Polymer Based Zinc-Silver Microbatteries

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Vision

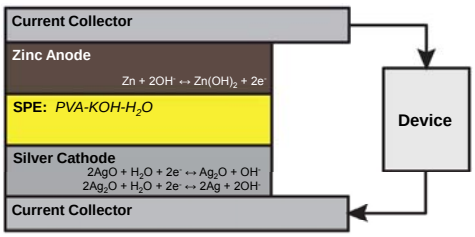
Zinc-silver batteries offers the highest power densities of commercial rechargeable batteries with up to 600 W/kg for continuous operation. Currently, zinc-silver batteries utilize an aqueous electrolyte such as potassium hydroxide (KOH) solution. The alkaline electrolyte allows for a high watt-hour output per unit volume. However, the strong basic solution corrodes and dissolves the electrodes over time resulting in a short wet life. Cycle life is also relatively low (<100 cycles) since the zinc anode exhibits shape change during cycling.

In this work, we are analyzing the use of solid polymer electrolytes (SPE) for zinc-silver battery systems to improve both the wet life and cycle life in microbattery applications. Furthermore, incorporating a solid polymer electrolyte will greatly simplify the packaging required for microbatteries (no liquid components).

Goals

Develop a zinc-silver battery system for microbattery applications.

- Easily fabricated (printing process)
- Rechargeable (lifetime > 100 cycles)
- Exhibiting a high energy density (comparable to Lithium-ion)



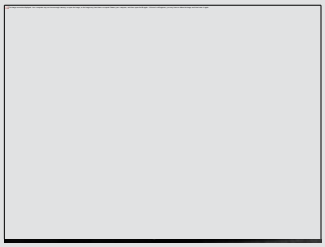
Schematic of zinc-silver battery system with charge-discharge reactions

Methods

As an alternative to an aqueous electrolyte, we are investigating the solid polymer electrolyte (SPE) of polyvinyl alcohol (PVA) dissolved in water and mixed with KOH for alkaline microbatteries. PVA is a polymer that exhibits a high solvent retention capacity, high gel strength, and is inexpensive. The cast PVA with KOH forms a solid film with high strength while exhibiting liquid like transport properties.

The solid polymer electrolyte (SPE) film was prepared by casting a PVA – KOH – H_2O solution and drying the solution to a film with a thickness ranging from 200 to 250 µm. A solid polymer Ag electrode was prepared by casting a Ag – PVA – KOH – H_2O solution and drying the solution into a film with a thickness of 200 to 250 µm. A battery cell was constructed with the PVA based positive electrode and electrolyte films along with a Zn foil negative electrode.

Solid Polymer Electrolyte (SPE)



Cross section of PVA – KOH – H_2O alkaline solid polymer electrolyte (15 wt% KOH)

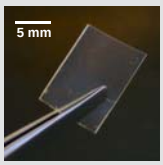
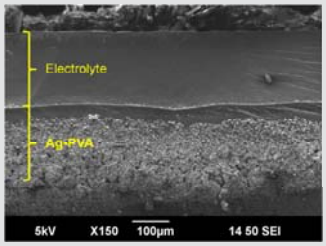
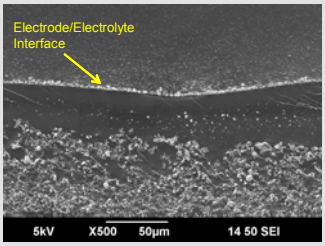


Photo of PVA – KOH – H_2O alkaline solid polymer electrolyte

Electrolyte/Electrode After Cycling



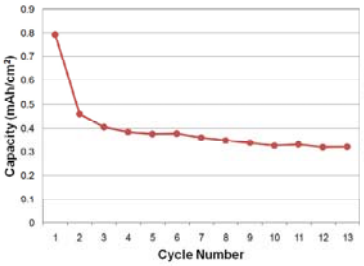
Cross section of PVA – KOH – H_2O alkaline polymer electrolyte and Ag – PVA – KOH – H_2O electrode



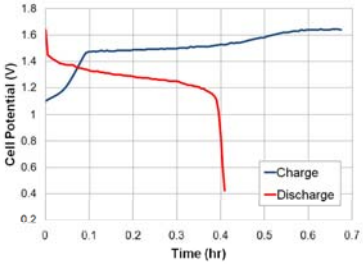
Higher magnification of the interface between the electrode and electrolyte

Findings

The charge/discharge behavior of the cell was analyzed by galvanostatic cycling. The discharge capacity of the cells 0.8 mAh/cm^2 during the first few cycles. After the second cycle, the capacity dropped to 0.4 mAh/cm^2. Cells cycled 15 to 20 times before failure. With improved manufacturing techniques, the PVA based zinc-silver battery system shows good potential for microbattery applications.



Discharge capacity during cycling of the zinc-silver cell with PVA – KOH – H_2O alkaline solid polymer electrolyte



Typical charge/discharge behavior of the zinc-silver cell with PVA – KOH – H_2O alkaline solid polymer electrolyte