

Thermal propagation test by Heating

Korea

■ Background

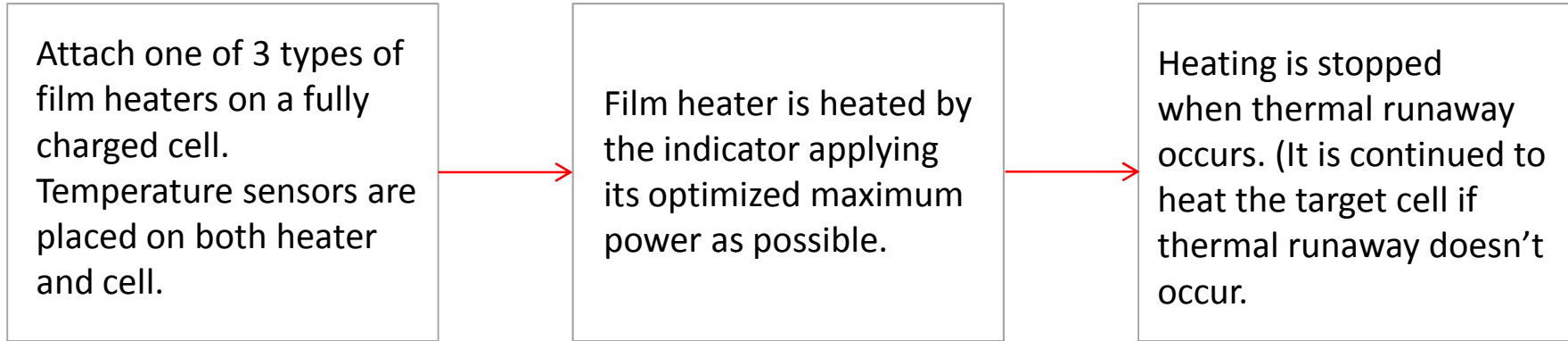
Korea has conducted Thermal Propagation test by heating for the confirmation of

- 1) Effect of film heater size (Pouch cell)
- 2) Effect of position of an initiation cell inside RESS
- 3) Repeatability and Reproducibility

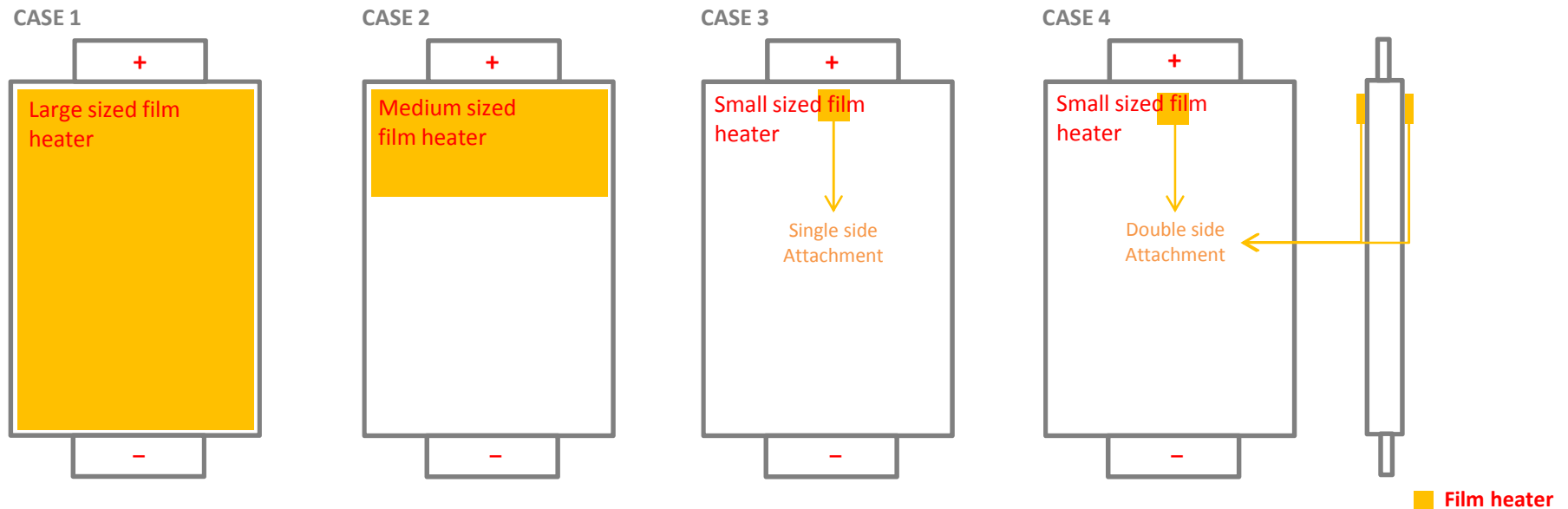
The purpose is to improve considerable initiation methods for simulating realistic thermal runaway caused by insulation failure inside the cell.

Effect of film heater size (1)

Test Procedure



Attachment of heating film

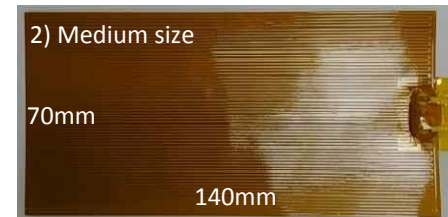
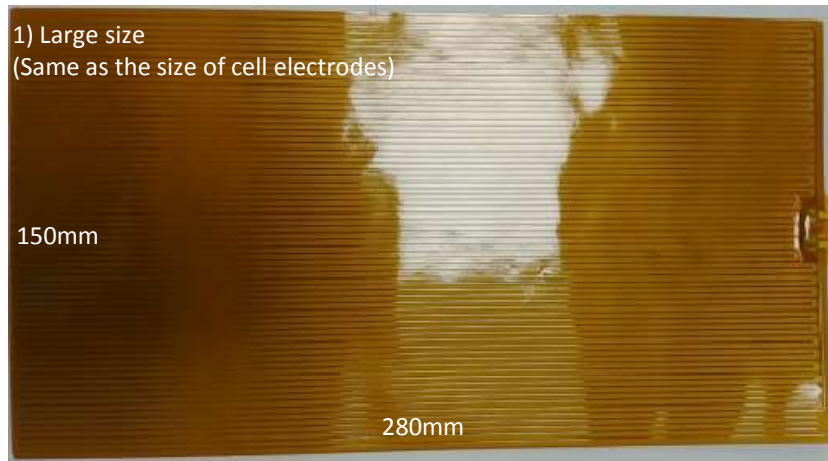


■ Effect of film heater size (2)

□ Film heater

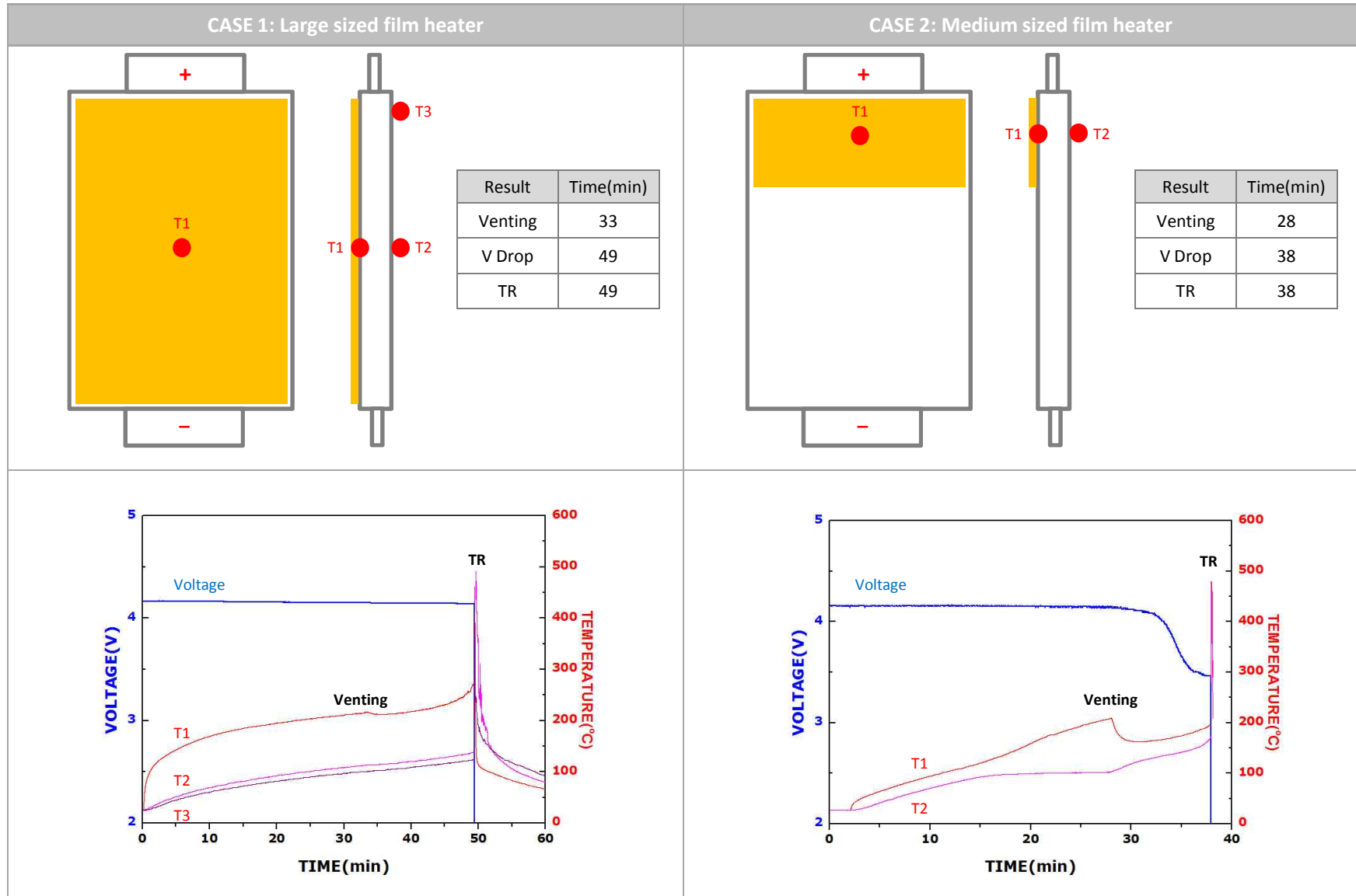
This is a stainless steel film surrounded with kapton tape to withstand in high temperature. Indicator heats film heater applying optimized maximum power as possible.

Film Heater	Length(mm)	Width(mm)	Thickness(mm)
Small size	24	24	0.07
Medium size	140	70	0.07
Large size	280	150	0.07



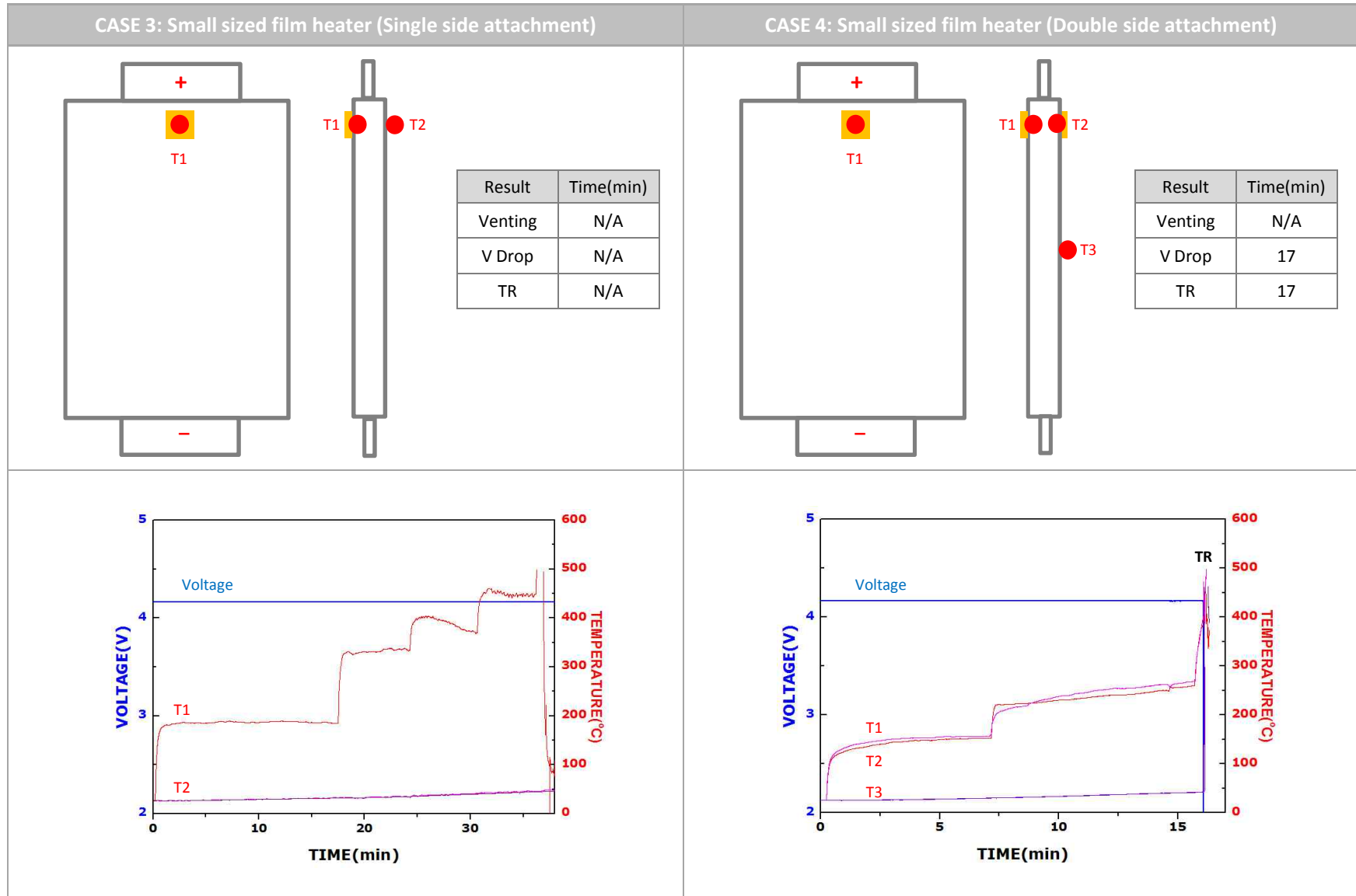
Effect of film heater size (3)

Test Result (Case 1, 2)



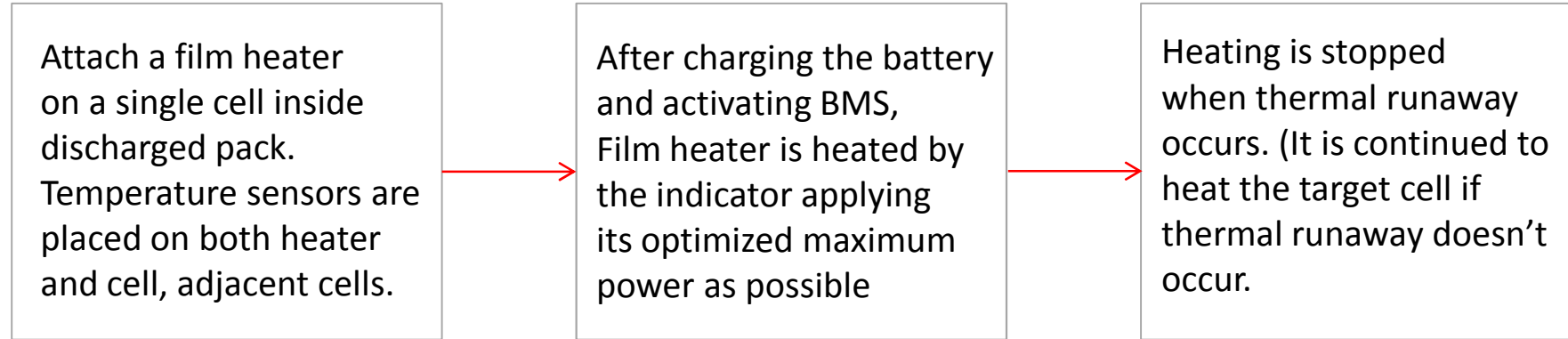
Effect of film heater size (4)

Test Result (Case 3, 4)



■ Thermal Propagation_Pack level (1)

□ Test Procedure



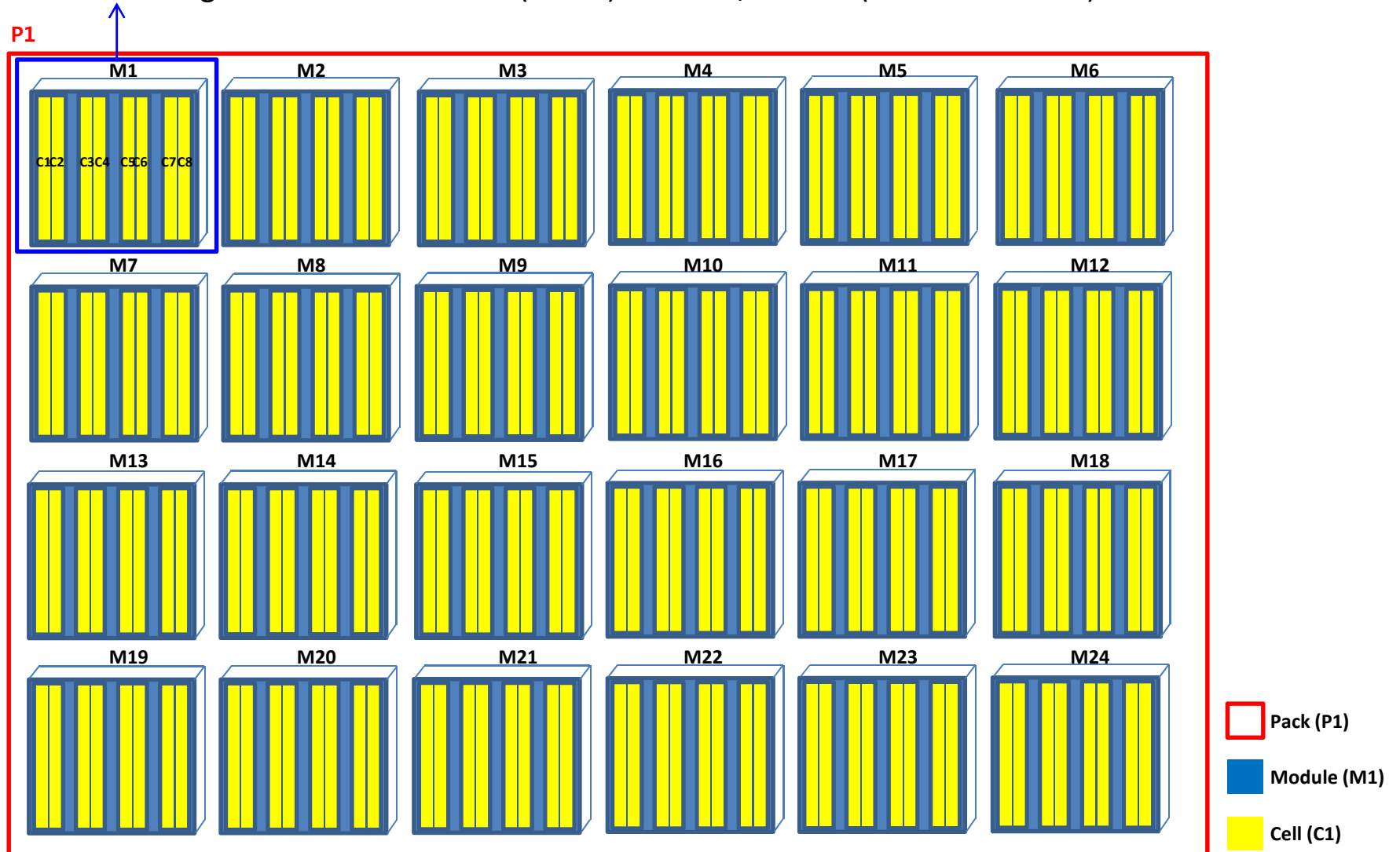
□ Repeatability and Reproducibility

	Test Institute	Position (A single Cell)	Test Completion
Case 1	A	Outer	Completed
Case 2	A	Center	Planned
Case 3	B	Outer	Planned
Case 4	B	Outer	Planned

Thermal Propagation_Pack level (2)

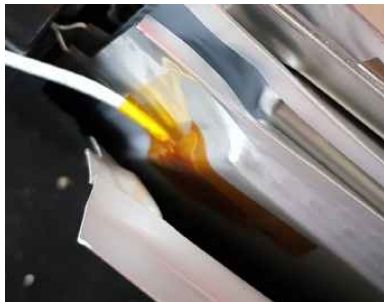
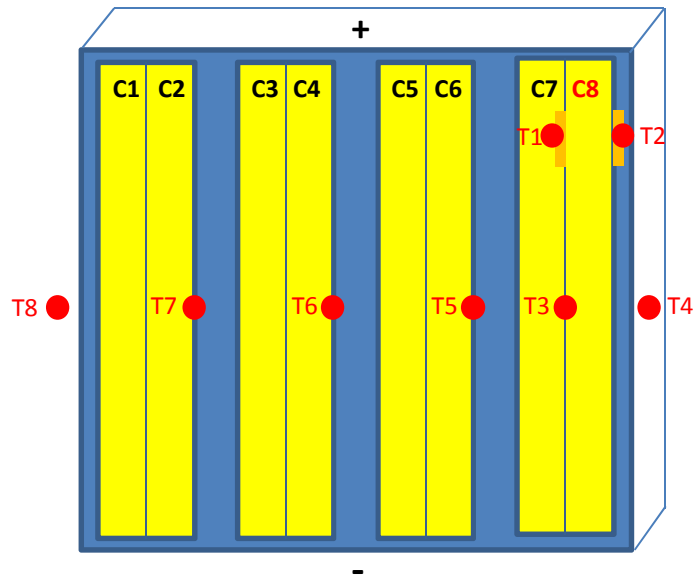
Installation

Position of target cell inside DUT: M1 (Outer) Module / C8 Cell (Worst condition)

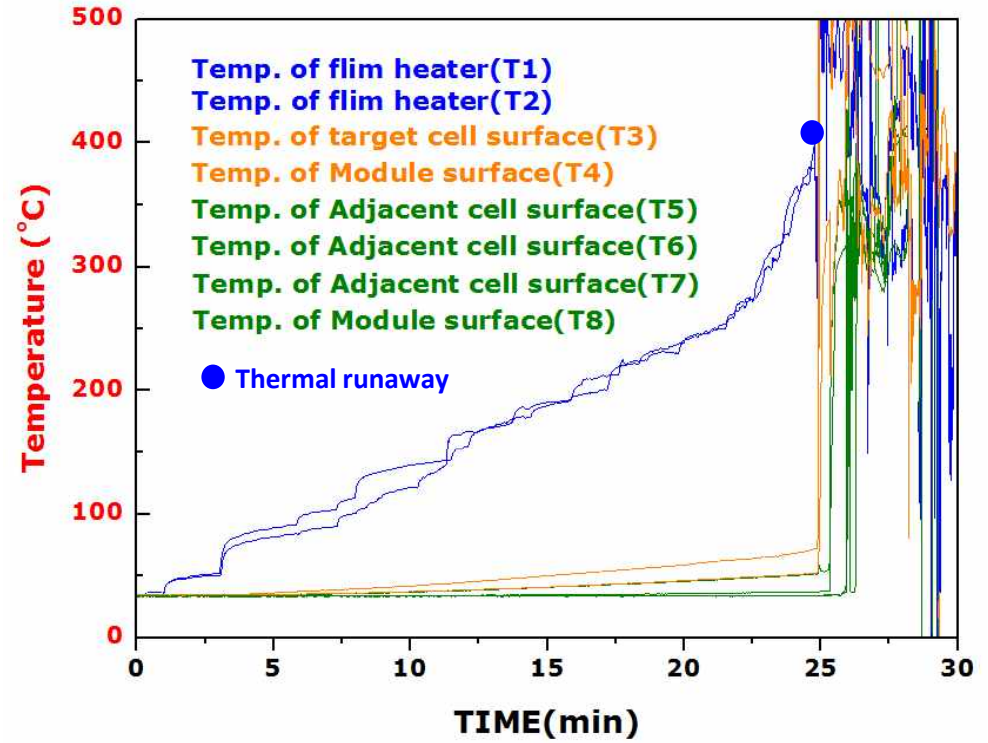


Thermal Propagation_Pack level (3)

Test Result (1)



- Film heater
- C8 Target cell
- C1 ~ C7 Adjacent cells
- T1 ~ T8 Temperature sensors



	Temperature
T1	399.4
T2	381.1
T3	91.8
T4	54
T5	53.7
T6	37
T7	34.1
T8	33.7

■ Thermal Propagation_Pack level (4)

□ Test Result (2)

Thermal runaway occurred in target cell as soon as temperatures of film heater reached up to 400 °C

Thermal runaway and Thermal propagation from target cell to cell occurred at the same time.

	Case 1	Case 2~4
Thermal runaway (Time)	Occurred (23.9 min.)	Planned
Voltage drop (Time)	Occurred (23.9 min.)	
Thermal propagation (Cell to Cell)	Occurred	
Thermal propagation (Module to Module)	Occurred	
Fire or Explosion	Fire (External)	

■ Conclusion

□ Effect of film heater size

Heater should be smaller and thinner to

- 1) simulate the realistic internal short circuit due to the contamination
- 2) minimize the manipulation to install the heater and thermal couples. (No space between target cell and adjacent cell)

Based on the test result,

Small and thin film heater type can cause Thermal runaway easily inserting the minimum energy to target cell at rapid rate than other cases if it is double side attachment.

Need to research how much film heater can be small to simulate the internal short-circuit and cause thermal runaway.

□ Thermal Propagation_Pack

Case 2 ~ 4 Will be tested for the confirmation of

- 1) Effect of position of an initiation cell inside RESS
- 2) Repeatability and Reproducibility.