Fully Printed Silver-Oxide Batteries

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Abstract

In order to design an energy-efficient, fully printed battery, it must have great stability in KOH, high conductivity, a low thermal budget, and each individual layer must be printed. A new fully printed battery architecture was designed to meet these requirements in order to achieve the most energy efficient system. An ideal battery has low internal resistance, an areal capacity between 4-10 mAh/cm^2 and a high specific capacity. One of the main limitations of printed silver-oxide batteries is the corrosive nature of KOH electrolytes. To remedy this issue, corrosion of the electrode-electrolyte system must be reduced to improve cell lifetime and make better use of the electrodes. By implementing a carbon separator layer in-between the electrolyte and cathode of the battery system, we were able to improve battery stability.

Background and Motivation

5 Main Components of Battery

- Anode (Negative)
- Electrolyte
- Cathode (Positive)
- Two Current Collectors

$$Ag_2O + H_2O + 2e^- \leftrightarrows 2Ag + 2OH^-, \quad E^0 = +0.345\ V$$

$$Zn + 4OH^- \leftrightarrows Zn(OH)_4^{2-} + 2e^-, \quad E^0 = -1.249$$

$$Zn(OH)_4^{2-} \leftrightarrows ZnO + H_2O + 2OH^-$$

$$Ag_2O + Zn \leftrightarrows 2Ag + ZnO$$

Figure 1: Electrochemistry of Battery

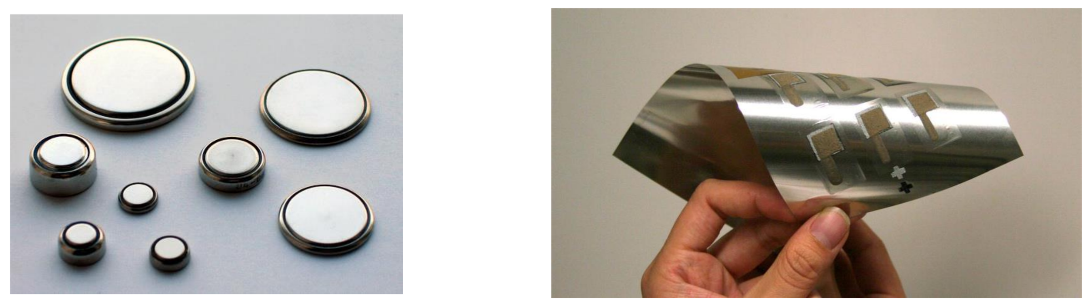

Figure 2: Coin cell battery (left), Batteries on flexible substrate (right)

Printed Current Collector Requirements

- Stability in KOH
- High conductivity
- Low thermal budget
- Fully printed

Methods

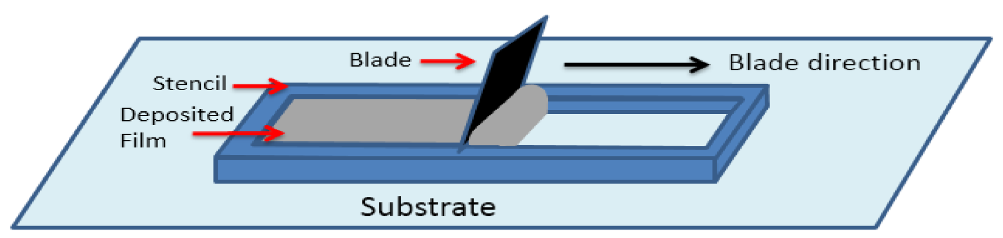

Figure 3: Blade coat printing technique

- Blade coating was used to print layers in the battery
- Each layer in stack made by blade coating besides PDMS

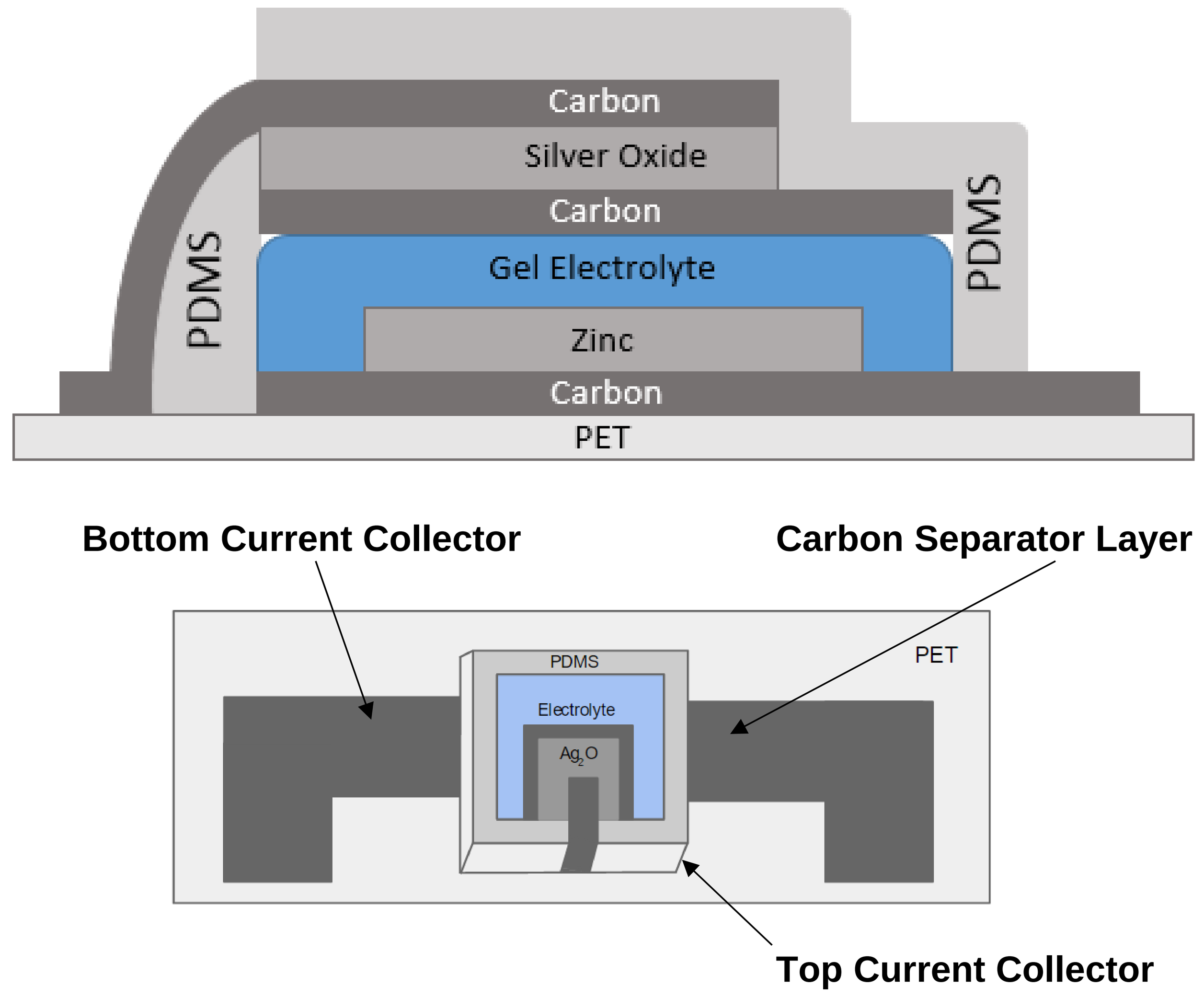

Figure 4: Fully printed battery stack architecture side view and top view

Results

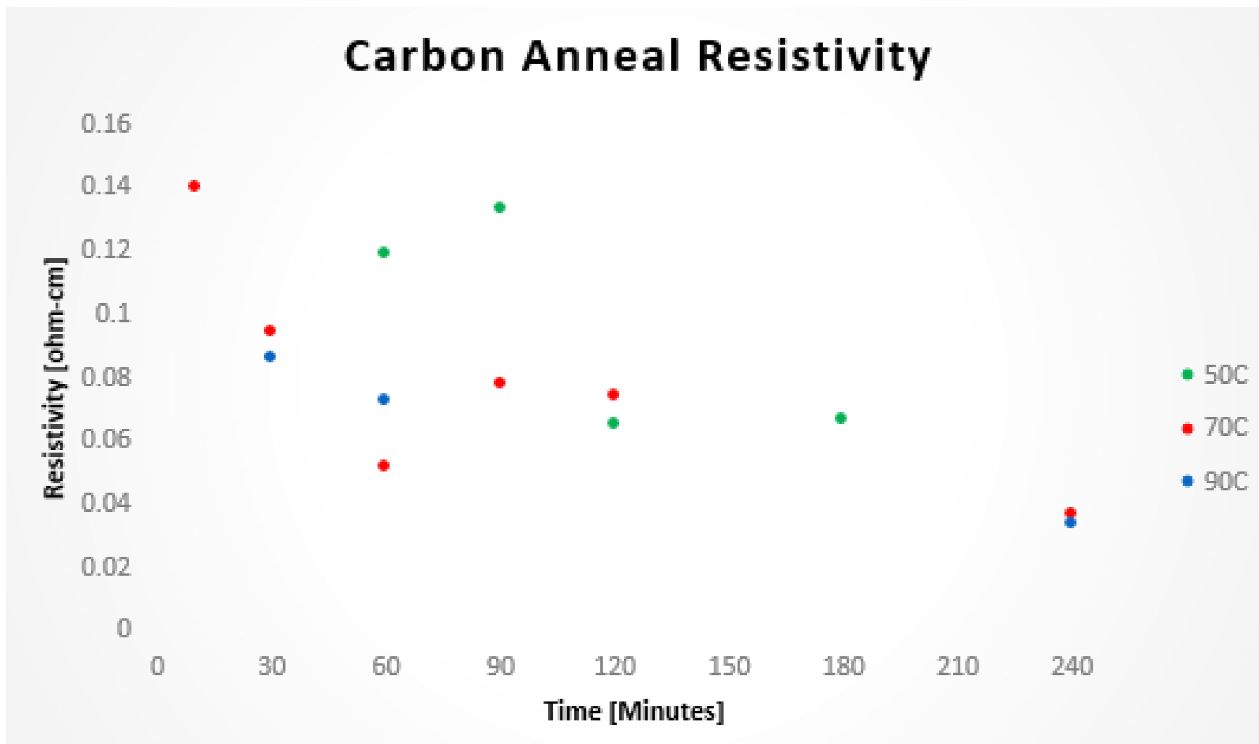

Figure 5: Carbon separator layer annealed at different times and temperatures

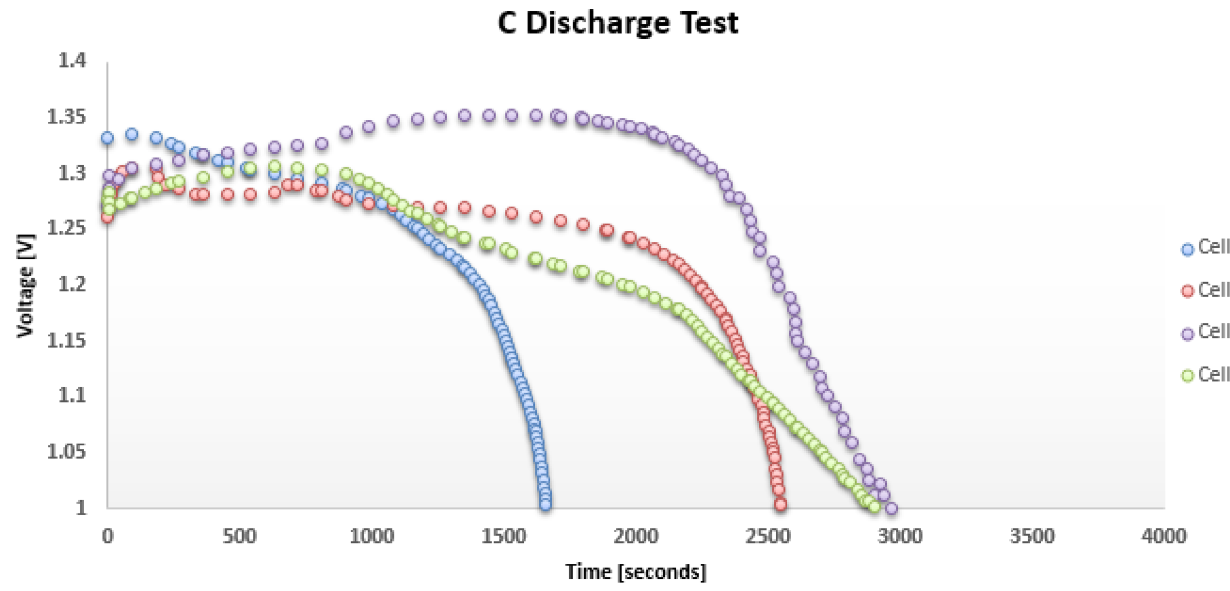

Figure 6: Carbon separator layer in sandwich structure C discharge experiments

Discharge Rate	Separator Thickness (um)	Electrode Stencil Thickness (um)	Specific Capacity (mAh/g)	Areal Capacity (mAh/cm^2)	Open Circuit Voltage (V)	Internal Resistance (Ω)	Ag_2O Utilization (%)
C (1)	25	300	227.5	4.3	1.52	113.6	38
C (2)	25	300	184	6.9	1.5	94.4	72
C (3)	125	300	172	4.84	1.65	313.2	110
C (4)	125	300	155	4.52	1.6	279	100

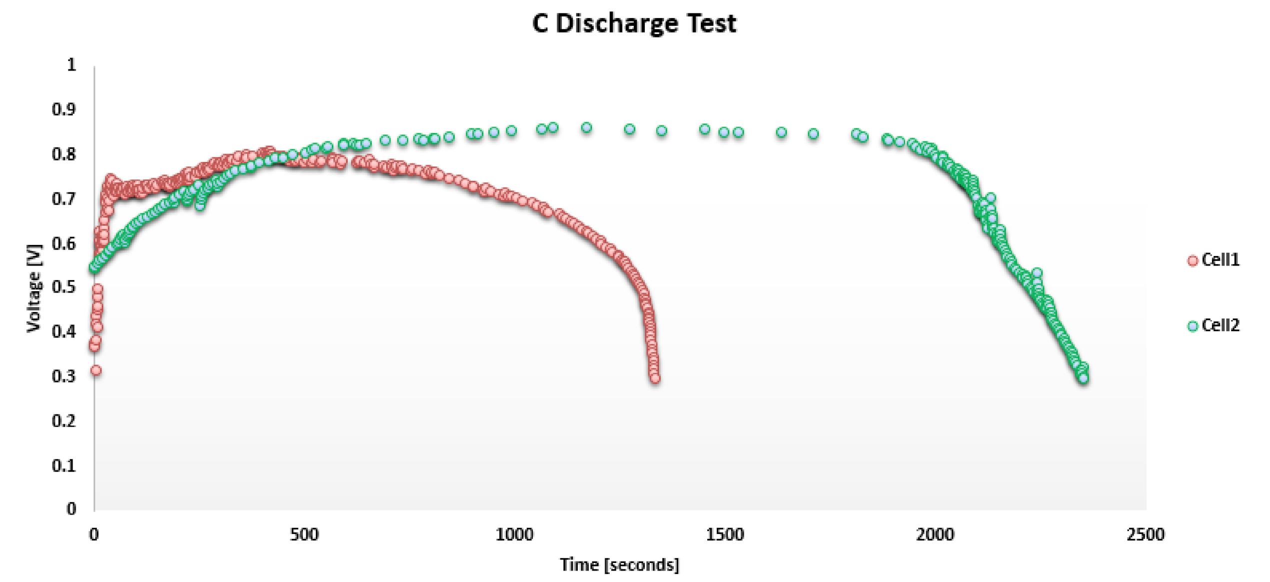

Figure 7: Fully Printed C discharge experiment

Discharge Rate	Separator Thickness (um)	Electrode Stencil Thickness (um)	Open Circuit Voltage (V)	Internal Resistance (Ω)	Ag_2O Utilization (%)
C (1)	125	125	1.66	506	37
C (2)	25	125	1.67	324	65

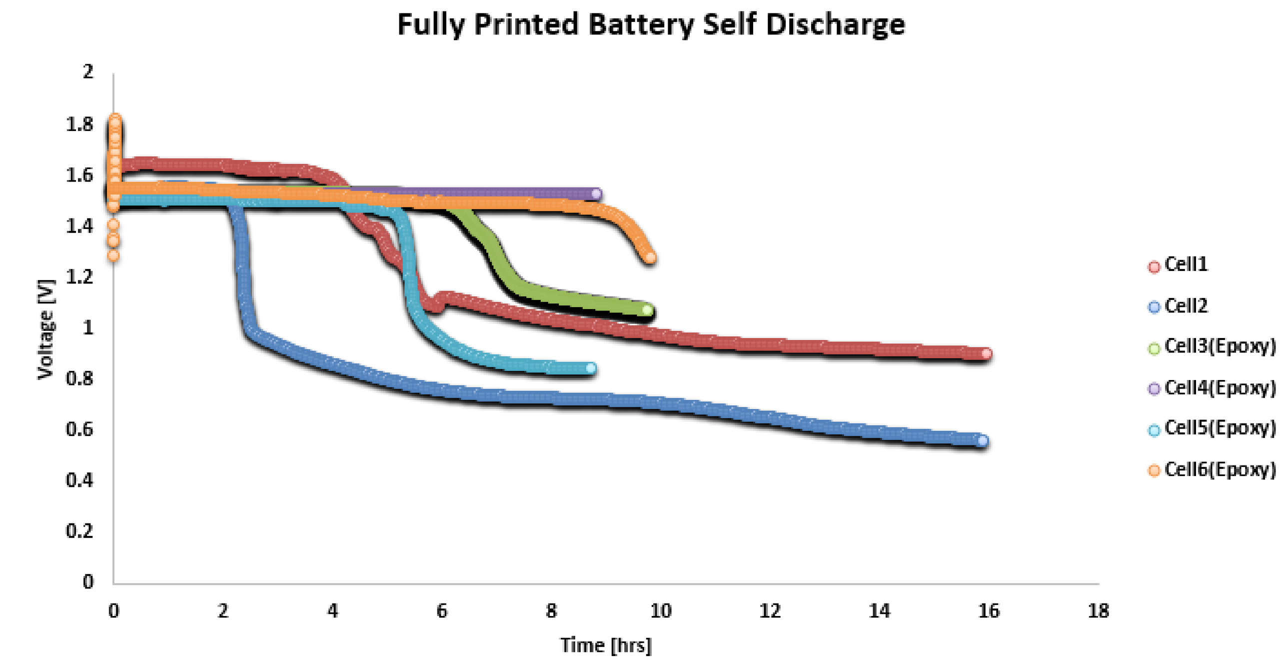

Figure 8: Self discharge experiment with fully printed cells

Conclusion

- Designed a fully printed battery stack architecture
- Met all requirements
- Epoxy seal after encapsulation increases lifetime

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Future Research

- Reduce internal resistance
- Implement a more efficient encapsulation method to increase cell life

References

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[2] Braam, Kyle, and Vivek Subramanian. "A Stencil Printed, High Energy Density Silver Oxide Battery Using a Novel Photopolymerizable Poly(acrylic Acid) Separator." *Adv. Mater. Advanced Materials* 27.4 (2014): 689-94. Web.