The electrochemical characteristics of amorphous V_2O_5 thin film cathodes prepared by sputtering method

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Recently. Thin film rechargeable batteries have received significant attention due to their broad applications such as micro-sensors, smart cards, and micro-electro-mechanical system (MEMS) devices. The energy storage capacity is in general dependent on cathode materials. It is well-known that the transition metal oxides, such as $LiCoO_2$, $LiMn_2O_4$, $LiNiO_2$ have been extensively studied due to their high voltages close to 4 V and long cycle life. However, these materials have certain drawback because the deposition temperatures are relatively high (about 400~800℃), which seems to be a restriction on practical applications. It is reported that vanadium oxide film is considered to be a promising candidate because it can be deposited at lower temperature. Moreover, vanadium oxide film have demonstrated high specific capacity and fairly good rechargeability in the voltage window between 3.5 V and 1.5 V.

Vanadium oxide film were prepared on Pt/Ti/Si substrate by rf magnetron sputtering using a V_2O_5 target in a mixed $Ar+O_2$ atmosphere. Pt and Ti are cathode current collector and adhesion layer, respectably. Substrate temperature fixed on 200℃. V_2O_5 target fabricated V_2O_5 powder (Junsei Chemical Co. Ltd) and PVA(poly vinyl alcohol) by solid state sintering. The target to substrate distance was 6 cm. The rf power and total pressure were 60 W and 15 mTorr. $Ar-O_2$ gas mixture ratio was 70/30.

The film thickness measured y a Tencor Alpha-step profiler.

X-ray diffraction data (XRD) were obtained using M18XHF-SRA in the 2Θ range from 15 to 35° with Cu $K\alpha$ radiation (λ = 1.5406 Å). Electrochemical characterization of the prepared film was performed in liquid electrolyte. Active area of sputtered vanadium oxide thin film for electrochemical analysis was about 1 cm^2. 1M $LiClO_4$ in PC (propylene carbonate) and a Li foil were used as a liquid electrolyte and an anode, respectively.

The galvanostatic charge/discharge test was carried out with WBCS 3000 charge/discharge analyzer at constant current density 100 $\mu A/cm^2$ in the voltage window between 4 V and 1.5 V.

Our as-deposited V_2O_5 thin film shows amorphous behavior and we achieve crystalline structure by heat treatment. Despite as-deposited V_2O_5 thin film shows irreversible capacity loss at first cycling, it shows approximately double capacity contrast to crystalline one. But heat-treated V_2O_5 thin film shows vivid voltage plateau at entire chare/discharge curves.

In conclusion, amorphous V_2O_5 exhibit better electrochemical properties, compared to crystalline ones. Amorphous V_2O_5 shows high capacity and small capacity fading compared with crystalline V_2O_5. However both two samples show excellent charge/discharge efficiency.