HV GEM™
A Hollingsworth & Vose Innovation

GLASS ELECTRODE MATERIAL

Asian Battery Conference – Sept 2025

21 ABC

“Novel glass fabric electrode material for grid replacement in lead batteries”

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Senior Scientist
Hollingsworth & Vose®

Shane Christie
CTO
ARCACTIVE

Introduction to ArcActive – A little bit of history

ArcActive Fabric Structured Electrodes

Original: Carbon Fiber Fabric

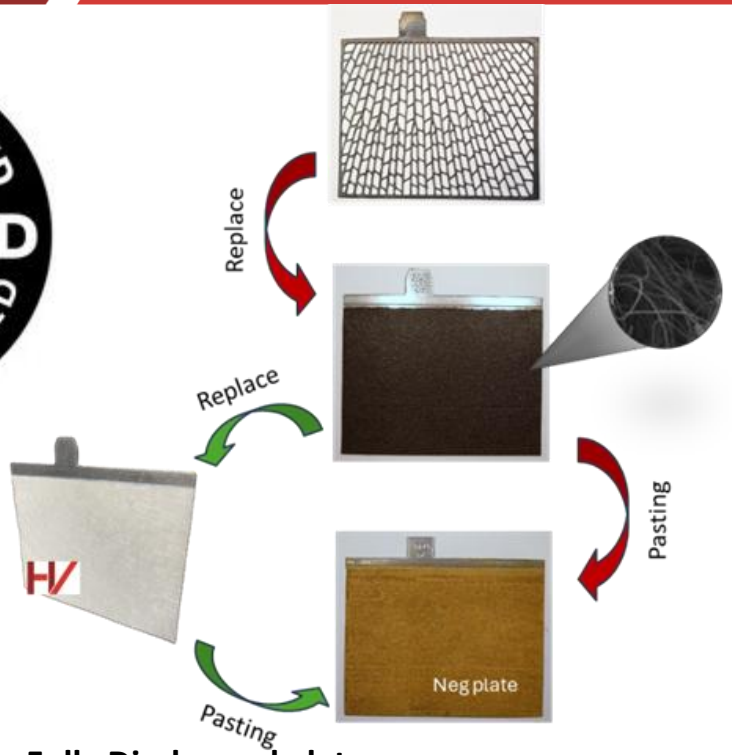
BCI Innovation Award

Winner, 2020

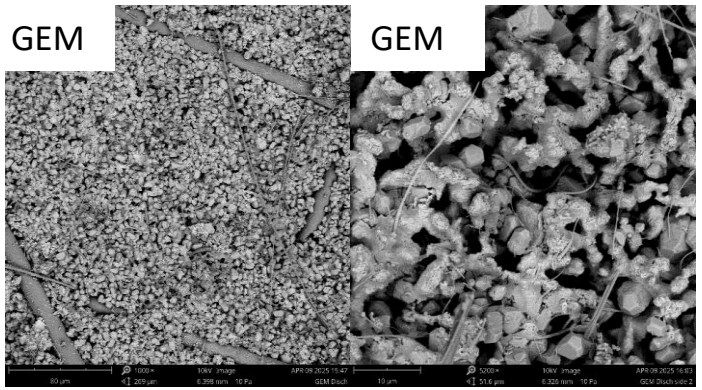
Battery Council International
INNOVATION AWARD
In honor of Sally Breidegam Miksiewicz

H&V innovation: Replace Carbon base media with Glass Fiber Material (→ GEM) to realise performance &cost improvements

PATENT APPLIED
PATENTED
PATENT APPLIED

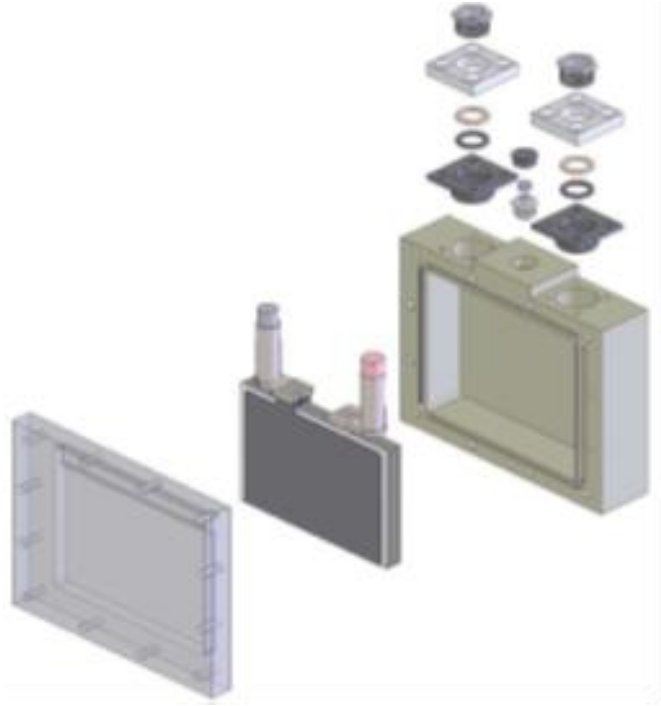


Fully Discharged plate



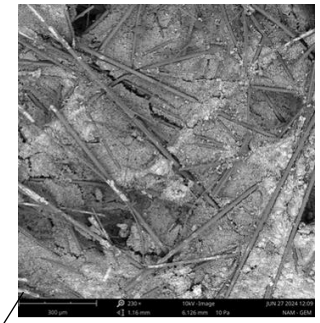
Summary of GEM Base 2V cell performances

Testing	GEM Performance vs Standard Neg plate	
Capacity – Reserve capacity	=	PERFORMANCE
CCA	=	
DCA (VDA)	+++	
Charge acceptance (EN 0C)	+++	
WLT8 after aging tests (PSoC or DCRss)	+++	
50% DOD	=	LIFE
17.5% DOD	=	
BCIs022	+++	



H&V 2V cell testing
3+ve/ 4 –ve electrodes

How to process GEM ?



Cut plates

Add Pb lugs

Stamp tabs

Active mass

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Roll form

GEM

GEM

GEM

Plates

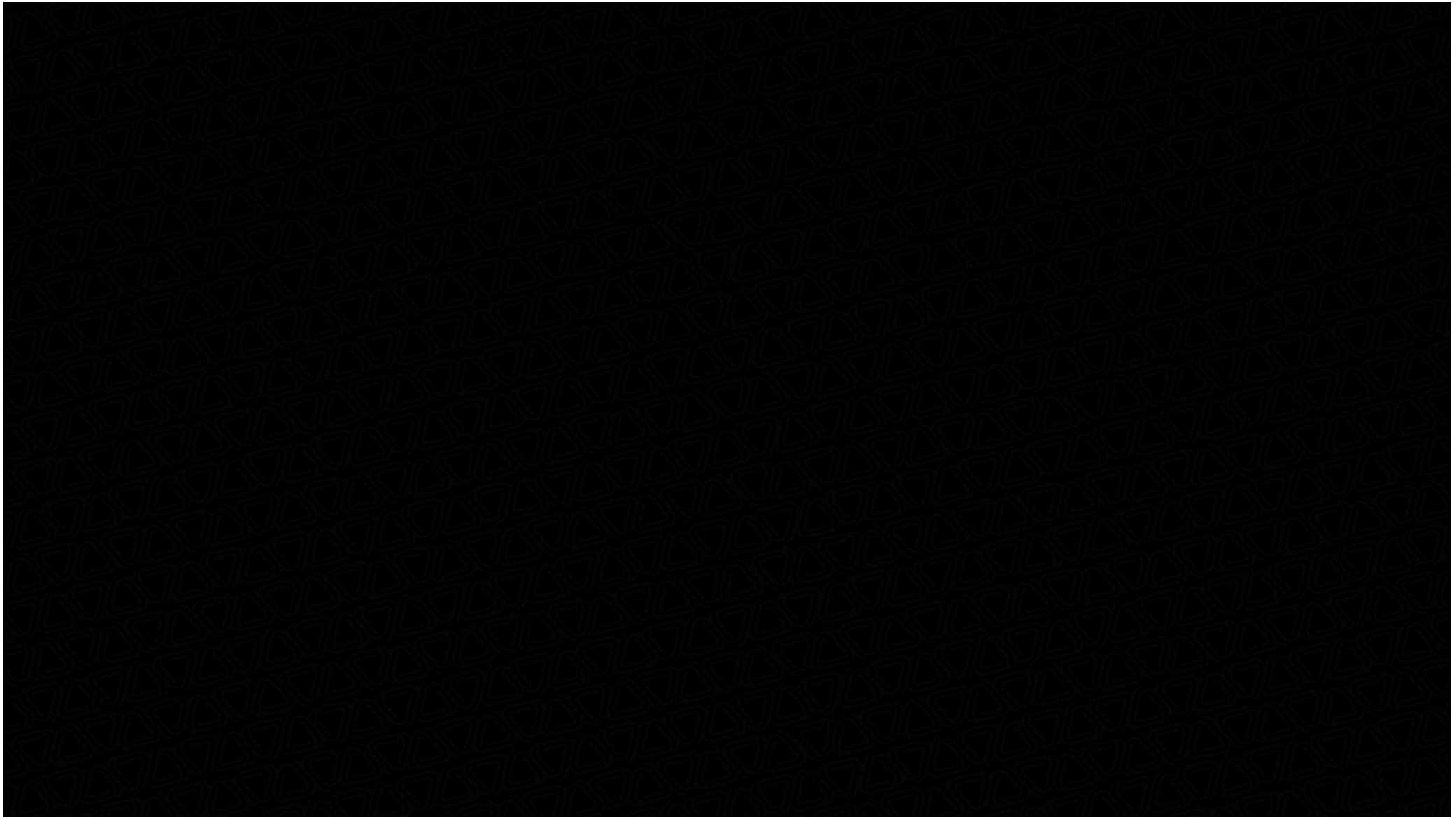
Plates

LUGGING

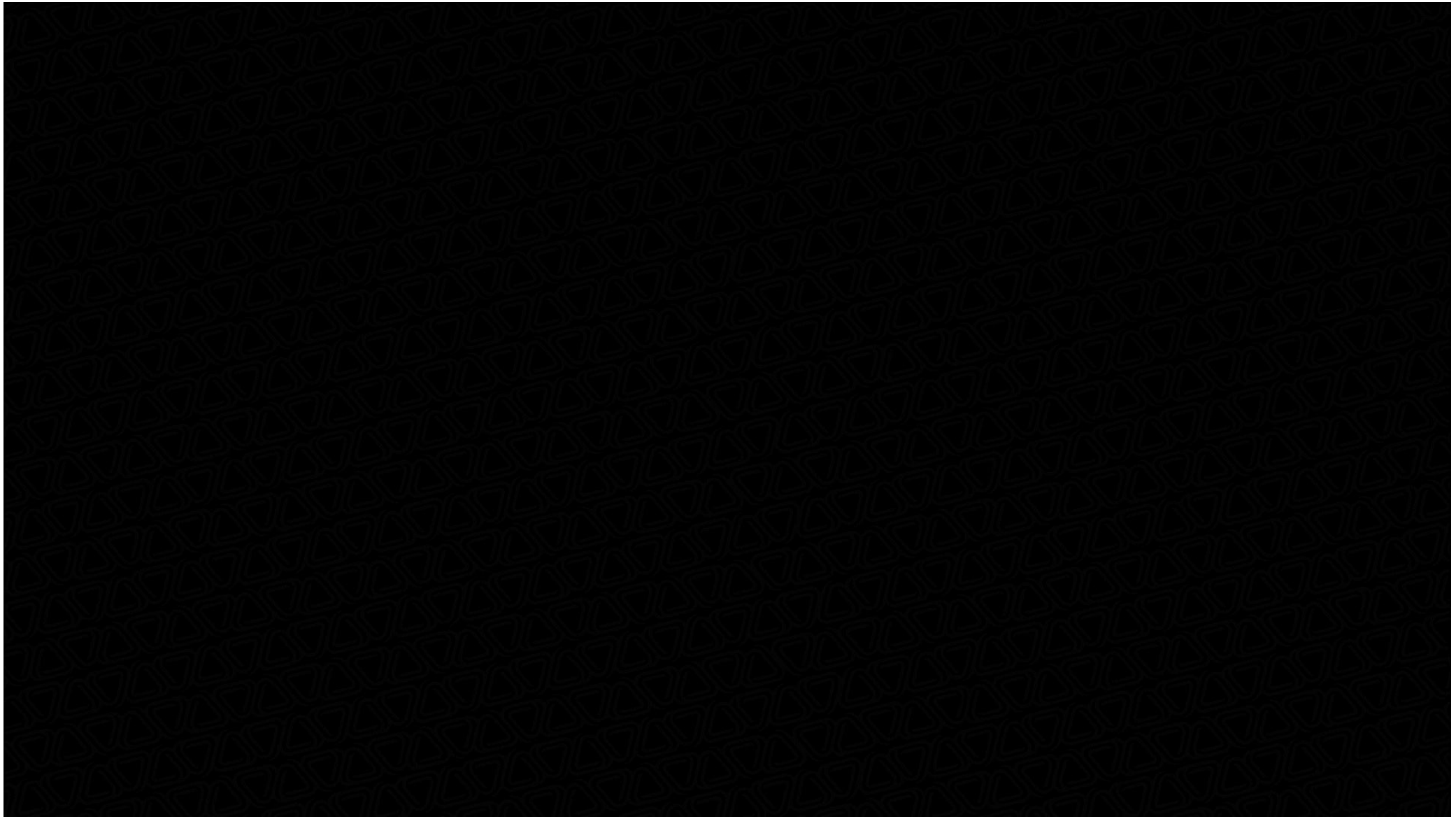
PASTING

From GEM to PLATE

Process video: Continuous Lug Casting

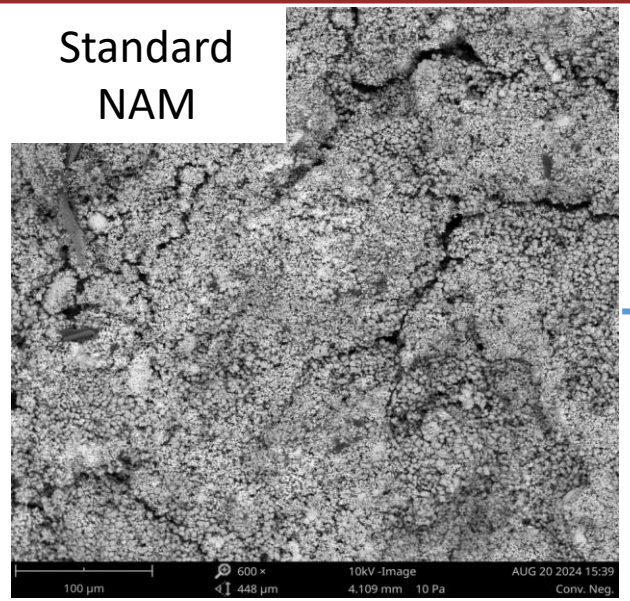


Process video: Continuous Pasting



SEM of Active Material

Standard NAM



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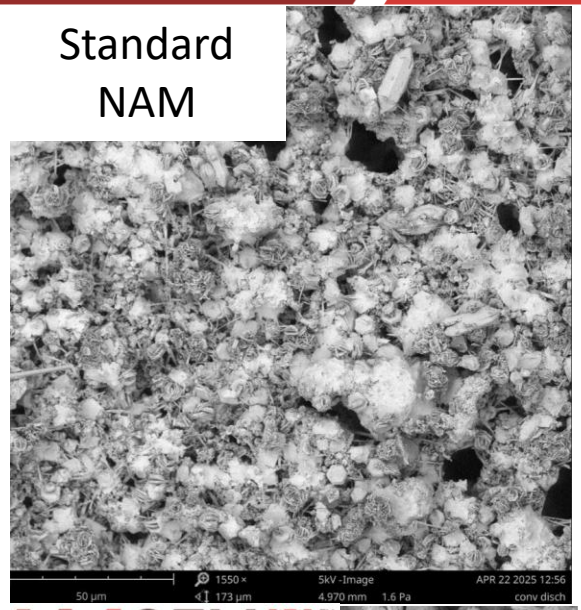
Formed Plates

Standard NAM



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Fully discharged Plates

NH_4OAC treated to remove surface sulfates

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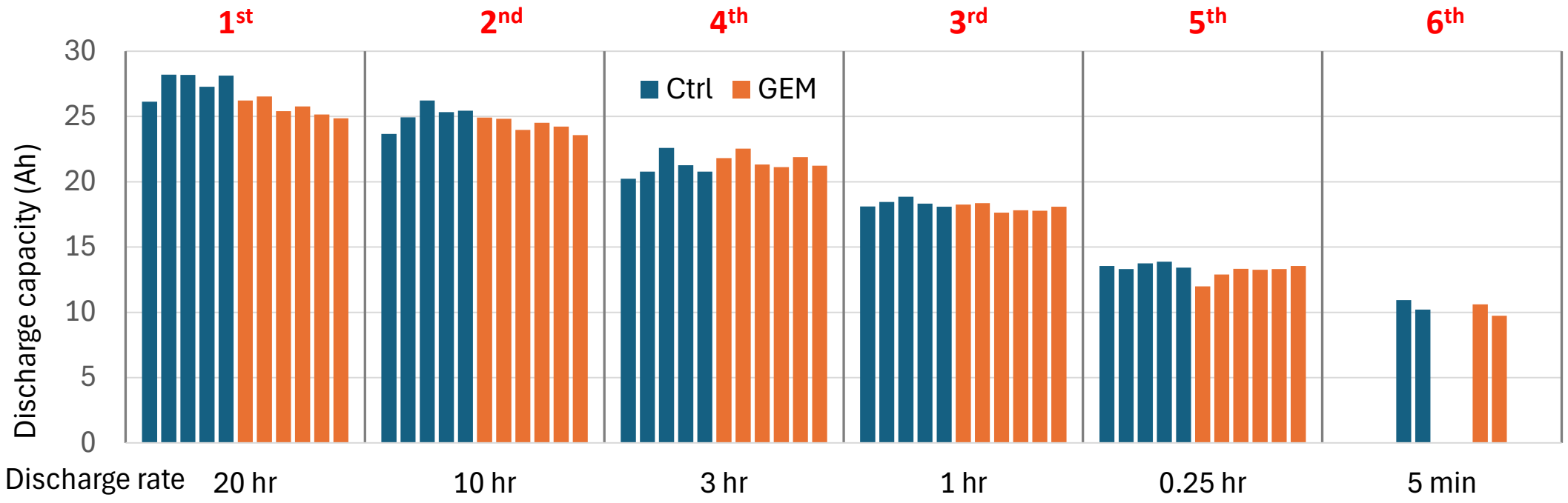
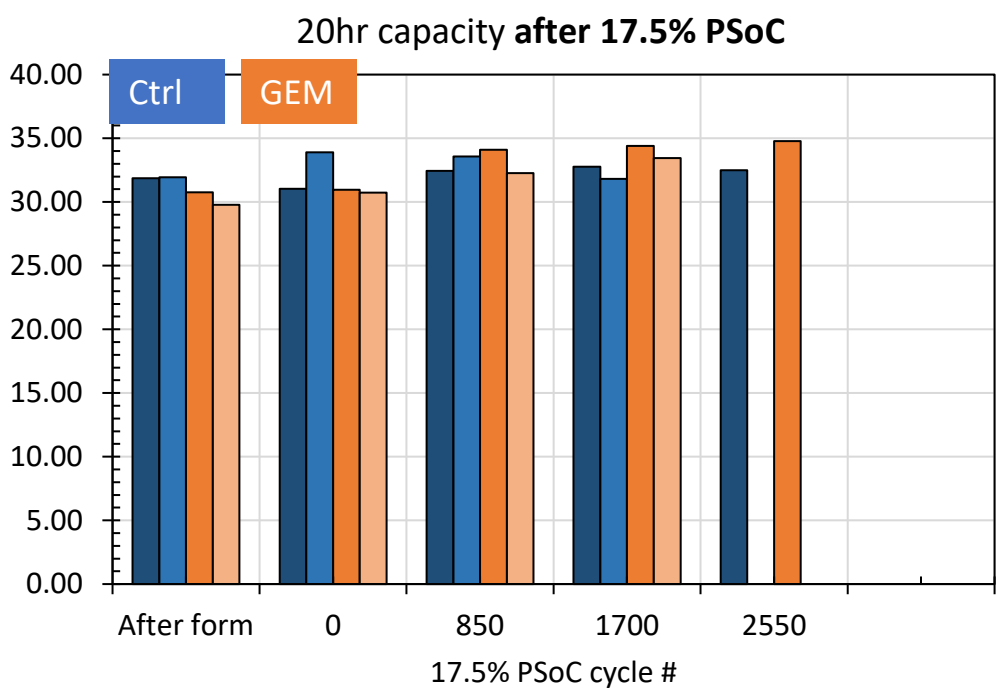
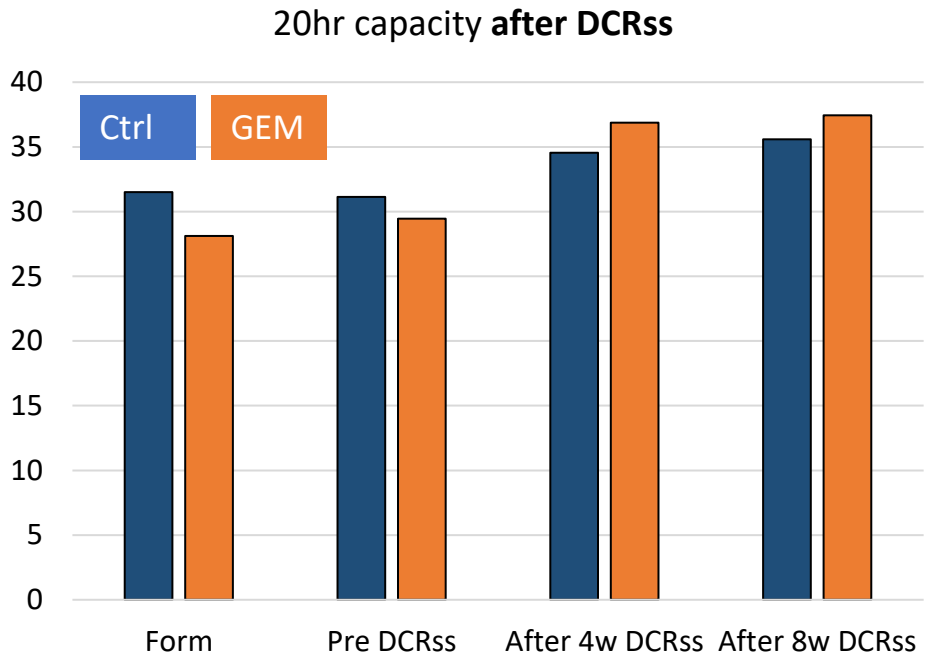
Capacity



	Test sequence
1	20 hr capacity
2	10 hr capacity
3	1 hr capacity
4	3 hr capacity
5	15 min capacity
6	5 min capacity

- **GEM has equivalent capacity as conventional cells in both lower rate and higher rate.**





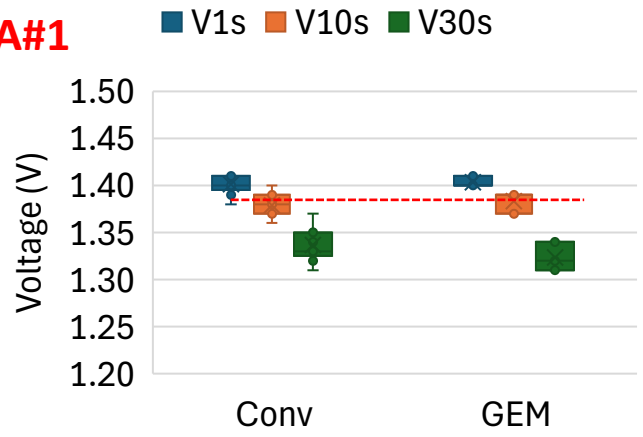
- GEM shows the capacity improvement in PSOC life cycle
- GEM structure is self-optimizing during test/use

Cold cranking

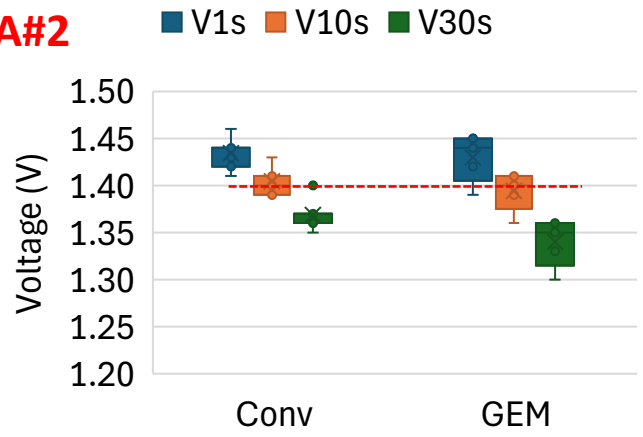
Cold cranking SAE
260 A, -18 C

Performance	
1	20 hr capacity #1
2	Cold cranking #1 260 A -18C (SAE)
3	Reserve capacity
4	Cold cranking #2 260 A -18C (SAE)
5	20 hr capacity #2

CCA#1



CCA#2

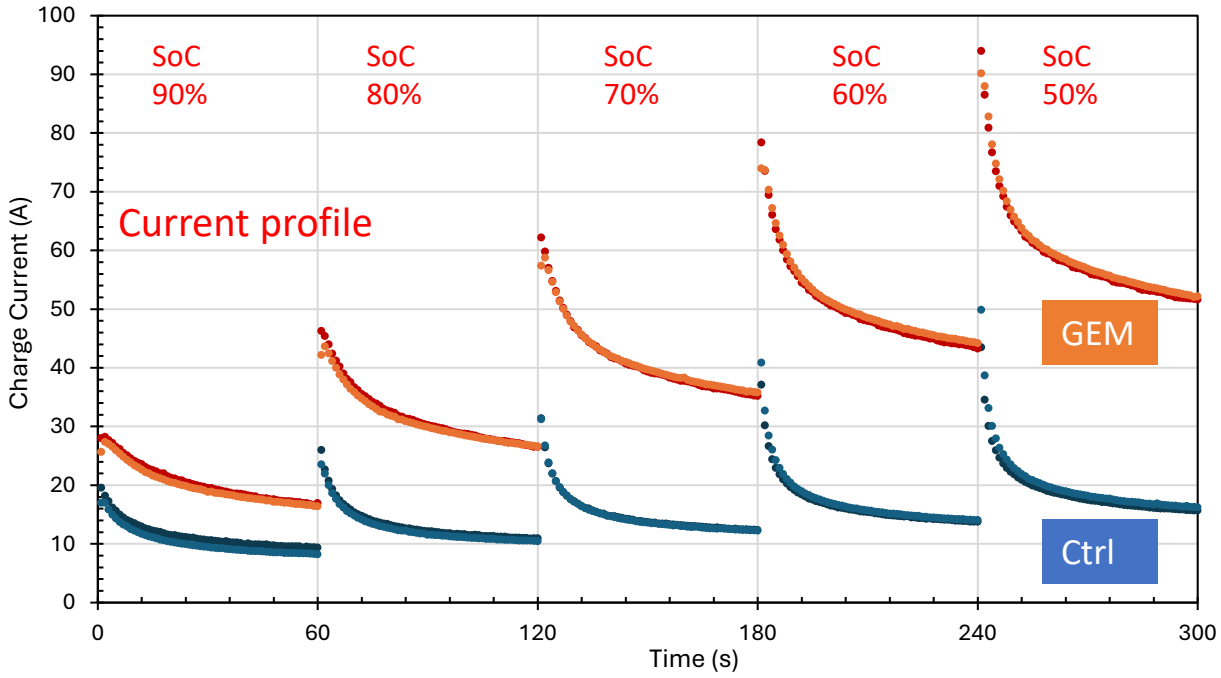


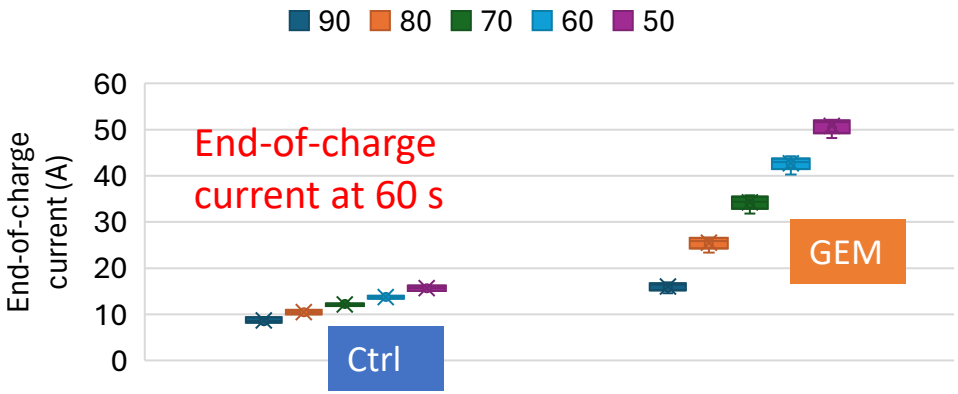
- GEM has equivalent cold cranking performance to conventional plates

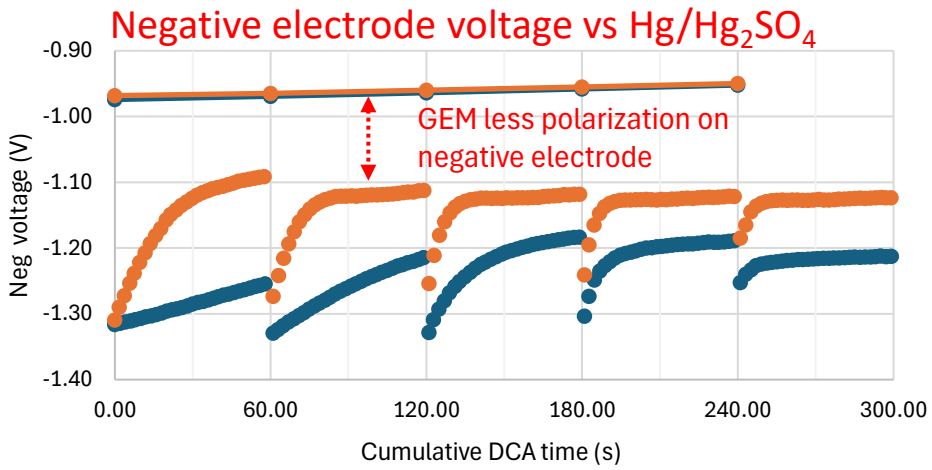
Dynamic charge acceptance (VDA)

Dynamic charge acceptance

2.47 Vpc, 1 min 50-90% SoC







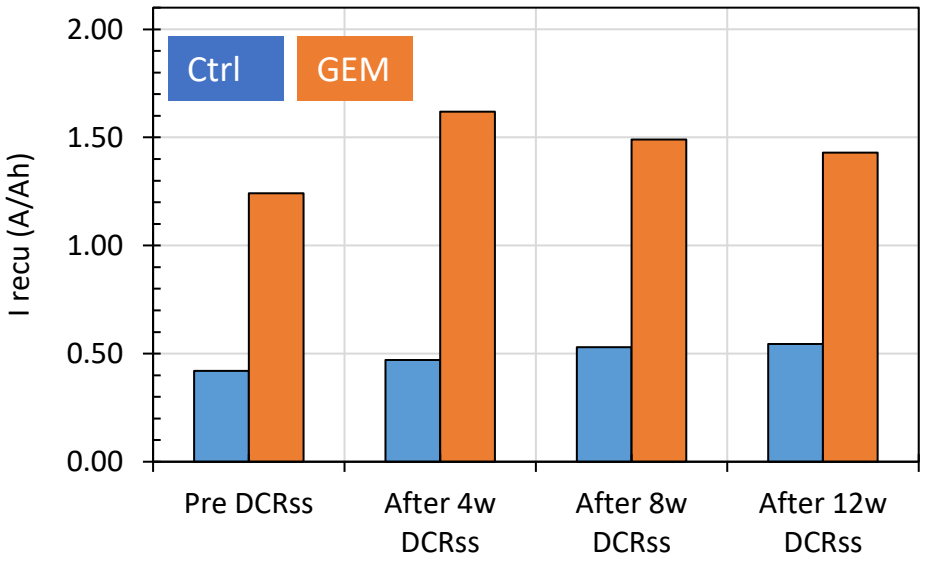
- GEM is significantly higher in DCA current, and capacity returned in 1 min.
- Unique structure of GEM plates enables higher current acceptance with less polarizations

WLT8 Charge acceptance + DCRss

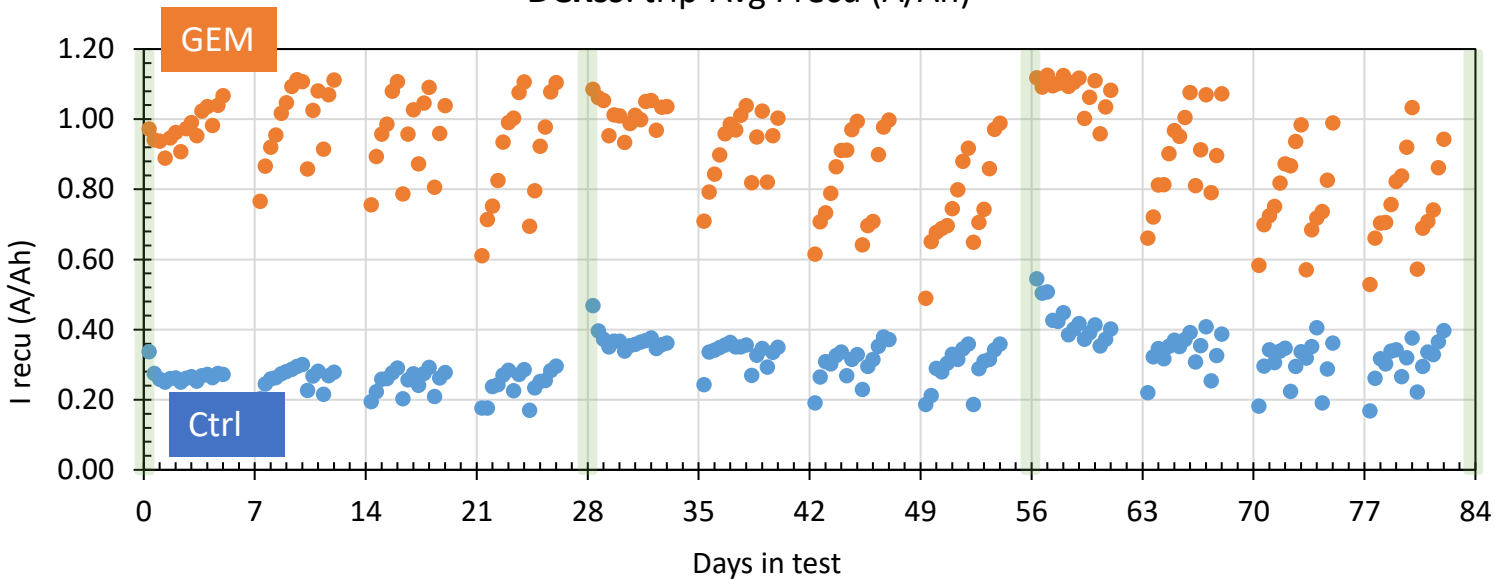
WLT8 Charge acceptance
Ford / Eckhard
2.47 Vpc recuperation

DCRss: Eckhard / Ford "TestB"

WLT8
Avg I recu (A/Ah)



DCRss: trip-Avg I recu (A/Ah)



- GEM exhibits a constantly better charge acceptance in terms of WLT8 I recu and DCRss I recu.
- Ctrl cell slightly increased during cycling but is still below 50% of GEM's performance

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Water loss at 60C (VDA)

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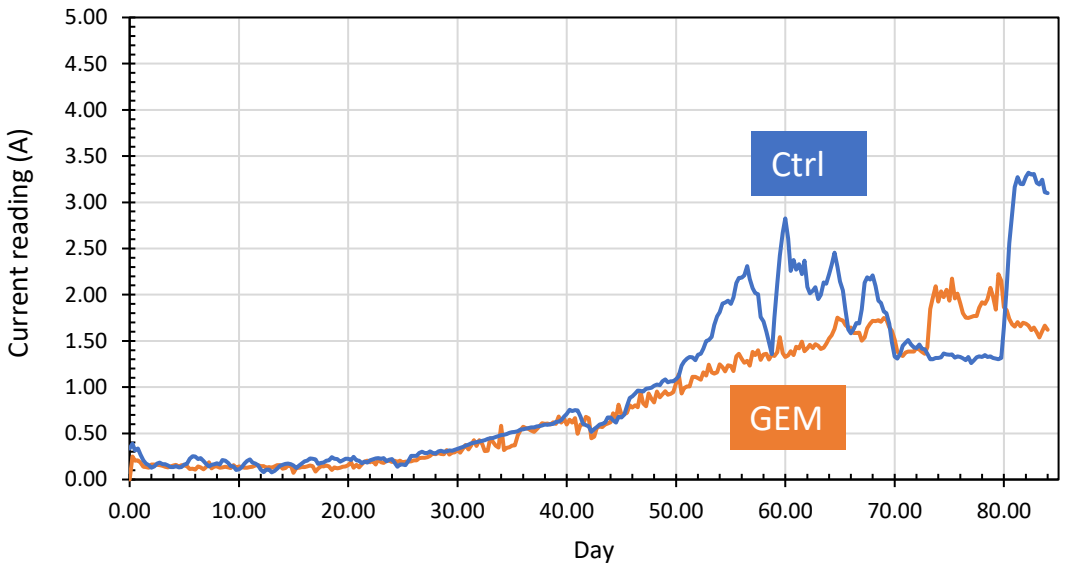
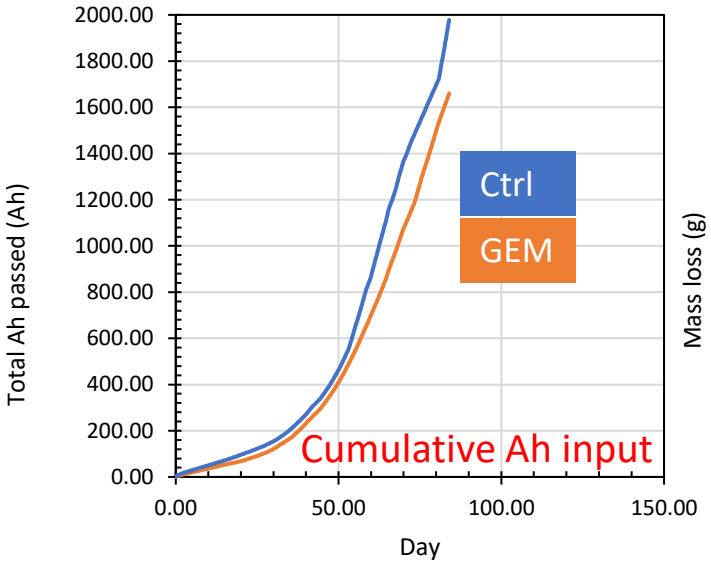
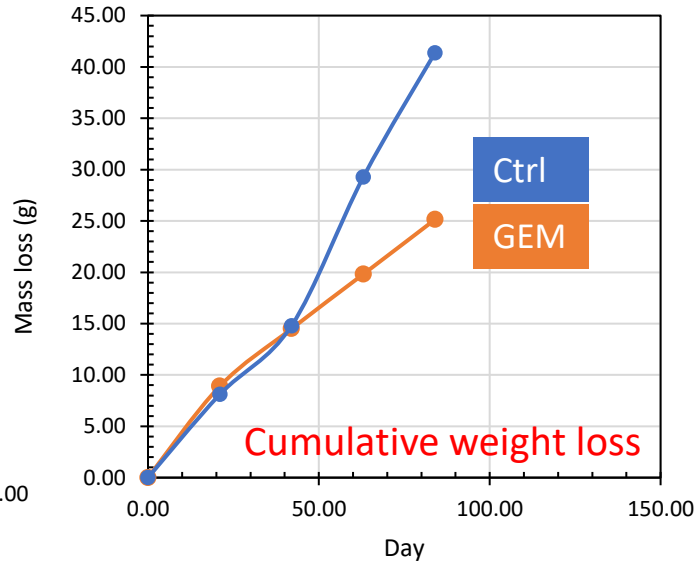
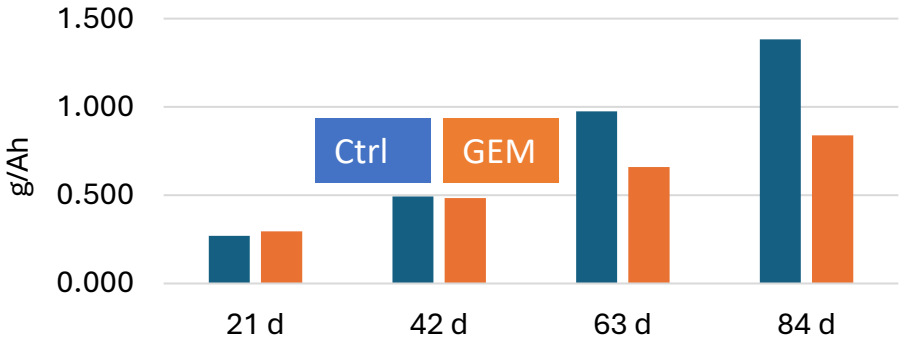
Water consumption EN/VDA

2.4 Vpc at 60 C









Post water loss WLT8	
GEM	Ctrl
1.0 A/Ah	**~0.85 A/Ah**
EOL saturation est.	
89%	**80%**

- Water loss test completed at 84 days
- Similar current profile, GEM lower water loss – higher saturation retained by GEM
- Both significant lower water loss vs Carbon veil plates

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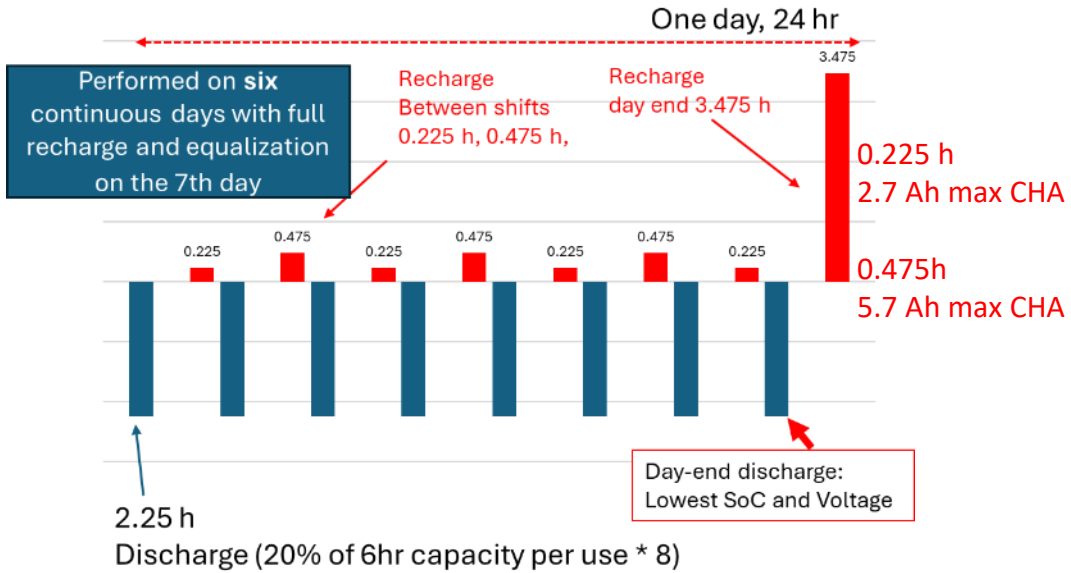
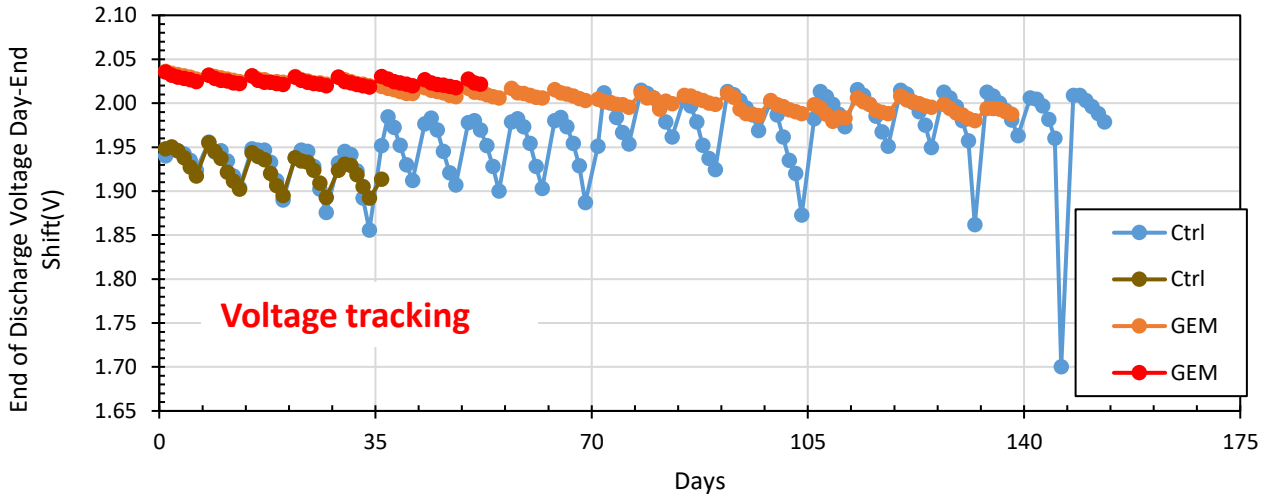
BCIS-022 FastCharge (0.5 A/Ah charge current limit)

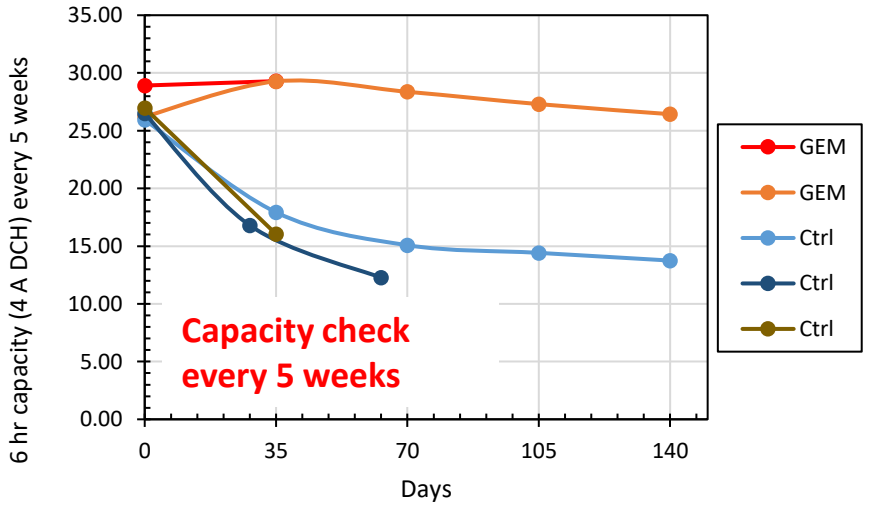


Total CHA 5.8 h/day, DCH 38.4 Ah/day



6h capacity	24 Ah
Max charge current	12 A
Max charge voltage	2.47 V
DCH current	2.13 A
DCH time per use	2.25 h
DCH capacity per use	2.13*2.25 = 4.8 Ah

- Very rapid capacity drop of Ctrl cells in first few weeks
- GEM is very stable, and keeping the cell capacity high



Application Potential

Traction

Applications	Advantages	Customer Benefits
Auto: Micro Hybrid	High and Sustained DCA with very low Water Loss	Lower fuel consumption and reduced emissions with maintained SOC
Auto: EV Aux	High Charge Recoverability	Reduce the risk of low SoF, which could render the EV inoperable and create potential safety hazards.
TRACTION	High charging speed	More opportunity charging

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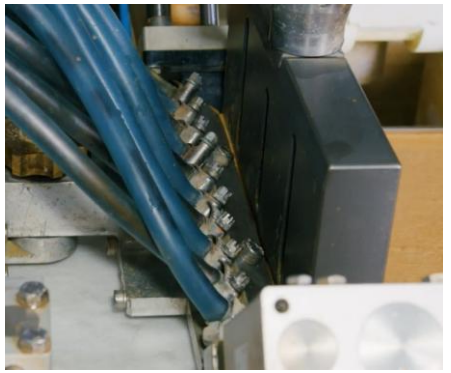
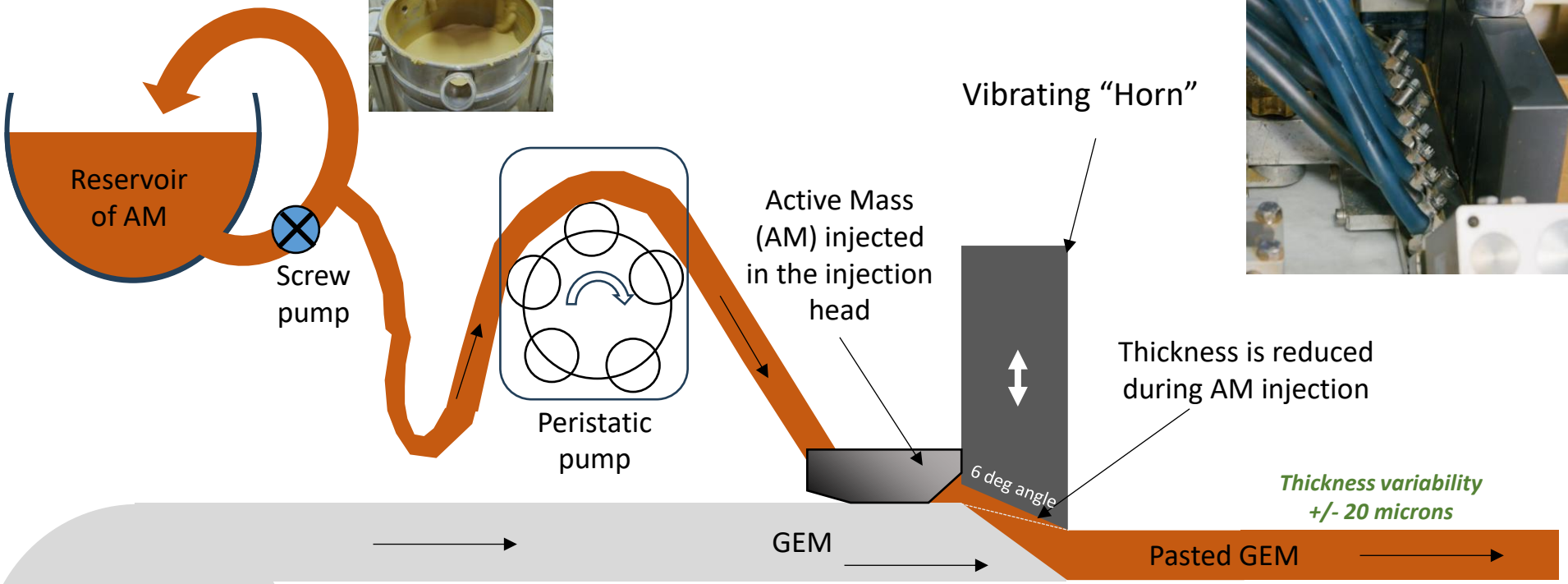
GEM Pasting process





- Active Mass main constituents are lead oxide and water plus some additives
- AM is injected under pressure through the injection head

MAIN ADVANTAGES of such active mass mix:

- Active mass easy to pump
- No need for temperature control (no chemical reaction with acid)

GEM process and plates availability

Hollingsworth and Vose has validated the capability to run GEM on multiple paper machines

Negative plates available upon request

- GEM made at H&V
- Then Lugged and pasted at ArcActive

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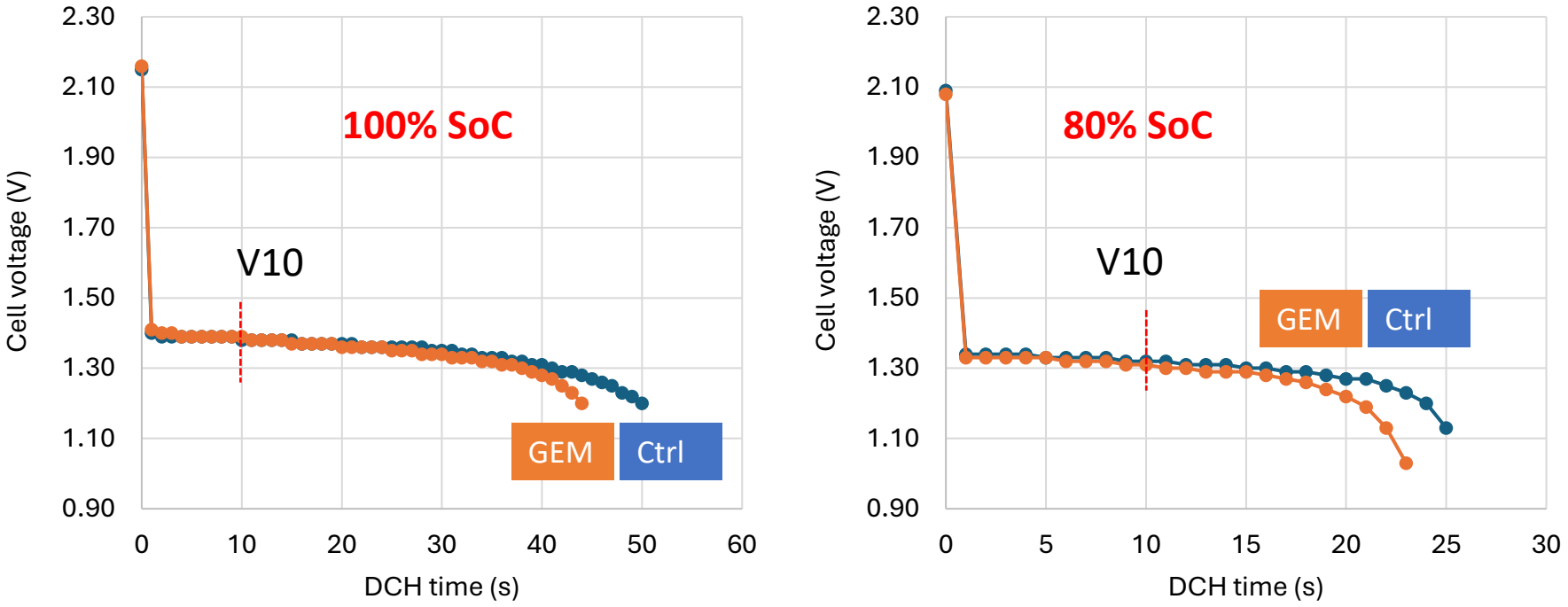
Cold cranking

Cold cranking SAE

260 A, -18 C



- GEM has nearly identical V10 to Ctrl cells.
- Runtime of GEM is a bit lower while entering the electrolyte transport limit.

50% DoD at 40ºC (EN 50342)

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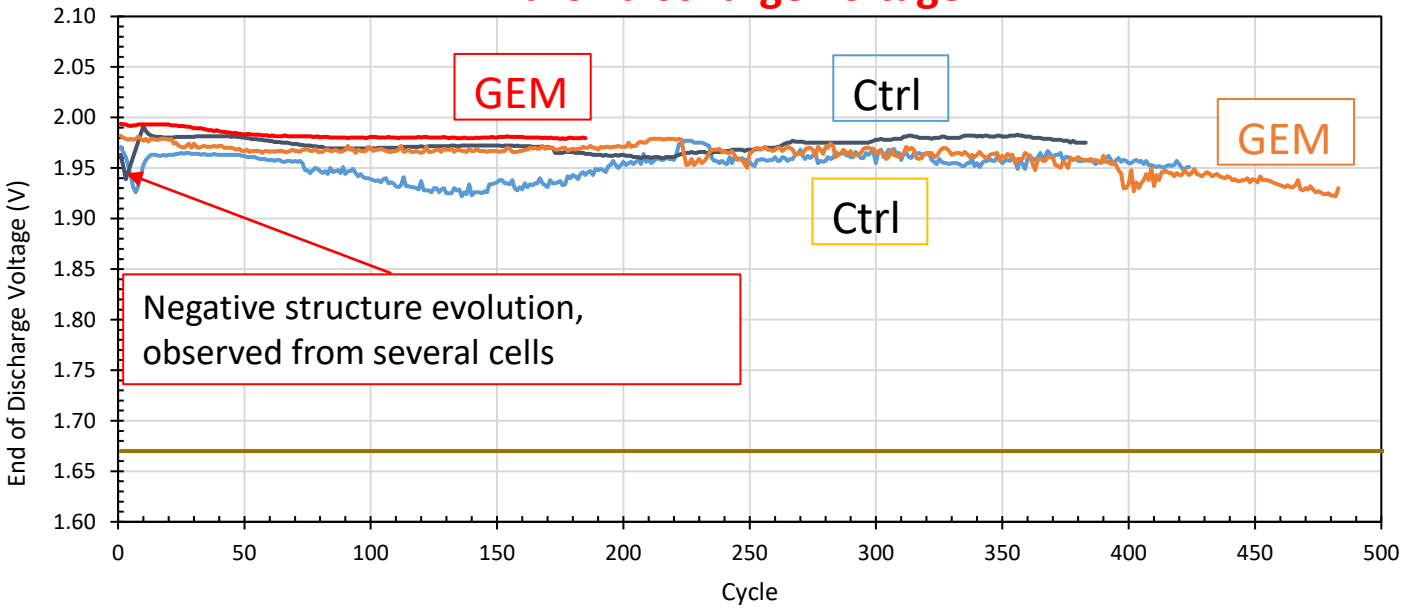
End-of-discharge voltage



- Usually positive limiting
- 108% charge factor (15.12 Ah)
- No significant difference in DCH voltage profile
- **GEM recharged faster: no CC recharge stage earlier**
  - GEM <4 h vs Ctrl >5 h to reach 108% CR
  - Maybe less water loss (no GEM failure so far)

Table 16 — Endurance 50 % DoD – Cycling part

Structure	*N° Step*	*t*	*U [V] I [A]*		*Description*	*T [°C]*	*Data acquisition frequency*	*Result of measurement of each step*
50 % DoD cycling part	20 DCH	2 h	≥ 10	$5 \cdot I_n$	Discharge 50 % DoD	40		U_{DCH}
	21 CHA	≤ 5 h	15,6[a] 14,4[b]	$5 \cdot I_n$	Charge 15,6V[a] for flooded Charge 14,4V[b] for VRLA Abort this step if CR ≥ 1,08	40		Recharged capacity C_{rch}
	22 CHA	≤ 1 h	18,0	$1 \cdot I_n$	Abort this step if CR ≥ 1,08	40		Recharge with I = const.
	23 RPT				Run steps 20 to 22 up to 360 times	40		

[a] The charging voltage for flooded batteries shall be 15.6V if not specified differently by the battery manufacturer.
[b] The charging voltage for VRLA batteries shall be 14.4V if not specified differently by the battery manufacturer.

CC recharge capacity