A High Power Thick-Film Lithium-Ion Microbattery For Powering Autonomous Microsensor Systems

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This paper documents our efforts to fabricate a thick-film lithium-ion microbattery suitable for use with autonomous microsensing systems. The work is an extension of previous efforts to develop a microfabricated cathode capable of high rate discharge [1]. It is anticipated that the microbattery will be implemented with an energy harvesting device in a hybrid micropower system designed to meet the needs of autonomous microsensors [2]. Hence, the duty cycle of the battery will consist of long standby periods at low power (charge) combined with short high-power pulses for data processing and/or transfer (discharge). Both energy and power per area are critical for these applications.

The lithium-ion microbattery developed in this study incorporated thick-film composite electrodes in an attempt to maximize both the energy and power available per footprint area of the battery. Total battery thickness ranged from 150-250 □m. Batteries were microfabricated layer-by-layer on a polymer substrate. The polymer substrate is well-suited for low-temperature low-cost fabrication. In addition, it is ideally suited for compliant applications, and for integration into all-polymer integrated circuits. Polymer-based IC's are expected to become increasingly important for low-end high-volume microelectronics where low cost and mechanical flexibility are critical [3-5]. A cycloolefin copolymer film (Topas®) was selected for use in this study. This polymer was used as the substrate as well as the packaging material for the batteries.

The procedure used for battery fabrication was similar to that described previously [1]. The active material was MCMB and $LiAl_{0.14}Mn_{1.86}O_4$ for the anode and cathode, respectively. The microbatteries were 2 mm x 2 mm (0.04 cm^2 electrode area) and had a capacity of 0.025-0.04 mAh per cell (corresponding to 0.625-1.0 mAh/cm^2). Cells were activated before testing using a procedure modified from Vaidyanathan (2002) [6].

Cycling tests were performed at various discharge rates. Charging was always performed at a 0.5 C rate. Figure 1 shows voltage profiles for a typical microbattery that was discharged at both a 0.5 and 10 C rate. Discharge rates up to 20 C were examined.

A cycling test representative of a microsensor duty cycle was also performed in which pulse discharges of a designated duration and current level were carried out instead of constant rate discharge. The batteries were charged at 0.5 C to full capacity between the pulse discharges. A current of 1.6 mA (corresponding to 40 mA/cm^2 of electrode area) was observed from a single cell during pulse discharge to 2.84 V. This corresponds to a power density >100 mW/cm^2. Over 12,000 cycles of pulse discharges at 1.2 mA for 100 ms have been demonstrated (see Fig. 2).

Efforts to optimize the structure of these microbatteries and further improve their performance are ongoing.

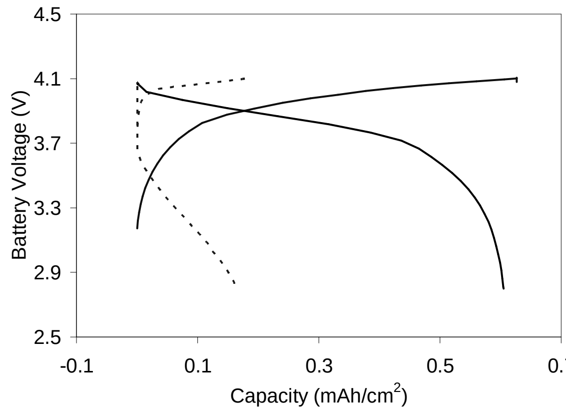

Figure 1. Voltage profiles of a microbattery of 0.025 mAh (Solid line: 0.5 C, dotted line: 10 C)

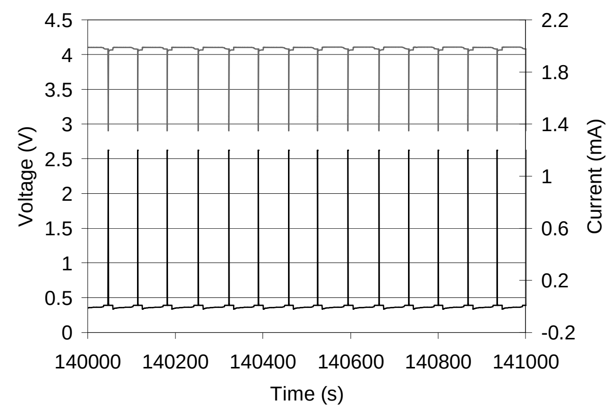

Figure 2. Microsensor duty cycle performance of a 0.025 mAh microbattery (upper curve: voltage profile; bottom curve: current profile).

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