Development of a Novel Layered Cathode Material for Li-ion Batteries

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The insertion or intercalation compounds such as transition metal oxides $LiCoO_2$, $LiNiO_2$, and $LiNi_xCo_{1-x}O_2$ are among the most suitable layered cathode materials[1-3] for the Li-ion batteries. Increasing social demands and practical applications of lithium rechargeable batteries have accelerated for development of new types of materials as an alternative energy source. Among those, the $LiCoO_2$ is easy to manufacture and has shown good electrochemical performance. However, the $LiCoO_2$ material suffers from two drawbacks namely the high cost of cobalt and the limited capacity due to the structural restriction. On the other hand, $LiNiO_2$ is isostructural with $LiCoO_2$ and the cost of nickel is about one-quarter that of cobalt. But, the $LiNiO_2$ material has disadvantages related to its synthesis and thermal properties. Substituting a part of the nickel in $LiNiO_2$ with other metal has been suggested to improve the thermal safety while maintaining the electrochemical performance. For example, the $LiNi_{0.8}Co_{0.2}O_2$ cathode material can be considered to possess the merits of both $LiNiO_2$ and $LiCoO_2$ materials. However, the cost and thermal safety of these materials still remain a question. The identification and development of new cathode material for a high-performance and safer Li-ion battery, therefore, is critical because of the cost limitations and safety concerns of the existing oxide cathodes. Recently, new-type of the layered structure cathodes such as $Li[Li_{0.2}Cr_{0.4}Mn_{0.4}]O_2$ and $Li[Ni_xLi_{(1/3-2x/3)}Mn_{(2/3-x/3)}]O_2$ for $0<x<1/2$, containing additional lithium in the transition metal layers have been reported.[4] A novel Layered $Li[Li_{0.12}Ni_zMg_{0.32-z}Mn_{0.56}]O_2$ cathode material was derived from Li_2MnO_3 or $Li[Li_{1/3}Mn_{2/3}]O_2$ by partial substitution of Ni^{2+} and Mg^{2+} for Li^+ and Mn^{4+}. The layered $Li[Li_{0.12}Ni_zMg_{0.32-z}Mn_{0.56}]O_2$ with z=0.28 and 0.3, incorporated with additional lithium in the transition metal layers, has been synthesized and the electrochemical and thermal properties are investigated by diverse electrochemical methods and by differential scanning calorimetry. Results of the synthesis, electrochemical behavior including the cycling performance as a function of temperature, and thermal properties of the layered $Li[Li_{0.12}Ni_zMg_{0.32-z}Mn_{0.56}]O_2$ cathode material will be presented and discussed in detail.

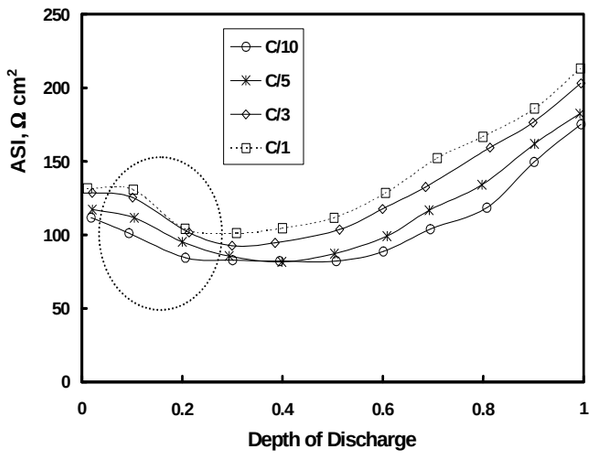

Fig. 1 Area specific impedance (ASI_{30s}) of the $Li[Li_{0.12}Ni_zMg_{0.32-z}Mn_{0.56}]O_2$ cathode for z = 0.3 at various rates.

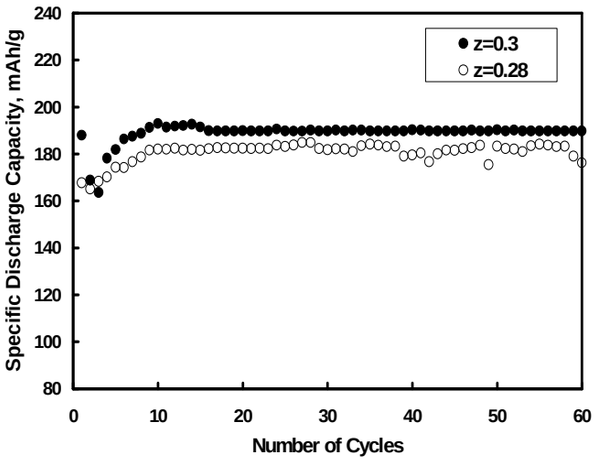

Fig. 2 Cycle life of the $Li[Li_{0.12}Ni_zMg_{0.32-z}Mn_{0.56}]O_2$ cathode with z=0.28 and z=0.3 cycled at a C/18 rate at room temperature.

References:

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