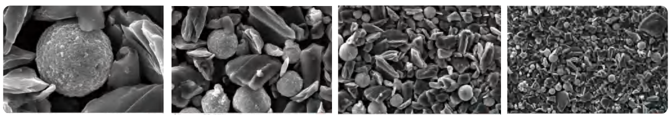
In Situ Rapid Swelling Screening For Silicon-Based Anode

RSS1400



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

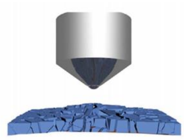
Due to its unique advantages such as high specific capacity (4200mAh/g) and rich resources, silicon (Si) anode is expected to replace the graphite anode and become the main anode material for the next generation of lithium-ion batteries (LIBs). However, the rapid capacity degradation of silicon materials during the cycling process seriously hinderedits practical applications., This is due to the large volume expansion of silicon anode of more than three times during the intercalation process of lithium-ions, which will destroy the original solid electrolyte interphase (SEI) formed on the surface of the silicon anodes. During the cycling of the LIBs, the SEI will be destroyed and regenerated continually, which consumes a large amount of electrolyte and results in a rapid degradation of the capacity.Therefore, it is urgent to solve the problems caused by the volume expansion of silicon anode.

At present, researchers often use composite technology (e.g, "buffer skeleton") to compensate the volume expansion of silicon materials. The common composite routes include silicon-carbon composites, silicon-polymer composites, silicon-based alloy composites, and so on. Silicon-carbon composites are relatively easy and these two elements can also be tightly combined.Because it combines the high stability and conductivity of carbon materials, with the high specific capacity of silic on materials, the silicon-carbon anodes can not only effectively suppresses the volume expansion within a controllable range, but also increase the energy density and cycle life of the LIBs. Thus, it is regard as the most promising silicon-based anode for industrialization, and has received a lot of attentions.

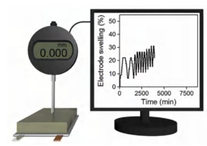
It is worth noting that although the composite technology can alleviate the volume expansion of silicon-based anode, it still cannot fundamentally solve the expansion problem. With the increase of silicon content in silicon-based anode, the volume expansion also becomes more significant. Therefore, iit has great significance for the research and manufacturing of silicon-based anodes if the volume expansion behavior of silicon-based anodes can be rapidly evaluated during the charging and discharging.

2. Traditional test methods

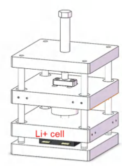
Traditional method	Disadvantage
Electron microscopy observation	Ex-situ test, high equipment requirements, small observation range, human / material consumption
Micrometer / PPG measurement	tEx-situest, large human error, poor repeatability, and small measurement range
Traditional fixtures	Fixed bolt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



Electron microscopic observation

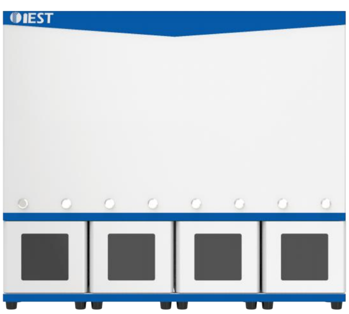


Micrometer measurement



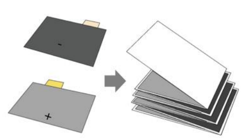
Traditional fixture measure expansion force

3. Introduction of in-situ rapid swelling screening for silicon-based anode



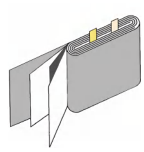
Model Coin Cell

Quickly evaluate the expansion properties of the material



Laminated Battery

Quickly evaluate the expansion behavior of the electrode



Pouch Cell

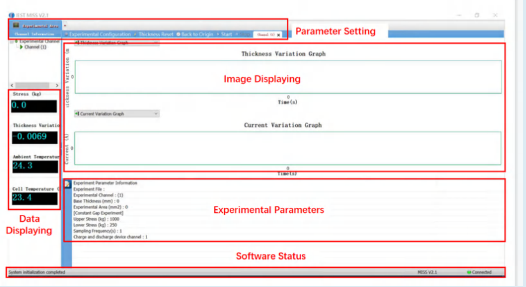
In-situ characterization of the expansion property of the cell

IEST

Product Features

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

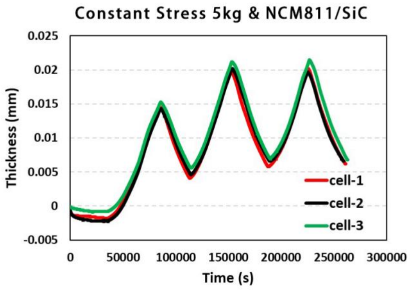
Software Interface



4. Application

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

- Cell parameters:Coin Full coin cell(NCM811 / SiC), with the capacity of about 3 mAh;
- Experimental parameters :Three parallel samples, charing and discharging for three cycles, and synchronously record the expansion thickness of these three full coin cells.
- Experimental result:



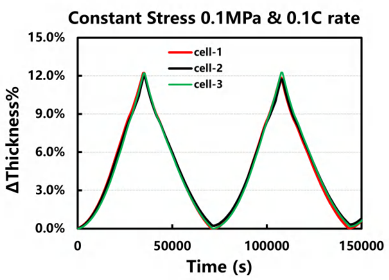
No.	charge Q/mAh	Thickness /mm
cell-1	3.13	0.0157
cell-2	3.07	0.0155
cell-3	3.11	0.0155
mean	3.10	0.0156
sigma	0.025	9.43E-05
cov	0.8%	0.6%

The full coin cellexpands / shrinks with the charge / discharge process, and the turning point of the voltage curve in the three cycles is highly consistent with the turning point of the thickness expansion curve, indicating that the expansion thickness curve can effectively reflect the volume change of the electrodes caused by the intercalation / deintercalation of lithium-ions. was only 0.6%, indicating the good cycle consistency of the model coin cell.

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

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

- Cell parameters:Multi-layer stacked cell (NCM811 / SiC), with a capacity of about 400 mAh;
- Experimental parameters:Three parallel samples, synchronously test the thickness expansion ratioat a constant pressure of 0.1MPa
- Experimental result:

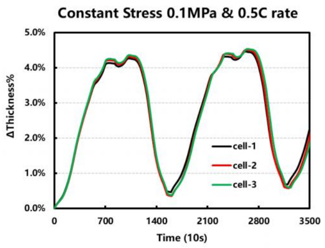


No.	charge Q/mAh	charge swelling/%
cell-1	371.2	12.5%
cell-2	371.6	12.1%
cell-3	374.1	12.2%
mean	372.30	12.3%
sigma	1.283	0.002
cov	0.3%	1.4%

The multilayer stacked cell expands / contracts with the charge / discharge process, and tthe thickness expansion curves of three parallel samples maintain good repeatability for both two cycles.. The maximum expansion ratio is about 12.5%, and the expansion thickness COV of three parallel samples is 1.4%, indicating a good agreement between the parallel samples.

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

- Cell parameters:Multi-layer pouch cell with winding structure (NCM811 / SiC), capacity of about 400 mAh;
- Experimental parameters: synchronously test thickness expansion ratio 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 multilayer pouch cellexpands/contracts with the charging/discharging process, and the thickness expansion curves of three parallel samples maintain good repeatability for both two cycles. When the pouch cell 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 among these three parallel samples.

5. Specifications

Different model parameters of the RSS series

Model	RSS1100	RSS1200	RSS1300	RSS1400
Number of channels	4		4	
Pressure control mode	Spring pressurized		By servo motor	
Pressure range	5kg		1~100kg	
Pressure Resolution /accuracy	±0.1kg		0.1kg/±0.3%F.S.	
Thickness range	±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%
Measurable samples	Model button cell		Model button cell、Laminated cells、soft-packed cells (MAX 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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