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Visualisation of the rapid Cu6Sn5 lithium-ion battery anode fabrication process via real-time X-ray imaging

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Under the sponsorship of the Australian Synchrotron International Synchrotron Access Program (ISAP), real-time X-ray imaging was conducted at the SPring-8 synchrotron BL20XU beamline to visualise the rapid formation of Cu6Sn5 for lithium-ion battery anode applications. This presentation describes the experimental setup employed at the BL20XU beamline, and shares the results obtained. Lithium-ion batteries have found numerous applications in modern technologies, especially in portable devices, and increasingly in electric vehicles and renewable energy storage applications. Sn-based lithium-ion battery anodes have a higher theoretical storage capacity of 993 mAh g-1 vs. 372 mAh g-1 compared to commercial carbon-based anodes. Their better safety profile due to a lower risk of lithium dendrite formation compared to the carbon-based anodes is also desirable. However, Sn-based anodes suffer from inferior cycling performance due to the enormous stresses during the lithiation and delithiation process. Alloying Sn with Cu can reduce the reaction stresses in the anode, as Cu does not react with Li, and acts as a stress buffer. Cu6Sn5 is therefore a promising candidate material to replace carbon-based anodes. Traditionally, anode fabrication is a multi-step process where the active materials are first fabricated, and then mixed with binders and conductive materials, followed by slip casting the resultant slurry on to a current collector and dried. To simplify this fabrication process, a simple method involving direct growth of Cu6Sn5 on a Cu current collector is proposed. Yet, the growth rate of Cu6Sn5 is limited by the inter-diffusion of Cu and Sn, restricting the potential of this method for large scale production. This study proposes a method to accelerate the growth rate of Cu6Sn5 by alloying Ni to the Cu current collector. A maximum growth rate is found when 6 wt% of Ni is present in the Cu current collector, where a growth rate of up to 50x faster compared to the growth rate on a pure Cu current collector is observed. Visualisation of the fabrication process via real-time synchrotron X-ray imaging allowed the kinetics and mechanisms of the rapid Cu6Sn5 growth to be characterised.

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