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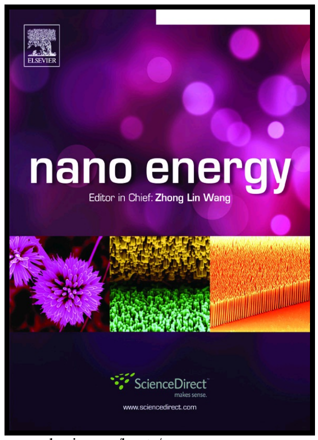

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A high-performance solid-state lithium-oxygen battery with a ceramic-carbon nanostructured electrode

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Abstract

Ceramic lithium-oxygen batteries that use non-flammable and non-volatile electrolyte have the potential to store a large amount of energy in a relatively safe way. However, the performance of this type of battery has been extremely low due primarily to the large ohmic-resistance from a thick electrolyte and the limited triple-phase boundaries (TPBs) in conventional cathodes. In this work, we fabricate a seamless electrolyte-electrode structure by one-step sintering a rather thin $Li_{1.3}Al_{0.3}Ti_{1.7}(PO_4)_3$ (LATP) electrolyte layer (20 μm thick) onto a porous LATP substrate. A hierarchical carbon is then grown in the pores of the porous LATP, uniquely forming three-dimensional pathways for the transport of lithium-ions, electrons, and oxygen throughout the entire cathode. It is found that the cathodic TPBs are 330 times larger than those of conventional solid-state lithium-oxygen batteries. As a result, the battery is capable of operating in O_2 for over 1,174 cycles (~150 days) and for over 450 cycles (75 days) with degradation of <3% in ambient air when RuO_2 and NiO are used as the catalysts. Moreover, the charge/discharge rate reaches as high as 15 mA cm^{-2}, 2-4 orders of magnitude higher than that of conventional lithium-oxygen batteries.

Keywords: lithium-air battery, solid-state LATP, electrolyte, membrane, mechanism