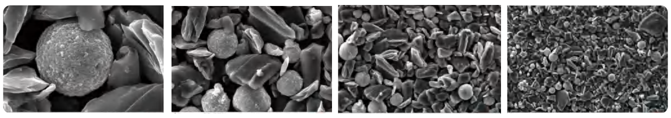
–Dedicated to lithium-ion battery testing and development–

IN SITU RAPID SCREENING FOR SILICON-BASED ANODE SWELLING

RSS1000



- ANALYTICS BEYOND MEASURE -

1. The significance of measuring the expansion behavior of silicon-based anode

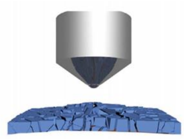
Due to its unique advantages such as high theoretical capacity (4200mAh/g) and rich resources, silicon (Si) anode is expected to replace the widely used graphite anode and become the main anode material for the next generation of lithium-ion batteries. However, the rapid capacity degradation of silicon materials in the cycle process seriously hindered the practical application process, which was mainly due to the volume expansion of silicon anode more than three times during the lithium insertion process, thus destroying the original solid electrolyte interface (SEI) on the surface of silicon atoms. With the charging and discharging cycle of the battery, the SEI film is also constantly destroyed and regenerated, and a large amount of electrolyte is consumed, resulting in a rapid decline in battery capacity. Therefore, it is urgent to solve some problems caused by the volume expansion of silicon anode.

At present, researchers often use composite technology to compensate the volume expansion of silicon materials by using "buffer skeleton". The common composite routes can be generally divided into silicon-carbon composites, silicon-polymer composites, silicon-based alloy composites, and so on. Silicon-carbon composites are relatively easy and tightly combined. Because it combines the high stability and conductivity of carbon materials, as well as the high specific capacity of silicon materials, it not only effectively suppresses the thickness expansion within a controllable range, but also increases the energy density and cycle life of the battery. It is regarded as the most industrialized silicon-based negative electrode product, and has received a lot of attention.

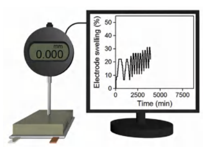
It is worth noting that although the composite technology can alleviate the volume expansion of silicon-based anode, it cannot fundamentally solve the problem. With the increase of silicon content in silicon-based anode, its volume expansion is also more significant. Therefore, if the volume expansion behavior of silicon-based anode can be rapidly evaluated in situ, it will affect the Material research and development, production and manufacturing have great significance!

2. Traditional test methods

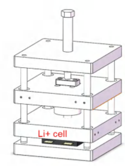
Traditional method	Disadvantage
Electron microscopy observation	Non in-situ test, high equipment requirements, small measurement range, human / material consumption
Micrometer / PPG measurement	Non in-situ test, large human error, poor repeatability, and small measurement range
Traditional tooling fixtures	Fixed bolt is easy to loosen and deform, resulting in large measurement error and poor repeatability



Electron microscopic observation

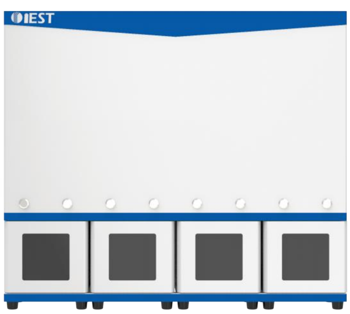


Micrometer measurement



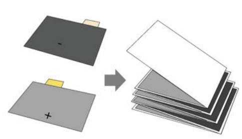
Traditional fixture measure expansion force

3. Introduction of silicon-based anode expansion in-situ fast screening system



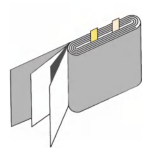
Model Coin Cell

Quickly evaluate the expansion properties of the material



Laminated Battery

Quickly evaluate the expansion behavior of the electrode



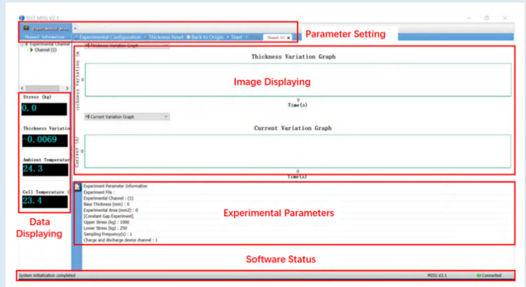
Pouch Cell

In-situ characterization of the expansion property of the cell

Product Features

1. In-situ characterization of the expansion thickness change of the silicon based system
2. Four-channel simultaneous testing of multiple cells
3. Suitable for in-situ testing of various battery cell structures: model coin battery, laminated battery, pouch battery, etc.
4. Visual operation interface, one-click export of data report

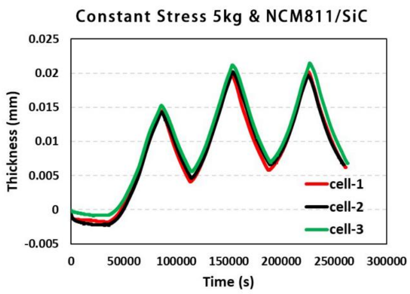
Software page



4. Application

1. In-situ expansion test of model coin cell:

- Cell parameters:Coin full battery (NCM811 / SiC), capacity of about 3 mAh;
- Experimental parameters of in-situ expansion:Current is 0.3 mA, voltage interval is 2.5~4.2V, co-cycle for three circles, and record the relative expansion thickness of the full Coin power synchronously;
- Experimental result:



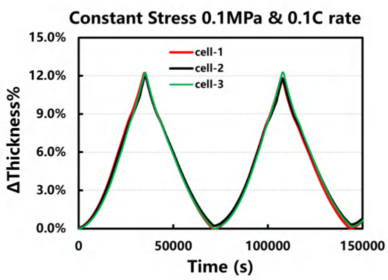
No.	charge Q/mAh	Thickness /mm
cell-1	3.13	0.0157
cell-2	3.07	0.0155
cell-3	3.11	0.0155
mean	3.10	0.0156
sigma	0.025	9.43E-05
cov	0.8%	0.6%

The total Coin current expands / shrinks with the charge / discharge process, and the inflection point of the voltage curve in the three cycles is highly consistent with the inflection point of the thickness expansion curve, indicating that the expansion thickness curve can effectively reflect the volume change in the process of electrode stripping / lithium embedding in the Coin plate. The average variation of the relative thickness was about 0.0156mm, and the COV of the expansion thickness was only 0.6%, indicating the good cycle consistency of the model Coin.

N Note: Coefficient of variation COV (Coefficient of Variation) = (standard deviation sigma) / (mean mean)

2.In-situ expansion test of multi-layer laminated cells:

- Cell parameters:Multi-layer laminated battery (NCM811 / SiC), with a capacity of about 400 mAh;
- Experimental parameters of in-situ expansion:
  Three parallel samples, synchronously test the percent expansion thickness at a constant pressure of 0.1MPa
- Experimental result:

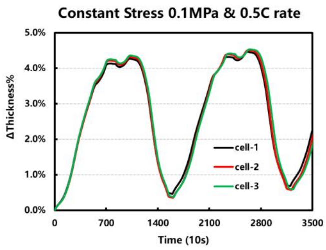


No.	charge Q/mAh	charge swelling/%
cell-1	371.2	12.5%
cell-2	371.6	12.1%
cell-3	374.1	12.2%
mean	372.30	12.3%
sigma	1.283	0.002
cov	0.3%	1.4%

The multilayer laminated battery expands / contracts with the charge / discharge process, and the two cycles maintain good repeatability. The maximum expansion ratio corresponding to the full battery is about 12.5%, and the expansion thickness COV of the three groups of cells is 1.4%, indicating a good agreement between the parallel samples.

3. In-situ expansion test of the pouch cell winding battery::

- Cell parameters:Multi-layer winding pouch cell battery (NCM811 / SiC), capacity of about 400 mAh;
- Experimental parameters of in-situ expansion:Three parallel samples, synchronously test the percent expansion thickness at a constant pressure of 0.1MPa.
- Experimental result:



No.	charge Q/mAh	charge swelling/%
cell-1	4416.7	4.1%
cell-2	4445.4	4.2%
cell-3	4439.3	4.3%
mean	4433.8	4.2%
sigma	12.345	0.001
cov	0.3%	1.9%

The soft pack battery expands/contracts with the charging/discharging process, and the results of the two cycles maintain good repeatability. When the battery is fully charged, the corresponding maximum expansion ratio is about 4.3%, and the expansion thickness COV between the three groups of batteries is 1.9%, indicating that the consistency between parallel samples is good.

5. Model Specifications Equipment parameters

Different model parameters of the RSS series

Model	RSS1100	RSS1200	RSS1300	RSS1400
Number of channels	4		4	
Pressure regulation mode	with weight		With servo motor	
Pressure range	0.5kg/1kg/5kg (Customizable according to customer needs)		1~100kg	
Pressure Resolution /accuracy	±0.01kg		0.1kg/±0.3%F.S.	
Scope of thickness detection	±5mm	±5mm	±5mm	±5mm
Thickness detection resolution / precision	0.1μm/±1μm	0.01μm/±0.1μm	0.1μm/±1μm	0.01μm/±0.1μm
Systematic error	≤3%	≤3%	≤3%	≤3%
Maximum cell size measurement	60*90*4mm (can be customized according to specific needs)			

Installation requirements

Model	RSS1100	RSS1200	RSS1300	RSS1400
Source	220~240V/50~60Hz		220~240V/50~60Hz	
Voltage change tolerance	±10%		±10%	
Power consumption	20W		400W	
Ambient temperature	25±5℃			
Ambient humidity	80% RH (no moisture condensation)			

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

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