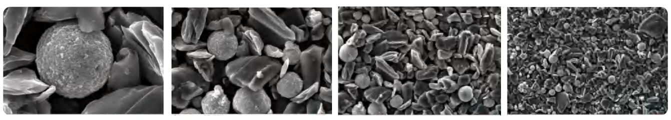
—DEDICATED TO LITHIUM-ION BATTERY TESTING AND DEVELOPMENT—

IEST®

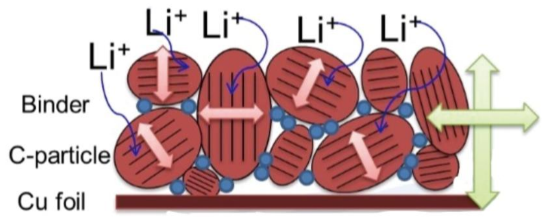
MULTI-CHANNEL IN-SITU SWELLING ANALYZER

MSWE1400



-ANALYTICS BEYOND MEASURE-

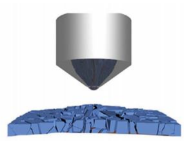
1. Expansion Behavior of Lithium-ion Batteries



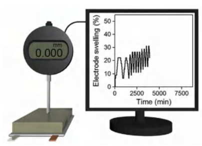
During the process of charging and discharging, the the intercalation and deintercalation of Li-ion in the electrodes will cause the lithium-ion batteries (LIBs) to expand and shrink.
Ideally, the volume change of the material during the lithium intercalation/deintercalation should be reversible. However, in is always a fraction of lithium ions that cannot be completely unembedded from the electrodes or deposited on the anode surface as insoluble byproducts during the cycle. This will cause irreversible expansion of the LIBs and serious consequences, such as: the deformation of the jelly roll, the rupture of the material particle, the break and regeneration of the solid electrolyte interphase (SEI) which constantly consume the electrolyte. Therefore, the expansion behavior of LIBs has become a very important reliability issue in the application of lithium-ion battery, and it needs to be considered in the design of battery structure, particle size, adhesive and electrode structure of anode materials.
for the next generation anode materials with higher energy density,, such as silicon and lithium metals, the expansion problem will be much more serious than graphite. Therefore, an accurate and effectivetool for evaluating the expansion behavior of LIBs can effectively the development and optimization of the silicon-based anode and lithium metal anodes. Moreover, on the aspect of pack design, the expansion evaluation of LIBs can also improve the utilization rate of the pack space under the premise of safety.

2. Traditional Test Methods

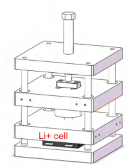
Traditional method	Disadvantage
Electron microscopy observation	Ex-situ test, high equipment requirements, small observation area, human / material consumption
Micrometer / PPG measurement	Ex-situ test, large human error, poor repeatability, and small measurement range
Traditional tooling fixtures	Fixed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



Electron microscopic observation

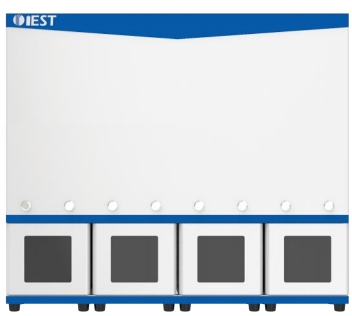


Micrometer / PPG measurement



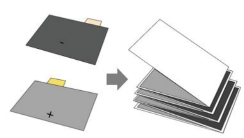
Traditional fixture measure expansion force

3. Introduction of Multi-channel In-situ Swelling Analyzer



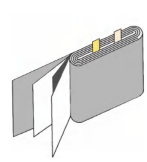
Model coin cell

Quickly evaluate the expansion properties of the material



Stacked battery

The expansion behavior of electrode



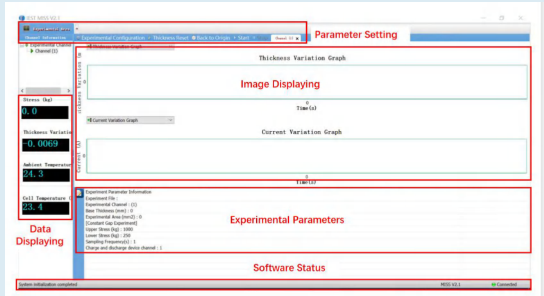
Pouch cell

In situ characterization of cell expansion

Product features

1. In-situ characterize the change of the expansion thickness of each type of cell
2. Four-channel Suitable for a variety type of cell:
3. Suitable for a variety type of cell::
   model coin cell, stacked battery, pouch cell, etc
4. Visualize the operation interface and export data reports with one button

Software interface



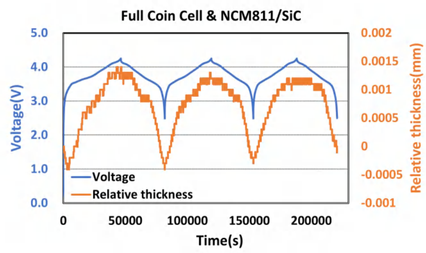
4. Application Cases

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

Cell parameters: Button full battery (NCM811 / SiC), capacity of about 3 mAh;

Experimental parameters of in-situ expansion: Setting the current is 0.3 mA, voltage interval is 2.5~4.2V,running for three circles, and recording the relative expansion thickness of the full coin cell synchronously;

Experimental result:



No.	Charge Q/mAh	Relative thickness/mm
Cycle-1	2.2807	0.0017
Cycle-2	2.2011	0.0017
Cycle-3	2.1147	0.0016
mean	2.1988	0.00167
sigma	0.0677	4.71E-05
cov	3.07%	2.82%

The full coin cell 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 the intercalation and deintercalation of Li-ion.. The average variation of the relative thickness is about 0.00167mm, and the COV of the expansion thickness is only 2.82%, indicating the good cycle consistency of the model coin cell.

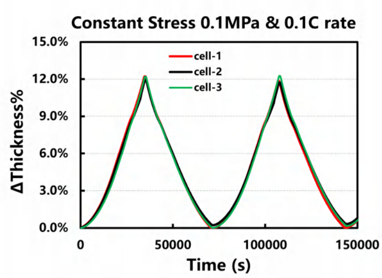
Note: COV (Coefficient of Variation) = (standard deviation sigma) / (mean mean)

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

Cell parameters: Multi-layer stacked ba tery (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:

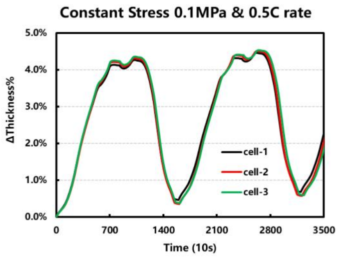


No.	charge Q/mAh	charge swelling/%
cell-1	0.371	12.5%
cell-2	0.371	12.1%
cell-3	0.374	12.2%
mean	0.372	12.3%
sigma	0.002	0.002
cov	0.4%	1.5%

The multilayer stacked battery expands / contracts with the charge / discharge process, and the two cycles maintain good repeatability. The maximum expansion ratio is about 12%, and the expansion thickness COV of these three groups of cells is 1.5%, indicating a good agreement among these parallel samples.

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

- **Cell parameters:** Multi-layer pouch cell (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	15.081	0.001
cov	0.3%	1.4%

The pouch cell expands / shrinks with the charge / discharge process, and the two cycles maintain good repeatability. The maximum expansion ratio is about 4%, and the expansion thickness COV of these three groups of cells is 1.4%, indicating a good agreement among these parallel samples.

5. Model Specifications

Equipment parameters

Model	MSWE1100	MSWE1200	MSWE1300	MSWE1400
Number of channels	4		4	
Pressure regulation mode	with counterweight		servo motor	
Pressure limit	0.5kg/1kg/5kg (Customizable according to customer needs)		1~100kg	
Pressure 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(customized according to specific needs)			

Installation Requirements

Model	MSWE1100	MSWE1200	MSWE1300	MSWE1400
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.

MSWE202211

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