absence of any dendrite growth is consistent with our observations and those of Jones et al. that, except for the gradual capacity loss, there is virtually no change in the charge-discharge curves after many cycles of thin film lithium cells.

The energy densities, specific energies, and capacities for the Li-TiS_2, Li-V_2O_5, and Li-$Li_xMn_2O_4$ thin-film batteries are listed in Table 3. The energy of the cells was determined from the integrals $\int V(q)dq$ over the respective discharge curves calculated between the voltages specified in the second column in the table. The mass and volume of the cells were based on 1-μm-thick cathode and electrolyte films plus an anode film thick enough to provide three times the maximum amount of Li required by the respective cathodes assuming discharg compositions $LiTiS_2$, $Li_3V_2O_5$, and $LiMn_2O4$. For the cathodes, the crystalline densities were assumed, although the actual densities of the TiS_2 and V_2O_5 films are lower. This procedure was followed because the density of the $LiMn_2O_4$ film has not been determined. For the electrolyte film, the density of 2.4 g/cm^3 reported [23] for a bulk lithium phosphorus oxynitride glass was assumed. If the actual film densities for V_2O_5 and TiS_2 were used, the energy densities would be reduced by about 10%.

Conclusions

The rechargeable thin-film lithium batteries described in this paper have high specific energies and energy densities, the ability to undergo thousands of charge-discharge cycles, and they can be fabricated into a variety of sizes and shapes on virtually any type of substrate. At the present time, the useful current that can be supplied by these cells is limited to 100 μA or less per cm^2 of cathode area at room temperature due to the slow rate of insertion of Li^+ ions into the cathodes. Possible methods for improving the insertion rate will be emphasized in future research.