MoO_3 Thin Film Cathodes for Elevated Temperature Applications

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Introduction

One of the important advantages Li thin film batteries offer beyond outstanding cycle life and shelf life is the robustness inherent in the solid-state design; *viz.* the ability to tolerate temperature extremes, mechanical shock, and moderate flexure far better than conventional Li-ion or Li polymer cells.

However, a critical limitation of state-of-art Li thin film batteries is the sensitivity to elevated temperature cycling. Cells incorporating $LiCoO_2$ cathodes, the most widely employed cathode for this type of battery, can be charged and discharged at 25°C over tens of thousands of cycles and experience capacity losses of only about 0.002% per cycle. In contrast, $LiCoO_2$ based cells that are operated at 60°C experience a factor of ten greater capacity loss per cycle.[1] Experimentation in our laboratories indicate that at higher temperatures, the capacity fade per cycle is even more severe, with cells capacity fading to 50% of initial values after only 100 cycles when operated at temperatures of 150°C. We are currently examining alternative cathode materials for elevated temperature cycling, and to this end have identified MoO_3 as a promising candidate material.

Experimental

All solid-state Li thin film battery cells were fabricated on glass slides. The deposition of all the films (except the anode layer) was carried out in a planar RF magnetron sputtering chamber. The cell design was a Ti/Pt current collector, MoO_3 cathode (0.3 □m thick), LiPON electrolyte (1 □m thick) and a thermally evaporated Li anode film.

MoO_3 film crystallinity was characterized via x-ray diffraction, and surface morphology was studied using scanning electron microscopy (SEM). The electrochemical characterization of the cells was performed using a Princeton Applied Research 273A potentiostat, and cycling experiments were carried out using an Arbin battery cycler. For elevated temperature testing, the cells were placed on a hot plate in the glovebox with the temperature monitored using a thermocouple.

Results

As deposited, the MoO_3 films were amorphous. Following an anneal at 280°C for one hour, the MoO_3 film crystallized as mixed phases of layered □-MoO_3 and monoclinic □-MoO_3.

The cells were tested at 150°C, with a charge/discharge current density of 0.7 mA/cm^2 . The first discharge shows two distinct plateaus, yielding an areal specific capacity of 89 □Ahr/cm^2□m (Figure 1). On recharge and subsequent discharges, these plateaus disappear and become broad, smoothly sloping profiles with specific areal capacity of about 140□Ahr/cm^2□m.

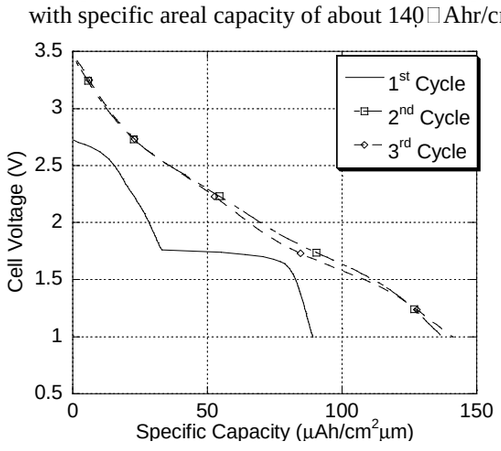

Fig. 1. First three discharges of MoO_3 cells.

The rate capability of the cells is very good at 150°C, as shown in Figure 2. The cells retained about 60% of the low discharge rate capacity when discharged at 3.6 mA/cm^2. At very low discharge rates of 0.014 mA/cm^2, the areal specific capacity from 3.5V – 1V was approximately 180□Ahr/cm^2□m.

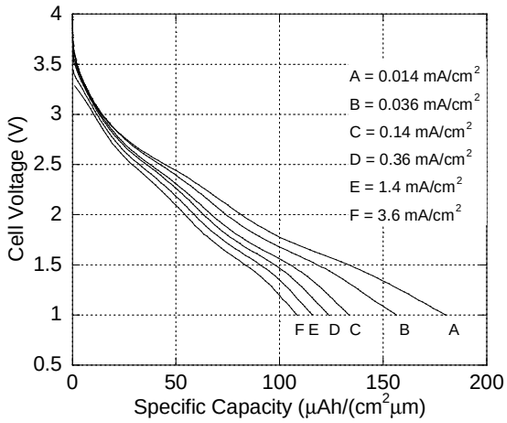

Fig. 2. Rate capability of MoO_3 cells.

The cycle life of the MoO_3 thin film batteries depends on a number of factors including charge/discharge cutoff voltages and temperature. However, preliminary results indicate that the capacity retention of the MoO_3 based thin film batteries is significantly better than conventional $LiCoO_2$ based thin film batteries.

Acknowledgments

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References

[1] B. Wang, J. B. Bates, F. X. Hart, B. C. Sales, R. A. Zuhr, and J. D. Robertson, *J. Electrochem. Soc.*, **143**, 3203 (1996).