Template Synthesis of Nano-structured Ruthenium Oxide Electrode For Supercapacitor Application

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There has been a great interest in the supercapacitors as the energy storage devices of high power applications such as power sources for digital mobile telecommunication devices, memory back-up devices, and hybrid electric vehicles. Among transition metal oxides considered as the promising electrode materials for supercapacitors, ruthenium oxide has been accepted as the best materials due to its advantages of a highly reversible redox reaction, remarkably high specific capacitance, and very long cycle life. Usually, ruthenium oxide for supercapacitor electrode material is prepared by thermal decomposition or sol-gel method. It has been reported that anhydrous and crystalline ruthenium oxide is obtained by decomposition of $RuCl_3$ precursor solutions at high decomposition temperature over 300℃. The maximum specific capacitance of thermally prepared ruthenium oxide is 380 F/g. Recently, hydrous and amorphous ruthenium oxide has been prepared by sol-gel process. In sol-gel technique, ruthenium oxide powders are precipitated from $RuCl_3$ based precursor solution at a proper pH. It is reported that sol-gel derived ruthenium oxide has been found to exhibit very high specific capacitance of 720 F/g.

In this study, nano-structured ruthenium oxide electrode for supercapacitor application was prepared by template synthesis method. This method involves synthesizing a desired material within the pores of a porous membrane having nano-sized cylindrical pores of uniform diameter. The template membranes used for nano-structured ruthenium oxide electrode synthesis is porous alumina membranes and they are prepared electrochemically from aluminum metal.

Nano-structured ruthenium oxide electrode was prepared using two different procedures. Firstly, ruthenium oxide was electrodeposited and filled up the nano-sized cylindrical pores of membrane. The alumina template membrane was then removed. Secondly, nano-structued Au or Pt substrate was made by electroplating using alumina membranes, and then the thin film of ruthenium was electroplated on nano-structured substrate. The ruthenium oxide thin film was anodized at a proper potential or grown by potential cycling.

Nano-structured ruthenium oxide has very high surface area compare with thermally prepared or sol-gel derived ruthenium oxide thin film electrode. Since pseudocapacitive redox reaction of ruthenium oxide is mainly took place at the surface of the electrode, high capacitance per unit mass of the electrode material (specific capacitance) can be obtained from nano-structured ruthenium oxide electrode.

The nano-structured ruthenium oxide electrode prepared by template synthesis method is characterized by X-ray diffraction and thermogravimetric analysis. The electrochemical properties such as specific capacitance, reversibility, and high rate capability, which means electrochemical performance at high potential scan rate, are examined by cyclic voltammetry.

References

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