SnS_2 Vertically Aligning on Graphene Enable Highly Robust Anode for Lithium-Ion and Sodium-Ion Batteries

Zijia Zhang [a], Hailei Zhao [a,b], Jiejun Fang [a], Zhaolin Li [a], Lina Zhao [a]

[a] *University of Science and Technology Beijing, School of Materials Science and Engineering, Beijing 100083, China*
[b] *Beijing Municipal Key Laboratory of New Energy Materials and Technologies, Beijing 100083, China*

E-mail: hlzhao@ustb.edu.cn

Lithium-ion batteries (LIBs) are considered as a key technology in large-scale energy storage devices such as energy storage systems for the electric grid and electric vehicles (EVs).[1] In addition, sodium-ion batteries (SIBs) are going on fast development as alternatives to LIBs due to the abundant sodium resources and low cost.[2] However, commercially used graphite anode has relatively low theoretical capacity for lithium-ion storage and is inert toward sodium-ion storage. To satisfy the requirements of the applications, the current LIB and SIB systems need high-performance anode materials with respect to cost, safety and energy/power density.

SnS_2, a representative laminar material, has received growing interests as a potential anode material for LIBs and SIBs because of its high lithium and sodium storage capacities, natural abundance and eco-friendliness.[3] Despite these advantages, the practical application of SnS_2 anodes is still handicapped by the poor cycling stability, due to the large volume fluctuation during Li-ion/Na-ion uptake/release process, and inferior rate capability associated with low electronic conductivity between adjacent layers.

To address these issues, we designed a unique 2D/2D lamellar hybrid structure built from SnS_2 nanosheets vertically grown on the surface of graphene sheets through strong C-O-Sn bond. The vertical aligning of SnS_2 nanosheets on graphene affords sufficient active sites for lithium/sodium insertion, accelerating the electrode reaction kinetics. The chemical coupling between SnS_2 and graphene provides fast electron transport and strong combination between SnS_2 and graphene, offering a durable hybride structure. As a result, the SnS_2/graphene nanocomposite delivers high reversible capacities of 1010 and 575 mAh g^{-1} at 0.1 A g^{-1} with a stable cycling performance for 200 cycles for LIBs and SIBs, respectively. Impressively, reversible capacities of 670 and 320 mAh g^{-1} are still retained for Li- and Na-ion storage at a current density as high as 10 A g^{-1}. More importantly, the composite can also endure high-rate (1 A g^{-1}) and long-term (1000 cycles) cycling with reversible capacities close to 910 and 480 mAh g^{-1} for LIBs and SIBs, respectively, without detectable capacity degradation.

Acknowledgements
This work was financially supported by National Natural Science Foundation of China (U1637202, 51634003), National Basic Research Program of China (2013CB934003), and Program of Introducing Talents of Discipline to Universities (B14003).

References:
[1] A.S. Arico, P. Bruce, B. Scrosati, J.M. Tarascon, W. Van Schalkwijk, Nat. Mater. 4 (2005) 366-377.
[2] N. Yabuuchi, K. Kubota, M. Dahbi, S. Komaba, Chem. Rev. 114 (2014) 11636-11682.
[3] Y.H. Liu, Y.H. Xu, Y.J. Zhu, J.N. Culver, C.A. Lundgren, K. Xu, C. Wang, ACS Nano 7 (2013) 3627-3634.