Introduction on thermal propagation Study in China

EVS-GTR IWG 6th meeting

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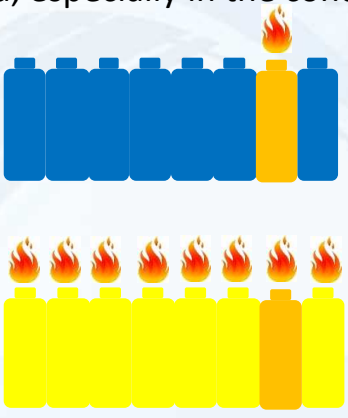
热扩散问题 Thermal propagation issues

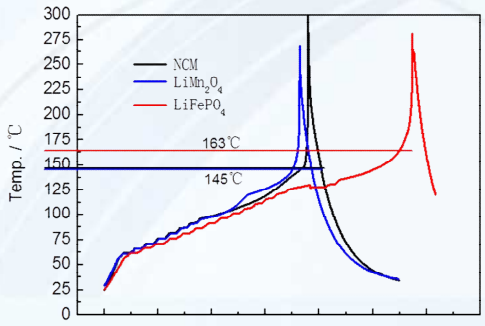
- 单体电池热失控在实际事故中不可避免。
- The cell with the happening of thermal runaway phenomena is not completely avoided during practical application.
- 热失控扩散到其他电池会引起严重的后果。
- The thermal propagation of the single cell to the surrounding cells may cause serious consequences, such as fire or explosion, etc.
- 单只电池热失控之后，应保证热失控不会扩散到相邻电池。
- The thermal propagation of the single cell to the surrounding cells should be prevented, especially in the condition of the thermal runaway.

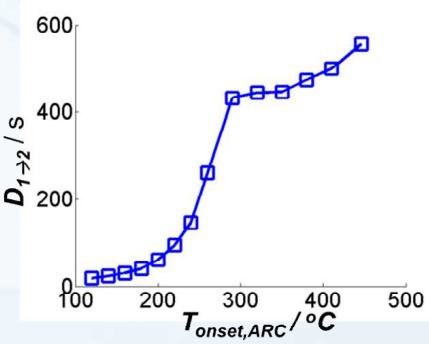


热失控扩散的主要影响因素main factors on thermal propagation

（1）热失控触发温度（隔膜熔断温度）thermal runaway onset temp.（separator meltdown temp.)

➢对于主流锂离子动力电池，使用EV-ARC测试获得其热失控触发温度为130°C~260°C（左下图）
➢For mainstream lithium ion cell chemistry, the onset temperature of thermal runaway is about 130~170°C, tested by EV-ARC.（see the left bottom fig.)
➢通过模型分析，可以得到不同隔膜崩溃温度对应的热失控扩散时间（右图）。
➢The thermal propagation time for different T_{onset} can be calculated by the model (Right Fig.).
➢由三种主流电池体系形成的动力电池模块的首节电池向次节电池热失控扩散的时间是21s-260s。
➢For LFP, NMC and LMO battery module，the thermal runaway propagation from the first cell to the second cell is about 21s-260s.
➢热失控触发温度大于446°C时热失控扩散不再发生。
➢The thermal runaway behavior will be prevented when T_{onset} is higher than 446°C in this case.

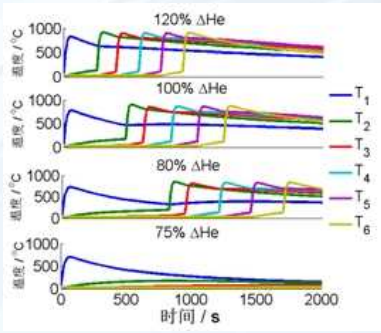


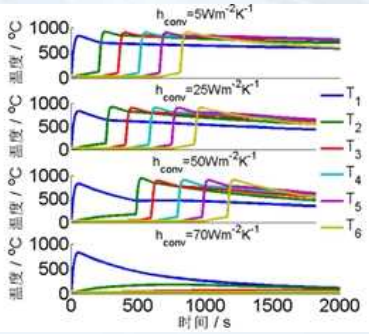


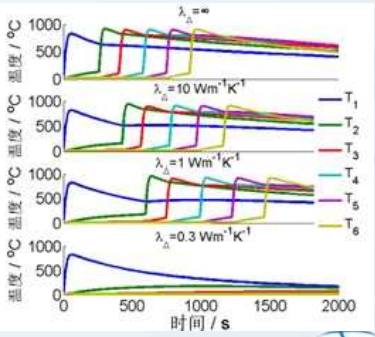
T_{onset}	Propagation time / s
130 (PE)	21
170 (PP)	35
200	60
260	259
290	433
446	549

热失控扩散的主要影响因素main factors on thermal propagation

（2）电池SOC
➢电池SOC越大，热失控扩散越快。
➢A higher level of SOC leads to a faster thermal propagation among battery module.
（3）散热条件（散热系数）heat dissipation condition
➢散热条件越差，热失控扩散越快。
➢A lower heat dissipation coefficient means a faster thermal propagation.
（4）电池间热阻 thermal resistance between cells
➢相邻电池间增加热阻可以延缓热失控扩散。
➢Increase the thermal resistance between adjacent batteries can postpone thermal propagation.
➢热阻增加会造成电池温度分布的问题，需要重新考虑热管理系统的设计。
➢But the thermal resistance increase will arouse temperature redistribution problems, need to re-design battery thermal management system.

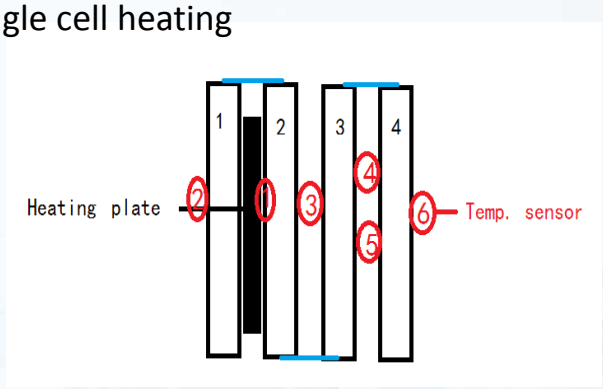


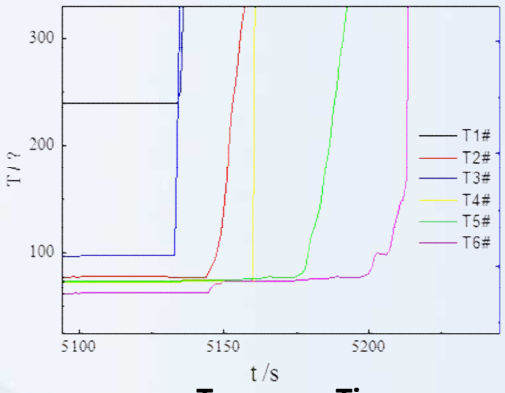




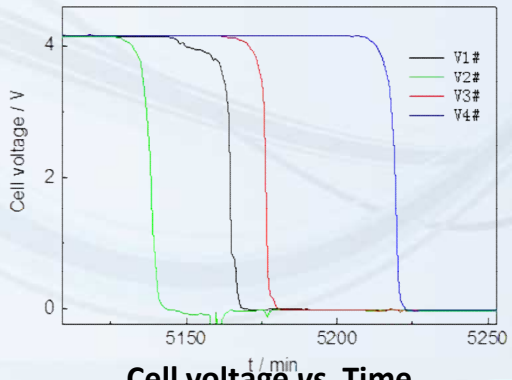
模块热扩散试验 Test of thermal propagation on module level

- 加热
- single cell heating





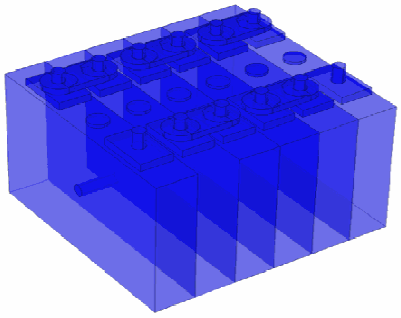
Temp. *vs.* Time

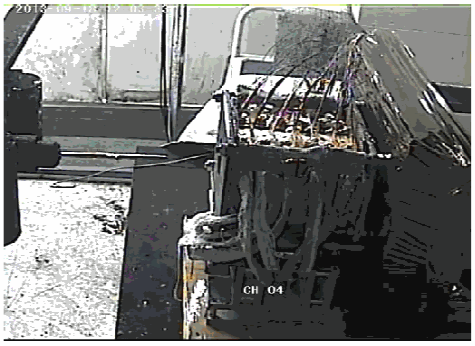


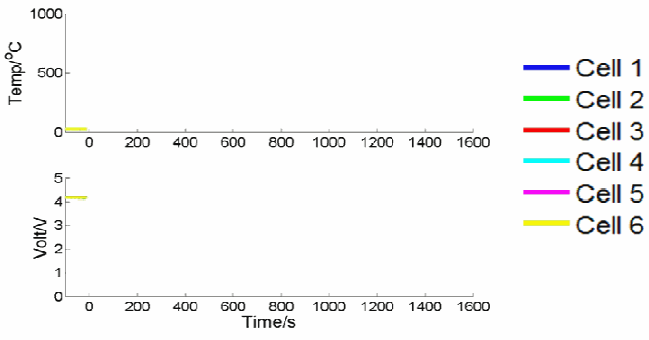
Cell voltage *vs.* Time

模块热扩散试验 Test of thermal propagation on module level

- 针刺
- single cell Nail penetration

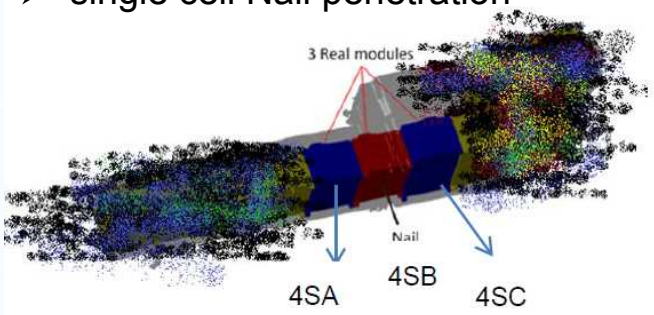


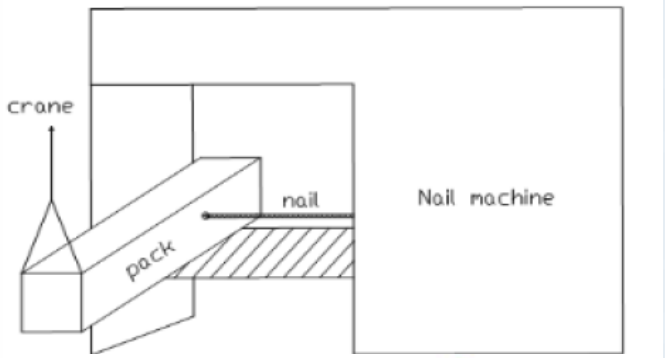


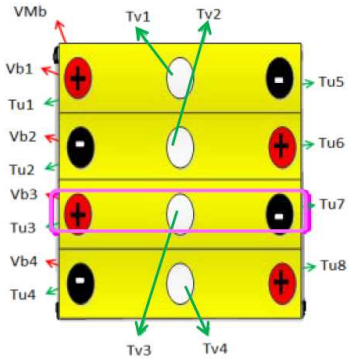


系统热扩散试验 Test of thermal propagation on system level

- 针刺
- single cell Nail penetration

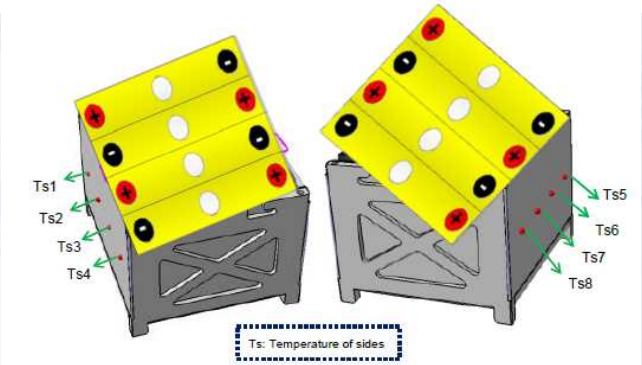






Tv: Temperature of vent
Tu: Temperature of terminal
Vb: Voltage of cells (4S-B)
VMb: Voltage of module (4S-B)

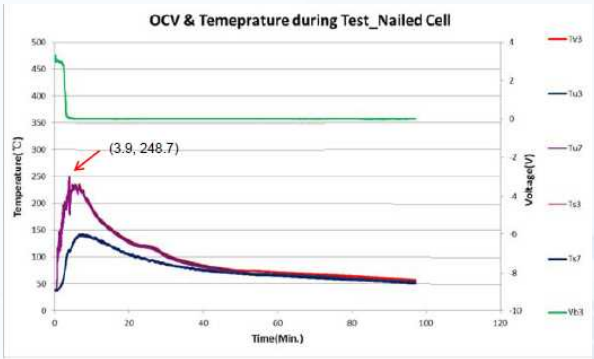
Location of Temperature and Voltage Sensors on Nailed Module

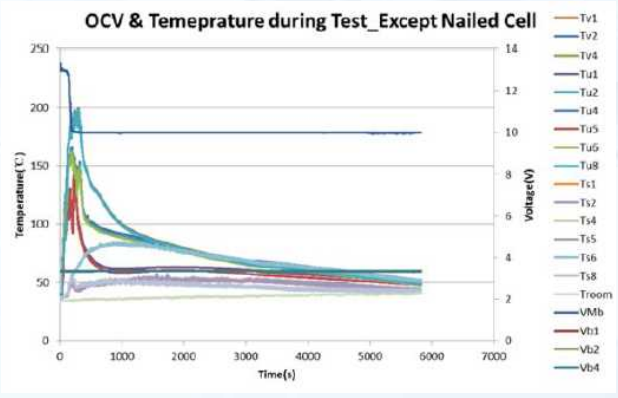


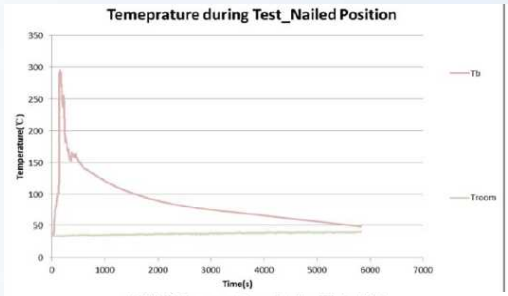
Location of Temperature and Voltage Sensors on two sides of Nailed Module

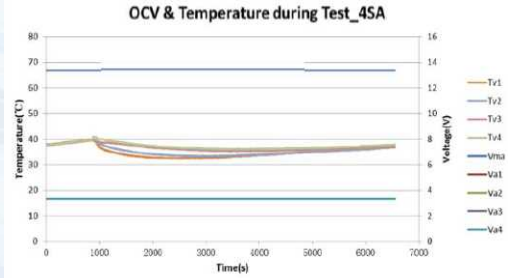
系统热扩散试验 Test of thermal propagation on system level

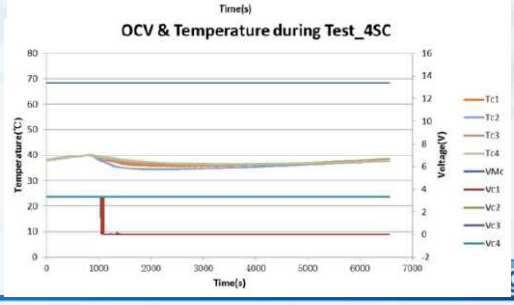
- 针刺 single cell Nail penetration











Method proposed for thermal propagation test

- 模块和系统的热扩散测试建议如下：
  Proposed testing method of thermal propagation of module or system are listed as below:

- 电池模块或系统中单个电池加热 single cell heating

对电池模块或系统中部的一个电池单体进行加热，看整个电池模块或系统防止热扩散的能力。

Heat single cell among the module or system to cause the happening of thermal runaway to see whether the module or system can prevent the thermal propagation or not.

- 电池模块或系统中单个电池针刺 single cell nail penetration

刺穿电池模块或系统中部的一个电池单体，看整个电池模块或系统防止热扩散的能力。

Penetrate single cell among the module or system to cause the happening of thermal runaway to see whether the module or system can prevent the thermal propagation or not.

Method proposed for thermal propagation test

- 模块和系统的热扩散测试建议如下：
  Proposed testing method of thermal propagation of module or system are listed as below:

- 电池模块或系统中单个电池短路 single cell external short circuit

对电池模块或系统中部的一个电池单体进行外短路，看整个电池模块或系统防止热扩散的能力。

Short circuit single cell among the module or system to cause the happening of thermal runaway to see whether the module or system can prevent the thermal propagation or not.

- 电池模块或系统中单个电池过充 single cell overcharge

对电池模块或系统中部的一个电池单体进行过充电，看整个电池模块或系统防止热扩散的能力。

Overcharge single cell among the module or system to cause the happening of thermal runaway to see whether the module or system can prevent the thermal propagation or not.

谢　谢！

Thank you!