Multi-cell thermogalvanic systems for harvesting energy from cyclic temperature changes

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Technologies for the Internet of Things (IoT) are being developed. An IoT network consists of large quantities of networked sensors that are often in remote or difficult to access locations, which drives the need for self-powered systems. Here we come up with two types of multi-cell thermogalvanic systems that can generate electrical power through temperature cycles.

The dual-temperature dual-stack self-powered electrochemical system is depicted in Figure 1. This system uses two identical electrochemical stacks, which can be a single battery or multiple batteries connected in series; however, each electrochemical stack is held at a different temperature. On the other hand, a single-temperature system works similarly, with the electrochemical stacks having similar operating potentials but oppositely signed temperature coefficients. Its operation is illustrated in Figure 2. Both systems can harvest energy from temperature cycles.

We have tested both dual-temperature systems and single-temperature systems with different cathode/anode materials, load resistances and frequencies of temperature cycles. The largest energy conversion efficiency was obtained from the dual-temperature experiment with two homemade $LiCoO_2$/Li coin cells in which the cathodes with composition $Li_{0.85}CoO_2$ were cycled between 20 °C and 50 °C. The loads were two 100Ω resistors. The current is shown in Figure 3, and the efficiency was calculated to be 0.22%. This value is comparable to the efficiency obtained using charging-free TRECs, thermocapacitive cycles and ionic thermoelectric supercapacitors, but with more flexibility of material selection. In the meantime, we have also tested two single-temperature systems with four LiV_2O_5/Li-Al and three $LiCoO_2$/Li cells, and one $LiMnO_2$/Li-Al and one LiV_2O_5/Li-Al cells, respectively. Although the efficiency and power were still limited, they confirmed the feasibility of this concept. These systems can be further optimized by using materials with higher temperature coefficients and decreasing internal resistance at the same time.

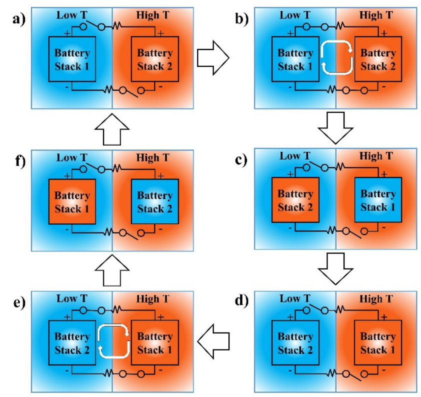

Figure 1: Schematic of dual-temperature system

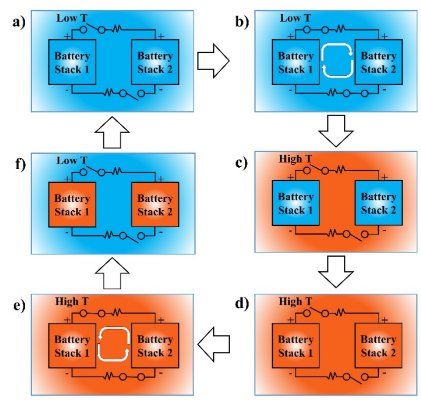

Figure 2: Schematic of single-temperature system

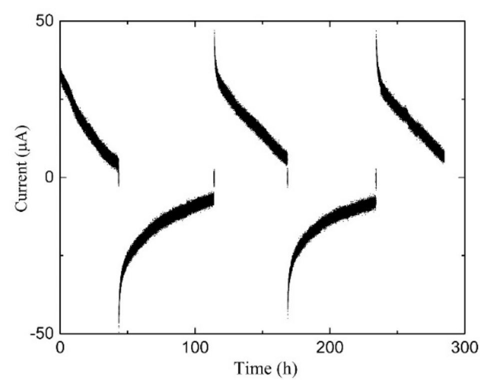

Figure 3: Results from the dual-temperature test with two 100Ω resistors and two homemade LiCoO2/Li cells using LP57 electrolyte and Celgard 2500 separators.

Further Reading

- Yang, Y. et al. (2014). PNAS, 111(48), 17011–17016.
- Härtel, A., Janssen et al. (2015). Energy Environ. Sci., 8, 2396–2401