INKJET PRINTED RECHARGEABLE BATTERY FOR INTEGRATION IN FLEXIBLE HYBRID ELECTRONIC APPLICATIONS

DoMicro is developing rechargeable flexible batteries as a power source compatible within the production process of flexible hybrid electronics by inkjet printing. Fast design, flexible form factor and creating ideal power parameters for product integration is possible by digital inkjet printing processing. A Silver-Zinc battery material configuration typically delivers 1.55V open voltage and has a high energy density by design. The Silver-Zinc system can outperform the Li-Ion battery systems when fully developed [1]. Batteries can be integrated in functional flexible hybrid electronics for low power applications like temperature sensors, energy harvesting or wireless connectivity.

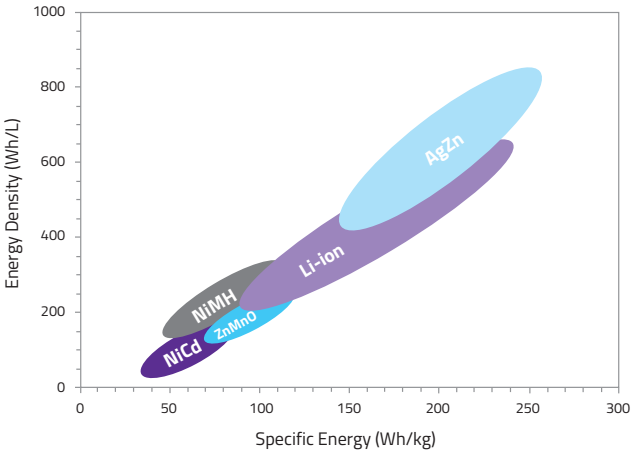

Figure 1: Specific energy and energy density of different battery systems [1]

MATERIALS AND METHODS

Characteristic of a printed battery depends on ratio and concentration of active material as well as on design and form factor. At start of our technology development program, initially selected materials were optimized for inkjet printing. A straightforward co-planer design was printed to study the battery cell functional performance by these inkjet printed materials. After achieving this principle milestone the battery system was further improved. Optimizing the material ratio and electrolyte concentration decreased internal resistance and increased battery utilization. Several battery prototypes were charged and discharged multiple cycles to study layer behavior, wear and tear over time. Characteristics were measured further improving performance. Key parameters are Open Circuit Voltage (OCV), Internal Resistance (IR), Capacity (C) and charge/discharge curve shape. Performance changes were noticed while testing different battery materials and design parameters. By optimizing active material, printing process and charging methods, cyclability and utilization of our battery concepts and prototypes have drastically improved.

Current development is focused on further improvement of internal resistance, stability of materials during charge/discharge cycles and shelf-life. Decreasing growth rate of internal resistance over time will benefit these functional variables. Enhanced cyclability is under development by improving the printing process and further exploration of material stability. Fundamental root causes and physics are under investigation.

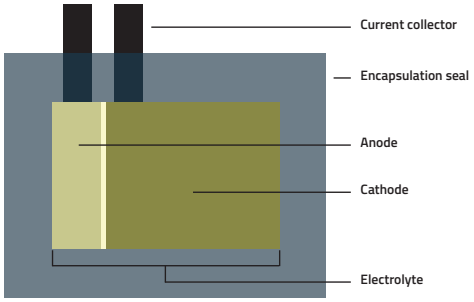

Figure 2: First prototype battery lay-out

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RESULTS, CONCLUSIONS AND OUTLOOK

Our inkjet printed rechargeable battery cell prototypes are able to deliver approximately 1.5V as a single cell and 3.0V as a double cell. The prototype cell can be recharged at least 6 times. The battery cell delivers a constant and stable voltage while discharging. A sharp discharge curve at the end of the load cycle shows optimal battery utilization of the Silver-Zinc material configuration.

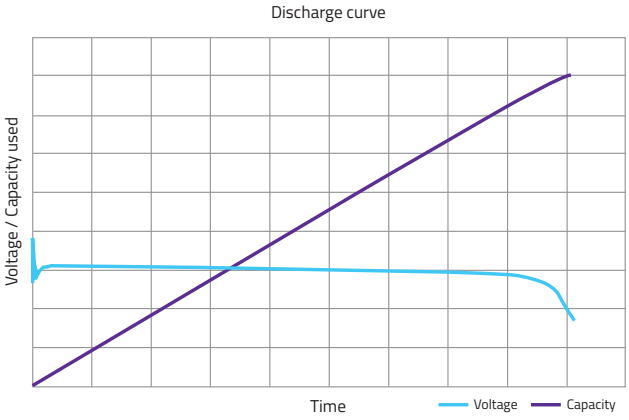

Figure 3: Discharge curve battery cell

- A functional rechargeable battery cell can be inkjet printed on a flexible substrate.
- The battery operating voltage is stable and constant under load, independent the state of charge available.
- Changing from co-planar to stacked design energy density, capacity and electrode thickness can further increase.
- Cyclability and shelf-life can be enhanced by finding and developing alternative materials for inkjet printing.
- Unlimited form factor and small series are feasible for integration in all kinds of functional product applications.

Figure 4: FlexBats 1.5 and 3 V

Figure 5: FlexBats in different shapes

REFERENCES AND LITERATURE

[1] D. L. Thomas Reddy, "Lindens Handbook of Batteries 4th edition," Mcgraw-Hill Professional, 2010, pp. 2120-2214

[2] D. A. Steingart, "A SUPER INK JET PRINTED ZINC-SILVER 3D MICROBATTERY," 2008.

[3] K. Braam, "Development of an air-stable, high energy density printed silver oxide battery for printed electronics," Electrical Engineering and Computer Sciences University of California at Berkeley, 2015.

[4] F. v. Sturm, "Secondary Batteries—Silver-Zinc Battery," Comprehensive Treatise of Electrochemistry, pp. 407-419.

DOMICRO COMPANY PROFILE

DoMicro develops innovative production technology for flexible hybrid electronics. A revolutionary fully integrated and automated production system solution (Micro Device FAB) provides the competitive edge with respect to time to market, total costs, ramp up volumes and your secured IP position. If you are challenged by the market and looking for a partner to move your ideas into realization, contact us.

We really do FACILITATE YOUR IMAGINATION.

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