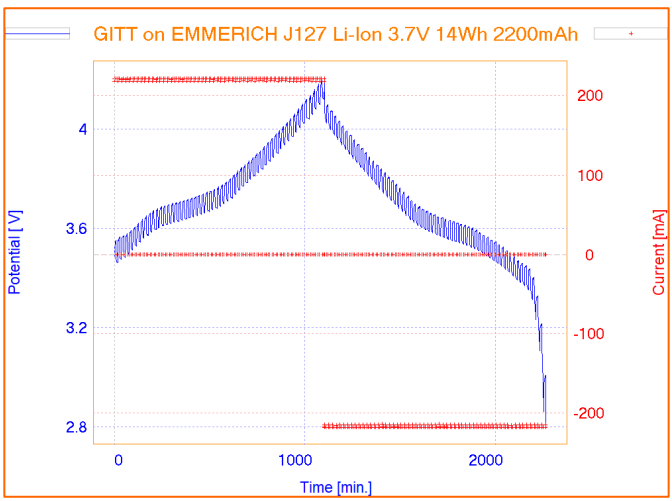
Application Note

Battery
AP-B09

Galvanostatic Intermittent Titration Technic (GITT) and its application in analysing of Li-ion battery



In this application note, GITT method was run on Li-ion battery 2,200 mAh and application of this method on exporting quantitative and qualitative data from battery samples are investigated.

INTRODUCTION

The GITT method consists of two main cycles:

Current Pulse + OCP Cycle no.1

The first cycle include applying galvanostatic charge pulses (positive current) each defined duration, followed by defined relaxation time (OCP), with no current passing through the cell till reach to maximum limit defined potential (depending on the properties of the battery).

Current Pulse + OCP Cycle no.2

Then, discharge negative current will be applied for defined duration, followed by relaxation time (OCP). The discharge pulses are repeated until the lower limit potential is achieved (depending on properties of the battery).

From the potential versus time curve, important information like calculation of the diffusion coefficient and thermodynamics parameters can be obtained.

NOTES:

During imposing charge current, the potential increases rapidly which is related to iR drop of system (consiste all uncompensated resistance of system like charge transfer, cables, etc.). Then it will increase slowly with a constant slope. This happens exactly while imposing discharge current too. It means by imposing negative current, the potential drop fast (related to iR drop) flowing by slowly decreasing in potential value by fixed slope versus time (more details on figure 4).

PARAMETERS

This experiment was performed by OrigaMaster software. The parameters of test are shown in figure 1.

Galvanostatic Intermittent Titration Technique	
Current Pulse + OCP Cycle no. 1	
Galvanostatic Pulse no. 1	
Set Current 1	220, mA
For Duration	10, min.
Open Circuit Potential no. 1	
Duration	10, min.
Exit conditionsCycle no. 1	
If Pulse Potentiel is	>, 15000
If Open Circuit Potential...	>, 4200
Current Pulse + OCP Cycle no. 2	
Galvanostatic Pulse no. 2	
Set Current 2	-220, mA
For Duration	10, min.
Open Circuit Potential no. 2	
Duration	10, min.
Exit conditionsCycle no. 2	
If Pulse Potentiel is	>, 15000
If Open Circuit Potential...	<, 2800
Global parameters	
Meas. period (sec.)	10, sec.
Or record every dE (mV)	5
Potential range	5V
Analog Filter	1 msec.
Digital Filter	0
Open circuit at end	Yes
Ordinate Y2	Current
Exit conditions	
If | Charge variation | >	0, mA.h
Max Total Duration	0, hour

Initialization - Cell configuration	
Electrodes connected with	OGS/OGF/LDS
Connection cell on	4 electrodes
E1 input	No
E2 input	No
Temperature sensor	No
Settings Instruments	
Delay before disjunction (msec.)	20
Auto ranging delay (msec.)	200
Bandwidth limit	No
Stopping criteria	
Variables initialization	

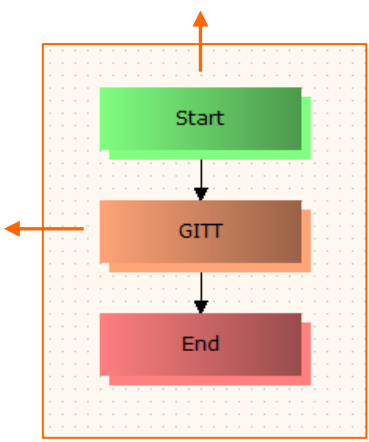


Figure 1: Parameters of GITT method on OrigaMaster software

NOTES:

In the « Start » menu, it is suggested to define 4 electrodes configuration if long cables are used for connecting the battery to potentiostat.

PARAMETERS

According to figure 2 as default settings, the method will start in applying galvanostatic charge pulses 220 mA of current by duration of 10 minutes long, followed by 10 minutes of relaxation time, with no current passing through the cell, from started open circuit potential to 4200 mV.

Then, discharge steps are applied. Each negative current pulses -220 mA are applied for 10 minutes long, followed by 10 minutes of relaxation time. The discharge pulses are repeated until the lower limit of 2800 mV is reached.

The other "Exit condition cycle No. " parameter consist of two main limits. "If pulse potential is" correspond to maximum or minimum value of potential of each pulse during imposing current.

"If circuit potential …" accords to value of OCP during relaxation times which should not passes the limitations.

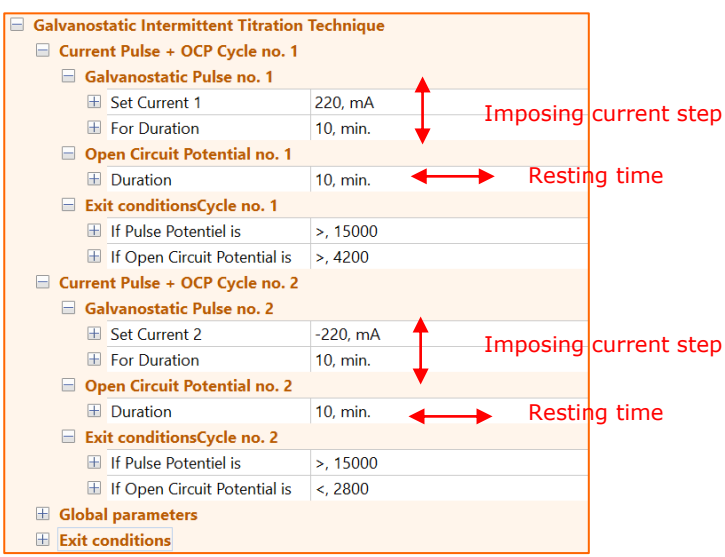


Figure 2: Default setting of GITT method

RESULTS AND DISCUSSIONS

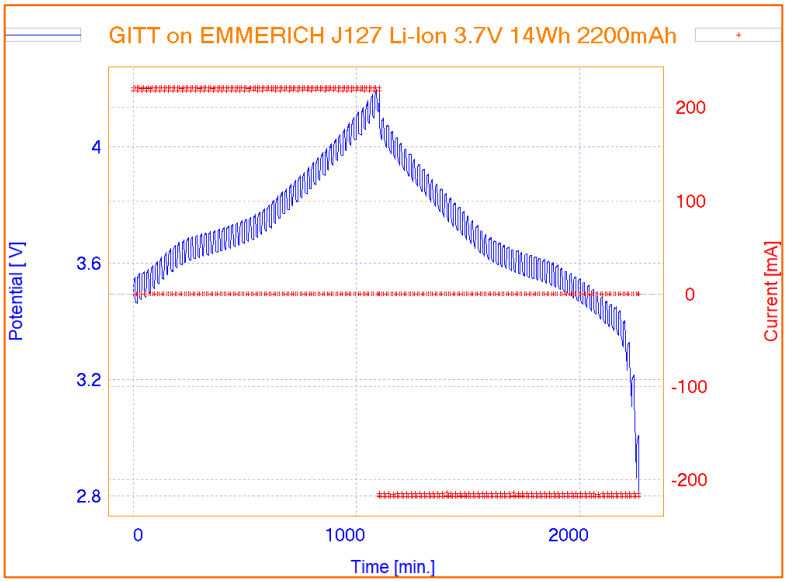


Figure 3: The whole curve of GITT at the end of the test

Figure 3 shows the curve results by performing complete cycles of GITT on Li-Ion battery.

The diffusion coefficient of electro analyte inside the battery could be calculated through this curve and the related equation.

RESULTS AND DISCUSSIONS

According to following equation, the diffusion coefficient of the battery sample can be determined:

$$D = \frac{4}{\pi\tau}\left(\frac{I_0 V}{zFA}\right)^2 \left(\frac{\Delta Es}{\Delta Et}\right)^2$$

While:

I_0 is the base current (A)

τ is the duration of the current pulse (s)

V is the molar volume of battery sample (cm^3/mol)

Z number of exchanged electron in the reaction

F faraday constant (96485 C/mol)

A is the surface of electrode/electrolyte (cm^2)

ΔEs is the potential change during the relaxation time correspond to the applied current (V)

ΔEt is the potential change during imposing current pulse (V)

Figure 4 Shows the ΔEs and ΔEt on the curve of GITT while zooming on one step of pulse imposed and following rest step.

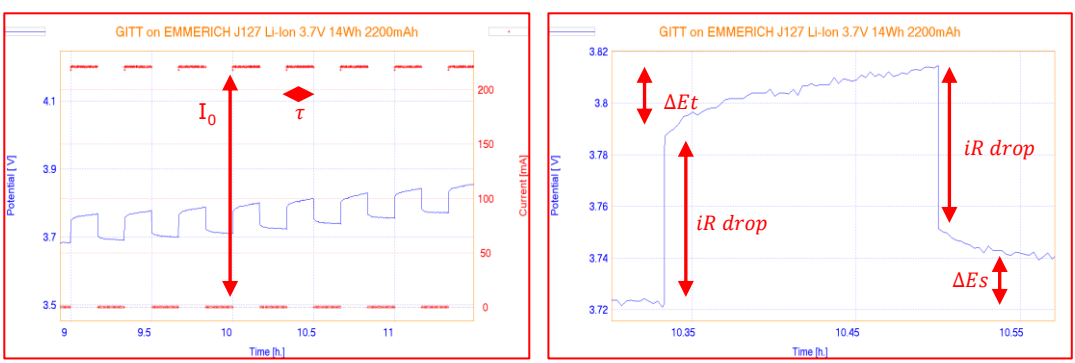


Figure 4: Zoom on pulse steps of GITT curve

INSTRUMENT AND ELECTRODES

Electrode setup	
Sample	Emmerich J127 Li-Ion 3.7V, 14 Wh, 2200 mAh
Instrument	OrigaFlex OGF500
Software	OrigaMaster

Figure 5: OrigaFlex OGF500

Figure 6: Li-Ion battery

NOTES:

As in this application note, a commercial battery was used, some information (like molar volume and surface of electrode/electrolyte) were missed to calculate the qualitative parameters. So, it will just explain how to calculate the desired values.

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