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Synthesis of Highly Stable Pseudocapacitors From Secondary Resources

Authors : Samane Maroufi, Rasoul Khayyam Nekouei, Sajjad Mofarah

Abstract : Fabrication of the state-of-the-art portable pseudocapacitors with the desired transparency, mechanical flexibility, capacitance, and durability is challenging. In most cases, the fabrication of such devices requires critical elements which are either under the crisis of depletion or their extraction from virgin mineral ores have sever environmental impacts. This urges the use of secondary resources instead of virgin resources in fabrication of advanced devices. In this research, ultrathin films of defect-rich Mn1−x−y(CexLay)O2−δ with controllable thicknesses in the range between 5 nm to 627 nm and transmittance (≈29–100%) have been fabricated via an electrochemical chronoamperometric deposition technique using an aqueous precursor derived during the selective purification of rare earth oxide (REOs) isolated from end-of-life nickel-metal hydride (Ni-MH) batteries. Intercalation/de-intercalation of anionic O2− through the atomic tunnels of the stratified Mn1−x−y(CexLay)O2−δ crystallites was found to be responsible for outstanding areal capacitance of 3.4 mF cm−2 of films with 86% transmittance. The intervalence charge transfer among interstitial Ce/La cations and Mn oxidation states within the Mn1−x−y(CexLay)O2−δ structure resulted in excellent capacitance retention of ≈90% after 16 000 cycles. The synthesised transparent flexible Mn1−x−y(CexLay)O2−δ full-cell pseudocapacitor device possessed the energy and power densities of 0.088 μWh cm^{-2} and 843 μW cm^{-2}, respectively. These values show insignificant changes under vigorous twisting and bending to 45–180° confirming these value-added materials are intriguing alternatives for size-sensitive energy storage devices. This research confirms the feasibility of utilisation of secondary waste resources for the fabrication of high-quality pseudocapacitors with engineered defects with the desired flexibility, transparency, and cycling stability suitable for size-sensitive portable electronic devices.

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