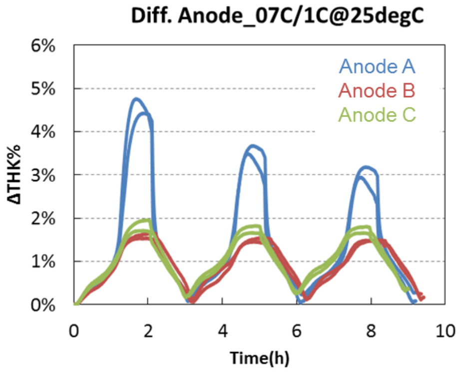
E Application Case -Cell structure

(1) Multi-layer jelly rolls vs. Single-layer stacked cells

Winding cell expansion



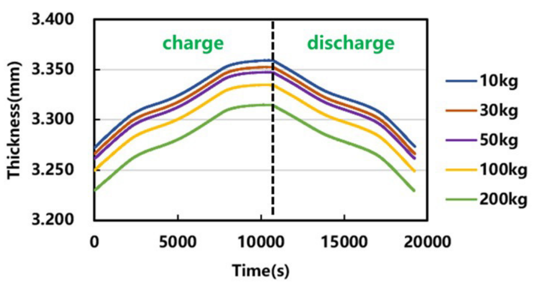
Stacked cell expansion



Conclusion: The swelling ratio of jelly rolls is greater than that of stacked cells, cause the stress in stacked cells can partially release in all directions, resulting in a smaller overall swelling thickness.

(2) Swelling stiffness VS Compression stiffness under constant pressure

Test Conditions: ✓Cell：LCO/GR 2400mAh ✓Constant pressure：10/30/50/100/200kg

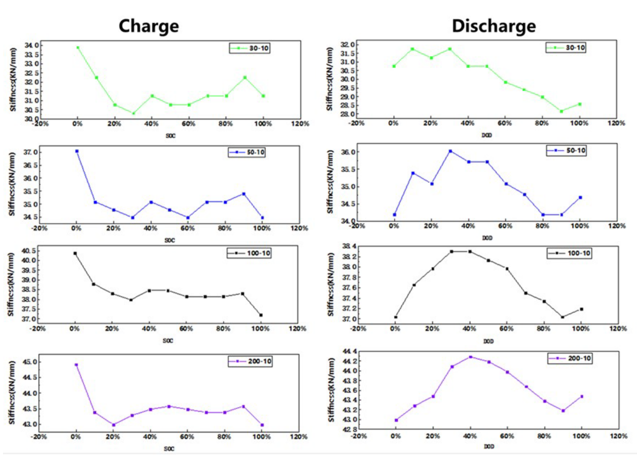


Compression stiffness

stress / stiffness (KN/mm) / SOC	30-10	50-10	100-10	200-10
0%	40.8	42.6	51.7	62.1
30%	90.9	64.5	67.7	75.7
50%	71.4	45.5	59.2	67.6
80%	83.3	66.7	69.8	77.6
100%	71.4	61.5	65.2	69.6

Expansion stiffness

stress / stiffness (KN/mm) / SOC	30-10	50-10	100-10	200-10
0%	33.9	37.0	40.4	44.9
30%	30.3	34.5	38.0	43.3
50%	30.8	34.8	38.5	43.6
80%	31.3	35.1	38.1	43.4
100%	31.2	34.5	37.2	43.0

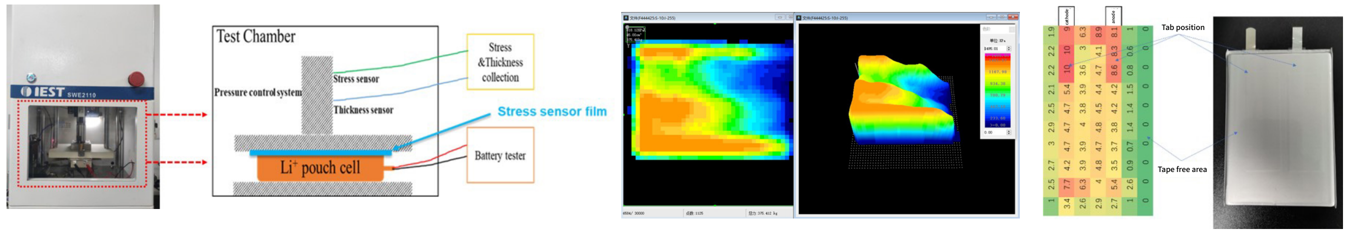


Conclusion

1. The expansion stiffness changes regularly with charging and discharging.
2. The difference between expansion stiffness and compression stiffness is obvious.

E Battery Pressure Distribution Film

(1) Application



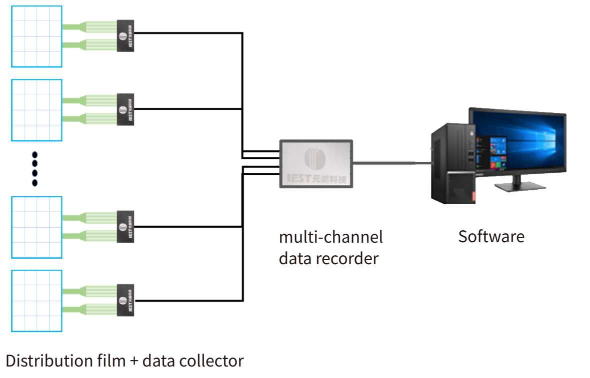
(2) Features

Real-time display of force-time curve

Real-time synchronization of charge & discharge data

One click test data export

Visualization of cell pressure distribution (Uniformity)



Model Table

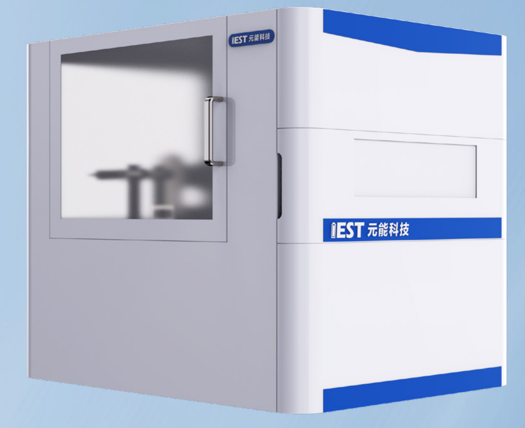
Image	Model	Range (MPa)	Points Supported	Precision	Thickness	Collection Equipment	Software
	BPD1100-M	0.2-2MPa, 0.3-3MPa 0.5-5Mpa, 1-10MPa	It's able to support up to 2288 points,but it needs to be converted according to the area. It can support up to 248/cm²	3%~10%	≤0.35mm	1.Data transmission：USB2.0 2.Equipment interface：quick self-locking aviation plug interface 3.system power consumption：2.5w (5V,0.5A) 4.Scanning frequency：MAX 100Hz 5.pressure resolution：256 (8bit) 6.Equipment weight：less than 1KG	1. Pressure lattice, 2D and 3D three-dimensional color scale images. 2. Real-time pressure distribution data automatic analysis function, recording and storage. 3. Able to record and stop, load recording files, fast forward, rewind, and slow playback. Pressure distribution images, mountain contours, thermal images. 4. Real-time display of the pressure value of each sensing unit, pressure data area, and pressure and time curves,etc. 5. Pressure distribution data import and export,etc. 6. Select a more suitable range according to the application scenario software.
	BPD1100-L	0.2-2MPa, 0.3-3MPa 0.5-5Mpa, 1-10MPa	It can support up to 9152 points. But it needs to be converted according to the area. It can support up to 248/cm²	3%~10%	≤0.35mm		

Note: IEST prioritizes continuous product updates, and our specifications are subject to change without prior notice.

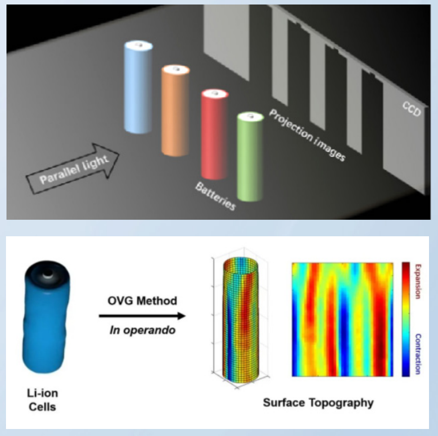
Multiple Measurement Ranges, Multiple Sensing Points, Multiple Software Features!

Cylindrical Cell Swelling Volume Analyzer

Scan QR code for details



A Product Features



- Optical Imaging + 3D Reconstruction + Real-time Online Monitoring
- Non-contact, Non-destructive
- High-throughput testing, suitable for mass production

Real time reconstruction of battery surface morphology and calculation of volume deformation during charge and discharge processes. Combining voltage and current data to detect and predict battery health condition from a higher dimension.

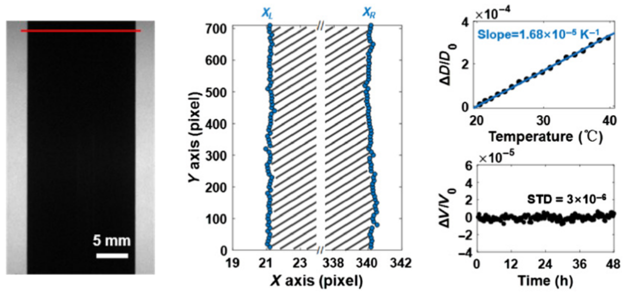
B Model Table

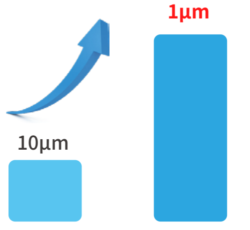
CCS1400				
Compatible Cell	Channel Number	Optical Detection Resolution	Weight	Size(W×D×H)
Cylindrical Cell	4	0.1μm	900kg	2500x2600x1850 mm

Note: IEST prioritizes continuous product updates, and our specifications are subject to change without prior notice.

C Leading Technology

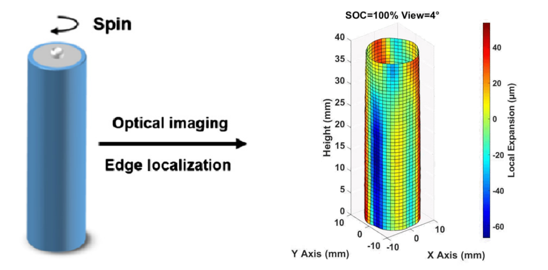
High-precision Detection Technology

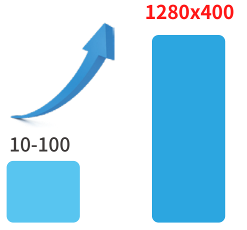




Measurement accuracy increased tenfold

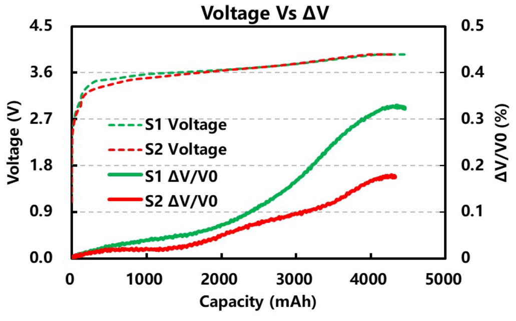
Rotational 3D Reconstruction Technology

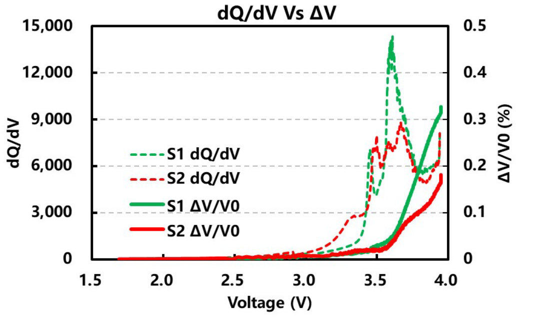




The number of sampling points increased by ten thousand times

D Application Case



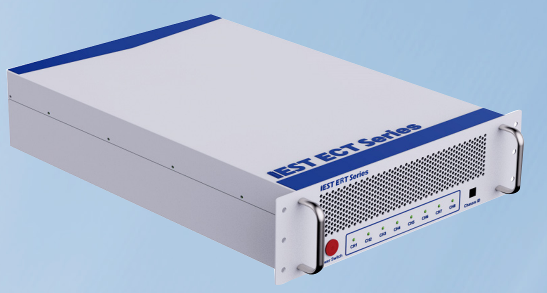


21700 Cell parameters: Sample 1-15%SiC ; Sample 2-10%SiC

The volume swelling curve during formation shows that as the silicon content increases, the volume swelling during formation process increases, and the peak corresponding to lithium intercalation on the differential capacity curve becomes higher.

Electrochemical Property Analyzer

Scan QR code
for details



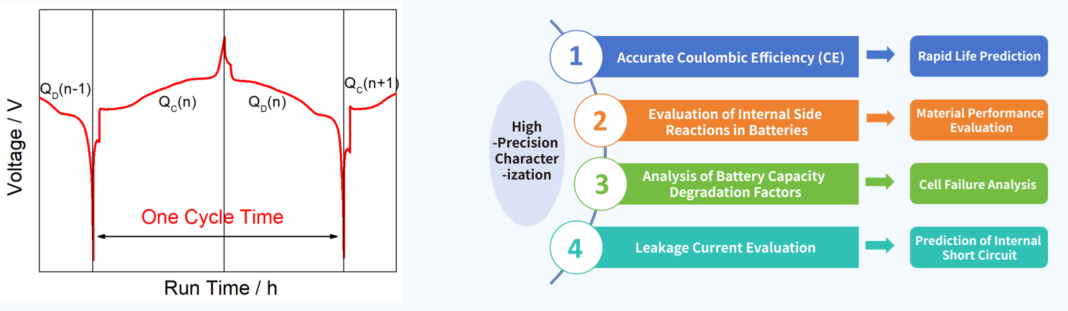
A Model Table

NO.	Product Name	Model	Current Range	Description
1	Electrochemical Performance Analyzer ECT Series	ECT6008 - 5V 100mA	Four range auto switch 0.1mA , 1mA, 10mA, 100mA	Number of channel: 8 Voltage range: ±5V Maximum sampling rate: 10 SPS Response time: 5 ms Accuracy: 0.01% **CV &LSV:none** Temperature range: 10 ~ 80°C (optional) Functions: Voltage-current-time curve, Capacity-cycle curve, dV/dQ & dV/dQ curve, DCIR analysis, GITT,PITT, CA-CP
		ECT6008 - 5V12A	Four range auto switch 12mA, 120 mA , 1.2A, 12A	
2	Electrochemical Performance Analyzer ERT-6 Series	ERT6008-5V100mA	Four range auto switch 0.1mA , 1mA, 10mA, 100mA	Number of channel: 8 Voltage range: ±5V Maximum sampling rate: 10 SPS Response time: 5 ms Accuracy: 0.01% **CV &LSV:available** Temperature range: 10 ~ 80°C Functions: Voltage-current-time curve, Capacity-cycle curve, dV/dQ & dV/dQ curve, DCIR analysis, GITT, PITT, CA-CP
		ERT6008-5V12A	Four range auto switch 12mA, 120 mA , 1.2A, 12A	
3	Electrochemical Performance Analyzer ERT-7 Series	ERT7008-5V 100mA	Four range auto switch 0.1mA , 1mA, 10mA, 100mA	Number of channel: 8 Voltage: 5V Accuracy: 0.01% **CV &LSV& EIS: available** Temperature range: -20 ~ 80°C Functions: Voltage-current-time curve, Capacity-cycle curve, dV/dQ & dV/dQ curve, DCIR analysis, GITT, PITT, CA-CP **EIS frequency range: 100k ~ 0.01Hz**
		ERT7008-5V12A	Four range auto switch 12mA, 120 mA , 1.2A, 12A	

Note: IEST prioritizes continuous product updates, and our specifications are subject to change without prior notice.

B High-Precision Current & Voltage Testing

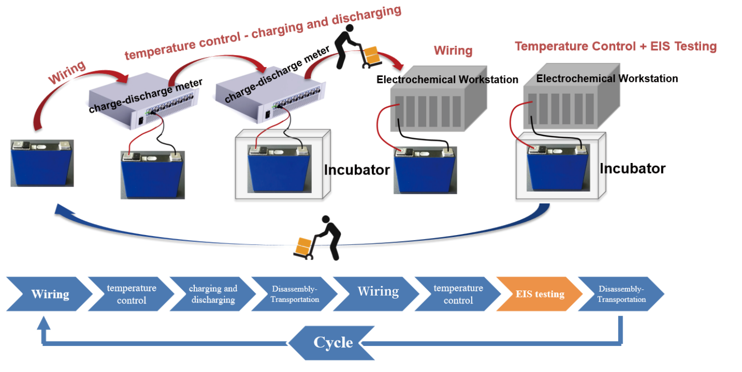
Accuracy Comparison — IEST: 0.01% VS Others: 0.05%



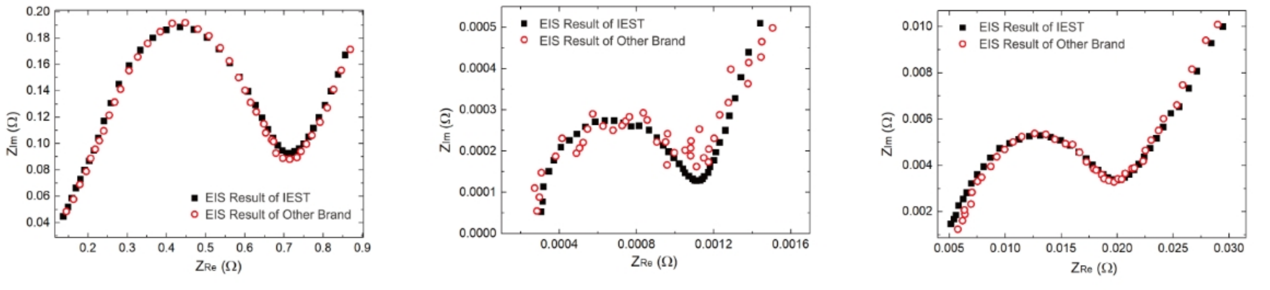
The 0.01% testing accuracy can precisely measure the specific capacity of new materials and detect subtle side reactions during the initial stages of battery cycling. This allows for a comprehensive performance evaluation and lifetime prediction of the battery in a short period.

C CV&EIS + Battery Cycler

Traditional method

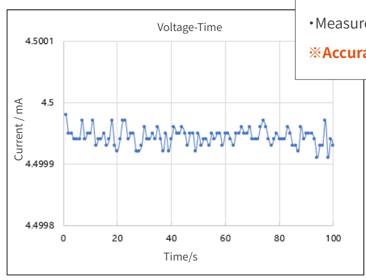


IEST Method



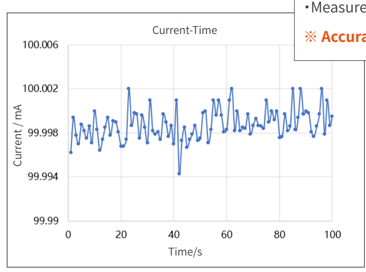
Minimize wiring, handling, and temperature adjustments, streamline operations

D IEST Innovative Solutions



Example of constant voltage control
- Set value: 4.5V
- Measured value: 4.5V ± 100μV

※ **Accuracy set at below 0.01%**



Example of Constant Current Control
- Set value: 100mA
- Measured value: 100mA ± 5μA

※ **Accuracy within 0.01% of the set value**

ECT & ERT Series Products

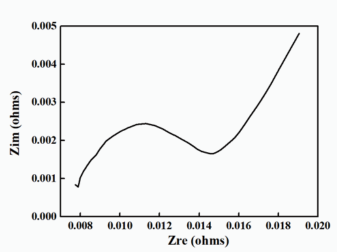
Product	Test Items	Function
ECT/ERT All Series	Constant current, constant voltage, constant power, constant resistance, rate mode, etc.	Conventional charging and discharging functions
ECT/ERT All Series	Capacity-cycle curve, dQ/dV curve, dV/dQ curve, etc.	Study the relationship between the diffusion process of matter and charge transfer
ECT/ERT All Series	PITT、GITT、DCIR	Study the relationship between the diffusion process of matter and charge transfer
ECT/ERT All Series	CA、CP	Record the change of potential/current with time under constant current or constant voltage
ERT All Series	CV、LSV	Apply linear voltage and record current-voltage curve
ERT-6Series/ ERT-7Series	EIS	Study the relationship between electrochemical impedance and frequency

Equipped with a 24-bit ADC and 16-bit DAC, achieving high-precision voltage and current control and testing.

E Offer common functions of an electrochemical workstation

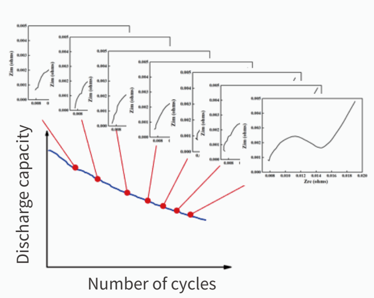
The ERT series includes common electrochemical workstation functions such as CV, LSV, EIS, CA, and CP.

Case 1: EIS Test

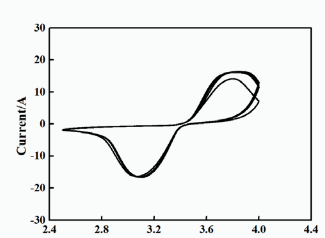


2.2Ah Pouch cell Impedance Test
[Frequency: 100KHz～0.1Hz]

Case 2: Cyclic EIS Test

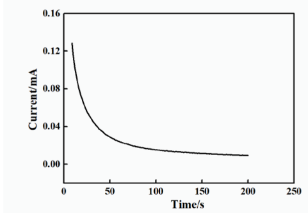


Case 3: CV (Cyclic Voltammetry) Test

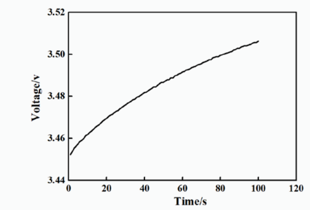


CV test of 120mAh Pouch cell
[Scan speed: 1mV/s]

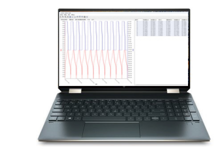
Case4: CA · CP Test



120mAh Pouch cell CA Test



120mAh Pouch cell CP Test



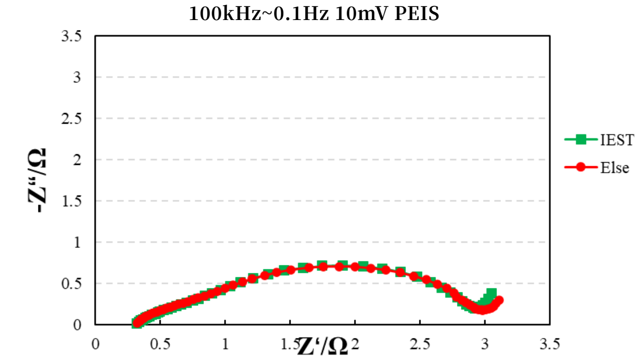
- EIS
- CV
- LSV
- CA
- CP
- GITT

Eliminate switching time between instruments

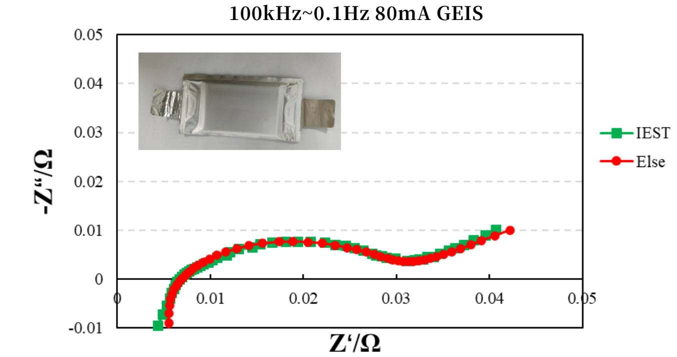
F Comparison of EIS results with other electrochemical workstations

High-frequency EIS impedance: 0.01Hz~100kHz, meeting the high-frequency impedance test requirements of 10mΩ~kΩ level batteries

Coincell-4.15V-25℃
100kHz~0.1Hz 10mV PEIS



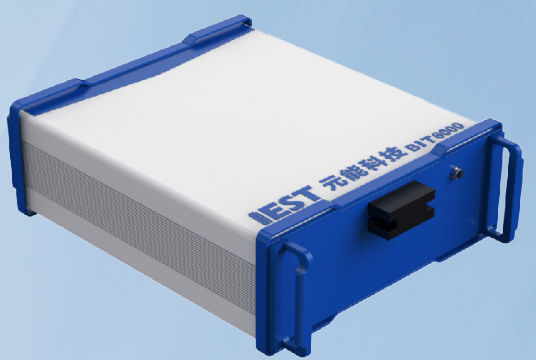
2Ah Pouchcell-3.19V-25℃
100kHz~0.1Hz 80mA GEIS



Compared with the EIS test results of well-known foreign electrochemical workstations, the error is within 5%.

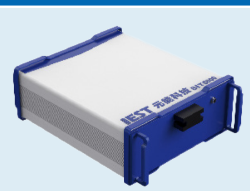
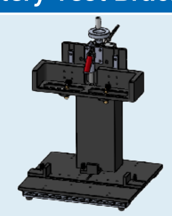
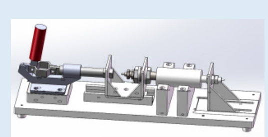
Battery Impedance Tester

Scan QR code
for details



- EIS Test for Large-capacity Batteries (Single & Cycle test)
- Battery Consistency Screening (Abnormal Battery Screening)
- SOH Rapid Estimation (Cascade Utilization)
- Battery Failure Analysis (Production Problem Troubleshooting)

A Model Table

	Battery Impedance Tester	Adjustable Prismatic Battery Test Bracket	Adjustable Cylindrical Battery Test Bracket
Physical picture			
Model	BIT6000	APTB1000	ACTB1000
Voltage control accuracy	±0.006% F.S	Applicable to all kinds of prismatic batteries Maximum length*width*height 284*94*255 mm Maximum tab spacing 40 ~ 240 mm (Other sizes can be customized)	Applicable to cylindrical batteries18650/21700, etc. Maximum length 130 mm Diameter range 18 ~ 50 mm (Other sizes can be customized)
Current control accuracy	±0.05% F.S		
EIS frequency range	1500Hz ~ 0.1 Hz		
EIS test range	0.05mΩ ~ 100mΩ		
Applicable battery capacity	2~1000A lithium-ion battery		

Note: IEST prioritizes continuous product updates, and our specifications are subject to change without prior notice.

B Background

Battery Manufacturers

Q1: The larger the battery capacity, the smaller the internal resistance. Traditional electrochemical workstations cannot perform effective testing and they are expensive if used with current amplifiers;

Q2: Different batteries can' t be distinguished by OCV or 1000Hz ACIR alone. How can the batteries be sorted more finely?

Q3: If there is an abnormality in the battery, how can we quickly locate the production problem? Is it a poor welding? Or a poor formation? Or is it a material failure?

Battery Use & Recycling Companies

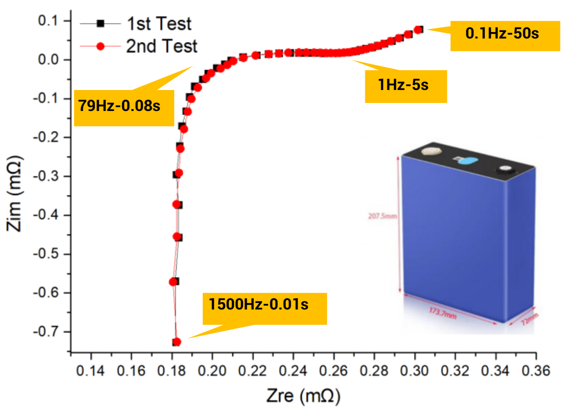
Q4: How to judge the consistency of the battery before assembling the battery module? OCV or 1000Hz ACIR alone can no longer meet the requirements;

Q5: Are there differences between the same type of batteries purchased from different manufacturers? Can they be mixed?

Q6: How much SOH is left for recycled or disassembled batteries? How to perform cascade utilization?

C EIS test of battery with large capacity & low internal resistance

EIS Test for 280Ah LFP Battery (1500 Hz~0.1 Hz)

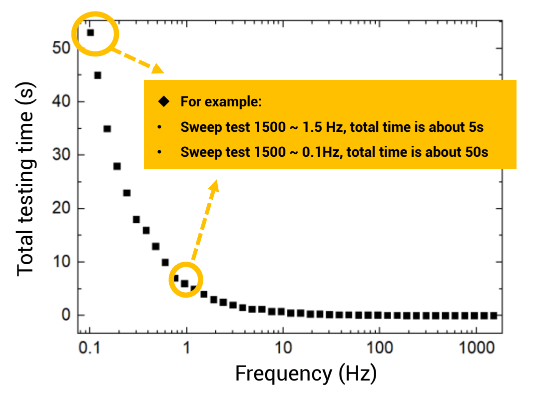


Easily test EIS of batteries with large capacity and low internal resistance

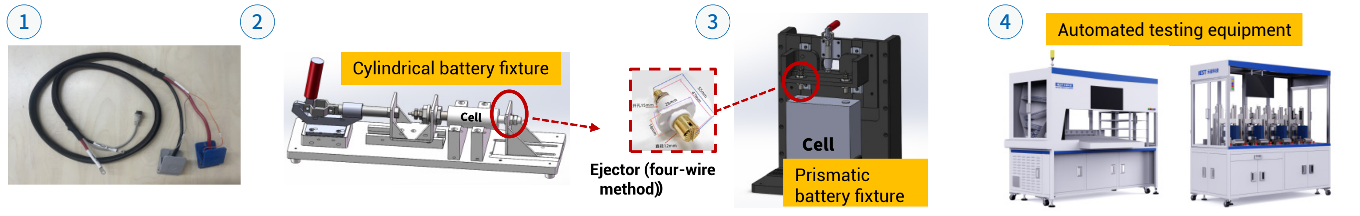
Fast EIS test, 1Hz impedance only takes 5 seconds

Can be used with various fixtures and automation equipment

Frequency vs. Total Test Time

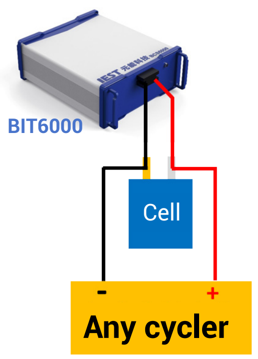


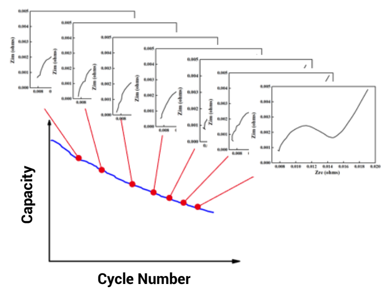
Support customization of various test lines or fixtures

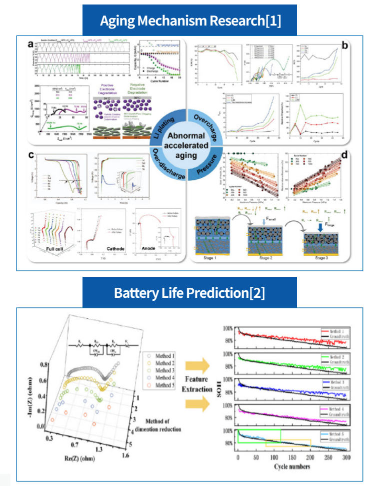


The EIS test frequency range can be adjusted according to the production line progress and process section

D EIS test during battery cycling







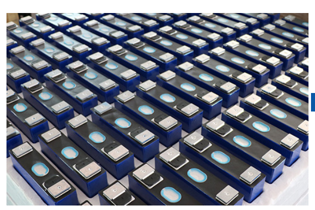
Save the switching time between "temperature adjustment ⇔ charge and discharge instrument ⇔ electrochemical workstation"

[1] J. Phys. Chem. C, 127 4465-4495 (2023);

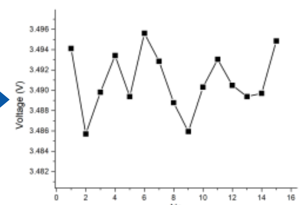
[2] J. Power Sources, 576 233139 (2023);

E Battery consistency screening (abnormal battery screening)

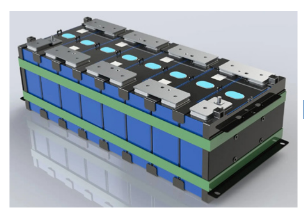
Traditional battery sorting method



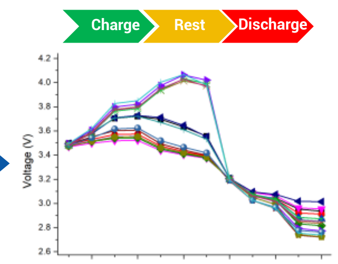
A batch of batteries "to be used"



Choose batteries with consistent "OCV"

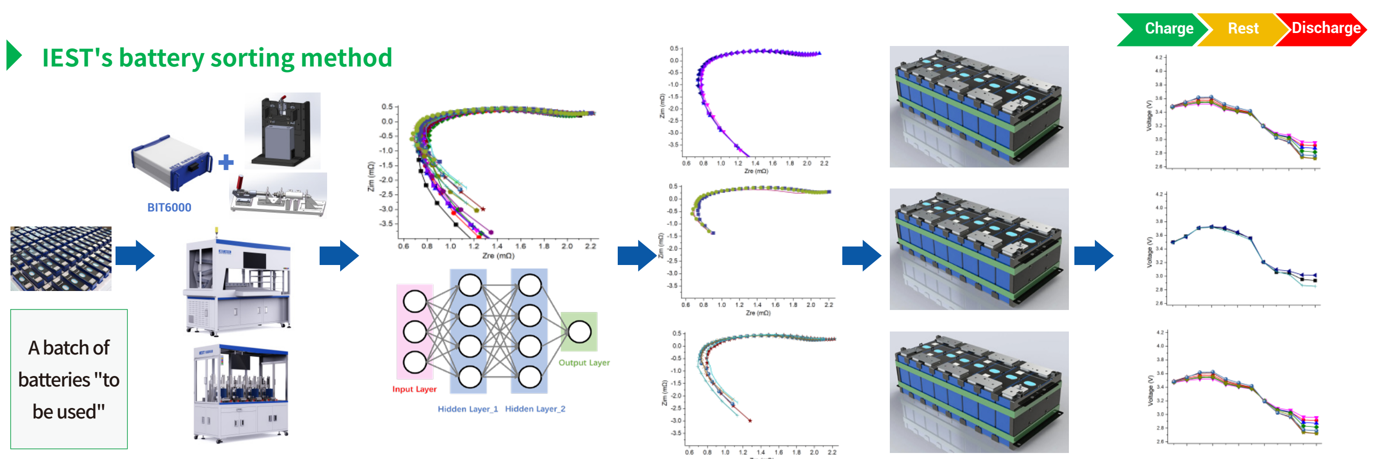


Assemble into battery module



Unable to solve the problem of inconsistent charging and discharging

IEST's battery sorting method



A batch of batteries "to be used"

Test the EIS curves and classify it using a neural network algorithm

Choose batteries with consistent "EIS"

Assemble into battery module

Ensure the consistency of batteries in the module

F SOH rapid estimation（cascade utilization）

Traditional battery grading and cascade utilization:

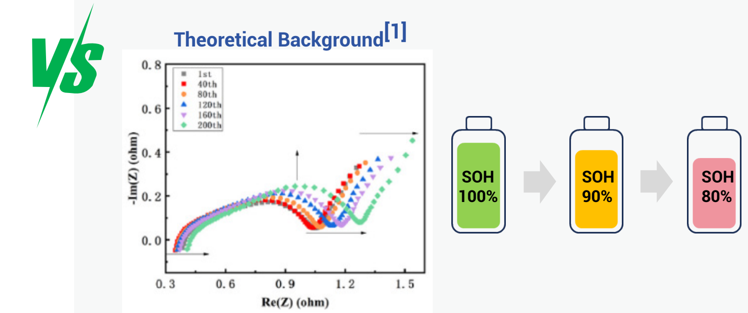
1. A batch of recycled batteries
2. Charge and discharge the batteries
3. Grouping and tiered utilization based on capacity

Three major disadvantages:

- Long grading time
- High power consumption
- Many channels occupied

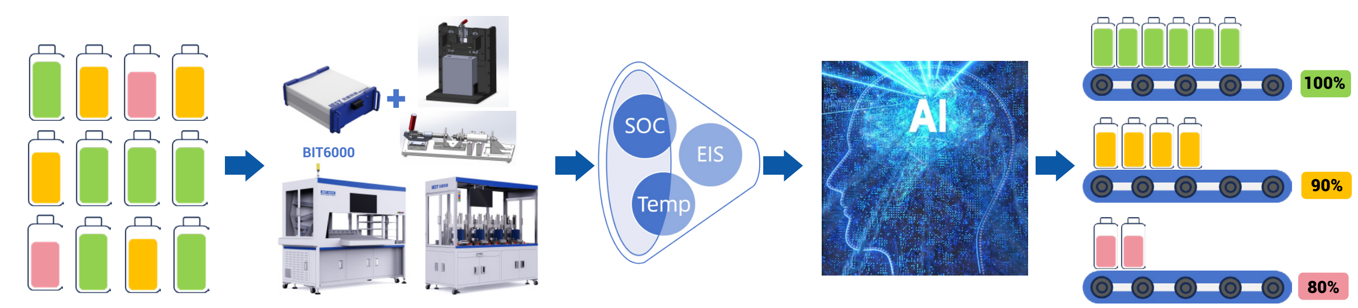
IEST's rapid grading solution:

1. A batch of recycled batteries
2. Perform EIS test on the batteries
3. According to the correlation model between EIS and capacity, conduct rapid capacity division



[1] J. Power Sources, 576 233139 (2023);

As the battery health (SOH) decreases, its EIS test results will also change accordingly



A batch of recycled batteries (different SOH)

SOH rapid prediction model based on EIS test

SOH estimation accuracy <5% (big data modeling required)

Applications:

Battery Recycling & Cascade Utilization

Battery Pack After-Sales Outlets

Used Car Recycling

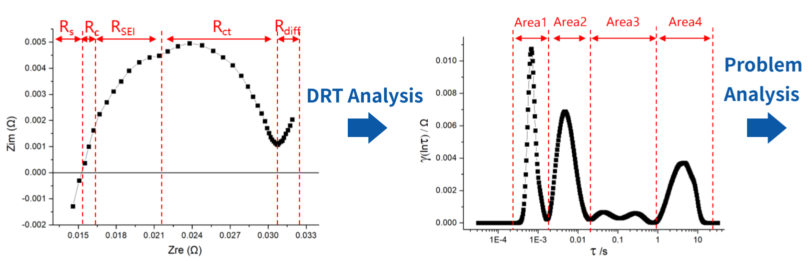
G Battery cell failure analysis (production problem troubleshooting)

Distribution of Relaxation Times (DRT) analysis is a mathematical method for analyzing EIS spectra. Different from conventional equivalent circuit fitting, DRT analysis can avoid various problems such as

① the fitting model depends on the initial value;

②the fitting result is distorted;

③ different models can be fitted, but the mechanism explanation is not unified.



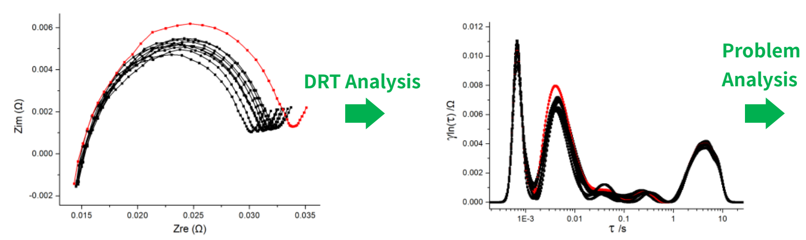
Contact impedance R_s : The sum of all electronic resistances inside the battery, which is related to various problems

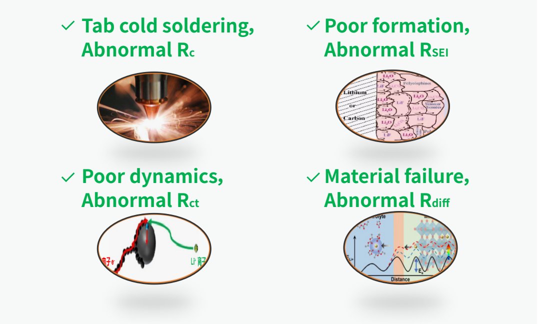
Contact impedance R_c ⇔ Area1 : problems such as poor soldering of the tab and poor contact

SEI film impedance R_{SEI} ⇔ Area2 : problems such as poor formation folding and wrinkling of the electrode

Charge transfer impedance R_{ct} ⇔ Area3 : problems such as poor interface dynamics and lithium precipitation

Ion diffusion impedance R_{diff} ⇔ Area4 : problems such as poor electrode compaction and poor electrolyte infiltration





Key Achievement

- **700+** Customers served
- **2500+** Instruments supplied
- **5** National Testing Standards drafted
- **100+** LIBs Testing Patents granted
- **230+** Application Articles published
- **20+** papers in leading journals published

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Featured Clients

CATL, ATL, BYD, Envision AESC, LG Energy Solution, ACC Automotive Cells Co, CABOT, SK, EcoPro BM, Factorial, Sila, Albemarle, Vianode, CUBERG, AM Batteries, OneD Battery Sciences, SINTEF, 容百科技 Ronbay Technology, Mitra Chem, wisk, Verkor, Cellforce, Amita Technologies, Inc., Amara Raja, HUAWEI, 清华大学 Tsinghua University, PowerCo, Hanwha Solutions, IBU tec, NOVO