Nickel foam supported MnO_2 nanosheet arrays for electrochemical energy storage

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Abstract

Well-defined γ-MnO_2 nanosheet arrays have been grown on nickel foam current collectors by one-step electrodeposition followed by low-temperature thermal annealing. Extensive SEM and TEM investigations reveal that the nanosheets are 20 nm thick on average and highly porous (see Fig. a below). The as-fabricated nickel foam supported MnO_2 nanosheets are directly utilized as an electrode in lithium-ion coin cells without using any binder. They are found to possess remarkably high specific capacity, which is around 1250 mAh/g at a charge/discharge current density of 100 mA/g. Even at a current density as high as 1000 mA/g, the specific capacity of these nanosheets still remains 680 mAh/g, much higher than the theoretical capacity of graphite (372 mAh/g) – the anode material currently being widely used in commercial lithium-ion batteries. Moreover, these nanosheets also exhibit very good cycling performance and a nearly 100% Coulombic efficiency. Aside from lithium-ion coin cells, supercapacitors based on nickel foam supported MnO_2 nanosheets are also fabricated and found to be able to work within a wide potential window from 0 to 1V *versus* saturated calomel electrode (SCE). Extensive electrochemical tests confirm that the MnO2 nanosheet based supercapacitors have reasonably high specific capacitance, good rate capability and satisfactory cycling performance (Fig. b).

The excellent electrochemical performance of the as-fabricated MnO_2 nanosheets/nickel foam electrodes can be attributed to the following advantages of the electrode structure: i) the open porous network of MnO_2 nanosheets effectively enhances the electrolyte/electrode contact area, and facilitates the mass transport of electrolyte and different charge carriers; ii) the ultrathin nature of the MnO_2 nanosheets shortens lithium insertion/extraction distances, offering enhanced rate capability; iii) the fact that nearly all nanosheets have a direct intimate contact with the underlying nickel foam (see the SEM image) and the binder free nature of the electrode eliminate the extra contact resistance between the current collector and active materials which usually prevails in an electrode using binder, therefore facilitating the electron transport in the electrode.

Our results manifest that nickel foam supported MnO_2 nanosheets hold great promise for use as high-performance anode in lithium-ion batteries.

Figures

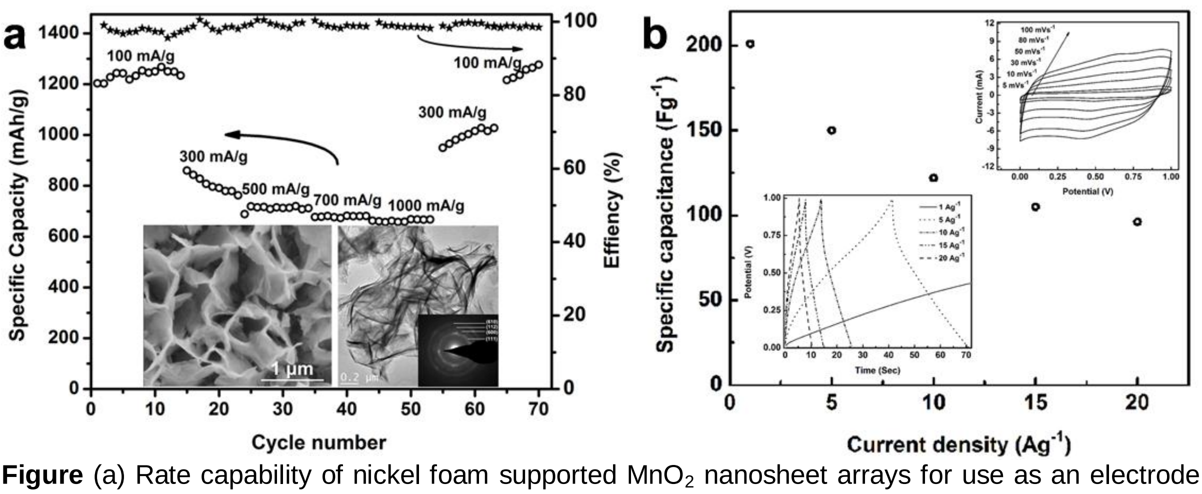

Figure (a) Rate capability of nickel foam supported MnO_2 nanosheet arrays for use as an electrode in lithium-ion batteries. Inset: SEM and TEM micrographs. (b) Specific capacitance of the nickel foam supported MnO_2 nanosheet electrode as a function of current densities. Inset: cyclic voltammograms and charge/discharge profiles. Electrolyte: 2 M KOH solution.