**Bi2Se3 thin films and Bi2Se3/SWCNT heterostructures as a perspective anode for lithium-ion batteries**

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In the last decades, lithium-ion batteries (LIBs) have dominated the field of energy storage and portable energy sources. Organic solvents-based lithium-ion batteries have been used in a variety of portable devices (phones, tablets, smartwatches, etc.). Also, LIBs have played a crucial role in the automotive industry, as well as being used in large-scale storage units for intermittent energy, which is usually produced by solar and wind power plants. However, organic solvents-based LIBs have three major drawbacks: high cost, sensitivity to high temperatures, and risk of ignition. The further development of LIBs, addressing these issues, is essential to sustain and facilitate the aforementioned energy consumption and storage technology. Aqueous electrolyte is a promising alternative to toxic and potentially flammable organic solvents. However, aqueous electrolyte-based LIBs suffer from disadvantages such as low voltage windows, poor cycling characteristics, formation of dendritic structures, resulting in a short connection between the battery electrodes, etc.

The main components of a battery are cathode, anode and electrolyte. Among these components, the anode is of great importance for the reliable and effective performance of the battery. One of the promising anode materials for application in LIBs is bismuth selenide (Bi2Se3). It has already shown good perspectives as an anode material for conventional organic electrolyte-based LIBs, and thus can be a promising candidate for use in aqueous rechargeable lithium-ion batteries (ARLIBs).

Here we present application of Bi2Se3 nanostructured films and Bi2Se3 deposited on single wall carbon nanotubes (SWCNT) for application as anodes in ARLIBs [1] and LIBs respectively. Bi2Se3 nanostructured thin films used as anodes were synthesized by physical vapor deposition on glass substrates or pre-fabricated SWCNT networks [2]. Deposition of Bi2Se3 on SWCNTs ensures direct mechanical and electrical contact between Bi2Se3 and SWCNTs, which can improve the performance of the anode material in battery applications.

The electrochemical behavior of Bi2Se3 nanostructured thin films in aqueous 5 M LiNO3 electrolyte with two different interface layers on the electrode surface—the solid electrolyte interphase (SEI) and the Bi2O3 layer—were investigated. The results of this work showed that the formation of the SEI layer on the surface of Bi2Se3 thin films ensures high diffusivity of Li+, high electrochemical stability, and high capacity up to 100 cycles. Bi2Se3 nanostructured thin films showed the highest capacity among reported state-of-the-art anode electrodes for aqueous electrolyte-based LIBs.

Bi2Se3/SWCNT heterostructures with different Bi2Se3:SWCNT mass ratios were investigated for application as anodes in organic solvent-based LIBs. It was found that the chalcogenide chemical composition, and consequently, the anode performance may be altered by the presence of copper back-electrode during the Bi2Se3 deposition. The novel Bi2Se3/SWCNT electrodes demonstrated high capacity up to 500 cycles.

**References**

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