Presentation ID #403

Polymer-sealed planar $Na-NiCl_2$ batteries at 180°C

Keeyoung Jung*, Hanul Choi, Seungmi Lee, Yoon-Cheol Park, Jeonghun Heo, Choongmo Yang,
Research Institute of Industrial Science and Technology (RIST), ROK

Jinhyuk Choi*, Sungeun Lee, Jay Park
Korea Electric Power Corporation (KEPCO), ROK

Guosheng Li*, David Reed, Vincent L. Sprenkle
Pacific Northwest National Laboratory (PNNL), USA

*contact K. Jung at keeyoung.jung@rist.re.kr

efficient electric power management

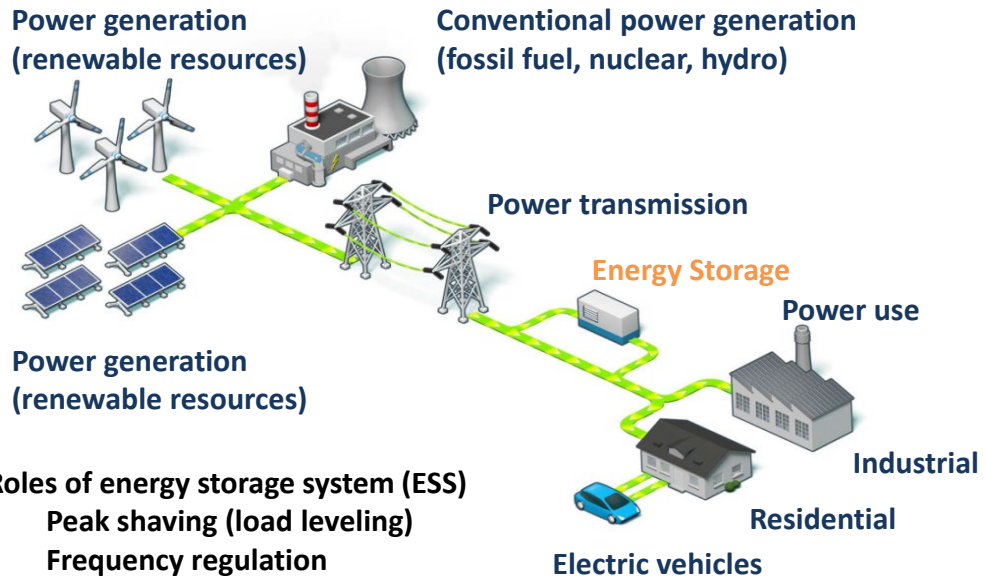
- ESS is an essential component for efficient electric power management.
- Stationary ESS market is expected to be as big as 368GWh in 2030.

Key requirements (1) High safety, (2) Long lifetime, (3) Low cost, (4) Sustainable law materials

- No battery meets market's technological demands yet.

  → Market expansion is being delayed than expected.

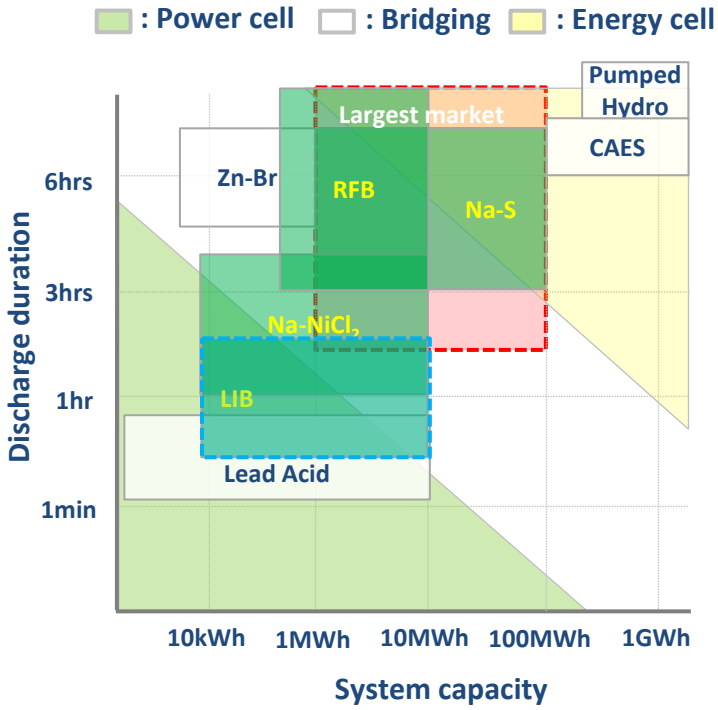
■ Energy storage in grid



Roles of energy storage system (ESS)
- **Peak shaving (load leveling)**
- **Frequency regulation**

→ **Efficient power management**

■ Candidate battery chemistries

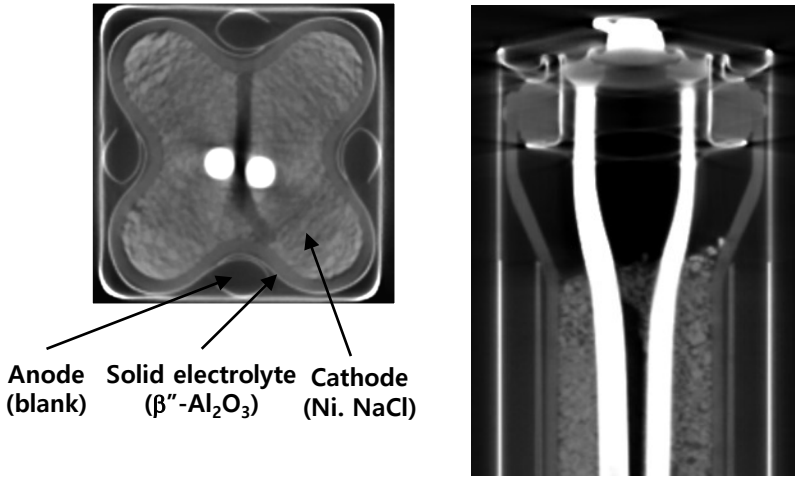


statement of the problem

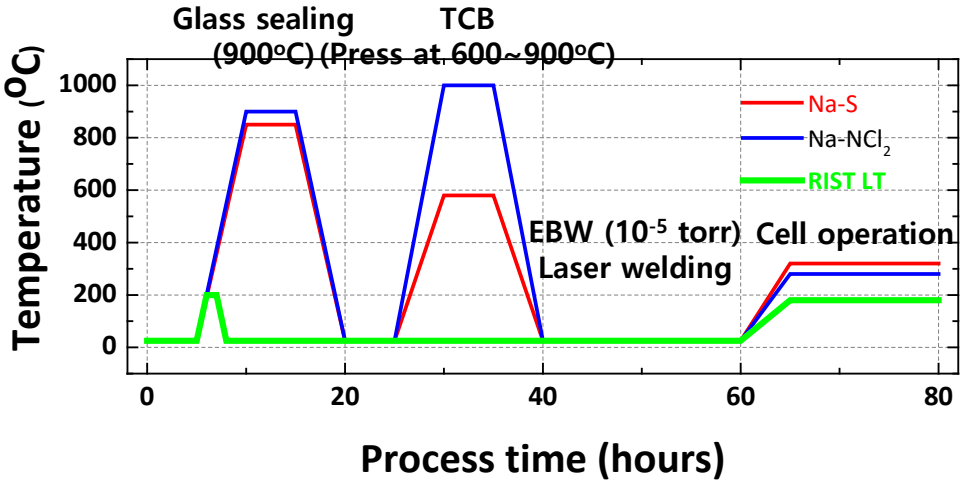
■ Total cost to operate an ESS system for 15 years

Chemistry	Installation and Maintenance Cost	Pros and Cons
LiB (1MW/6MWh)	$350/kWh ('21): 200 Battery pack; 90 BMS/ Container; 60 PCS+PMS; ?? Maintenance Cost (cell replace, HVAC etc.)	Robust supply chain through EV/mobile Safety issue, HVAC, Lifetime
Na-S (1MW/5.6MWh)	$320/kWh ('21): 270 Battery System; 50 PCS; 90 Maintenance Plan for 15 years	Proven performance Safety concern, Limited supply
Na-$NiCl_2$ (1MW/2MWh)	$610/kWh (best case): 70 Materials; 250 Process; 7 Misc.; 90 Module Indirect; 50 PCS; 140; ?? Maintenance Cost	Excellent safety, Long lifetime High cost
Goal	<$190/kWh: <50; 30; 7; 30; 50; <90 Maintenance Cost	

■ Cross-sectional computed X-ray tomography



■ Assembly and cell operation steps



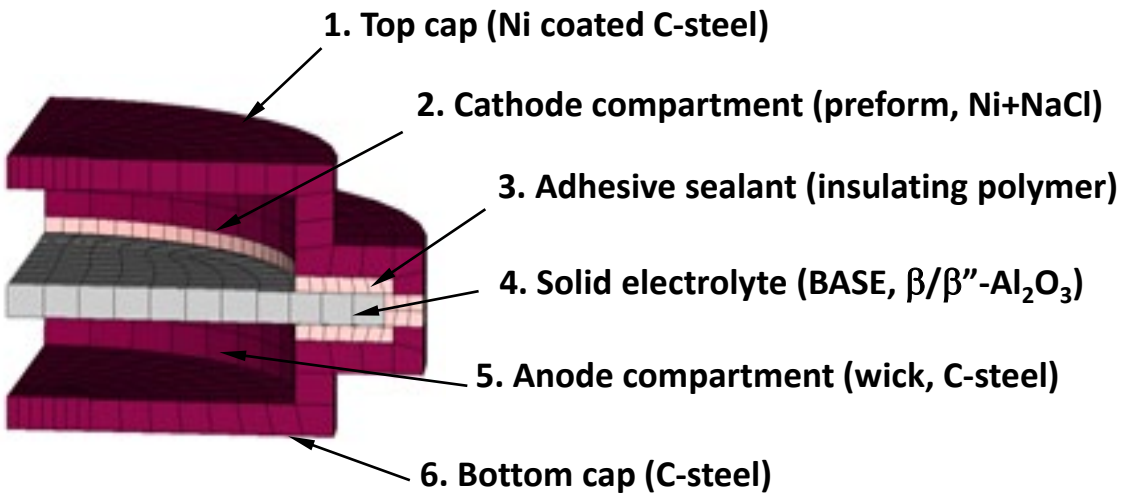
a novel Na-$NiCl_2$ cell design

■ Research direction

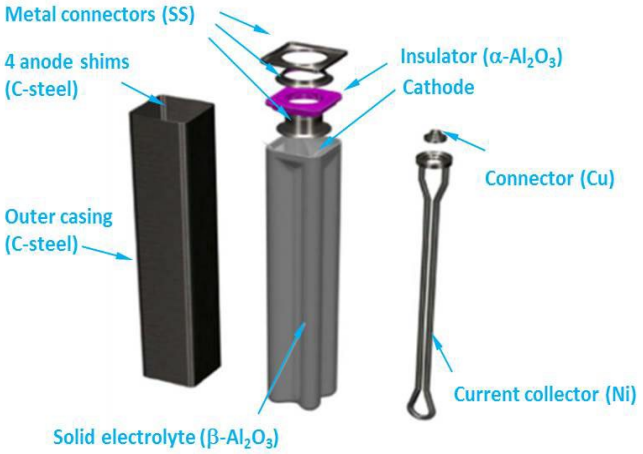
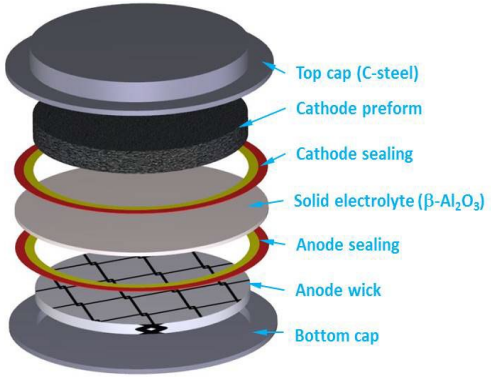
1. Remove expensive bonding technologies.
2. Reduce number of components and simplify cell manufacturing process.
3. Try to avoid thermal stress issues.

■ Our design concepts

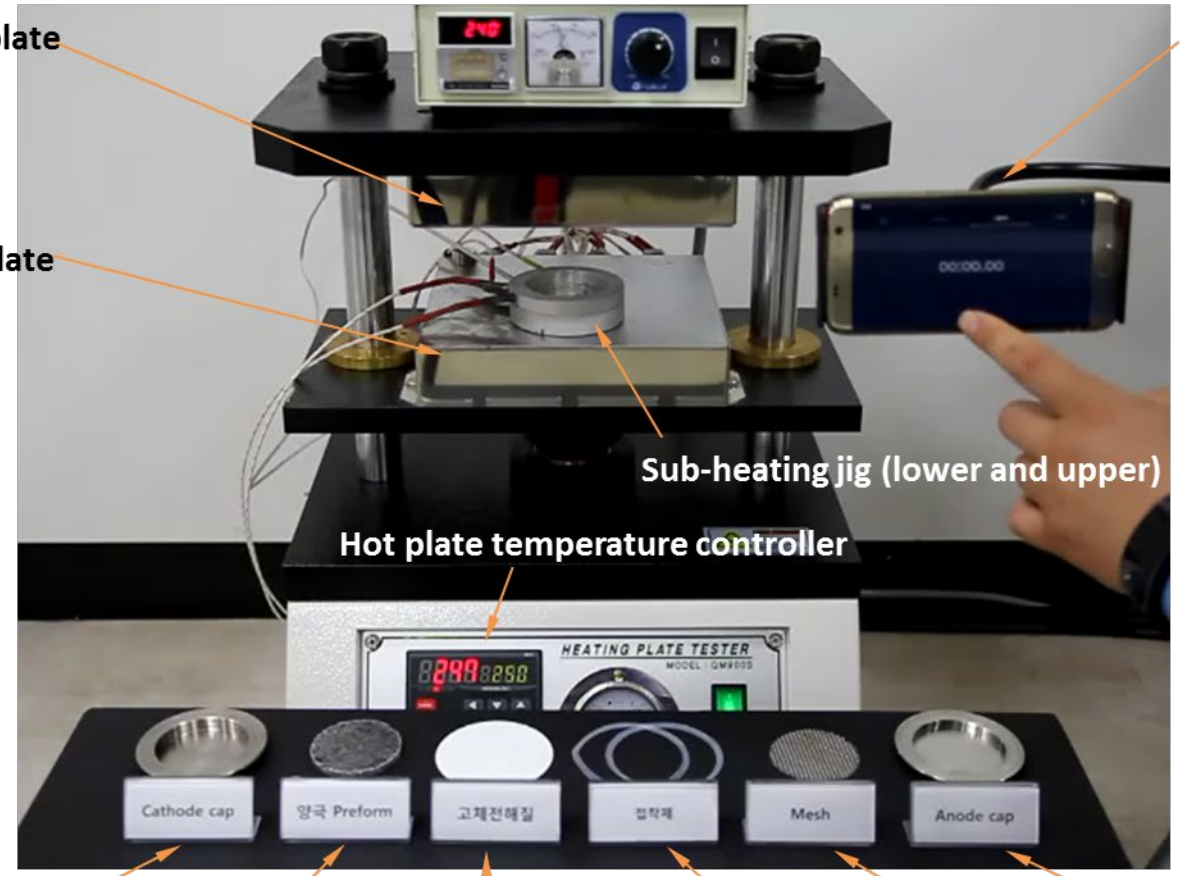
1. Adopt **polymer seal** in order to (1) avoid conventional sealing and (2) compliant joints.
2. Need to **reduce operation temperature** (<200°C) in order to use conventional high T polymers.
3. Adopt **planar cell designs** in order to simplify cell manufacturing process.



a novel Na-$NiCl_2$ cell design

	Na-$NiCl_2$ (100Wh)	Lower T planar cell (25Wh class)
C/DC Reaction	Ni(s)+NaCl(s)=$NiCl_2$, V=2.58V	Ni(s)+NaCl(s)=$NiCl_2$, V=2.58V
Temperature	280°C	190°C
Cell design	 Number of components ~20	 Number of components <10
Heterogeneous bonding	C-C: Glass sealing (900°C) C-M: TCB (Ni metallization + pressing, 1000°C) M-M: Laser welding or E-beam welding	C-C: none C-M: Polymer sealing (170~300°C, 1 min Press) M-M: none
Key components	BASE (CIP), Cathode (Particulate granules), Machined α-Al_2O_3 insulating ring	Solid electrolyte (Tape casting), Cathode (Preform), Metal components (Stamping), No use of α-Al_2O_3 ring

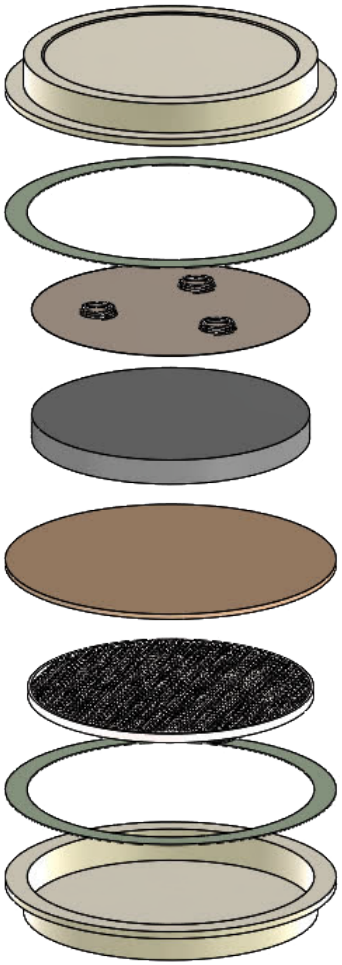
proof of concept (video clip)



6Ah unit cell

○ **KPI:** 15Wh, SOC utilization 80% @30mA/cm^2

○ **Cycling condition:** UCV/LCV=2.8V/1.8V, CC 3.3~30mA/cm^2



(8) Cathode cap

(7) Cathode seal

(6) Cathode current collector

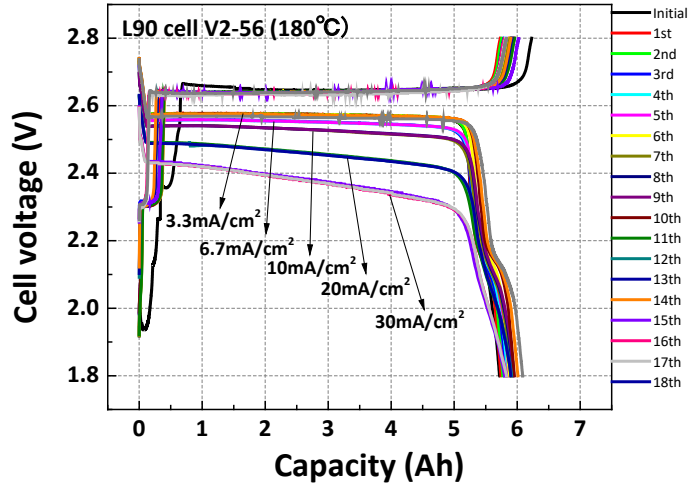
(5) Cathode preform

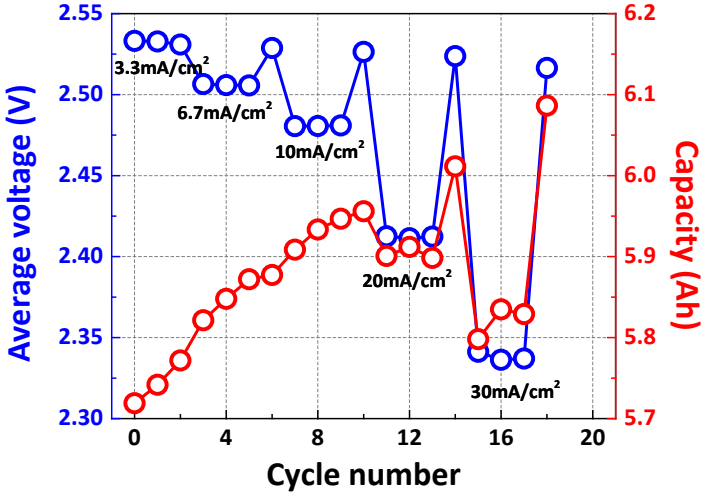
(4) Carbon coated BASE

(3) Anode wick

(2) Anode seal

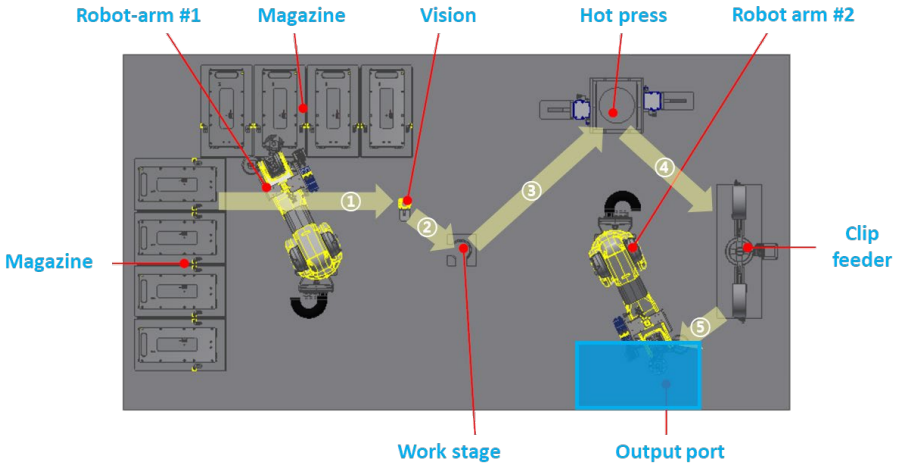
(1) Anode cap

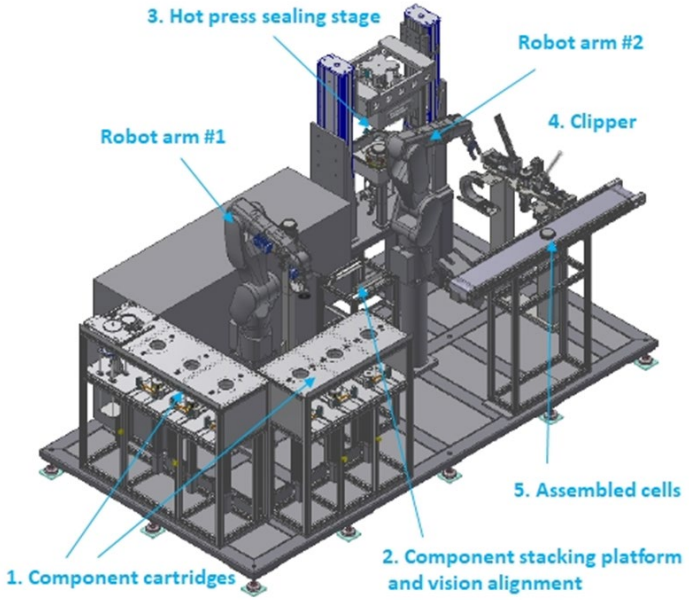


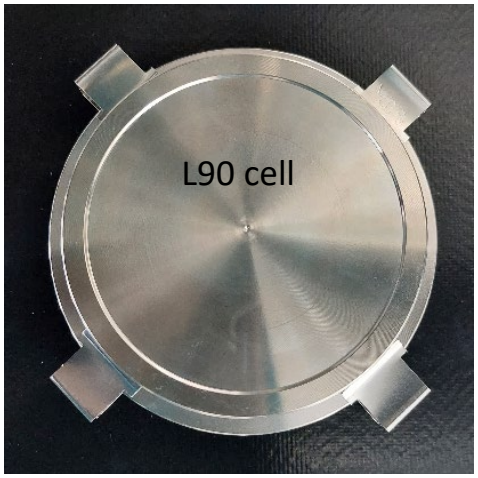


semi-automated cell manufacturing

■ Semi-automated Cell Assembly Set-up



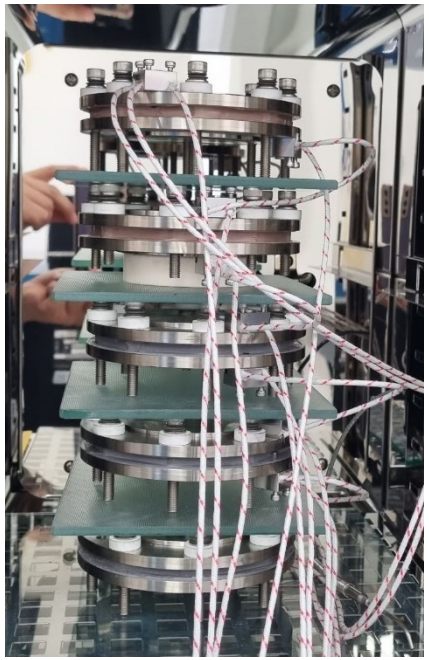


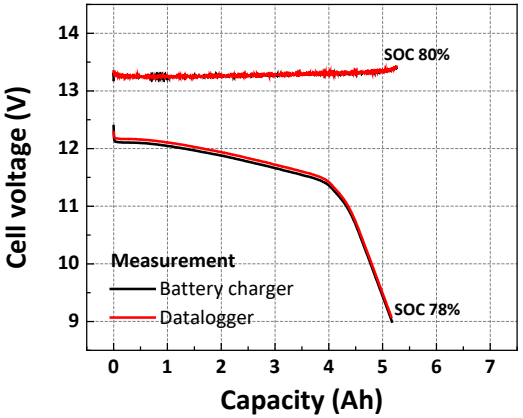


semi-automated cell manufacturing (video clip)

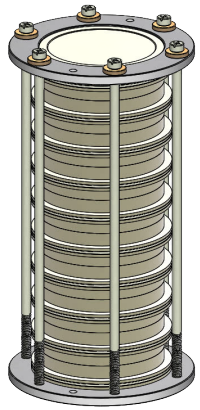
stacked cell (in progress)

5S connected cell
(Minimizing difference in cell performance)

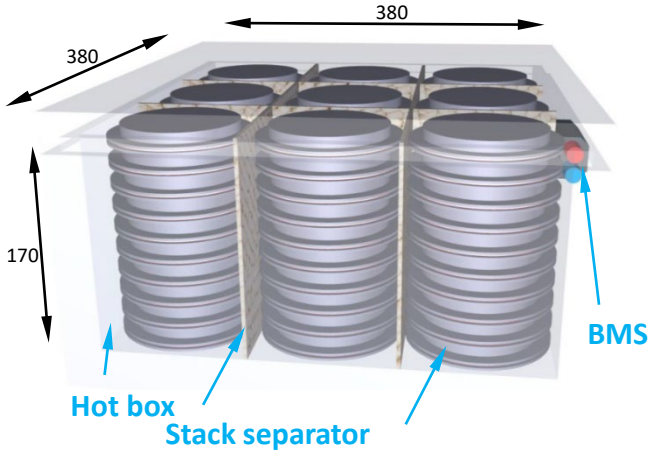




10s stack cell
(~'22E)



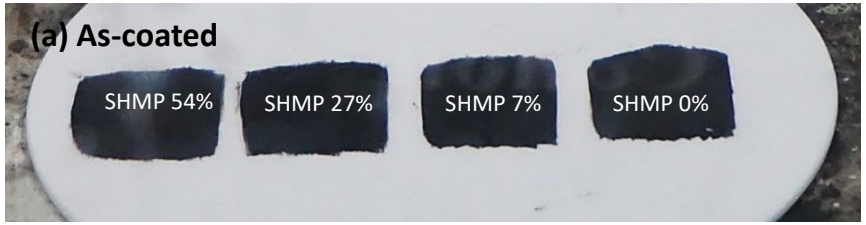
kWh class block
(~'23.6)

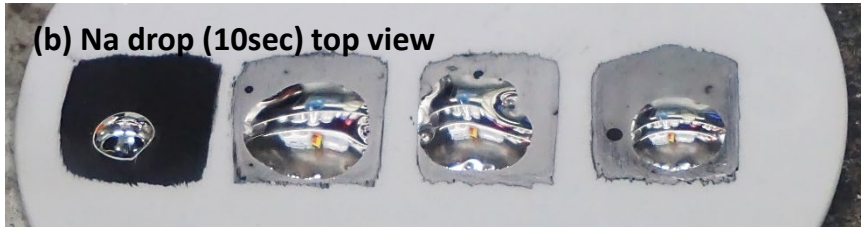


Item	5s	10s	90 cell block
Energy	75Wh	150Wh	1.35kWh
Operating V	9-14V	18-28V	60-86V
Operating T	180°C	180°C	180°C

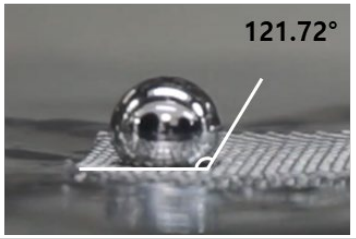
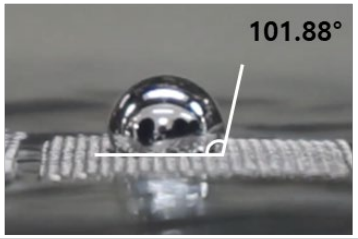
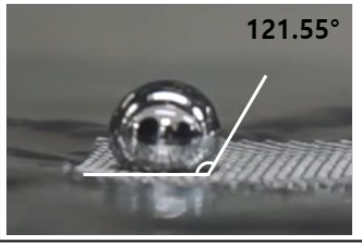
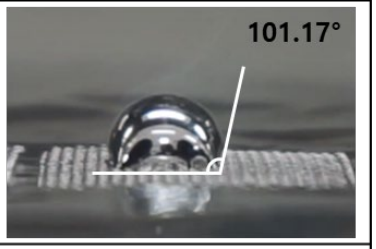
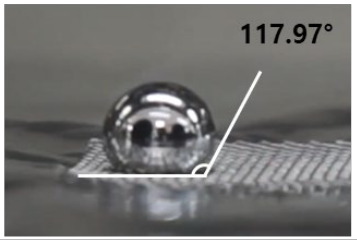
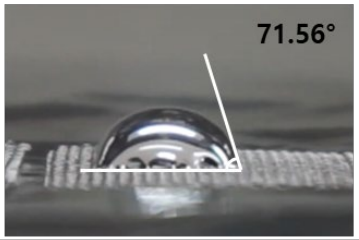
Interfacial resistance reduction

■ Na(l) drop on C-coated BASE





■ Na(l) drop on uncoated and Ni-coated SS mesh

Time (s)	Uncoated mesh	Ni coated mesh
0		
60		
90		

Acknowledgement

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