Three-Dimensional Array Electrodes Designed for High-Rate Full Sodium Ion Storage Device

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Three-dimensional (3D) batteries continue to be of widespread interest for flexible energy storage where the 3D nanostructured cathode is the key component to achieve both high energy and power densities. While current work on flexible cathodes tends to emphasize the use of flexible scaffolds such as graphene and/or CNTs, this approach is often limited by poor electrical contact and structural stability. This paper presents a novel synthetic approach to forming 3D array cathode for the first time, the single-crystalline Na3(VO)2(PO4)2F (NVOPF) by using VO2 array as a seed layer precursor. The NVOPF cathode exhibits both high-rate capability (charge/discharge in 60 s) and long-term durability (10k cycles at 50C) for Na ion storage. Utilizing in situ XRD and first principles calculations, the high-rate properties are correlated with the small volume change, 2D fast ion transport and the array morphology. A novel all-array flexible Na+ hybrid energy storage device based on pairing the intercalation-type NVOPF array cathode with a cogenetic pseudocapacitive VO2 nanosheet array anode is demonstrated.