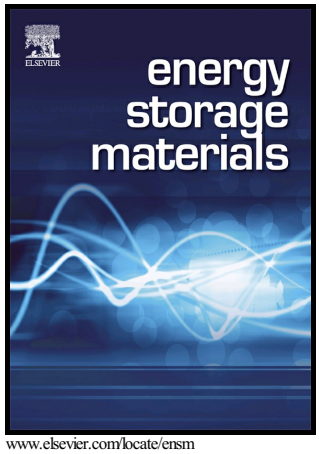

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Intercalation Na-Ion Storage in Two-Dimensional $MoS_{2-x}Se_x$ and Capacity Enhancement by Selenium Substitution

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Abstract

Two-dimensional (2D) layered transition-metal dichalcogenides has been regarded as highly promising electrode materials for fast-rate Li-ion and Na-ion batteries. Monolayer or multilayer MoS_2 nanoflakes have been employed for metal ion batteries but the material suffers from poor cyclic stability due to damage of the layered structure in a decomposition reaction. Herein, we synthesize ultrathin $MoS_{2-x}Se_x$ nanoflakes quasi-vertically aligned on the graphene-like carbon foam (the obtained material is referred to as $MoS_{2-x}Se_x$/GF) and investigate the Na-ion storage property using in-situ Raman spectroscopy and ex-situ XRD measurements. We show that by choosing appropriate potential range, it is possible to maintain the 2D layered structure and thus significantly improve the capacity retention due to the intercalation mechanism. As a freestanding electrode, the $MoS_{2-x}Se_x$/GF demonstrates high-rate reversible Na-ion storage, where both the capacity and rate-performance are enhanced by the selenium substitution. This study sheds new light on better understanding of the metal ion storage mechanism of 2D transition metal chalcogenides that are being widely investigated.

Graphical abstract

Ultrathin $MoS_{2-x}Se_x$ nanoflakes quasi-vertically aligned on the 3D graphene foam ($MoS_{2-x}Se_x$/GF) was successfully synthesized and be used as anode material in sodium ion battery. The sodiation mechanisms at different potential ranges were revealed with in-situ Raman measurement and ex-situ XRD characterization.

Keywords: 2D materials; Na-ion battery; transition-metal dichalcogenides; in-situ Raman; charge storage mechanism.

Introduction

In the pursuit of the large-scale energy storage systems, sodium-based energy storage devices,