

Development of Transition Metal Oxynitride Electrodes for Supercapacitors

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INTRODUCTION

Many transition metal oxides, nitrides and oxynitrides possess pseudocapacitive characteristics for supercapacitors. Molybdenum oxynitride is one of these materials, which is electrochemically active, highly conductive and low cost [1,2]. To be applied as electrodes in supercapacitors, it is necessary to develop a methodology that not only can produce high performance molybdenum (and other transition metal) oxynitrides but also can be readily scaled-up. In this work, we report our efforts on developing such processes for molybdenum oxynitride electrodes.

EXPERIMENTAL

A two-step approach was utilized in this study. Molybdenum oxides (MoO_2 , MoO_3) were first electrodeposited onto titanium current collector in a plating bath (0.4M Na_2MoO_4 , 0.12M Na_2SO_4 and 0.005M H_2SO_4). The oxide was then converted into oxynitride via a thermal nitridation using nitrogen gas (99.998%).

Cyclic voltammetry was used to characterize the electrochemical performance of the samples in 0.5 M H_2SO_4 solution. For comparison, molybdenum oxide electrode without nitridation was studied as well.

RESULTS AND DISCUSSION

The cyclic voltammograms (CV) of molybdenum oxide and molybdenum oxynitride on electrodes were shown in Fig.1. Compare to the oxide, the oxynitride exhibited a higher capacitance of $8.2\text{mF}/\text{cm}^2$ ($356\text{F}/\text{cm}^3$ base on an average coating thickness of 230nm) in a voltage window from -0.15V to 0.45V. The relatively rectangular shape of the CV for Mo oxynitride suggested a good capacitive behavior. The superior electrochemical performance of Mo oxynitride to Mo oxide also illustrated the importance of the nitridation process.

The cycle life of molybdenum oxynitride electrode was shown in Fig.2, where the CV of the 1st cycle, 2500th cycle and 5000th cycle were compared. The result showed little change in CV profile, indicating that the oxynitride electrode was stable for long time cycling in acidic media. There was a slight increase in capacitance from 1st cycle to 5000th cycle (ca. 6%). This may be due to the further activation of the bulk oxynitride through electrolyte penetration during a repeated cycling.

In addition to the process development and electrochemical characterizations, the composition, morphology and structure of the produced Mo oxide and oxynitride were also investigated. These results will be presented as well.

REFERENCES

- [1] Hossein Farsi, Fereydoon Gopal, Heidar Raissi and Shokufeh Moghiminia, *Journal of Solid State Electrochem* 14,643 (2010)
[2] T.C. Liu, W.G. Pell, B.E. Conway and S.L. Roberson, *J. Electrochem. Soc.* 145, 1882 (1998)

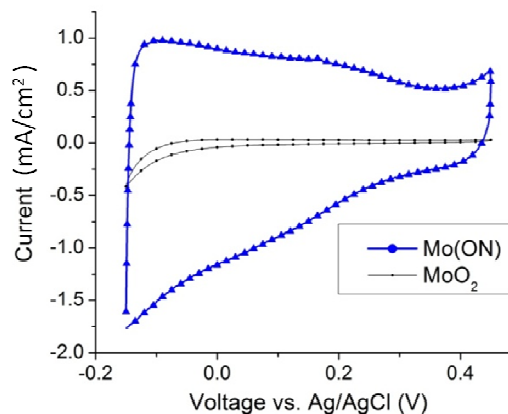


Fig. 1 CV of molybdenum oxide vs. molybdenum oxynitride in 0.5M H_2SO_4 at 100mV/s from -0.15V to 0.45V

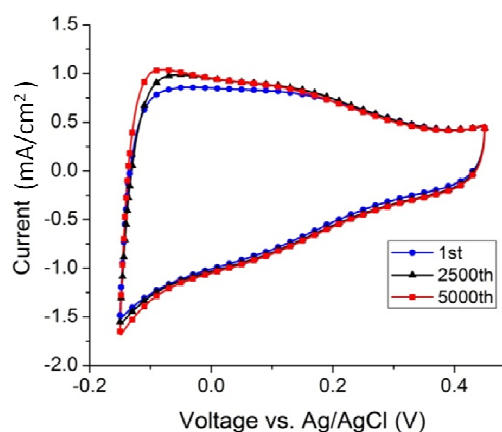


Fig. 2 CV of molybdenum oxynitride in 0.5M H_2SO_4 at 100mV/s at 1st, 2500th and 5000th cycle.