14th International Conference on
Plasma Based Ion Implantation & Deposition

PBII&D 2017

New World Shanghai Hotel

October 17-20, 2017, Shanghai, China

Program

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Oxygen-deficient V_2O_5 nanosheets for superior LIB cathodes

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Abstract: V_2O_5 is a promising cathode material for lithium ion batteries boasting a large energy density due to its high capacity as well as abundant source and low cost. Oxygen-deficient transition metal oxides (TMOs) prepared by H_2 thermal treatment have attracted increasing attention as electrodes in LIBs and supercapacitors on account of the improved conductivity and kinetics in the electrochemical reactions. In this work, we report the design and fabrication of an oxygen-deficient V_2O_5 nanosheets with super Li storage properties. The V_2O_5 nanosheets with most of O(II) vacancies are fabricated by hydrogenating V_2O_5 nanosheets at a relatively lower temperature of 200 ^oC, enabling easier and faster Li ion diffusion. In our work, hydrogen atoms first adsorbed at the oxygen sites forming OH and then H-V_2O_5 with most oxygen vacancies at O(II) sites could be produced because the formation of the oxygen vacancy in O(II) sites by removing the OH^- group requires less energy than removing oxygen directly. The H-V_2O_5 with most oxygen vacancies in O(II) sites has improved conductivity, faster diffusion of Li^+, and improved structure stability for Li^+ intercalation/deintercalation, resulting in higher capacity, rate capability, and improved cycling stability. The hydrogenated V_2O_5 (H-V_2O_5) nanosheets deliver an initial discharge capacity as high as 259 mAh g^{-1} and it remains at 55% when the current density is increased 20 times from 0.1 to 2 A g^{-1}. The H-V_2O_5 electrode has excellent cycle stability with only 0.05% capacity decay per cycle after stabilization. The effects of oxygen defects on Li^+ diffusion and overall electrochemical lithium storage performance are revealed. Our results reveal a simple and effective strategy to improve the capacity, rate capability, and cycling stability of V_2O_5 materials which have large potential in energy storage and conversion applications.

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