Preparation of a silicon-based anode from nanofibres prepared by the electrospinning

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Abstract

The rapid growth of electric vehicles (EVs) has become a prominent trend in the automotive industry, driven by advancements in lithium-ion batteries (LIBs). The anode, or negative electrode, plays a crucial role in battery performance, and the prevalent use of graphite electrodes is attributed to their high porosity, conductivity, low weight, and cost-effectiveness. Nevertheless, scientists have recently explored monocrystalline silicon as a promising alternative to graphite. This shift offers advantages such as higher capacity, increased energy density (both volumetric and gravimetric), and a generally recognized safety benefit due to silicon's non-flammable nature. However, challenges arise from silicon's pronounced expansion and contraction tendencies during battery cycling. In this study, we address this issue by employing silicon in the form of nanofibers, which exhibit greater resilience to changes during cycling, ensuring enhanced battery stability throughout its lifecycle. Monocrystalline silicon particles were utilized as the active component in the nanofibers, obtained through grinding and sieving. A solution comprising these particles, along with organic precursors (PVP and TEOS), was processed using the electrospinning method to form fibres. To remove the polymeric PVP component, the fibres were subsequently annealed at 650 $\circ$C.

The transformations in material properties before and after the final annealing were analysed using X-ray fluorescence analysis, and changes in the phase composition were identified through X-ray diffraction analysis. The characteristics of individual fibres were observed using scanning electron microscopy and optical confocal microscopy.

Each annealed layer was pressed to achieve the highest density of active material and maximize the contact between individual fibres. The pressed layers were also examined using optical confocal microscopy. Additionally, the electrochemical properties were measured on the anode material.

This study employed a comprehensive approach combining X-ray techniques, microscopy, and pressing methods to investigate the material changes and optimize the structure of annealed layers. The results provide valuable insights into the characteristics and interactions of the individual fibres in the context of their application in advanced materials and energy storage devices.

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