

Surface-coating Mediated Electro-Chemical Performance in CuO-based Sodium Ion Batteries

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Sodium ion batteries (SIBs) have recently attracted extensive attentions as a result of high demand from the rechargeable battery market and the rapid development of lithium ion batteries (LIBs)¹⁻⁵. The cost of SIBs should be lower than that of LIBs because the natural storage capacity of sodium is high enough to satisfy the demand for large-scale energy storage in a range of applications from electronic vehicles to power backup. Metal oxide nanostructures are considered as promising candidates for the electrode materials in SIBs⁶. However, the intermediate species and the evolution of the morphology of the electrode materials during the discharge - charge processes in SIBs, which are closely associated with the cycling efficiency and capacity storage of batteries, are still obscure. As such, it is imperative to investigate the real-time evolution of the microstructure and composition of electrode materials during electrochemical reactions⁷.

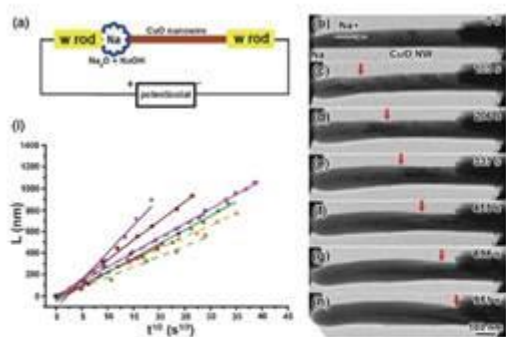


Fig. 1. Sodiation process in CuO NW.

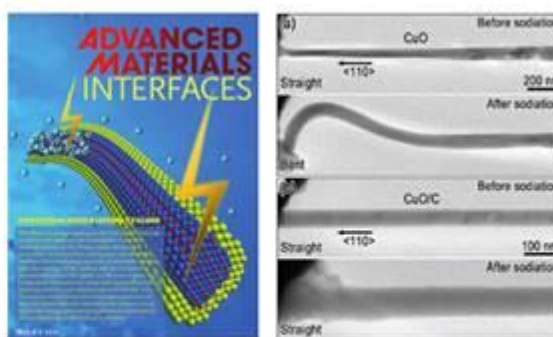


Fig. 2. Anisotropic expansion of CuO NW with carbon coating.

Herein, dynamic microstructural evolution during the sodiation of CuO nanowires (NWs) is directly recorded applying the *in situ* transmission electron microscopy (TEM)⁸⁻¹². The sodiation length is consistently proportional to the square root of the reaction time, indicating that the sodiation procedure is controlled by a long-range diffusion transport mechanism (Fig. 1). Nonetheless, the rate performance and cycling numbers of CuO based SIBs suffer from the poor conductivity and large volume change during the ion transportation process. We show that the surface coating with carbon (C), gold (Au) could effectively constrain the NW elongation rate along the $\langle 110 \rangle$ growth direction as well as increase the electro-chemical reaction speed, which result in the improved cycling performance¹³ (Fig. 2). Additionally, the *in situ* TEM observation of sodiation-desodiation cycling in coated CuO NWs indicate the detailed electro-chemical reaction pathways. These results reveal the vital role of surface coating in affecting the electrochemical performance of CuO, which may also provide insight into the behavior of other transition oxide electrode materials^{14,15}.

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