Research on formation process of contact with high temperature and pressurization

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Abstract: Systematic analysis is made on two processes of contact and non-contact high-temperature formation process through non-contact air coupled ultrasonic testing, AC impedance, angle of infiltration testing and thermal imaging analysis. Through the comparison of polarization, adsorption and diffusion, AC impedance comparison and thermal imaging analysis, it is proved that the influence of the type of contact high-temperature formation process on the polarization of the lithium battery and the subsequent potential problems are suggested, and play a role in the selection of lithium battery formation process equipment and process [1].

1. Introduction

At present, in the lithium ion battery industry, a kind of heating and pressurizing (especially for soft package battery) is introduced; all the people in the industry follow this ways of formation process. As a result, industry equipment manufacturers are actively developing and popularizing that type of equipment around this formation process, and vigorously promote the advantages of this method on batteries [2]. As a scientific worker, use rigorous and scientific attitude to analyze and test different formation process: Take two "high porosity quasi solid polymer lithium ion power batteries" (soft packet batteries developed and produce by China-Russia new energy material and technology research institute) were fitted and tested in two environmental conditions by the same batch process.

Table 1. Test introduction

Testing Purposes	1. Research on lithium battery problems caused by different formation process modes 2. Analysis of electrolyte diffusion and lithium battery polarization
Test Standard	At 40±2°C, the standard process of formation process

2. Battery information:

Table 1. Test Information

Project	Information	Remarks
Specification	Size:95-200-300 （mm）	
Type	ENV-PLIB-95-200-300;3.7V-50Ah	
Exterior	Aluminum plastic film appearance, no breakage	
Weight	1344.6g （NCM333/C/LiPF6）	5-0.1g Balance
Voltage	3.74 V before test	
Battery resistance	About 1.4 m Ω	HIOKI
Test temperature	40±2℃	
Non-contact formation process	Formation process at normal	High temperature formation process
Contact formation process	Contact with heating surface Exposure pressure	Contact with heating surface

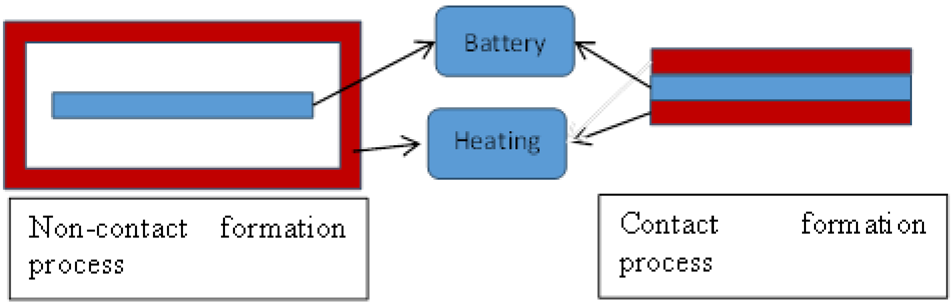


Figure 1.Example of experiment

3. Experimental process:

The same battery PLIB-95-200-300-3.7V-50Ah, battery materials, specifications and systems are all consistent and from the same batch production, respectively placed in the 40 ±2℃ temperature environment boxes and 40 ±2℃ heating plate (the cell pressure is small to contact the surface of the battery), the battery is charged and discharged in a unified system. After the first formation process, stay the battery for 3days, and then do the second formation process, and remove the remaining electrolyte, and then vacuum sealing, as a battery to be detected. The influence of the AC impedance study on the polarization of the battery was analyzed by calibrating the non-contact air ultrasonic coupled scanner [3].

3. Test result:

3.1. Formation curve

3.1.1 In non-contact high temperature box: voltage: 4.2-2.75V ,internal resistance: 1.4mΩ, capacity: 51Ah.

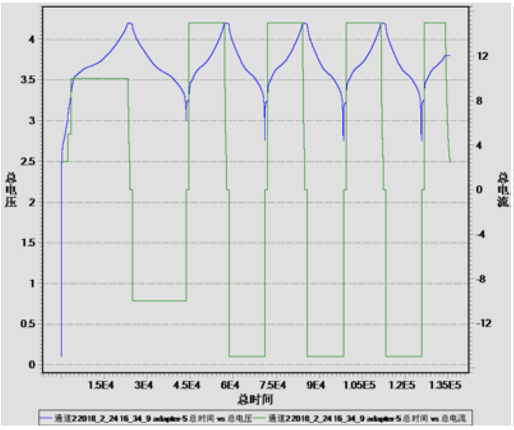


Figure 2.First formation process

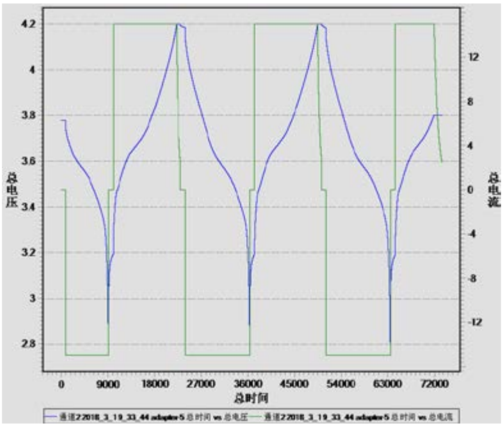


Figure 3.Second formation process

3.1.2 High temperature contact formation, voltage: 4.2-2.75V, internal resistance: 1.4mΩ, capacity: 53Ah.

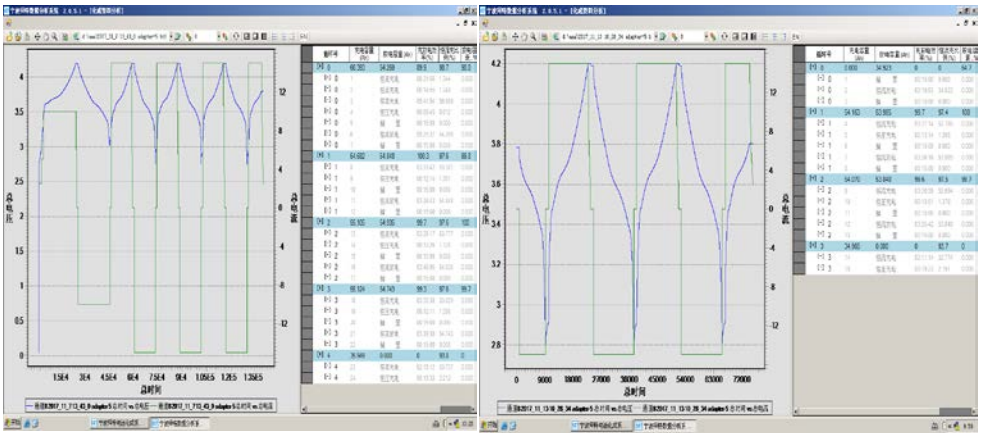
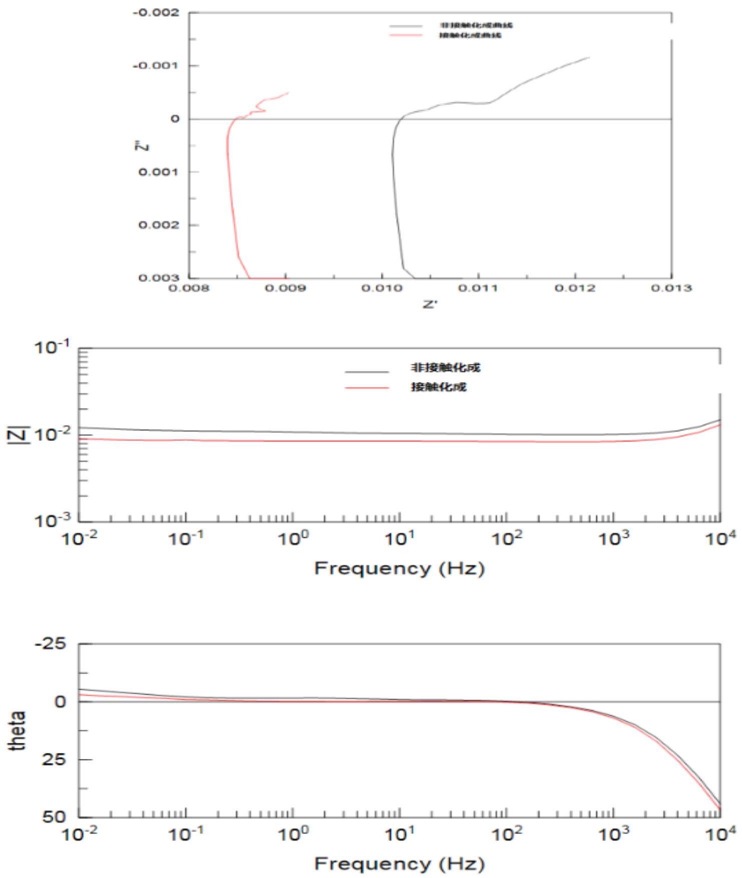


Figure 4.Cyclic performance

3.2. AC impedance after non-contact and contact with high temperature formation process:

The battery is tested on the AC impedance meter, with a positive and negative electrode, selected in the mode of input mode, frequency mode Logarithmic Free Agency Sweep, AC amplitude 10mV, starting at 10000 HZ, ending at 0.01 HZ, and Steps Decade 5.



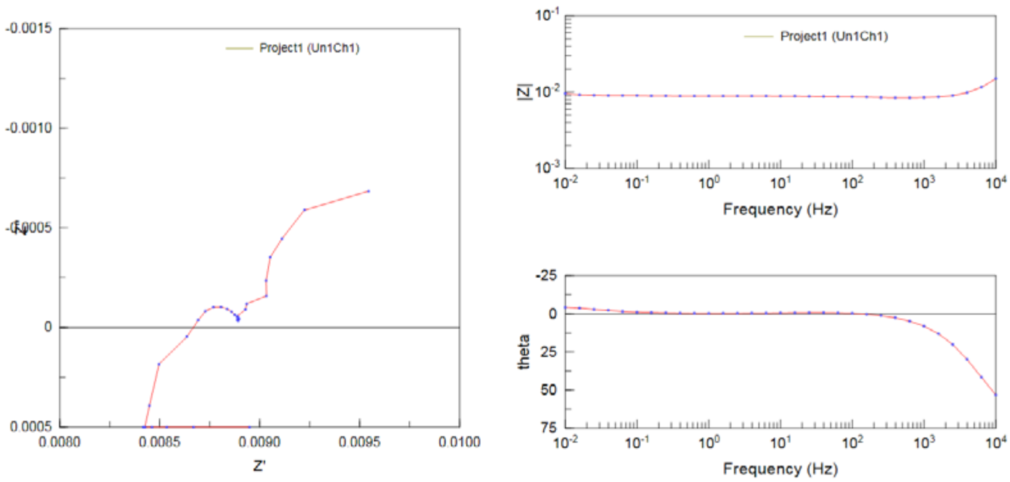
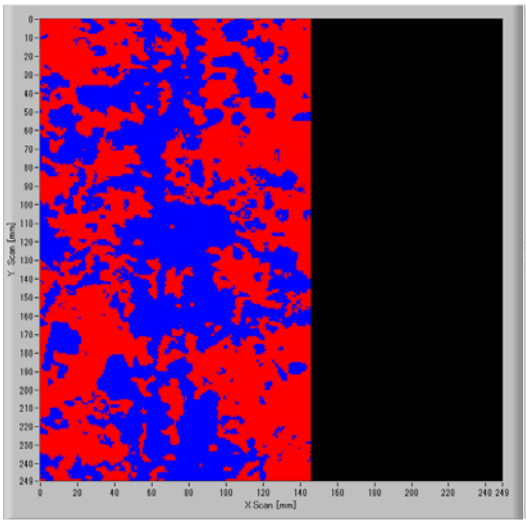


Figure 5.Red as contact impedance; gray as non-contact AC impedance.
Figure 6.High temperature contact formation

3.3. Non-contact air coupled ultrasonic testing after contact formation, the distribution of electrolyte is scattered[4].

Scan the battery on a non-contact air ultrasonic coupling at a frequency of 0.2-0 .8 MHz with a scanning area of X = 279.55 mm Y = 248.0 mm, at a scanning speed of 100 MGS, at a test frequency of 400 kHz, damped 1000 ohms, gain of Gain[dB] 5.0.



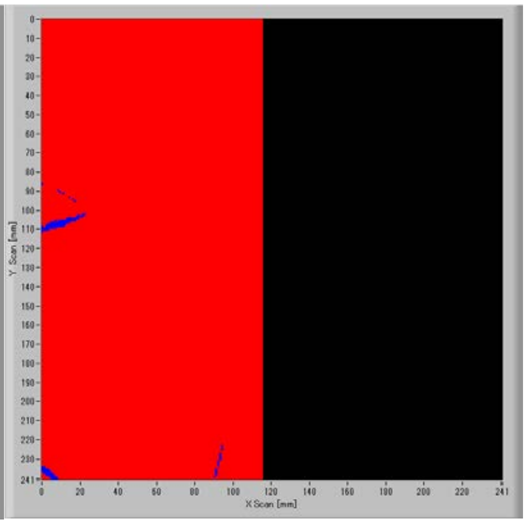


Figure 7.High temperature contact Figure 8.High temperature non-contact

It can be seen that the poor diffusion and distribution uniformity of the electrolyte . it will lead to an increase in the chemical impedance[5].

3.4. Angle of infiltration testing

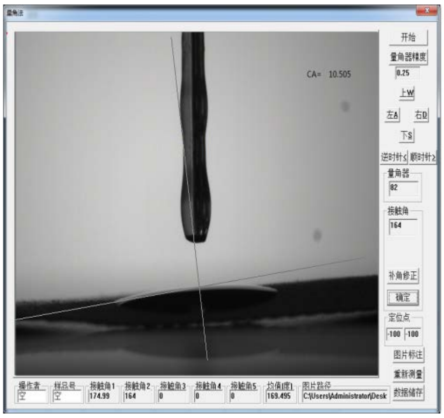


Figure 9.High temperature non-contact formation Figure 10.High temperature contact formation

The angle of infiltration polar after high temperature and pressure is 12.255° , and with room temperature is 10.505° ,it shows that after high temperature ,the angle of infiltration is larger than normal .It shows that the adsorption and diffusion resistance of the electrolyte is becoming larger [6].

3.5 Thermal imaging analysis

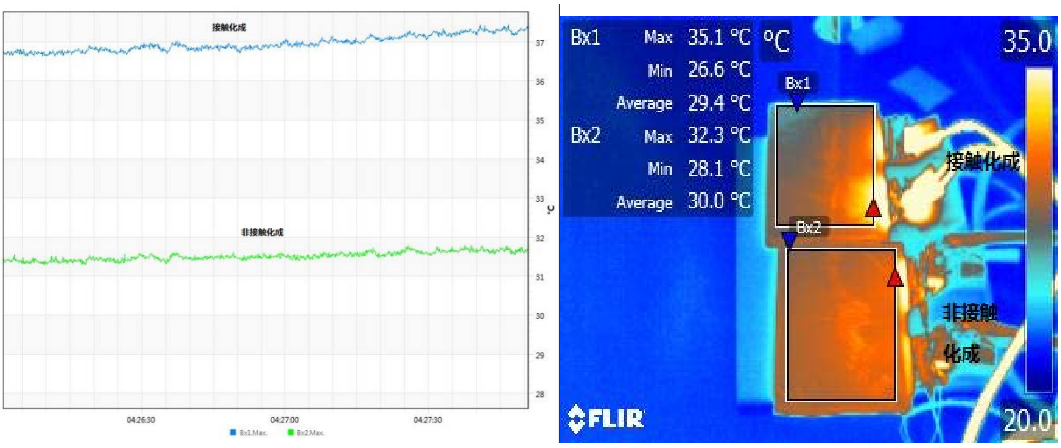


Figure 11.Infrared scanning

After high temperature contact formation process, the distribution of the whole temperature field of the battery is not uniform, and some where is higher than non-contact formation process [7].Polarization impedance is not uneven, and increases the probability of failure mode of polymer materials.

Conclusion

From the above AC impedance and battery capacity, there is no big difference between the two processes (because of the short polarization of time). However, from the ultrasonic coupling scanning, the contact formation process shows the uneven of the diffusion and distribution of the electrolyte, although the temperature is the same, but because of the different heating methods. The effect of electrolyte diffusion is different [8]. Through the comparison and analysis of the electrolyte infiltration angle, the contact heating turns into a large angle indicates that the adsorption diffusion resistance of the electrolyte is larger. Pressure and contact formation affect the wetting and absorption of electrode materials to electrolyte [9].Due to the large temperature difference between the contact surface and the non-contact surface of the battery, the thermal expansion coefficient of the material is inconsistent, and the influence of the stress load transfer on the interface of the material on the electrolyte siphon diffusion is affected. In particular, the polymer material in the battery material is very sensitive to the change of temperature, so the unevenness of the thermal expansion affects the bonding strength of the matrix material, which may increase the possibility of the failure of the peeling off of the material interface and affect the battery life.

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