

RF Sputtered Thin-Film $\text{LiNi}_{0.8}\text{Co}_{0.2}\text{O}_2$ Cathodes

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To date, the best performing Li-based rf-sputtered thin-film secondary cathodes have been composed of polycrystalline LiCoO_2 .¹ Several other Li metal oxide compounds have been used to create traditional (powder-based) cathodes that display superior capacities and discharge characteristics. One such compound is the $\text{LiNi}_{0.8}\text{Co}_{0.2}\text{O}_2$ system, which has demonstrated capacities up to 30% higher than LiCoO_2 in traditional wet cells.² The focus of our work is to explore the possibility of using rf-sputtered $\text{LiNi}_{0.8}\text{Co}_{0.2}\text{O}_2$ as a cathode layer in solid state thin-film batteries, and to determine whether the capacity increase observed in traditional electrochemical cells translates to the thin-film regime.

Three-inch planar sputter targets made of $\text{LiNi}_{0.8}\text{Co}_{0.2}\text{O}_2$, (several also had less than 5% of Al and/or Mn) were created and thin films 0.1 to 2 μm thick were rf sputter deposited at room temperature onto a variety of substrates including glass, silicon, and platinum current collectors. Some films were annealed for 1 hour at 300 °C to enhance grain size and relax lattice strain. Film structure and texturing was examined using x-ray diffraction, TEM, and SEM, while composition was determined using a combination of RBS and ICP-MS. The electrochemical performance of the layers was studied using cyclic voltammetry, impedance spectroscopy, and cell cycling experiments.

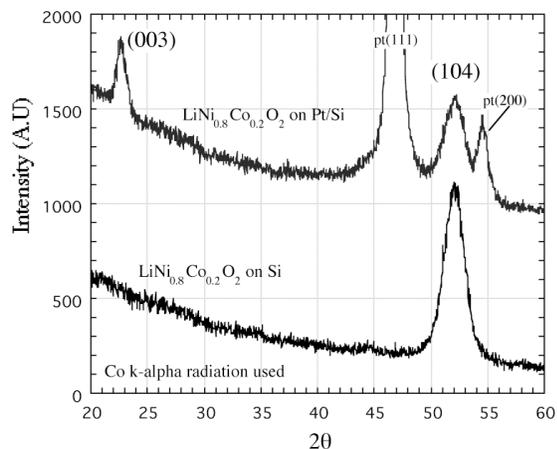
Results showed that thin films of nanocrystalline $\text{LiNi}_{0.8}\text{Co}_{0.2}\text{O}_2$ were created even when sputtered at room temperature. The crystal lattice had the expected layered rhombohedral structure. It was found that the substrate surface material affected the type and degree of texturing in the film. Figure 1 shows x-ray diffraction patterns from $\text{LiNi}_{0.8}\text{Co}_{0.2}\text{O}_2$ films deposited at the same time onto SiO_2 and a Pt current collector layer. The former displayed only a strong (104) peak, a result that is consistent with the existence of (104) type out-of-plane texture, while the film deposited onto the Pt layer collector had a mixed (104)/(003) out-of-plane texture. This finding is relevant because it has been found previously that thin film cathode performance depends on the type and degree of texture present.³

Figure 2 shows capacity and discharge data for a solid-state cell created using a $\text{LiNi}_{0.8}\text{Co}_{0.2}\text{O}_2$ thin film cathode deposited onto a Pt current collector. The electrolyte was Lipon and the anode was evaporated Li metal.

Figure 1: X-ray diffraction patterns collected from $\text{LiNi}_{0.8}\text{Co}_{0.2}\text{O}_2$ films sputtered onto amorphous SiO_2 and Pt surfaces.

The cells were charged to 4.25 V (current taper to 1 μA) and discharged to 2.5 V at 10 $\mu\text{A}/\text{cm}^2$. Over the first 100 cycles, the total capacity increased approximately 25%. The normalized capacity of this cell was 50 $\mu\text{Ah}/\text{cm}^2\mu\text{m}$, a value significantly lower than the 62 $\mu\text{Ah}/\text{cm}^2\mu\text{m}$ that has been documented in our lab using similar cells made with sputtered LiCoO_2 cathodes.

This shows that $\text{LiNi}_{0.8}\text{Co}_{0.2}\text{O}_2$ cathode layers



deposited onto Pt current collectors do not have capacities that exceed those of LiCoO_2 . The relationship between film texture and battery capacity will be discussed, and possible mechanisms responsible for the increase in capacity during cycling will be described.

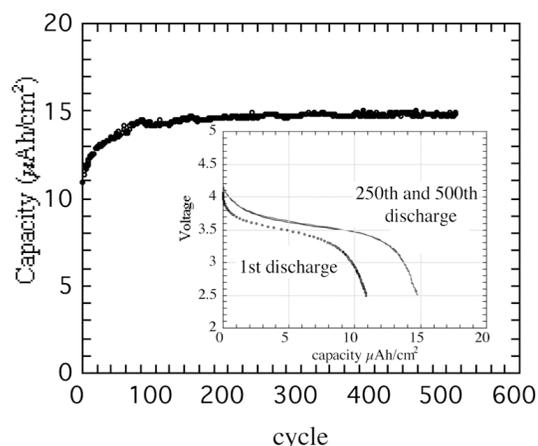


Figure 2: Cycle life and discharge data for a solid-state cell utilizing a 0.3 μm thick $\text{LiNi}_{0.8}\text{Co}_{0.2}\text{O}_2$ cathode layer annealed at 300 °C.

Acknowledgments

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¹ J.B. Bates, N.J. Dudney, B. Neudecker, A. Ueda, C.D. Evans, *Solid State Ionics* **135** 33-45 (2000).

² K Lee, K. Kim, *J. Electrochem. Soc.* **147** (5) 1709-1717 (2000).

³ J.B. Bates, N.J. Dudney, B.J. Neudecker, F.X. Hart, H.P. Jun, S.A. Hackney, *J. Electrochem. Soc.* **147** (1) 59-70 (2000).