Effects of Nano-Metal Oxide on Interface of Cathode/Electrolyte in Lithium Ion Batteries

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Lithium-ion batteries are widely used in portable electronics, electric vehicles, energy storage and some other fields. To meet the needs in industries, the cycling and high-rate performances of lithium ion batteries should be further improved. In recent, it is believed that the interfacial reactions between the cathode material and the electrolyte lead to the formation of cathode/electrolyte interface (CEI)[1], which dramatically influences the electrochemical performances, thermal stabilities and safety properties of lithium ion batteries. To modify and stabilize the CEI, the cathode material was coated with nano-metal oxides (MgO, Al_2O_3, CuO, ZrO_2 and TiO_2)[2] to prevent direct contact from the electrolyte and the cathode material, and hence the cell performances were improved. However, the mechanism of cathode material coated with nano-metal oxide to improve battery performances is unclear due to the series of complex physical and chemical processes involved in the reactions and the migration of lithium ions on the CEI. In this work, the cathode materials, namely $LiFePO_4$ and $LiNi_{0.5}Mn_{1.5}O_4$, were coated with a layer of amorphous Al_2O_3 film by the sol-gel method. The structures, morphologies and elemental distributions of the samples were characterized by XRD, TEM, SEM, EDS and XPS. The electrochemical performances were measured by using Land CT2001A cyclers. Results show that the high-rate capabilities and the cycle performances of the electrode materials are greatly improved after coating with Al_2O_3 film. The interface resistances and charge transfer resistances decrease significantly with the amorphous Al_2O_3 film on the CEI. The SEM images of the cathodes after cycling test show that the morphology of the coated samples remains intact, while a serious filming phenomenon occurred on the surface of the naked cathode materials. The band gap of the cathode materials with coating layer is decreased to reduce the electronic transition barrier and improve conductivity[3] compared with the naked samples. The coated Al_2O_3 effectively impede the generation of the CEI film owing to prevent the direct contact from the cathode material and electrolyte, and the interface impedance and the charge transfer resistance are reduce. Then the lithium ion migration rate increases. Moreover, the coated Al_2O_3 stabilizes the structure of the cathode material and avoids the structure damage caused by high rate charging and discharging. The high-rate performances of the lithium-ion batteries are then improved.

References:

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