Investigation of anode materials for lithium-ion batteries

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CHAPTER 10. GENERAL CONCLUSIONS

10.1 Review of this study

Investigations on novel anode materials for lithium ion batteries have been presented in the previous chapters. These studies include the following aspects:

10.1.1 Tin oxides based anodes for lithium ion battery

Highly porous spheres consisting of active small grains of tin oxides were prepared by the spray pyrolysis technique, followed by fabrication to lithium coin cells. The spherical porous SnO$_2$ anode shows superior electrochemical properties, i.e. a large initial capacity (601 mAh/g) and excellent cyclability. The retained capacity up to 50 cycles is 68.2% of the initial capacity, which is far superior to the previous SnO$_2$ electrode.

Tin oxide anodes suffer big capacity fading during lithium alloying and de-alloying because the volume changes. To get better cyclability, one of the solutions is to make tin oxide based nanocomposites to suppress the volume changes.

SnO$_2$-carbon nanocomposites were obtained by spray pyrolysis of a mixed solution of SnCl$_2$·2H$_2$O and sucrose at 700°C. The SnO$_2$ presents a structure resembling broken hollow spheres, which is porous on both the inside and outside particle surfaces. This structure promises a highly developed specific surface area. The SnO$_2$-carbon
composites showed a significantly improved cycle-life performance compared with SnO$_2$ without carbon. We suggest that the nanostructure of crystalline SnO$_2$ prevents the Sn regions from aggregating to some extent, and that the presence of the carbon matrix provides an effective cushion against the specific volume changes in the tin regions.

SnO$_2$-PPy composite, suitable for lithium-ion battery anodes, was prepared by chemical polymerization. The conductive polypyrrole serves as a conducting matrix to buffer the active material in the composite and thus to reduce the volume change associated with Li$_x$Sn alloying and dealloying reactions. The cyclability was improved compared to bare SnO$_2$ anodes.

10.1.2 Transition metal oxide anodes for lithium ion battery

Transition metal oxide (NiO and Co$_3$O$_4$) anodes for the lithium ion battery with controllable morphology were examined.

Spherical clusters of NiO nanoshafts were prepared by chemical precipitation followed by precursor decomposition at 280 °C in air. Electrochemical measurements showed that the as-prepared nanoshaft cluster electrodes could be charged and discharged reversibly with high capacities and superior cycling reversibility. The enhanced electrochemical character of nanoshaft cluster electrodes arises from their relatively high specific surface areas and easier lithium diffusion. Therefore, spherical clusters of NiO nanoshafts are promising materials for application in rechargeable lithium-ion batteries.
Co₃O₄ powders with visible tetragonal dipyramid structures were synthesized via a versatile non-aqueous reaction system using benzyl alcohol solvent. The reaction between cobalt oxide and alcohol leads to polyhedral particle shapes; the morphology is controlled by selection of the solvent. The as-synthesized Co₃O₄ demonstrates high lithium storage capacity and promising cycle-life as an electrode material for Li-ion batteries.

**10.1.3 Mesoporous gold anode for lithium ion battery**

Mesoporous gold anode materials for the lithium ion battery were prepared for the first time. The multilayer mesoporous Au electrode showed superior discharge capacities and better cycle stability than the thin, solid gold film. The mesoporous structure of Au probably contributes to accommodating the large volume changes in the electrode that occur during alloying and de-alloying, which can reduce the fading in capacity to some extent.

**10.2 Suggestions for future study**

Although a series of studies on the physical, structural and electrochemical properties of different anode materials have been carried out in the present studies, it should be noted that the characterisation of the electrode performance has focused on the specific capacity, cycle life, and rate capability. Other performance parameters of the electrode such as high temperature behaviour and thermodynamic properties, have not been considered. It is therefore suggested that efforts should be made on the parameters
mentioned above in order to further understand and improve the performance of the electrodes.